Paiute Cutthroat Trout Restoration Project

Silver King Creek, Humboldt-Toiyabe National Forest, Alpine County, California

March 2009

Draft

ENVIRONMENTAL IMPACT STATEMENT/ ENVIRONMENTAL IMPACT REPORT

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Prepared for

U.S. Fish and Wildlife Service

California Department of Fish and Game

SILVER KING CREEK
HUMBOLDT-TOIYABE NATIONAL FOREST, ALPINE COUNTY, CALIFORNIA

Paiute Cutthroat Trout Restoration Project

MARCH 2009

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ABBREVIATIONS, ACRONYMS, & UNITS OF MEASURE

%	percent
°C	degree Celsius
°F	degree Fahrenheit
µg/L	micro-grams per liter
AFR	Alternatives Formulation Report
APDE	areas of potential direct effect
APE	area of potential effect
AQCR	Mountain Counties Intrastate Air Quality Control Region
ATCMs	Air Toxics Control Measures
ATSDR	Agency for Toxic Substances and Disease Registry
Basin Plan	Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin
BEHMA	Lake Davis Bald Eagle Habitat Management Area
BGEPA	Bald and Golden Eagle Protection Act
BLM	Bureau of Land Management
BOD	biochemical oxygen demand
CAA	Clean Air Act

CAAA	Clean Air Act Amendments
CAAQS	California Ambient Air Quality Standards
CalEPA	California Environmental Protection Agency
CAR	Critical Aquatic Refuge
CARB	California Air Resources Board
CCR	California Code of Regulations
CDEC	California Data Exchange Center
CDF	California Department of Forestry & Fire Protection
CDFG	California Department of Fish and Game
CDPR	California Department of Pesticide Regulation
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CHHSLs	California Human Health Screening Levels
CHP	California Highway Patrol
CHRIS	California Historical Resources Information System
CNEL	Community Noise Equivalent
CO	Carbon Monoxide
CRHR	California Register of Historical Resources
CSM	conceptual site model
CSUC	California State University, Chico
CSWRCB	California State Water Resources Control Board
CVP	Central Valley Project
CWA	Clean Water Act
CWD	Coarse Woody Debris
dB	Decibels
DBDW	Department of Boating and Waterways
dbh	diameter of breast height
DBW	California Department of Boating and Waterways
DDE	Dichlorodiphenyldichloroethylene
DFG	California Department of Fish and Game
DFPZ	Defensible Fuel Profile Zone
DHS	California Department of Health Services
DTSC	California Department of Toxic Substances Control
DWR	California Department of Water Resources
EA	Environmental Assessment
EAC	Early Action Compact
EDUs	equivalent dwelling units
EHAP	Environmental Hazards Assessment Program
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPC	exposure point concentration

ERP	Ecosystem Restoration Program
ESA	Federal Endangered Species Act
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FFDCA	Federal Food, Drug, and Cosmetic Act
FGC	California Fish and Game Code
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act of 1972
FY	fiscal year
GIS	Geographic Information Systems
GLRID	Grizzly Lake Resort Improvement District
gpm	gallons per minute
HAP	hazardous air pollutant
HBSL	Health Based Screening Level
HTNF	Humboldt-Toiyabe National Forest
ICS	Incident Command System
ISO	Insurance Services Office
KOP	Key Observation Point
LDSC	Lake Davis Steering Committee
Leq	equivalent noise level
LLNL	Lawrence Livermore National Laboratory
Lmax	maximum sound level
Lmin	minimum sound level
LOAEL	Lowest Observable Adverse Effects Level
LOP	Limited Operating Period
LORs	local laws, ordinances, and regulations
LRMP	Land and Resource Management Plan
M&I	municipal and industrial
MACT	maximum achievable control technology
MBTA	Migratory Bird Treaty Act
MCAB	Mountain Counties Air Basin
MCLs	Maximum Contaminant Levels
mg	milligram
MIS	management indicator species
MOA	Memorandum of Agreement
MSDS	material safety data sheet
NAHC	California Native American Heritage Commission
NAICS	North American Industry Classification System
NEIC	Northeast Information Center
NEPA	National Environmental Policy Act
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act of 1966

NIOSH	National Institute for Occupational Safety and Health
NO	nitric oxide
NO2	nitrogen dioxide
NOA	Notice of Availability
NOAEL	no-observed adverse effects level
NOC	Notice of Completion
NOEL	no observed effect level
NOI	Notice of Intent
NOP	Notice of Preparation
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
NRHP	National Register of Historic Places
NSAQMD	Northern Sierra Air Quality Management District
NSPS	New Source Performance Standards
NSR	New Source Review
NVUM	National Visitor Use Monitoring
O&M	operations and maintenance
OEHHA	Office of Environmental Health Hazard Assessment
OHV	Off-Highway Vehicle
OM	Operations Manual
OPR	California Office of Planning and Research
OSHA	Occupational Safety and Health Administration
PAC	Protected Activity Center
PAOT(s)	Person(s) At One Time
PBO	piperonyl butoxide
PCEH	Plumas County Environmental Health
PCFCD	Plumas County Flood Control and Water Conservation District
PCT	Paiute cutthroat trout
PELs	permissible exposure limits
pH	Phosphates
PM	Particulate Matter
PNF	Plumas National Forest
ppb	parts per billion
PPE	Personal Protective Equipment
Proposed Action	Paiute Cutthroat Trout Recovery Project
PSD	Prevention of Significant Deterioration
PUC	Public Utilities Code
PWC	Personal Water Craft
RCA	Riparian Conservation Area
RCO	Riparian Conservation Objective
RfD	reference dose

ROD	Record of Decision
RT	rainbow trout
RWQCB	Regional Water Quality Control Board
SCAQMD	South Coast Air Quality Management District
SEIS	Supplemental EIS
semi-VOCs	semi-volatile organic compounds
SF	slope factor
SHPO	State Historic Preservation Officer
SIC	Standard Industrial Classification System
SIP	State Implementation Plan
SMS	Scenic Management System
SNFPA	Sierra Nevada Forest Plan Amendment
SO2	Sulfur Dioxide
SPL	sound pressure levels
SPPPC	Sierra Pacific Power Company
SWP	State Water Project
SWRCB	State Water Resources Control Board
TACs	toxic air contaminants
TMDL	Total Maximum Daily Load
TOC	total organic carbon
TRV	toxicity reference value
TSCA	Toxic Substances Control Act
TWA	Time-Weighted Average
UCD	University of California at Davis
UR	unit risk
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOCs	volatile organic compounds
VOL	volatile organic liquid
VQO	Visual Quality Objective
WoE	weight of evidence
WUI	Wildland Urban Intermix

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C H A P T E R 1

Executive Summary

This Draft Environmental Impact Statement /Environmental Impact Report (EIS/EIR) has been prepared jointly by the California Department of Fish and Game (CDFG) and the U.S. Fish and Wildlife Service (USFWS) (collectively referred to hereafter as the Agencies) for the proposed Paiute Cutthroat Trout Restoration Project (proposed Action). The objective of the proposed Action is to establish native Paiute cutthroat trout (*Oncorhynchus clarkii seleniris*) as the only trout species in Silver King Creek for the purpose of preventing hybridization with other trout species. This is a critical and necessary step to preventing Paiute cutthroat trout from becoming extinct, conserving the species, and restoring it to a level that could allow it to be removed from the federal threatened species list. The proposed Action entails the eradication of non-native trout species from 11 stream miles of Silver King Creek, its tributaries and Tamarack Lake. The Agencies propose to use the piscicide rotenone to eradicate non-native trout and to neutralize the rotenone downstream of Silver King Canyon at its confluence with Snodgrass Creek using potassium permanganate. The Agencies also propose to restock Silver King Creek with native Paiute cutthroat trout. Chapter 3.0, Project Alternatives, presents a detailed description of the proposed Project and alternatives.

The USFWS is the National Environmental Policy Act (NEPA) lead agency for Paiute Cutthroat Trout Restoration Project. The USFWS is proposing this action in fulfillment of its responsibilities to implement the Revised Paiute Cutthroat Trout Recovery Plan (USFWS 2004), which has an ultimate goal of delisting the species from being threatened and/or endangered. NEPA directs that federal agencies prepare an environmental evaluation for any major activity having the potential to significantly affect the environment. This EIS/EIR addresses the potential impacts of the proposed Action and will:

- Help public officials make decisions on the recovery project based on an understanding of environmental consequences and take actions that protect, restore, and enhance the environment;
- Identify ways to avoid or significantly reduce environmental impacts;
- Prevent significant, avoidable impacts to the environment by requiring changes in projects by considering alternatives and mitigation measures when the governmental agency finds the changes to be feasible;
- Disclose to the public the environmental information and analysis upon which Federal decisions is based; and
- To complete site-specific analysis of all public lands potentially affected by the proposed Action.

This document also addresses the requirements for an EIR under the California Environmental Quality Act (CEQA) and thus satisfies CDFG’s CEQA lead agency responsibilities. It describes the proposed Action and a reasonable range of alternatives (including the no Action alternative) and the natural and human environments. The document presents an analysis of direct and indirect impacts on these environments for each of the alternatives, describes the mitigation measures to reduce adverse environmental effects. It addresses cumulative and growth-inducing effects and identifies unavoidable impacts that cannot be reduced to less than significant with mitigation. It also presents a record of consultation and coordination with others during EIS/EIR preparation.

1.1 BACKGROUND

Silver King Creek, downstream from Llewellyn Falls to Silver King Canyon and associated tributaries in Alpine County, is the native range of the Paiute cutthroat trout, one of the rarest trout subspecies (USFWS 1985). Indigenous only to Silver King Creek, Paiute cutthroat trout were listed as endangered by the USFWS under the Endangered Species Preservation Act of 1966 on March 11, 1967 (USFWS 1967) and reclassified to threatened under the Endangered Species Act (ESA) of 1973 on July 16, 1975 (USFWS 1975). Out-of-basin populations of Paiute cutthroat trout have been established by the Agencies in several California streams including the North Fork of Cottonwood Creek and Cabin Creek in the Inyo National Forest (Mono County), Sharktooth Creek (Fresno County) and Stairway Creek (Madera County) on the Sierra National Forest.

Hybridization with non-native trout species is the primary threat to Paiute cutthroat trout (USFWS 2004, 1985). When interbred with Lahontan cutthroat or rainbow trout, Paiute cutthroat trout tend to lose their distinctiveness through hybridization (USFWS 2004). The fish in the reach between Llewellyn Falls and Silver King Canyon are a genetic mixture of introduced rainbow (*O. mykiss*), Lahontan cutthroat (*O. c. henshawi*), golden trout (*O. aquabonita* sp.), and native Paiute cutthroat trout. An unauthorized introduction of rainbow trout in Paiute cutthroat trout populations required rotenone treatments and restoration efforts spanning from 1950 to present to remove hybridized fish and safeguard restored pure populations of Paiute cutthroat trout. Genetically pure Paiute cutthroat trout are currently found in the area upstream of Llewellyn Falls, where a sheepherder moved fish from Silver King Creek (in 1912) and from where other tributary populations have been established (i.e., Four Mile Canyon Creek, Fly Valley Creek, Coyote Valley Creek and Corral Valley Creek). Native Paiute cutthroat trout seldom move great distances within the stream system and are rarely found downstream of Llewellyn Falls in Silver King Creek. However, hybridized fish could easily be introduced inadvertently above the falls, where Paiute cutthroat trout were restored by CDFG in the early 1990s.

1.2 OBJECTIVE/PURPOSE AND NEED FOR ACTION

The objective of the proposed Action is to establish the Paiute cutthroat trout as the only salmonid fish species in Silver King Creek for the purpose of preventing hybridization with other salmonids. This is an important and necessary step in preventing Paiute cutthroat trout from going extinct and conserving the species and restoring it to a level that would allow it to be removed from the federal threatened species list. To accomplish this objective, the Agencies would remove all non-native trout from the project area prior to restocking with pure Paiute cutthroat trout. The Agencies are also evaluating the necessity of removing fish from Tamarack Lake at the headwaters of Tamarack Lake Creek, a tributary of Silver King Creek, if fish are present. Chapter 3.0, Project Alternatives presents the surveys the Agencies will complete to determine the presence or absence of fish and the criteria that would be used to determine whether treatment of the lake is necessary.

Paiute cutthroat trout are currently found upstream of Llewellyn Falls; however, easy public access between areas downstream and upstream of Llewellyn Falls may result in an unauthorized transplant of hybridized fish to areas above the falls where Paiute cutthroat trout are currently found in its genetically pure form (see Figure 1-1). Therefore, the Agencies are proposing to eradicate non-native trout within the historical range of Paiute cutthroat trout from areas downstream of Llewellyn Falls and restocking Paiute cutthroat trout, expanding its range to a series of six impassible fish barriers in Silver King Canyon and associated tributaries and increasing its population. These barriers, the two highest being 8 and 10 feet high, would geographically isolate Paiute cutthroat trout from other trout species and greatly reduce the likelihood of an illegal introduction.

The purpose and need for the proposed Action is to restore Paiute cutthroat trout to its historic range as stated in the Revised Recovery Plan (USFWS 2004), and thereby satisfy one critical Recovery Plan component for delisting the species. The project would make Paiute cutthroat trout the only trout species in Silver King Creek above Silver King Canyon. By expanding the populations and range of the species, the proposed Action would also increase the probability of long-term viability and reduce threats from genetic bottlenecking and stochastic events.

1.3 PROPOSED ACTION

Under the proposed Action, the Agencies would:

- Eradicate non-native trout from Silver King Creek and its tributaries between Llewellyn Falls and Silver King Canyon, as well as Tamarack Lake (if fish are present), using chemical treatment (rotenone);
- Neutralize the rotenone downstream of Silver King Canyon to the 30-minute travel time mark near the confluence with Snodgrass Creek using potassium permanganate; and
- Restock the Project area with pure Paiute cutthroat trout from donor streams in the upper Silver King Creek Watershed (i.e., Fly Valley Creek, Four Mile Canyon Creek, Silver King Creek, or possibly Coyote Valley Creek).

The proposed Action would also include pre-treatment removal of fish by seeking Fish and Game Commission approval for an increase daily bag limit of 5 fish per day in an attempt to reduce existing non-native trout populations; pre-treatment biological surveys and monitoring for amphibians and benthic macroinvertebrates; placement of signs to inform the public; water quality monitoring (during and post treatment); and post-treatment biological monitoring. Chapter 3.0, Project Alternatives, presents a more detailed description of the proposed Action and alternatives, including a map (Figure 3-1) depicting the components of the proposed Action, including treatment area, drip stations and other activities. The Agencies would apply rotenone to the project area in the summer of 2009 and 2010 (and 2011 if needed). Additional treatments would be scheduled as necessary to ensure complete removal of non-native trout from the project area.

1.4 PUBLIC INVOLVEMENT SUMMARY

The CDFG and Humboldt-Toiyabe National Forest (HTNF) originally scheduled the proposed Action for 2002 or 2003. The HTNF mailed notices to approximately 700 citizens, groups, and agencies. The NEPA process requires notifying and involving affected and interested parties. Project notices were mailed to the following stakeholders:

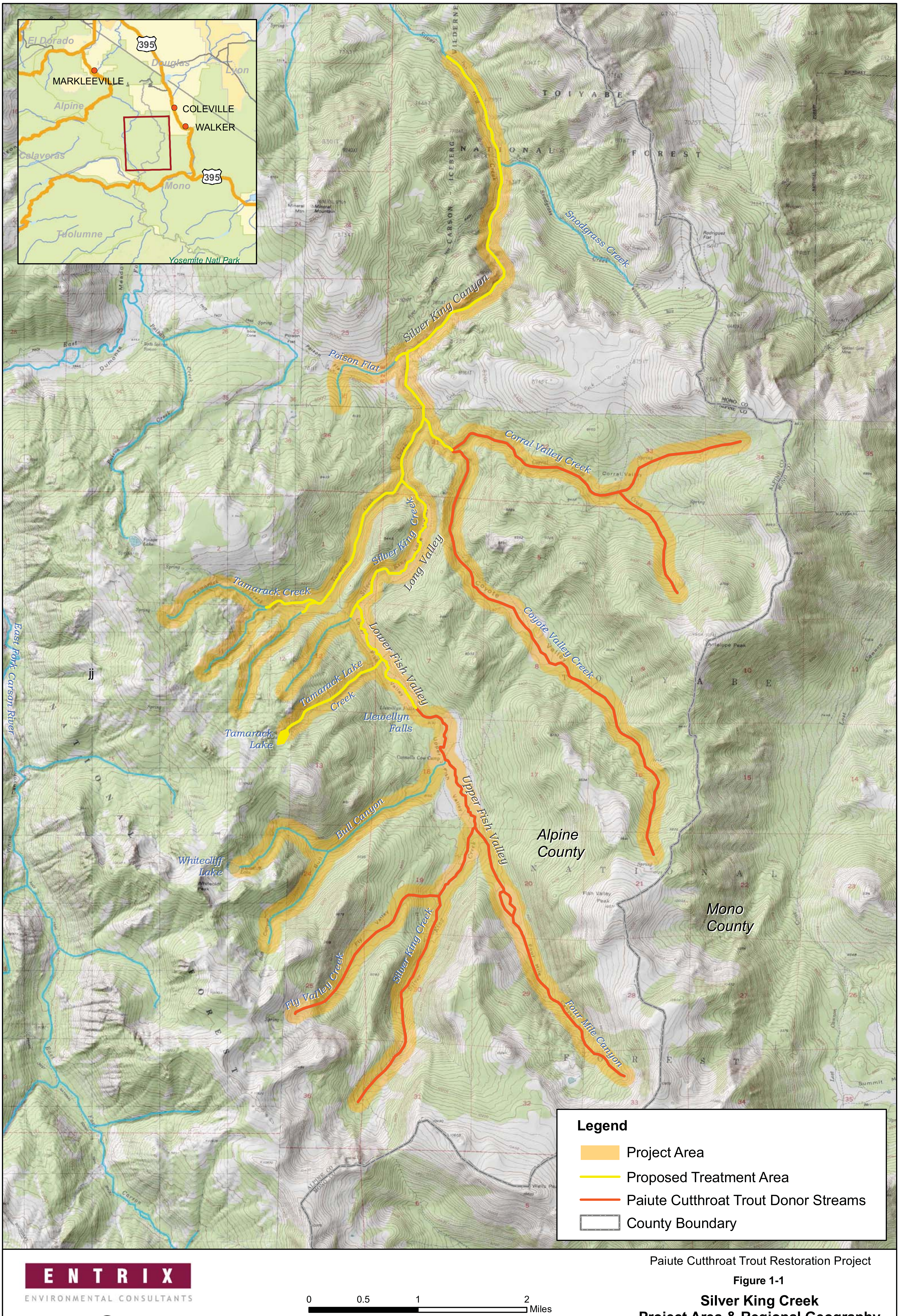
- Citizens who live, work, or recreate in the area of the proposed Action.
- Public interest groups and native communities concerned about environmental, social, or economic impacts.
- Federal, state, local, and tribal governmental agencies with public resource responsibility.
- Representatives of recreational industry conducting business in the project area.
- Scientists and other technical experts with knowledge of the natural resources in the project area.

On April 2, 2002, CDFG and HTNF staff met with the Alpine County Board of Supervisors to discuss the proposed Action. CDFG filed a CEQA Mitigated Negative Declaration on May 29, 2002, and a Notice of Determination on April 10, 2003. Public meetings were held on April 26, 2002; April 11, 2003; and April 30, 2004. CDFG also met with the Alpine County Board of Supervisors on May 20, 2002.

On April 30, 2002, HTNF issued 198 NEPA scoping letters. An additional three letters were sent upon request. Public scoping continued through May 30, 2002. Eight response letters were received. Public meetings were held at Turtle Rock Park in Alpine County on April 26, 2002 and in Markleeville on May 20, 2002. On July 31, 2002, HTNF distributed an Environmental Assessment for 30-day public review and comment. HTNF mailed the Environmental Assessment to the citizens, groups, and agencies that responded to the scoping notice or requested the Environmental Assessment. HTNF received seven comment letters. However, HTNF postponed the project on March 13, 2003 and mailed a letter informing interested parties.

The CDFG and HTNF rescheduled the proposed Action for 2004 and the HTNF Schedule of Proposed Actions was mailed to the same approximately 700 parties. On December 22, 2003, HTNF mailed 218 NEPA scoping letters to inform the public that HTNF was preparing an EA and was accepting comments until January 9, 2004. However, in 2005, the courts determined that an EIS was required so the action was postponed again.

In 2006, the USFWS determined to undertake the EIS and published a Notice of Intent (NOI) to prepare an EIS in the Federal Register (FR 71 32125 – 32126) on June 2, 2006. The NOI, included with this EIS/EIR (refer to Appendix A), requested public comment on the proposal from June 2 through July 3, 2006. In addition, as part of the public involvement process, the USFWS held a public scoping meeting in Markleeville on June 19, 2006. Approximately nine citizens attended the meeting. USFWS used the comments raised at the meeting to develop a list of issues requiring further analysis in the EIS/EIR (refer to Appendix A and Chapter 2.0, Introduction).



ENTRIX
ENVIRONMENTAL CONSULTANTS

Paiute Cutthroat Trout Restoration Project

Figure 1-1

Silver King Creek
Project Area & Regional Geography

Project area showing trout habitat in Silver King Creek, Humboldt-Toiyabe National Forest, Alpine County, California.

CDFG prepared a CEQA Notice of Preparation (NOP) on September 16, 2008. The NOP opened the public scoping period and invited the public to offer comments on the Project until October 31, 2008. The NOP is included as Appendix A herein. One public scoping meeting for the EIR was held in Alpine County at Turtle Rock Park in Markleeville, California on October 7, 2008, at 4:00 p.m. Press releases were issued to local radio, television, and print media outlets to notify the public of the meeting. CDFG sent approximately 210 direct mail notices to potentially interested parties including residents, various State, local, and Federal agencies along with existing CDFG, Regional Water Quality Control Board (RWQCB) and U.S. Forest Service (USFS) contacts. USFWS and CDFG presented information on the proposed Action and its potential effects and the role the public plays in the environmental review process. Participants were encouraged to provide verbal comments at the scoping meetings or to provide written comments. The Agencies met with the Alpine County Board of Supervisors on October 21, 2008, and November 18, 2008, and the Alpine Watershed Group on January 13, 2009, to discuss the proposed Action.

1.4.1 Agency Consultation and Coordination

The Agencies are actively consulting and coordinating with Federal, State, and local agencies, and tribes that have an interest in the proposed Action or could have a role in reviewing and/or providing permits or other approvals for aspects of the Paiute Cutthroat Trout Restoration Project. The Agencies have met with representatives of various federal, state, and local agencies regarding the respective interests of these agencies. This section presents a list of agencies that were asked to review the portions of the document relevant to that agency's jurisdiction, responsibilities, and concerns, and provide input on the following: 1) errors and omissions; 2) significance criteria; 3) environmental effects; and 4) potential mitigation measures. The USFWS and CDFG have posted the Draft EIS/EIR on their respective websites and mailed copies to the following agencies, individuals and organizations:

FEDERAL AGENCIES

- Advisory Council on Historic Preservation
- Federal Tribes
- U.S. Army Corps of Engineers (USACE)
- U.S. Army Corps of Engineers (USACE), San Francisco Division
- U.S. Department of Agriculture (USDA)
- U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service
- U.S. Department of Agriculture (USDA) National Agricultural Library
- U.S. Department of Agriculture (USDA) Natural Resources Conservation Service
- U.S. Department of Agriculture (USDA) Office of Civil Rights
- U.S. Department of Interior, Office of Environmental Policy and Compliance
- U.S. Environmental Protection Agency (USEPA)
- U.S. Environmental Protection Agency (USEPA), Region 9 San Francisco
- U.S. Fish and Wildlife Service (USFWS)

- U.S. Forest Service (USFS), Humboldt-Toiyabe National Forest (HTNF)
- U.S. Forest Service, Carson Ranger District

STATE AGENCIES

- California Department of Boating and Waterways
- California Department of Food & Agriculture
- California Department of Health Services (CDHS)
- California Department of Pesticide Regulation (CDPR)
- California Department of Toxic Substances Control (DTSC)
- California Department of Water Resources (DWR)
- California Native American Heritage Commission (NAHC)
- Office of Environmental Health Hazard Assessment (OEHHA)
- State Clearinghouse
- State Historic Preservation Officer (SHPO)
- State Water Resources Control Board (SWRCB)

REGIONAL AND LOCAL AGENCIES

- Northern Sierra Air Quality Management District (NSAQMD)
- Lahontan Regional Water Quality Control Board (Water Board)
- Alpine County Board of Supervisors
- Town of Markleeville

INDIVIDUALS AND OTHER ORGANIZATIONS

- Alpine County Chamber of Commerce
- Alpine County Clerk
- Alpine County Sheriff
- Alpine Watershed Group
- Carson River Resort
- Sorensen's Resort
- Woodfords Station
- Washoe Tribe of Nevada and California
- Center for Collaborative Policy
- Friends of Hope Valley
- Nancy Erman
- Jim Crouse
- David Katz

- Mike Matuska
- John Regan
- Bob Rudden
- Judy Wickwire
- Dave Zelmer

The Notice of Availability (NOA), including a web link to the EIS/EIR, was sent to the project mailing list and residents of Alpine County. In addition, CDs were made available at no cost to the public.

1.4.2 Public Review of EIS/EIR

After the Draft EIS/EIR is published, USFWS and CDFG will send the NOA/NOC and a newsletter to local newspapers including the Tahoe *Tribune*, Douglas County *Record Courier*, the project mailing list, and several libraries in the region.

The NOC will be filed with the Office of Planning and Research, State Clearinghouse, and the USFWS will publish the NOA in the Federal Register, beginning a 45-day public comment period.

1.4.3 Intended Uses of the EIS/EIR

This section identifies the agencies that are expected to use the EIS/EIR in their decision-making, potential permits and approvals, and related environmental review and consultations required by Federal, State, and local laws, regulations, or policies.

As described above, the USFWS is the lead agency under NEPA. The USFWS will issue a Record of Decision (ROD) stating whether the EIS complies with NEPA requirements. CDFG is the lead agency under CEQA. CDFG will decide whether to certify the EIR and to issue a Notice of Determination (NOD), Findings of Fact, and a Statement of Overriding Considerations. The USFS will determine whether or not to approve the use of motorized equipment and whether or not to approve the use of pesticides for this Project. The Lahontan Regional Water Quality Control Board (Water Board) will decide whether to issue a discharge permit.

Other Federal, State, and local permits, approvals and consultations that may be required for the Proposed Action are identified in Table 1-1.

Table 1-1 Potential Permits, Approvals, and Consultations

Agency	Permits/Approvals/Consultations
Alpine County	Hazardous materials permit
Alpine County	Restricted Materials Permit (Restricted Pesticides)
NAHC	Coordination and consultation on Section 106 NHPA consultation
OEHHA	Consultation on risk assessment, toxicology of active and inert ingredients of rotenone formulation used, and health and safety issues
SHPO	Section 106 National Historic Preservation Act (NHPA) consultation

1.5 ALTERNATIVES CONSIDERED AND PROPOSED ACTION

In addition to the proposed Action of rotenone treatment, the alternatives evaluated in this EIS/EIR include No Action and Combined Physical Removal (a non-chemical alternative).

Alternative 1: No Action. Both NEPA and CEQA require consideration of the No Action alternative. This option includes continuing the current stream and fishery management practices into the foreseeable future. This alternative would include the continued protection of pure Paiute cutthroat trout populations in Upper Fish Valley by restricting recreational fishing on a small portion Silver King Creek below Llewellyn Falls.

Alternative 2: Proposed Action (Rotenone Treatment). The proposed Action includes pre-treatment biological surveys and monitoring for amphibians and benthic macroinvertebrates, placement of signs to inform the public, rotenone treatment of Silver King Creek and its tributaries as well as Tamarack Lake (if fish are present), neutralization downstream of the project area at Silver King Canyon using potassium permanganate, water quality monitoring, and post-treatment biological monitoring. After two to three years of treatment, the Agencies would restock the project area with pure Paiute cutthroat trout.

Alternative 3: Combined Physical Removal. This non-chemical alternative would include a combination of electrofishing, gill netting, seining, and other physical methods to address Silver King Creek and its tributaries, springs, and Tamarack Lake (if fish are present). Because this method could have low efficiency in a rocky stream environment, it would be implemented over multiple years (i.e., until no fish are found using physical removal techniques).

1.6 SUMMARY OF ENVIRONMENTAL IMPACTS

The proposed Project would result in the following environmental impacts as described in detail in Chapter 5.0, Environmental Consequences.

- Biological impacts on species composition and potential loss of benthic macroinvertebrate species. Although, no known special-status macroinvertebrates or endemic species (occur only within the Silver King Creek Watershed) exist in the project area, the rotenone treatment could result in loss of rare or endemic species.
- Less-than-significant impacts on amphibians present in Silver King Creek, because the Agencies would implement amphibian monitoring and relocation efforts prior to commencing chemical treatment.
- Elimination of existing non-native trout but significant beneficial effects on Paiute cutthroat trout, expanding the population and range of the species and increasing the probability of long-term viability.
- Less-than-significant risk of exposure to wildlife species in the project area, including such species as the marten, yellow warbler, and willow flycatcher.
- Less-than-significant impacts to human exposure based on the remoteness of the project area, distance to any downstream human population, and the possible controls placed on human access during and after the treatment (potential emergency closure issued by the Fish and Game Commission).
- Temporary but significant water quality impacts.

- Less-than-significant impacts on recreation, wilderness values and management, and environmental justice.
- Potential localized economic and recreation effects with the future possibility of reopening the stream to fishing under the Fish and Game Commission.
- The proposed Action would result in cumulative beneficial effects to Paiute cutthroat trout by expanding their range and population.

Section 5.10, Comparison of Alternatives, presents a tabular comparison of the impacts of each alternative, including the No Action alternative. Section 5.10, Comparison of Alternatives, also presents a summary of the mitigation measures required to reduce the impacts of the proposed Action to less-than-significant. Impacts that are not reduced to less-than-significant are identified as significant and unavoidable.

1.7 ENVIRONMENTALLY SUPERIOR ALTERNATIVE

CEQA requires the designation of the environmentally superior alternative, which is the alternative that would result in the fewest or least significant environmental impacts. However, if the No Action alternative is identified as the environmentally superior alternative, then CEQA requires that another alternative be identified as the environmentally superior alternative.

As demonstrated in Section 5.10, Comparison of Alternatives, and as illustrated by Table 5.10-1, the No Action alternative would be the environmentally superior alternative because it would avoid all of the potentially significant impacts of the proposed Action. However, with respect to longer-term consequences, the No Action alternative would fail to implement the Revised Recovery Plan (USFWS 2004) and Paiute cutthroat trout would not inhabit its historic range and would be vulnerable to stochastic events, further hybridization, and possible extinction. While the significant impacts of the proposed Action would be completely avoided in the short-term under the No Action alternative, the No Action would fail to protect and preserve the species. In comparison, Alternative 3 (Combined Physical Removal) would result in significant, direct physical impacts, but may not be effective in the long term and would be very difficult to implement and potentially infeasible. Therefore, the proposed Action is the environmentally superior alternative.

1.8 ISSUES TO BE RESOLVED

This EIS/EIR examines the potential impacts of using the chemical rotenone and other techniques to eradicate non-native trout from 11 miles of Silver King Creek and associated tributaries as well as Tamarack Lake. Potential impacts include application of pesticide to water and the resulting exposure of this stream and its aquatic receptors, within a designated wilderness area, to this chemical. Issues to be resolved include whether this impact and chemical exposure of non-target organisms, such as stream benthic macroinvertebrates (aquatic insects that live in or on the bottom sediments) outweigh the risks of inaction to the existence of Paiute cutthroat trout.

1.9 REFERENCES

U.S. Fish and Wildlife Service (USFWS). 2004. Revised Recovery Plan for the Paiute cutthroat trout (*Oncorhynchus clarkii seleniris*). Portland, Oregon. Ix + 105 pp.

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CHAPTER 2

Introduction

The USFWS and CDFG are proposing the Paiute Cutthroat Trout Restoration Project in Silver King Creek in the HTNF. The proposed Action entails the eradication of non-native trout species from 11 stream miles of Silver King Creek, its tributaries and Tamarack Lake. The Agencies propose to use the piscicide rotenone to eradicate non-native trout and to neutralize the rotenone downstream of Silver King Canyon at its confluence with Snodgrass Creek using potassium permanganate. The Agencies also propose to restock Silver King Creek with native Paiute cutthroat trout from donor streams in the upper watershed (i.e., Fly Valley Creek, Four Mile Canyon Creek, Silver King Creek, or possibly Coyote Valley Creek). Chapter 3.0, Project Alternatives, presents a detailed description of the proposed Action and the other alternatives.

The USFWS is the NEPA lead agency for the proposed Action and CDFG is the CEQA lead agency. The USFWS is proposing this Action in fulfillment of its responsibilities to implement the Revised Paiute Cutthroat Trout Recovery Plan (USFWS 2004), which has an ultimate goal of delisting the species. CDFG is proposing this Action in its role as trustee agency for fish and wildlife resources for the State of California, and will serve as the technical lead for this Action. The USFS is a cooperating agency under NEPA because activities within designated wilderness on National Forest Systems lands require USFS authorization (36 CFR 261.9f, 293.6c). Specifically, the proposed Action would require USFS' authorization for pesticide and motorized equipment use (see Section 2.4 below). The proposed Action would also require a discharge permit from the Lahontan Regional Water Quality Control Board (Water Board), which would be a responsible agency under CEQA. Section 2.4 below lists other permits and approvals likely to be required for this Action.

2.1 HISTORY AND BACKGROUND

Silver King Creek, downstream from Llewellyn Falls to Silver King Canyon in Alpine County, is part of the native range of the Paiute cutthroat trout, one of the rarest trout subspecies (USFWS 1985). Indigenous only to Silver King Creek, Paiute cutthroat trout were listed as threatened under ESA on July 16, 1975 (USFWS 1975). Out-of-basin (referring to the Silver King Creek Watershed) populations of Paiute cutthroat trout have been established by the Agencies in several California streams including the North Fork of Cottonwood Creek and Cabin Creek in the Inyo National Forest (Mono County), Sharktooth Creek (Fresno County), and Stairway Creek (Madera County) in the Sierra National Forest.

Hybridization with non-native trout is the primary threat to Paiute cutthroat trout (USFWS 2004, 1985). When interbred with Lahontan cutthroat or rainbow trout, Paiute cutthroat trout tend to lose their distinctiveness through hybridization (USFWS 2004). The fish in the reach between Llewellyn Falls and Silver King Canyon are a genetic mixture of introduced rainbow, Lahontan cutthroat, golden trout, and native Paiute cutthroat trout.

2.1.1 Conservation Planning

At the time of its listing under ESA, non-native trout were considered a threat to the Paiute cutthroat trout. When Paiute cutthroat trout were classified as threatened, a 4(d) rule was issued to facilitate management between CDFG and the USFWS. As described above, through efforts completed by CDFG, five small isolated populations of pure Paiute cutthroat trout have been established outside of its native range. These small populations are and will continue to be at a high risk of extinction due to the small size of the population and small habitat occupied by the subspecies.

In 1994, CDFG prepared a programmatic EIR entitled “Rotenone Use for Fisheries Management” to assess potential impacts of CDFG fisheries management programs and to outline best management practices to minimize environmental effects.

To further recovery of the species, the USFWS published a Revised Recovery Plan for Paiute cutthroat trout (USFWS 2004). Criteria for delisting Paiute cutthroat trout include:

- Removal of all non-native trout in Silver King Creek and its tributaries from downstream of Llewellyn Falls to the fish barriers in Silver King Canyon;
- Restoration of a viable population to all historic habitat in Silver King Creek and its tributaries from Llewellyn Falls to the impassable barriers in Silver King Canyon;
- Maintenance of Paiute cutthroat trout in all occupied streams;
- Maintenance of out-of-basin populations as refugia; and
- Development of a long-term conservation plan and agreement.

2.1.2 Past Restoration Efforts in Silver King Creek

The Agencies have conducted numerous rotenone treatments in the Silver King Creek Watershed; however, the Agencies have not attempted eradication of non-native trout in the proposed project area. Previously treated areas are depicted on Figure 5.1-1 (see Section 5.1, Aquatic Biological Resources). The lower reaches of Four Mile Canyon Creek were treated with rotenone from 1991 through 1993. Corral Valley Creek was treated with rotenone in 1964 and 1977. Coyote Valley Creek was treated with rotenone in 1964, 1977, and 1987 through 1988. Silver King Creek above Llewellyn Falls was treated in 1964, 1976, and 1991 through 1993. As a result, Paiute cutthroat trout have been successfully reintroduced to all these streams. Population monitoring verified with genetic testing concluded that these previous efforts have been successful in eliminating non-native trout. Genetic study results indicate Paiute cutthroat trout in areas above Llewellyn Falls and in Corral Valley and Coyote Valley creeks are not hybridized (Israel et al. 2002, Cordes et al. 2004).

CDFG proposed to restore Paiute cutthroat trout in the proposed project area in 2003–2004. Under CEQA, CDFG completed an Initial Study and a Mitigated Negative Declaration. CDFG also applied to the Water Board for a National Pollutant Discharge Elimination System (NPDES) permit to apply rotenone in Silver King Creek. The SWRCB granted an NPDES permit on July 6, 2005.

Because the proposed Action would occur on National Forest Service land, HTNF prepared an EA under NEPA in July 2002, followed by a Decision Notice and Finding of No Significant Impact (FONSI) in 2004. HTNF also prepared a Biological Assessment pursuant to Section 7 under ESA with USFWS and a Biological Evaluation addressing potential effects on listed species. USFWS issued a Biological Opinion on April 4, 2003.

Before the rotenone application began, a group of plaintiffs named Californians for Alternatives to Toxics filed actions in federal and California courts to halt the project. On August 19, 2005, the Sacramento Superior Court declined to issue a temporary restraining order against implementation of the SWRCB permit, ruling that there was not enough evidence to decide that the "degrading impacts on the watershed and its ecosystem outweigh the public's interest in preserving the Paiute cutthroat trout." On August 23, 2005, the plaintiffs filed a request for a temporary restraining order in U.S. District Court stating that the project warranted an EIS. On August 31, 2005, the U.S. District Court granted a temporary restraining order against the project. Finally, on September 1, 2005, the U.S. District Court granted a preliminary injunction against the project, ruling that 1) the plaintiffs demonstrated a strong likelihood of irreparable harm to potential rare and endemic species, 2) the balance of interests (imminent threats to macroinvertebrates versus possible future threats to the survival of Paiute cutthroat trout) tipped sharply in favor of the plaintiffs, and 3) the plaintiffs had raised "serious questions" that the USFS had violated federal environmental laws in failing to prepare an EIS and/or an adequate EA.

On September 30, 2005, CDFG requested the SWRCB to rescind its NPDES permit, and on October 20, 2005, the SWRCB rescinded the permit. The court found that the action had become moot and imposed no further requirements or restrictions.

CDFG had initially closed the area between Llewellyn Falls and Silver King Canyon prior to the planned treatment in 2005. To protect pure Paiute cutthroat trout above Llewellyn Falls, and in response to judicial decisions regarding the Water Board permit, CDFG closed the area to fishing for an additional 90 days on an emergency basis. This closure was modified to the current closure of Silver King Creek and tributaries from Llewellyn Falls downstream to Tamarack Lake Creek based on California Fish and Game Commission findings in May 2006. Silver King Creek also remains closed to fishing above Llewellyn Falls since the successful establishment of Paiute cutthroat trout in this area since 1993. In addition, the California Fish and Game Commission closed Corral Valley Creek and Coyote Valley Creek to fishing to protect pure Paiute cutthroat trout populations established in these tributaries. Section 5.6, Recreation, presents a detailed description of recent closure decisions.

2.2 OBJECTIVE/PURPOSE AND NEED FOR ACTION

The objective of the proposed Action is to establish the Paiute cutthroat trout as the only trout species in Silver King Creek for the purpose of preventing hybridization with other trout. This is an important and necessary step in preventing Paiute cutthroat trout from going extinct and conserving the species and restoring it to a level that would allow it to be removed from the federal threatened species list. To accomplish this objective, the Agencies would remove all non-native trout from the proposed project area prior to restocking with pure Paiute cutthroat trout from donor streams in the upper watershed. The Agencies are also evaluating the necessity of removing fish from Tamarack Lake at the headwaters of Tamarack Lake Creek, a tributary to Silver King Creek, if fish are present. Chapter 3.0, Project Alternatives, presents the surveys the Agencies will complete to determine the presence or absence of fish in these waters and the criteria that would be used to determine whether treatment of the lake is necessary.

Paiute cutthroat trout are currently found upstream of Llewellyn Falls; however, easy public access between areas downstream and upstream of Llewellyn Falls (see Figure 1-1) may result in an unauthorized transplant of hybridized fish to areas above the falls where Paiute cutthroat trout are currently found in its genetically pure form. Therefore, the Agencies are proposing to eradicate non-native trout within the historical range of Paiute cutthroat trout from areas downstream of Llewellyn Falls and restocking Paiute cutthroat trout, expanding its range to a series of six impassible fish barriers in Silver King Canyon and associated tributaries, thereby increasing its population. These barriers, the two highest being 8 and 10 feet high, would geographically isolate Paiute cutthroat trout from other trout species and greatly reduce the likelihood of an illegal introduction.

The purpose and need for the proposed Action is to restore Paiute cutthroat trout to its historic range as stated in the Revised Recovery Plan (USFWS 2004), and thereby satisfy one critical Recovery Plan component for delisting the species. The proposed Action would make Paiute cutthroat trout the only trout species in Silver King Creek above Silver King Canyon. By expanding the populations and range of the species, the proposed Action would also increase the probability of long-term viability and reduce threats from genetic bottlenecking and stochastic events.

Many sections of the California Fish and Game Code (FGC) provide for the protection, conservation, and management of California fisheries and other aquatic resources, including but not limited to the following sections: 1600 et seq., 1700, 2050 et seq., 2118, 2119, 5501, and 15500 et seq. and associated regulations in Title 14 of the CCR such as 5.51, 236, 238, 238.5, and 671. In some instances, the CDFG uses chemicals (piscicides) to manage fisheries in California.

As discussed in additional detail below, the proposed Action would be consistent with USFS' responsibility to manage and restore significant values within the wilderness. Additionally, the proposed Action would further CDFG's mandate to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public.[1]

2.3 PROPOSED ACTION

Under the proposed Action, the Agencies would:

- Eradicate non-native trout from Silver King Creek and its tributaries between Llewellyn Falls and Silver King Canyon, as well as Tamarack Lake (if fish are present), using chemical treatment (rotenone);
- Neutralize the rotenone downstream of Silver King Canyon to the 30-minute travel time mark near the confluence with Snodgrass Creek using potassium permanganate; and
- Restock the project area with pure Paiute cutthroat trout from donor streams in the upper Silver King Creek Watershed (i.e., Fly Valley Creek, Four Mile Canyon Creek, Silver King Creek, or possibly Coyote Valley Creek).

The proposed Action would also include pre-treatment removal of fish by seeking Fish and Game Commission approval for an increase daily bag limit of 5 fish per day in an attempt to reduce existing non-native trout populations; pre-treatment biological surveys and monitoring for

[1] www.dfg.ca.gov/about

amphibians and benthic macroinvertebrates; placement of signs to inform the public; water quality monitoring (during and post treatment); and post-treatment biological monitoring. Chapter 3.0, Project Alternatives, presents a more detailed description of the proposed Action and other alternatives, including a map (Figure 3-1) depicting the components of the proposed Action. As part of the proposed Action, the Agencies would apply rotenone to the project area in the summer of 2009 and 2010 (and 2011 if needed). Additional treatments would be scheduled as necessary to ensure complete removal of non-native fish from the project area. The Agencies would use one or a combination of three commercially available rotenone formulations, such as CFT Legumine™, Noxfish®, and Nusyn-Noxfish®. CFT Legumine™ is a recently developed “alternative” formulation that contains less potentially objectionable “inert” ingredients. The use of CFT Legumine™ is consistent with Basin Plan rotenone provisions that encourage the development of and the use of alternative formulations. Rotenone is a naturally-occurring substance derived from the roots of several tropical and subtropical plant species belonging to the genus *Lonchocarpus* or *Derris*. It has traditionally been used for fishing by indigenous tribes in South America.

Depending on the formulation used for treatment of the proposed Project area, CFT Legumine™ and Noxfish® would be applied at a target concentration of 0.5 milligram per liter (mg/L) and Nusyn-Noxfish® at a target concentration of approximately 1.0 mg/L rotenone formulation. The amount of chemical applied would be based on field conditions (i.e., streamflow, etc.). The treatment process would be completed over a week timeframe (or 7 working days). Rotenone would be applied to the streams using 4 to 6-hour drip stations, with hand spraying in backwater areas as necessary. As described in Chapter 3.0, Project Alternatives, Tamarack Lake, which forms the headwaters of Tamarack Lake Creek, may be fishless and would only be treated if gillnetting and/or other survey techniques, prior to implementation of the proposed Action, showed that fish were present.

A neutralization station would be operated downstream of the application (to the 30-minute travel time mark), at the confluence of Silver King Creek and Snodgrass Creek. Potassium permanganate would be applied using a motorized auger at a rate of approximately 2 to 4 mg/L until it was no longer necessary to detoxify rotenone. Under these conditions, potassium permanganate would be reduced to manganese oxide, which would be present for less than a couple of days (24-48 hours) following treatment. At these levels, potassium permanganate would not threaten human health (see Section 5.3, Human and Ecological Health Concerns) and would not violate water quality objectives (see Section 5.4, Water Resources). However, potassium permanganate would temporarily result in purple or brown discoloration up to 2 stream miles downstream of the project boundary.

Fish killed during the treatment would be gathered and buried. Any remaining fish would be washed downstream, consumed by foraging wildlife, or provide needed nutrients for repopulating aquatic invertebrates.

Post-treatment stocking of Paiute cutthroat trout would begin in early summer during the year following the final treatment, and would occur annually until the target population density is established, with guidance from ongoing fish population monitoring and historic population data (Deinstadt et al. 2004). Restocking would be conducted pursuant to guidelines and recommendations for stocking and genetic diversity management in the Revised Recovery Plan (USFWS 2004) and recent genetic studies (Cordes et al. 2004, Finger et al. 2008). Paiute cutthroat trout used for restocking would come from pure populations within the Silver King

Creek Watershed, namely Fly Valley Creek, Four Mile Canyon Creek, Coyote Valley Creek, Corral Valley Creek, and Upper Silver King Creek (above Llewellyn Falls) (Cordes et al. 2004).

2.4 PERMITS AND APPROVALS FOR THE PROJECT

The following paragraphs describe the authority of the primary implementing and permitting Agencies for this Action. Federal laws, regulations, and policies applicable to this decision include the National Forest Management Act (NFMA), ESA, NEPA, the National Historic Preservation Act (NHPA), the Clean Water Act (CWA), the Wilderness Act, and other legal mandates.

U.S. FISH AND WILDLIFE SERVICE

The USFWS has responsibilities under ESA to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people[2] and recover threatened and endangered species. The proposed Action would implement major components of the Paiute cutthroat trout Revised Recovery Plan (USFWS 2004).

The decisions to be made include determining the method for and the extent of fish removal in Silver King Creek and its tributaries. Based on the environmental analyses presented in this Draft EIS/EIR, USFWS will determine how to implement non-native trout eradication and would issue a NEPA ROD signed by the Field Office Supervisor.

U.S. FOREST SERVICE

The Wilderness Act of 1964 established a National Wilderness Preservation System "to secure for the American people of present and future generations the benefits of an enduring resource of wilderness." The Carson-Iceberg Wilderness became part of the National Wilderness Preservation System with passage of the California Wilderness Act of 1984. Human uses such as recreation are allowed but are subordinate to the higher purpose of maintaining wilderness values of 1) outstanding opportunities for solitude, and 2) the ability of natural processes to operate free of human influence.

The use of chemicals and motorized equipment in wilderness require the approval of the USFS Regional Forester (36 CFR 261.9f and 293.6c). The decision to be made by USFS is limited to whether or not to approve the use of motorized equipment and whether or not to approve the use of pesticides for this Project.

This decision helps implement the standards and guidelines of the Toiyabe National Forest Land and Resource Management Plan, specifically Wildlife and Fish standards 4 (page IV-49), 5, 6, and 11 (page IV-50), regarding threatened and endangered species and the wilderness. Forest Service Policy (FSM 2100) states that pesticide use in designated wilderness areas occur only when necessary to restore significant values within the wilderness, and to base actual use on analyses of effectiveness, specificity, environmental impacts, economic efficiency and human exposure.

Forest Service Policy (FSM 2300) also states that motorized equipment use in designated wilderness areas may occur when an essential activity is impossible to accomplish by non-motorized means because of such factors as time or season limitations, safety, or other material

[2] www.fws.gov/policy/npi99_01.html

restrictions. All other aspects of the proposed Action fall within the jurisdiction of CDFG and USFWS.

CALIFORNIA DEPARTMENT OF FISH AND GAME

The State of California's fish and wildlife resources are held in trust for the people of the State by and through CDFG (FGC, Section 711.7). Many sections of the FGC provide for the protection and management of California fisheries and other aquatic resources, including but not limited to the following: FGC Sections 1001, 1726, 1727, 1755(a)(1), 7260, for the Wild Trout Policy and Trout policy; Sections 1600 *et seq.*, 1700, 2050 *et seq.*, 2118, 2119, 5501, and 15500 *et seq.*, and associated regulations in Title 14 of the California Code of Regulations (CCR), such as, 5.51, 236, 238, 238.5, and 671. In addition, as lead agency under CEQA, CDFG will issue a NOD, Findings of Fact, and a Statement of Overriding Considerations on the EIR.

LAHONTAN REGIONAL WATER QUALITY CONTROL BOARD

The Water Board will determine whether to grant Waste Discharge Requirements and whether the proposed Action is consistent with Basin Plan provisions for rotenone treatments. The Agencies have applied for a project-specific NPDES permit for rotenone application. The NPDES permit for the proposed Action would contain receiving water limits applicable to rotenone projects as contained in the Basin Plan. It would also require water quality monitoring to verify compliance with receiving water limits within the project area and in downstream waters both during and after the treatment.

2.5 ENVIRONMENTAL ISSUES AND CONCERNS

The paragraphs below summarize the environmental concerns raised by the public and agencies that submitted comments on the 2004 Environmental Assessment and the recently published NEPA NOI and CEQA NOP (refer to Appendix A). The issue of greatest public concern was the potential impact of rotenone on benthic macroinvertebrates or aquatic invertebrates. These species live all or part of their life cycle in or on the bottom sediments of Silver King Creek. The U.S. Environmental Protection Agency (USEPA) suggests that rotenone use for fish control, when implemented properly, does not present a significant threat of adverse effects on humans or the environment (USEPA 2006). However, there has been increasing concern regarding potential short and long-term impacts on non-target species, including aquatic macroinvertebrates and amphibians.

In response to concerns over potential effects on aquatic macroinvertebrates and pursuant to permit conditions issued by SWRCB, CDFG and HTNF implemented a pre-treatment monitoring program, including collection of benthic macroinvertebrate samples from 2003 through the present. To evaluate potential effects on benthic macroinvertebrates inhabiting Silver King Creek, the Agencies compiled all the benthic macroinvertebrate population data collected in Silver King Creek over the past 40 years to monitor the effects of rotenone on benthic macroinvertebrates in Silver King Creek and similar sites within the Watershed. The resulting technical report by Vinson and Vinson (2007) is provided as Appendix D herein. This report provides part of the basis for Section 5.1, Aquatic Biological Resources.

Several concerns were raised during the public involvement process completed in 2004 and were addressed in the Environmental Assessment. These issues are also addressed in Chapter 5.0, Environmental Consequences, and include:

- The potential effects of the proposed Action on Paiute cutthroat trout recovery and the feasibility of removing hybridized fish from the project area.
- Potential effects on non-target organisms, including aquatic invertebrates, amphibians, plankton, Forest Service Management Indicator Species and Sensitive Species, and other federally-listed species. This may include species that rely on emerging aquatic insects, such as the yellow warbler, willow flycatcher, mountain yellow-legged frog.
- Effects of rotenone formulations on water quality, including effects on human uses.
- Concern that water quality monitoring be employed to determine if applied chemicals migrate outside the proposed project area.
- Effects on wilderness values and management and the use of chemicals and motorized equipment.
- Effects on recreational fisheries resulting from temporary closure of 11 miles of stream in the Iceberg-Carson Wilderness and Alpine County, including removal of a healthy non-native fishery.

Additional concerns rose during subsequent appeals of the Decision Notice and FONSI. These concerns area also addressed in Chapter 5.0, Environmental Consequences, and include:

- Potential effects on macroinvertebrate communities - specifically on any rare and endemic species that may exist in the Project area, including larval forms.
- Potential effects of rotenone application on human health – particularly potential relationships between rotenone exposure and Parkinson’s disease.
- Potential impacts of chemical treatment on other non-target species, including two amphibian candidate species, the Sierra Nevada population of the mountain yellow-legged frog and the Yosemite toad.
- Economic impacts on Alpine County and recreation-related businesses.
- Concern regarding the history of CDFG stocking of non-native trout in the area, questions regarding the effectiveness of rotenone, and the necessity of increasing Paiute cutthroat trout range.
- Inclusion of provisions to prevent future re-introduction of non-native trout through public education and outreach.
- Potential impacts on downstream water quality resulting in fish kills or violation of antidegradation policies.
- Concern regarding the content of the cumulative impact analysis.

These issues led the Agencies to explore a wide range of fish eradication technologies and to complete a detailed evaluation and screening analysis of these technologies and combinations of technologies, including optional chemicals. Through this process, the Agencies selected the alternatives evaluated in detail in this EIS/EIR, which include Alternative 1: No Action (required by NEPA and CEQA), the Alternative 2: Proposed Action (rotenone treatment), and Alternative

3: Combined Physical Removal (a non-chemical alternative). Appendix B presents the resulting "Alternatives Formulation Report."

Major conclusions presented in this EIS/EIR regarding the potential effects of the proposed Action include:

- The proposed Action would result in significant biological impacts, including impacts on species composition and potential loss of benthic macroinvertebrate species. Although, no known special-status macroinvertebrates or endemic species (occur only within the Silver King Creek Watershed) exist in the project area, the rotenone treatment could result in loss of rare or endemic species.
- The proposed Action would result in less-than-significant impacts on amphibians present in Silver King Creek because the Agencies would implement amphibian monitoring and relocation efforts prior to commencing chemical treatment.
- The proposed Action would eliminate existing non-native trout but would result in a significant beneficial effect on Paiute cutthroat trout populations by expanding the population and range of the species and increasing the probability of long-term viability.
- The proposed Action would not result in significant risk of exposure to wildlife species in the project area including such species as the marten, yellow warbler, and willow flycatcher.
- Human exposure pathways would be incomplete based on the remoteness of the project area, distance to any downstream human population, and the possible controls placed on human access during and after the treatment (potential emergency closure issued by the Fish and Game Commission).
- Application of rotenone formulations to Tamarack Lake would result in residual concentrations that could persist for more than two weeks.
- The proposed Action would not result in significant impacts on recreation, wilderness values and management, or environmental justice.
- The proposed Action could result in beneficial localized economic and recreation effects with the future possibility of reopening the stream to fishing under the Fish and Game Commission.
- The proposed Action would result in cumulative beneficial effects for Paiute cutthroat trout by expanding their range and population.

2.6 DOCUMENT STRUCTURE

The Agencies prepared this EIS/EIR in compliance with NEPA, CEQA, and other relevant Federal and State laws and regulations. This EIS/EIR discloses the direct, indirect, and cumulative environmental impacts that would likely result from the proposed Action and other alternatives. The document is organized into 8 chapters as follows:

- **Chapter 1.** The Executive Summary presents project background, objectives, and purpose and need for the proposed Action. It summarizes public involvement, the alternatives considered in developing the proposed Action, agencies consulted during the EIS/EIR process, and potential environmental issues.
- **Chapter 2.** The Introduction describes the background leading to the proposed Action, the purpose and need for the action, a summary of the proposal, the alternatives considered,

environmental concerns, permits and approvals required for the action, and document contents.

- **Chapter 3.** Project Alternatives presents a more detailed description of the proposed Action as well as alternatives for achieving the stated purpose. The alternatives were developed based on the potential impacts of the action and input from the public and other agencies.
- **Chapter 4.** Scope of the Analysis lists the resource areas that will be addressed in the EIS/EIR and the scope of the analysis, including the impact significance terminology used. This section also identifies resource areas not addressed in detail (e.g. Public Services) and the reasons the Agencies determined these resources would not be affected.
- **Chapter 5.** Environmental Consequences provides a detailed analysis of the potential environmental consequences of the proposed Action and each alternative, including direct and indirect effects. This analysis is organized by resource area (e.g. 5.1 Aquatic Biological Resources), describes the environmental setting, and effects (including direct and indirect effects) of each alternative and identifies impacts requiring mitigation.
- **Chapter 6.** Other Required Disclosures addresses the relationships between short-term uses and long-term productivity, unavoidable adverse effects, irreversible or irretrievable commitments, and growth-inducing impacts. The chapter also addresses cumulative impacts, and analyzes the potential significance of the proposed Action when considered in combination with past, present, and reasonably foreseeable projects with related impacts.
- **Chapter 7.** Mitigation Measures lists and describes the mitigation measures required to address the significant impacts identified in Chapter 5.0, Environmental Consequences.
- **Chapter 8.** List of Preparers lists the agencies and consulting personnel that prepared the EIS/EIR.

2.7 REFERENCES

U.S. Fish and Wildlife Service (USFWS). 2004. Revised Recovery Plan for the Paiute cutthroat trout (*Oncorhynchus clarkii seleniris*). Portland, Oregon. Ix + 105 pp.

C H A P T E R 3

Project Alternatives

This chapter presents a summary of the proposed Action, one other action alternative, and a No Action Alternative. Additional alternatives were considered during the development of the EIS/EIR, but rejected because they did not meet stated goals or objectives of the Agencies or were not considered reasonable. These are briefly described below in Section 3.4, "Alternatives Considered but Dismissed."

The Agencies prepared an Alternatives Formulation Report (Appendix B) which describes in detail how the Agencies selected a reasonable range of alternatives for detailed evaluation in the EIS/EIR. The report discusses the range of options identified through literature reviews on fish eradication, the comments received on the USFWS NOI (Federal Register June 2, 2006) for the proposed Action (USFWS 2006), and on similar environmental documents prepared for other fish restoration projects, including the recently prepared Lake Davis Pike Eradication EIS/EIR (CDFG 2007).

3.1 ALTERNATIVES DEVELOPMENT

The EIS/EIR evaluates the potential environmental impacts of the proposed Action and a suite of other alternatives to the proposed Action that were considered during the development of the EIS/EIR. This section provides a description of the process used to develop alternative approaches to mitigating impacts on species addressed in the EIS/EIR and a comparison of alternatives selected. Reasons for rejecting specific alternatives are also explained.

The Alternatives Formulation Report describes the initial identification and screening of technologies and alternatives. The technologies identified included the use of a variety of chemical agents as piscicides (fish-killing agents), fisheries management actions and fish eradication techniques, stream dewatering, and the introduction of predators. In addition to evaluating these as independent techniques, the Agencies considered combined approaches. All options were evaluated using a two-phase assessment approach.

In Phase I, the options were evaluated to determine if they would effectively and, in compliance with current laws and regulations, accomplish the initial step of eradicating all non-native trout from Silver King Creek and its tributaries between Llewellyn Falls and Silver King Canyon. The options that met this criterion were then evaluated in Phase II against a second set of criteria, including: protection of public health and safety; timely implementation; use of a proven, effective method; technical feasibility; minimization of environmental impacts; and cost-effectiveness. Using these criteria, summarized below, the remaining options were ranked and used to select the desired action as well as a reasonable range of alternatives to the desired action for consideration in the EIS/EIR. If a technology warranted further consideration as the possible basis for a comparative alternative in the EIS/EIR, potentially in combination with other strategies, it was retained.

3.1.1 Public Health and Safety

The public heath and safety criterion addresses the safety of the public and the workers implementing the proposed Action. Protection of public health includes consideration of potential impacts to air quality, drinking water, and other exposure pathways through which people could be exposed to hazards. Any proposal to use a chemical agent would require approval of the intended use and measures to protect public health. Options that posed substantial risks to public health and safety were eliminated from further consideration.

3.1.2 Speed of Implementation

Because stochastic events or rogue introduction of non-native trout could threaten pure populations of Paiute cutthroat trout, USFWS and CDFG believe time is of the essence and has identified a three-year schedule to remove non-native trout from Paiute cutthroat trout native habitat.

3.1.3 Proven Effective in the Laboratory and Field

The method must be proven by laboratory and field tests and be a known effective method of removing non-native trout in a stream environment. Because the survival of a species is at stake, any new or experimental methods were screened out. Using a method with demonstrated effectiveness dramatically increases the chance of success.

3.1.4 Technically Feasible to Implement

The technology must be technically and logistically feasible to implement. For example, it must not require a prohibitive amount of equipment or number of workers such that it would be possible to implement in a remote area.

Site-specific data and reports regarding the habitat types present, stream dimensions, water temperature, and fish densities were used to make accurate determinations regarding technical feasibility. Reports included cross-section surveys (CDFG 2004), unpublished data collected during fish surveys in August of 2000, and habitat assessments completed for Upper Fish Valley, Coyote Valley Creek, and Corral Valley Creek (O'Brien 1998, 1999, 2002).

3.1.5 Wilderness Considerations

Silver King Creek lies within a designated wilderness. There are numerous restrictions on activities and equipment that can be used in wilderness areas. For example, wilderness areas restrict motor vehicles, mechanical transport, and motorized equipment. These activities require Forest Service authorization.

3.1.6 Potential for Environmental Impacts

The method should minimize significant adverse environmental impacts that cannot be mitigated to reduce their significance. Such impacts may include damage to archaeological resources, biological resources or water resources, or significant noise or air quality impacts inconsistent with adjacent land uses (i.e., wilderness). This objective was not used by itself to eliminate potential technologies or management options. The EIS/EIR would analyze potential environmental impacts to determine their significance, compare the environmental consequences of the alternatives, and identify mitigation measures.

3.1.7 Cost-Effectiveness

While cost alone was not used to screen out any technology or strategy, overall cost and effectiveness was used as a balancing criterion in comparing options that were approximately equal in effectiveness or environmental impact.

3.2 ALTERNATIVES CONSIDERED IN DETAIL FOR THE EIS/EIR

3.2.1 Alternative 1: No Action

Both NEPA and CEQA require consideration of the No Project or No Action alternative, referred to herein as No Action. This option involves continuing the current stream and fishery management practices into the foreseeable future. Under the No Action alternative, the Paiute cutthroat trout Revised Recovery Plan (USFWS 2004) would not be implemented. No eradication of non-native, hybridized trout or reintroduction of Paiute cutthroat trout below Llewellyn Falls would be implemented. Paiute cutthroat trout would not be reintroduced to its historic habitat and its ESA status of threatened would likely remain unchanged. Therefore, this alternative would include continued ESA protection of pure Paiute cutthroat trout populations in the Silver King Creek Watershed as well as out-of-basin populations, but the recovery of Paiute cutthroat trout would not be obtained.

3.2.2 Alternative 2: Proposed Action (Rotenone Application)

The Agencies intend that the proposed Action would include pre-treatment removal of fish and would seek Fish and Game Commission approval for an increased daily bag limit of 5 fish per day in an attempt to reduce existing non-native trout populations; pre-treatment biological surveys and monitoring for amphibians and benthic macroinvertebrates; placement of signs to inform the public; water quality monitoring (during and post treatment); and post-treatment biological monitoring.

Potential variations on the proposed Project include the method of chemical application (i.e., CFT Legumine™, Noxfish®, and/or Nusyn-Noxfish®). The use of pesticides (with rotenone) without authorization is prohibited on National Forest Service System lands. Assuming that the USFS authorizes the use of motorized equipment and pesticides and the Water Board issues a discharge permit, the Agencies would apply the rotenone using non-motorized, vacuum-operated drip stations and hand sprayers. Mini-drips and gel or sand matrices may be used on small seeps if the possibility exists that they provide a refugia source of fresh water from treated waters. To eliminate the toxic effects of rotenone downstream of the project area, potassium permanganate would be administered using generator-powered volumetric augers at a downstream detoxification station. Potassium permanganate is a powerful oxidizing chemical that quickly renders rotenone harmless to aquatic organisms. The in-stream application of potassium permanganate below Silver King Canyon would ensure that no adverse effects of rotenone are experienced downstream of the project area. After 2 to 3 years of treatment, Paiute cutthroat trout restocking and repopulation would begin.

Chemical treatment of the project area is limited in timing to the period of mid- August to mid-September due to a number of biological and physical constraints. First, the waters must be treated after the non-native trout fry exit the gravels of redds (nests) which is typically late July to early August in Silver King Creek. Treatment before the fry emerge from redds would result in survival of these fish because they would not be exposed to the chemical treatment, thereby allowing their recruitment into the next year's cohort. Second, most if not all chorus frogs and western toads should have metamorphosed into adult life forms reducing their exposure to rotenone during the proposed treatment timing. Third, conducting a chemical treatment during the prescribed period would be at base low stream flows, allowing for less chemical to be used and less water to be treated. Numerous springs and seeps would naturally dry up, reducing the complexity of the treatment. The prescribed treatment period would be during the most stable and warm weather of the year for this location in the northern Sierra Nevada. Stream water temperatures would also be at or near warmest of the year to allow more rapid chemical reaction for the action of the piscicide and for rapid neutralization.

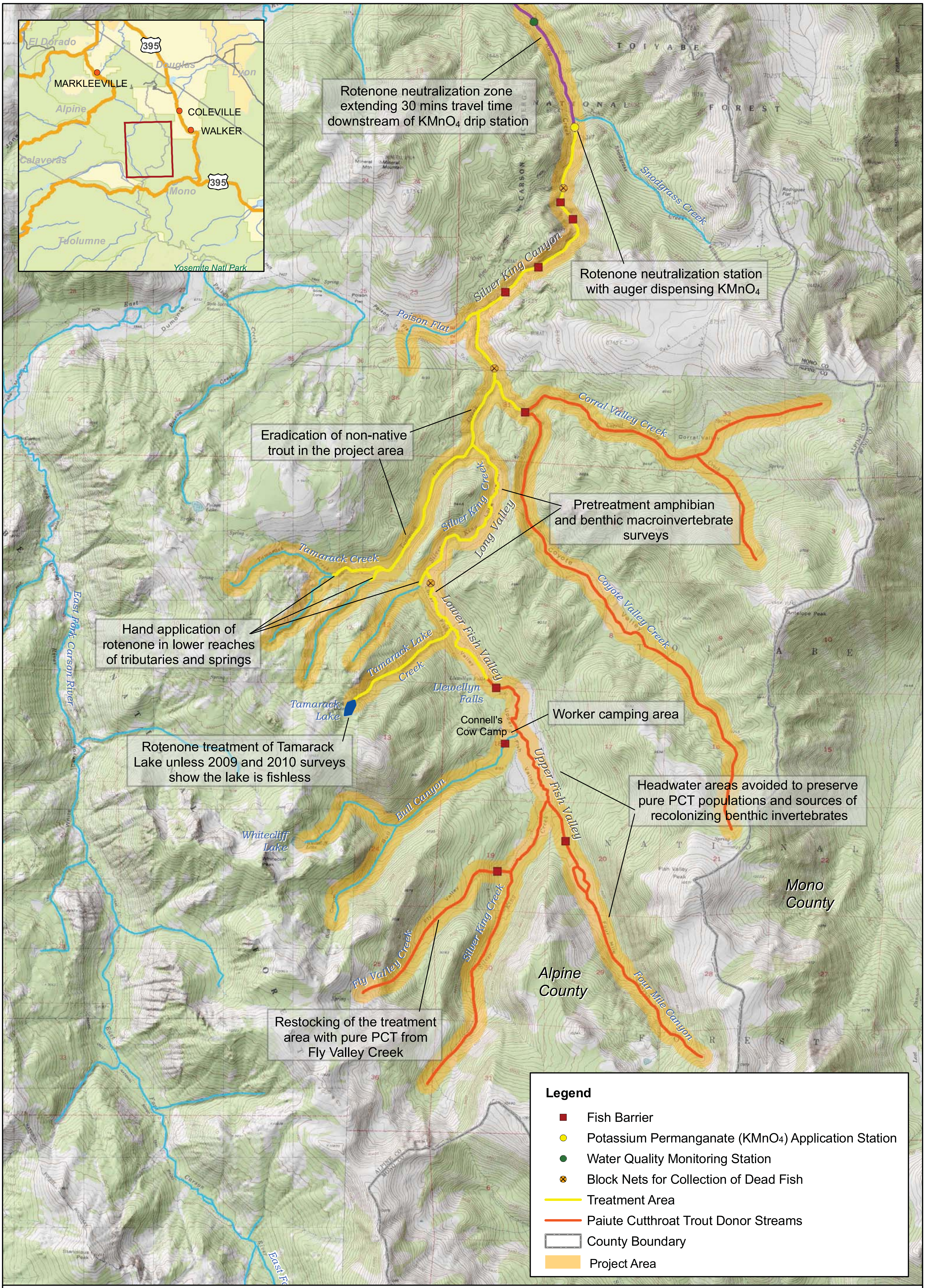
The Agencies have applied for a project-specific NPDES permit for rotenone application. The NPDES permit for the proposed Action would outline receiving water limits applicable to rotenone projects as contained in the Basin Plan. It would also require water quality monitoring to verify compliance with receiving water limits within the project area and in downstream waters both during and after the treatment.

The following paragraphs provide a detailed description of the proposed Action, including the location, pre-treatment activities, rotenone application, neutralization, and post-treatment activities. Figure 3-1 depicts the treatment area and locations of components of the proposed Action.

3.2.2.1 Project Location

Silver King Creek, downstream from Llewellyn Falls to Silver King Canyon in Alpine County, is part of the native range of the Paiute cutthroat trout, one of the rarest trout subspecies (USFWS 1985). Silver King Creek is a tributary of the East Fork Carson River, which drains into the Lahontan Basin. Silver King Creek's headwaters are located approximately 9,600 feet above mean sea level (msl) and the creek flows in a northerly direction through three distinct valleys where it meets the East Fork Carson River. The total length of the creek is 14 miles with an average gradient of 4.1 percent and a minimum gradient of 1.6 percent.

The project area, located within the Silver King Creek Watershed, includes the proposed treatment area, the neutralization area, and the area downstream of the neutralization station up to a 30-minute travel time (see Figure 3-1). The Agencies would apply rotenone formulation and potassium permanganate into Silver King Creek and associated tributaries between Llewellyn Falls and Snodgrass Creek, located downstream of Silver King Canyon. Tributaries would include Tamarack Lake Creek, an unnamed tributary, Tamarack Creek, and Coyote Valley Creek downstream of natural barriers. The Agencies would also treat the downstream reaches of tributary springs that may harbor fish including those near Llewellyn Falls and at Poison Flat.



ENTRIX
ENVIRONMENTAL CONSULTANTS

0 0.5 1 2 Miles

Paiute Cutthroat Trout Restoration Project

Figure 3-1

Proposed Action Components and Description

Project area showing trout habitat in Silver King Creek, Humboldt-Toiyabe National Forest, Alpine County, California.

Depending on the results of presence/absence surveys planned for 2009 and 2010, if fish are present, the Agencies would also treat Tamarack Lake and downstream portions of its tributaries. Tamarack Lake is a 5-acre lake located west of Silver King Creek at the headwaters of Tamarack Lake Creek. The planned surveys, which include gillnetting, snorkeling and electrofishing, are described below. Rotenone would not be applied to areas upstream of Llewellyn Falls. Fishless headwater areas within the project area would not be treated above natural barriers.

3.2.2.2 Pre-Fish Removal

The Agencies are completing ongoing biological monitoring in the study area. Amphibian surveys are completed annually and would be completed prior to treatment. If mountain yellow-legged frog and/or Yosemite toad are found, adults and tadpoles would be removed from waters to be treated, to the extent practicable, and relocated into suitable waters out of the project area but within the drainage. The Agencies would determine suitable waters for relocation.

The Agencies would also continue benthic macroinvertebrate population monitoring as part of the proposed Action. The sampling is required by the Water Board to evaluate Silver King Creek’s response to treatment and follows the protocols established in the Silver King Creek Monitoring Program proposal submitted to the Water Board (refer to Appendix E, Aquatic Invertebrate Interagency Monitoring Plan).

A portion of the project area between Llewellyn Falls and Tamarack Lake Creek is currently closed to fishing by the Fish and Game Commission. Prior to the treatment, signs would be posted at trailheads and other strategic places to inform recreational users of areas to avoid during the treatment as well as areas where potable water can be accessed. Additional signs that identify the areas closed to fishing would be posted. This information would be provided by USFS Carson Ranger District office prior to treatment.

In January 2009, CDFG proposed modifying bag limits by submitting an Initial Statement of Reason (ISOR) for Fish and Game Commission consideration at their meeting in March 2009. If approved, the regulation would allow fishing with a relaxed bag limit in the proposed treatment area during the summer of 2009 prior to treatment. CDFG wardens would monitor bag limits and other restrictions.

3.2.2.3 Fish Removal

Prior to the rotenone application, and throughout the treatment process, public access would be restricted through the use of signs located at trailheads and other strategic places. Equipment, personnel, and chemicals would be transported to and from the project area by pack stock and on foot. All personnel assisting in the fish removal would use hardened or durable sites for camping and would be familiar with and practice Leave-No-Trace (LNT) principles. A crew of less than 50 people will be required to implement the treatment, exceeding the wilderness area limit of 15, thus requiring USFS authorization. Trails would be used whenever possible to move from one location to another to minimize soil and vegetation disturbance and to prevent establishing new trails. Sensitive plant habitat will be avoided. Treatment activities would be coordinated with wilderness management personnel.

During the fish removal phase, commercial formulations of rotenone, including CFT Legumine™, Noxfish®[1] (EPA Reg. No. 655-805; new formulation) and/or Nusyn-Noxfish®, would be applied to 6 miles of mainstem Silver King Creek and 5 miles of associated tributary streams using methods described by Finlayson et al. (2000). Tamarack Lake would only be treated if fish are present (see decision criteria below).

Rotenone is a naturally occurring pesticide found in the roots of certain plants. It is used for insect control and for fisheries management. Rotenone acts by interfering with oxygen use. It is especially toxic to fish because it is readily absorbed through the gills. The California Department of Pesticide Regulation (DPR) regulates rotenone as a restricted material. Commercial rotenone formulations contain certain "inert" ingredients (solvents, dispersants, emulsifiers, etc.) as well as the active ingredient rotenone. The active ingredient rotenone and some of the inert ingredients are potentially toxic chemicals. Chemical concentration, duration, and route of exposure must all be considered in determining potential risk to non-target organisms. At the concentrations proposed for the Paiute Cutthroat Trout Restoration Project, the rotenone formulations will be toxic to gill-breathing organisms such as fish as well as amphibians and benthic macroinvertebrates (aquatic insects) in their aquatic life stages. There is no evidence of adverse effects to humans or terrestrial wildlife such as deer or bears from incidental contact (for example, through drinking water or eating dead fish) with rotenone formulation ingredients applied to surface waters at concentrations typical of fishery management projects (refer to Section 5.3, Human and Ecological Health Concerns, and Appendix C).

Under normal field conditions (water temperature greater than 5°C), when applied to water, rotenone breaks down naturally within approximately 5 days. It can also be detoxified by oxidation with potassium permanganate or chlorine. It binds readily to organic matter in soil. Consequently, it does not persist as a pollutant in groundwater. Inert ingredients are generally volatile compounds that are expected to dissipate within 2 weeks.

Rotenone would be applied to flowing water at a target minimum concentration of 0.5 parts per million (ppm or mg/L) formulation per product label instructions for CFT Legumine™ and Noxfish® and 1.0 ppm formulation for Nusyn-Noxfish®. A State-licensed Agricultural Pest Control Adviser and a State-certified Qualified Applicator would supervise the application. Because drip stations are calibrated to the total stream flow and do not uniformly apply the rotenone across the entire stream width at the target concentration, rotenone may reach localized concentrations of approximately 1.0 mg/L for CFT Legumine™ and Noxfish®. Appendix C provides a more detailed rationale for the proposed treatment concentration. Application of rotenone would be done by 4 to 6-hour drip stations and hand spray. Mini-drips and gel or sand matrices may be used on small seeps if the possibility exists that they provide a refugia source of fresh water from treated waters. Fish would be collected prior to the treatment process from the project area and placed in net baskets just upstream of the drip stations to monitor the effectiveness of the fish toxicant. In addition, water samples would be collected throughout the project area to verify rotenone concentrations. Block nets will be placed at selected locations throughout the project area to catch the dead fish. The nets would be maintained at a frequency adequate to ensure that captured fish are not in the water long enough to decompose.

[1] The new formulation of rotenone (a.k.a. CFT Legumine™, PW Rotenone®) does not use petroleum hydrocarbons as solvents and emulsifiers.

The rotenone application would be supervised by licensed applicators and in adherence to safety precautions identified on the product label. The application supervisor would be knowledgeable and experienced in state regulatory requirements regarding safe and legal use of the rotenone product and applicator safety. All personnel involved with the rotenone application would receive pre-treatment safety training specific to the formulated rotenone product. All personnel would be required to wear protective equipment to avoid unintended exposure to rotenone.

The Agencies would conduct the treatment over 2 to 3 years. CDFG experience indicates multiple treatments are necessary to eradicate non-native trout from streams (Finlayson et al. 2000). The treatments would occur between mid-August to mid-September beginning in 2009. Treatments would be repeated during mid-August to mid-September 2010. If hybridized fish carcasses were found during the 2010 treatment, a third year of treatment would be necessary in 2011. All or part of the chemical treatment may be applied twice in any given treatment year to assure complete non-native fish removal. An individual treatment would require a total of seven working days (one week) including mobilization, application, and neutralization.

The Agencies would treat Tamarack Lake depending on the results of pre-treatment presence/absence fish surveys. Gillnetting surveys have been conducted over the last several years (since 2001) and have found no fish. However, because any fish present in the lake could enter Tamarack Lake Creek and subsequently Silver King Creek, the Agencies would conduct more extensive pre-treatment surveys. Tamarack Lake would not be treated concurrently with Silver King Creek in 2009. In 2009, the Agencies would conduct extensive fish presence absence surveys including further gillnetting surveys as well as snorkeling visual surveys and electrofishing surveys. The Agencies would continue over-winter gillnetting surveys in 2009 and 2010. This would constitute a total of 8 years of gillnetting. The Agencies would also conduct electrofishing surveys in the tributaries and springs around the lake in the event that spawning habitat is present.

If no fish are found in 2009 and 2010, the Agencies would consider the lake fishless and withdraw treatment of Tamarack Lake from the proposed Action. However, if fish were detected, Tamarack Lake would be treated during the fall of 2010 or 2011. The Agencies would treat Tamarack Lake with approximately 50 gallons of rotenone. The rotenone would be administered by gasoline-powered pumps and dispersed from two non-motorized rafts transported to the lake by pack horses. The lake’s 5-acre surface would be treated in a single day.

3.2.2.4 Rotenone Neutralization

To contain the effects of rotenone within the project area and prevent a fish kill downstream of the Silver King Canyon, a neutralization station would be operated near Snodgrass Creek. The oxidizing agent potassium permanganate would be applied to Silver King Creek near Snodgrass Creek to neutralize rotenone, approximately 0.75 miles downstream of the lowest falls in Silver King Canyon.

Potassium permanganate would be applied at the resulting concentration of 2 to 4 mg/L. A generator powered auger would be used to apply the granular potassium permanganate. A back-up auger system would be on site in the event of primary auger failure. Potassium permanganate could also be applied from 30 to 55 gallon drums in a liquid form as a backup.

The project area extends approximately one-quarter to one-half mile downstream of the treatment area to include the stream reaches within the neutralization zone (refer to Figure 3-1). A 1 mg/L potassium permanganate residual would be maintained at the 30-minute travel time downstream location by increasing or decreasing the amount of permanganate to ensure complete neutralization of rotenone leaving the project area.

Block nets would be placed at selected locations throughout the project area to catch the dead fish. Dead fish collected at the block nets would be buried no closer than 300 feet from the stream and away from known camping areas to minimize bear/human interactions. The USFS would assist in selecting all burial sites before any ground disturbing activity occurred. Fish not collected at the block nets would be left in the stream to decompose and become part of the food chain.

During and after treatment, water quality will be monitored. As described in the Basin Plan, the monitoring program would assess the effects of treatment on surface waters and bottom sediments. The monitoring would determine: 1) that effective piscicide concentrations of rotenone are applied; 2) that sufficient degradation of rotenone has occurred prior to the resumption of public contact; and 3) that rotenone toxicity does not occur outside the project area. An analytical laboratory would analyze water samples for rotenone and rotenolone concentrations as well as for volatile organic compound and semi-volatile organic compound concentrations.

The Agencies would not neutralize Tamarack Lake with potassium permanganate. The rotenone applied to the lake would detoxify through natural degradation and breakdown.

As part of the proposed Action, to mitigate the potential effects of applying excess potassium permanganate to downstream fish populations, the Agencies would require placement of “sentinel” fish in cages downstream of the neutralization station. Mortality of these fish would alert workers to potential releases of excess chemical in the event of human or equipment error and potential downstream effects. The Agencies will also develop and implement a spill contingency plan that addresses chemical transport and use guidelines, as well as spill prevention and containment that adequately protects water quality. This plan will also describe the use of an auger to dispense the neutralizing agent.

3.2.2.5 Post-Fish Removal (Post-Treatment)

Post-treatment stocking of Paiute cutthroat trout would begin in early summer during the year following the final treatment, and would occur annually until the target population density is established, with guidance from ongoing fish population monitoring and historic population data (Deinstadt et al. 2004). Restocking would be conducted pursuant to guidelines and recommendations for stocking and genetic diversity management in the Revised Recovery Plan (USFWS 2004) and recent genetic studies (Cordes et al. 2004, Finger et al. 2008). The approach would seek to maximize the genetic diversity of existing populations and to minimize the risks from genetic bottlenecks (USFWS 2004). Paiute cutthroat trout used for restocking would come from pure populations within the Silver King Creek watershed, namely Fly Valley Creek, Four Mile Canyon Creek, Coyote Valley Creek, Corral Valley Creek, and Upper Silver King Creek (above Llewellyn Falls) (Cordes et al. 2004). The number of fish to be taken from donor stream(s) would be determined based on population trends and status from all available information (Deinstadt et al. 2004 and ongoing fish population monitoring).

Fish would only be stocked in the treatment area between Llewellyn Falls and Coyote Valley Creek. Tamarack Creek would be stocked with fish from source populations as described previously, or from the re-established fish population in the treated area. No fish would be stocked in fishless headwater streams, springs, or above natural barriers in tributaries, including

Tamarack Lake. The preliminary goal proposed in the Revised Recovery Plan would be to have 2,500 fish greater than 75 mm in length occupying the historic range from Llewellyn Falls downstream to Silver King Canyon, but this goal may be revised as additional information becomes available (USFWS 2004). The Agencies would continue ongoing monitoring of Paiute cutthroat trout populations in the treated reach and index reaches of donor streams after removal of transplant stock to determine population status and track achievement of density goals in the restored reach as well as the donor streams.

The Agencies would seek to have the project area remain closed to fishing during the restocking phase. To educate the public regarding the Paiute Cutthroat Trout Restoration Project and prevent reintroduction of non-native trout, the Agencies would provide informational signage at trailheads. The Agencies would continue monitoring of benthic macroinvertebrates in years 1, 2, 3, and 5 post-treatment to evaluate the response of aquatic invertebrate community to the chemical treatment, as outlined in Appendix E. The Agencies would also continue amphibian monitoring.

3.2.3 Alternative 3: Combined Physical Removal

This alternative includes the use of non-chemical means to remove non-native trout from the project area. It includes a combination of electrofishing, gill netting,[2] seining,[3] and other physical methods to remove fish from Silver King Creek and its tributaries, springs, and Tamarack Lake. The Combined Physical Removal alternative would not employ rotenone or any other chemical treatment. Because this method could have low efficiency in a rocky stream environment, it would need to be implemented over multiple years (i.e., until no fish are found using physical removal techniques).

This multiyear removal effort would involve large teams working for much of the summer (as many as 72 consecutive days each year) over a period of several years (more than 10 years). These removal efforts would eradicate a high proportion of undesirable species; however, they could fail to capture small fish and could be compromised by trout moving into the project area from untreated upstream areas. Restocking efforts would begin only when no fish are found within the project area. After the third year of physical removal, the fish would be genetically tested to ascertain its genetic heritage. If the remaining fish were hybridized, more removal would be needed. If the remaining fish were pure Paiute cutthroat trout, then recolonization efforts would begin. It is not possible to differentiate pure Paiute cutthroat trout from hybridized fish in the field. Genetic testing results would not be available until tissue samples are processed in the laboratory. Thus, there could ultimately be problems with the effectiveness of this alternative if not completed in a single year.

3.2.3.1 Pre-Fish Removal

Pre-implementation activities would include monitoring and possibly fish removal through relaxed bag limits. Biological monitoring would be completed for amphibians. Similar to the proposed Action, if approved by the California Fish and Game Commission, the Agencies would allow fishing in the proposed project area during the summer of 2009 prior to treatment. CDFG wardens would monitor bag limits and other restrictions.

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[2] Gillnets are set vertically so that fish swimming into it are entangled by the gills in its mesh.

[3] Seining is pulling a fishing net that hangs vertically in the water with floats at its upper edges and weights at the lower edges.

3.2.3.2 Fish Removal

Equipment and personnel would be transported to and within the project area by horses and on foot. All personnel assisting in the fish removal would use hardened or durable sites for camping and would be familiar with and practice LNT principles. Groups would be limited in size so they would not require USFS authorization. An eleven person crew would work throughout the project area. Trails would be used whenever possible to move from one location to another to minimize soil and vegetation disturbance and to prevent establishing new trails. Sensitive plant habitat would be avoided during action implementation. Action implementation would be coordinated with wilderness management personnel. The removal would follow CDFG's standard population monitoring methods. The Agencies would electrofish approximately 116 500-foot reaches in 6 miles of mainstem Silver King Creek and 5 miles of associated tributary streams. A crew would consist of 3 personnel using backpack electrofishers, 6 netters retrieving stunned fish, 2 personnel with buckets receiving and disposing of fish. Assuming that after five-passes, no fish would remain within the reach, it would take 580 hours to electrofish 116 reaches (greater than 72 days) and would continue over multiple years (at least 10 years). Sampling efficiency would be substantially less in areas with heavy aquatic vegetation, root wads, woody debris, and boulder fields. Removal activities would be undertaken between late-June or early July and mid-October because of access, streamflows, and good weather.

Conceptually, an intensive multiyear removal effort could eradicate undesirable species within the scheduled three-year period; however, these efforts could fail to capture small fish and could be confounded by trout moving into the project area from untreated upstream areas. Any fish captured after the third year of physical removal would be genetically tested to ascertain its genetic heritage. If the remaining fish are hybridized, more removal would be needed. If the remaining fish are pure Paiute cutthroat trout, then stocking efforts would begin.

Dead fish collected would be buried no closer than 300 feet from the stream and away from known camping areas to minimize bear/human interactions. The HTNF would assist in selecting all burial sites before any ground disturbing activity occurred. Tamarack Lake would be gill-netted for multiple years to confirm that hybridized trout were absent. Nets would be placed at various depths and locations throughout the year. The nets would be inspected regularly to detect fish presence and to insure they are in good working condition.

3.2.3.3 Post-Fish Removal

Post-fish-removal activities would be the same as those described for the proposed Action. Provided genetic testing of fish shows they are pure Paiute cutthroat trout that entered the project area from above Llewellyn Falls, then restocking with pure Paiute cutthroat trout would begin.

3.3 MITIGATION COMMON TO ACTION ALTERNATIVES

Mitigation measures that would apply to the action alternatives include:

- Pre-treatment and post-treatment amphibian population monitoring, including transfer of amphibians out of the project area.
- Pre-treatment monitoring of Tamarack Lake to determine if fish populations exist.
- Confining activities to existing trails and stream access points to the extent practical to minimize disturbance of vegetation and potential cultural resources.

- Using Leave-no-Trace policies.

A detailed description of avoidance measures and any project-specific mitigation measures is presented in Chapter 7.0, Mitigation Measures.

3.4 ALTERNATIVES CONSIDERED BUT DISMISSED

Federal agencies are required by NEPA to rigorously explore and objectively evaluate all reasonable alternatives and to briefly discuss the reasons for eliminating any alternatives that were not developed in detail (40 CFR 1502.14). Public comments received in response to the NOI/NOP provided suggestions of alternative methods for achieving the purpose and need. Some of these alternatives may have duplicated the alternatives considered in detail or the Agencies determined they would be ineffective or cause unnecessary environmental harm. Therefore, a number of alternatives were considered, but dismissed from detailed consideration for reasons summarized below.

3.4.1 Chemical Treatment

Powdered rotenone was removed from further consideration based on its limited effectiveness in moving water. Chlorine, chloramines, copper sulfate, and antimycin were removed because they are not registered pesticides in California, and their use would not comply with current laws and regulations.

3.4.2 Stream Dewatering

Stream dewatering by diverting stream flows to an adjacent watershed was screened out because of the major technical and logistical challenges involved as well as the environmental impacts compared to other fish removal techniques.

3.4.3 Fisheries Management Techniques

Six fisheries management techniques were evaluated in the Alternatives Formulation Report (Appendix B) such as physical removal, introducing a predator, fish-out, explosives, genetic swamping, and sonar. Most of these techniques were eliminated, because they were not expected to achieve complete removal of non-native fish in a stream environment. Introducing a highly predatory non-native fish to Silver King Creek was not seriously considered because it would only worsen the existing situation. Sonar is not sufficiently developed as a fish removal technique. The use of genetic swamping was removed because numbers of non-native trout and Paiute cutthroat trout hybrids are greater than three times that of the native Paiute cutthroat trout. With such an imbalance, it would take an enormous effort to “swamp” the hybrid population and the resulting population would never be a pure-strain Paiute cutthroat trout.

3.4.4 Habitat Management/Alteration

The habitat alteration options (nitrogen, carbon dioxide, oxygen depletion) were eliminated because they are unproven and considered unlikely to be effective, particularly in moving water.

3.4.5 Treatment of a Smaller Area

Smaller treatment areas would be infeasible because the absence of fish barriers within the 11-mile reach proposed for the action would allow repopulation of treated areas after treatment. The second option would install a permanent fish barrier upstream of Silver King Canyon to establish a smaller project area. Constructing an impassable barrier that would withstand all potential flow rates, such as may occur during winter storms, would be technically and logistically challenging without using heavy equipment. Implementation of this option would require a large workforce, as well as constant shuttling of workers and equipment into the project area via horseback or helicopter. Construction would also disturb the streambed and bank areas and could result in permanent geomorphologic changes in Silver King Creek. Chemical treatment of a smaller area would require a smaller amount of chemicals for the separate reaches, but would require the same amount, or more, by the time the entire project area was treated. Therefore, little benefit would be derived from reducing the size of the project area and causing potential environmental impacts from constructing an artificial fish barrier where none exists now. In addition, this scenario would not reintroduce Paiute cutthroat trout to its entire historic habitat and its success would be dependent on an artificial fish barrier that could be compromised by stochastic events (e.g., storm, seismic). For these reasons, the concept of a smaller project area is not evaluated further in this EIS/EIR.

3.4.6 Chemical Application Combined with Other Approaches

Stream dewatering followed by rotenone treatment would considerably reduce the amount of rotenone needed for treatment but would require the construction of diversion dams and other structures including pipelines to bypass the treatment area. Because of the relatively high flows in Silver King Creek, the agencies screened out this alternative based on technical and regulatory feasibility as well as the considerable environmental damage that would result including import of heavy equipment and materials, a large workforce, fill placement, water pumping, air emissions, noise, schedule and cost. Appendix B provides further discussion of dewatering techniques and impacts.

3.4.7 Combined Non-Chemical Options

The non-chemical combinations of stream dewatering strategies followed by physical removal and physical removal followed by genetic swamping were eliminated because they were not expected to achieve complete removal of undesirable fish and were not consistent with the PCT Recovery Plan.

3.4.8 Alternative Locations

Alternative locations were not considered because they would not meet the intent of the proposed Action which is to reintroduce Paiute cutthroat trout back into their historical habitat. The Revised Recovery Plan discusses exploring other additional out-of-basin locations; however, the proposed Action is intended to implement recovery actions number 1 and number 2 in the Revised Recovery Plan which are: 1) remove nonnative fish from Silver King Creek downstream from Llewellyn Falls to barriers in Silver King Canyon, and 2) reintroduce Paiute cutthroat trout into renovated stream reaches in historical habitat (USFWS 2004). Since the proposed Action occurs in the historical habitat of Paiute cutthroat trout, no other locations were considered. The introduction of pure Paiute cutthroat trout into other waters would not meet the criteria established in the Revised Recovery Plan (USFWS 2004) nor would it meet the criteria necessary to delist the species. In addition, waters that are currently fishless have other native endemic species of amphibians or macroinvertebrates that would be impacted by the introduction of a non-native fish species. Numerous studies have shown that introduction of non-native trout into fishless waters have played a role in the decline of native amphibians (Bradford 1989, Drost and Fellers 1996, Knapp and Matthews 2000).

3.4.9 Alternate Timeframe for Implementation

Alternative timeframes to the proposed Action from mid-August to mid-September were screened out due to environmental, biological and/or logistical constraints such as high winter flows and access issues during winter and possible presence of juvenile amphibians and egg masses and the presence of salmonid fry in stream gravel during the spring. Thus, chemical treatment of the proposed project area is limited in timing to the period of mid- August to mid-September for the following reasons: 1) waters must be treated after non-native trout fry exit the gravels of redds which is typically late July to early August in Silver King Creek; 2) most if not all chorus frogs and western toads should have metamorphosed into adult life forms reducing their exposure to rotenone during the proposed treatment timing; and 3) conducting a chemical treatment during the prescribed period would be at base low stream flows, allowing for less chemical to be used and less water to be treated. The prescribed treatment period would be during the most stable and warm weather of the year for this location in the northern Sierra Nevada.

3.5 REFERENCES

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CHAPTER 4

Scope of the Analysis

The environmental resources investigated in depth were those determined to be potentially affected by the proposed Action and alternatives. These resource areas addressed in Sections 5.1 through 5.9 are as follows:

- Aquatic Resources
- Terrestrial Resources
- Human and Ecological Exposure
- Water Resources
- Greenhouse Gases and Climate Change
- Recreation
- Wilderness Values and Management
- Economic Resources
- Environmental Justice

For purposes of CEQA, any project-related economic or social changes would not be considered significant effects on the environment. Economic or social changes may be evaluated, however, to determine if a physical change to the environment would be significant. If the physical change causes adverse economic or social effects on people, those adverse effects may be used as a factor in determining whether the physical change is significant (CCR, Title 14, §15064(e)).

The remaining CEQA and NEPA requirements, including growth-inducing effects and cumulative impacts, are addressed in subsequent chapters. The Mitigation Monitoring and Reporting Program will be prepared for the Final EIS/EIR.

The proposed Action and alternatives were determined through the scoping and environmental screening process to have no impacts on the following CEQA-required resources and are not addressed further in this EIS/EIR.

- **Aesthetics.** The proposed Action and alternatives would create no new structures or visual changes that could affect a scenic vista or scenic resources nor create new temporary or permanent sources of light or glare. No state scenic highways or other roadways exist within the proposed project area (refer to Figure 3-1). In addition, the proposed Action and alternatives would not substantially degrade the existing visual character or quality of the site or its surroundings because no visual changes would occur after the proposed Action or alternatives are implemented.
- **Agriculture Resources.** The proposed project area is comprised solely of wilderness area administered by the USFS. There is no land zoned or used for agriculture.
- **Air Quality.** The Great Basin Unified Air Pollution Control District's (GBUAPCD) air quality plans are site-specific and do not apply to the project area. Therefore, the proposed

Action and alternatives would not conflict with or obstruct implementation of any air quality plan. The proposed Action and alternatives would not result in emissions of particulate matter; therefore, they would not result in a cumulatively considerable net increase in criteria pollutants for which the GBUAPCD is in nonattainment. No sensitive receptors to pollutants (e.g., residences, hospitals, childcare centers, etc.) exist within two miles of the proposed project area, and the proposed Action and alternatives would not result in emissions of substantial amounts of pollutants. Chemicals used for the treatment as part of the proposed Action could result in a slight odor in the proposed project area. Although access to the project area would not be restricted during implementation of the proposed Action, potential odors would likely only affect workers involved in the treatment process.

- **Archaeological Resources.** During EIS/EIR scoping, the Agencies investigated the potential for archaeological resources to occur in the proposed project area and conducted a search through the California Historical Resource Information System (CHRIS) for the area as well as a two-mile surrounding buffer area. Very few studies have been conducted in the area and included a timber sale inventory northeast of the proposed project area in 1992 and 3 other surveys within 2 miles. No archaeological sites have been recorded within the proposed project area. One prehistoric site associated with a hot spring was recorded along Silver King Creek above Llewellyn Falls. No Traditional Cultural Properties are listed within 2 miles of the proposed project area. The Agencies have determined that because the proposed Action and alternatives do not involve excavation and workers would use existing camps, trails, and access points, the proposed Action and alternatives would have no impacts on archaeological resources. Suitable locations for burial of fish would be identified by the Forest Service Archaeologist. USFS is consulting with the Reno Sparks and Washoe tribes regarding the proposed Action as well as the Native American Heritage Commission and the State Historic Preservation Office (SHPO).
- **Historic Architectural Resources.** The CHRIS search described above identified several historic resources in the area including the cow camp in Upper Fish Valley, a Forest Service guard station, the remains of a cabin, and a wooden flume. Connell’s Camp Cabin is considered eligible for the National Register of Historic Places; however, no modification of the cabin is proposed. The Silver King Mine and Mining District were situated slightly north of the northern end of the Project area. The Silver King Mine was of minor importance, even locally, and it was apparently the most substantial (or only) mine in the mining district. The Agencies have determined that because the proposed Action and alternatives would not disturb any structures, the proposed Action and alternatives would have no impacts on historic architectural resources. USFS is consulting with SHPO regarding this determination.
- **Fire Management.** The proposed Action and alternatives would not change the existing environment such that it would impair adoption of or physically impede fire management or adopted emergency response plan.
- **Geology and Soils.** The proposed Action and alternatives would not build structures that would be susceptible to unstable soils or to seismic activity. Any potential for erosion or surface water turbidity is addressed in Section 5.1, Aquatic Resources.
- **Groundwater.** The proposed Action and alternatives would not substantially deplete groundwater supplies because it would not require any water for implementation. In addition, the proposed Action and alternatives would not interfere substantially with groundwater recharge because no new impervious surfaces would be created. Under the proposed Action,

workers would not apply chemicals to the ground and short-term treatment of surface water followed by neutralization would not result in groundwater contamination.

- **Hazards and Hazardous Materials.** The CEQA Guidelines outline significance criteria for evaluating impacts on human and ecological health from the transport, use and disposal of hazardous materials and/or wastes[1]. Because the proposed Action and alternatives are highly unlikely to create significant hazards, hazards and hazardous materials are not evaluated further in this EIS/EIR. The proposed Action and alternatives would not transport (see spill discussion below) or dispose of hazardous materials. Use of rotenone as part of the proposed Action would be carried out by licensed applicators according to label directions and the MOU between CDFG and the Water Board. An upset or accident involving the relatively small quantities of chemicals involved as part of the proposed Action is discussed below under "Hazardous Materials Spills." There are no existing or proposed schools within a one quarter-mile radius of the proposed project area and there are no airports within 2 miles of the proposed project area. Further, there are no private airstrips or hazardous materials sites; therefore, none of these criteria would apply. Finally, the area is not subject to any adopted emergency response plans or evacuation plans. Potential human and ecological exposures to rotenone and its formulation constituents, and rotenone formulation handling and application are addressed in Section 5.3, Human and Ecological Exposure and Appendix C herein.
- **Wildfire.** The CEQA Guidelines contain criteria for potential exposure of people or structures to the risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands. This criterion is not applicable to this EIS/EIR. While the proposed Action involves the use of combustible materials that could, if improperly handled, provide a combustion source, the quantities of these materials would be very small. Additionally, campfires would be needed to cook meals for work crews implementing the proposed Action and Alternative 3 (combined physical removal). However, work crews would follow applicable fire prevention precautions. Moreover, the proposed project area is located miles from any residences; therefore, neither the proposed Action nor the alternatives present risk of loss, injury, or death resulting from wildfires.
- **Hazardous Materials Spill.** The proposed Action would involve the transport of 20 gallons of rotenone formulation, between 300 and 600 pounds of granular potassium permanganate, and small quantities of fuel (approximately 30 gallons of gasoline for the generators) to the proposed project area. The one exception would be the treatment scenario involving Tamarack Lake in which an additional 50 gallons of rotenone formulation would be needed to treat the lake. Any spill could affect human or ecological receptors along the transport route. These impacts are addressed through preparation and implementation of the spill prevention, contingency and containment plan by the Agencies. To further minimize the risks

[1] A "hazardous material" is defined in Title 22, California Code of Regulations (CCR), Section 66084, as "a substance or combination of substances which, because of its quantity, concentration or physical, chemical or infectious characteristics, may either: (1) cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible or incapacitating irreversible illness, or (2) pose a substantial present or potential hazard to human health or environment when improperly treated, stored, transported or disposed of or otherwise managed." In essence, any liquid, solid, gas, sludge, synthetic product, or commodity that exhibits characteristics of toxicity, ignitability, corrosivity, or reactivity has the potential to be considered a "hazardous material." A "hazardous waste," in contrast, is simply defined as "any hazardous material that is abandoned, discarded, or recycled" (Title 22, C.C.R. section 66084).

of spills, transportation routes will be identified in the spill prevention, contingency and containment plan. The safest access routes would be selected for transporting hazardous materials to the proposed project area. Within the National Forest, equipment, personnel and chemicals would be transported to and within the proposed project area by pack stock and on foot and risk of spills would be minimal. With these measures in place and the small quantities of materials required for the proposed Action, spills do not present a significant risk and are not addressed further in the EIS/EIR.

- **Land Use and Management.** Because the Carson-Iceberg Wilderness does not contain any urban or residential uses, no communities exist within or near the proposed project area. The proposed Action and alternatives would not change land uses and would therefore not divide an established community or conflict with any applicable land use plan, policy or regulation. In addition, no habitat conservation plans or natural community conservation plans apply to the proposed project area.
- **Noise.** The proposed Action and alternatives would not create permanent sources of noise. The proposed Action and Alternative 3 (combined physical removal) would cause a temporary increase in ambient noise levels at the treatment areas when workers are present. However, with the exception of localized noise from the mechanical auger at the neutralization station near Snodgrass Creek under the proposed Action, noise generated by crews would not exceed those normally generated by visitors to the wilderness. This additional noise would not result in a substantial temporary or periodic increase in ambient noise above existing levels. Impacts on wildlife would be localized and less-than-significant (see Section 5.2, Terrestrial Resources). The proposed Action and alternatives are not located within an airport land use plan or within 2 miles of any airport or private airstrip.
- **Wild Horses and Burros.** The proposed project area does not provide rangeland for wild horses or burros; therefore, neither the proposed Action nor the alternatives would impact these resources.
- **Livestock Grazing.** An active grazing allotment occurs in the proposed project area below Snodgrass Creek. However, the proposed Action and alternatives would not interfere with this grazing allotment or impede grazing at any of the other protected cattle or sheep grazing allotments within the Carson-Iceberg Wilderness.
- **Mineral Resources.** No known mineral resources occur in the proposed project area. The proposed Action and alternatives do not involve excavation or fill and thus no loss or commitment of mineral resources would occur.
- **Paleontological Resources.** There are no known paleontological resources in the proposed project area, and the Agencies have determined that because the proposed Action and alternatives do not involve excavation and workers would use existing camps, trails, and access points, the proposed Action and alternatives would have no impacts on fossils. Suitable locations for burial of fish would be identified by the Forest Service Archaeologist.
- **Population and Housing.** The proposed Action and alternatives would not add new housing or increase the resident population within the proposed project area, which is currently unpopulated.
- **Public Services.** The proposed Action and alternatives would not create a need for new or physically altered facilities related to public services because these alternatives would not create additional demand for fire protection, police protection, schools, parks, or other

facilities by new residents or businesses. The proposed Action and alternatives would not induce population growth, nor would they interfere with existing public services.

- **Transportation and Traffic.** The proposed Action would generate approximately 20 automobile trips and 2 truck trips from Agency personnel and contracted workers traveling to the worksite. These vehicles would primarily use Highway 395 and Mill Creek Road and would not cause a substantial increase in traffic relative to the existing traffic load and road capacity. These vehicles would park at the trailhead until the treatment is concluded. Transport to the proposed project area would be on foot or horseback. No automobile or truck trips would occur after the treatment concludes. The proposed Action and alternatives would not exceed a level of service standard established by the county congestion management agency, and it would not result in a change in air traffic patterns. The proposed Action and alternatives involve no new construction or roadway design changes and therefore would not substantially increase hazards or impede emergency access or conflict with alternative transportation adopted policies, plans or programs.
- **Utilities and Service Systems.** The proposed Action and alternatives would not exceed the wastewater treatment requirements of the Water Board, require construction of new water or wastewater treatment facilities, create wastewater disposal needs, or require construction of new storm water drainage facilities because there would be no new impervious surfaces. The proposed Action and alternatives would produce only minimal solid waste (e.g. trash) that would be containerized and removed. The proposed Action and alternatives would comply with all federal, state and local statutes and regulations related to solid waste.

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CHAPTER 5

Environmental Consequences

This chapter contains the environmental impact assessment of the proposed Action and alternatives. The assessment addresses the requirements of NEPA and CEQA. The CEQA analysis directly addresses the significance thresholds contained in Appendix G of the CEQA guidelines. The environmental impact assessment addresses the following:

- 5.1 Aquatic Biological Resources
- 5.2 Terrestrial Biological Resources
- 5.3 Human and Ecological Exposure
- 5.4 Water Resources
- 5.5 Greenhouse Gases and Climate Change
- 5.6 Recreation
- 5.7 Wilderness Values and Management
- 5.8 Economic Resources
- 5.9 Environmental Justice
- 5.10 Comparison of Alternatives

Each subsection addresses the current regulatory environment, significance thresholds, and direct and indirect impacts of each alternative selected for detailed environmental analysis. In addition, each subsection evaluates the environmental impacts of the alternatives as described in Chapter 3.0, Project Alternatives, including the No Action alternative.

Chapter 6.0, Other Required Disclosures, provides information required by NEPA and CEQA, including:

- Relationship between Short-term Uses of the Environment and Maintenance and Enhancement of Long-term Productivity (Section 6.1)
- Unavoidable Adverse Effects (Section 6.2)
- Irreversible and Irretrievable Commitments of Resources (Section 6.3)
- Growth-Inducing Impacts (Section 6.4)
- Cumulative Effects (Section 6.5)

IMPACT SIGNIFICANCE TERMINOLOGY

For each resource evaluated, the key environmental issues and criteria for determining whether an adverse impact is significant under CEQA are discussed first. Note that the USFWS does not address significance in the findings of its EIS documents, so significance language is primarily a CEQA requirement. A "significant impact" is defined as:

> *a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance. An economic or social change by itself shall not be considered a significant effect on the environment. A social or economic change related to a physical change may be considered in determining whether the physical change is significant*. (CEQA Guidelines §15382)

The environmental impact analysis section for each resource defines the criteria used to judge whether an impact is significant. These criteria include the "Mandatory Findings of Significance" set forth in CEQA Guidelines §15065, as well as relevant criteria set forth in the Initial Study checklist (CEQA Guidelines, Appendix G), agency regulatory standards, or other criteria relevant to the specific Action. The significance terminology for adverse impacts should only be used with the CEQA conclusion of impact. The term "beneficial" is a NEPA term, and can be used to mean a beneficial impact if applicable. Otherwise, the conclusions for impacts or effects under NEPA are "adverse" or "no impact."

In describing the significance of adverse impacts or a beneficial effect, the following categories of significance are applied, based on the best professional judgment of the EIS/EIR preparers:

- **Significant and Unavoidable**: An impact that cannot be avoided or reduced to below the threshold level, given reasonably available and feasible mitigation measures. Such an impact is irreversible. (It requires a Statement of Overriding Considerations by CDFG, if the action is to be approved).
- **Significant but Mitigable**: An impact that can be reduced to below the threshold level (i.e., to less-than-significant) given reasonably available and feasible mitigation measures. The statement is made that the particular impact is significant, but with the application of the specific mitigation measure, the impact can be reduced to less-than-significant. (Such an impact requires findings to be made by CDFG).
- **Less-than-Significant**: An impact that may be adverse but does not exceed the threshold levels and does not require mitigation measures. However, mitigation measures that could further lessen the environmental effect may be suggested if such measures are readily available and easily achievable. The appropriate use is: the impact is less-than-significant or there is a "less-than-significant impact."
- **No Impact**: Where an impact is neutral or is clearly deemed "no effect," the preparer uses this term.
- **Beneficial**: This is a NEPA term for an effect that would have a positive impact on the environment, such as reducing an existing environmental problem or minimizing potential hazards to animals and/or humans.

Impacts that "may be significant" or "potentially significant," given some level of uncertainty are treated as "significant." Furthermore, uncertainty is also expressed with "could" rather than "would" as appropriate. Uncertainty is usually attributable to the limited availability of data or limitations in the application of mathematical models. Nevertheless, this EIS/EIR takes a conservative approach under these uncertain circumstances, and the impact is identified as significant under CEQA.

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5.1 AQUATIC BIOLOGICAL RESOURCES

This section describes the existing aquatic biological resources associated with the proposed project area and assesses the potential impacts of the proposed Action and alternatives on those resources. Aquatic biological resources, for the purpose of this assessment, include fish, aquatic invertebrate species, and riparian habitats. Amphibians are addressed in Section 5.2, Terrestrial Wildlife Resources.

This impact assessment incorporates information presented in the Biological Assessment prepared by USFS (2002) and the Biological Opinion prepared by the USFWS (2003). These documents assessed the potential effects of the proposed Action on species warranting protection under ESA and other sensitive species that may occur within the proposed treatment area (refer to Figure 3-1). Specifically, aquatic species evaluated in the Biological Assessment included Paiute cutthroat trout and Lahontan cutthroat trout. Additional information was needed to provide a more comprehensive analysis of the potential effects of the proposed Action. Therefore, this impact analysis incorporates background information contained in the Revised Recovery Plan (USFWS 2004), historic USFS and CDFG reports (e.g., Behnke and Zarn 1976, Ryan and Nicola 1976), CDFG benthic macroinvertebrate studies (Trumbo et al. 2000a), and a recent USFS-commissioned report (Vinson and Vinson 2007) on the impacts of past rotenone treatments on Silver King Creek benthic macroinvertebrates.

5.1.1 Environmental Setting

The Silver King Creek Watershed is located in eastern California (Figure 1-1). Aquatic habitat in the watershed includes Silver King Creek (a major tributary to the East Fork Carson River), six tributaries, and Tamarack Lake. Silver King Creek originates at approximately 9,600 feet above msl and flows approximately 14 miles to the confluence with East Fork Carson River. Silver King Creek flows through sub-alpine glacially formed meadows. Lodgepole pine forests transition to mountain mahogany and western junipers on the drier, upper slopes above the stream. Aspen groves and willows dominate the riparian zones adjacent to the stream. For the purposes of this analysis, the watershed has been divided into three major segments (Figure 5.1-1):

- Upper Silver King Creek – the watershed upstream of Llewellyn Falls, where Silver King Creek drops 20 feet. This area includes a 4 mile long reach of Silver King Creek flowing through Upper Fish Valley, and the tributaries of Fly Valley Creek, Four Mile Canyon Creek, and Bull Canyon Creek.
- Silver King Creek Valley (the treatment area) – a 6 mile long reach bounded by Llewellyn Falls at the upper end and Silver King Canyon at the lower end. Silver King Creek flows through Lower Fish Valley and Long Valley. The gradient in this reach is lower than in Upper Fish Valley. Tributaries in this reach include Tamarack Lake Creek, an unnamed tributary, Tamarack Creek, and Corral Valley/Coyote Valley Creek. Tamarack Lake is a 5-acre lake at the upper end of Tamarack Lake Creek.
- Silver King Canyon to confluence (also the treatment area) - approximately 1.7 miles below the mouth of Corral Valley/Coyote Valley Creek, Silver King Creek descends through Silver King Canyon. At the bottom of the canyon, Snodgrass Creek joins Silver King Creek, which flows another 3.4 miles to its confluence with the East Fork Carson River

The Silver King Creek Watershed lies within the boundaries of the Carson-Iceberg Wilderness. Resource uses within the wilderness area are generally restricted (see below). Historically, however, aquatic resources in the watershed have been affected by timber harvest, log transport, mining, livestock grazing, and recreational fishing. The earliest known activity in the Silver King Creek Watershed occurred during the Comstock era in the late 1800s when the area was logged (Deinstadt et al. 2004). Logs were transported downstream via Silver King Creek using splash dams, whereby the dam was breeched and the flow transported the logs downstream.

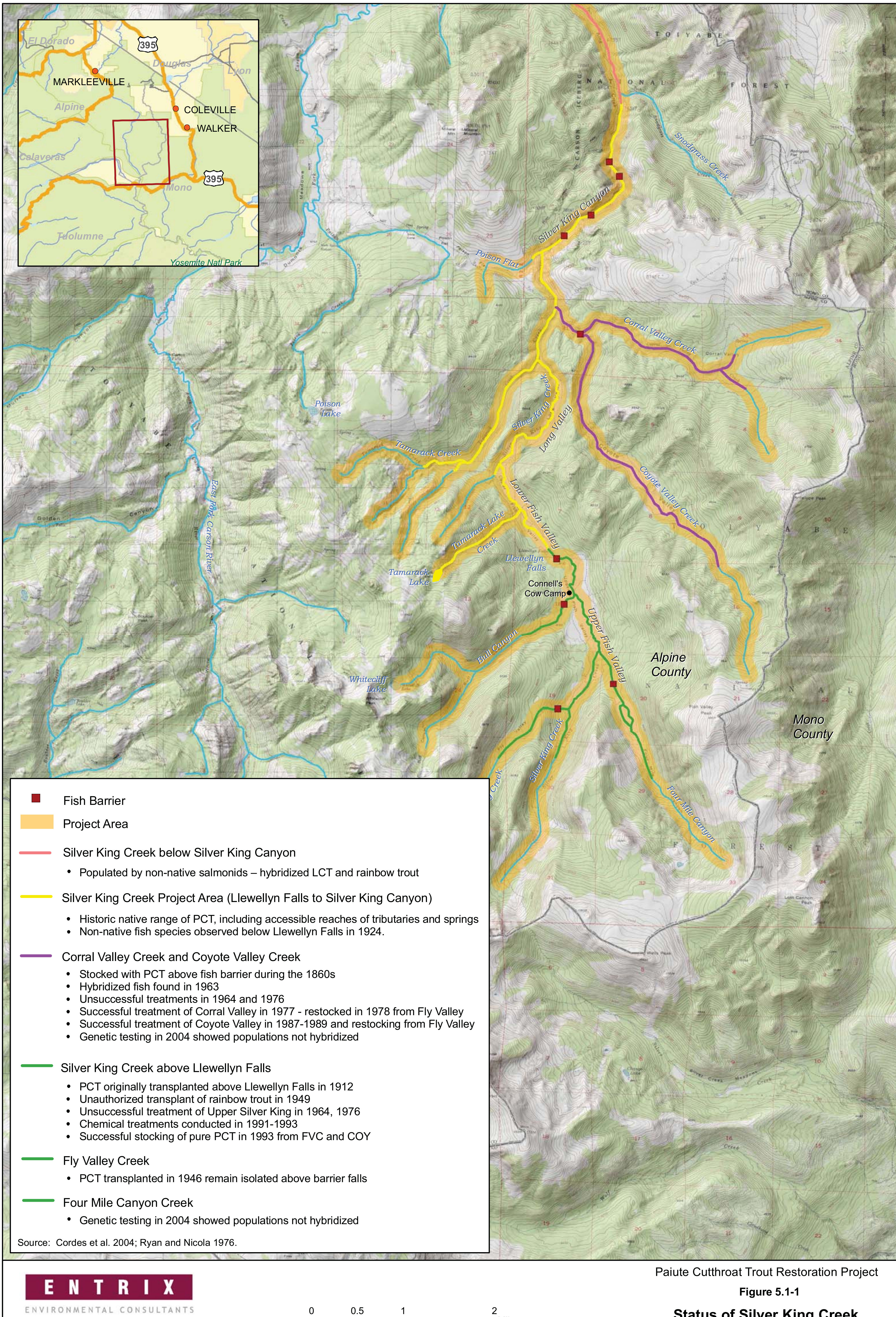
The area was used for cattle grazing from the turn of the 19^{th} century until 1994 (Deinstadt et al. 2004). Beavers have also disturbed the hydrology and habitat in the watershed, particularly in Four Mile Canyon Creek and Fly Valley Creek. Several habitat improvement projects were completed by the Agencies in Upper Fish Valley and tributaries to Silver King Creek in the 1980s. Fish barriers were improved in Four Mile Canyon Creek and beaver dams were demolished near the mouth of Fly Valley and Silver King Creeks. In the early 1980s, the USFS re-connected an old diversion structure to a secondary channel adjacent to Silver King Creek at the upper end of Upper Fish Valley to provide additional spawning habitat for Pauite cutthroat trout to offset the impacts from cattle grazing and beaver dams. Designation of the Carson-Iceberg Wilderness Area in 1984 resulted in the prohibition of logging and other activities requiring vehicle access or motorized equipment. The grazing allotment has been at rest since 1994 and vegetation and habitat conditions have been improving (see Section 5.1.1.2, Riparian Habitat below). Stream width to depth ratios have continually decreased (channel narrowing) and mean stream depths have increased as a result of the lack of grazing (Overton et al. 1994, CDFG 1998).

Although logging and grazing have ceased, the proposed treatment area is still subject to natural disturbance from large storms and snowmelt that may result in occasional floods, drought, forest fires, and subsequent erosion, resulting in bank destabilization, scouring of bottom sediments, as well as transport and deposition of sediments. These effects create a mosaic of patchy, dynamic habitats that support diverse and resilient communities of aquatic and terrestrial flora and fauna.

The Silver King Creek Watershed has been affected by a long history of fish transplants and chemical treatments (reviewed by Cordes et al. 2004). Non-native fish species, including rainbow trout have been introduced in areas above and below Llewellyn Falls. The native Paiute cutthroat trout was saved by being transplanted above Llewellyn Falls (1912) and barriers in Corral Valley (1860s), Four Mile Canyon (pre-1956), and Fly Valley Creeks where they were isolated from non-native trout (1946) (Behnke 1992, Ryan and Nicola 1976, Moyle et al. 2008). Between 1964 and 1993, rotenone treatments have been applied to several reaches and tributaries in the watershed (Flint et. al. 1998, Cordes et al. 2004, Vinson and Vinson 2007). A more detailed description of past trout management activities in Silver King Creek Watershed is provided below and summarized in Table 5.1-1.

Streams in the treatment area have been or are planned for use as unimpaired references to help the Water Board establish biocriteria for water quality standards (LRWQCB 1995). However, Silver King Creek has already been treated with rotenone multiple times in the past, as recently as 1993. In addition, throughout the first half of the 20^{th} century, the Silver King Creek Watershed was grazed by cattle.

The following subsections describe existing aquatic and riparian habitats and fish and benthic invertebrate populations in the proposed treatment area.



ENTRIX
ENVIRONMENTAL CONSULTANTS

Paiute Cutthroat Trout Restoration Project

Figure 5.1-1

Status of Silver King Creek Fisheries Resources

Project area showing trout habitat in Silver King Creek, Humboldt-Toiyabe National Forest, Alpine County, California.

Table 5.1-1 History of Paiute Cutthroat Trout from mid-1800s to the Present

Year	Event	Description
Pre-1860s		Historical distribution of PCT in SKC from below Llewellyn Falls downstream to Silver King Canyon Gorge
1860s	PCT Stock	Fishless COR and COY believed to be stocked with PCT from SKC below Llewellyn Falls
1860s to 1912	PCT Stock	Fishless FMC either stocked w/PCT or colonized from 1912 introduction above Llewellyn Falls
1912	PCT stock	PCT stocked into fishless upper SKC above Llewellyn Falls
1924		Hybrid RT/PCT and LCT/PCT noted in SKC below Llewellyn Falls
1946	PCT Stock	NFC stocked w/PCT from USKC, COR, and COY
1947	PCT Stock	Fishless FVC stocked w/PCT from COR and COY
1949	RT stock	Unauthorized introduction of RT into USKC , COR, COY
1955	LCT Stock	LCT stocked into Whitecliff Lake in Silver King watershed
1963		Hybrid RT/PCT found in COR and COY
1964	Chem	Unsuccessful chemical treatments of USKC, COR, COY, and BCC. Whitecliff Lake successfully treated. Hybrids found in NFC below a barrier
1966	Stock	Delaney Creek stocked from FVC and FMC
1968	PCT Stock	CC stocked w/PCT from NFC. Sharktooth Creek (Fresno County) stocked from Delaney Creek
1970		Unsuccessful chemical treatment of NFC
1972	PCT Stock	Stairway Creek (Madera County) stocked from Delaney Creek
1976	Chem	Unsuccessful chemical treatments of USKC and NFC
1976		RT/PCT hybrids found in USKC and NFC, but not FMC
1977	Chem	Successful chemical treatment of COR, unsuccessful in COY
1978	PCT Stock	COR stocked w/PCT from FVC
1980-83	Chem, PCT Stock	Successful chemical treatment of NFC. Restocked with NFC from above barrier
1984		CC population deemed not hybridized based on allozymes
1987-89	Chem, PCT Stock	Successful chemical treatment of COY. Restocked w/PCT from FVC
1991		COR, COY and FMC deemed not hybridized based on allozymes
1991-93	Chem	Successful chemical treatment of USKC in 3 consecutive years
1994-98	PCT Stock	USKC restocked w/PCT from FVC and COY
2004		No RT genes found in any of the PCT populations sampled by Cordes et al. (2004)

Source: Cordes et al. (2004, summarizing from Vestal (1964), Ryan and Nicola (1976), Flint (1980), Busack and Gall (1981)) and B. Somer CDFG pers. comm.

BCC = Bull Canyon Creek
CC = Cabin Creek (Mono County)
COR = Corral Valley Creek
COY = Coyote Valley Creek
FMC = Four Mile Canyon Creek
FVC = Fly Valley Creek
NFC = North Fork Cottonwood Creek (Mono County)
PCT = Paiute cutthroat trout
RT = Rainbow trout
SKC = Silver King Creek
USKC = Upper Silver King Creek (above Llewellyn Falls)

5.1.1.1 Aquatic Habitat

Silver King Creek and surrounding tributaries support various habitats ranging from steep canyon reaches with gradients as high as 23% (Tamarack Lake Creek) to low valley bottom meadows with gradients as low as 1% (Coyote Valley Creek) (USFWS 2004).

Habitat conditions in Silver King Creek (upstream of the proposed treatment area) and several confluent tributaries within the proposed treatment area were assessed in 1984, 1987, and 1990 (Duff 1985, 1991; USFWS 2004) and classified per Rosgen (1996). Most stream reaches were classified as low gradient, meandering, alluvial riffle-pool, channels with point bars and broad, well-defined floodplains and a gravel-dominated substrate (C3 channels as per Rosgen classification). Several tributaries had similar classifications, but had a silt/clay dominant substrate (C6 channels). These studies found improving post-grazing habitat conditions at all sampling locations; however, 12 of 21 stations had a Habitat Condition Index ranking of fair to poor. Hollow core sampling of substrates in Silver King Creek was conducted in 1984 and 1990 by an inter-agency team to assess fine sediment composition less than 6.35 mm (0.2 in.) (USFWS 2004, Appendix A). Duff (1991) recommended that the minimum amount of fine sediment should not exceed 30% and that natural fine sediment amounts in Silver King Creek fluctuated between 20 and 30%. Results of the interagency sampling effort revealed that fine sediment was constant between 1984 and 1990 (39.3 and 39.4%, respectively) (USFWS 2004, Table A2).

5.1.1.2 Riparian Habitat and Wetlands

Riparian zones are floristically and structurally diverse, with relatively high species richness, biomass, and structural complexity that, in turn, support a great diversity of mammal, bird, reptile, and amphibian species. Riparian zones along river networks possess important ecological properties, far in excess of their spatial extent. They are regarded as one of the biosphere’s most complex ecological systems but also one of the most important for maintaining the vitality of landscapes (Decamps et al. 2004). Riparian vegetation is an important component of Paiute cutthroat trout habitat, providing streamside cover and shade, supplying terrestrial insects, and contributing to stream bank stability and sediment routing.

The riparian vegetation along Silver King Creek (8,000 - 9,000 feet elevation) prior to grazing was likely dominated by willows along the main creek channel and various native sedges, grasses, and forbs with willows patchily distributed along abandoned side channels, high flow channels, and side seeps in the wider valley reaches (Winward et al. 1984). Historical livestock grazing practices have degraded the quality of the riparian habitat along the creek. During the 1980s, the numbers of livestock and time periods of grazing were restricted in an attempt to restore the riparian and in-stream habitats (Deinstadt et al. 1994). All grazing activities in the watershed were discontinued in the summer of 1994 (USFWS 2007).

A survey was conducted in 1984 along Silver King Creek to assess the riparian vegetation, evaluate its condition, and provide recommendations for management to improve Paiute cutthroat trout habitat (Winward et al. 1984). The riparian community then was dominated by sedge and grass species, including: Rocky Mountain sedge (*Carex scopulorum*), Nebraska sedge (*C. nebraskensis*), water sedge (*C. aquatilis*), rusty sedge (*C. subfusca*), winged sedge (*C. microptera*), beaked sedge (*C. rostrata*), Kentucky bluegrass (*Poa pratensis*), tufted hairgrass (*Deschampsia caespitosa*), red fescue (*Festuca rubra*) and western needlegrass (*Stipa occidentalis*). Willow species that dominated the canopy layer were interspersed (not continuously present) and included Geyer willow (*Salix geyeriana*), Lemmons willow (*S. lemmoni*), blueberry willow, (*S. boothii*), Eastwoods willow (*S. eastwoodiae*), Sierra willow (*S. crestera*) and little willow (*S. planifolia*). The quality of the riparian habitat in 1984 was clearly degraded by livestock practices, including severely grazed young willows sprouts and apparent reduced minimal successful regeneration. A transition from the native sedges to non-native species as Kentucky bluegrass and other invasive forbs had occurred along the creek. Winward et al. (1984) provided recommendations for changes in livestock grazing along the creek to improve the riparian habitat to benefit Paiute cutthroat trout. Willow recovery was expected within 3-5 years, with recovery of native grasses and sedges expected to take longer.

Riparian and stream channel response to modification and cessation of livestock grazing practices was assessed in Upper Fish Valley and Lower Fish Valley from 1999 through 2002 (Flint 2004). Willows were responding positively, compared with conditions in 1984. Successful expansion of the willow community and regeneration was observed on in-stream features and floodplains. Sedges and other vegetation also had established and expanded, contributing to stabilization of the stream bank and in-stream depositional features.

Limited habitat monitoring has been conducted within Silver King Creek since 1991, when USFS researchers conducted surveys of select grazed and ungrazed stream reaches (Overton et al. 1994). Their report provides grazing history, descriptions of cattle exclusion fencing, stream channel descriptions, and evaluation of bank condition and riparian vegetation. Comparisons of grazed areas with reference reaches revealed that, in 1991, the stream was still exhibiting signs of grazing effects as several stream habitat parameters were still below regional and in-basin standards. USFS concluded that changes in bank conditions should be observable within 2-4 years, as vegetation recovered from grazing (Overton et al. 1994).

5.1.1.3 Aquatic Biota

FISH

California has a great diversity of native trout (Behnke 1992). Moyle et al. (2008) lists 10 extant trout species and the extinct bull trout, a char (*Salvelinus confluentus*). These trout range from the familiar coastal rainbow trout (*O. mykiss irideus*) to the interior McCloud River redband (*O. m stoneii*) and California golden trout (*O. m. aguabonita*), and three subspecies of cutthroat trout: (Lahontan (*O. c. henshawi*), Paiute cutthroat trout, and the coastal cutthroat (*O. c. clarkii*). Many native trout populations, however, have declined in abundance and geographical distribution during the last 200 years and are at risk of extinction. Presently, all of these trout species carry a status of state species of special concern, Federal sensitive species, state and/or federally-listed as threatened, or some combination thereof (Moyle et al. 2008). The actions evaluated in this EIS/EIR are part of a directed effort to conserve and recover federally threatened Paiute cutthroat trout within their historical range (refer to USFWS 2004). The following subsection describes the evolution of trout species in the Great Basin and the trout species that occur in the proposed treatment area, species range and status, and a brief history of their management.

Cutthroat trout became established in the Lahontan Basin long before the last glacial epoch, perhaps during the mid-Pleistocene Epoch (Behnke 1992). The Lahontan cutthroat trout arose from this epoch and has given rise to four forms, including the Humboldt and Paiute forms in the Lahontan Basin. During the last ice age, about 10,000 to 70,000 years ago, and during previous Pleistocene periods of glaciation, large lakes existed in separate basins. About 8,000 years ago, these lakes shrank, leaving behind remnant waters. The Lahontan cutthroat trout and its forms were able to persist in remnant populations until recent times, but they have shown themselves to be poorly suited to compete with non-native strains of highly stream-adapted trout with different life histories and behaviors, and most of their remnants have disappeared since non-native trout were introduced to the Great Basin (Behnke 1992).

Three Great Basin forms of cutthroat trout remain, including Paiute, Lahontan and Bonneville cutthroat trout. Paiute cutthroat trout are a recent derivative of Lahontan cutthroat trout and are meristically different from them by the near absence of spots on their body (Moyle 2002). Paiute cutthroat trout were derived in relatively recent geological times after a population was isolated in Silver King Creek (Behnke 1992), and likely became established as a distinct subspecies in Silver King Creek between 5,000 and 8,000 years ago.

The species currently inhabiting the proposed treatment area, including hybridized Paiute cutthroat trout and rainbow trout, are described below. The proposed Action seeks to remove rainbow trout and Paiute cutthroat trout/rainbow trout hybrids from the drainage. This would allow re-establishment of a genetically “pure” population of Paiute cutthroat trout and restore a species to its entire historical range as recommended in the Revised Recovery Plan (USFWS 2004). The following life history descriptions were summarized from Moyle (2002) and Moyle et al. (2008) and were presented in the Biological Assessment (USFS 2002) and Biological Opinion (USFWS 2003). Information on Paiute cutthroat trout is also presented from the Paiute cutthroat trout 5-Year Review (USFWS 2007) and the Revised Recovery Plan (USFWS 2004).

PAIUTE CUTTHROAT TROUT (O. CLARKII SELENIRIS)

Paiute cutthroat trout were first described by Snyder (1933) as an isolated variant of Lahontan cutthroat trout. The paragraphs below describe the status, range, and habitat requirements of Paiute cutthroat trout.

STATUS AND RANGE

Paiute cutthroat trout were first listed as endangered in 1967 under the Endangered Species Preservation Act of 1966 (32 FR 4001). They were reclassified as threatened in 1975 under the ESA of 1973 (as amended) (40 FR 29863). Due to the small and restricted populations that continue to face threats from catastrophic events such as floods, fires and non-native fish introductions, the USFWS recently determined that Paiute cutthroat trout continues to meet the definition of threatened (USFWS 2007). Moyle et al. (2008) concluded that Paiute cutthroat trout have a high likelihood of extinction in their native watershed within the next 50 years without continued intense monitoring and management.

The historical distribution of the Paiute cutthroat trout is limited to 9.1 miles of habitat in Silver King Creek from Llewellyn Falls downstream to Silver King Canyon as well as the accessible reaches of three small named tributaries: Tamarack Creek, Tamarack Lake Creek, and the lower reaches of Coyote Valley Creek downstream of barrier falls. The extremely limited native range of the Paiute cutthroat trout, within a single watershed, presents a unique challenge for efforts to recover the species and to address population-level threats. In the early part of the 20th century, Paiute cutthroat trout were eliminated from their presumed historical habitat through displacement and hybridization with introduced rainbow trout, golden trout, and Lahontan cutthroat trout (Moyle 2002).

Currently, Paiute cutthroat trout are found only where they have been introduced outside their historic range. They occupy approximately 20.6 miles of habitat in five widely-distributed drainages. The present distribution in the Silver King Creek Watershed consists of populations in Upper Silver King Creek above Llewellyn Falls (2.7 miles total), Fly Valley Creek (1.1 miles), Four Mile Canyon Creek (1.9 miles), and Bull Canyon Creek (0.6 miles), as well as below the falls including Coyote Valley Creek (3.0 miles) and Corral Valley Creek (2.2 miles). All of these areas were historically fishless (USFWS 2004). The Agencies have established 4 self-sustaining, pure populations outside the native drainage in the North Fork of Cottonwood Creek (3.4 miles), Cabin Creek (1.5 miles) (Inyo National Forest, Mono County), Stairway Creek (2 miles) (Sierra National Forest, Madera County), and Sharktooth Creek (2 miles) (Sierra National Forest, Fresno County). The range of Paiute cutthroat trout was extended into the upper reaches of Silver King Creek and its tributaries by one or more unofficial transplants of fish above Llewellyn Falls starting in 1912 (reviewed by Behnke and Zarn 1976, Ryan and Nicola 1976, Moyle 2002). The current distribution of Paiute cutthroat trout reflects decades of management efforts to expand the species beyond its native range, conserve the species within its native watershed, but does not include their historical and presumably stable distribution. Cordes et al. (2004) provide a comprehensive documentation of the known history of Paiute cutthroat trout management activities with associated genetic and/or population consequences (Table 5.1-1).

Approximately 1,020 adult Paiute cutthroat trout reside in the Silver King Creek drainage, based on CDFG population assessments in 2001 (USFWS 2004). CDFG estimated approximately 424 fish in the Upper Silver King Creek above Llewellyn Falls, and an effective population size of 400-700 fish in Four Mile Canyon, Fly Valley and Corral Valley Creeks combined.

CDFG investigated the falls in Silver King Canyon to be a potential factor in isolating fish above Silver King Canyon and allowing speciation (Heise 2000). This series of falls presents a formidable barrier to upstream fish movement (Figure 5.1-2) including a high gradient channel with large boulders and numerous vertical drops in excess of five feet and one drop of approximately ten feet. CDFG concluded these features most likely constitute a total barrier to fish passage (Heise 2000). Although high flow conditions could reduce these waterfalls to heights of less than 6 feet (generally considered a total barrier to fish passage) and ideal wave conditions could seasonally occur to facilitate fish jumping performance, CDFG concluded that the magnitude of the barriers, the narrowness of the gorge, the slope of the stream channel, and the potential for inhibiting air entrainment and water turbulence would prevent fish passage at Silver King Canyon (Heise 2000).

Figure 5.1-2 Barrier Falls in Silver King Canyon (CDFG 2000)

EXISTING GENETIC STRUCTURE

Paiute cutthroat trout are genetically and meristically (physically) similar to Lahontan cutthroat trout from which they recently diverged. Behnke and Zarn (1976) concluded that the separation of Paiute cutthroat from Lahontan cutthroat trout occurred relatively recently (no more than 5,000 to 8,000 years ago), following the desiccation of Lake Lahontan.

Paiute cutthroat trout have limited genetic variability, due in part to the bottleneck and founder effects when Paiute cutthroat trout were originally isolated from a common ancestor with Lahontan trout and/or more recent bottlenecks resulting from small number of fish typically used as transplant stocks (Nielsen and Sage 2002, Cordes et al. 2004). Genetic analyses could not discriminate Paiute cutthroat trout from Lahontan cutthroat trout (Busack and Gall 1981, Finger et al. 2008). Investigations of population genetic structure of the

Lahontan group of cutthroat trout (Lahontan, Paiute, and Humboldt cutthroat trout) detected no unique alleles in Paiute cutthroat trout (Nielsen and Sage 2002).

Genetic studies evaluated levels of rainbow trout hybridization and relationships among 9 populations of Paiute cutthroat trout (Cordes et al. 2004, Finger et al. 2008). These studies indicate that past efforts to remove trout hybrids in several creeks in the Silver King Creek Watershed have been successful. The results of Cordes et al. (2004) suggest that none of the 9 populations tested have undergone recent hybridization with rainbow trout. These populations of "pure" Paiute cutthroat trout include populations in the Silver King Creek Watershed (Fly Valley Creek, Upper Silver King Creek, Four Mile Canyon Creek, Bull Canyon Creek, Coyote Valley Creek, and Corral Valley Creek) and populations established in other watersheds (North Fork Cottonwood Creek (Mono County), Cabin Creek (Mono County), Stairway Creek (Madera County), and Sharktooth Creek (Fresno County). The genetic similarities among the populations reflect the past history of stocking and management (Figure 3 in Cordes et al. 2004). In contrast, the fish residing in Silver King Creek downstream of Llewellyn Falls, including Tamarack Creek are non-native hybrids of rainbow trout and California golden trout, comprised mostly of rainbow trout (Finger et al. 2008). Very little remains of cutthroat trout (Paiute or Lahontan) genetic influence in the proposed treatment reach (Finger et al. 2008). Cordes et al. (2004) concluded that all extant populations of Paiute cutthroat trout should be considered part of a single management unit with regard to restoration, and recommended that restocking should ideally consist of large numbers of fish from multiple donor populations with as much genetic variation as possible in order to minimize loss of diversity and the effects of inbreeding.

Continuing to preserve a fragmented population structure potentially reduces overall species viability (Spruell et al. 1999, Rieman and Dunham 2000). Management of small populations with low genetic diversity presents one of the most challenging conservation problems for managers. The USFWS (2004) has identified potential recovery activities to reduce the threat of genetic introgression from non-native trout by removing non-native trout in Silver King Creek from Llewellyn Falls downstream to Silver King Canyon (Priority 1 rating), and to increase population viability by reintroducing Paiute cutthroat trout to this area once non-native trout have been removed (Priority 1 rating) and protecting stream habitat in the Silver King Creek Watershed (Priority 2 rating).

HABITAT AND LIFE HISTORY REQUIREMENTS

Paiute cutthroat trout life history and habitat requirements are similar to those reported for other western stream-dwelling salmonids. All life stages require cool, well-oxygenated waters. Adult fish prefer stream pool habitat in low gradient meadows with undercut or overhanging banks and abundant riparian vegetation. Pools are important rearing habitat for juveniles and act as refuge areas during winter (Hickman and Raleigh 1982, Swales et al. 1986, Berg 1994). During the winter months, trout move into pools to avoid physical damage from ice scouring (Scrimgeour et al. 1994) and to conserve energy (Everest and Chapman 1972, Cunjak 1996). As with other salmonids, suitable winter habitat may be more restrictive than summer habitat (Jakober et al. 1998). Paiute cutthroat trout survive in lakes, but there is no evidence that they ever occurred naturally in any lakes within the Silver King Creek Watershed.

Paiute cutthroat trout spawn in flowing waters with clean gravel substrates (USFWS 2004). They reach reproductive maturity at the age of 2 years. Peak spawning activity occurs in June and July. The eggs hatch in 6 to 8 weeks and the fry emerge from the gravel in another 2 to 3 weeks. Young-of-the-year fish rear in mainstem shoals or backwaters, and often move into intermittent tributary streams until they reach about 50 mm in length. Like other trout, Paiute cutthroat trout feed mostly on drift, typically a mixture of terrestrial and aquatic insects (Moyle 2002).

EXISTING THREATS

Currently, the greatest threat facing Paiute cutthroat trout is loss of genetic diversity due to hybridization with non-native trout, compounded by its extremely limited distribution and lack of metapopulation connectivity (USFWS 2004, Moyle et al. 2008). The long-term survival of the current populations is uncertain due to the small size of the drainages and populations, limited genetic diversity, and no hydrologic connections between populations. These key threats are discussed further below.

Historic threats include habitat loss due to past livestock grazing practices, introduction of rainbow trout, unregulated angling, and habitat alteration due to introduced beavers (USFWS 2004). Although some habitat improvement has occurred in Silver King Creek due to changes in grazing management, similar threats still exist (USFWS 2004). Recreation occurs in and around Paiute cutthroat trout streams. Heavy recreation poses a risk to stream bank stability and trout habitat. Introduced trout pose the greatest risk to the species. Effective fish barriers occur downstream of all remaining populations, but the threat of humans moving other trout species into these protected reaches continues. An ill intentioned angler could easily catch a rainbow trout and release it above Llewellyn Falls, involving a transport of the fish of only a few hundred feet. This action would unravel decades of restoration efforts and place the populations of Paiute cutthroat trout in Upper Fish Valley and Four Mile Canyon Creeks at risk. A similar action could also impact the Paiute cutthroat trout populations in Coyote Valley and Corral Valley Creeks. Conducting the proposed Action would substantially reduce these risks by removing non-native trout from the Silver King Creek Watershed above the Silver King Canyon and greatly increasing the distance that fish would have to be moved (Rahel 2004).

1. THREAT OF HYBRIDIZATION

Paiute cutthroat trout are threatened with loss of genetic integrity through hybridization with non-native trout. Like their Lahontan cutthroat trout ancestors, Paiute cutthroat trout are vulnerable to replacement by or hybridization with non-native trout and must be maintained in isolation if they are to be preserved (Behnke 1992). Cutthroat trout will hybridize with rainbow trout through introductions of rainbow trout into interior basins (Moyle 2002).

If Paiute cutthroat trout occurred only in currently occupied habitat, this species would remain highly vulnerable to extinction because: 1) genetic diversity could be dramatically reduced by a catastrophic event within any of the five drainages; 2) populations could become quickly introgressed as the result of an unauthorized introduction of other trout; and 3) genetic diversity could be subjected to additional severe bottlenecks due to inadequate population size. However, reintroduction of Paiute cutthroat trout to historical habitat, in combination with maintaining populations existing upstream of Llewellyn Falls and out-of-basin, will substantially reduce these extinction threats.

While some Paiute cutthroat trout populations within the Silver King Creek drainage have had immediate genetic threats lessened, the genetic threat of introgression by rainbow trout and other con-specifics persists within the historical range of Paiute cutthroat trout. Efforts to restore pure populations of Paiute cutthroat trout above Llewellyn Falls appear to have been successful. The population in Fly Valley Creek has remained isolated by a barrier falls. Hybridized trout have been removed by chemical treatments from Upper Silver King Creek, Four Mile Canyon Creek, Fly Valley Creek (downstream of the fish barrier), Bull Canyon Creek, Corral Valley Creek, and Coyote Valley Creek. However, trout populations in the mainstem of Silver King Creek downstream of Llewellyn Falls still present a genetic threat. Deinstadt et al. (2004) characterize the trout population in this reach as a "hybrid swarm" of Paiute cutthroat trout, Lahontan cutthroat trout, rainbow trout, and golden trout. Here, the population density was one of the highest in their regional survey of trout populations (1,478 fish per mile). A recent genetic study of the fish population downstream of Llewellyn Falls found rainbow trout and golden trout hybrids, with little evidence of cutthroat trout genetics (Finger et al. 2008). This hybrid population dominates the core area for expansion of Paiute cutthroat trout, acts as the primary mechanism isolating and fragmenting Paiute cutthroat trout populations in the Silver King Creek drainage, and remains a genetic threat to the species and a limit for recovery efforts unless removed.

2. THREAT OF FRAGMENTED POPULATIONS

Isolated populations such as the remaining Paiute cutthroat trout populations are vulnerable to extinction through stochastic factors such as random fluctuations in birth and death rates variation in environmental conditions, catastrophic events such as floods and fire, loss of genetic diversity from small population size, and human disturbance including introduction of non-native species (Hedrick and Kalinowski 2000, Lande 2002, Reed and Frankham 2003, Pringle 2006, Cordes et al. 2004). Completely isolated populations are the most severe form of fragmentation, because no gene flow occurs, resulting in inbreeding and reduction of population fitness (Hedrick and Kalinowski 2000, Reed and Frankham 2003, Frankham 2005, Scribner et al. 2006, Pritchard et al. 2007, Guy et al. 2008).

3. THREAT OF LIMITED RANGE/OCCUPIED HABITAT

Paiute cutthroat trout were able to persist and evolve for 5,000-8,000 years in their historical range of 9.1 miles of Silver King Creek below Llewellyn Falls (USFWS 2004). They currently occur in separate populations isolated by waterfalls and occupying shorter stream reaches ranging 1.1-3.5 miles in length (USFWS 2004). Given the current literature in trout population ecology, the existing small isolated populations of Paiute cutthroat trout are not large enough to sustain the subspecies in the long term. In general, population viability of cutthroat trout is correlated with stream length or habitat size (Hilderbrand and Kershner 2000, Hildebrand 2003, Harig and Fausch 2002, Young et al. 2005). Stream length is important because trout move throughout streams searching for necessary microhabitats for spawning, rearing, refuge, and migration (Baltz et al. 1991, Fausch and Young 1995, Young 1996, Muhlfeld et al. 2001, Schmetterling 2001, Hilderbrand and Kershner 2004, Schrank and Rahel 2004, Colyer et al. 2005, Neville et al. 2006, Umak 2007).

Longer stream reaches have more complexity and have a higher probability of supplying sufficient amounts of microhabitats than shorter reaches (Horan et al. 2000, Harig and Fausch 2002, Dunham et al. 2003). Larger, more connected habitat patches also decreases the likelihood of stochastic events (i.e., fire, flood, drought) from negatively impacting a population.

Hilderbrand and Kershner (2000) estimated 8.2 km (5.1 mi) were required to maintain a population of 2,500 cutthroat trout when fish abundance was high [300 fish/km (484 fish/mi)]. Adding a 10% loss rate of individuals, to account for emigration and mortality, increased the required length up to 9.3 km (5.8 mi) in order to maintain 2,500 fish. For streams with smaller population sizes of 200 fish/km (320 fish/mi) and 100 fish/km (160 fish/mi), the corresponding length increased to 12.5 (7.8 mi) and 25 (15.5 mi) stream km, respectively (Hilderbrand and Kershner 2000). Young et al. (2005) found that to maintain a population of 2,500 cutthroat trout, 8.8 km (5.5 mi) of stream was needed. Therefore, implementation of the proposed Action should provide adequate habitat for the long-term viability of Paiute cutthroat trout once non-native trout have been removed from the system.

RAINBOW TROUT (O. MYKISS)

Rainbow trout are the most abundant and widespread native salmonid in western North America, and were originally native to Pacific coast streams from Alaska to Baja California (Moyle 2002). They are the most widely distributed fish in California and their natural distribution has been greatly expanded by transplants into most coldwater streams and lakes, including many waters that were originally fishless (Moyle 2002). In fact, rainbow trout have been introduced into coldwater streams throughout most of the world. Rainbow trout are present in the project area as a relic population from stocking and as introgressed hybrids with golden trout and Lahontan and Paiute cutthroat trout (Finger et al. 2008). They are not the subject of conservation efforts in the project area and are likely of mixed stock lineage used in regional hatchery programs.

Rainbow trout have adapted to a wide variety of habitats and have flexible life history patterns. They prefer streams with clear, cool, fast flowing water and ample aquatic cover such as riparian vegetation or undercut banks. In small streams and high mountain lakes, rainbow trout seldom live longer than six years of age or grow to be larger than 16 inches (40 cm) total length. Most wild rainbow trout reach sexual maturity in their second or third year. They spawn between February and June in the gravel of riffles. As fish grow in size, habitat use generally shifts from riffles for the smallest fish to runs for intermediate sized fish and pools for the largest fish. Stream dwelling fish feed mostly on drifting invertebrates, but will also feed on benthic invertebrates. Rainbow trout in lakes can feed on zooplankton, benthic invertebrates, or small fish.

Rainbow trout often dominate other salmonids. They are highly aggressive and often defend feeding territories in streams. Moyle (2002) concluded that “indiscriminate planting of rainbow trout has led to loss through hybridization of many populations of rainbow, redband, and golden trout, as well as of cutthroat trout.”

TROUT MANAGEMENT IN SILVER KING CREEK

Silver King Creek has a long and complicated history of trout management (Table 5.1-1, Cordes et al. 2004). Four different trout species have been moved into and around the proposed treatment area, including Paiute cutthroat trout, Lahontan cutthroat trout, golden trout, and rainbow trout (USFWS 2004). Ironically, Paiute cutthroat trout are now extirpated from their historic habitat due to introduced trout, but exist in formerly fishless areas of the Silver King Creek Watershed above passage barriers. This subsection presents a history of trout management in Silver King Creek, including the establishment of trout in the basin and proposed treatment area, the species stocked, the hybridization that has occurred, past rotenone treatments, and the status of the existing fish populations.

Sometime in the 1860s or 1870s, Paiute cutthroat trout were transplanted from Silver King Creek into Corral Valley and Coyote Valley Creeks by loggers. In 1890, Virgil Connell (sheepherder) observed that there were no fish present above Llewellyn Falls. In 1912, a Basque sheepherder, Joe Jaunsaras, transported fish by bucket from Lower Fish Valley to Upper Fish Valley upstream of Llewellyn Falls. In 1914, golden trout were reportedly planted downstream of Llewellyn Falls in Silver King Creek. By 1924, the Paiute cutthroat trout that had been planted upstream of Llewellyn Falls and had established a robust population and the fishery downstream had become "mixed with other kinds, probably due to stocking" (Letter from Virgil Connell in Ryan and Nicola 1976).

CDFG's involvement in Silver King Creek began shortly after Snyder's description of the species in 1933 and 1934. The California Fish and Game Commission closed Silver King Creek to fishing in 1934 to protect this unique fishery. The fishery remained closed until 1952 when it was reopened. At the same time as Silver King Creek was reopened to angling, the Fish and Game Commission closed Coyote Valley and Corral Valley Creeks to angling. This closure remains in effect. Opening Silver King Creek to angling was a management tool that was employed in an attempt to fish out the hybrids and the rainbow trout that were inadvertently planted in 1949. The effect of opening the fishery to angling did not have the intended effect of removing the hybridized fish and rainbow stocks due to the Paiute cutthroat trout's vulnerability to angling harvest. The fishery remained open to angling until 1965 when it was closed again to protect the remaining pure fish population following the 1964 chemical treatment. During the historic closure (1934 to 1952) and current closure (1965 to present), there was regular poaching of fish within the closed reaches of Silver King Creek. Actions taken by CDFG included the posting of wardens, stream guards and outreach to the U.S. military, which reduced this activity to a minimum. In 2005, the angling closure upstream of Llewellyn Falls was expanded to include a reach of stream from Llewellyn Falls downstream to the confluence of the outlet creek from Tamarack Lake. This was done to create a buffer zone between the pure Paiute cutthroat trout populations upstream of Llewellyn Falls and hybridized fish populations present in Silver King Creek to reduce the risk of an illegal introduction of hybridized trout by anglers.

The first concerted attempt at restoration of Paiute cutthroat trout in Silver King Creek upstream of Llewellyn Falls following the unauthorized introduction of rainbow trout (1949) was an unsuccessful chemical treatment in 1964. Chemical treatments in 1976 and 1977 were also performed; however, only Corral Valley Creek was successful. Another chemical treatment of Coyote Valley Creek was conducted in 1987 and 1988. This treatment was successful and in 1991 genetic analysis confirmed that these populations were not hybridized. A final suite of chemical treatments were conducted in the upper Silver King Creek system in 1991, 1992, and 1993. Post-treatment sampling and genetic analysis have confirmed the successful eradication of non-native trout and the establishment of pure Paiute cutthroat trout populations in Upper Fish Valley and the upper tributaries to Silver King Creek upstream of Llewellyn Falls (Cordes et al. 2004).

CDFG began attempts to stock fish into previously fishless waters in 1947 by transplanting Paiute cutthroat trout into Fly Valley and Bull Canyon Creeks upstream of Llewellyn Falls (Vestal 1947, Ryan and Nicola 1976). The transplant was successful in Fly Valley Creek but not in Bull Canyon Creek. CDFG also planted Paiute cutthroat trout into Leland Lakes (El Dorado County) in 1937 and North Fork Cottonwood Creek (Mono County) in 1946. The plant in Leland Lakes was later deemed unsuccessful, but the North Fork Cottonwood Creek plant persists (Ryan and Nicola 1976, Moyle et al. 2008). Fish were planted in many other waters around the State;

however, only the plants into Cabin Creek (Mono County), North Fork Cottonwood Creek, Stairway Creek (Madera County), and Sharktooth Creek (Fresno County) were successful and the progeny of the original transplanted Paiute cutthroat trout remain genetically pure (Cordes et al. 2004).

Other fish species were also stocked in the Silver King Creek drainage, most notably a mistaken air plant of Lahontan cutthroat trout into Whitecliff Lake in 1955 and 1956. These fish were successfully removed by the 1964 treatment of Whitecliff Lake. As previously noted, there were numerous plants of rainbow, cutthroat and golden trout into Silver King Creek as of 1924 by a variety of entities. Fish stocking by CDFG is presented in Table 5.1-2.

Table 5.1-2 Department of Fish and Game fish stocking records for Silver King Creek Watershed (1930 to present)

Date	Trout Species	Number	Hatchery Source	Stocking location
Silver King Creek				
Aug 15 1930	Rainbow	5,000	Mt. Whitney	
Aug 18 1930	Steelhead	5,000	Mt. Whitney	
Aug 27 1931	Rainbow	10,000	Alpine	
Sep 15 1932	Rainbow	10,000	Alpine	
Aug 13 1933	Rainbow	10,000	Alpine	
July 20 1935	Brook	5,000	Alpine	
Sep 12 1935	Lahontan cutthroat	10,000	Alpine	
Aug 21 1946	Lahontan cutthroat	8,700	Hot Creek	Near Poison Valley
Sep 5 1947	Lahontan cutthroat	19,600	Hot Creek	Long Valley – Forks
Sep 6 1947	Lahontan cutthroat	19,600	Hot Creek	Forks – mouth
Sep 7 1947	Lahontan cutthroat	9,800	Hot Creek	Long Valley – forks
Sep 29 1949	Rainbow	8,400	Hot Creek	Below Llewellyn Falls
Sep 30 1949	Rainbow	5,040	Hot Creek	Above Llewellyn Falls
Aug 8 1951	Rainbow	6,010	Markleeville	Snodgrass Canyon above Corral Valley Creek
Aug 13 1952	Rainbow	5,017	Markleeville	U. Bagley Valley to Llewellyn Falls
Aug 7 1953	Rainbow	4,960	Markleeville	~2 miles above Vaquero Camp
Sep 23 1976	Rainbow	960	American	Lower Fish Valley
Sep 23 1976	Rainbow	2,900	American	Lower Fish Valley
Coyote Valley Creek				
Aug 21 1946	Lahontan cutthroat*	1,740	Hot Creek	Lower Stream
Sep 7 1947	Lahontan cutthroat*	4,200	Hot Creek	Mouth to barrier

Source: CDFG data, B. Somer.
*Lahontan cutthroat were also called black spotted cutthroat

Tamarack Lake was likely historically fishless because of the steep drop of the outlet creek into Lower Fish Valley that contains numerous waterfalls. The lake has been stocked for recreational angling of golden trout and Lahontan cutthroat trout since 1955 (Table 5.1-3). Brook trout were reportedly stocked in 1968 but the success of these plants is unknown, and this species of trout has not been caught in CDFG net surveys. Various surveys have been conducted to evaluate the fish plants over the intervening years. In September, 1955, Mr. Robert Butler visited Tamarack Lake (CDFG file note, September 13, 1956) and reported “several redds were noted along the shore”. He also observed numbers of fish in the lake and collected one “cutthroat.” Gill nets set by CDFG staff during August 1974 caught five golden trout in two sinking nets; two other nets captured no fish. Mr. Eric Gerstung sampled Tamarack Lake with gill nets in August 1978 (CDFG file note Sep 21, 1978). He caught nine golden trout of “3 or more year classes.” He also observed “the three tributaries average less than a foot wide and are accessible to fish for about 50 feet each. The substrate is largely decomposed granite. No adults or fry were observed and no pools or cover are present. Spawning, if it occurs at all, most likely occurs in the mouths of the tributaries.” Mr. Ron Rogers visited the lake during July 1985 (CDFG file note July 22, 1985) and observed no fish, but found “frogs and tadpoles were fairly abundant, indicating few, if any, fish”. Mr. Rogers observed the inlet to be flowing at 0.5 to 1 cfs and that “limited spawning may be possible here.” Preceding the chemical treatment of Upper Fish Valley during 1991, approximately 800 rainbow-Paiute cutthroat hybrids were collected by electrofishing and stocked into Lower Fish Valley and Tamarack Lake using a helicopter. These non-native trout hybrids provided good fishing for anglers during the early and mid -1990s.

Table 5.1-3 Department of Fish and Game Fish Stocking Records for Tamarack Lake (1955 to Present)

Date	Trout Species	Number
1955	Lahontan cutthroat	1,005
1957	Lahontan cutthroat	1,000
1959	Lahontan cutthroat	1,035
1962	Lahontan cutthroat	1,020
1967	Lahontan cutthroat	4,000
1968	Brook	500
1968	Lahontan cutthroat	5,000
1969	Golden	1,018
1971	Lahontan cutthroat	4,000
1972	Golden	1,000
1973	Golden	1,141
1973	Lahontan cutthroat	3,600
1974	Golden	2,250
1975	Lahontan cutthroat	3,600
1976	Golden	2,272
1976	Lahontan cutthroat	4,000
1980	Lahontan cutthroat	4,200
1982	Lahontan cutthroat	4,000
1985	Paiute cutthroat	173
1987	Lahontan cutthroat	3,000
1987	Paiute cutthroat	100
1991	Rainbow-Paiute cutthroat- hybrid*	unknown

Source: CDFG data, B. Somer.

*In 1991 prior to chemical treatment, multiple age classes of hybrid rainbow-Paiute cutthroat were rescued from Upper Silver King Creek and transported via helicopter to Tamarack Lake.

Stocking of golden trout in Tamarack Lake has contributed to the genetic composition of fish in Silver King Creek. Genetic analysis of rainbow trout collected in 2006 at various locations in Silver King Creek (from Lower Fish Valley to Snodgrass Creek) indicate that golden trout stocked in Tamarack Lake have contributed to the genetic makeup of the rainbow trout population in Silver King Creek (Finger et al. 2008). This also demonstrates the high potential for trout to move out of Tamarack Lake into Silver King Creek.

Gill net surveys have been conducted since 2001 to assess the presence of trout in Tamarack Lake resulting from previous plantings or natural reproduction (Table 5.1-4). Floating and sinking Swedish gill nets of the standard mesh and panel sizes used by CDFG High Mountain Lake Project were used for sampling. Nets used were 36 m in length, 1.8 m in depth, with 6 panels of variable net mesh size (10 mm, 12.5 mm, 18.5 mm, 25 mm, 33 mm, and 38 mm). Gill net sets have increased in effort and duration to assess the presence of trout in Tamarack Lake. Nine nets were set over the winter of 2007-2008 and collected in summer 2008. Although these nets fished for approximately 1 year, their effectiveness through time was likely reduced by fish avoidance due to the buildup of algae, aufwuchs, sediment, and sticks which collect in nets. Knapp and Matthews (1998) stated “Rotenone is also effective on a wide range of lake sizes, while gill netting likely to be ineffective in large lakes (>3 ha), deep lakes (>10 m), lakes with self-sustaining trout populations in inlets and outlets, and lakes with abundant trout spawning habitat.” Since 2001, no fish have been caught in gill nets or seen in visual surveys of the lake or tributary inlets.

Table 5.1-4 Gill Net Sets in Tamarack Lake, Silver King Creek Watershed, Alpine County, During 2001 to 2008

Year	Net Types	Date Set	Date Pulled	Total Hours	Fish Collected
2001	1 Sink, 1 Float	7/25/2001	7/26/2001	43	0
2002	12 Sink	8/21/2002	8/22/2002	255	0
2003	8 Sink, 1 Float	7/17/2003	8/17/2003	7154	0
2004	8 Sink, 3 Float	7/6/2004	8/5/2004	7650	0
2008	7 Sink, 2 Float	8/2/2007	8/14/2008	70080	0

Following the successful 1991–1993 chemical treatments, pure Paiute cutthroat trout were collected from Coyote Valley and Fly Valley Creeks for transplanting into the treated waters upstream of Llewellyn Falls. Table 5.1-5 presents the number, donor creek, and location of the fish that were restocked into Silver King Creek upstream of Llewellyn Falls. The area above Llewellyn Falls remained closed to fishing in 1993 to protect restocked Paiute cutthroat trout from further hybridization through inadvertent introduction of rainbow trout.

Table 5.1-5 Paiute Cutthroat Trout Reintroduction to Upper Fish Valley Following the 1991–1993 Chemical Treatment

Year	Number stocked	Donor Creek	Planting Location
1994	139	Coyote Valley Creek	Above upper exclosure fence to treeline (upper meadow)
1995	49	Fly Valley Creek	Connell’s Camp at trail crossing
1995	109	Coyote Valley Creek	Lower pasture fence (lower meadow)
1996	134	Coyote Valley Creek	Connell’s Camp at trail crossing
1997	145	Coyote Valley Creek	Vicinity of Fly Valley Creek
1998	30	Fly Valley Creek	Above Four Mile Canyon
Total	606		
Source: CDFG			

USFWS RECOVERY EFFORTS FOR PAIUTE CUTTHROAT TROUT

Under ESA section 4(f) authority, the Secretary of Interior, through the USFWS, is charged with developing and implementing recovery plans for the conservation and survival of threatened and endangered species. The approved Revised Recovery Plan (USFWS 2004) outlined the following recovery actions:

- Remove non-native fish from historical habitat (Silver King Creek downstream from Llewellyn Falls to barriers in Silver King Canyon).
- Reintroduce Paiute cutthroat trout into renovated stream reaches in historical habitat.
- Protect and enhance all occupied Paiute cutthroat trout habitat.
- Continue to monitor and manage existing and reintroduced populations.
- Develop a long-term conservation plan and conservation agreement
- Provide public information.

The proposed Action would implement the 2 highest priority recovery actions: remove non-native trout and reintroduce Paiute cutthroat trout to their historical range.

BENTHIC MACROINVERTEBRATES (AQUATIC INSECTS)

OVERVIEW

Benthic macroinvertebrates are aquatic animals without backbones that live on the bottom of freshwater habitats during all or part of their life cycle and that are large enough to be seen with the naked eye. Major groups of benthic macroinvertebrates include arthropods (i.e., crustaceans and insects), mollusks, sponges, and nematode worms. The most abundant are typically immature life stages (larvae) of aquatic insects such as mayflies and stoneflies. The benthic macrovinvertebrate community or “assemblage” is largely determined by the range of habitat conditions, such as water quality, vegetation structure and bottom substrate. More complex habitats generally support a more diverse assemblage of groups[1] or “taxa” than more uniform habitats.

This section reviews the general ecology of benthic macroinvertebrates and the current status of benthic macroinvertebrates in the Silver King Creek Watershed. Benthic macroinvertebrates are an important biological resource for several reasons:

- Biodiversity value – they represent an extremely diverse group of aquatic animals.
- Food web support – they are an important part of the aquatic food web, including a primary food source for Paiute cutthroat trout.
- Indicators of ecological health – Benthic macroinvertebrates have diverse microhabitat requirements and ecological functions. They exhibit a wide range of responses to ecological changes and stressors, thus making them valuable indicators of water quality.

Several methods have been developed to measure and assess macroinvertebrates. Some measures are better suited to address certain questions about species and/or populations. In this analysis, we reviewed the types, uses, and limitations of these measures to provide context for interpreting

[1] The taxonomic ranks for classifying living things are (in order) Kingdom, Phylum, Class, Order, Family, Genus, and Species. Most macroinvertebrate studies typically identify samples to the genus level.

the results of various macroinvertebrate surveys conducted in the Silver King Creek Watershed, as well as to guide development of mitigation measures and monitoring for the proposed Action.

GENERAL ECOLOGY

The benthic macroinvertebrate assemblage in streams encompasses a wide variety of taxa, but larvae of aquatic insects are often the most abundant. Aquatic insects are extremely diverse. Species with life stages that use aquatic habitats include dragonflies and damselflies (Order Odonata), stoneflies (Order Plecoptera), mayflies (Order Ephemeroptera), caddisflies (Order Trichoptera), hellgrammites (Order Megaloptera), beetles (Order Coleoptera) and true flies (Order Diptera). Important taxa in the Sierra Nevada include the larvae of three orders of insects, the Ephemeroptera, Plecoptera and Trichoptera, collectively referred to as EPT. They tend to occur in habitats with cold, clear, high quality water often associated with trout species. The absolute and relative abundance of these three taxa, the EPT Index, is often used to evaluate stream health.

Most stream invertebrates are benthic meaning that they associate with the channel bottom, such as cobble and finer sediments or other surfaces (e.g., roots, emergent aquatic vegetation) (Hauer and Resh 2006). The hyporheic zone, where stream water and ground water meet below the substrate surface, often provides a protected microhabitat. The hyporheic zone serves as a refuge for benthic insects (Ward 1992). This zone also provides a reservoir capable of recolonizing the surface benthos if depleted from floods, drought or extreme temperatures, and provides suitable conditions for immobile life stages such as eggs, pupae, diapausing nymphs, and larvae (Williams and Hynes 1976, Ward 1992). Many stonefly species spend most of their larval lives in the hyporheic zone, returning to the main stream channel to emerge as adults (Stanford et al. 1996).

The macroinvertebrate assemblage serves an important ecological function in stream food webs. They can be divided into several feeding guilds, or groups, that fill specific ecological niches (Merritt and Cummings 1996) such as shredders (feed on leaves and other organic matter), scrapers (feed on algae attached to leaves and rocks), filterers (collect food from water column), and predators. Because of their abundance and role in the aquatic food chain, benthic macrovinvertebrates (insects in particular) are an important source of food for birds, mammals, amphibians, reptiles, fish and other invertebrates (Erman 1996).

Most macroinvertebrates exhibit dispersal, or movement of individuals from one area or habitat patch to another (Bilton et al. 2001, Smock 2006). Dispersal is also a key process in the recolonization of disturbed areas of streams. Drift is one of the most important mechanisms for dispersal to, and colonization of, downstream habitats. The majority of species drift at night. Macroinvertebrates may actively disperse in search of suitable substrate or food, escape from predators or competitors, avoidance of environmental conditions (including pollution), or reproduction. Other forms of dispersal include crawling and swimming both upstream and downstream. Macroinvertebrates can move between the surface strata and the hyporheic zone (Williams and Hynes 1976, Ward 1992). Streams may also be recolonized via aerial dispersal by egg-laying adults from nearby source populations. Additionally, recolonization can occur from emerging adults that fly upstream and downstream, as well as laterally to other drainages (Smock 2006).

Endemic species are species that are native to, and restricted to, a particular geographic region. Springs have been known to harbor species endemic to the Sierra Nevada (Erman 1996). Spring invertebrates can be unique because spring habitats are typically isolated from each other.

Springs maintain consistent temperatures and may therefore harbor relict species that were more widespread in previous climate conditions (Erman 1996). Groups that specialize in spring habitats and contain many endemic species in the Sierra Nevada include caddisflies of the families Rhyacophilidae, Limnephilidae, Uenoidae, and Hydropsychidae as well as springsnails of the family Hydrobiidae. Very little is known about the complete ranges and populations of these species (Erman 1996).

Mangum (2005) observed that macroinvertebrate communities are remarkably consistent across great distances of the western United States, based on his 25 years of monitoring experience in Montana, Washington, California, and Utah. He attributed the similar species composition among coldwater streams to the fact that macroinvertebrate species have good dispersal mechanisms which allow them to disperse over great distances to colonize streams elsewhere.

SURVEYS OF MACROINVERTEBRATE ASSEMBLAGES

The metrics used to assess benthic macroinvertebrates depend on the question posed. There is no single perfect metric or absolute measure. Conversely, the questions that can be answered may be constrained by the measures and sampling methods used. For example, it would be difficult to detect a rare, endemic or new species without conducting a complete inventory and identifying samples down to the species level. Most surveys focus at higher taxa levels (genus or family), a subset of taxa, or certain functional groups. Few species-level inventories of macroinvertebrates exist for the Sierra, and the distribution of most species is not well known (Sierra Nevada Ecosystem Project 1996, Vol. I, Ch. 8).

MEASURING COMMUNITY HEALTH AND ECOLOGICAL FUNCTION

Most studies of benthic macroinvertebrates focus on measuring community characteristics or “metrics” such as abundance (number of individuals), richness (number of different kinds), diversity (number of different kinds and their relative abundance), or number of certain indicator taxa (e.g., EPT index). These metrics provide an indication of community health and ecological function. The Lahontan Basin Plan (LRWQCB 2005) refers to this generally as “species composition,” although no specific definition is provided. The species composition of a diverse, ecologically healthy benthic invertebrate community would be represented by the community metrics or indices listed above (e.g., high diversity). This analysis is focused on indices that are useful indicators of macroinvertebrate community health (e.g. EPT and total taxonomic richness) (Karr and Chu 1999). For example, higher numbers of EPT taxa typically indicate good water quality. Conversely, high numbers of Diptera (true flies), which are more tolerant of environmental stressors, typically indicate degraded water quality or other environmental stress. Table 5.1-6 provides definitions of the community metrics used to assess benthic macroinvertebrate populations in the Silver King Creek Watershed.

Table 5.1-6 Common Indices and Metrics of Macroinvertebrate Composition and Population Attributes

Community parameter	Definition
Abundance	Number of individuals
Diversity	S-W = Shannon-Weiner (sometimes called Shannon-Weaver) Index. This index takes into account the number of species and their relative abundances.
Richness Number of taxa	Number of different kinds (species, genera, or other grouping). This index makes no use of relative abundance.
Biomass or Standing crop	Community dry weight of organic matter in a sample. An index of productivity.
Biotic Condition Index (BCI)	BCI indicates as a%age how close an aquatic ecosystem is to its own potential. Scoring: 91-100 Excellent, 80-90 Good, 72-79 Fair, <72 Poor
Percent taxon or family dominance	An assemblage dominated by a single taxon or several taxa from the same family suggests environmental stress.
Dominance and Taxa Diversity index (DAT)	The DAT combines a measure of dominant species in the community and the number of species present. Scoring: 18-26 Excellent, 11-17 Good, 6-10 Fair, 0-5 Poor
Number of EPT taxa	EPT = Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These taxa are often used as indicators because of their sensitivity to poor water quality conditions.
EPT Index	Proportion of EPT individuals
Number of stoneflies	Number of Plecopterans, one of the sensitive taxa.
Source: California Stream Bioassessment Procedure (CSBP) (Harrington and Born 2003) and Surface Water Assessment Ambient Monitoring Program (SWAMP, http://www.swrcb.ca.gov/swamp/), Vinson 2007, Mangum 2005	

DETECTING RARE AND ENDEMIC SPECIES

Aquatic biologists are also concerned with rare and endemic species. There is no single definition of rarity, but measures of rarity usually consider organism abundance, habitat occupancy, and range size. The most common understanding of a rare species is one that is constantly sparse in abundance or occurs infrequently, whether over a large or small range. At local scales, abundance can vary based on the amount of preferred habitat, while at broad scales, local abundance is generally higher near the center of a species' range (Poff 1997). However, a locally abundant species could also be rare if it is restricted to a specific habitat or geographic area (Meffe et al. 1997). Species that occur in Silver King Creek may be defined as rare under several of these categories and at different spatial and temporal (i.e., seasonal and/or interannual) scales. Following disturbance events, like rotenone treatments, floods or fires, rarity will be related to both organism dispersal rates and community succession during the colonization phase. Poor dispersers will have slower colonization rates and thus lower incidences of occupancy, making them more difficult to collect (Vinson and Vinson 2007). Vinson and Vinson (2007) analyzed macroinvertebrate samples collected historically (between 1984 and 1996) and more recently (2003-2006) from various treated and untreated locations in the Silver King Creek Watershed. They defined rare taxa as those that accounted for less than 1% of the total number of individuals identified to genera.

Potential loss of endemic species is of particular concern. Endemic species are species that are native to, and restricted to, a particular geographic region. They have evolved in a particular area and are not naturally found elsewhere. Endemism is scale-specific (e.g., endemic to the Sierra Nevada). Any species endemic to the Silver King Creek Watershed would be considered rare because of the small size of this area. For example, Paiute cutthroat trout are endemic to the watershed. Endemic species are more likely to occur in small, isolated habitats, such as springs. However, no endemic macroinvertebrate species have been found to date in the Silver King Creek Watershed.

There are several challenges in detecting rare and endemic species in the proposed treatment area, including:

- No complete inventories of macroinvertebrate taxa are available.
- Species-level identification is difficult and lacking.
- Requires intensive sampling effort beyond scope of the proposed Action.

The following sections discuss each of these challenges.

1. LACK OF INVENTORY DATA

Determining rarity or endemism would require that regional species lists and previous collections of immature benthic organisms were available to determine number of expected taxa. Identification of a species endemic to Silver King Creek would require an inventory of species present in Silver King Creek as well as in neighboring watersheds. However, no complete inventories of macroinvertebrates have been conducted in the entire Sierra Nevada (Erman 1996), much less Silver King Creek. Species' inventories require sampling at multiple stations over different seasons and across multiple years. Obtaining this information in Silver King Creek and indeed, Sierra Nevada wide, would require an intensive effort (discussed below) that is beyond the scope of the proposed Action.

2. SPECIES-LEVEL IDENTIFICATION IS CHALLENGING

In order to detect rare or endemic species, all collections must be identified to the species level. However, for some taxa the state of the art of benthic invertebrate taxonomy is not sufficiently advanced to allow such fine resolution identification. As a result, a portion of the individuals collected in Silver King Creek, including those collected over the last few years, have only been identified to the genus level or higher level of classification, such as family (Vinson and Vinson 2007). Many individuals cannot be identified to species. The tools to accomplish this task do not exist, particularly for highly speciated groups such as mites and flies. Identification keys are not available for most immature insects, and keys are based on mature specimens (M. Vinson pers. comm. to C. Mellison, email October 10, 2006).

Because it is difficult to identify some larval stages, a more complete species inventory would also require extensive (and expensive) field surveys of emerging adults for definitive identification. Such an effort would require 2-4 years of more specialized field sampling, not including the difficult task of keying out the samples to species (which may not be possible for certain groups).

3. INTENSIVE SAMPLING EFFORT IS REQUIRED

Macroinvertebrates often have a patchy geographic and temporal distribution. Many taxa are rare to begin with, and sampling is conducted within limited space and time. In Silver King Creek, many of the rare taxa observed in recent samples (2003–2006) were not observed consistently in historical samples (between 1984 and 1996) (Vinson and Vinson 2007). A tremendous amount of sampling would be required to detect even a majority of rare species. The likelihood of observing rare or uncommon species either before or after treatment would be governed by their rarity, the sampling methods used, the number and distribution of samples collected, and sampling frequency.

Species inventories require sampling at multiple stations over different seasons and across multiple years. Complete inventory has been attempted at only a few creeks in the world (e.g. Breitenbach Stream in Germany) and after many years of collection, new species continue to be found (M. Vinson pers. comm. to C. Mellison USFWS, email October 11, 2006). CDFG completed a species inventory for Lake Davis including trapping and identification of emerged adults; however, it was not considered a “complete” inventory but rather a “one time” species inventory that did not attempt to identify new or added species through subsequent repeat surveys.

Compiling a complete inventory for Silver King Creek would require a much larger effort than has been conducted to date. Most surveys have been conducted using quantitative methods to determine relative abundances, rather than qualitative sampling designed to broadly sample more varieties of habitat. Vinson and Vinson (2007) calculated a genus level collection curve using methods developed by Colwell and Coddington (1994) for recent data collected from Silver King Creek (2003–2005) and estimated that approximately 90% of the genera have been collected to date. Vinson estimated that pre-treatment surveys would only collect 80 to 90% of aquatic macroinvertebrate assemblages present (pers. comm. 2006 to C. Mellison, USFWS) It would be difficult to determine the number of years required to increase this%age; however, this type of effort would require sampling of the hyporheic zone and would be logistically and economically prohibitive, and on a practical level, likely infeasible. This level of effort would far exceed the standard for what is “reasonably feasible” (CEQA Guidelines §15151) and may not be attainable.

4. LIMITS OF CERTAINTY AND THE STANDARDS FOR BEST AVAILABLE INFORMATION

Even with a complete species inventory, it would be very challenging to determine through post-treatment sampling whether a species was present or whether it was absent or eradicated by rotenone treatment. Sampling results are subject to variability. Vinson and Vinson (2007) evaluated the natural variability of macroinvertebrate assemblages, the probability of collecting rare taxa to evaluate the problem of taxa that are reported “missing” from post-treatment samples, and the likelihood of this situation occurring from rotenone treatments or sampling variability. Sampling artifacts make it difficult to determine if any individual taxon is present. Examples of potential sampling artifacts include spatial variation, temporal variation (season and year), microhabitat variation, sediment grain size, and main stem versus tributaries.

When a rare species is absent after treatment, it may not be possible to determine if the species was actually absent or if it was missed during sampling (sampling artifact). It is not unusual for individual species to be absent in any given year. Species may be rare to begin with. In addition, macroinvertebrate sampling is conducted within limited space and time. For example, sediment sampling in the proposed treatment area may only assess a small proportion of the stream bottom and may be completed over one or two days per year. Thus, when a rare species is absent after treatment, it may not be clear whether this species was simply missed during sampling or was actually absent (absence may not necessarily be a treatment outcome, but could be a stochastic natural event). Previous sampling may not establish clearly which species would be expected to occur frequently or sporadically.

The recent and ongoing surveys being completed by the Agencies are intended to assess achievement of the standard described in the Lahontan Basin Plan, which examines species composition of non-target biota as one of its water quality objectives for the use of rotenone (LRWQCB 1995).

BENTHIC MACROINVERTEBRATES IN SILVER KING CREEK WATERSHED

The proposed treatment area contains diverse aquatic microhabitats for invertebrates in lotic (flowing water) and lentic (still water) environments. Microhabitats include riffles, pools, runs, backwaters, springs, and lakes, with a variety of substrates such as boulders, cobble, gravel, sand, logs, undercut banks, vegetation. Stream habitat, substrate, and hydrology all influence macroinvertebrate community composition.

No endemic species have been identified for the proposed treatment area or the adjacent USGS quadrangles (CNDDB 2008). In part, this may be due to the fact that recent invertebrate sampling completed by the Agencies was conducted in order to assess achievement of the standard described in the Lahontan Basin Plan, which examines species composition of non-target biota as one of its water quality objectives for the use of rotenone (LRWQCB 1995). Based on the factors discussed above, the surveys did not provide the level of resolution needed to determine presence of rare or endemic species.

The following sections describe the macroinvertebrate assemblage in the proposed treatment area and present analyses of the potential effects of past rotenone treatment. Rotenone has been applied in the watershed several times since 1964 (see Table 5.1-1).

COMMUNITY CHARACTERIZATION

The proponent Agencies have conducted extensive characterization of benthic macroinvertebrate communities in Silver King Creek. Historical macroinvertebrate data were collected in 1977, 1978, 1983, 1984, 1987, and 1991 through 1996 (Mangum 1984, 1987, 1991; Trumbo et al. 2000a). In 1991, before the most recent rotenone applications in 1991–1993, Mangum (2005) sampled sites previously treated in 1964 and 1977 and found that the BCI index rated conditions at most stations as “excellent,” suggesting that the macroinvertebrate community had recovered well since 1977.

In response to permit requirements, the Agencies conducted annual monitoring of Silver King Creek benthic invertebrates from 2003 through 2006 (Vinson and Vinson 2007 provided in Appendix D herein). The monitoring and earlier surveys were conducted using quantitative sampling methods and were not designed to sample broadly to detect taxa that may have limited distribution and/or low densities. The sampling design was modified by USFS in 2007 (provided as Appendix E herein) based on recommendations in Vinson and Vinson (2007). Data collected in 2007 used the modified sampling design. This design also includes qualitative sampling (i.e., sampling across all major habitat types rather than set locations) to collect as many different kinds of invertebrates living at a site as possible (USFS 2007). This will improve the likelihood of collecting rare taxa, although no program can guarantee that all species will be collected.

The potential effects of rotenone on Silver King Creek macroinvertebrates were recently assessed by reviewing published studies and analyzing all available data (historic and recent) from Silver King Creek where rotenone has been used in various treatments over the last 40 years (Vinson and Vinson 2007). Both historical (1984–1993) and recent (2003–2006) data were evaluated for differences between treated and untreated sites, annual variation, variation among sampling sites, and rarity of taxa. The National Aquatic Monitoring Center (NAMC) calculated and analyzed several metrics of measures of abundance as well as composition and function (NAMC 2006). These included: 1) taxa richness; 2) abundance; 3) EPT richness; 4) EPT Index; 5) number of families; 6) percent dominant taxon; 7) Shannon Diversity Index; 8) mean tolerance value, and 9) Community Similarity Indices (Jaccard and/or Brillouin Index). A summary of these results is presented in Appendix A of the Vinson and Vinson (2007) report (refer to Appendix D herein).

Vinson and Vinson (2007) compared pre-treatment versus post-treatment data collected from the Silver King Creek Watershed. Historic data (1984-1993) was collected from 6 sites. The treatment sites included Silver King Creek above Llewellyn Falls (treated in 1964, 1976, and 1991–1993), Corral Valley Creek (1964 and 1977), and Coyote Valley Creek (treated 1964, 1976, 1977, 1987, and 1988). Control sites were located in Fly Valley Creek, Four Mile Canyon Creek, Bull Canyon Creek, and Tamarack Creek. Recent data (2003–2006) were collected from treated streams (Coyote Valley and Corral Valley Creeks) and a control site (Tamarack Creek).

The results from this assessment are provided below.

- **Treated and untreated locations.** Statistical comparisons could not definitively establish whether significant long-term impacts of past rotenone applications on the benthic macroinvertebrate community occurred. There were few measurable differences in community metrics between locations, including samples from untreated areas. The only difference between treated and untreated locations was Coleoptera (beetles). Also, two genera were found at untreated sites that were not found at treated sites: *Ephron* (Ephemeroptera, Family Polymatarcyidae) and *Dolophilodes* (Trichoptera, Family Philopotamidae). However, 27 genera were collected at treated sites that were not found at untreated sites. The large discrepancy in the number of samples may account for these differences.
- **Annual variation.** Few discernable differences were observed in diversity or abundance between historical (1984–1996) and recent (2003–2006) data.
- **Spatial variation.** In recent samples (2003–2006), 25% of the metrics evaluated varied significantly among sites. Several metrics of measures of abundance as well as composition and function were significantly higher in tributary streams, but no metrics were highest at untreated sites.

Recent samples contained more species than historic samples in both treated and untreated areas. However, this may be explained by the time elapsed (10 years) since the last rotenone treatment in Silver King Creek (1993) and since grazing ceased, so populations have had time to recover.

Statistical comparisons also found interannual variability in several mean aquatic invertebrate assemblage measures. There were no specific trends in diversity or abundance in historical (1984–1996) or recent (2003–2006) data, except that more taxa were observed in recent times in both treated and untreated sites.

Several factors limit data analysis:

- No samples were collected before the first rotenone treatment in 1964.
- Different treated and untreated stations were sampled, compromising any direct statistical comparison between groups of samples.
- Potential differences in laboratory methods

- Samples were collected at relatively few untreated stations, limiting comparison with treated stations.
- Confounding influences on results may have included the existence of and then cessation of cattle grazing in the watershed during the study period.

Considering the data collected and appropriate limits on analyses (listed above), Vinson and Vinson (2007) suggest that few measurable differences in community metrics were observed between historic and recent data groups, between treated and untreated sites, among years, among sampling locations, or in the frequency of rare taxa occurrence.

Vinson and Vinson (2007) also evaluated potential confounding factors in determining the effects of rotenone, including other stream ecosystem disturbances, such as fires, droughts, floods, or land management activities. Differences among sampling stations and different studies could have resulted from environmental differences including climate, elevation, hydrology, sediment grain size and other stream characteristics. Significant interannual (between years) variability as well as differences between stations in the same year may be more an artifact of these phenomena than any effects of rotenone treatment. Although these confounding factors exist, Vinson and Vinson (2007) were not able to discern the effects of rotenone in Silver King Creek.

SPECIAL STATUS MACROINVERTEBRATES

There are no federally endangered, threatened, or candidate macroinvertebrate species that are known to occur in the Silver King Basin or in the proposed treatment area (USFWS, Species List, File No. 1-5-01-SP-2002). In addition, no macroinvertebrates have been identified that are protected under the California Endangered Species Act and no Forest Service Region 4 sensitive macroinvertebrate species have been identified. None of the “rare” taxa have any State or Federal species status.

RARE AND ENDEMIC SPECIES

Vinson and Vinson (2007) concluded that “the majority” of the taxa found in Silver King Creek between 2003 and 2006 could be considered uncommon or rare (<1% of identified individuals). Rarity was not determined through identification of known rare taxa but through analysis of abundance data and a qualitative evaluation of the number of species that seldom appeared in collected samples. A total of 85 genera were collected between 2003 and 2006. Of these 85 genera, 47 genera (55%) were collected in all 4 sampling years, 7 genera (8%) were collected in 3 of the years, 16 genera (19%) were collected in 2 of the years, and 15 genera (18%) were collected in only 1 year.

No benthic macroinvertebrate species strictly endemic to the Silver King Creek Watershed have been identified (Mangum 1985, 1988, 1992, 2005, Vinson and Vinson 2007). However, the surveys were not designed to identify taxa down to species or detect endemic species, and thus cannot rule out the possibility that endemic species may be present. Mangum (2005) noted:

> *“The likelihood that there are rare and endemic macroinvertebrates in Silver King Creek is very low. The stream is not unique or isolated, but is typical coldwater stream habitat found through the mountains of the western United States. This stream has a similar history of logging and grazing as do many stream systems in the West and in the Sierra Nevada. Although previous monitoring was not intended to identify all species present within the project*

area, no unique macroinvertebrates were observed during sample processing of Silver King collections (1984, 1987, 1990-1996) that had not been found outside of the Silver King drainage in other western watersheds."

"It is even less likely that the stretch of the Silver King Creek between Llewellyn Falls and the Silver King Canyon barrier contains a macroinvertebrate that is not present in other parts of the Silver King watershed. This section of stream does not contain any unique characteristics that make it different with respect to macroinvertebrates from other sections. Thus, even if the Silver King Creek itself harbored a rare macroinvertebrate species, it would be highly unlikely that it would exist only in the stretch of the Silver King that would be treated. The 17 miles of untreated headwaters in addition to seven miles of untreated downstream areas would provide a source for replacing any macroinvertebrates that were reduced in numbers."

Some members of the public have expressed concern about loss of rare and endemic species and have suggested that the Agencies do more to complete a more detailed characterization of the benthic macroinvertebrate species present in Silver King Creek. Past comments raised concerns that the proposed annual monitoring of benthic macroinvertebrates would not be sufficiently detailed to identify rare or endemic species, particularly those present as larvae in bottom sediments. The Agencies have conducted extensive macroinvertebrate studies over more than 30 years in Silver King Creek (including the ongoing interagency study), and post-treatment monitoring of macroinvertebrates would continue.

Several public comments to the NOP requested that the environmental document present a complete inventory of all benthic invertebrates in Silver King Creek, including any rare or endemic species. Vinson and Vinson (2007) provide the species list for both historic and recent data. This list is not considered a complete species inventory. However, the Agencies have determined that establishing a complete species inventory is infeasible, outside the scope of the EIS-EIR, and beyond that required to the meet the standard for what is "reasonably feasible" (CEQA Guidelines § 15151).

5.1.2 Regulatory Environment

The following subsections describe federal and state laws and regulations governing aquatic resources. No local ordinances protecting aquatic resources have been identified.

5.1.2.1 Federal

ENDANGERED SPECIES ACT OF 1973 (16 USC §1531 ET SEQ.; 50 CFR PARTS 17 AND 222)

ESA is the primary Federal law providing protection for the Paiute cutthroat trout. Section 9 of the ESA prohibits the "take" of federally listed endangered species of fish or wildlife and many plant species (16 USC 1538[a][1][B]). The ESA defines take to mean "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or attempt to engage in any such conduct" (16 USC 1532[19]). Section 7(a)(2) of the ESA requires that actions authorized, funded, or carried out by federal agencies (i.e., issuing a permit pursuant to the CWA) do not "jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of lands determined by the USFWS to be 'critical habitat'" for such species (16 USC 1536[a][2] and 16 USC 1532[5]). If a federal agency determines that a proposed federal action (e.g., issuing a CWA Section 404 permit) “may affect” a listed species and/or designated critical habitat, the agency must consult with the USFWS in accordance with Section 7 of the ESA. USFWS is the administering agency for ESA authority for freshwater species considered in this project action.

Section 7(a)(2) requires Federal agencies to consult with USFWS prior to authorizing, funding, or carrying out activities that may affect listed species. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild or reducing its reproduction, numbers or distribution (50 CFR §402.02). A non-jeopardy opinion may include reasonable and prudent measures that minimize the amount or extent of incidental take of species from a project. Incidental take refers to taking that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by a Federal agency or applicant (50 CFR §402.02). While projects that are likely to result in adverse effects often include minimization measures, the USFWS is limited to requesting minor modifications in the project description. In instances where some incidental take is unavoidable, the USFWS requires that additional measures be performed by project proponents to compensate for adverse impacts. In cases where the USFWS is the lead Federal agency, an intragency consultation is completed.

NATIONAL FOREST MANAGEMENT ACT

The Paiute cutthroat trout is considered a rare or at-risk species by the USFS because of its Federal listing. Each National Forest is required to complete a Land and Resource Management Plan (LRMP) by the Forest and Rangeland Renewable Resources Planning Act of 1974, as amended by the National Forest Management Act of 1976 (NFMA; 16 U.S.C. 1600). Those acts require that the LRMPs provide for multiple use and sustained yield of the products and services obtained from the National Forests, including wildlife. The Humboldt-Toiyabe Forest Plan now in effect was completed in 1986 and is in the process of being revised to accommodate the increased land base created with the combination of the Humboldt and Toiyabe National Forests into one administrative unit. Consideration of Paiute cutthroat trout by the USFS under NFMA and through ESA Section 7(a)(1) has led to Paiute cutthroat trout population and habitat surveys as well as implementation of other projects for the conservation of Paiute cutthroat trout.

5.1.2.2 State

CALIFORNIA FISH AND GAME CODE §1600, ET SEQ.

This law provides for protection and conservation of fish and wildlife resources with respect to any project or action that may substantially divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of any river, stream, or lake. The administering agency is CDFG.

CALIFORNIA ENDANGERED SPECIES ACT OF 1984 (CALIFORNIA FISH AND GAME CODE §2050-2098)

This law provides for the protection and management of species and subspecies listed by the state of California as endangered or threatened, or designated as candidates for such listing. California plants and animals declared endangered, threatened, or rare are listed at 14 CCR 670.2 and 670.5, respectively. The act requires consultation “to ensure that any action authorized by a State lead agency is not likely to jeopardize the continued existence of any endangered or threatened species … or results in the destruction or adverse modification of habitat essential to the continued existence of the species" (Section 2053). This law prohibits "take" of state listed or candidate species, except as otherwise authorized by the Fish and Game Code (The term "take" is defined by Section 86 of the Fish and Game Code as "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." This definition is different in some respects from the definition of "take" under the Federal ESA). The administering agency is CDFG; however, Paiute cutthroat trout are not listed under CESA.

CDFG may also authorize public agencies through permits or a memorandum of understanding to import, export, take, or possess any endangered species, threatened species, or candidate species for scientific, educational, or management purposes (Section 2081[a]). CDFG may also authorize, by permit, the take or endangered species, threatened species, and candidate species provided specific conditions are met (Section 2081[b]).

CALIFORNIA FISH AND GAME CODE §5501

This law authorizes CDFG to take any fish which, in its opinion, is unduly preying upon any bird, mammal, or fish.

CALIFORNIA FISH AND GAME CODE §5650

This law protects water quality from substances or materials deleterious to fish, plant life, or bird life. It prohibits such substances or materials from being placed in waters or places where it can pass into waters of the state, except as authorized pursuant to, and in compliance with, the terms and conditions of permits or authorizations of the SWRCB or a regional water quality control board such as a waste discharge requirement issued pursuant to Section 13263 of the Water Code, a waiver issued pursuant to Section 13269(a) of the Water Code, or permit pursuant to Section 13160 of the Water Code. The administering agency for FGC section 5650 is CDFG.

Other regulations administered by CDFG include Fish and Game Code Sections 1930–1933, which provide for the Significant Natural Areas program and database; the California Species Preservation Act of 1970 (California Fish and Game Code Sections 900–903) which includes provisions for the protection and enhancement of the birds, mammals, fish, amphibians, and reptiles of California; and Fish and Game Code, Sections 3511 and 5050, which prohibit the taking or possessing of birds and reptiles listed as "fully protected."

PORTER-COLOGNE WATER QUALITY CONTROL ACT

In compliance with the Porter-Cologne Water Quality Control Act, the SWRCB adopted the Water Quality Control Plan for the Lahontan Basin Plan that became effective on March 31, 1995 (LRWQCB 1995). The Basin Plan incorporates SWRCB plans and policies by reference, contains beneficial use designations and water quality objectives for all waters of the Lahontan Region, and provides a strategy for protecting beneficial uses of surface and ground waters throughout the Lahontan Region.

ROTENONE POLICY

In 1990, the SWRCB adopted amendments to the Basin Plans to permit conditional use of rotenone by CDFG. The SWRCB and CDFG then executed an MOU to facilitate amendment implementation (see Section 5.4, Water Resources).

The Basin Plan establishes specific water quality objectives for rotenone projects, including species composition (LRWQCB 1995). This objective specifies that "non-target aquatic populations (e.g. invertebrates, amphibians) that are reduced by rotenone treatments are expected to repopulate project areas within two years. For multi-year treatments (i.e., when rotenone is applied to the same water body during two or more consecutive years), the established objective(s) shall be met for all non-target aquatic organisms within 2 years following the final rotenone application to a given water body." These requirements include macroinvertebrate monitoring. The Basin Plan further specifies that "Threatened or endangered aquatic populations (e.g. invertebrates, amphibians) shall not be adversely affected. CDFG shall conduct pre-treatment monitoring to prevent rotenone application where threatened or endangered species may be adversely impacted."

HERITAGE TROUT PROGRAM

Successful reintroduction of Paiute cutthroat trout could lead to creation of a California Fish and Game Commission-designated Heritage Trout Fishery. CDFG's Heritage Trout Program restores native trout populations and implements post-restoration management policies that may allow angling compatible with native trout conservation. The California Fish and Game Commission established this program in 1998, by expanding its Wild Trout Policy so that streams or lakes featuring one or more of California's native trout, and meeting other specific criteria, may be designated as Heritage Trout waters. Heritage Trout waters are a special subset of Wild Trout waters. Therefore, they are monitored and managed by CDFG's Heritage and Wild Trout Program staff. The objectives of this program are to increase public awareness, promote collaborative efforts, build public support and involvement in native trout restoration, and to diversify opportunities for observing, enjoying, and fishing for native trout in their historic habitats. The management of designated Heritage Trout waters is guided by written management plans that identify actions and policies necessary to protect native trout habitats, and maintain or enhance native trout populations.

Inclusion of Silver King Creek Paiute cutthroat trout in the Heritage Trout Program is not part of the proposed Action (or its alternatives) which focuses on restoration of the species. If Paiute cutthroat trout restoration is successful, future management action such as inclusion in the Heritage Trout Program may be proposed and/or implemented by CDFG.

5.1.3 Assessment Criteria and Methodology

5.1.3.1 Significance Thresholds

The environmental impact assessment uses specific thresholds of significance for biological resources from Appendix G of the CEQA Guidelines. Impacts were considered significant if they would:

- Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by CDFG or by the USFWS.
- Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, and regulations or by CDFG or USFWS.
- Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the CWA (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means.

- Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites.
- Conflict with any local policies or ordinances protecting biological resources.
- Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.

Conclusions regarding these criteria will be used to prepare CEQA-required mandatory findings of significance as outlined in CEQA, Pub. Res. Code sec. 21083; guidelines sec. 15065. These findings are included in the CEQA "Findings of Fact" and determine whether the action will:

- Substantially degrade environmental quality;
- Substantially reduce fish or wildlife habitat;
- Cause a fish or wildlife habitat to drop below self-sustaining levels;
- Threaten to eliminate a plant or animal community; or
- Substantially reduce the numbers or range of a rare, threatened, or endangered species.

For Silver King Creek, the environmental impact assessment for aquatic resources evaluates whether the proposed Action or its alternatives would have a substantial effect on fish populations, benthic macroinvertebrate populations, and wetland and riparian habitat. For benthic invertebrates, it evaluates whether the proposed Action or its alternatives would significantly affect benthic macroinvertebrate species composition for more than 2 years after the last treatment. Species composition is important for ecological function, including providing a food source for Paiute cutthroat trout after restocking. In addition, because of the inherent value of rare and endemic species, the assessment evaluates whether the proposed Action or its alternatives would result in the permanent loss of rare or endemic aquatic insect species.

5.1.3.2 Evaluation Methods and Assumptions

Impacts on aquatic resources were evaluated by considering both potential temporary and permanent impacts of the proposed Action and its alternatives. Potential impacts evaluated included direct or indirect impacts on wetlands and riparian habitats; and direct or indirect impacts on federally or state-listed rare, threatened, or endangered species or species that are candidates for listing.

The assessment cites recently published agency reports and studies. It addresses questions raised by agencies and the public in response to the NEPA NOI and CEQA NOP (refer to Appendix A herein).

Several of the significance criteria listed above are not applicable to this EIS/EIR. The proposed Action would have no impact on the movement of any native resident or migratory fish. The proposed Action would not erect any structures such as fish barriers or obstruct the flow (e.g. temporary diversion dams) of waters used by native resident or migratory fish. Paiute cutthroat trout are the only native resident fish present. Therefore, no impacts on movement or migration would result and no further analysis is presented.

The proposed Action would not conflict with the provisions of an adopted habitat conservation plan, natural community conservation plan, or other approved local, regional, or State habitat conservation plan because no such plans have been adopted in the areas that would be affected by the action. Therefore, no impacts would occur and no mitigation measures would be required.

The impact assessment focuses on the potential impacts of the proposed Action and alternatives on special-status fish species (e.g. Paiute cutthroat trout), benthic macroinvertebrates, and riparian habitats. Potential impacts on benthic invertebrates were assessed using available literature regarding the effects of rotenone on the benthic community and data collected in Silver King Creek over the last 30 years. It evaluates whether the proposed Action would significantly affect the species composition of the benthic macroinvertebrate community for more than two years after the last treatment, which is consistent with Basin Plan criteria. Although not stated in the Basin Plan, the two-year time period would allow two seasons of re-colonization to occur. This timeframe is used to differentiate between short-term and long-term impacts under CEQA. Potential impacts on species composition were evaluated through analysis of Silver King Creek responses to past treatments (i.e., changes in species abundance, diversity) as well as inferring results of studies of similar streams. The evaluation considers the natural variability of these populations and the variability inherent in the indices commonly used to evaluate differences in their community structures. It also considers other factors that confound interpretation of community metrics, such as sampling artifacts or natural disturbance.

In addition, because of the inherent value of rare and endemic species, the assessment evaluates whether the proposed Action would result in the permanent loss of rare or endemic benthic macroinvertebrate species. The Agencies would view the loss of any single rare or endemic benthic macroinvertebrate species, regardless of any legal designation, as a significant impact. However, the assessment identifies several factors that would make such an impact very difficult to verify. For example, individual species may be missing from sampling data for different reasons, such as sampling artifacts.

5.1.4 Environmental Impact Assessment

This section presents the significance criteria used to evaluate the likely impacts of the proposed Action and alternatives. The significance criteria establish thresholds for determining whether an impact is environmentally significant.

5.1.4.1 Alternative 1: No Action

Under this alternative, the Agencies would not undertake actions to recover Paiute cutthroat trout by removing non-native trout and expanding the existing habitat of Paiute cutthroat trout into its historic range. The No Action alternative would not meet the purpose and need for the proposed Action, would not be consistent with the Revised Recovery Plan (USFWS 2004), and would increase the risk of extinction. Paiute cutthroat trout have a high likelihood of extinction in their native watershed within the next 50 years without continued intense monitoring and management (Moyle et al. 2008). Without the proposed Action, it is not certain that the species will continue to exist unless a suitable recovery action equal in effect to the proposed Action is found.

Under the No Action alternative, the main threat of hybridization would not be reduced and would likely increase. Non-native trout would remain in the treatment area, which would increase the risk of hybridization in existing pure populations in the Silver King Creek Watershed. In addition, under the No Action alternative, none of the additional public education aspects of the proposed Action (e.g. signage, publicity) would be implemented to reduce the threat of illegal transplants. The most recent genetic study of Paiute cutthroat trout shows that past efforts to eliminate non-native trout have been successful and that pure populations of Paiute cutthroat trout currently exist in the Silver King Creek Watershed (Cordes et al. 2004, Finger et al. 2008). It would be relatively easy to transplant non-native trout above natural fish barriers in Corral Valley Creek and Silver King Creek (above Llewellyn Falls). New illegal transplants would unravel years of work to eradicate non-native trout in the headwaters and would compromise future restoration efforts.

In addition, the Agencies would not re-establish Paiute cutthroat trout in the proposed 11-mile-long treatment area, whose length may be ideally suited to the species and is part of its native range. Under existing conditions, Paiute cutthroat trout populations are isolated in Upper Silver King Creek and tributaries as well as the conservation populations established in small headwater reaches in Mono, Madera, and Fresno counties. The USFWS has determined that expansion of their present range is a key element in continued survival and recovery of the species (USFWS 2004). Increased habitat size enhances the size and persistence of populations (Hildebrand and Kershner 2000). An increase in effective population size and gene flow improves population viability (Lande and Barrowclough 1996, Hildebrand and Kerschner 2000, Rieman and Allendorf 2001, Pritchard et al. 2007).

Under the No Action alternative, no fish or benthic invertebrates would be affected directly or indirectly by chemical treatment, physical removal (e.g. electrofishing, netting), transport of fish to Silver King Creek, or transport of fish from Silver King Creek to adjacent drainages. Thus, the No Action alternative would have no direct mortality on any threatened, endangered, proposed, or state-listed or special-status species. Woody riparian and native understory species would continue to recover in response to the elimination of grazing pressures. Water quality would not be subject to any short-term degradation.

5.1.4.2 Alternative 2: Proposed Action (Rotenone Treatment)

The proposed Action would involve treating 11 miles of stream in the Silver King Creek Watershed with the piscicide rotenone to remove non-native trout and reintroduce pure Paiute cutthroat trout to the restored stream (Figure 3-1). The treatment area consists of approximately 6 miles of aquatic habitat in the mainstem Silver King Creek from Llewellyn Falls downstream to Silver King Canyon. Tributary streams make up the remaining 5 miles of creek habitat, including Tamarack Lake Creek, an unnamed drainage, Tamarack Creek, and the lowermost reach of Coyote Valley/Corral Valley Creek. No fish have been observed in Tamarack Lake in recent years, but if any exist, they could enter Tamarack Lake Creek and subsequently Silver King Creek. Therefore, the Agencies would conduct more extensive pre-treatment surveys in 2009 and 2010; if fish were found, then the 5-acre Tamarack Lake would also be treated with rotenone.

Following the treatment, the restored reach would be restocked with pure Paiute cutthroat trout from populations within the watershed (e.g. Fly Valley Creek, Four Mile Canyon Creek, Coyote Valley Creek, Corral Valley Creek, and/or Upper Silver King Creek). Restocking would be conducted pursuant to guidelines and recommendations for stocking and genetic diversity management in the Revised Recovery Plan (USFWS 2004) and recent genetic studies (Cordes et al. 2004, Finger et al. 2008).

The following subsections address the potential effects of rotenone treatment on aquatic resources in Silver King Creek, including effects on fish, benthic invertebrates, and wetland and riparian habitat.

FISH

Rotenone treatment would eradicate trout in the Silver King Creek between Llewellyn Falls and Silver King Canyon. Rotenone is highly toxic to fish because it is readily transmitted across permeable gill membranes and inhibits a biochemical process at the cellular level. This makes it impossible for fish and other aquatic organisms to use the oxygen normally absorbed in the blood and utilized in the release of energy during respiration (Finlayson et al. 2000, refer to Appendix C herein, Screening-level Ecological and Human Health Risk Assessment). Trout are particularly susceptible, allowing fisheries managers to use lower concentrations than would be required to eradicate more tolerant species such as carp or catfish.

The proposed rotenone treatment targets non-native trout that are a threat to the conservation and recovery of Paiute cutthroat trout and their loss would be a less-than-significant impact and a benefit in terms of Paiute cutthroat trout habitat. The proposed treatment may also result in mortality of an unknowable but likely low number of pure Paiute cutthroat trout incidentally present in the treatment area that may have passed over Llewellyn Falls or the Coyote Valley Creek or Corral Valley Creek barriers. However, genetic studies indicate that the fish in the treatment area are non-native trout (i.e., rainbow trout and/or golden trout hybrids) with very little remaining of Paiute cutthroat trout genetic influence (Finger et al. 2008). There is no practical way to identify and separate, in situ, potentially pure Paiute cutthroat trout from hybrid individuals in treated areas. The loss of these fish would not result in a significant impact on this species.

The proposed Action would result in a substantial benefit for the recovery of Paiute cutthroat trout. It is the highest priority action required by the Revised Recovery Plan (USFWS 2004) which provides the foundation for Paiute cutthroat trout management. The proposed rotenone treatment would greatly reduce the risk of genetic hybridization from non-native trout. As noted earlier, expansion of their present range is another key element in continued survival and recovery of the species (USFWS 2004). Restocking the treated stream reach with pure Paiute cutthroat trout would expand the current range, restore the species to some of its historic range, increase the population size and improve gene flow, which would enhance population viability (Lande and Barrowclough 1996, Hildebrand and Kerschner 2000, Rieman and Allendorf 2001, Pritchard et al. 2007). This alternative would reduce the risk of catastrophic loss of Paiute cutthroat trout due to illegal restocking or stochastic events, such as flood or drought. Post-treatment restocking has the potential to more than double the in-basin population of pure Paiute cutthroat trout numbers (Somer pers. comm. 2003, Table 5.1-7).

Table 5.1-7 Stream Habitat (Miles) Occupied by Pure Paiute Cutthroat Trout under Existing Conditions and with the Proposed Action

Stream / Reach	Existing Habitat (miles)	Additional Habitat after Proposed Project (miles)
Upper Silver King Creek (Upper Fish Valley)	2.7	
Fly Valley Creek	1.1	
Four Mile Canyon Creek	1.9	
Bull Canyon Creek	0.6	
Coyote Valley Creek	3.0	
Corral Valley Creek	2.2	
Silver King Creek (Historic Range, Project Area)	–	5
Tamarack Lake Creek	–	~1
Unnamed Tributary		~1
Tamarack Creek	x	~2
Total	11.5	9
Total with proposed Project	20.5 miles	
Source: USFWS 2004		

Rotenone treatment of Tamarack Lake would result in impacts on fish populations, namely mortality of all fish in the lake. There would also be adverse impacts on amphibians (Section 5.2, Terrestrial Biological Resources) and aquatic invertebrates (discussed below). This lake was historically fishless, and therefore the action would ultimately benefit native amphibians and other aquatic organisms. The Agencies have conducted gill net surveys (2001 through 2008) resulting in no fish being observed or captured. If no fish are discovered in 2009 and 2010 pre-treatment surveys, Tamarack Lake would not be treated with rotenone and no impacts would occur.

The proposed Action would eliminate all fish in the treatment area of Silver King Creek and Tamarack Lake (if present), which would be a less-than-significant impact. The Agencies would restock with Paiute cutthroat trout as soon as practicable following treatment in order to restore a stable fish population. Tamarack Lake was historically fishless and would not be restocked following treatment, which would benefit other aquatic biota (amphibians and invertebrates).

In Silver King Creek, fish populations would also be exposed to potassium permanganate used to neutralize applied rotenone. This inorganic chemical would be applied at the downstream boundary of the treatment area near the confluence of Snodgrass Creek, and potential effects would extend downstream of the neutralization station up to a 30-minute travel time. Potassium permanganate is toxic to gill-breathing organisms at the rate (2 to 4 mg/L) required for neutralization. The toxicity of potassium permanganate to fish ranges from 0.75 to 3.6 mg/L (96 hr LC50 values) and is about 1.8 mg/L for rainbow trout. Potassium permanganate will neutralize rotenone in 15 to 30 minutes, depending on water temperature. During oxidation, potassium permanganate is converted to manganese oxide, a biologically inactive compound (CDFG 1994). In flowing water treatments, this balance usually limits aquatic exposure to permanganate and rotenone to 0.25 to 0.5 mile downstream of the neutralization site (Hobbs et al. 2006). Any affected areas would be repopulated by fish from the downstream sources.

Application of excess potassium permanganate could adversely affect downstream fish populations. As described in Chapter 3.0, Project Alternatives, the Agencies would avoid and minimize any effects of potassium permanganate on fish populations. Therefore the neutralization would occur with less-than-significant impacts on aquatic biota and no mitigation measures would be required. Potential impacts of potassium permanganate are addressed in greater detail in Section 5.3, Human and Ecological Health Concerns; Section 5.4, Water Resources; and Appendix C, Screening-level Ecological and Human Health Risk Assessment.

In conclusion, the proposed Action would have a short term adverse but not significant impact on fish populations; however, the impact would be temporary since the area would be restocked with pure Paiute cutthroat trout. The proposed Action would have a long term beneficial impact on Paiute cutthroat trout by implementing priority recovery actions.

BENTHIC MACROINVERTEBRATES

The proposed Action would directly affect all aquatic biota in Silver King Creek, including macroinvertebrates. These impacts may include mortality and differential effects on species assemblages (composition) that are an unavoidable consequence of rotenone treatment to re-establish Paiute cutthroat trout in part of its historic range. Macroinvertebrates play a key role in aquatic ecosystem function, and are an important food source for trout and terrestrial fauna. The potential impact of the proposed Action on endemic species of macroinvertebrates that may occur in the Silver King Creek watershed is also a matter of public concern as reflected in public comments on the NOI and NOP.

The impact assessment evaluates potential effects on species composition as required by the Basin Plan (LRWQCB 1995). The following subsections present a literature-based and site-specific assessment of the potential effects of the rotenone treatment on benthic macroinvertebrates in Silver King Creek. It provides a detailed summary of a quantitative analysis of historical and recent macroinvertebrate population data collected in Silver King Creek (Vinson and Vinson 2007, provided as Appendix D herein). The assessment addresses potential short- and long-term changes in abundance, shifts in species composition during these time frames, natural in-stream disturbances that have effects similar to rotenone treatment, and time to recovery from both rotenone and natural disturbance.

SHORT-TERM EFFECTS OF ROTENONE ON MACROINVERTEBRATE ASSEMBLAGES

Rotenone can harm non-target aquatic organisms. In general, benthic macroinvertebrate communities tend to be more tolerant of rotenone than most fishes, but individual macroinvertebrate species have varying ranges of rotenone tolerance (Mangum and Madrigal 1999, Chandler and Marking 1982, Engstrom-Heg et al. 1978) (see Appendix C, Table C-7). Toxicity of rotenone to benthic macroinvertebrates (96 hr LC50) varies widely from 0.002 to 100 ppm (Vinson and Vinson 2007). Toxicity also varies widely both within and among taxonomic divisions. Depending on exposure time, mortality was near 100% at rotenone formulation concentrations greater than 1-1.5 ppm for lotic (stream) invertebrates and 3 ppm for lentic (lake) adult aquatic invertebrate taxa (e.g. Heteroptera, Coleoptera) (Vinson and Vinson 2007). Many of the studies reviewed, however, reported results of 96 hr exposure, far exceeding that proposed for this action. The planned treatment concentration for the proposed Action would be 0.5-1.0 mg/L [ppm] for CFT Legumine™ or Noxfish®, or 1.0 mg/L (ppm) for Nusyn-Noxfish®. The application duration would be 4 to 6 hours.

The sensitivity of individual species and life stages to rotenone appears related to their oxygen uptake process (Engstrom-Heg et al. 1978). Smaller invertebrates appear more sensitive than larger invertebrates, and species that use gills to extract aqueous oxygen are more sensitive than species that obtain oxygen through other means (Vinson and Vinson 2007). The insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and some Trichoptera (caddisflies) (EPT taxa) are all gill breathers. These EPT taxa are a major component in the trout diet. They are less tolerant to environmental stressors than other aquatic invertebrate groups and have not been found after some rotenone treatments (Mangum and Madrigal 1999). Sensitivity to rotenone can also vary within the same taxonomic family. Whelan (2002) reported that while caddisflies (Order Trichoptera) had the highest number of species affected by rotenone, many caddisflies were tolerant.

Rotenone treatment may not be toxic to all benthic macroinvertebrates. CDFG conducted toxicity testing for exposure of benthic macroinvertebrates to Nusyn-Noxfish® and CFT Legumine™. Macroinvertebrates considered representative of the treatment area were collected from the East Fork Carson River in August 2007. Test organisms were exposed to the planned treatment concentrations. Testing showed that 4 hr LC50 values varied from 41 to 274 µg/L rotenone and 8 hr LC50 values varied from 13 to 174 µg/L rotenone for various species of caddisflies, mayflies and stoneflies (Table 5.1-8, CDFG unpublished data). These results show that the treatment concentrations required to achieve 100% rainbow trout mortality would have differential effects on EPT and that the planned treatment concentration of 0.5 ppm is below the "no observed effect level" (NOEL) for some sensitive macroinvertebrate species in the proposed treatment area.

The short-term effects of rotenone can be quite marked. Rotenone treatment results in short term decreases in abundance (20–85%, Engston-Heg et al. 1978, Darby et al. 2004) and diversity (Binns 1967, Cook and Moore 1969, Engstrom-Heg et al. 1978, Maslin et al. 1988a, 1988b, Mangum and Madrigal 1999, Trumbo et al. 2000a, 2000b, Whelan 2002, Darby et al. 2004). The long-term effects as the system recovers are discussed below.

Table 5.1-8 Four- and eight-hour exposure toxicity values of two formulations of rotenone (µg/L) for rainbow trout fry and several species of invertebrates. Unless otherwise noted, values represent survival at 48 hours

Species	4 hr LC50 Values		8 hr LC50 Values	
	CFT Legumine™	Nusyn-Noxfish®	CFT Legumine™	Nusyn-Noxfish®
Vertebrates				
Oncorhynchus mykiss	7.4	7.7	5.3	6.2
Invertebrates				
Caddisflies				
Arctopsyche grandis	ND	96*	34*	74*
Hydropsyche (tana and amblis)	274	ND	174	ND
Mayflies				
Baetis tricaudatus	ND	18	ND	23
Rhithrogena morrisoni	41	54*	40	13
Stoneflies				
Claassenia sabulosa	142	ND	60	ND
Oroperla barbara `	197	70	102	57

Source: CDFG unpublished data

*24-h observation
ND – non-detectable

LONG-TERM EFFECTS – RECOVERY OF MACROINVERTEBRATE ASSEMBLAGES

Rotenone treatment can be considered akin to a severe pulse physical disturbance such as a large, unpredictable flood (Vinson and Vinson 2007). Streams such as Silver King Creek are dynamic environments, and the organisms that inhabit them must be able to cope with disturbances. Flood, drought and fire are natural disturbances that affect streams. Understanding the recovery patterns of macroinvertebrate assemblages in response to natural disturbances provides additional context for interpreting and assessing the potential long-term effects of the proposed rotenone treatment. Disturbance can be any discrete physical event that disrupts community structure by changing the physical environment (White and Pickett 1985, Yount and Niemi 1990). Vinson and Vinson (2007) described disturbance as a discrete event that removes organisms and creates conditions for recolonization.

Disturbances, natural or anthropogenic, must be considered in any attempt to evaluate changes in benthic community taxa potentially attributable to rotenone application. Disturbances physically affect the stream environment, and their historical and contemporary occurrence would need to be considered in any investigation of the effects of the proposed Action. These phenomena can have additive or cumulative effects on stream benthos and mimic or mask short- or long-term effects hypothesized for rotenone.

The following sections review the available literature on recovery from natural disturbance and rotenone treatment.

RECOVERY FROM NATURAL DISTURBANCE: FLOOD, DROUGHT AND FIRE

A review of the extant literature on flood, fire and drought disturbances suggests the time-frames for recovery of benthic communities vary with the type of disturbance, presence and proximity of colonizer source populations, and biological characteristics of the invertebrates (i.e., life history attributes and dispersal) (Vinson and Vinson 2007). Disturbances vary by frequency, intensity, duration, geographic extent and seasonality (Lake 2003). These factors influence the ability of the stream to recover and the time required to recover to pre-disturbance levels of function.

Floods are common disturbances that change the physical environment and ultimately affect macroinvertebrate community structure and composition (Vinson and Vinson 2007). Although resistance to floods by stream biota is low, the resilience or capacity to recover is typically high (Lake 2000). The rate of substrate recolonization is usually rapid, and depends on the intensity of the disturbance, the spatial extent of the area disturbed, the availability of colonists, and the composition of the biota (Lake 2000).

Recovery of macroinvertebrate assemblages generally occur within weeks to months to years following the flood event (Niemi et al. 1990, Mackay 1992), depending on the flood regime and habitat complexity (Lepori and Hjerdt 2006). Slower recovery occurs following floods that occur at uncommon or unpredictable times of year (Giller et al. 1991), which suggests that invertebrates have adapted to the flood regimes they typically experience (Resh et al. 1988). Recovery of assemblages is also slower following floods with greater magnitude (Scrimgeour et al. 1988), which suggests that the effectiveness of small-scale refugia decreases with increasing flood magnitude and as sources of colonization become further apart. The rate of recovery after floods is also determined by intrinsic biological characteristics of the invertebrates themselves, which allows them to better adapt to unpredictable disturbances (Townsend and Hildrew 1976). Aquatic invertebrate adaptations to frequently or unpredictably disturbed environments include rapid growth and development, lack of diapause or resting stages, small size, flexible life histories, high adult mobility and longevity, and the near year-around presence of adults available for post-flood oviposition (Gray 1981, Fisher et al. 1982, Lake 2000, Townsend et al. 1997). Local factors such as season, substrate, and geomorphology are important to benthic assemblage response to disturbance.

Droughts and wildfire are other natural disturbances that can disrupt macroinvertebrate communities. Fowler (1984) found that recovery in 2 dewatered streams was affected more by the duration, not intensity, of disturbance. In a stream dewatered by drought and treated with rotenone, invertebrate populations recovered as soon as stream flow resumed (Larimore et al. 1958). The insects that were most abundant at first apparently were winged reproductive adults, colonizers from other streams. Larval insects can also move into the hyporheos as refugia from drought disturbance (Lake 2003).

The effects of wildfire disturbance have been studied in 20 streams in Yellowstone National Park over 10 years (Minshall 2003; Minshall et al. 1997, 2003, 2004). These fires had large scale long-lasting effects on many aspects of riparian and stream habitat (Minshall et al. 2004). The direct effects of fire on macroinvertebrate communities were minor, but indirect effects due to increased runoff and channel alteration had the greatest impact on community metrics and foodweb response (Minshall 2003). Benthic macroinvertebrate metrics such as species richness and diversity recovered substantially within the first year after the wildfires, whereas assemblage composition displayed significant changes that were apparent even 5 years after fire. Opportunistic species, particularly those easily dispersed through drift and having short generation times (e.g. chironomids and *Baetis spp.*), were found to be especially adapted to conditions following fire. In contrast, other species decreased in abundance soon after the fire (e.g. *Cinygmula* spp.) and showed little or no recovery during the study (Minshall et al.1997). Ten years after the fire, macroinvertebrate density, biomass and richness median values remained relatively constant and did not differ from the reference streams (Minshall et al. 2003). The most pronounced differences between burned and reference streams were in taxa dominance and similarity: the relative abundances of two disturbance-adapted taxa (Chironomidae and *Baetis* [Ephemeroptera]) were higher in the burned area than in the reference streams.

In a review of 150 case studies of aquatic ecosystem recovery from disturbance (15 of which were in response to rotenone treatments), Niemi et al. (1990) found that most recovery times were less than 3 years. Recovery of macroinvertebrate assemblages to 85% of pre-disturbance densities after pulse disturbances (including rotenone) occurred in less than 18 months. Recovery times were slightly quicker for low order (1^{st} to 3^{rd} order) streams than they were for larger rivers (4^{th} to 5^{th} order). They summarized that rates of recovery of aquatic invertebrate assemblages were influenced most by: 1) persistence of the impact, including changes in system productivity, habitat integrity, and persistence of the stressor; 2) life history of the organism, including generation time, and propensity to disperse; 3) time of year the disturbance occurs; 4) presence of refugia; and 5) distance to the recolonization source.

Niemi et al. (1990) found that assemblage densities recovered much quicker than individual taxon. Times of recovery for common insect orders following pulse disturbances that did not affect physical habitat characteristics (mostly rotenone and DDT) varied among orders. Assemblage recovery times were near 80% for Diptera after 1 year, 70% for Ephemeroptera after 1 year and about 60% after 2 years for Trichoptera and Plecoptera. Coleoptera was not represented in enough studies, but they felt that Coleoptera likely recovered more slowly than Trichoptera and Plecoptera. They speculated that recovery time was primarily related to generation time, propensity to drift, and distance from colonization source. Downstream drift from unimpacted upstream areas was the critical factor in determining the recovery times for stream ecosystems following pulse disturbances that do not impact the physical characteristics of the habitat. Coincidentally, some of the species most sensitive to rotenone are also highly mobile with short life cycles; thus they may have the ability to repopulate depleted areas rapidly through dispersal and oviposition (Engstrom-Heg et al. 1978).

RECOVERY FROM ROTENONE TREATMENT

As mentioned above, rotenone treatment can be considered akin to a severe pulse physical disturbance. Various studies have evaluated recovery of the benthic community from rotenone treatment by tracking the return of taxa (family, genus, and species) to approximate pre-treatment levels. While some studies have evaluated recovery of abundance and biomass (Binns 1967, Cook and Moore 1969, Engstrom-Heg et al. 1978), others have focused on community indices such as taxa richness or other diversity indices (e.g. EPT Index, BCI) (Maslin et al. 1988a, 1988b, Trumbo et al. 2000a, 2000b, Whelan 2002, Darby et al. 2004). Mangum and Madrigal (1999) focused solely on the presence or absence of the species present before the treatment. Most other authors used some combination of these metrics.

Rapid recovery (< 1 year) to pre-treatment macroinvertebrate levels has been documented following treatment by rotenone (Ling 2003) but not in all studies. The time needed for aquatic invertebrate assemblages to recover following rotenone treatment across studies have varied from a few months to 3 years or more depending on the measure of recovery and study length. Overall, aquatic invertebrate assemblage abundances generally return to pre-treatment levels quicker than measures of biodiversity or community composition. Assemblage abundances typically return to pre-treatment levels within a few months to a year (Binns 1967, Cook and Moore 1969, Beal and Anderson 1993, Mangum and Madrigal 1999, Melaas et al. 2001, Whelan 2002). Mangum and Madrigal (1999) found that the total abundance of invertebrates returned to pre-treatment levels in 1 to 36 months across their sampling sites. In Great Basin National Park, total abundance recovered to an average of 1,167 individuals (-34% of pre-treatment average) after 2 years. EPT group abundance recovery was slower being only 362.5 individuals (-57% of pre-treatment average) after 2 years. Only one sample site had total abundances that exceeded pre-treatment levels over the 3-year sampling period.

The recovery times for biodiversity and community composition measures have been longer and have exceeded 2 years in some studies (Binns 1967, Whelan 2002) and more than 5 years for individual species (Mangum and Madrigal 1999). Unfortunately, longer-term (2 or more years of post-treatment sampling) studies of aquatic invertebrate assemblage recovery following rotenone treatments are limited to 4 studies: Binn’s (1967) study of the Green River, Wyoming; Mangum and Madrigal’s (1999) study of the Strawberry River, Utah; Whelan’s (2002) study of Manning Creek, Utah; and Darby et al. (2004) study of Snake Creek in Great Basin National Park.

In 1962, over 435 miles of the Green River were treated with rotenone prior to the closure of Fontenelle and Flaming Gorge Dams (Binns 1967). The target concentration was 5 parts per million (ppm) of 5% rotenone, but the concentration reached nearly 10 ppm at some sites due to lower than expected flows. Binns (1967) reported that 2 years after treatment the patterns of dominant invertebrate groups were still different from pre-treatment assemblages and that two genera, Pentagenia and Hexagenia (Ephemeroptera: Ephemeridae), had not reappeared. The abundances of 3 taxonomic groups (Ephemeroptera, Trichoptera and Chironomidae) were found to increase with time after rotenone poisoning. The abundance of each group increased more quickly upstream, perhaps reflecting colonization from upstream sources. Monitoring was not continued beyond 2 years. The observed patterns are confounded with the effects of dam closure soon after the treatment.

In the Strawberry River Watershed, Utah, the entire drainage received a double treatment within a single year. Mangum and Madrigal (1999) found that the total abundance of invertebrates returned to pre-application levels in 1 to 36 months across their sampling sites. The authors collected 46% of the pre-treatment taxa 1 year after treatments, and 79% of the taxa after 5 years. This study provided evidence that macroinvertebrate community composition had significantly declined and had not fully recovered 5 years after treatment with rotenone. The comparability of this study, however, is limited because the rotenone for that project was applied at a higher concentration of 3 times recommended for normal stream use (150 parts per billion (ppb) active rotenone), for a longer duration (48 hours instead of 4 to 8 hours), and across a wider watershed.

Manning Creek, Utah, was treated with rotenone in 1995 and 1996 (Whelan 2002). Rotenone was applied at a target concentration of 1.5 mg/L in the stream channel for 12 to 18 hours. Utah Division of Wildlife Resources collected pre-treatment samples in 1988, 1990, and 1995, as well as post-treatment samples in 1997 and 1999. Whelan (2002) reported that about 50% of the taxa were found both pre-and post treatment, 21% taxa were collected only pre-treatment, and 30% were found only post-treatment. The author stated that the taxa found only during post–treatment surveys were due to sampling errors in detecting rare taxa, as discussed earlier in this document. The most impacted orders of aquatic insects were Trichoptera, with about 10% of the taxa missing after 3 years. In Snake Creek, Great Basin National Park, taxa numbers recovered to an average of 42 taxa by the second year, which was 91% of the average pre-treatment richness (Darby et al. 2004). The number of EPT taxa recovered to an average of 20 taxa by the second year, which was 77% of the mean pre-treatment richness. EPT abundances had not returned to pre-treatment levels after 3 years (Darby et al. 2004). Overall after 3 years, 96% of the pre-treatment taxa were present, but abundances of EPT taxa had not recovered.

USFS (Trumbo et al. 2000b) evaluated the impacts of rotenone treatment on Silver Creek (located in the watershed adjacent to Silver King Creek). This study evaluated the effects of repeated treatments with 1 mg/L rotenone on Plecoptera using a panel of standard metrics and 3 indices (BCI, EPT and DAT). The results were similar to Silver King Creek. While overall abundance was not affected, large Plecopterans were mostly affected. Study limitations were similar to those described by Vinson and Vinson (2007) for Silver King Creek (i.e., few pre-treatment data). No statistical comparisons were provided; however, the response of some metrics was similar to Silver King Creek (Trumbo et al. 2000a), such as reduction in DAT (6.6%) and BCI (8.4%). Overall, this study showed that certain taxa are affected by rotenone applied at 1 mg/L and that some short term shifts in diversity occur but not to a significant degree.

These studies indicate that recovery may occur within as little as 2 months, but could take more than 5 years. Table 5.1-9 lists the estimated time to re-establish the benthic invertebrate community after rotenone treatment. Different studies defined recovery differently, making comparison among estimated recovery times difficult. Comparison is also confounded by the specifics of the treatment (e.g. rotenone concentration) and other factors such as insufficient pre-treatment monitoring (typically limited to one or two sampling events), the highly variable temporal and spatial nature of macroinvertebrate communities, lack of adequate control and reference sites, and other confounding factors such as dams that altered hydrologic patterns (Binns 1967, Whelan 2002, Vinson and Vinson 2007).

Table 5.1-9 Time to Re-establishment from Rotenone Treatments

Stream	Study	Time to Re-establishment
Robinson Creek	Cook and Moore (1969)	2 months
Ten Mile River	Engstrom-Heg et al. (1978)	Little effect, a few months
Big Chico Creek	Maslin et al. (1988a)	5 months
Silver King Creek. Silver Creek	Trumbo et al. (2000a, 2000b)	1 year
Green River	Binns (1967)	14 to 24 months
Manning Creek	Whelan (2002)	1 to 3 years
Strawberry Creek	Darby et al. (2004)	More than 3 years
Strawberry River	Mangum and Madrigal (1999)	More than 5 years

Discriminating between the effects of the proposed Action, the effects of natural disturbance and population variability, and the cumulative effects of historic management is complex. As Vinson and Vinson (2007) found, historical data are not easily utilized and multiple factors confound interpretation:

- Most studies have not collected adequate baseline (pre-treatment) data to allow comparison with post-treatment data.
- Most studies focused on gross measurements, such as richness or abundance, with little data on the effects of rotenone on individual taxa or post-treatment recovery.
- There were too few studies and to little comparability between studies to make broad statements about the long-term effects of rotenone.
- Sampling effort was often uneven, with more samples taken from treated sites, which affects the likelihood of sampling rare taxa and reduces comparability among sites.
- Some studies have not accounted for the natural variation that occurs in benthic macroinvertebrate communities or historic disturbances that may have affected that area.

The USFS recently adjusted the Silver King Creek monitoring methodology to address some of these concerns by incorporating more sampling stations throughout the watershed as well as additional “control” and “treatment” sites (refer to Appendix E herein). The sampling methodology was also changed to allow for additional analyses such as the River Invertebrate Prediction and Classification System (RIVPACS) analysis model (Hawkins et al. 2000). The objectives of the revised study are to: 1) analyze changes in macroinvertebrate assemblages and taxa from the use of rotenone during Paiute cutthroat trout recovery activities; 2) collect and identify taxa from the Silver King Creek Watershed; and 3) re-establish historic collection sites in selected streams (USFS 2007).

Detecting changes in rare taxa, much less ascribing cause, can be especially challenging. For example, in Manning Creek Whelan (2002) observed that: 1) most of the species absent in Manning Creek after treatment were relatively rare in samples before treatment; 2) several species observed in the treated area several years before the treatment were missing immediately prior to treatment; and 3) some species missing in post-treatment samples were known to be present through other observations. The author believed that many of the “missing” taxa could survive rotenone treatment because 10 of the 11 “missing” taxa were found following rotenone treatment at Strawberry Creek drainage or in the North Snake Range of Nevada (Whelan 2002).

In the Strawberry River, Mangum and Madrigal (1999) focused exclusively on the presence or absence of taxa and did not report the relative abundance of the missing taxa in pre-treatment samples or the potential for taxa to be absent due to other causes, such as an artifact of sampling. The rotenone for that project, however, was applied at an extremely high concentration and longer duration, which limits the comparability of this study.

Review of the available literature on rotenone impacts and disturbance ecology of aquatic invertebrates led Vinson and Vinson (2007) to the following conclusions regarding potential impacts on benthic invertebrates in Silver King Creek:

- Rotenone impacts on benthic invertebrates would be initially high as impacts appear to be greatest in mountain streams characterized by snowmelt dominated hydrologic regimes, cold water and high oxygen levels, as these streams are characteristically dominated by small, gilled invertebrates, namely EPT.
- Rotenone impacts may be greatest in streams with lower frequency of disturbance or predictable discharge patterns. Recovery will also likely be longer in streams where long reaches are treated. Increasing the distance to colonization sources will reduce the ability of species to colonize the treated reach.
- Disturbance events will have greater impacts if they occur during critical life stages or if they occur in the fall when lower winter drift rates and lack of winter reproduction will delay recovery until the following spring, particularly if the site will be dependent on downstream drift of larvae for recolonization.
- The ability of taxa to recolonize treated areas appears to be a function of treatment mortality levels, overall population sizes within the treated watershed, upstream and local habitat conditions, and the dispersal abilities of individual taxon.
- Common taxa would quickly recolonize treated areas; rarer taxa may be eradicated for a number of years or indefinitely.

ROTENONE TREATMENT AND RECOVERY AT SILVER KING CREEK

Rotenone treatments have been applied 8 times in the Silver King Creek Watershed from 1964 to 1993 (Cordes et al 2004). As discussed earlier (Section 5.1.1.3), Vinson and Vinson (2007) assessed historic and recent (2003–2006) status of benthic macroinvertebrate assemblages in treated and untreated sites in Silver King Creek. The effects of rotenone on stream invertebrates appear similar to a large unpredictable flood (Vinson and Vinson 2007). Rotenone is typically applied during low flow periods. In Silver King Creek, high flow events are typically caused by snowmelt in late spring and early summer, with occasional winter rains in 1997 and 2006. Summer thunderstorms can cause flash floods which can dramatically alter stream channels and impact aquatic macroinvertebrates. From 1991 to 1993, rotenone was applied in Silver King Creek in August and September on 2.5 to 7 miles of stream during each treatment. The greater length of treated stream reach would likely prolong recolonization of treated areas. There are intermittent tributaries and fishless headwater tributary streams along much of Silver King Creek that may supply invertebrates into the treatment area.

Overall, comparisons of treated and untreated stream sites revealed little or no difference in measures of the macroinvertebrate assemblage (Vinson and Vinson 2007). The authors noted that any current or future assessments of the effects of rotenone on aquatic biota in the Silver King Creek basin are hampered by the long history of rotenone treatments in the watershed, the lack of data on aquatic invertebrate assemblages prior to the use of rotenone, and prior land use practices, such as logging and sheep and cattle grazing. The oldest data available on aquatic invertebrate assemblages were from 1984. No data are available for the period before the initial rotenone treatments in the Silver King Creek Watershed in 1964, 1976, and 1977. Therefore, Vinson and Vinson (2007) were unable to compare the original pre-treatment and post-treatment conditions.

INVERTEBRATE RECOVERY IN LAKE ECOSYSTEMS

Field studies have focused on rotenone's impacts on lentic zooplankton communities, noting a substantial short-term adverse effect on zooplankton abundance and taxa richness. Vinson and Vinson (2007) conducted a review and summary of the literature regarding rotenone effects on lentic invertebrates, including the following studies. Almquist (1959) observed that most zooplankton were killed with the addition of 0.5 to 0.6 ppm rotenone and that the toxicity of rotenone in lakes varied in response to light, oxygen, alkalinity, temperature, and turbidity. Kiser et al. (1963) observed 100% mortality of zooplankton within 2 days after applying 0.5 ppm rotenone. Similarly, Beal and Anderson (1993) found no surviving zooplankton 2 days after treatment with 0.06 ppm of 2.5% rotenone. Reinertsen et al. (1990) found a substantial reduction in species abundance after a 0.5 ppm rotenone treatment.

However, recovery of the zooplankton community in lakes following rotenone treatment appears to be rapid and robust. After the 1997 rotenone treatment at Lake Davis, overall zooplankton abundance increased to roughly 300% of the pre-treatment abundance within 1 year after the treatment (CDFG 2006). Furthermore, all zooplankton taxa identified before the treatment were identified after treatment. In another evaluation, Kiser et al. (1963) reported that all 42 species collected before a treatment, killing all zooplankton, were subsequently present within 5 months. Melaas et al. (2001) reported complete recovery of prairie wetland zooplankton assemblages within 1 year of treatment.

MODERATING EFFECTS AND FACTORS FOR MACROINVERTEBRATE RECOVERY

The preceding sections establish that the proposed treatment may have an unavoidable effect on macroinvertebrate abundance and species composition. Studies show that while taxa will be differentially affected and recovery of species composition is variable, recovery can reasonably be expected. Recovery mechanisms, survival of many species, treatment technique, and areal limits on treatment would moderate the effects of the proposed Action on macroinvertebrates.

The size and location of the treatment area relative to the watershed limits the effects of the treatment on the watershed as a whole. The treatment area (11 miles) comprises approximately 30% of the total length of Silver King Creek and its tributaries (about 37 miles). The location is well downstream of the headwaters, which preserves upstream source populations and ensures that recolonization could occur within several years via downstream drift. Recolonization by aerial winged adults can also easily occur from untreated stream reaches both above and below the treatment area and adjacent drainages (Smock 2006). These factors will ensure restoration of invertebrate ecological function, including providing a food source for restocked Paiute cutthroat trout.

Previous comments on the proposal expressed concern that the proposed Action would threaten headwater ecosystems (Herbst 2005). Approximately 17 miles of tributary streams would be left untreated under the proposed Action. Some of these areas (e.g. Fly Valley Creek, Four Mile Canyon Creek, and headwaters above treated reaches) have never been affected by rotenone. Other streams have not been treated in several years (e.g. Upper Silver King Creek in 1993, Corral Valley Creek in1977, and Coyote Valley Creek in 1988). These areas would remain untreated under the proposed Action as well. These waters are presumed to have recovered from any historic effects, have healthy macroinvertebrate communities (Mangum 2005), are increasing in function from elimination of grazing and other disturbances, and now support pure populations of Paiute cutthroat trout.

The hyporheic zone may also accelerate recovery. The hyporheic zone serves as a refuge for benthic insects (Ward 1992, Lake 2003). While the area and complex hydrologic mechanisms that create and maintain hyporheic habitats in the treatment area have not been established for this analysis, it is reasonable to assume that hyporheic fauna will not be subject to the same effects of treatment that surface organisms will and may contribute to recolonization and recovery.

Impacts to non-target aquatic invertebrates may also be minimized by the concentration and duration of rotenone applied, a method recommended by Mangum and Madrigal (1999). The Agencies would use a rotenone concentration that would be effective for trout eradication but below the “no observed effect level” (NOEL) for some sensitive macroinvertebrate species in the treatment area (Table 5.1-8).

IMPACTS OF PROPOSED PROJECT ON BENTHIC MACROINVERTEBRATES

SILVER KING CREEK AND TRIBUTARIES

The Basin Plan establishes water quality objectives for rotenone projects, including re-establishment of community composition within 2 years. The proposed application of rotenone would have an adverse short-term effect on benthic macroinvertebrate community composition through mortality of sensitive species. The rotenone treatment would have a stronger effect on the small, gilled EPT species (stoneflies, caddisflies, mayflies) that are abundant in Silver King Creek and are typical of cold-water, mountain streams.

The impacts of the proposed rotenone treatment would be less-than-significant; however, because recovery of the community composition would likely occur within 2 years. Several factors support this assessment. Despite the history of multiple rotenone treatments in the watershed, little difference can be detected in benthic macroinvertebrate community composition between treated and untreated reaches (Vinson and Vinson 2007). The system is healthy and has returned to a high level of diversity after historic treatments (Mangum 2005). Other studies demonstrate that recovery can occur within as little as 2 months, extending to more than 5 years in some streams that received more intensive treatment. As described in Chapter 3.0, Project Alternatives, the proposed Action is designed to reduce impacts by using a lower rotenone dose targeted for trout. Furthermore, headwaters and tributaries upstream of the treatment area will remain untreated, thereby providing ample source populations to recolonize the treated area. Therefore, the proposed Action would have a temporary adverse effect but not a significant impact on macroinvertebrate community composition.

Although unlikely, the proposed Action could result in loss of individual macroinvertebrate taxa, potentially including rare or as yet unidentified species endemic to Silver King Creek. No specific aquatic insect species that are classified as threatened, endangered or other special-status categories or endemic species are known to be present in the proposed treatment area. The Silver King Creek system has been treated several times in the past and some rare or endemic species present before these treatments may already be lost.

Neither existing macroinvertebrate surveys nor proposed monitoring would detect endemic species, thus the Agencies cannot rule out the possibility that endemic species may be present and could be adversely affected by rotenone application. The taxonomic resolution used to process stream bottom samples (2003 to present) by the National Aquatic Monitoring Center at Utah State University could not determine if rare or endemic species were present. Further studies at a finer resolution would be costly, inconclusive without range distribution data, and may be technically infeasible for many taxa. In conclusion, because the treatment could result in loss of rare or endemic species, this would be a significant and unavoidable impact.

Impact AR-1: The proposed Action could result in the loss of individual benthic macroinvertebrate taxa, potentially including rare (unquantified) and/or unidentified species endemic to Silver King Creek. (Significant and Unavoidable)

There are several mitigating factors. The treatment area is of limited geographic range. The proposed Action does not involve treating the headwaters above Llewellyn Falls or fishless portions of tributaries or springs; these areas would remain as important sources for recolonization efforts and could contain the same rare and endemic species that may occur in the treatment area. In addition, the Agencies would use lower rotenone concentrations than have been used in the past to minimize impacts on benthic invertebrates.

According to the Basin Plan rotenone policy (see Section 5.4, Water Resources), temporary effects on non-target organisms from the use of rotenone is justifiable in certain situations, including restoration and preservation of threatened and endangered species such as Paiute cutthroat trout. These species are of important economic and social value to the people of the State.

As discussed earlier, the proposed Action would neutralize rotenone by applying potassium permanganate (2 to 4 mg/L). This could adversely affect benthic macroinvertebrates in the neutralization zone extending approximately 0.25 to 0.5 mile below the confluence of Snodgrass Creek. Potassium permanganate is considered toxic to aquatic invertebrates and zooplankton, although there is likely to be a wide tolerance range among various freshwater invertebrates. For invertebrates, the 96 hr LC50 value is 5 mg/L. Like rotenone, toxicity differs between species but is often toxic in freshwater at concentrations between 1000 and 2000 ppb (EPA 2006). Potential impacts of potassium permanganate are addressed in greater detail in Section 5.3, Human and Ecological Exposure; Section 5.4, Water Resources; and Appendix C, Screening-level Ecological and Human Health Risk Assessment.

The Agencies would avoid and minimize the potential for overdosing the creek with potassium permanganate by implementing measures described in Chapter 3.0, Project Alternatives. The macroinvertebrate resources would be expected to re-establish within a few months after the neutralization treatment ends. Areas below this point and tributary springs would serve as sources for recolonization. As a result, no taxa are expected to be lost, and re-establishment is expected to occur within a few months, thus resulting in a less-than-significant impact.

TAMARACK LAKE

If no fish are discovered in 2009 and 2010 during pre-treatment surveys, Tamarack Lake would not be treated with rotenone and no impacts would occur. Rotenone application in Tamarack Lake would affect the lake's invertebrate community, including benthic and planktonic invertebrates, but recovery is expected to be robust as discussed in the previous section on recovery in lake treatments. Invertebrate communities would experience a long-term benefit through restoration of the lake to its historically fishless condition. Introduction of fish to alpine/subalpine lakes in the western United States has greatly reduced large-bodied macroinvertebrates and zooplankton species (Anderson 1972, Knapp et al. 2001, 1996). The literature suggests that if the lake were maintained in a fishless condition, the invertebrate community would recover more quickly following fish removal (Knapp et al. 2005).

The effects of rotenone may not be uniform throughout the lake. Not all zones of the lake would receive the same level of exposure. Rotenone in littoral areas would likely break down faster from exposure to oxygen and light. Hyporheic refugia may be present in the littoral zone. Finally, the lake's tributaries may provide source populations and refugia.

In summary, the proposed Action would have an adverse but temporary impact on aquatic invertebrates (benthic and zooplankton) in Tamarack Lake. The treatment would have a greater impact on lentic zooplankton in the short term, but it is expected that the re-establishment of zooplankton after the proposed rotenone treatment at Tamarack Lake will occur rapidly, with significant recovery measurable within months and full recovery anticipated within 1 year of a treatment. With fewer sources of recolonization upstream, benthic invertebrates may not recover within 2 years (CDFG 2006). As discussed earlier for stream habitat, the proposed Action could result in loss of individual taxa, potentially including rare or as yet unidentified species endemic to the Silver King Creek Watershed.

Impact AR-2: The proposed Action could result in the loss of individual benthic macroinvertebrate taxa, potentially including rare (unquantified) and/or unidentified species endemic to Tamarack Lake. (Significant and Unavoidable)

This risk is unquantified because no sampling has been done of Tamarack Lake invertebrates. Samples would be collected and stored in 2009 and processed and identified only if fish are found in Tamarack Lake and rotenone treatment of the lake becomes necessary.

RIPARIAN HABITAT AND WETLANDS

Rotenone does not affect riparian or aquatic vegetation. Initially, several drip stations would be installed along the stream. Some riparian vegetation may be removed and/or trimmed to access the stream channel, install the drip stations, and apply the rotenone by hand. Light trampling of herbaceous vegetation and sprouts and seedlings on bars may also occur during installation, treatment(s), and collection and removal of fish. Vegetation loss is expected to be temporary and the affected vegetation would recover quickly. The woody riparian and native understory species will continue to recover in response to the elimination of grazing pressures. The impact would be expected to be small and mitigable.

5.1.4.3 Alternative 3: Combined Physical Removal

Under Alternative 3, intensive electrofishing would be employed in an attempt to remove all fish from Silver King Creek and its tributaries within the treatment area. This method would involve passing an electric current through the water to stun fish, which would be netted and placed in buckets (Reynolds 1983). Using this approach, sections of stream are isolated with small mesh block nets before a crew makes multiple passes through the site with electrofishing equipment until fish are no longer captured. All captured fish would be disposed of via burial. Following successful removal of non-native trout, Paiute cutthroat trout stock of known genetic lineage would be re-introduced into the treatment area following guidelines in the Revised Recovery Plan (USFWS 2004) and recent genetic studies (Cordes et al. 2004, Finger et al. 2008).

Electrofishing is a common method for capturing fish, surveying for presence, or estimating fish population size. Typically, either removal-depletion or mark-recapture methods are employed to subsample the population. In this alternative, electrofishing would be employed with the intent of removing every individual fish, requiring a more intensive procedure than typical population assessment efforts (e.g. high electrical power, multiple passes). Presumably, multiple passes would be made through stream reaches until more than 1 pass resulted in no fish captured. However, electrofishing to capture all fish would be more intensive (multiple passes until no fish are captured, higher electrical power) than typical population assessment surveys. Factors such as habitat complexity, fish cover, fish behavior, and susceptibility to the electric field would challenge technicians and make verification of complete removal difficult and uncertain. Using physical removal techniques would require many years of work (10 or more years), longer than the proposed Action (rotenone treatment) to achieve removal of all non-native trout. Physical disturbance of the streambed would occur as workers conduct sufficient passes to complete the procedure.

Tamarack Lake is too deep for electrofishing to be an effective means of fish eradication. In the event that fish are confirmed to be in Tamarack Lake, gill nets (and other physical removal methods) would be employed over several years in an attempt to eliminate any fish or their progeny that may have remained from the 1991 fish planting.

<u>FISH POPULATIONS</u>

Under Alternative 3, all fish in the treatment area would be removed through electrofishing and buried. Any Paiute cutthroat trout that have passed over Llewellyn Falls and the Coyote Valley/Corral Valley Creek barriers would also be removed. Captured Paiute cutthroat trout would not be transported above Llewellyn Falls or above the Coyote Valley/Corral Valley Creek barrier because their genetic origin would be uncertain. As stated earlier, genetic studies indicate that the fish in the treatment area are principally non-native trout (i.e., rainbow trout and/or golden trout hybrids) with very little Paiute cutthroat trout genetic influence (Finger et al. 2008). There is no practical way to identify and separate, in situ, potentially pure Paiute cutthroat trout from hybrid individuals in treated areas. The loss of these fish would not result in a significant impact on this species.

Pure Paiute cutthroat trout from within the Silver King Creek drainage would be restocked into the treated reaches, where they are expected to become re-established to population levels commensurate with carrying capacity. Therefore, Alternative 3 would not have a long-term significant impact on fish populations. A short-term impact would occur as donor stocks redistribute and repopulate treated areas. This action and impact is similar for both the action alternatives.

If complete removal of non-native trout species is not achieved, the potential for re-establishment of a hybridized population remains and no net benefit to Paiute cutthroat trout viability (recovery) may be achieved.

Electrofishing or various net methods may not result in complete removal of undesired trout species in the treatment area. Therefore, this alternative may not meet the purpose and need for the proposed Action and may not be consistent with the Revised Recovery Plan (USFWS 2004). The recovery of the species may not occur and the proposed Action to recover Paiute cutthroat trout by removing non-native trout and establishing a viable population in historic habitat may not be successful. In addition, because some non-native trout would remain, the threat of an illegal introduction above Llewellyn Falls would be greater with this potential source nearby, although the threat of introduction from other out-of-basin sources remains the same for all alternatives. The genetic integrity of Paiute cutthroat trout would continue to be threatened.

Electrofishing crews would not be able to efficiently shock deep pools (waist deep or greater than 1 meter) because of safety reasons and the attenuation of the electrical field. The potential for undesirable trout species to remain in deep and/or complex habitats is likely.

If fish are present in Tamarack Lake, the lake would be gillnetted over the course of several years. Knapp et al. (1998) estimated that 15 to 20% of high lakes in the Sierra have characteristics that would allow the eradication of trout by means of gill netting. He found, however, that in lakes greater than 10 meters in depth, gillnetting is likely to be ineffective. Gillnetting would be challenging in Tamarack Lake, because the maximum depth is approximately 14 meters.

MACROINVERTEBRATE COMMUNITIES

Benthic macroinvertebrate communities in Silver King Creek may be affected by electrofishing. Electrofishing may force macroinvertebrates to move from their substrate habitat to the water column and be transported downstream; a phenomenon known as drift, and in this case, electrofishing-induced drift (Elliot and Bagenal 1972, Fowles 1975, Bisson 1976, Mesick and Tash 1980, Brown et al. 2000, Kruzic et al. 2005). However, the current and voltage used during electrofishing rarely result in mortality (Bisson 1976, Mesick and Tash 1980) and any effects tend to be short-lived (Fowles 1975, Kruzic et al. 2005).

Studies have shown that macroinvertebrate populations subject to electrofishing have been reduced through drift by more than 90% when macroinvertebrates are the target organism (Taylor et al. 2001), and as much as 80% with commonly used methods (Fowles 1975). However, not all studies have shown such dramatic reductions (Elliot and Bagenal 1972). Stream macroinvertebrates are not affected equally by electrofishing. Most authors report that the members of the Ephemeroptera order are most susceptible to electrofishing-induced drift (Elliot and Bagenal 1972, Fowles 1975, Mesick and Tash 1980, Taylor et al. 2001), while members of the order Trichoptera tend to be the least susceptible (Elliot and Bagenal 1972, Fowles 1975, and Taylor et al. 2001). Mesick and Tash (1980) found that the displacement rate or the rate of induced drift of macroinvertebrate species was directly related to their normal drift behavior with slight variations in rates among species due to body size differences, stream temperature, and type of electric current used.

The overall effect of electrofishing on macroinvertebrates in streams depends on several factors including the voltage and current used, shock duration, number of passes conducted, length of stream shocked, community type (proportion of tolerant versus non-tolerant species), and the presence of more resistant or unaffected life stages (eggs or emergent adults). Kruzic et al. (2005) mentions that electrofishing later in the season, when most invertebrates have hatched, would likely minimize effects on macroinvertebrates (Kruzic et al. 2005).

Macroinvertebrates are unlikely to drift for long distances and displacement is positively correlated with water velocity. For example, Fowles (1975) noted during electrofishing that macroinvertebrates were quick to return to the streambed after drifting only 10 meters. Similar drift distances were noted by Elliot and Bagenal (1972) and McLay (1970), as cited in Fowles (1975). Kruzic et al. (2005) found that the number and weight of drifting macroinvertebrates decreased by a factor of 3 between drift distances of 2.5 and 5 meters at one site. At a second site with greater discharge and faster flows, no such decline occurred. Faster flows may have carried even those insects with highly-evolved swimming morphologies and behaviors further downstream when compared to the slower flowing sites. Indeed, many of the species with the greatest susceptibility to induced drift are the same species with a high propensity to drift naturally and, as such, have evolved high rates of compensatory upstream movements (Madsen et al. 1973 as cited in Mesick and Tash 1980) as well as high rates of recolonization from regions upstream. Kruzic et al. (2005) found the effects of electrofishing on macroinvertebrate drift to differ based on insect size and morphology. Large-bodied Plecoptera (stoneflies) were only found to drift 2.5 meters from the treatment area, while smaller and lighter taxa, such as Chironomidae (midges) exhibited longer drift distances and comprised the majority of the most downstream (20 and 30 meter) samples. Previous studies have also noted that smaller taxa drift further downstream. Elliot (1971 as cited in Kruzic et al. 2005) found that chronomids were small, poor swimmers incapable of rapid reattachment to the substratum or aquatic vegetation.

In addition to the effects of the electrical current, electrofishing requires crews of several individuals, typically 3 or more. In stream channels where shocking from the bank is not feasible, workers would walk on the streambed, directly disturbing bottom sediments. Macroinvertebrate abundance has been shown to decrease in areas of disturbance versus undisturbed control sites in a northern Vermont stream (McCabe and Gotelli 2000). Walking on stream substrate or bottom sediments can also cause an increase in drift (Elliott and Bagenal 1972, Kruzic et al. 2005). Such disturbances may cause drift among species less likely to be affected by electrofishing alone (Elliott and Bagenal 1972), especially among species that tend to either burrow into the substrate or inhabit the underside of rocks or gravel (Elliott and Bagenal 1972). However, although Kruzic et al. (2005) noted greater numbers of invertebrates in the drift during electrofishing and trampling compared to electrofishing only, the increase was not significant ($p < 0.05$). Therefore, electrofishing conducted by crews operating within the stream may cause greater disturbance and increased drift than electrofishing from the stream banks.

The multiple passes required for fish removal (total capture) would involve repeated trampling and shocking disturbance over the survey area, potentially leading to displacement or crushing of large numbers of macroinvertebrates. Populations in disturbed areas of the stream may recolonize rapidly following the treatment, as in the studies conducted by McCabe and Gotelli (2000). However, their study evaluated routine electrofishing techniques, not the more intensive effort required to achieve project objectives.

Reductions in the macroinvertebrate populations would be temporary. Electrofishing would occur over a relatively short period (over the course of a month each late summer/fall). Headwater areas above Llewellyn Falls in Upper Fish Valley would not be affected by this alternative and would provide source populations for recolonization of electrofished areas. As described earlier, benthic macroinvertebrates have the ability to recolonize areas by drift from untreated upstream reaches in the watershed, aquatic and aerial movements of colonizers from downstream areas, and aerial colonizers from adjacent drainages (Smock 2006). It is reasonable to expect that the treatment area would be re-colonized rapidly with benthic invertebrates critical for ecological function, including a food source for restocked Paiute cutthroat trout. Recovery would be faster than under the proposed Action (Alternative 2) because the disturbance of electrofishing is likely less severe than from rotenone treatment, and therefore the macroinvertebrate community would not be as depleted. Recovery from rotenone can occur within a few months and upwards of 5 years for wide scale treatment (Vinson and Vinson 2007). Since electrofishing would occur in the fall during lower winter drift rates and lack of winter reproduction, recovery would be delayed until the following spring, particularly if the site would be dependent on downstream drift of larvae for re-colonization (Vinson and Vinson 2007).

There is also the risk that an endemic species may be eliminated, but this risk is difficult to quantify (as discussed above). The probability is lower than for the rotenone treatment because electrofishing is not expected to result in complete eradication of the macroinvertebrates in the area.

Because electrofished areas would be re-colonized rapidly (less than 2 years) from upstream areas and a diverse community would be re-established, impacts on the benthic macroinvertebrate community from physical removal would be less-than-significant and no mitigation measures would be required.

RIPARIAN HABITAT AND WETLANDS

Intensive electrofishing would have minimal effects on the Silver King Creek Watershed. Associated activities such as the use of block nets, the application of electric current to the water column, and substrate trampling would be temporary, although it would be repeated annually for several years. Water quality would quickly return to pre-treatment levels as sediment mobilized from in-stream activities would soon settle. There would be no need to construct dams or diversions. The use of gasoline to fuel the generator may pose a pollution risk to the watershed.

Electrofishing work would occur within the stream channel, with minimal activities conducted on the stream banks and bars. Some riparian vegetation may need to be removed and/or trimmed to access the stream channel and light trampling of herbaceous vegetation and seedlings on bars may occur during the collection and removal of the fish. Vegetation loss is expected to be temporary and the affected vegetation would recover quickly. The woody riparian and native understory species would continue to recover in response to the elimination of grazing pressures. The impact would be expected to be small and mitigable. Efforts would be made to minimize disturbance of the riparian zone where possible (e.g. using the same access trail each time, avoiding newly recruiting willow seedlings on bars).

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5.2 TERRESTRIAL BIOLOGICAL RESOURCES

This section describes the existing terrestrial wildlife resources that are associated with the proposed project area. Terrestrial wildlife includes all vertebrate species except fish. Fish and benthic invertebrates are addressed in Section 5.1, Aquatic Biological Resources. Amphibians are addressed under terrestrial wildlife even though they have an aquatic larval life history stage. This section provides an overview of typical terrestrial wildlife species and their habitats that are present within the proposed project area as well as information on special status species that may also occur in the area.

This impact assessment builds on assessments presented in CDFG's Programmatic EIR (CDFG 1994), the Biological Assessment prepared by USFS in 2002, the Biological Opinion prepared by the USFWS in 2003, and the Biological Evaluation prepared by the USFS in 2004. A revised Biological Assessment and Biological Evaluation are in preparation and will be completed prior to the final decision. The Biological Assessment and Biological Opinion addressed bald eagle (*Haliaeetus leucocephalus*), Sierra Nevada yellow-legged frog (*Rana sierrae*), and Yosemite toad (*Bufo canorus*) and contained conservation recommendations for amphibians. On June 28, 2007, the bald eagle was removed from the Federal list of threatened and endangered species and is now managed as a Forest Service Sensitive Species. The Sierra Nevada yellow-legged frog and the Yosemite toad were also recently added to the Region 4 Forester's Sensitive Species list. The Biological Evaluation analyzes potential impacts to Forest Service sensitive wildlife and plant species.

5.2.1 Environmental Setting

The proposed project area is in the 160,000-acre Carson-Iceberg Wilderness located within the Humboldt-Toiyabe National Forest. This rugged area is dominated by volcanic ridges and peaks. Streams within the proposed project area flow through granitic canyons. Elevations range from 5,000 feet to over 11,000 feet. Snow pack remains into June. Summers are generally dry and mild.

5.2.1.1 Terrestrial and Riparian Vegetation

The proposed Action and surrounding area is represented by a mosaic of high elevation (7,000 to 8,000 feet) forest, upland brush communities, and a mix of riparian associated communities including aspen, willow and wet meadow habitat types. Forest cover types vary markedly from drier south-facing slopes dominated by Jeffrey pine and associated mountain mahogany and bitterbrush understories, to higher elevation forest consisting of red fir, western white pine and lodgepole pine. Extensive stands of lodgepole pine are also well represented. Small patches of late successional forest are present within or adjacent to the proposed project area; however, most of what remains is mid-seral stands that were once harvested during the Comstock era. The most significant stands of old growth are outside of the proposed project area and include the vicinity of Rodriquez Flat in the headwaters of Snodgrass Creek (near Little Antelope Pack Station) and adjacent to the project area in Corral Valley and Coyote Valley Creeks. Both dry and wet meadow community types line most of Silver King Creek. Willow and sedges are the dominant riparian species present in the Silver King Creek basin (Smith 1994). A significant willow component occurs in the wetter portions of the meadows. Habitat surrounding Tamarack

Lake is a combination of large granitic rock outcroppings, patchy brush communities, and open canopied conifer stands.

Specific geology and soil maps are not available for the proposed project area, but a general description of the Sierra Range was used. The soils are primarily formed from weathered granitic, metamorphic, and basic igneous rock with glacial deposits and alluvium present (Soil Conservation Service 1974). The soils are generally described as shallow, well drained and sandy with varying amounts of coarse fragments.

5.2.1.2 Terrestrial Wildlife

Wildlife species that occur in the Silver King Creek Watershed are typical of high elevation northern Sierra Nevada species. The list of wildlife species that potentially occur in the Humboldt-Toiyabe National Forest area includes numerous species of birds, mammals, and amphibians. The threatened, endangered, candidate, Management Indicator Species, and Forest Sensitive Species that have the potential to occur in the proposed project area are summarized below.

FEDERALLY LISTED AND CALIFORNIA STATE LISTED SPECIES

No federally listed terrestrial wildlife species are known to occur in the proposed project area. State listed species potentially present in the proposed project area include California wolverine (*Gulo gulo*). The threatened California wolverine was recorded during the 1990's within the project area (California Natural Diversity Database [CNDDB] 2007).

FEDERAL AND STATE CANDIDATE SPECIES

Three terrestrial wildlife species are considered candidates for Federal listing under the ESA; Sierra Nevada yellow-legged frog (*Rana sierrae*), Yosemite toad (*Bufo canorus*), and the Pacific fisher (*Martes pennanti*). The Sierra Nevada yellow-legged frog and the Yosemite toad were also recently added to the Region 4 Forester's Sensitive Species list and were considered for analysis in the Biological Evaluation. The Sierra Nevada willow flycatcher (*Epidonax trailii brewsteri* and *adastus*) is considered a candidate for listing in the State of California. These 3 species were also identified in the Sierra Nevada Forest Plan Amendment (SNFPA) as regional "species at risk" and have the potential to occur in the proposed project area.

Standards and guidelines for conserving these species were developed under the Sierra Nevada Forest Plan Amendment (SNFPA) and included a mandate to complete a Conservation Assessment (CA) for each of the 3 species. A CA synthesizes the best available information on status and distribution of a species and outlines the information necessary to develop a plan of action to conserve the species. The CA for the Sierra Nevada willow flycatcher was finalized in 2003 and draft CAs for the Yosemite toad and Sierra Nevada yellow-legged frog have been developed.

MANAGEMENT INDICATOR SPECIES

The Toiyabe National Forest Land and Resource Management Plan (LRMP) (1986) identifies USFS Management Indicator Species (MIS) as species representing a group of species with similar habitat requirements. USFS MIS are selected to represent the significant ecosystems in the forest and associated wildlife and fish that depend upon those ecosystems. USFS MIS are not federally listed (threatened, endangered, or forest sensitive) but could be affected by the proposed Action. A review was conducted to determine: 1) if the proposed Action is within the range of any MIS; 2) if habitat is present within the proposed project area; and 3) if there are potential direct, indirect or cumulative effects on habitat components. MIS associated with habitats that may be affected by the project will be analyzed below. The following terrestrial MIS were included for analysis for the Paiute Cutthroat Trout Restoration Project:

- Mule deer (*Odocoileus hemionus*)
- American marten (*Martes americana*)
- Yellow warbler (*Dendroica petechia*)
- Yellow-rumped warbler (*Dendroica coronata*)
- Hairy woodpecker (*Picoides villosus*)
- Williamson's sapsucker (*Sphyrapicus varius*)
- Northern goshawk (*Accipiter gentilis*)
- Sage grouse (*Centrocercus urophasianus*)

The following species were not selected for further analysis due to absence of habitat or because the project will not directly or indirectly affect the habitat:

- Palmer's Chipmunk (*Eutamias* spp.)

Pauite cutthroat trout and benthic macroinvertebrate populations are described in Section 5.1, Aquatic Resources. Lahontan cutthroat trout were not analyzed because they are not present within the project area and the project area is outside of their historic habitat.

FOREST SENSITIVE SPECIES

The Forest Sensitive Species (FSS) are based on the USFS Regional Forester's (R4) list of sensitive species (November 1995 list, updated in 1999 and 2003 and 2008). FSS species analyzed in the Biological Evaluation include 5 mammals (Spotted bat, Townsend's big-eared bat, pygmy rabbit, wolverine, and fisher), 8 birds (Northern goshawk, bald eagle, California spotted owl, flammulated owl, great gray owl, white-headed woodpecker, mountain quail, and sage grouse), 2 amphibians (Sierra Nevada yellow-legged frog and Yosemite toad) and 10 plants (Lavin's eggvetch, upswept moonwort, dainty moonwort, slender moonwort, seaside sedge, Tahoe draba, Marsh's bluegrass, Webber ivesia, Sierra Valley ivesia, and Galena Creek rockcress).

OTHER SPECIES CONSIDERED

NEOTROPICAL MIGRATORY SONGBIRDS

The neotropical migratory songbirds (NTMB) found in North America include roughly 350 species, of which about 250 are known as "neotropical migrants." Migratory birds spend their winters in the tropics of southern Mexico, Central and South America, and the West Indies. The other 100 species, called "short-distance migrants," winter chiefly in the southern U.S., particularly along the Gulf Coast. Migratory songbirds can be found in virtually every habitat on the continent, and usually half or more of the breeding birds in any sampled area are migratory (Robinson 1997).

Executive Order (EO) 13186, signed January 10, 2001, requires Federal agencies to protect migratory birds by supporting the conservation intent of the Migratory Bird Treaty Act. Under this EO, Federal agencies must integrate bird conservation principles, measures, and practices, into agency planning and activities. Federal agencies should also, to the extent practicable, avoid or minimize adverse impacts on migratory bird resources when conducting agency actions. A Memorandum of Understanding (MOU) between the USDA Forest Service and the USDI Fish and Wildlife Service, signed January 17, 2001, identifies specific activities for bird conservation pursuant to EO 13186 including: 1) the need to identify management practices that impact populations of high priority migratory bird species; and 2) to develop management objectives or recommendations that minimize these impacts.

Meadow-riparian habitat found throughout the project area is identified as "high priority" habitat for NTMB in the 1999 Draft Avian Conservation Plan for the Sierra Nevada Bioregion (Siegel et al. 1999). The 1999 Draft Plan lists species considered critically dependent upon meadow-riparian habitats found in the Sierra Nevada including the Carson Iceberg Wilderness.

The two largest threats to NTMB are habitat fragmentation on breeding grounds and deforestation of wintering habitat (Finch 1991). Compared to other birds, migratory species are the most negatively affected by fragmentation, and are usually absent from small or highly isolated forests (SERC 2003). The distribution and diversity of birds is highly associated with structural diversity in vegetation (MacArthur and MacArthur 1961). Species such as yellow warbler, MacGillivray's warbler, Wilson's warbler, and common yellowthroat are considered high priority species and require heavy shrub or herbaceous cover for nesting and foraging (Sedgwick and Knopf 1987).

5.2.2 Regulatory Setting

5.2.2.1 Federal

ENDANGERED SPECIES ACT OF 1973 (16 USC §1531 ET SEQ.; 50 CFR PARTS 17 AND 222)

This law includes provisions for protection and management of species that are federally listed as threatened or endangered and designated critical habitat for these species. This law prohibits "take" of federally listed species, except as authorized under an incidental take permit or incidental take statement. The USFWS is the administering agency for this authority.

MIGRATORY BIRD TREATY ACT OF 1918

The Migratory Bird Treaty Act (16 U.S.C. Sections 703-712, July 3, 1918, as amended 1936, 1960, 1968, 1969, 1974, 1978, 1986 and 1989) implements various treaties and conventions between the United States and other countries, including Canada, Japan, Mexico, and the former Soviet Union, for the protection of migratory birds. Under the act, taking, killing, or possessing migratory birds or their eggs or nests is unlawful. Most species of birds are classified as migratory under the act, except for upland birds such as pheasant, chukar, and gray partridge. The act contains several exemptions, such as waterfowl hunting. Many types of development result in the taking of migratory birds: collision with windows, for example, is a leading cause of death among songbirds. Taking may be allowed under a scientific permit if research is deemed beneficial to migratory birds. USFWS is the administering agency for this authority.

BALD AND GOLDEN EAGLE PROTECTION ACT (BGEPA) OF 1940

On August 8, 2007, the bald eagle was removed from the federal list of threatened and endangered species (72 FR 37346). Bald eagles will continue to be protected under the Bald and Golden Eagle Protection Act (BGEPA) of 1940, as amended (16 U.S.C. 668-668d) and the Migratory Bird Treaty Act (MBTA) of 1918, as amended (16 U.S.C. 703 et seq.). Both of these laws prohibit killing, selling or otherwise harming eagles, their nests, or their eggs.

The USFWS developed the National Bald Eagle Management Guidelines (Guidelines) to advise landowners, land managers, and others when and under what circumstances the protective provisions of the BGEPA may apply to their activities. These documents and further information about the bald eagle are available at http://www.fws.gov/migratorybirds/baldeagle.htm. A variety of human activities can potentially interfere with bald eagles, affecting their ability to forage, nest, roost, breed, or raise young. The Guidelines are intended to help people minimize such impacts to bald eagles, particularly where they may constitute “disturbance”, which is prohibited by the BGEPA. The USFWS developed final regulations providing two mechanisms which authorize “take” under the BGEPA for those currently authorized under the Act. These final regulations are available on the website address provided above.

5.2.2.2 State

CALIFORNIA FISH AND GAME CODE, SECTION 1600, ET SEQ.

This law provides for protection and conservation of fish and wildlife resources with respect to any project that may substantially divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of any river, stream, or lake. The administering agency is CDFG.

CALIFORNIA ENDANGERED SPECIES ACT OF 1984 (CALIFORNIA FISH AND GAME CODE SECTION 2050-2098)

This law provides for the protection and management of species and subspecies listed by the state of California as endangered or threatened, or designated as candidates for such listing. They are listed at 14 CCR Section 670.5. This law prohibits take of state listed or candidate species, except as otherwise authorized by the Fish and Game Code. The term take is defined by Section 86 of the Fish and Game Code as “hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill.” This definition is different in some respects from the definition of take under the ESA. The administering agency is CDFG.

CALIFORNIA FISH AND GAME CODE SECTION 5650

This law protects water quality from substances or materials deleterious to fish, plant life, or bird life. It prohibits such substances or materials from being placed in waters or places where it can pass into waters of the state, except as authorized pursuant to, and in compliance with, the terms and conditions of permits or authorizations of the SWRCB or a regional water quality control board such as a waste discharge requirement issued pursuant to Section 13263 of the Water Code, a waiver issued pursuant to Section 13269(a) of the Water Code, or permit pursuant to Section 13160 of the Water Code. The administering agency for Fish and Game Code Section 5650 is CDFG.

5.2.3 Assessment Criteria and Methodology

5.2.3.1 Significance Thresholds

CEQA thresholds of significance for biological resources were used in the following evaluation. Impacts were considered significant if they would:

- Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by CDFG, USFWS or USFS;
- Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations, or by CDFG, USFWS or USFS;
- Have a substantial adverse effect on federally-protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means (Evaluated in Section 5.4, Water Resources);
- Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites (Evaluated in Section 5.1, Aquatic Resources);
- Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance; or
- Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.

5.2.3.2 Evaluation Methods and Assumptions

Numerous sources were used to gather existing information on terrestrial wildlife resources in the project area, including documents drafted for previous attempts to implement the Paiute cutthroat trout recovery program (USFWS 2003, USFS 2002, 2004), and unpublished data from the CDFG. Lists of special status species potentially occurring in the proposed project area were obtained from the USFWS, USFS and a review of records from the CNDDB. These data were used to establish the environmental setting.

The resources described in the environmental setting were evaluated to determine the potential impacts of activities associated with the proposed Action and alternatives and to develop mitigation measures, as appropriate. The impacts of the proposed Action and alternatives were evaluated based on the potential for impacts on terrestrial wildlife resources such as chemical impacts from rotenone treatment, disturbance during electroshocking activity, and potential reductions of prey species for terrestrial wildlife, including effects on aquatic insect and fish communities.

Impacts on biological resources were evaluated by considering potential direct, indirect and cumulative impacts of the proposed Action and alternatives on protected species and habitats. Potential impacts on biological resources include the following:

- Direct or indirect impacts on riparian habitats;
- Direct, indirect and cumulative impacts on federally- or state-listed rare, threatened, or endangered species or species that are candidates for listing;

- Direct indirect and impacts on other special status species;
- Loss of wildlife habitat; or
- Disturbance to riparian habitat.

As part of the impact assessment, the EIS/EIR team searched for and reviewed any local policies and ordinances that may contain provisions protecting biological resources to identify potential conflicts. No conflicts were identified; therefore, this threshold is not assessed further in this EIS/EIR. No local, regional, or state Habitat Conservation Plans or Natural Community Conservation Plans affecting the proposed project area were identified. Therefore, no conflicts with habitat or species conservation plans would occur and no further analysis is provided in this EIS/EIR.

5.2.4 Environmental Impact Assessment

This section analyzes the potential impacts on terrestrial wildlife resources due to the proposed Action and alternatives. The assessment evaluates direct, indirect and cumulative impacts associated with implementation (e.g., chemical application, worker activity) and indirect impacts, which are secondary effects but delayed or spatially removed from implementation (e.g. residual chemical effects, stream sedimentation, habitat impacts, etc.).

5.2.4.1 Alternative 1: No Action

WILDLIFE IMPACTS

The No Action alternative would maintain existing conditions in the proposed project area and would have no direct, indirect, or cumulative effects on any federally listed or state listed threatened, endangered, proposed or candidate species, Similarly, the No Action alternative would not have any direct, indirect, or cumulative impacts on any FSS. The No Action alternative would not affect habitat or cause a downward trend in populations for any MIS species or NTMB listed above (USFS 2004).

RIPARIAN OR OTHER SENSITIVE NATURAL HABITATS

The No Action alternative would not involve chemical application or any physical disturbance and would therefore have no direct or indirect impacts on riparian habitat or any other sensitive natural habitat identified in local or regional plans, policies, or regulations or by the CDFG or USFWS.

5.2.4.2 Alternative 2: Proposed Action (Rotenone Treatment)

WILDLIFE IMPACTS

The proposed rotenone treatment of Silver King Creek and its tributaries could affect terrestrial wildlife through the physical disturbance that would result from presence of workers and their activities. It could also expose them to rotenone and other chemicals associated with the application and neutralization process through direct body contact, ingestion of treated water, and consumption of fish killed by rotenone. All mammals break down rotenone in their digestive tract rendering short-term exposure virtually harmless. Toxicity data for orally administered rotenone indicate that mammals would not be affected by drinking rotenone treated water or eating rotenone-killed fish (Bradbury 1986). The mammalian digestive system is not an efficient mode for rotenone entry into an animal's body, thus limiting potential for harm. Rotenone residues in dead fish are generally very low (< 0.1ppm), unstable, and not readily absorbed through the gut of an animal eating a rotenone-killed fish (Finlayson et al. 2000). Appendix C presents a detailed screening-level ecological risk assessment.

The treatment could also affect terrestrial wildlife by temporarily reducing their food source. The proposed Action would remove all non-native trout (of all sizes), which may constitute an important prey base for several locally occurring wildlife species. The prey base for these species may be reduced until pre-treatment fish densities and size-class distributions are reestablished through stocking.

Other terrestrial wildlife that prey on the aquatic invertebrate community could be affected by the treatment. Insectivorous wildlife species in the proposed project area include yellow warbler and Williamson's sapsucker, among others. These species prey on emerging aquatic invertebrates as they forage in and around the water. Rotenone is toxic or noxious to gill-breathing aquatic invertebrates. The resulting reduction in this prey base could impact insectivorous wildlife species. The paragraphs below assess potential exposure or food chain impacts on protected species.

Noise generated by the proposed Action would be of short duration and would not adversely affect any of the wildlife species addressed below. The proposed Action would generate only minor disturbance from workers and the small mechanical pumps that would be used to apply rotenone and potassium permanganate. Few criteria are available to assess potential noise impacts on wildlife. Some jurisdictions (including the City and County of San Diego) have adopted a 60 decibels A-weighted (dBA) significance threshold for special status bird species, based on a bird's ability to vocalize loud enough to ensure successful breeding. The low hum of the generators that would be used during the treatment process would be well below this criterion.

FEDERALLY LISTED AND STATE LISTED THREATENED, ENDANGERED, AND CANDIDATE SPECIES

CALIFORNIA WOLVERINE (STATE THREATENED)

Wolverines typically occur in high elevation, remote areas and do not inhabit grassland-chaparral or sagebrush and creosote scrublands in California (Ruggiero 1994 and USDA 1991). In the northern Sierra Nevada, wolverines have been found in mixed conifer, red fir, and lodgepole habitats, and probably use subalpine conifer, alpine dwarf-shrub, wet meadow, and montane riparian habitats. Elevations in the northern Sierra Nevada mostly fall in the range of 4,300-7,300 feet.

Although the proposed project area contains habitat components associated with wolverines, the probability of wolverines occurring in the area is considered low. Only 1 unverified occurrence of wolverines has been recorded in the proposed project area in the early 1990s. With the exception of a recent detection on the Tahoe National Forest, only anecdotal sightings have been recorded for the rest of the Central Sierra Nevada (Easton 2009). No direct and indirect effects to wolverines foraging opportunities are expected from the proposed Action. Wolverines typically forage on large terrestrial animals and are not dependent on fish or other aquatic species that may be impacted from chemical treatment. No direct or indirect effects to habitat for wolverines will result from the proposed Action.. No new roads or trails would be constructed and there would be no vehicular traffic throughout the area. The proposed Action would not result in removal of trees or other ground disturbance that would potentially affect wolverine habitat. Based on the above assessment, it is determined the proposed Action will have no direct, indirect or cumulative effects on wolverines or their habitat.

FISHER (FEDERAL CANDIDATE)

The Pacific fisher (West Coast Distinct Population Segment [DPS]), was placed on the federal candidate list on April 8, 2004 (Federal Register 69:18770-18792). Though the proposed project area is potential habitat for the fisher, its current range has been shown to exclude this area (Zielinski et al. 1995).

The probability of fisher occurring in the proposed project area is considered very low. According to the Sierra Nevada Forest Plan Amendment, fishers historically have never occurred in the HTNF (USDA 2001). Furthermore, fishers are closely associated with contiguous, late seral stands of dense mixed conifer which is not typical of the proposed project area. Although small patches of dense conifer occur along Silver King Creek, the most significant stands of old growth are outside of the proposed project area and include the vicinity of Rodriquez Flat in the headwaters of Snodgrass Creek. Any potential foraging and/or denning habitat for fishers would not be impacted under the proposed Action. Fishers rely primarily on terrestrial animals for prey and are not dependent on fish or other aquatic species that may be impacted from chemical treatment. The proposed Action would not result in removal of trees or other ground disturbance that would potentially affect habitat for the fisher. Based on the above assessment, it is determined the proposed Action will have no impacts to the fisher.

AMPHIBIANS-SIERRA NEVADA YELLOW-LEGGED FROG AND YOSEMITE TOAD (FEDERAL CANDIDATE)

Sierra Nevada yellow-legged frogs and Yosemite toads are known to historically have inhabited portions of the Silver King Creek basin (USFWS 2004). However, surveys conducted by CDFG between 2001 through 2005 and again in 2008 in the proposed project area resulted in no detections of either species.

Potential direct impacts to Sierra Nevada yellow-legged frogs and Yosemite toad include absorption of rotenone during implementation of the proposed Action. Rotenone is highly toxic to amphibians, including Sierra Nevada yellow-legged frog and Yosemite toad. A lipid-soluble chemical, rotenone is absorbed into both skin and respiratory membranes. Fontenot et al. (1994) reported that amphibian larvae with gills are most sensitive to rotenone (a detailed description of rotenone toxicity in amphibians is presented in Appendix C). Amphibians in their terrestrial life stage should not be affected by the rotenone treatment. However, gill-breathing life stages, if present, would be susceptible. Most amphibians, such as toads, present during a late summer treatment would have completed their metamorphosis and would not be affected. However the treatment could result in mortality of Sierra Nevada yellow-legged frog juveniles, which stay in the tadpole stage for up to 4 years.

However, as mentioned above, the potential for impacting Sierra Nevada yellow-legged frogs and Yosemite toads is considered very low due to the lack of detections recorded during annual surveys over the last 6 years. Furthermore, the Agencies would conduct thorough pre-treatment amphibian surveys immediately before treatment, according to protocols described in the Biological Assessment (USFS 2002) and Biological Opinion (USFWS 2003) and the previously issued NPDES permit for the Monitoring and Reporting Program. If adult or tadpole life stages of any threatened, endangered, sensitive, candidate or rare amphibians are found during pre-treatment surveys, they will be captured by net and relocated out of the proposed project area to suitable nearby habitat. The Agencies would continue to conduct the amphibian surveys until the proposed Action is completed and the area is restocked with Paiute cutthroat trout.

Potential indirect impacts on amphibians include loss of prey species from rotenone treatments. For example, reductions in emerging aquatic insects could occur over several years, particularly if multiple treatments are required. However, as described in Section 5.1, Aquatic Biological Resources, aquatic insect populations would recover quickly through drift from areas above Llewellyn Falls and untreated tributaries. In addition, based on survey and relocation activities over the past 4 years, neither Sierra Nevada yellow-legged frog nor Yosemite toads are believed to occur in the proposed project area.

Current populations of non-native trout in the proposed project area have adverse effects on amphibian populations through predation and competition for prey resources (Knapp and Matthews 2000). Therefore, removal of non-native trout and no future stocking of Whitecliff Lake and Tamarack Lake will benefit Sierra Nevada yellow-legged frogs and Yosemite toads over the long term. Paiute cutthroat trout co-evolved with these amphibian species in the Silver King Creek Watershed, and the only individuals found currently co-occur with the Paiute cutthroat trout.

Based on the above factors and because recent surveys have indicated no presence of Sierra Nevada yellow-legged frogs or Yosemite toads within the proposed project area, it is determined the proposed Action may impact individual Sierra Nevada yellow-legged frogs and Yosemite toads but will not lead to a trend toward federal listing or loss of viability to the population.

FOREST SENSITIVE SPECIES

The FSS include 5 mammals (Spotted bat, Townsend's big-eared bat, pygmy rabbit, wolverine, and fisher), 8 birds (Northern goshawk, bald eagle, California spotted owl, flammulated owl, great gray owl, white-headed woodpecker, mountain quail, and sage grouse), 2 amphibians (Sierra Nevada yellow-legged frog and Yosemite toad) and 10 plants (Lavin's eggvetch, upswept moonwort, dainty moonwort, slender moonwort, seaside sedge, Tahoe draba, Marsh's bluegrass, Webber ivesia, Sierra Valley ivesia, and Galena Creek rockcress).

According to the Biological Evaluation, the proposed Action may impact individuals of the following FSS: bald eagles, Sierra Nevada yellow-legged frogs, and Yosemite toads due to disturbance from noise associated with the proposed Action and or amphibian relocation efforts (if necessary). However, impacts are expected to be minor and temporary and will not lead to a trend toward federal listing or loss of viability. According to the Biological Evaluation, the proposed Action will have no impacts on any Forest Sensitive plant species.

MANAGEMENT INDICATOR SPECIES

AMERICAN MARTEN

Preferred habitat for marten denning and resting is characterized by dense (60 to 100% canopy), multi storied, multi species late seral coniferous forests with a high number of large (> 24 inch dbh) snags and downed logs. These areas are generally in close proximity to both dense riparian corridors (used as travelways), and include an interspersion of small (<1 acre) openings with good ground cover. Alterations of habitat are considered the greatest threat to marten and may even cause local extinctions. The wooded riparian corridors of Silver King Creek and conifer stands surrounding Tamarack Lake may provide suitable areas for the marten to move and rest between foraging and denning sites. Although late seral stands occur adjacent to the proposed project area, denning would be unlikely along Silver King Creek and Tamarack Lake because old growth structure is absent.

No direct effects to marten are expected from the proposed Action. Activities associated with the proposed Action will occur during the day when marten are not typically active. Furthermore, alterations to habitat could potentially disrupt marten denning or resting sites; however, workers will use existing campsites, trails and stream access points during treatment operations.

Indirectly, the proposed Action could affect marten my reducing available prey. Rotenone application could lead to a temporary reduction in invertebrates, amphibians, and fish within the proposed project area and a temporary reduction in marten prey availability. However, the primary food source for martens is small mammals and rodents, which would not be affected by rotenone (see Appendix C). Because martens have a diverse diet and a very large home range, a temporary decrease in fish and amphibians from the treatment process would not have a significant effect on the marten.

Martens could be exposed to rotenone and formulation constituents by feeding on dead fish. However, because rotenone residues are generally extremely low in treated fish, broken down quickly, and readily not absorbed by mammals, ingestion of prey exposed to rotenone would not affect marten (see Appendix C).

Cumulatively, martens may be impacted by an increase in recreation use in the Alpine County area. Although visitors to the Carson Iceberg Wilderness are relatively infrequent compared to other areas in Alpine County, the number of users has increased in the last 10 years and is likely to continue (Steve Hale USFS 2009 pers. comm.). However, martens can generally tolerate human disturbance provided the disturbance is temporary and the marten’s habitat is not impacted (Koehler et al 1975). Currently, there are no foreseeable actions, with the exception of a catastrophic wildfire, that would reduce available habitat for martens in the proposed project area. Based on the above assessment, implementation of the proposed Action may affect individual marten, but will not affect marten habitat and will not lead to a downward trend in the population.

MULE DEER

Summer range for the mule deer is present in the proposed project area. Declining habitat is considered the main reason for population declines of mule deer. The proposed Action would not remove trees or otherwise alter or reduce mule deer habitat.

Mule deer may be temporarily displaced by noise caused by workers and equipment associated with rotenone application. However, this impact would be temporary and mule deer would be expected to return to the area shortly after implementation of the proposed Action. Furthermore, the proposed Action would occur in an area where mule deer are commonly exposed to human disturbance from wilderness hikers and pack stock.

Mule deer likely use Silver King Creek and tributaries that would be treated with rotenone for drinking water. However, the low concentration of rotenone and the rapid dissipation, dilution, flushing and degradation of rotenone in the water would reduce this exposure and not harm mule deer (Appendix C presents the ecological exposure assessment showing exposure of deer and other mammals to chemicals resulting from the proposed Action).

Over the last 30 years, urban development in Carson Valley and the increased traffic on Highway 395 and Highway 88 have led to a loss of critical winter range and a subsequent decline in the Carson River deer herd (Cox 2007). The highways have fragmented migratory routes and led to numerous deer being hit by vehicles. Large scale fires such as the Cannon Fire in 2002 and the Larson Fire in 2007 burned over 30,000 acres, much of which was important winter range for mule deer. Many burned areas have been replaced by invasive or non-native species such as cheatgrass that out-compete native vegetation and provide little forage value for mule deer. Competition from livestock grazing historically may have interfered with deer foraging capability. However, grazing has not occurred in the proposed project area in approximately 15 years with most of the rangelands recovered from past grazing events. The proposed Action will not affect habitat, long term behavior, or population trends and therefore will not add to any cumulative effects to mule deer.

Based on the above assessment, it is expected that some disturbance to mule deer may occur from implementation of the proposed Action. However, the overall disturbance to mule deer is expected to be minor and temporary. Therefore, the proposed Action may affect individual mule deer, but will not affect habitat and will not contribute to a downward trend in the population of the Carson River deer herd.

YELLOW WARBLER, YELLOW-RUMPED WARBLER, HAIRY WOODPECKER, AND WILLIAMSON'S SAPSUCKER

The proposed project area supports a wide diversity of insectivorous birds, including yellow warbler, yellow-rumped warbler, hairy woodpecker, and Williamson's sapsucker. Habitat destruction is the primary threat to all of these species. Reductions in the quality of habitat can also lead to an increase in nest parasitism from brown-headed cowbirds. The proposed Action would not alter, disturb, or eliminate habitat or increase vulnerability to parasitic species, such as the brown-headed cowbird. Reductions in populations of some aquatic insect hatchings would likely result from the rotenone treatment process, which may lead to a temporary reduction in prey availability for yellow warbler, yellow-rumped warbler, and Williamson's sapsucker. This may temporarily cause these species to forage over greater distances (e.g. to untreated tributary areas and upstream of Llewellyn Falls), while insect populations recover within the proposed project area. However, because insects have rapid life cycles and the number of insects affected by the rotenone treatment would be relatively low, the temporary loss of insects from the proposed Action would not cause long term impacts on food availability for these species.

In addition, these species may not feed strictly on aquatic insects lowering their potential exposure to treatment chemicals. For example, hairy woodpeckers feed primarily on wood boring insects and insect larvae found on and in trees. Because rotenone would only be applied to water, it would not affect insects that comprise the hairy woodpecker's diet. Williamson's sapsucker primarily feeds on conifer sap and ants but will occasionally forage on other insects as well. Yellow warblers and yellow-rumped warblers feed on mayflies and damselflies; however, they have a varied diet including many terrestrial insects, such as bees, wasps, ants, moths and caterpillars.

Implementation of the proposed Action may temporarily displace yellow warblers, yellow-rumped wablers, hairy woodpecker, and Williamson's sapsucker; however, direct disturbance would be temporary and of short duration and would not have long-term effects on bird activity. Furthermore, rotenone treatment would be conducted in mid-August to mid-September, which is well outside the nesting season for yellow warblers, thereby minimizing any disturbance to reproduction activities. Based upon these reasons, the proposed Action may temporarily affect individual yellow warblers, yellow-rumped warblers, hairy woodpeckers, and Williamson's sapsuckers, but will not affect habitat and will not contribute to a downward trend in the population of these species.

NORTHERN GOSHAWK

Northern goshawks are typically associated with late seral or old growth forests, characterized by contiguous stands of large trees and large snags with closed canopies (>40%) and an understory which contains varying vertical structure but is not over crowded with "dog-hair" thickets of trees or other vegetation types. Goshawks historically occurred within and adjacent to the proposed project area near Snodgrass Creek, Poison Flat, and Corral Valley Creek. Incidental sightings were reported between 1992, 1996, and 2003 near Snodgrass Creek and Poison Flat. Although nest sites were not located, it is assumed nesting occurred due to behavior of adults and presence of juveniles. In accordance with the SNFPA, both nesting territories are protected by a designated 200 acre protected activity center (PAC). Surveys conducted in these areas and along Silver King Creek in 2008 resulted in no detections of goshawks. Some of the denser pockets of Jeffrey pine located adjacent to Silver King Creek provide suitable habitat for goshawks.

The major threat to goshawk populations is loss of nesting and foraging habitat through land management activities and natural events. The proposed Action will not alter or reduce goshawk habitat nor impact goshawk prey species or their habitat. Human disturbance is another potential threat to goshawk viability. Goshawks will readily abandon nest sites if disturbed during the early stages of nesting, often causing reproductive failure. The proposed Action is occurring in mid-August to mid-September, at a time when juveniles have usually reached independence and have dispersed from their natal area. Therefore, it is determined the proposed Action will have no effect on goshawk habitat and will not cause a downward trend in the population.

SAGE GROUSE

Sage grouse are largely dependent upon sagebrush ecosystems for both foraging and breeding. Breeding sites (or "leks") are usually situated on ridge tops or grassy areas surrounded by a substantial brush and herbaceous component. Nesting habitat for sage grouse is characterized primarily by Wyoming big sagebrush communities that have 15 to 38 percent canopy cover and a grass and forb understory (Terres 1980). Dense sagebrush cover is important to nesting success of sage grouse (Connelly et al. 2000). Sage grouse breed between mid-February and late August with nesting and brood-rearing occurring during May through July (Neel 2001).

Sage grouse have been recorded in Bagley Valley and near Little Antelope Pack Station but are not known to occur in the proposed project area. Although sagebrush occurs along portions of Silver King Creek, the stands are discontinuous and lack sufficient density to support sage grouse. Therefore, it is determined the proposed Action will have no effect on sage grouse habitat and will not cause a downward trend in the population.

NEOTROPICAL MIGRATORY BIRDS

Habitat fragmentation is considered the major factor for population declines in migratory bird species. Urbanization and other land management activities can have short and long term impacts on foraging and nesting habitat of NTMB. Implementation of the proposed Action as described in Chapter 3.0, Project Alternatives, would not alter, disturb, or eliminate habitat for migratory birds. Reductions of some aquatic insect populations would be expected to occur following rotenone treatment applications, which may lead to a temporary reduction in prey availability for several NTMB.

The reduction in prey may temporarily force these species to forage greater distances while insect populations recover. However, it is expected that due to the rapid life cycles of insects and the relatively low numbers of insects to be affected by the proposed Action, the temporary loss of insects from the proposed Action would not be significant to migratory birds. Some bird species may be temporarily displaced from human disturbance associated with the proposed Action. However, disturbance would be temporary and short in duration and would occur outside of the normal breeding season for most NTMB.

The ecotoxicology model presented in Appendix C herein indicates that concentrations of all chemicals used for the treatment process would be well below any of the threshold levels (e.g., No Observed Adverse Effect Level). Therefore, exposure to rotenone and other chemicals would not be significant. Based on all the factors described above, the proposed Action would have less-than-significant impacts on migratory birds.

RIPARIAN OR OTHER SENSITIVE NATURAL HABITATS

The proposed Action would have temporary and less-than-significant impacts on riparian habitats adjacent to the stream corridor. The proposed Action would not involve use of any heavy equipment or any excavation of trees or vegetation removal. The only disturbance would be from foot traffic of workers applying treatment chemicals from the stream banks. Workers will use existing trails to the extent possible, thus the proposed Action would not affect any other sensitive natural habitat identified in local or regional plans, policies, or regulations or by the CDFG or USFWS. Therefore, the proposed Action would have only minor direct impacts on riparian habitat and no indirect effects.

5.2.4.3 Alternative 3: Combined Physical Removal

This non-chemical alternative would include a combination of electrofishing, gill netting, seining, and other physical methods as appropriate to remove non-native trout from Silver King Creek and its tributaries, springs, and Tamarack Lake. Because this method could have low efficiency in a rocky stream environment, it would be implemented over multiple years (i.e., until no fish are found using physical removal techniques). This alternative could be compromised by trout moving into the project area from untreated upstream areas, potentially extending the project duration.

WILDLIFE IMPACTS

Potential indirect effects of electrofishing and other physical removal techniques on wildlife, including the special status species identified above, could result from reductions in aquatic invertebrate populations. These organisms provide an important food source for several indicator wildlife species, such as the willow flycatcher. Benthic macroinvertebrate species would likely be affected by the electrical currents applied to the water during electrofishing, resulting in mortality or drift. Previous studies have shown that drift caused by electrofishing can reduce benthic macroinvertebrate populations by 80 to 90 percent (Taylor et al. 2001). In addition, work crews would cause additional disturbance by walking in the channel, potentially resulting in additional drift (see Section 5.1, Aquatic Resources, for a detailed assessment of potential electrofishing effects on benthic macroinvertebrates). However, benthic macroinvertebrates would be repopulated by upstream populations. Headwater areas above Llewellyn Falls in Upper Fish Valley would not be affected by this Alternative and would provide refugia for recolonization of electroshocked areas. Because electroshocked areas would be recolonized by upstream populations in Upper Silver King Creek as well as tributaries in the project area, indirect impacts on wildlife from disturbance of the benthic macroinvertebrate community from use of physical removal techniques would be temporary and less-than-significant.

Physical removal of fish would be conducted within Silver King Creek, its tributaries, and potentially Tamarack Lake and immediately adjacent areas. Electrofishing of Silver King Creek would result in more physical disturbance from workers walking adjacent to the waterway and within the stream channel. However, electrofishing would be a continuously moving operation and would easily be avoided by most wildlife species present in the area, particularly those that inhabit upland areas, such as wolverine, fisher, American marten, mule deer, hairy woodpecker, and migratory birds.

This Alternative would result in physical disturbance within the riparian corridor adjacent to Silver King Creek and could affect riparian bird species, such as Williamson's sapsucker and willow flycatcher. Workers would conduct the electrofishing operation in the streambed or from the banks. Because the objective would be to remove all fish, crews would be present for an extended period of time compared to the proposed Action (refer to Chapter 3.0, Project Alternatives). Workers would use existing campgrounds and trails; however, the additional activity associated with this Alternative, compared to the proposed Action, could temporarily disturb some birds. However, birds would be expected to return after the fish removal activities are completed, thus this Alternative would not have significant direct impacts on wildlife or their habitat.

This Alternative would also result in more general disturbance associated with camping and movement of work crews and weekly pack stock trips coming in and out of the project area. Because electrofishing equipment would be needed for several weeks, the equipment would need to be recharged in the field or removed from the field for recharge. The Agencies would need to use gasoline-powered generators to re-charge the equipment or use existing electrical service off-site, requiring more use of pack stock. Therefore, the Agencies would use small, gasoline-powered generators that would have minimal impact on wildlife.

Physical removal techniques, including electrofishing, could have direct impacts on populations of mountain yellow-legged frog, Yosemite toad, and tadpoles if present. Worker activities would not affect enough of the streambed or banks to affect amphibian populations significantly. However, the electrical currents required to complete the removal and collection of fish could result in some mortalities. Therefore, Physical Removal would result in significant impacts on amphibians present in the project area during electrofishing.

Impact TR-1: Physical removal techniques could result in mortality of amphibians, including adults and juveniles, from exposure to electrical currents or direct mortality caused by worker activity (less-than-significant).

Similar to the proposed Action, the Agencies would conduct pre-treatment amphibian surveys. If adult or tadpole life stages of any threatened, endangered, sensitive, candidate or rare amphibians are found during pre-project surveys, they will be captured by net and relocated out of the project area to suitable nearby habitat. With implementation of this mitigation measure, impacts of the Physical Removal on mountain yellow-legged frog would be less-than-significant.

Amphibians would also be affected indirectly by the potential effects of electrofishing on aquatic invertebrate communities, as described above for wildlife. However, amphibians are opportunistic feeders and would likely supplement their diet with a variety of aquatic and terrestrial insects until benthic macroinvertebrates populations recover. Headwater areas above Llewellyn Falls in Upper Fish Valley would not be affected by electrofishing and would provide refugia for recolonization of electroshocked areas. Because electroshocked areas would be recolonized by upstream populations in Upper Silver King Creek, as well as tributaries in the project area, indirect impacts on amphibians from disturbance of the benthic macroinvertebrate community from use of physical removal techniques would be temporary and less-than-significant.

RIPARIAN OR OTHER SENSITIVE NATURAL HABITATS

Alternative 3 would have temporary impacts on riparian habitats adjacent to the stream corridor. This Alternative would not involve use of any heavy equipment or any excavation of trees or vegetation removal. The only disturbance would be from foot traffic of workers conducting electrofishing within the stream and from the stream banks. In contrast to the proposed Action, electrofishing would be conducted over a longer period (refer to Chapter 3.0, Project Alternatives). Minor indirect impacts could include effects on stream banks and sedimentation from worker activity. However, the electrofishing would be conducted by Agency personnel with responsibility to protect and conserve natural resources, minimizing any such effects. Furthermore, Alternative 3 would not affect any other sensitive natural habitat identified in local or regional plans, policies, or regulations or by the CDFG or USFWS. Therefore, Alternative 3 would have only minor direct impacts on riparian habitat and no indirect effects.

5.2.5 References

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5.3 HUMAN AND ECOLOGICAL HEALTH CONCERNS

This section addresses potential toxicological impacts on human and ecological receptors from the proposed use of commercial rotenone liquid formulations. Application of rotenone and potassium permanganate to the environment could result in toxic effects on exposed receptors. A detailed screening-level risk assessment analysis that evaluates the risks to humans, aquatic organisms and wildlife from exposure to rotenone formulations and potassium permanganate is presented in Appendix C, Screening-Level Human Health and Ecological Risk Assessment.

5.3.1 Affected Environment

The study area for the risk assessment includes the mainstem of Silver King Creek between Llewellyn Falls and Silver King Canyon, the lower reaches of tributaries and springs (that could support fish), waters immediately downstream of the proposed treatment area including Silver King Canyon and areas downstream of Snodgrass Creek and Tamarack Lake. Air, surface water, groundwater, sediments and biota potentially containing rotenone or formulation constituents are considered potential exposure media in the affected environment. Beneficial uses of Silver King Creek as set forth and defined in the Water Quality Control Plan for the Lahontan Region (the Basin Plan) include municipal and domestic and agricultural water supply as well as agricultural supply, groundwater recharge, contact recreation, fishing, and habitat (see Section 5.4, Water Resources). The following sections provide a general overview of the toxicology and use of rotenone and potassium permanganate to eradicate non-native trout species as part of the proposed Action.

5.3.1.1 Rotenone Toxicity

Rotenone is a naturally occurring chemical obtained from the roots of several tropical and subtropical plant species belonging to the genus *Lonchocarpus* or *Derris*. Rotenone can be extracted with chloroform and determined by ultraviolet spectroscopy or analyzed using high performance liquid chromatography (HPLC) with UV detection. Liquid formulations of rotenone may contain petroleum hydrocarbons as solvents and emulsifiers to disperse rotenone in water (naphthalene, methylnaphthalenes, xylenes, etc.) (WDFW 2002). The proportion of these carriers varies substantially by formulation, and formulations with synergists generally contain far less petroleum-based carrier products. The potential effects on ecological receptors associated with the adjuvants and carriers in the proposed formulations are discussed below.

The proposed Action involves the use of commercial rotenone formulations containing dispersants and emulsifiers such as CFT Legumine™, Noxfish®, and Nusyn-Noxfish®, which are hazardous materials as defined in Title 22, Section 66084 of the California Code of Regulations. Hazardous constituents in the rotenone formulations are summarized in Table 5.3-1 along with their expected aquatic concentrations when fully diluted in the receiving waters.

Table 5.3-1 International (CAS), National (EPA-RC) and State (CDPR) Registration Codes for Chemicals Detected in Rotenone Formulations Proposed for Use in the Silver King Creek Watershed

Chemical Name	Estimated Concentration in Water Treated with 0.5 mg/L product[1]	Estimated Concentration in Water Treated with 1.0 mg/L product[1]	CAS #	EPA-PC #	CDPR Chemical Code
CFT Legumine™ Formulation					
Rotenone (active ingredient)	25.5 µg/L	50.9 µg/L	83-79-4	71003	518
Rotenolone	3.67 µg/L	7.34 µg/L	None	None	4095
1-Methyl-2-pyrrolidinone (Methyl pyrrolidone)	49.5 µg/L	98.9 µg/L	872-50-4	--	--
Diethylene glycol monoethyl ether (Diethylene glycol ethyl ether)	305 µg/L	610 µg/L	111-90-0	11504	2505
1,3,5-Trimethylbenzene (mesitylene)	0.00200 µg/L	0.00400 µg/L	108-67-8	None	5884
sec-Butylbenzene	0.00195 µg/L	0.00390 µg/L	135-98-8	--	--
1-Butylbenzene (n-Butylbenzene)	0.0120 µg/L	0.0239 µg/L	104-51-8	--	--
4-Isopropyltoluene (isopropyltoluene)	0.00255 µg/L	0.00510 µg/L	98-87-6	--	--
Methylnaphthalene	0.0700 µg/L	0.140 µg/L	1321-84-4	54002	942
Naphthalene	0.127 µg/L	0.253 µg/L	91-20-3	55801	421
Fennodefo 99	86.5 µg/L	173 µg/L	--	--	--
NoxFish® Formulation at 0.5 mg/L; Nussyn-Noxfish® at 1.0 mg/L					
Rotenone	25.0 µg/L	25.0 µg/L	83-79-4	71003	518
Piperonyl butoxide	not present	25.0 µg/L	51-03-6	--	--
Rotenolone	7.50 µg/L	15.0 µg/L	None	None	4095
Trichloroethene (Trichloroethylene)	0.0365 µg/L	0.073 µg/L	79-01-6	81202	595
Toluene	0.900 µg/L	1.80 µg/L	108-88-3	80601	1281
1,3- and/or 1,4-Xylene (M/p xylene)	0.305 µg/L	0.610 µg/L	108-38-3/ 106-42-3	--	--
1,2-Xylene (o xylene)	0.0380 µg/L	0.0760 µg/L	1330-20-7	086802	622
Isopropylbenzene	0.0260 µg/L	0.0520 µg/L	98-82-8	None	3116
1-Propylbenzene(n-Propylbenzene)	0.155 µg/L	0.310 µg/L	103-65-1	--	--
1,3,5-Trimethylbenzene (mesitylene)	0.430 µg/L	0.860 µg/L	108-67-8	None	5884
1,2,4-Trimethylbenzene	5.00 µg/L	10.0 µg/L	95-63-6	None	5883
1-Butylbenzene (n-Butylbenzene)	4.50 µg/L	9.0 µg/L	104-51-8	--	--
4-Isopropyltoluene (p-Isopropyltoluene)	0.500 µg/L	1.00 µg/L	98-87-6	--	--
Naphthalene	35.0 µg/L (w/EPA 8260)	70.0 µg/L (w/EPA 8260)	91-20-3	55801	421
Potassium Permanganate (for Rotenone Neutralization)					
Potassium permanganate	2 mg/L-water	4 mg/L-water	7722-64-7	068501	498

[1] Based on chemical analysis of commercial formulations and proposed treatment concentration; concentrations will vary by lot by approximately 10 percent. Data from ENVIRON 2007; Noxfish®: report date 7/9/02, Lab Nos. P-2297, 2298, 2300, 2302). EPA Method 8260, 8270.

[2] Data listed from CDFG Pesticide Laboratory Reports (CFT Legumine®: report date 7/7/04, Lab No. P-2399)

-- No data available

Use of rotenone enables fisheries managers to eradicate entire populations and communities of fish government agencies have conducted substantial research to determine the safety of rotenone for fisheries management applications in the re-registration approval process (Finlayson et al. 2000; USEPA 2006). Section 5.3.2, Regulatory Setting, below provides a detailed discussion regarding EPA and CDPR pesticide registration. The EPA (2006) study found that while risks to terrestrial wildlife and plants were insignificant when rotenone was applied as a piscicide, risks to non-target aquatic organisms could be significant. Because the proposed project area is located within a wilderness area populated by both terrestrial and aquatic non-target species, and because the public expressed concern regarding human exposure, the Agencies conducted a screening-level human and ecological risk assessment to help identify exposure issues and potential mitigation measures needed beyond applying the rotenone formulation according to label directions for fisheries management. Appendix C, Screening-level Human and Ecological Exposure Assessment, presents a literature review of pertinent study findings associated with rotenone toxicity to non-target organisms, including fish, and provides a site-specific assessment of potential exposure effects on aquatic invertebrates, terrestrial wildlife receptors, birds, terrestrial insects, amphibians and reptiles. It also provides a project-specific assessment of whether or not rotenone formulation constituents may have adverse human health effects while accounting for the distance between the proposed project area and human populations and the magnitude and duration of exposure.

5.3.1.3 Potassium Permanganate Toxicity

The neutralization of rotenone would involve the use of potassium permanganate ($KMnO_4$). Potassium permanganate salt, also known as “permanganate of potash,” is a strong oxidizing agent used in many industries and laboratories. It is also used as a disinfectant, especially in the treatment process of potable water. It has been used effectively as a neutralizing compound for rotenone treatments for many years (USEPA 2006; Ling 2003).

Potassium permanganate is toxic to gill-breathing organisms at the rate (2 to 4 mg/L) required for neutralization. However, as it deactivates the rotenone and oxidizes other organic materials in the water, it becomes reduced. The by-product of the oxidation of rotenone by potassium permanganate is manganese oxide, a biologically inactive (or principal detoxifier) compound (CDFG 1994). Appendix C provides a literature review of pertinent study findings associated with potassium permanganate toxicity.

5.3.2 Regulatory Setting

Under the proposed Action, rotenone formulations would be used according to regulatory requirements for the transportation of and treatment involving the use of rotenone formulations for eradicating target non-native fish species. Federal and state regulations impose requirements on the registration and use of pesticides. The regulatory framework pertaining to the use of pesticides is discussed below.

5.3.2.1 Federal Regulations

DEFINITIONS AND REGISTRATION PROCEDURES FOR PESTICIDES AND OTHER CHEMICALS

The USEPA regulates pesticides under two major statutes: the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), Title 7 U.S.C. section 136, et seq., and the Federal Food, Drug, and Cosmetic Act (FFDCA), Title 21 U.S.C. section 301, et seq. Pesticides are defined under FIFRA as, “any substance intended for preventing, destroying, repelling, or mitigating any pest.” FIFRA requires that pesticides be registered (licensed) by the USEPA before they may be sold or distributed for use in the United States, and that they perform their intended functions without causing unreasonable adverse effects on people and the environment when used according to USEPA-approved label directions.

USEPA requires extensive scientific research and supporting test data as part of its pesticide review and approval process before granting a registration for most pesticides. These studies allow the USEPA to assess risks to human health, domestic animals, wildlife, plants, groundwater and beneficial insects, and to assess the potential for other environmental effects. When new evidence raises questions about the safety of a registered pesticide, the USEPA may take action to suspend or cancel its registration and revoke the associated residue tolerance. The USEPA may also undertake extensive special review of a pesticide’s risks and benefits or work with manufacturers and users to implement changes in a pesticide’s use (e.g., reducing application rates, or cancellation of a pesticide’s use).

Special uses of pesticides, outside their original label specifications, can be considered on a case-by-case basis through FIFRA Section 24C (USEPA 1996). However, the use of rotenone as a piscicide is already authorized in the State of California under FIFRA, and a 24C application to the USEPA is not required. The FFDCA authorizes the USEPA to set tolerances, or maximum legal limits, for pesticide residues in food. Thus, the FFDCA does not expressly regulate pesticide use, but residue limits established by this agency may result in a change in the use pattern regulated under FIFRA.

Rotenone was first registered for aquatic use in 1947. The USEPA challenged the re-registration in 1976 (after the enactment of the Clean Water Act) when it became aware of a study that alleged rotenone might be a carcinogen. The conclusions of that study were further evaluated and subsequently disproven by the USEPA (USEPA 1981), and the USEPA concluded that the use of rotenone for fish control did not present a risk of unreasonable adverse effects to humans and non-aquatic wildlife. Notwithstanding, the action initiated a joint federal-state effort to fully evaluate all environmental aspects of rotenone toxicity and environmental fate through a re-registration process. Under the re-registration process, the USEPA is systematically reviewing all pesticides registered before November 1984 to ensure that they meet current testing and safety standards. The USEPA recently released their ecological risk assessment on the re-registration of rotenone (USEPA 2006). This assessment summarized that aquatic risks to non-target aquatic organisms are significant, while risks to terrestrial wildlife and plants were determined to be insignificant when rotenone was applied as a piscicide.

TOXIC SUBSTANCES CONTROL ACT

The Toxic Substances Control Act (TSCA), Title 15 U.S.C. section 2601, et seq., requires regulation of commercial chemicals, other than pesticide products, that present a hazard to human health or to the environment. Thus, TSCA specifies the registration requirements for the rotenone formulation constituents, other than the active pesticide ingredient.

CLEAN WATER ACT AND THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

The discharge of toxic pollutants into the nation’s waters is regulated under the Clean Water Act (CWA), Title 33 U.S.C. section 1251. The CWA provides an integrated approach to protecting aquatic ecosystems and human health by regulating potentially toxic discharges to surface waters through the NPDES permit, and by regulating ambient water quality through numeric criteria and narrative (“beneficial use”) water quality standards defined in the Basin Plan and California Toxics Rule, Title 40 C.F.R. section 131.38. Section 5.4 addresses the more traditional narrative water quality standards, whereas this section address water quality toxics through a screening-level risk assessment. Notably, none of the constituents in the proposed rotenone formulations have promulgated numeric criteria for the protection of aquatic life, and only two constituents, toluene and trichloroethylene, have promulgated numeric criteria under the California Toxics Rule for human health (in both cases, the maximum estimated environmental concentrations in Silver King Creek waters would fall well below the criteria). In California, the SWRCB, through the local Regional Water Quality Control Boards, administers the program and issues the NPDES permits. The release of aquatic pesticides into waters of any state may require an NPDES permit, depending on the pesticide considered, and the conditions proposed for application. The federal Ninth Circuit Court of Appeals has held that an NPDES permit is not required where a pesticide is applied intentionally, in accordance with label instructions, and there is no residue or unintended effect (SWRCB 2005). However, because non-target aquatic species would be affected by the proposed rotenone treatment, an NPDES permit would be required. The NPDES permit will specify conditions to prevent the permanent degradation of beneficial use designations for waters in the Silver King Creek Watershed from rotenone treatment and neutralization if the proposed Action is selected for removal of non-native fish from the proposed project area.

The Agencies have applied for a project-specific NPDES permit for rotenone application. The NPDES permit for the proposed Action would contain receiving water limits applicable to rotenone projects as contained in the Basin Plan. It would also require water quality monitoring to verify compliance with receiving water limits within the proposed project area and in downstream waters both during and after the treatment.

SAFE DRINKING WATER ACT OF 1974

The Safe Drinking Water Act (SDWA), Title 42 U.S.C. section 300(f), et seq., was adopted in 1974 to protect the quality of public drinking water and its sources. USEPA sets standards for drinking water quality and oversees the states, localities and water suppliers who implement those standards.

5.3.2.2 State of California

STATE REGISTRATION OF PESTICIDES AND COMMERCIAL CHEMICALS

California’s programs addressing product registration of pesticides and commercial chemicals, licensing and certification, data review and evaluation and pesticide residue monitoring closely parallel federal programs. However, California data requirements are stricter than federal requirements and are California-specific (e.g., manufacturers must prove their products are effective and can be used safely under California conditions). The registration of pesticides and commercial chemicals in California is within the jurisdiction of the California Environmental Protection Agency (CalEPA).

The California Department of Pesticide Regulation (CDPR), a department overseen by the CalEPA, coordinates a number of programs to regulate pesticides to include product evaluation and registration through use enforcement, environmental monitoring, residue testing and re-evaluation, if deemed appropriate. The CDPR works with county agricultural commissioners who act as local pesticide enforcement authorities. CDPR also evaluates, conditions, and approves or denies permits for restricted-use pesticides; certifies private applicators; conducts compliance inspections; and takes formal compliance or enforcement actions. California's pesticide regulatory program has been certified by the Secretary of Resources as meeting the requirements of CEQA (CDPR 2006). The State of California also requires commercial growers and pesticide applicators to report commercial pesticide applications to local county agricultural commissioners. The CDPR compiles this information in annual pesticide use reports. Agricultural use comprises a vast majority of the total reported annual pesticide use while nonagricultural uses, like that associated with some of the project alternatives, comprise approximately 4% of the annual use. In addition to pesticide applications for fisheries management, other nonagricultural uses of pesticides include: pest control of right-of-ways, fumigation of nonfood and non-feed materials, pesticide research and regulatory pest control in the ongoing control and/or eradication of pest infestations (CDPR 2003).

HEALTH AND SAFETY CODE SECTION 116751

Health and Safety Code section 116751 prevents CDFG from introducing a pesticide into surface or groundwater drinking supplies unless the Department of Health Services (DHS) determines the activity will not have an adverse impact. DHS is responsible for evaluating the short- and long-term effect(s) of pesticide use on water quality and for ensuring alternative water supplies are available during pesticide applications that may contaminate drinking waters. Health and Safety Code 116751 requires a standard of "non-detect" for formulation constituents for their approval of safety. DHS also has the authority to set non-regulatory advisory levels, such as the "notification levels" for some of the inert ingredients in the rotenone formulations.

THE SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT OF 1986

The Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) was enacted as a ballot initiative in November 1986. The proposition was intended to protect California citizens and the state's drinking water sources from chemicals known to cause cancer, birth defects, or other reproductive harm and to inform citizens about exposures to such chemicals. Proposition 65 requires the governor to publish, at least annually, a list of chemicals known to the state to cause cancer or reproductive toxicity. The following chemicals are currently listed under Proposition 65 and are components of one or both of the liquid rotenone formulations: N-methyl pyrrolidone (found in CFT Legumine™ formulation), naphthalene (found in CFT Legumine™ and NoxFish® formulations), toluene (found in NoxFish® formulation), and trichloroethylene (found in NoxFish® formulation) (OEHHA 2008).

The regulation lists an allowable daily amount (presented in µg/day) that may be contacted for each listed chemical (OEHHA 2008). For the carcinogens, such as naphthalene and trichloroethylene, the allowable amounts listed are based on the assumption that daily exposure to the compound occurs continuously over a 70-year lifetime. Because the proposed Action for Silver King Creek is a short-term exposure, these ingestion values are extremely conservative, and, therefore, not appropriate for assessing exposure from this action.

PROPOSITION 65

Three inert ingredients present in one or both proposed rotenone formulations (N-methyl-2-pyrrolidone, ethylbenzene and naphthalene) are on the Proposition 65 list of chemicals known to the State of California to cause cancer or reproductive toxicity. The Proposition 65 statute is contained in California Health and Safety Code sections 25249.9-25249.13. Proposition 65 prohibits the discharge of chemicals known to cause cancer or reproductive toxicity. The State Attorney General's Office is the State agency responsible for enforcing Proposition 65. Section 25249.11(b) specifically exempts State Agencies from the statute's provisions. Therefore, as a State agency, CDFG is exempt from Proposition 65.

5.3.3 Assessment Criteria and Methodology

5.3.3.1 Significance Thresholds

Enforceable criteria established by federal or state agencies to be protective of human and/or ecological health were used as the default thresholds for interpreting whether a potentially adverse impact was significant to human or ecological health. In the absence of such criteria, health-based *guidance levels* proposed by federal or state agencies as protective of human and ecological health were used, when appropriate, to evaluate the short-term exposure associated with the proposed Action. Estimated environmental exposure concentrations or "doses" were compared with these criteria and guidance levels. Human and ecological exposures to rotenone, formulation constituents, and potassium permanganate were evaluated to determine if they would:

- Exceed a literature-based toxicity reference value (i.e., threshold) for aquatic toxicity in aquatic animals.
- Exceed a literature-based toxicity reference value for ingestion and/or inhalation uptake in relevant terrestrial or avian wildlife.
- Exceed regulatory guidance or human health based screening level for inhalation risk.

5.3.3.2 Evaluation Methods and Assumptions

A screening-level ecological and human risk assessment was the principal method used to evaluate human and ecological health impacts associated with the use of hazardous materials under the proposed Action (refer to Appendix C). The risk assessment includes analysis of the potential hazards of the active ingredient (rotenone), volatile and semivolatile solvents, emulsifiers and other dispersant ingredients identified in the proposed commercial rotenone formulations. It reviews hazards due to direct toxicity and bioaccumulation potential. It also includes an assessment of the environmental fate of the compounds, including their partitioning within the environment, and rates and mechanisms by which the compounds naturally biodegrade so that they do not persist in the environment over long periods.

The evaluation of human health and ecological risks followed established regulatory guidance designed to evaluate the presence of chemicals in the environment and their potential for adverse health effects when those chemicals are contacted (USEPA 1991 and 1998, CalEPA 1996). For humans, both cancer and non-cancer risks were considered. Only non-cancer risks were considered for risks to ecological receptors, as the state of the science does not permit a reliable interpretation of the effects of the environmental chemicals on cancer incidence in animals. In brief, these methods involve: (1) an analysis of the toxicity hazards identified from the scientific literature, (the "hazard assessment"); (2) an analysis of potential exposure in ecological receptors from air, sediment, water and/or food (the "exposure assessment"); and (3) a comparison of exposure to toxicity thresholds (the "risk characterization").

The environmental exposure concentrations (doses) of hazardous materials in the rotenone formulations were estimated through exposure modeling. Water concentrations were estimated based on the assumption of complete mixing of rotenone and the rotenone formulation constituents identified in the undiluted commercial products

The methodology for estimating ingestion doses in wildlife is described in Appendix C. To characterize risks to fish and wildlife species, estimated exposure doses were compared against toxicity thresholds by calculating a "hazard quotient" (HQ). The HQ is derived by dividing the estimated exposure or dose by the relevant toxicity threshold. Hazard quotients for fish and aquatic invertebrates were calculated only for rotenone, as the immediate effects of the active ingredient in the aquatic system overwhelm the potential effects of the inert dispersant ingredients. The "Level of Concern" (LOC) associated with the calculated HQ was determined based on whether the estimated dose was compared against an LD_{50} value or a No-Observed-Adverse-Effect Level (NOAEL) toxicity threshold value from the scientific literature. The LD_{50} value is the dose (usually per body weight) that is lethal to 50 percent of the test population. A more detailed discussion of these toxicity values and their significance is provided in Appendix C.

5.3.4 Environmental Impact Assessment

This section evaluates the potential impacts of the proposed Action and its alternatives on human and ecological health based on potential exposure to applied rotenone formulations and the neutralizing agent (potassium permanganate). Appendix C presents the screening-level human and ecological risk assessment of the potential toxic effects of rotenone on biological resources in the proposed project area.

5.3.4.1 Alternative 1: No Action

The No Action alternative would not involve the application of rotenone or other chemicals and therefore would not result in significant adverse impacts or risk of exposure of human or ecological receptors to rotenone or its formulation constituents or potassium permanganate. Therefore, no hazardous chemicals would be transported to the area or used in conjunction with this alternative.

5.3.4.2 Alternative 2: Proposed Action (Rotenone Treatment)

The paragraphs below evaluate potential impacts from exposure to formulations of CFT-Legumine™, Noxfish®, and Nusyn-Noxfish® applied to waters in the proposed project area as well as the rotenone formulation constituent concentrations estimated in Table 5.3-1. This assessment also evaluates effects from exposure to potassium permanganate applied at the proposed downstream neutralization station near Snodgrass Creek.

CREATE A SIGNIFICANT HAZARD TO THE PUBLIC

USE OF HAZARDOUS MATERIALS – ROTENONE FORMULATIONS

Because the land surrounding the proposed project area is a designated wilderness, there are restrictions on land use and human activities. Human presence in the project area is limited. Prior to the rotenone application, and throughout the treatment process, the public will be notified through the use of signs located at trailheads and other strategic places of the treatment process.

Thus, the only human receptors would likely be workers applying the chemical formulations. Worker exposure would be minimized by the use of the necessary personal protective equipment (PPE) and the development of the project health and safety plan by the Agencies prior to rotenone application.

Research conducted to date on the potential effects of rotenone on public health have concluded that rotenone does not cause birth defects, reproductive dysfunction, gene mutations, or cancer (Abdo 1988). When used according to label instructions for the control of fish, rotenone poses little, if any, hazard to public health (American Fisheries Society's Task Force on Fishery Chemicals 2000).

Public comments submitted in response to the Notice of Intent expressed concern about the potential effects of rotenone on human health, specifically any causative relationship with Parkinson's disease. Parkinson's disease is a degenerative disorder of the central nervous system that often impairs the sufferer's motor skills, speech, and other functions. Symptoms of the disease usually include limb tremors and occasional rigidity. The causes of Parkinson's disease are diverse and complex. Some cases can be attributed to genetic factors and several mutations have led to familial Parkinson's disease, among members of the same family (Giasson and Lee 2000).

Public concern over links between rotenone use and Parkinson's disease likely results from an Emory University study (Betarbet et al. 2000) that demonstrated that rotenone produced Parkinson's-like anatomical, neurochemical and behavioral symptoms in some laboratory rats when administered chronically and intravenously. In the study, 25 rats were continuously exposed to 2 to 3 mg for 5 weeks by direct injection into the right jugular vein. The authors observed, however, that "rotenone seems to have little toxicity when administered orally." In fact, investigators could not administer rotenone in any other manner except intravenously to deliver rotenone to the brain; otherwise, rotenone would have been neutralized in the gut and liver (American Fisheries Society's Task Force on Fishery Chemicals 2000). This study did not show a cause-and-effect relationship between rotenone exposure and Parkinson's disease.

Due to the remoteness of the proposed project area, the distance to any downstream human population, and the likelihood of exposure during and after treatment (see Chapter 3.0, Project Alternatives), human exposure pathways were considered incomplete in the risk assessment (refer to Appendix C). For these reasons, no impacts from the use of rotenone formulations or the neutralizing agent would occur in humans. The application of rotenone formulations poses a less-than-significant impact on human health, and no mitigation measures would be required.

CREATE A SIGNIFICANT HAZARD TO THE ENVIRONMENT

To prevent the release of rotenone downstream of the treatment area, potassium permanganate, an oxidizing agent, will be used for neutralization. When balanced to rotenone concentrations and organic loads in the stream, in-stream neutralization poses essentially no risk to human or ecological health. Rotenone is rapidly neutralized and permanganate is subsequently reduced. Neither persists in the environment. However, neutralization presents the risk of human and equipment error that is difficult to predict. In the event of an unintentional release, monitoring at 30 minute intervals, approximate travel time for potassium permanganate residual, would reduce this risk/impact to a level of less-than-significant.

Because potassium permanganate can be toxic, care must be applied when using it to make sure the rotenone is neutralized, while minimizing the amount of excess potassium permanganate in the water. Overdosing with potassium permanganate occurred in 1992 on Silver King Creek (CDFG 1994) and in Big Grizzly Creek following the 1997 treatment. This resulted in unintentional fish kills on both systems. The Agencies do not believe that this will occur under the proposed Action, because they will be employing the monitoring methodologies as outlined in Parmentor and Fuujimura (1995) and further refined by Fujimura (2007) that have greater precision for measuring potassium permanganate. These methodologies utilize field colorimeters and chlorine meters to measure the concentration of potassium permanganate and residual potassium permanganate after colloidal material is removed (Parmentor and Fujimura 1995, Fujimura 2006). As part of the proposed Action, to mitigate the potential effects of applying excess potassium permanganate to downstream fish populations, the Agencies will place "sentinel" fish in cages downstream of the neutralization station. Mortality of these fish would alert workers to potential releases of excess chemical in the event of human or equipment error and potential downstream effects.

AQUATIC INVERTEBRATES

The screening-level risk assessment (Appendix C) evaluated exposure of aquatic invertebrates to rotenone and formulation constituents applied to stream water. Because of the known toxicity of rotenone to benthic macroinvertebrates, water exposure was considered a reasonable worst case exposure scenario. The concentrations of the other formulation ingredients at their respective application rates (refer to Appendix C) were several orders of magnitude than the acute lethal (LC_{50}) concentrations, so additional assessment of the inactive ingredients were not specifically evaluated. Because of the degree of direct exposure to water-borne rotenone, exposure to rotenone-absorbed sediment was not considered a significant exposure pathway. The risk assessment found that at the proposed treatment concentrations, the proposed Action would not expose most aquatic invertebrate taxa to lethal concentrations of rotenone. Cladocerans and several other invertebrate species could be affected by the treatment (see Table C-19, Appendix C).

Although many aquatic invertebrate taxa would likely survive the proposed chemical treatment, benthic population levels would be affected in the short term. The proposed Action would likely result in changes in benthic invertebrate community composition through treatment induced downstream drift and mortality of sensitive species. However, because upstream areas would not be treated, aquatic invertebrates from these areas would speed re-colonization of the treated area and restoration of species composition and ecological function. Recovery of populations particularly sensitive to rotenone would depend on the individual species' ability to re-colonize from nearby habitats. Sections 5.1, Aquatic Resources, and Section 5.4, Water Resources, present detailed evaluations of the potential effects of rotenone treatment on species composition of sensitive, rare, and endemic species, and on the challenges associated with distinguishing between the effects of rotenone treatments and other phenomena, including natural disturbances and sampling artifacts, including those related to natural variability.

If the Agencies treat Tamarack Lake, impacts on invertebrates including limnetic zooplankton and benthic invertebrates could be significant in the short term. However, after the 1997 rotenone treatment of Lake Davis, California, overall zooplankton abundance recovered to approximately 300 percent of pre-treatment levels within one year (CDFG 2006). Further, all zooplankton taxa observed before the treatments were identified after population recovery. Recovery of zooplankton populations after treatment is similar to the response seen when grazing by fish is removed. Therefore, zooplankton populations would likely return within months, with full recovery within 1 year.

Impact HEH-1: The proposed Action will result in temporary changes in species composition in non-target aquatic invertebrate communities (Significant and Unavoidable).

There are several mitigating factors. The treatment area is of limited geographic range. The proposed Action does not involve treating the headwaters above Llewellyn Falls or fishless portions of tributaries or springs; these areas would remain as important sources for recolonization and could contain the same rare and endemic species that may occur in the proposed project area. In addition, the Agencies would use lower rotenone concentrations than have been used in the past to minimize impacts on benthic invertebrates. However, this impact would remain significant and unavoidable after mitigation.

AQUATIC INVERTEBRATES

No special-status benthic macroinvertebrate species are known to occur in Silver King Creek; therefore, the proposed Action would have no impact on state or federally listed species. However, rotenone treatment could potentially result in the temporary or permanent loss of rare or endemic species existing in Silver King Creek that have not been identified or described. Therefore, this potential impact cannot be quantified because of a number of factors that hamper full characterization of the stream community (see Section 5.1, Aquatic Biological Resources) and no mitigation or post-treatment monitoring is available beyond those moderating factors and other measures presented in Section 5.1, Aquatic Biological Resources. Therefore, as described in Section 5.1, Aquatic Biological Resources, this impact would remain significant and unavoidable after mitigation.

AMPHIBIANS

Amphibians, particularly gilled larvae, if present, could be adversely impacted through uptake of rotenone from the water across their gills (Fontenot et al. 1994). Risks to larval stages of amphibians were considered potentially significant (refer to Table C-19 in Appendix C). Impacts to amphibians would be significant if gill breathing life stages are present in Silver King Creek, its tributary streams and springs at the time of treatment (i.e., late August). Special-status amphibian species that could occur in the proposed project area are the mountain yellow-legged frog and the Yosemite toad (refer to Section 5.2, Terrestrial Biological Resources, regarding the potential for occurrence of Yosemite toad in the proposed project area).

Dietary uptake was also considered a complete pathway (refer to Appendix C). Risks to amphibians from ingestion of food and water were considered potentially significant for rotenone, if CFT Legumine™ were to be applied at the maximum 1.0 mg/L formulation rate. The ingestion pathway did not indicate a significant risk for Noxfish®, Nusyn-Noxfish® or the 0.5 mg/L application rate for CFT Legumine™ (refer to Appendix C).

Based on an analysis of the treatment concentrations relative to species' sensitivity, amphibians could be significantly impacted by the proposed Action through direct rotenone exposure and uptake with food and water (refer to Appendix C). Mortality of Yosemite toads from the treatment is not considered likely because by mid-August gill breathing juveniles, that may be present in the creek and its tributary streams and springs earlier in the year, would be absent. Juvenile mountain yellow-legged frog tadpoles may reside in the stream at the time of treatment. In addition, although this species could occur in the proposed project area, it has not been documented in recent surveys (2001 to present); thus, the potential for its occurrence would be low. Further, during these annual surveys, the Agencies relocate juvenile amphibians to outside the proposed project area. Therefore, any impacts from rotenone treatment on mountain yellow-legged or Yosemite toad would be less-than-significant.

TERRESTRIAL AND AVIAN WILDLIFE

In contrast to the potential impacts on fish, aquatic invertebrates, and amphibians, the risk assessment concluded that rotenone formulation exposure for all terrestrial and most avian wildlife species through food chain exposure, primarily through ingestion, would be less-than-significant. The exception was the marsh wren. The NOAEL for the marsh wren was exceeded for CFT Legumine™ applied at the 1.0 mg/L application rate; however, the LOAEL-based HQs were all far less than 1 for the avian species. All LD_{50}-based HQs were far less than 0.1. These results indicate that adverse affects to birds from the proposed Action are very unlikely (refer to Appendix C).

Along with rotenone, the primary constituents of CFT Legumine™, Noxfish®, and Nusyn-Noxfish® were evaluated for toxicity to birds and mammals through the ingestion pathway. The three most concentrated constituents in CFT Legumine™ evaluated were diethylamide monoethyl ether, 1-methyl-2-pyrrolidinone and Fennodefo 99™. The primary chemicals evaluated for Noxfish® were naphthalene, toluene and 1, 2, 4-trimethylbenzene. None of the calculated ingestion doses exceeded relevant toxicity thresholds for any of these constituents, nor did any calculated HQs exceed the more conservative LOCs developed by the USEPA (1998) (refer to Table C-17 in Appendix C). Similarly, exposure to the most concentrated rotenone formulation constituents (i.e., the “inert” ingredients) did not pose a risk to terrestrial or avifauna.

The terrestrial and avian risk assessment used a conservative food web modeling process to estimate exposures via the ingestion of water, food and sediment or soil. The daily ingestion rates of water, food and soil or sediment from the Wildlife Exposure Factors handbook (USEPA 1993). All water consumed was assumed to contain the maximum concentration of the ingredient being assessed. For carnivorous receptors (marsh wren, bald eagle, California wolverine, Sierra Nevada red fox, black bear, Yosemite toad and mountain yellow-legged frog), all food was assumed to be aquatic organisms that were in equilibrium with the water. Simple bioconcentration factors (BCFs) were used to estimate the ingredient concentrations in food (i.e., fish and invertebrates). Equilibrium partitioning was used to estimate the ingredient concentrations in sediments. For herbivores and other upland-foraging receptors (northern bobwhite quail, hairy woodpecker, mouse, pygmy rabbit, and mule deer), all food and ingested soil was assumed to contain the ingredients being assessed at concentrations equal to the water (bioaccumulation factors = 1) to address the possibility that streamside vegetation received overspray during application. Essentially, all wildlife were assumed to drink and eat only from the stream and banks, which is a very conservative approach; since wild animals are mobile and forage over a large range, thus increasing their likelihood of ingesting uncontaminated food.

Based on conservative food web modeling, wildlife exposure to rotenone formulation constituents would not result in adverse affects to most terrestrial or avian wildlife. Only birds such as marsh wren nestlings and adult amphibians could be exposed to rotenone at concentrations of concern, and then only at the highest application rate (1.0 mg/L) of CFT Legumine™, and only if they ate a diet consisting solely of aquatic insects that were in equilibrium with the maximum possible concentration of rotenone.

5.3.4.3 Alternative 3: Combined Physical Removal

Alternative 3 would employ mechanical removal methods instead of chemical methods to eradicate the non-native trout from Silver King Creek. Therefore, Alternative 3 would not result in any toxicological hazard to human or ecological receptors.

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5.4 WATER RESOURCES

This section describes the hydrology and water quality of the proposed treatment area and addresses potential hydrologic and water quality impacts of the proposed Action and its alternatives, including impacts from application of rotenone and potassium permanganate and the implementation of the proposed Action on water toxicity, turbidity, dissolved oxygen, bacteria concentrations, and color. Potential toxic effects from human and ecological exposure to rotenone formulation constituents and the neutralization agent, potassium permanganate, are addressed in Section 5.3, Human and Ecological Health Concerns.

5.4.1 Affected Environment

Silver King Creek is located on the eastern slope of the Sierra Nevada Range in Alpine County, California. The proposed project area occurs within the Carson-Iceberg Wilderness on National Forest System lands administered by the Carson Ranger District, Humboldt-Toiyabe National Forest (see Figure 1-1). This section describes existing hydrology and surface water quality in Silver King Creek and its tributaries based on data and information collected during previous stream surveys and monitoring programs.

5.4.1.1 Physical Conditions

Silver King Creek is a tributary of the East Fork Carson River, which drains into the Lahontan Basin. Silver King Creek’s headwaters are located approximately 9,600 feet above msl and the creek flows in a northerly direction through three distinct valleys where it meets the East Fork Carson River. The total length of the creek is 14 miles with an average gradient of 4.1% and a minimum gradient of 1.6%.

Figures 1-1 and 3-1 depict the reaches of Silver King Creek, including the valleys and tributary features described below. The upper reaches of the creek flow through stringer meadows and Upper Fish Valley. The stream is a typical meandering meadow creek approximately 12 feet wide and 1 foot deep in the summer. Several soda springs and tributaries (Four Mile Canyon Creek, Bull Canyon Creek, and Fly Valley Creek) flow into the upper reaches of Silver King Creek. Fly Valley Creek forms the southwestern portion of the headwaters. From the southeast, Four Mile Canyon Creek enters 1.2 miles (2.0 kilometers) above Llewellyn Falls, while Bull Canyon Creek joins the mainstem from the west 0.5 mile (0.8 kilometer) above Llewellyn Falls (USFWS 2004).

The proposed treatment area begins at Llewellyn Falls, at an elevation of 8,000 feet (2,348 meters), is located at the head of Lower Fish Valley, some 10 miles (16.2 kilometers) above the confluence with the East Fork of the Carson River (USFWS 2004). The vertical drop of Llewellyn Falls is approximately 20 feet.

The stream gradient increases downstream of Llewellyn Falls and into the treatment area. Several tributaries join Silver King Creek between Llewellyn Falls and its confluence with the East Fork of the Carson River as follows. Tamarack Lake Creek and an unnamed creek flow into Lower Fish Valley. Tamarack Creek and Coyote Valley Creek join Silver King Creek below the steeply-sloped Long Valley. An unnamed tributary from the Poison Flat area flows into Silver King Creek just above Silver King Canyon.

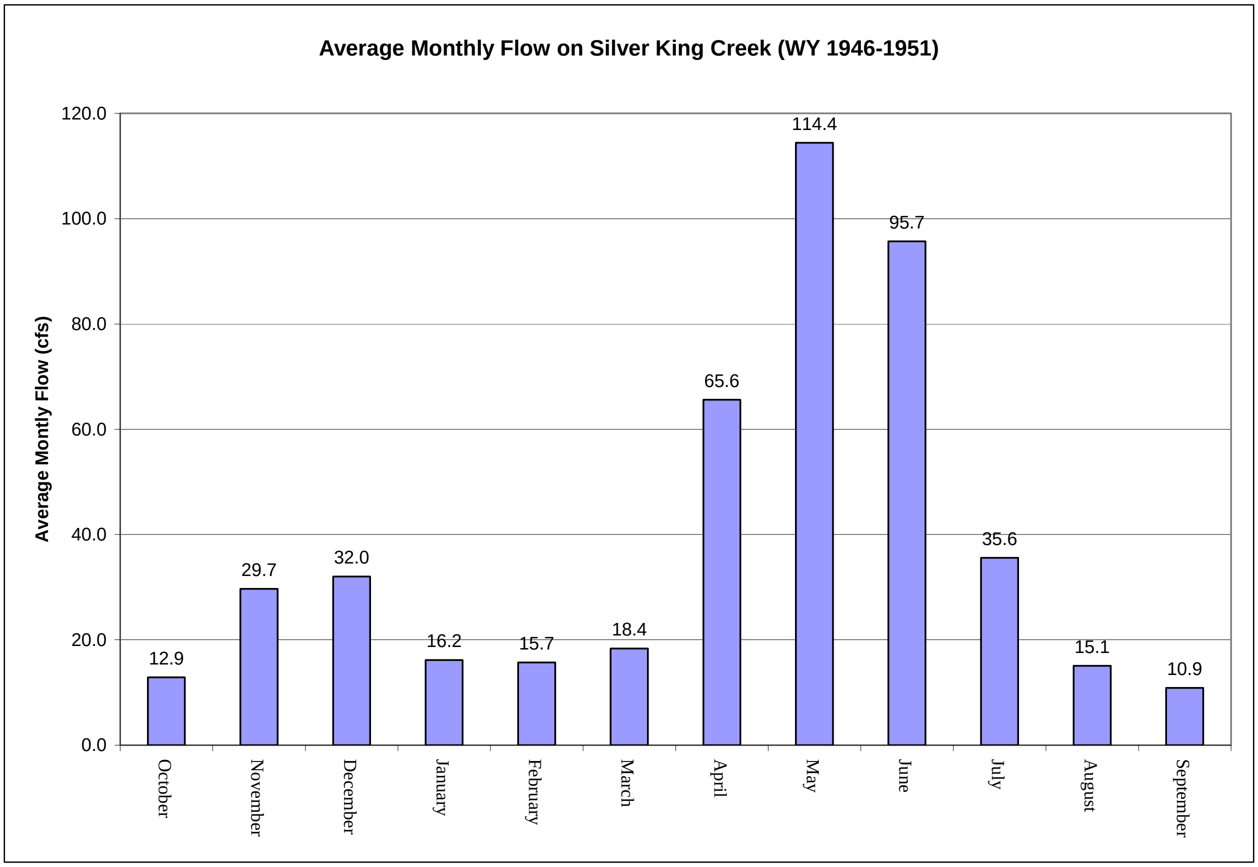
Approximately 2 miles downstream of the confluence with Coyote Valley Creek, Silver King Creek flows through Silver King Canyon. Through this canyon, a series of falls pose a natural barrier to upstream fish passage. At the bottom of the canyon, Snodgrass Creek joins Silver King Creek, which flows another 3.4 miles to its confluence with the East Fork Carson River at an elevation of 6,400 feet.

Three small lakes occur in the drainage; 1) Tamarack Lake, 2) Whitecliff Lake, and 3) an unnamed lake in the headwaters of Four Mile Canyon Creek. Tamarack Lake is the only lake in the treatment area. It has a surface area of approximately 5 acres and is located in the southwest portion of the treatment area at the head of Tamarack Lake Creek (refer to Figure 3-1).

The climate of the proposed project area is influenced by its proximity to the Pacific Ocean. The seasonal weather patterns consist of wet winter and spring months and dry summer months. The majority of the precipitation falls as snow during the winter. Individual storms may produce more than five feet of snow. The variability in precipitation influences flows in Silver King Creek, with low flow periods during the summer months and higher flows during the winter and spring months (see Section 5.4.1.2, Hydrology, below).

5.4.1.2 Hydrology

Flow data for Silver King Creek and its tributaries are limited. The U.S. Geological Survey (USGS) operated one stream gage on Silver King Creek from October 1, 1946, through September 30, 1951. The gage was located approximately 1.6 miles upstream from the confluence with Snodgrass Creek, within the proposed treatment area. Although the elimination of grazing has allowed vegetation to recover and potentially mute flows, land use within this area has not altered significantly (e.g. additional of impervious surfaces, stream diversions) since the early 1950s. Therefore, excluding other factors such as climate change, these historical flow records approximate current seasonal stream flow fluctuation patterns. The mean annual flow on Silver King Creek was 37 cubic feet per second (cfs) for the period of record. Figure 5.4-1 depicts the average monthly flows. These historical flow records indicate flows are dominated by snowmelt, which begins in March and peaks in April and May, then gradually decreases throughout the summer. During mid-August to mid-September, the planned treatment period, average monthly flow was approximately 15 cfs and 10.9 cfs, respectively. Because limited data are available, stream flows in August and September in any particular year could be higher or lower.



Source: USGS

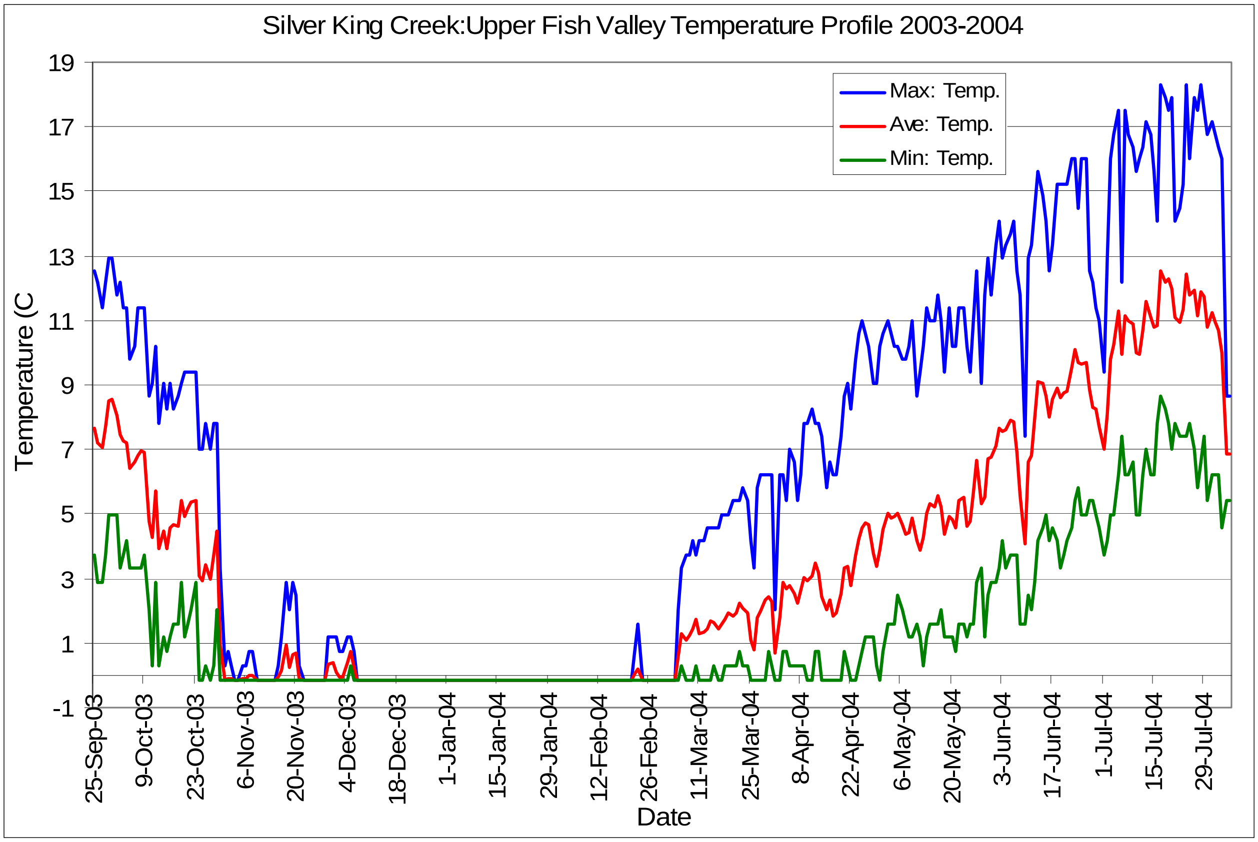
Figure 5.4-1 Average Monthly Flows Recorded on Silver King Creek (1945-1951)

5.4.1.3 Water Quality

The Water Board considers water quality in Silver King Creek to be ‘exceptional’ (LRWQCB 1995). Silver King Creek Watershed is within a designated wilderness area and is undeveloped.

The beneficial uses of Silver King Creek, as set forth and defined in the Water Quality Control Plan for the Lahontan Region (the Basin Plan), are: Municipal and Domestic Supply; Agricultural Supply; Groundwater Recharge; Water Contact Recreation; Non-contact Recreation; Commercial and Sport Fishing; Cold Freshwater Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species; and Spawning, Reproduction and Development (LRWQCB 1995).

Water temperature data were recorded in Silver King Creek at Upper Fish Valley (elevation 8,088 feet) between September 25, 2003 and August 5, 2004 (Figure 5.4-2). Average daily summer stream temperature was less than 13 degrees Celsius (°C). The highest maximum daily water temperature was 18.3°C, reached in mid-July. These data suggest that July may be the month of peak temperatures with gradual cooling through August and September. The stream was iced over from early December through February. A similar temperature regime can reasonably be expected during implementation of the proposed Action or its alternatives.



Source: Humboldt-Toiyabe National Forest

Figure 5.4-2 2003-2004 Temperature Profile for Silver King Creek: Upper Fish Valley, Carson Ranger District.

Dissolved oxygen (DO) and pH (measure of acidity or alkalinity) were measured at 14 stream sites within or proximal to the treatment area during annual biological surveys conducted by the Agencies in July and August 2003 (Table 5.4-1). Dissolved oxygen ranged from 9.9 to 12.8 milligrams per liter (mg/L) (close to saturation), and pH ranged from 5.7 to 7.1. The majority of the measurements were below 7.0. These data are reasonably representative of water quality in the treatment area, and indicate neutral, highly oxygenated waters are predominant in the entire project area.

Table 5.4-1 Dissolved Oxygen and pH in Silver King Creek and Tributaries. Single Measurements at Each Site, July and August 2003

Water Body Name	pH	DO (mg/L)
Silver King Creek (Upper Fish Valley)	6.0	12.8
Silver King Creek (Upper Fish Valley)	5.7	12.4
Silver King Creek (Upper Fish Valley)	6.1	11.8
Silver King Creek (Upper Fish Valley)	6.6	11.9
Silver King Creek (Lower Fish Valley, Upstream)	6.8	11.0
Silver King Creek (Lower Fish Valley, Downstream)	7.1	11.5
Silver King Creek (Long Valley, Upstream)	6.5	10.1
Silver King Creek (Long Valley, Downstream)	6.8	10.1
Corral Valley Creek (Downstream)	7.0	11.7
Corral Valley Creek (Upstream)	6.8	11.0
Coyote Valley Creek (Downstream)	6.5	10.4
Coyote Valley Creek (Upstream)	6.7	9.9
Tamarack Creek (Upstream)	6.6	11.2
Tamarack Creek (Downstream)	6.6	11.4

5.4.2 Regulatory Setting

5.4.2.1 Federal

The federal agencies with jurisdiction over surface and subsurface hydrology and water quality include the USEPA, U.S. Army Corps of Engineers (USACE), USFWS, and USFS. Specific regulations that relate to inland and coastal water resources are described below.

CLEAN WATER ACT OF 1972

Enacted in 1972, the Federal Clean Water Act (CWA), Title 33 U.S.C. section 1251, et seq., and subsequent amendments outline the basic protocol for regulating discharges of pollutants to waters of the United States. It is the primary federal law regulating water quality of the nation’s surface waters, including lakes, rivers, and coastal wetlands. Enforced by the USEPA, it was enacted “… to restore and maintain the chemical, physical, and biological integrity of the Nation’s waters.” CWA authorizes states to adopt water quality standards and includes programs addressing both point and non-point pollution sources. It gives the USEPA the authority to implement pollution control programs, such as setting wastewater standards for industry and water quality standards for surface waters, and established the NPDES. Under Section 402 of CWA, a discharge of pollutants to navigable waters is prohibited unless the discharge is in compliance with an NPDES permit. The USEPA and other agencies have developed numeric and narrative water quality criteria to protect aquatic life and to protect aesthetic water quality. The following subsections describe the portions of CWA applicable to the proposed Action and its alternatives.

SECTION 303(D)–IMPAIRED WATER BODIES AND TOTAL MAXIMUM DAILY LOADS

Section 303(d) of CWA requires states to identify waters where the permit standards, any other enforceable limits, or adopted water quality standards are still unattained. These lists of prioritized impaired water bodies, known as the “303(d) lists,” are submitted to the USEPA every two years. Once a stream is placed on the list, CWA requires that the state develop a plan to reduce pollution. States must submit this list to the USEPA every two years. The law requires the development of total maximum daily loads (TMDLs) to improve water quality of impaired water bodies. TMDLs are the quantities of pollutants that can be safely assimilated by a water body without violating water quality standards. States are developing TMDLs for impaired water bodies to maintain beneficial uses, achieve water quality objectives, and reduce the potential for future water quality degradation.

SECTION 402–NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

The USEPA determined that California’s water pollution control program has sufficient authority to manage the NPDES program under state law in a manner consistent with CWA. Therefore, the SWRCB and 9 RWQCBs implement and enforce the NPDES program. These agencies also implement the Waste Discharge Requirements (WDR) Program, which regulates discharges of waste to land or groundwater under the California Water Code (CWC).

Issued in 1972, the NPDES regulations initially focused on municipal and industrial wastewater discharges, followed by storm water discharge regulations, which became effective in November 1990. NPDES permits for wastewater and industrial discharges specify discharge prohibitions, effluent limitations, monitoring and reporting.

In implementing the NPDES program, the RWQCB protect beneficial uses of waters, including the resources, services and qualities of aquatic ecosystems and underground aquifers that benefit the State of California. Numerous beneficial uses have been identified, including agricultural supply, wildlife habitat, recreation, groundwater recharge and municipal and domestic water supply. In most cases, the RWQCBs protect beneficial uses by requiring water quality control measures (see Water Board Rotenone Policy described below). The discharge permit provides 2 levels of control: technology-based limits and water-quality-based limits. Technology-based limits are based on the ability of dischargers in the same category to treat wastewater, while water-quality-based limits are required if technology-based limits are not sufficient to protect the water body.

Dischargers with water-quality-based effluent limitations must achieve water quality standards in the receiving water. The provisions of sections 301 and 402 of CWA require controls that use best available technology economically achievable (BAT), best conventional pollutant control technology (BCT) and any more stringent controls necessary to reduce pollutant discharges and meet water quality standards. NPDES permits must also incorporate TMDL waste load allocations when they are developed.

Title 40, section 122.44 of the Code of Federal Regulations (CFR) states that if a discharge causes, has the reasonable potential to cause, or contributes to an excursion above a numeric or narrative water quality criterion, the permitting authority must develop effluent limits as necessary to meet water quality standards. Best Management Practices (BMPs) may be required in NPDES permits in lieu of numeric effluent limits to control or abate the discharge of pollutants when numeric effluent limits are infeasible.

WILD AND SCENIC RIVERS ACT OF 1968

No waters in the proposed treatment area or downstream are designated under the Wild and Scenic Rivers Act of 1968, Title 16 U.S.C. section 1271, et seq. Therefore, the proposed Action and its alternatives would not compromise any protections afforded by the Wild and Scenic Rivers Act.

5.4.2.2 State

California's surface water quality is regulated under the Porter-Cologne Water Quality Control Act. This law established the SWRCB and 9 RWQCBs. As described above, the USEPA has delegated the discharge permitting provisions of the CWA to these boards. Surface water and groundwater are also managed by CDFG. The following subsections describe state water resources regulations.

PORTER-COLOGNE WATER QUALITY CONTROL ACT

The RWQCBs regulate water quality under the Porter-Cologne Water Quality Control Act through the regulatory standards and objectives set forth in water quality control plans prepared for each region. These plans identify existing and potential beneficial uses and provide numerical and narrative water quality objectives to protect those uses.

In compliance with the Porter-Cologne Water Quality Control Act, the Water Board adopted a Basin Plan that became effective on March 31, 1995 (LRWQCB 1995). The Basin Plan incorporates SWRCB plans and policies by reference, contains beneficial use designations, contains water quality objectives for all waters of the Lahontan Region, in which Silver King Creek is located, and provides a strategy for protecting beneficial uses of surface and ground waters throughout the Lahontan Region.

The Agencies have applied for a project-specific NPDES permit for rotenone application. The NPDES permit for the proposed Action would contain receiving water limits applicable to rotenone projects as contained in the Basin Plan. It would also require water quality monitoring to verify compliance with receiving water limits within the treatment area and in downstream waters both during and after the treatment.

WATER QUALITY STANDARDS

CWA defines water quality standards as "provisions of State or Federal law which consist of a designated use or uses for the waters of the United States and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the Act" (Title 40 C.F.R. Section 131.3(i)) In California, Basin Plans designate the beneficial uses of waters of the state and water quality objectives (WQOs) to protect those uses. The SWRCB and RWQCBs adopt Basin Plans through a formal administrative rulemaking process, and, upon approval by the USEPA, the WQOs for waters of the United States (generally surface waters) become state water quality standards.

ROTENONE POLICY

In 1990, the Water Board adopted amendments to the Basin Plan to permit conditional use of rotenone by CDFG. The Water Board and CDFG then executed a Memorandum of Understanding (MOU) to facilitate amendment implementation. The MOU specifies the detailed information to be provided by CDFG before undertaking a rotenone application project and the monitoring required. It also lists the criteria the Water Board Executive Officer will use to evaluate rotenone application projects. These include whether:

- The proposed Action will meet the Basin Plan limits on chemical residue levels.

- The planned treatment protocol will result in the minimum discharge of chemical substances that can reasonably be expected for an effective treatment.
- Chemical transport, spill contingency plans and application methods will adequately provide for protection of water quality.
- Suitable measures will be taken to notify the public and potentially affected residents.
- Suitable measures will be taken to identify potentially affected sources of potable surface and groundwater intakes and to provide potable drinking water if necessary.
- A suitable monitoring program will be followed to assess the effects of treatment on surface and groundwater and on bottom sediments.

Application of rotenone solutions and the neutralization agent potassium permanganate can cause several water quality objectives to be temporarily exceeded, both inside and outside of project boundaries. The Basin Plan defines the project boundaries as the treatment area, the neutralization area, and the area downstream of the neutralization station up to a 30-minute travel time. It also establishes the following specific water quality objectives for rotenone projects including color, pesticides, toxicity and species composition. The Water Board Executive Officer may grant CDFG conditional variances to these objectives if the action meets certain conditions.

Water quality objectives for CDFG rotenone projects are as follows:

- Color: The characteristic purple discoloration resulting from the discharge of potassium permanganate shall not be discernible more than two miles downstream of project boundaries at any time. Twenty-four hours after shutdown of the detoxification operation, no color alteration(s) resulting from the discharge of potassium permanganate shall be discernible within or downstream of project boundaries.
- Pesticides: Chemical residues resulting from rotenone treatment must not exceed the following limitations:
  - The concentration of naphthalene outside of project boundaries shall not exceed 25 µg/liter [parts per billion (ppb)] at any time.
  - The concentration of rotenone, rotenolone, trichloroethylene (TCE), xylene, acetone, or potential trace contaminants such as benzene or ethylbenzene outside of project boundaries shall not exceed the detection levels for these respective compounds at any time. “Detection level” is defined as the minimum level that can be reasonably detected using state-of-the-art equipment and methodology.
  - After a two-week period has elapsed from the date that rotenone application was completed, no chemical residues resulting from the treatment shall be present at detectable levels within or downstream of project boundaries.
  - No chemical residues resulting from rotenone treatments shall exceed detection levels in groundwater at any time.
- Species Composition: The reduction in fish diversity associated with the elimination of non-native fish or exotic species may be part of the proposed Action, and may therefore be unavoidable. However, non-target aquatic populations (e.g. invertebrates, amphibians) that are reduced by rotenone treatments are expected to repopulate the treatment area within 2 years. Where species composition objectives are established for specific water bodies or hydrologic units, the established objective(s) shall be met for all non-target aquatic

organisms within 1 year following rotenone treatment. For multi-year treatments (i.e., when rotenone is applied to the same water body during 2 or more consecutive years), the established objective(s) shall be met for all non-target aquatic organisms within 2 years following the final rotenone application to a given water body. An assessment of potential impacts on benthic macroinvertebrates and post-treatment recovery of aquatic species composition is addressed in Section 5.1, Aquatic Biological Resources.

Threatened or endangered aquatic populations (e.g. invertebrates, amphibians) shall not be adversely affected. The Agencies shall conduct pre-treatment monitoring to prevent rotenone application where threatened or endangered species may be adversely impacted.

- Toxicity: Chemical residues resulting from rotenone treatment must not exceed the limitations listed above for pesticides.

PROPOSITION 65 CONSIDERATIONS

Three inert ingredients present in one or both proposed rotenone formulations (N-methyl-2-pyrrolidone, ethylbenzene and naphthalene) are on the Proposition 65 list of chemicals known to the State of California to cause cancer or reproductive toxicity. The Proposition 65 statute is contained in California Health and Safety Code sections 25249.9-25249.13. Proposition 65 prohibits the discharge of chemicals known to cause cancer or reproductive toxicity. The State Attorney General’s Office is the State agency responsible for enforcing Proposition 65. Section 25249.11(b) specifically exempts State Agencies from the statute’s provisions. Therefore, as a State agency, CDFG is exempt from Proposition 65.

CALIFORNIA TOXICS RULE

USEPA promulgated the California Toxics Rule (CTR), Title 40 C.F.R. section 131.38, establishing numeric criteria for priority toxic pollutants for the State of California. The SWRCB adopted the Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California, also known as the State Implementation Policy (SIP), which established procedures for implementing water quality standards in NPDES permits. Section 5.3 of the SIP allows the SWRCB and RWQCBs to grant short-term or seasonal categorical exceptions from meeting the CTR priority pollutant criteria for resource or pest management projects conducted by public entities. To qualify for this exception from meeting priority pollutant standards, a public entity must fulfill the requirements listed in Section 5.3, Human and Ecological Health Concerns, and among other requirements, comply with CEQA, Public Resources Code section 21000, et seq.

CEQA EXEMPTION

Pursuant to Section 13389 of CWA, the SWRCB is exempt from the requirement to comply with CEQA when adopting NPDES permits. While adoption of this NPDES permit is exempt from preparation of a CEQA document, public entities receiving exceptions pursuant to Section 5.3 of the SIP are required to prepare a CEQA document, as discussed below.

STATE IMPLEMENTATION POLICY EXCEPTION

SIP was adopted by the SWRCB on March 2, 2000, and became fully effective on May 22, 2000 (SWRCB 2000). SIP’s goal is to standardize the permitting of discharges of toxic pollutants to non-ocean surface waters in a manner that promotes statewide consistency. As such, the SIP is used in conjunction with watershed management approaches and, where appropriate, the development of TMDLs to ensure compliance with water quality standards.

The SIP provides that categorical exceptions may be granted to allow short-term or seasonal exceptions from meeting the priority pollutant criteria/objectives if "necessary to implement control measures … for resource or pest management … conducted by public entities to fulfill statutory requirements." The SIP specifically refers to fishery management as a basis for a categorical exception. The exceptions are available only to public entities that have adequately provided the following, as listed in the SIP:

- CEQA documentation including notifying potentially affected public and government agencies;
- A detailed description of the proposed Action which includes the proposed method of completing the action;
- A time schedule;
- A discharge and receiving water monitoring plan that specifies monitoring prior to application events, during application events, and after completion with the appropriate quality control procedures;
- Contingency plans; and
- Residual waste disposal plans.

WASTE DISCHARGE REQUIREMENTS

Waste discharge prohibitions applicable to the Lahontan Basin include:

- The discharge of waste which causes violation of any narrative water quality objective contained in the Basin Plan, including the "Nondegradation Objective," is prohibited.
- The discharge of waste which causes violation of any numeric water quality objective contained in the Basin Plan is prohibited.
- Where any numeric or narrative water quality objective contained in the Basin Plan is already being violated, the discharge of waste which causes further degradation or pollution is prohibited.
- Direct discharge of wastes, including sewage, garbage and litter into surface waters of the region is prohibited.

"Waste" is defined to include any waste or deleterious material, including, but not limited to, waste earthen materials (such as soil, silt, sand, clay, rock, or other organic or mineral material) and any other waste as defined in the California Water Code section 13050(d).

5.4.3 Assessment Criteria and Methodology

5.4.3.1 Significance Thresholds

The following CEQA significance thresholds were used in the environmental impact assessment. Impacts were considered significant if they would:

- Violate any water quality standards or waste discharge requirements.

- Otherwise substantially degrade water quality.

Evaluation of these significance criteria will be used to evaluate CEQA Mandatory Findings of Significance, including whether the proposed Action would violate any water quality standards or waste discharge requirements or substantially degrade environmental quality.

As described in Chapter 4.0, Scope of the Analysis, this section does not address groundwater supplies or recharge. In addition, CEQA significance criteria related to potential impacts on water quality or flooding resulting from alteration of drainage patterns, creation of runoff, placement of housing or other structures, or flooding are not evaluated in detail because neither the proposed Action nor its alternatives would change existing conditions related to these issues. Neither the proposed rotenone treatment nor the alternatives would involve any activity (e.g. dams, levees, diversions, drainage structures) that would alter the stream course or drainage patterns or construct housing or any other structure. Further, the proposed Action and its alternatives would not expose people to a seiche, tsunami, or mudflow.

This section also does not provide a detailed assessment of impacts on drinking water for the following reasons. The proposed Action would not affect a sole-source aquifer. No new injection wells would be required and no pollutants would be expected to reach drinking water supplies as defined by the Safe Drinking Water Act. The nearest drinking water supply is in the town of Markleeville, located approximately 10 miles downstream. These and other potential downstream users are addressed in Section 5.3, Human and Ecological Health Concerns. Under the proposed Action, neutralization with potassium permanganate occurs near the downstream end of the treatment area (refer to Figure 3-1), thus there would be no adverse impacts to municipal drinking water supplies. Drinking water issues are also addressed in detail in Appendix C.

The water quality concerns addressed below include:

- Reduced DO concentrations resulting from chemical oxygen demand as a result of rotenone degradation;
- Reduced DO concentrations resulting from biological oxygen demand as a result of the decomposition of dead fish;
- Elevated bacterial levels associated with the decomposition of dead fish;
- Elevated turbidity resulting from physical disturbance in and near waterways;
- Effects on water color, specifically the persistence of purple discoloration resulting from application of potassium permanganate; and
- Toxic concentrations of rotenone and formulation constituents.

5.4.3.2 Evaluation Methods and Assumptions

This assessment evaluates and identifies short-term or temporary water quality impacts, long-term impacts that could persist for years, and residual impacts. Analysis was based on review of the activities associated with the proposed Action (Alternative 2) and Combined Physical Removal (Alternative 3) and water quality concerns identified in the Basin Plan rotenone policy including color, pesticides, bacteria, species composition and toxicity.

The Basin Plan definitions of these water quality objectives include:

- **Color.** Waters shall be free of coloration that causes nuisance[1] or adversely affects the water for beneficial uses.
- **DO.** The DO concentration, as percent saturation, shall not be depressed by more than 10%, nor shall the minimum DO concentration be less than 80% of saturation. For waters with the beneficial use designation of COLD with SPWN[2], the minimum DO concentration shall not be less than 8.0 mg/l (1-day minimum).
- **Bacteria.** Waters shall not contain concentrations of coliform organisms attributable to anthropogenic sources, including human and livestock wastes.
- **Turbidity.** Waters shall be free of changes in turbidity that cause nuisance or adversely affect the water for beneficial uses. Increases in turbidity shall not exceed natural levels by more than 10%.
- **Toxicity.** All waters shall be maintained free of toxic substances in concentrations that are toxic to or that produce detrimental physiological responses in human, plant, animal, or aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, bioassays of appropriate duration and/or other appropriate methods as specified by the Water Board. The survival of aquatic life in surface waters subjected to a waste discharge, or other controllable water quality factors, shall not be less than that for the same water body in areas unaffected by the waste discharge, or when necessary, for other control water that is consistent with the requirements for “experimental water” as defined in Standard Methods for the Examination of Water and Wastewater (American Public Health Association, et al. 1998).

Toxicity is addressed in several sections of this EIS/EIR. Section 5.1, Aquatic Biological Resources, addresses potential impacts on benthic invertebrate species composition. Section 5.3, Human and Ecological Exposure, addresses the potential toxicity of rotenone and its formulation constituents and potassium permanganate, including evaluation of bioassay data and comparison with toxicity benchmarks. Both of these sections refer to toxicity data presented in Appendix C. This section specifically addresses the toxicity criteria in the Water Board rotenone policy that address chemical concentrations outside project boundaries, and presence of chemical residues in water, sediment and groundwater.

5.4.4 Environmental Impact Assessment

This section analyzes the potential water quality impacts of the proposed Action and its alternatives. It evaluates direct impacts associated with implementation (e.g. chemical application, worker activity) and indirect impacts, which are secondary effects but delayed or spatially removed from implementation (e.g. residual chemical effects). It addresses potential

[1] The Lahontan Basin Plan defines nuisance as anything which meets all of the following requirements: 1) Is injurious to health, or is indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property; 2) Affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted upon individuals may be unequal. 3) Occurs during or as a result of the treatment or disposal of wastes.

[2] The Basin Plan beneficial use designation of COLD with SPWN require water column dissolved oxygen concentrations not less than 8.0 mg/l to achieve the required intergravel concentrations (5.0 mg/l) to maintain all embryonic and larval stages and all juvenile forms to 30days following hatching (SPWN).

impacts on water toxicity, color, turbidity, and impacts on DO concentrations (resulting from added chemical or biological oxygen demand) and bacteria concentrations.

5.4.4.1 Alternative 1: No Action

The No Action alternative would have no impact on the water quality of Silver King Creek. No workers would enter this area and no chemicals would be applied to surface waters of Silver King Creek or its tributaries.

5.4.4.2 Alternative 2: Proposed Action (Rotenone Application)

The Agencies propose to use rotenone to eradicate non-native trout and to use potassium permanganate as a neutralization agent. The application of rotenone solution and the detoxification agent potassium permanganate could cause several water quality objectives to be temporarily exceeded, both within and downstream of the treatment area, including the neutralization area (the area downstream of the neutralization station up to a 30-minute travel time).

SILVER KING CREEK AND TRIBUTARIES

ROTENONE, FORMULATION CONSTITUENTS AND NEUTRALIZATION AGENT

The rotenone formulations proposed for application are Noxfish®, Nusyn-Noxfish®, and CFT Legumine™. The specific components and toxicities of these 3 formulations are discussed in detail in Appendix C. Application of rotenone would result in immediate but temporary and localized adverse impacts on water quality in the treatment area, including presence of rotenone and its formulation ingredients, and potassium permanganate in the neutralization area.

To eliminate the toxic effects of rotenone, potassium permanganate would be administered at a downstream neutralization station. Potassium permanganate is a powerful oxidizing chemical that quickly renders rotenone harmless to aquatic organisms. Potassium permanganate is toxic to gill-breathing organisms at the rate required for neutralization (2 to 4 mg/L). However, as it oxidizes the rotenone and other degradable materials in the water, it becomes reduced. The by-product of the oxidation of rotenone by potassium permanganate is manganese oxide, a biologically inactive compound (CDFG 1994). In flowing water treatments, this balance usually limits aquatic exposure to permanganate and rotenone to 0.25 to 0.5 mile downstream of the neutralization site (Hobbs et al. 2006). As described in the Basin Plan (LRWQCB 1995), water quality impacts outside the project boundaries are expected to be minimal. Trace amounts of rotenone and formulation constituents may persist beyond the project boundaries. However, as described in the Basin Plan, these residues generally do not persist beyond 1 or 2 days, and beneficial uses are not expected to be impaired in the long-term.

In addition to rotenone, liquid rotenone formulations also contain “inert” ingredients (e.g. carriers, solvents, dispersants, and emulsifiers). Synergized formulations (e.g. Nusyn-Noxfish®) also contain synergists such as piperonyl butoxide. The organic solvents, depending on the formulation may include naphthalene, methylnaphthalene, xylene, acetone, trichloroethylene (TCE), benzene and ethylbenzene. According to the Basin Plan, concentrations of these compounds in rotenone-treated water are expected to meet current drinking water standards. Water quality impacts from these chemicals would be short-term as the compounds would rapidly decompose or volatilize within hours. According to the Basin Plan, some chemical residues may be detectable for up to two weeks. The Basin Plan also states that short-term impacts can adversely affect aesthetics, recreation (see Section 5.6), and water supply; however, because visitors to the area will be advised to avoid the proposed treatment area during the treatment process, these beneficial uses would not be affected.

Appendix C provides a detailed discussion of the environmental transport and degradation of rotenone and persistence of residues. In summary, rotenone dissipates rapidly in soil and water. It adheres to soil and is unlikely to be found in groundwater. Rotenone degrades rapidly in the presence of sunlight and warm temperatures and may persist in natural water bodies from between a few days to several weeks depending on the season. Similarly, dispersant concentrations, such as volatile and semi-volatile compounds dissipated rapidly. Therefore, according to the data contained in Appendix C, particularly during summertime treatment in shallow waters, the proposed Action would not result in residual concentrations in water, sediment, or groundwater.

The proposed Action would result in a temporary degradation of water quality. The SWRCB's policy for maintaining high quality water directs that whenever the existing quality of waters is better than standards established in water quality objectives, the existing level of quality shall be maintained (SWRCB 1968). Accordingly, the proposed Action would require the Water Board to determine that this temporary deterioration in water quality would result in a benefit. Similarly, the Federal Antidegradation Policy, Title 40 C.F.R. section 131.12, dictates that water quality shall be preserved unless deterioration is necessary to accommodate important economic or social development. The Water Board has determined that certain situations justify the use of rotenone.

The temporary deterioration of water quality due to the use of rotenone by CDFG is justifiable in certain situations, including restoration and preservation of threatened and endangered species. These species are of important economic and social value to the people of the State, and the transitory degradation of water quality and short-term impairment of beneficial uses that would result from rotenone application is therefore justified, provided suitable measures are taken to protect water quality within and downstream of the treatment area. Therefore, application of rotenone would result in significant and unavoidable impacts on water quality.

To minimize potential water quality impacts, the rotenone application would be supervised by licensed applicators in adherence to safety precautions identified on the product label. The application supervisor would be knowledgeable and experienced in state regulatory requirements regarding safe and legal use of the rotenone product and applicator safety. All personnel involved with the rotenone application would have received, before treatment, safety training specific to the formulated rotenone product that would be used. In addition the Agencies would conduct water quality monitoring to ensure that: 1) rotenone concentrations do not exceed the effective concentration required for eradication of non-native trout; 2) sufficient degradation of rotenone has occurred before the area is opened to the public; and 3) rotenone toxicity does not occur outside the treatment area. As described in the Basin Plan conditions, the monitoring program would assess the effects of treatment on surface waters and bottom sediments. An analytical laboratory would analyze water samples for rotenone and rotenolone concentrations, as well as for volatile organic compound and semi-volatile organic compound concentrations. Further, the Agencies would minimize water quality impacts by limiting the treatment concentration applied and the duration of rotenone activity to the shortest time period needed to meet the fish removal objective. By following these procedures, the direct effects from the treatment on water quality would be confined to the treatment area and would result in short-term effects on water quality that would be less-than-significant and that mitigation measures are not required.

However, during the routine application of these chemicals, there exists a potentially significant risk of an accidental spill during travel to the treatment site or at the site. The impacts of a potential spill could be significant; however, these impacts would be significantly reduced by the inclusion of a spill contingency plan, site safety plan, and site security plan. These plans would address chemical transport and use guidelines, procedures for maintenance and calibration of dispensing equipment, handling of small quantities of chemical, as well as spill prevention and containment that adequately protects water quality. The plans would require application of rotenone supervised by licensed applicators and in adherence to safety precautions identified on the product label. It would require the application supervisor to be knowledgeable and experienced in state regulatory requirements regarding safe and legal use of the rotenone product and applicator safety. All personnel involved with the rotenone application would receive safety training specific to the selected rotenone formulation. The plan would also describe the use of an auger to dispense the neutralizing agent while minimizing the risk of an inadvertent release. Potential visitors would be advised regarding the availability of comparable recreation areas. The safest access routes need be selected for transporting hazardous materials to the treatment site. The impact of spills under the proposed Action would therefore be less-than-significant and no further mitigation would be required.

DISSOLVED OXYGEN

The proposed Action could affect DO concentrations in Silver King Creek and its tributaries. Aerobic degradation of rotenone in the water column could result in reduced DO concentrations; however, this effect was not observed during the recent treatment of Lake Davis (Lehr 2009). Additionally, decomposition of dead fish could also reduce DO concentrations and elevate bacteria levels in the water. Low DO concentrations can result in stress, reduced growth, or death of fish and other gill-breathing aquatic organisms. The Basin Plan specifies that the DO concentration, as percent saturation, shall not be depressed by more than 10%, nor shall the minimum DO concentration be less than 80% of saturation. To address this issue, block nets would be placed at selected locations throughout the treatment area to catch the dead fish. The nets would be maintained at a frequency adequate to ensure that captured fish are not in the water long enough to decompose.

In addition, the natural geomorphology of Silver King Creek will help prevent the persistence of low oxygen levels in the stream. Silver King Creek is shallow and stream riffles would rapidly reoxygenate stream flows. In addition, waterfalls in Silver King Canyon would reoxygenate waters immediately downstream of the treatment area. Therefore, any reduction in DO would be temporary and would be quickly offset by entrainment of atmospheric oxygen. Because of this, effects on DO would not substantially degrade environmental or water quality in Silver King Creek. Any reduction in DO below the Basin Plan criteria would be of short duration (<24 hours) and DO levels would recover as described above.

Collection of fish using block nets as well as additional gathering by hand as practicable would reduce the impacts of the proposed Action on DO to less-than-significant.

BACTERIA LEVELS

Following the rotenone treatment, the decomposition of dead fish may result in elevated bacteria levels in the water, particularly in pools or backwater areas where carcasses may collect. The proposed Action would involve removing fish carcasses using block nets and by gathering additional fish by hand to the extent practicable (see description above). Thus, there would be few areas with elevated bacterial levels.

While the Basin Plan includes bacterial levels as a water quality objective, the bacteria criteria are focused on levels of fecal coliform bacteria. Specifically, page 3-4 of the Basin Plan states "*that waters shall not contain concentrations of coliform organisms attributable to anthropogenic sources, including human and livestock wastes*." Fecal coliform bacteria can enter rivers through direct discharge of waste from mammals and birds, from agricultural and storm runoff, and from untreated human sewage. However, this bacterial indicator is not associated with fish decay and no other indicators are specified by the Basin Plan. Therefore, elevated bacteria levels resulting from fish decomposition would not violate water quality standards and this temporary effect on water quality would have less-than-significant adverse impacts.

ELEVATED TURBIDITY

The Basin Plan specifies that increases in turbidity shall not exceed natural levels by more than 10%. Turbidity could be increased during the application of chemicals due to the transport of equipment, personnel and chemicals to and within the treatment area by pack stock and on foot. Elevations in turbidity would be temporary and would not substantially degrade environmental or water quality in the long-term. Rotenone would be applied by drip stations and if by hand sprayers, primarily from stream banks. Because of the sand and gravel content of the stream's bottom sediments, any temporary increases in turbidity resulting from workers walking in the stream during application of rotenone formulation to reach backwater areas would not exceed the Basin Plan standard and thus this impact would be less-than-significant.

EFFECTS ON COLOR

The rotenone treatment would be followed by the addition of potassium permanganate at a neutralization site downstream from the rotenone application area (Figure 3-1). Potassium permanganate causes a characteristic temporary purple discoloration when discharged into water. The Basin Plan recognizes that the color change caused by this agent can be visible up to 2o miles downstream (LRWQCB 1995). Therefore, the Basin Plan water quality objectives for color specify that discolorations shall not be discernable more than 2 miles downstream of the project boundaries at any time, nor shall any color be discernable within or downstream of project boundaries 24 hours after the potassium permanganate application.

Potassium permanganate would be discharged into treatment-area streams at an effective rate of 2 to 4 mg/L as the detoxifying agent. At this concentration, the potassium permanganate is expected to result in a noticeable purple color for less than 1 mile downstream from the neutralization site. Under these conditions, potassium permanganate would quickly be reduced to manganese oxide and would not persist for more than a day following detoxification (LRWQCB 1995). Because the public would be advised to avoid the treatment area during treatment and for 2 weeks afterward, the purple color would not interfere with human beneficial uses such as fishing, nor would these low concentrations of short duration adversely affect wildlife habitat, special status species, or water quality needed for fish to spawn, reproduce and develop. Therefore, potassium permanganate would not violate water quality objectives for color at these levels and the application of rotenone would result in less-than-significant impacts on color.

TAMARACK LAKE

ROTENONE, FORMULATION CONSTITUENTS AND NEUTRALIZATION AGENT

If rotenone formulations are applied to Tamarack Lake, breakdown residues may persist beyond 24 hours. No potassium permanganate would be used to neutralize rotenone in the lake. When applied to water, rotenone breaks down naturally within approximately 5 days depending on pH, alkalinity, temperature, dilution, and exposure to sunlight (Schnick 1974). According to Appendix C, rotenone dissipates rapidly in water, particularly in the presence of sunlight and warm temperatures and may persist in natural water bodies from between a few days to several weeks depending on the season. In addition, the lake's depth may affect rotenone's persistence. As described in Appendix C, rotenone half-lives range up to over a week. After the 2007 rotenone treatment of Lake Davis, rotenone persisted for approximately 30 days and had a half-life of 5.6 days. In addition, although most volatile and semi-volatile compounds in the formulations would dissipate rapidly, several of the dispersants contained in CFT Legumine™ persisted longer than rotenone after the 2007 Lake Davis treatment. Therefore, given the measured persistence of rotenone and formulation dispersants in Lake Davis, the depth of Tamarack Lake, and its colder temperatures compared with Lake Davis, residual levels of rotenone and formulation dispersants in Tamarack Lake would potentially result in short term but significant impacts on water quality standards and beneficial uses.

Impact WQ-1: Application of rotenone formulations to Tamarack Lake would result in residual concentrations that could persist for more than two weeks, resulting in significant adverse impacts on water quality.

Because no mitigation measures are available to accelerate the degradation of rotenone and its formulation constituents in the lake, this impact could be significant and unavoidable.

REDUCED DISSOLVED OXYGEN

During the natural rotenone degradation process, oxidation could result in lower DO concentrations in the lake. However, because of the high oxygen saturation levels in oligotrophic high-elevation lakes such as Tamarack Lake, this phenomenon is not expected to be significant. DO levels were not affected significantly during the recent treatment of Lake Davis. Even with the high fish densities in Lake Davis, post-treatment water quality monitoring found no depression in DO (Lehr 2009).

Tamarack Lake would produce very few fish, if any, during a rotenone treatment. In addition, any effects on DO would be moderated by natural processes including surface water oxygenation by wave action in littoral areas and removal of fish carcasses by carrion-feeding wildlife. Any dead fish would be removed from the lake to the extent practicable and buried. Any dead fish not collected would provide nutrients for recolonizing benthic and planktonic invertebrates.

Therefore, the slight reduction in DO in Tamarack Lake that could result from the proposed Action would not violate water quality standards. Background DO concentrations in this high, oligotrophic, alpine lake would likely be well above the minimum water quality standard. Any reductions in oxygen concentrations should be localized and less than significant.

ELEVATED BACTERIAL LEVELS

Following rotenone treatment, the decomposition of dead fish could result in elevated bacteria levels in the water, particularly in near-shore areas. There are a small number of fish, if any in

Tamarack Lake, and the Agencies would remove dead fish to the extent practicable as described above.

As described above for Silver King Creek, the Basin Plan includes criteria specific to fecal coliform bacteria. Because these bacteria are primarily an indicator of human and livestock wastes, the decomposition of fish in Tamarack Lake would not result in violation of the Basin Plan water quality standards. Moreover, any elevated bacteria levels resulting from fish decomposition would be temporary and would not cause water quality criteria to be exceeded. Therefore, application of rotenone would result in less-than-significant impacts on bacteria levels in Tamarack Lake.

TURBIDITY

The proposed Action would have little or no impact on turbidity in Tamarack Lake. Localized turbidity could result from shoreline foot traffic during chemical application. However, this effect would be temporary and would not substantially degrade water quality. The Basin Plan specifies that increases in turbidity shall not exceed natural levels by more than 10%. Because of the rocky nature of the lake's shoreline, temporary increases in turbidity resulting from workers would be unlikely to increase turbidity by 10%. Therefore, the proposed Action would result in less-than-significant impacts on Tamarack Lake turbidity levels.

COLOR

The Agencies are not planning to use potassium permanganate in Tamarack Lake. If required to address residual rotenone concentrations, rotenone would be quickly reduced to manganese oxide under these conditions and according to the Basin Plan would not persist for more than a day following the end of detoxification. Because visitors would be advised to avoid the treatment area during treatment and for 2 weeks afterward, the purple color would not interfere with human beneficial uses such as fishing, nor would these low concentrations of short duration adversely affect wildlife habitat, special status species, or water quality. Therefore, at the low application rate that would be used as a contingency if rotenone remains in the lake, potassium permanganate would not violate water quality objectives for color and the application of rotenone would result in less than significant impacts on color.

5.4.4.3 Alternative 3: Combined Physical Removal

Alternative 3 would employ electrofishing, seining and gill netting to achieve fish removal. No chemicals would be applied. The following paragraphs evaluate potential water quality impacts in Silver King Creek and Tamarack Lake from such activities.

<u>SILVER KING CREEK AND TRIBUTARIES</u>

DISSOLVED OXYGEN

Because no chemicals or other sources of oxygen demand would be added to the stream, Alternative 3 would have no chemical oxygen demand impacts on DO concentrations in proposed treatment areas. However, decomposition of dead fish could result in reduced DO concentrations and elevate bacteria levels in the water. Low DO concentrations can result in stress, reduced growth, or death of fish and other gill-breathing aquatic organisms. The Basin Plan specifies that the DO concentration, as percent saturation, shall not be depressed by more than 10%, nor shall the minimum DO concentration be less than 80% of saturation.

As described above for the proposed Action, the natural geomorphology of Silver King Creek would help prevent the persistence of low oxygen levels in the stream. Stream riffles and waterfalls would rapidly reoxygenate stream flows. Therefore, any reduction in DO would be temporary and would not substantially degrade environmental or water quality in Silver King Creek.

Collection of fish using electrofishing and gill nets would reduce the impacts of this alternative on DO to less-than-significant.

BACTERIA LEVELS

Decomposition of dead fish following electrofishing could result in elevated bacteria levels in the water, particularly in pools or backwater areas where carcasses may collect. This alternative would involve removing fish during the electrofishing operation and capture of further carcasses using block nets and by gathering additional fish by hand to the extent practicable. Thus, there would be few areas with elevated bacterial levels.

As described above for the proposed Action, while the Basin Plan includes bacterial levels as a water quality objective, the bacteria criteria are focused on levels of fecal coliform bacteria. Specifically, page 3-4 of the Basin Plan states “that waters shall not contain concentrations of coliform organisms attributable to anthropogenic sources, including human and livestock wastes.” This bacterial indicator is not associated with fish decay and no other indicators are specified by the Basin Plan. Therefore, elevated bacteria levels resulting from fish decomposition would not violate water quality standards and this temporary effect on water quality would have less-than-significant adverse impacts.

ELEVATED TURBIDITY

The Basin Plan specifies that increases in turbidity shall not exceed natural levels by more than 10%. However, given the coarse material present in the stream and the limited number of depositional areas where silt could be disturbed by electrofishing crews, any disturbance of sediments would be temporary and sediments would be re-deposited within a short distance. Therefore, any impacts on stream turbidity would be less-than-significant and no mitigation measures would be required.

TAMARACK LAKE

Because no chemicals or other sources of oxygen demand would be added to the lake and no motorized watercraft would be used to dispense rotenone, Alternative 3 would have no impacts on DO concentrations. Although very few fish would be expected, any fish captured using physical techniques (i.e., gillnetting) would be gathered and buried to the extent practicable as described above and therefore bacteria levels would not be affected. Remaining fish would provide nutrients for repopulating benthic and planktonic invertebrates. Because gillnetting and electrofishing from the shoreline would not cause the level of disturbance that the intensive electrofishing efforts associated with Alternative 3 would cause in streams proposed for treatment, lake turbidity would not be affected significantly. Therefore, Alternative 3 would result in less-than-significant impacts on water quality in Tamarack Lake.

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5.5 GREENHOUSE GASES AND CLIMATE CHANGE

This section evaluates the potential impacts of the proposed Action and alternatives on global climate change in terms of its contribution to state and national greenhouse gas emissions.

5.5.1 Environmental Setting

Gases that trap heat in the atmosphere are often called greenhouse gases. Common greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, ozone, and aerosols. Greenhouse gases are emitted by both natural processes and human activities. The accumulation of greenhouse gas in the atmosphere can increase the earth's temperature over time. Greenhouse gas emissions from human activities, such as fossil-fueled generation of electricity and vehicle use, have elevated the concentration of these gases in the atmosphere, causing global warming (Association of Environmental Professionals 2007). The principal greenhouse gases that enter the atmosphere due to human activities are as follows:

- **Carbon dioxide** enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions. Carbon dioxide also is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.
- **Methane** is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.
- **Nitrous oxide** is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste. Nitrous oxide comprises a small fraction of nitrogen oxide emissions from combustion sources, which are mainly nitric oxide and nitrogen dioxide.[1]
- **Fluorinated gases** such as hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are often used as substitutes for ozone-depleting substances (i.e., chlorofluorocarbons, hydrochlorofluorocarbons, and halons). These gases typically are emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases (USEPA 2006).

The greenhouse gas of greatest concern is carbon dioxide, because it is released by the burning of fossil fuels (coal, oil, and gas) and is therefore the most common greenhouse gas emission from human activities. It can last in the atmosphere for centuries and, due to its prevalence in the atmosphere, contributes more to climate change than any other greenhouse gas. The California Energy Commission has estimated that in 2004 the state emitted 492 million metric tons of carbon dioxide-equivalent greenhouse gas emissions. Eighty-one percent were emissions of carbon dioxide from fossil fuel combustion, 2.8% were from other sources of carbon dioxide, 5.7% were from methane, and 6.8% were from nitrous oxide. The remaining source of greenhouse gas emissions was high-Global Warming Potential gases at 2.9% (California Energy Commission 2006).

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[1] Nitrogen oxides from high-temperature sources are about 85 to 90 percent nitric oxide, about 9 to 14 percent nitrogen dioxide, and less than 1 percent nitrous oxide.

5.5.2 Regulatory Setting

5.5.2.1 Federal

CLEAN AIR ACT

The Clean Air Act of 1970 (42 USC 7401 et seq. as amended in 1977 and 1990) is the federal law that regulates air emissions from area, stationary, and mobile sources. The law authorizes the USEPA to set National Ambient Air Quality Standards to regulate the quantity of pollutants that can be in the air. Standards have been established for six criteria pollutants that have been linked to potential health concerns.

The goal of the Clean Air Act was to set and achieve National Ambient Air Quality Standards in every state by 1975. States were directed to develop state implementation plans to achieve attainment of National Ambient Air Quality Standards. The Clean Air Act was amended in 1977 to set new dates for attainment (since many areas of the country had failed to meet the deadlines) and again in 1990 to meet unaddressed or insufficiently addressed problems such as acid rain, ground-level ozone, stratospheric ozone depletion, and air toxics.

MASSACHUSETTS VS. ENVIRONMENTAL PROTECTION AGENCY

In Massachusetts v. Environmental Protection Agency, 549 U.S. 497 (2007), the U.S. Supreme Court held that not only did USEPA have authority to regulate greenhouse gases, but that USEPA's reasons for not regulating greenhouse gas emissions did not fit the statutory requirements. The U.S. Supreme Court ruled that carbon dioxide and other greenhouse gas emissions are pollutants under the federal Clean Air Act, which USEPA must regulate if it determines they cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare. To date, USEPA has not made such a finding or developed a regulatory program for greenhouse gas emissions.

5.5.2.2 State

ASSEMBLY BILL 1493

In September 2002, Governor Davis signed Assembly Bill (AB) 1493, requiring the development and adoption of regulations to achieve "the maximum feasible reduction of greenhouse gases" emitted by noncommercial passenger vehicles, light-duty trucks, and other vehicles used primarily for personal transportation in the state. Setting emission standards on automobiles is normally the responsibility of USEPA. The federal Clean Air Act, however, allows states to set a state-specific emission standard on automobiles if they first obtain a waiver from USEPA. In December 2007, USEPA denied California's request for a waiver. In response, California sued USEPA claiming that the denial was not based on the scientific data.

EXECUTIVE ORDER S-3-05

In June 2005, Governor Schwarzenegger signed Executive Order S-3-05, which established greenhouse gas emissions reduction targets for the state as well as a process to ensure that the targets are met. As a result of this executive order, the Climate Action Team, led by the Secretary of the California State Environmental Protection Agency (CalEPA), was formed. The Climate Action Team published a March 2006 report that laid out several recommendations and strategies for reducing greenhouse gas emissions and reaching the targets established in the executive order (CalEPA 2006). The greenhouse gas targets are:

- By 2010, reduce emissions to 2000 levels;
- By 2020, reduce emissions to 1990 levels; and
- By 2050, reduce emissions to 80 percent below 1990 levels.

GLOBAL WARMING SOLUTIONS ACT

In September 2006, Governor Schwarzenegger signed California's Global Warming Solutions Act of 2006 (AB 32). AB 32 requires the California Air Resources Board (CARB) to:

- Establish a statewide greenhouse gas emissions cap for 2020, based on 1990 emissions, by January 1, 2008;
- Adopt mandatory reporting rules for significant sources of greenhouse gas emissions by January 1, 2008;
- Adopt an emissions reduction plan by January 1, 2009, indicating how emissions reductions will be achieved via regulations, market mechanisms, and other actions; and
- Adopt regulations to achieve the maximum technologically feasible and cost effective reductions of greenhouse gases by January 1, 2011.

SENATE BILL 97

California Senate Bill (SB) 97, passed in August 2007, is designed to work in conjunction with CEQA and AB 32. SB 97 requires the California Office of Planning and Research to prepare and develop guidelines for the mitigation of greenhouse gas emissions or the effects thereof, including but not limited to, effects associated with transportation and energy consumption. These guidelines must be transmitted to the Resources Agency by July 1, 2009, to be certified and adopted by January 1, 2010. The Office of Planning and Research and the Resources Agency shall periodically update these guidelines to incorporate new information or criteria established by CARB pursuant to AB 32. SB 97 will apply to any EIR, negative declaration, mitigated negative declaration, or other document required by CEQA, prepared for a limited number of types of projects, which has not been finalized. SB 97 will be automatically repealed January 1, 2010.

In summary, no rules or regulations have been promulgated by CARB or any other state agency that define a "significant" source of greenhouse gas emissions. In addition, there are no applicable project-specific emission limitations or caps for greenhouse gas emissions, either statewide or at the local air district level. Thus, at this time, there are no thresholds of significance for greenhouse gas impacts that can be applied under CEQA.

5.5.3 Assessment Criteria and Methodology

Direct impacts on climate change were evaluated by estimating greenhouse gas emissions from implementation of the proposed Action.

5.5.3.1 Significance Thresholds

For NEPA compliance, there are no readily available significance thresholds for climate change-related impacts. CEQA significance criteria for greenhouse gas emissions are presented in the CEQA Guidelines (Appendix G). Specifically, the proposed Action would have a significant impact if it would:

- Individually or cumulatively impede the state's ability to meet its 2020 greenhouse gas emission reduction goal.

5.5.3.2 Evaluation Methods and Assumptions

The significance criterion listed above was used to assess potential impacts from the release of greenhouse gases from the proposed Action and alternatives.

5.5.4 Environmental Impact Assessment

5.5.4.1 Alternative 1: No Action

Under the No Action alternative, no piscicides would be applied to Silver King Creek and no generators would be used. Thus, the No Action alternative would not result in emissions of greenhouse gases.

5.5.4.2 Alternative 2: Proposed Action (Rotenone Treatment)

Implementation of the proposed Action would result in minor greenhouse gas emissions from vehicle and generator emissions as well as the degradation of rotenone in the environment. Rotenone, which occurs naturally in the roots and stems of several plants, breaks down naturally when exposed to sunlight and would be oxidized by potassium permanganate. The ultimate breakdown products of rotenone are carbon dioxide and water. Based on the chemical formula of rotenone ($C_{23}H_{22}O_6$), each kilogram of rotenone released could potentially result in emissions of about 2.5 kilograms of carbon dioxide after complete breakdown. The required 120 gallons of 5% rotenone solution contain approximately 25 kilograms of rotenone. Combined with vehicle and generator exhaust, the proposed Action would emit less than 100 kilograms of carbon dioxide. As discussed above, 2.8% of the 492 million metric tons of greenhouse gases emitted in California in 2004, or about 14 million metric tons, were from non-fossil fuel sources. Carbon dioxide emissions from the proposed Action would represent less than one millionth of this portion of the State's greenhouse gas emissions. Because the proposed Action would only result in emissions during the treatment process and would not be an on-going new source of greenhouse gas emissions, it would not impede the State's ability to meet its 2020 greenhouse gas emission reduction goal.

5.5.4.3 Alternative 3: Combined Physical Removal

Implementation of Alternative 3 would avoid the use of rotenone and therefore would only result in vehicle and generator emissions as discussed under the proposed Action. However, this alternative would involve more extensive use of small, gasoline-powered generators to recharge batteries used for electrofishing. Approximately 100 gallons of gasoline would be used for electrofishing over the course of this Alternative as well as approximately 500 gallons of gasoline for vehicles transporting workers to the treatment site. The USEPA estimates that on average, combustion of one gallon of gasoline emits 8.8 kilograms of carbon dioxide; thus, 100 gallons would result in emissions of over 5,000 kilograms. As discussed above, 81% of the 492 million metric tons of greenhouse gases emitted in California in 2004, or about 400 million metric tons, were from fossil fuel sources. Carbon dioxide emissions from Alternative 3 would represent less than one millionth of this portion of the State's greenhouse gas emissions. Because this Alternative would only result in short-term emissions during fish eradication and would not be an on-going new source of greenhouse gas emissions, it would not impede the State's ability to meet its 2020 greenhouse gas emission reduction goal.

5.5.5 References

Association of Environmental Professionals. 2007. Alternative Approaches to Analyzing Greenhouse Gas Emissions and Global Climate Change in CEQA Documents. Available online at http://www.califaep.org/userdocuments/File/AEP_Global_Climate_Change_June_29_Final.pdf.

California Energy Commission. 2006. Inventory of California Greenhouse Gas Emissions and Sinks: 1990 To 2004. Available online at http://www.energy.ca.gov/2006publications/CEC-600-2006-013/CEC-600-2006-013-SF.PDF.

U.S. Environmental Protection Agency (USEPA). 2005. Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel. Available online at http://www.epa.gov/oms/climate/420f05001.htm.

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5.6 RECREATION

This section evaluates the potential impacts of the proposed Action and alternatives on recreation resources in the proposed project area which is part of the Carson-Iceberg Wilderness Area (Wilderness Area).

5.6.1 Environmental Setting

The proposed treatment area is located within the 160,000-acre Carson-Iceberg Wilderness Area. This area straddles the crest of the central Sierra Nevada, within the Stanislaus and Humboldt-Toiyabe National Forests. The proposed project area is within Alpine County and is bordered by State Highway 108 on the south and State Highway 4 on the north. It is used for a number of recreational activities including hiking, camping, angling, hunting, and horseback riding. Nearly 200 miles of trails exist throughout the wilderness area with 10 major trailheads (USFS 1986). No motorized vehicles are allowed within the wilderness area per Section 4(c) of the Wilderness Act (see Section 5.7, Wilderness Values and Management).

Angling is a popular activity along Silver King Creek in the stream reaches open to fishing. The recreational fishery in Silver King Creek is composed of a genetic mixture of introduced rainbow, golden, and Lahontan cutthroat trout. Rarely, a pure Paiute cutthroat trout will wash below one of the barrier falls and be available to sport anglers. The fishery is self-sustaining and is popular with local angling groups. Fishing is allowed in Silver King Creek below the confluence with Tamarack Lake Creek downstream to the confluence with the East Fork of the Carson River. Currently, the areas closed to fishing within the proposed project area are the reach above Llewellyn Falls, including the tributaries Corral and Coyote Creeks, and the 3,600-foot reach from Llewellyn Falls downstream to Tamarack Lake Creek. Fishing season is open from the last Saturday in April through November 15.

Different reaches of Silver King Creek have been closed to fishing in recent years. Figure 5.6-1 depicts the reaches of the creek and their recreational status. Paiute cutthroat trout were restored to the area above Llewellyn Falls and for this reason the area is currently closed to fishing. CDFG initially closed the area between Llewellyn Falls and Silver King Canyon prior to the planned treatment in 2005. To protect pure Paiute cutthroat trout above Llewellyn Falls, CDFG adopted emergency regulations on August 18, 2005, to close Silver King Creek between Llewellyn Falls and Snodgrass Creek (see Figure 3-1) until December 22, 2005. The reach reopened at the beginning of the fishing season in April 2006.

CDFG subsequently proposed a regulatory change to permanently close 6 miles of Silver King Creek above Snodgrass Creek in order to reduce the threat of non-native trout being introduced upstream of Llewellyn Falls and compromising over 50 years of restoration efforts. The California Fish and Game Commission (hereinafter referred to as the Fish and Game Commission) held hearings on the proposal. At the May 4, 2006, meeting, representatives of the Alpine County Board of Supervisors and other interested parties concerned about the potential economic impact of the closure, proposed an alternative closure. To address potential economic effects, these parties proposed closing only the area between Llewellyn Falls downstream to the confluence of Tamarack Lake Creek, reducing the length of the stream closure to approximately 3,600 feet. The Fish and Game Commission adopted the modified proposal on June 23, 2006 (Fish and Game Commission 2006). Fishing is allowed in Silver King Creek below the confluence with Tamarack Lake Creek downstream to the confluence with the East Fork of the Carson River.

Wilderness permit data show a total of 2 visitor days in 2006 and 32 visitor days in 2007 (Kling 2008a). In both cases, these visits represent less than 1 percent of the total recreational use in the Carson-Iceberg Wilderness Area. However, actual recreation use in the area is higher because the available permit data does not account for all of the wilderness use (Kling 2008b).

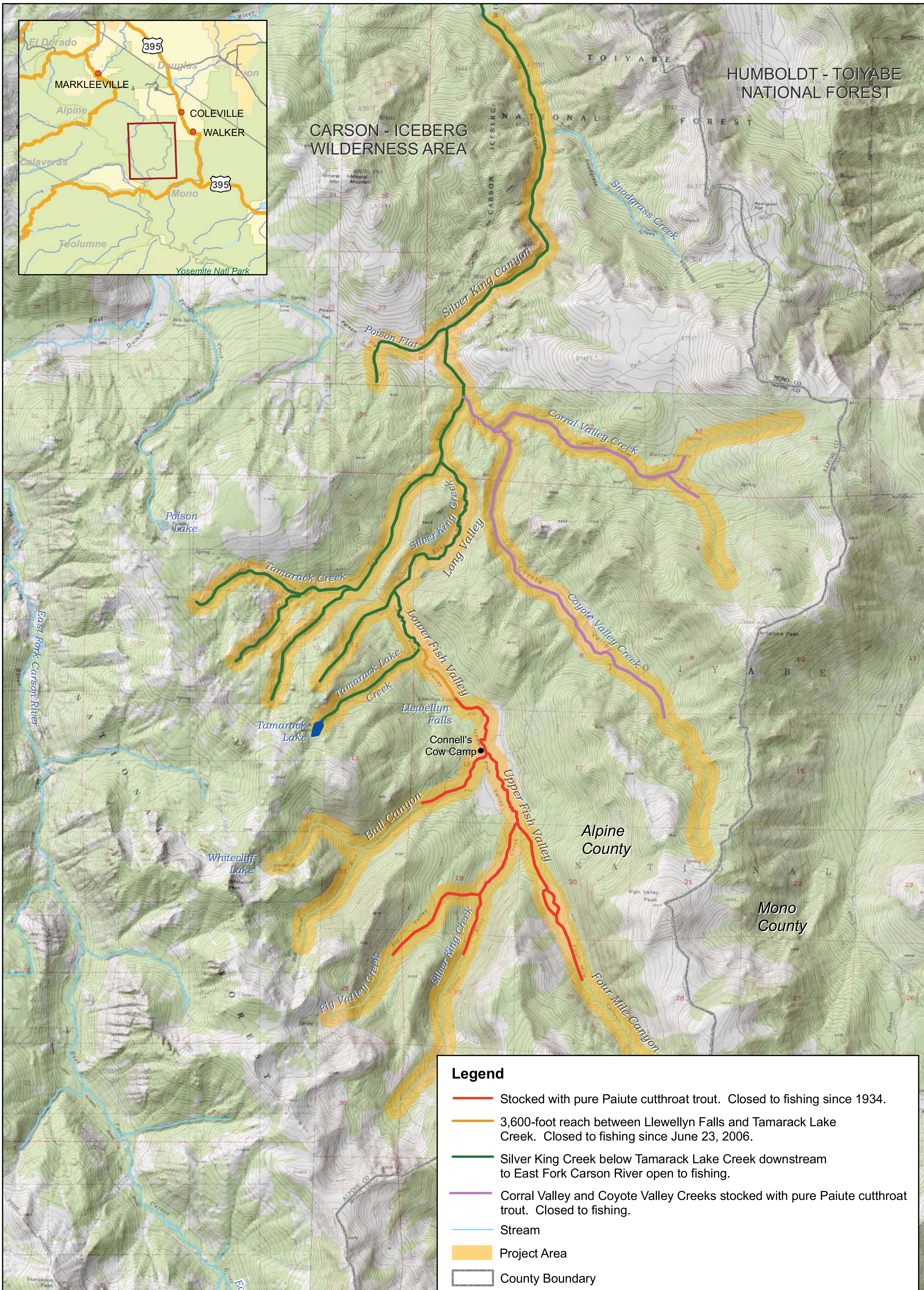
5.6.2 Regulatory Setting

The California Fish and Game Code (Section 200) authorizes the Fish and Game Commission to regulate the taking or possession of birds, mammals, fish, amphibia, and reptiles. The Fish and Game Commission's regulations may establish, extend, shorten, or abolish open and closed seasons; establish and change areas or territorial limits for their taking; and/or prescribe the manner and means of taking (Section 205). Current law (Section 315) further states that the Fish and Game Commission may, at any time, close any stream, lake, or other inland waters, or portions thereof, to the taking of any species or subspecies of fish to protect and properly conserve the fish.

5.6.2.1 California Fish and Game Code

Applicable excerpts from the Fish and Game Code (Sections 200, 205, 220 and 315) are listed below.

> *200. There is hereby delegated to the commission the power to regulate the taking or possession of birds, mammals, fish, amphibia, and reptiles to the extent and in the manner prescribed in this article.*
>
> *205. Any regulation of the commission pursuant to this article which relates to fish, amphibia, and reptiles, may apply to all or any areas, districts, or portion thereof, at the discretion of the commission, and may do any or all of the following as to any or all species or subspecies:*
>
> > *(a) Establish, extend, shorten, or abolish open seasons and closed seasons.*
> >
> > *(b) Establish, change, or abolish bag limits, possession limits, and size limits.*
> >
> > *(c) Establish and change areas or territorial limits for their taking.*
> >
> > *(d) Prescribe the manner and the means of taking.*
>
> *220. (a) Any regulation of the commission added or amended pursuant to this article shall remain in effect for the period specified therein or until superseded by subsequent regulation of the commission or by statute.*
>
> > *(b) Notwithstanding this article, the commission may add, amend, or repeal regulations at any regular or special meeting if facts are presented to the commission which were not presented at the time the original regulations were adopted and if the commission determines that those regulations added, amended, or repealed are necessary to provide proper utilization, protection, or conservation of fish and wildlife species or subspecies.*



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Paiute Cutthroat Trout Restoration Project

Figure 5.6-1

Silver King Creek Recreational Resources

Project area showing trout habitat in Silver King Creek, Humboldt-Toiyabe National Forest, Alpine County, California.

315. The commission may at any time close any stream, lake, or other inland waters, or portions thereof, to the taking of any species or subspecies of fish to protect and properly conserve the fish, except for the taking of fish otherwise permitted by this code under a commercial fishing license, for such time as the commission may designate, or until such time as new legislation thereon enacted by the Legislature may become effective.

5.6.2.2 Title 14, California Code of Regulations, Rulemaking

The Fish and Game Commission issued a Final Statement of Reasons for Regulatory Action. This action amended subsection (b)(178), Section 7.50, Title 14, California Code of Regulations, as follows:

7.50. Alphabetical List of Waters with Special Fishing Regulations (b)

Area or Body of Water: (178) Silver King Creek and tributaries (Alpine Co.) including lakes above Tamarack Lake Creek (within section 7 T7N R22E).

Open Season: Closed to all fishing all year

A rulemaking file with attached file index is maintained at the Fish and Game Commission, 1416 Ninth Street, Sacramento, California 95814. There is also a 4d rule 40 FR 29863; 50 CFR 17.44(a) which states that a violation of state law is also a violation of ESA.

5.6.3 Assessment Criteria and Methodology

Direct impacts on recreation were evaluated by estimating changes in the use or quality of existing parks or other recreational facilities in or near the affected areas. No new recreational facilities would be constructed and/or expanded as a result of the proposed Action or implementation of the alternatives.

5.6.3.1 Significance Thresholds

For NEPA compliance, there are no readily available significance thresholds for recreational resources. CEQA significance criteria for recreation are presented in the CEQA Guidelines (Appendix G). Specifically, the action would have a significant impact if it would:

- Increase the use of existing parks or other recreational facilities such that a substantial physical deterioration of the facility would occur or be accelerated.
- Include recreational facilities or requires the construction or expansion of recreational facilities which might have an adverse physical effect on the environment.

For CEQA, only the former criterion was examined because the proposed Action does not propose or require the construction of additional recreational facilities.

5.6.3.2 Evaluation Methods and Assumptions

The significance criterion listed above was used to assess potential impacts on recreational resources in the proposed project area. For purposes of this environmental impact assessment, components of the proposed Action were evaluated to determine whether implementation would cause a physical deterioration of the Carson-Iceberg Wilderness Area and if so, the level of deterioration was quantified relative to the entire recreational resource.

5.6.4 Environmental Impact Assessment

5.6.4.1 Alternative 1: No Action

Under the No Action alternative, the existing non-native trout fishery in Silver King Creek below Tamarack Lake Creek and the closure of 3,600 feet of stream from Llewellyn Falls to Tamarack Lake Creek would continue indefinitely. The No Action alternative would not affect hiking, camping, hunting or horseback riding. This alternative would not contribute to any direct physical deterioration of the area or the larger Carson-Iceberg Wilderness Area.

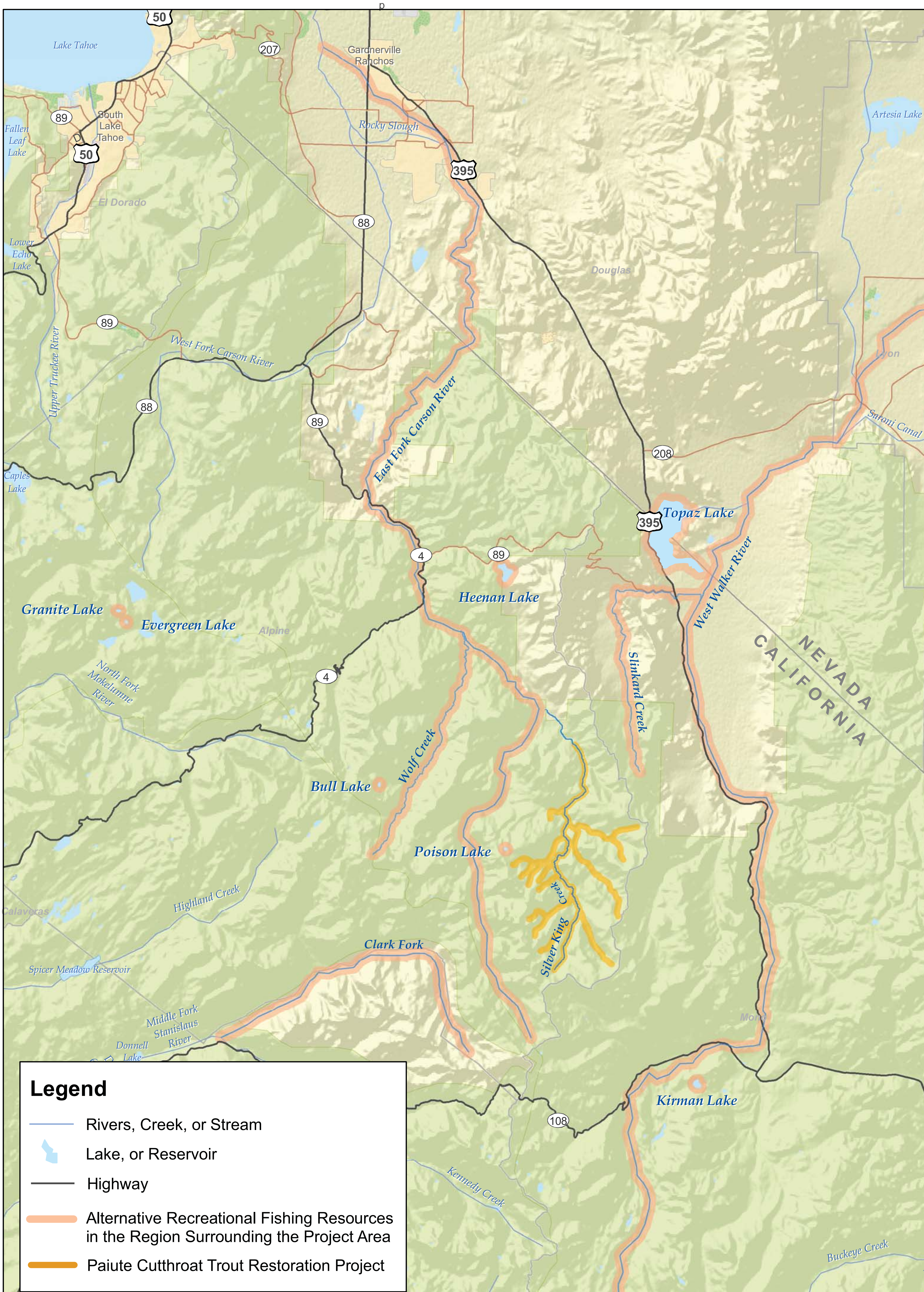
5.6.4.2 Alternative 2: Proposed Action (Rotenone Treatment)

Implementation of the proposed Action would have a direct adverse short term impact on recreational fishing in Silver King Creek. The entire treatment area from Llewellyn Falls to Silver King Canyon would not be closed to fishing during the chemical treatment process; thus, potential visitors who seek this fishing opportunity could be impacted during implementation of the proposed Action. However, there are other recreational fishing opportunities in a number of nearby waters, including the East Fork Carson River, Wolf Creek, Bull Lake, Silver King Creek below the treatment area, and Poison Lake.

The possible diversion of recreational fishing activity resulting from this area would not appreciably increase the use of other areas such that substantial physical deterioration would occur or be accelerated. The region provides a broad range of recreational opportunities and similar recreation experiences to those provided by Silver King Creek. As shown on Figures 5.6-1 and 5.6-2, the East Fork Carson River and greater Alpine County have a wide range of recreational fishing opportunities. Similarly, because visitors would be advised to avoid the treatment area and directed to other opportunities in the wilderness, and because workers would only be present for 7 working days and only in areas directly adjacent to the stream, the proposed Action would not significantly affect hiking, camping, hunting or horseback riding.

After Paiute cutthroat trout are successfully reintroduced into their historic habitat (adequate numbers of all age classes represented), the Fish and Game Commission could re-open the area to angling for native trout, which has not occurred in this area for over 50 years (prior to Wilderness designation). However, re-opening the area to fishing is not part of the proposed Action and would depend on separate decisions by the California Fish and Game Commission.

Similarly, if restoration is successful, Silver King Creek could be considered for designation as a California “Heritage Trout Water” by the Fish and Game Commission. The state’s Legislature recognized the special value of native trout by passage of an act (Fish and Game Code Sections 7260 and 7261) that acknowledges the importance of designating Heritage Trout waters to provide angling for forms of California native trout. The Heritage Trout Program is a feature of the Wild Trout Program that highlights restoration, education, and angling activities relating specifically to California’s native trout.



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0 2 4 8 Miles

Paiute Cutthroat Trout Restoration Project

Figure 5.6-2

Silver King Creek
Regional Recreational Fishing Resources

Project area showing trout habitat in Silver King Creek, Humboldt-Toiyabe National Forest, Alpine County, California.

The objectives of this program are to:

- Increase public awareness about the beauty, diversity, historical significance, and special values of California's native trout and their habitats.
- Build public support and increase public involvement in native trout restoration efforts.
- Promote collaborative efforts with organizations and individuals involved with native trout restoration and management.
- Diversify opportunities to fish for, observe, and enjoy native trout in their historic habitats.

The Fish and Game Commission established this program in 1998, by expanding its Wild Trout Policy so that streams or lakes featuring one or more of the State's native trout, and meeting other specific criteria, may be designated as Heritage Trout waters. Heritage Trout waters are a special subset of Wild Trout waters. Therefore, they are monitored and managed by the Department's Heritage and Wild Trout Program staff. In addition, the management of designated Heritage Trout waters will be guided by written management plans which identify actions and policies necessary to protect native trout habitats, and maintain or enhance native trout populations. Designation of Silver King Creek as a "Heritage Trout Water" would require a separate decision by the Fish and Game Commission that would not be part of the proposed Action.

5.6.4.3 Alternative 3: Combined Physical Removal

Implementation of Alternative 3 would not include chemical treatment during eradication efforts. As with the proposed Action, implementation of this Alternative would affect the area between Tamarack Lake Creek and Silver King Canyon; however, because visits to Silver King Creek account for less than 1% of the total recreational visits to the Carson-Iceberg Wilderness Area, implementation of this Alternative would not result in a significant impact on recreational fishing.

As such, any diversion of recreational fishing activity resulting from implementation of this Alternative would not increase the use of other areas such that substantial physical deterioration would occur or be accelerated. As shown on Figure 5.6-2, the East Fork Carson River and greater Alpine County have a wide range of recreational fishing opportunities.

Similar to the proposed Action, because visitors would be advised to avoid the project area and directed to other opportunities in the wilderness, and because workers would only be present in areas directly adjacent to the stream, Alternative 3 would not significantly affect hiking, camping, hunting or horseback riding.

As described above for the proposed Action, after Paiute cutthroat trout are successfully reintroduced into their historic habitat, the Fish and Game Commission could re-open the area to angling for native trout, providing a unique recreational fishery. In addition, if Paiute cutthroat trout were restored, Silver King Creek could be designated as a California "Heritage Trout Water." However, neither re-opening the area to fishing nor establishing a specially designated fishery are part of the proposed Action and would depend on separate decisions of the Fish and Game Commission.

Implementation of Alternative 3 would not result in significant impacts on recreational fishing. Individuals seeking a wilderness permit to fish in Silver King Creek would be directed to other areas in the wilderness. Because of the low number of visits to Silver King Creek, displacement of this activity to the areas depicted on Figure 5.6-2 would not result in their deterioration. For these reasons, the Combined Physical Removal alternative would result in less-than-significant impacts on recreational use and no mitigation measures would be required.

5.6.5 References

Fish and Game Commission. 2006. Final Statement of Reasons for Regulatory Action. Silver King Creek. June 23.

Kling J. 2008a. Visitor Permit Destination Use Summaries for 2005 – 2007. U.S. Forest Service.

Kling J. 2008b. USDA-FS Personal Communication with Bill Spain, ENTRIX Inc. November 5, 2008.

U.S. Forest Service (USFS). 1986. Humboldt National Forest Land and Resource Management Plan. http://www.fs.fed.us/r4/htnf/projects/forestplan/revision_documents/hfp/humb-fp.shtml. August

5.7 WILDERNESS VALUES AND MANAGEMENT

This section evaluates the potential impacts of the proposed Action and alternatives on wilderness values and management in the proposed project area. As described in Section 5.6, Recreation, the treatment area is located within the 161,181-acre Carson-Iceberg Wilderness Area (Wilderness Area).

5.7.1 Environmental Setting

The U.S. Congress designated the Carson-Iceberg Wilderness as a part of the California Wilderness Act of 1984. The Wilderness Area is managed in California by both the Humboldt-Toiyabe and Stanislaus National Forests. Various human uses, such as recreation, grazing, and mining, are allowed by the Wilderness Act, but all activities are managed or carried out subordinate to the higher purpose of maintaining wilderness values. These overriding values are 1) outstanding opportunities for solitude, and 2) the ability of natural processes to operate free of human influence.

The Pacific Crest Trail runs the length of this area for over 26 miles in the nearby Carson River drainage, while 200 total miles of foot and horse trails provide access. Recreation use is light to moderate especially on the eastern (Humboldt-Toiyabe) side (Wilderness.net 2007). In recent years, overnight recreation use in the Silver King Creek area has been low; wilderness permit data show a total of two visitor days in 2006 and 32 visitor days in 2007 (Kling 2008a). However, actual recreation use in the area is higher because the available permit data does not account for all of the wilderness use (Kling 2008b). The Paiute cutthroat trout is native to Silver King Creek. The historic range of the species is between Llewellyn Falls and the Silver King Canyon (USFWS 2004). Restoring the native trout to it native range is consistent with the Wilderness Act.

5.7.2 Regulatory Setting

The Wilderness Act of 1964 established a National Wilderness Preservation System "to secure for the American people of present and future generations the benefits of an enduring resource of wilderness." The Wilderness Act allows for activities within wilderness boundaries that involve the protection and propagation of federally Threatened and Endangered Species. Section 4(b) of the Wilderness Act and House Report 98-40, which supplements the California Wilderness Act of 1984, establishing the Carson-Iceberg Wilderness, specifically states that "certain wildlife management activities, designed to enhance or restore fish populations, are permissible and often desirable in wilderness areas to aid in achieving the goal of preserving the wilderness character of the area."

The USFS may authorize occupancy and use of National Forest land to carry out the purposes of the Wilderness Act. In general, it is desirable to not allow motorized use in designated wilderness areas. However, the USFS can prescribe conditions under which motorized equipment, mechanical transport, aircraft, aircraft landing strips, heliports, helispots, installations, or structures may be used, transported, or installed by the USFS and its agents and by other Federal, State, or county Agencies or their agents, to meet the minimum requirements for authorized activities to protect and administer the Wilderness Area.

5.7.3 Assessment Criteria and Methodology

5.7.3.1 Significance Thresholds

In general, potential impacts on wilderness values could be classified as either biophysical or social. Biophysical impacts include those that may be detrimental to the ecosystem such as large-scale erosion leading to increased turbidity. Social impacts include those that may be detrimental to the wilderness recreation experience. Wilderness Areas are intended to provide opportunities for solitude and wilderness visitors seek environments with limited evidence of human use. Therefore, allowing large groups in the wilderness or building large structures would be inconsistent with wilderness values.

5.7.3.2 Evaluation Methods and Assumptions

The proposed Action and its alternatives were assessed to determine if biophysical or social conditions in the Wilderness would be affected. The analysis assumes that activities to protect native fish species are consistent with wilderness values and management pursuant to the Wilderness Act of 1964. It assumes, however, that actions that would cause substantial biophysical impacts would be inconsistent.

5.7.4 Environmental Impact Assessment

5.7.4.1 Alternative 1: No Action

The No Action alternative would have no immediate effects on wilderness character in the Silver King Creek area. Paiute cutthroat trout would not be restored to its native range. All other aspects of the wilderness character would remain the same. The No Action alternative would not affect the ecological component of wilderness value; however, Paiute cutthroat trout, a native species, would not be restored to its historic habitat. There would be no disturbance of the human environment as camping, hiking, and other wilderness activities would not be affected. The No Action alternative could be detrimental to the uniqueness that Paiute cutthroat trout provides in this wilderness area. Transfer of fish above Llewellyn Falls could result in the loss of this unique wilderness element.

5.7.4.2 Alternative 2: Proposed Action (Rotenone Treatment)

Under Alternative 2, rotenone treatment of Silver King Creek would have short- and long-term effects on wilderness character. An assessment of potential effects on specific wilderness qualities or attributes is presented below.

UNTRAMMELED

Silver King Creek has a long history of human manipulation of ecological systems. Paiute cutthroat trout were introduced into historically fishless areas within the Silver King Creek basin in the late 1800s. Non-native trout were introduced into Silver King Creek in the early 1900s. CDFG have been managing fisheries, including Paiute cutthroat trout in Silver King Creek, since the early 1930s. Rotenone treatments occurred in the Silver King Creek Watershed upstream from the proposed project area beginning in 1964, with the latest treatment occurring in 1993 after the Wilderness Designation in 1984. Efforts have established pure populations throughout the watershed; however, Paiute cutthroat trout has not yet been restored to its native range.

The proposed Action would impair the untrammeled quality of wilderness as it is an intentional human caused manipulation of ecological systems inside wilderness. The proposed Action would result in short-term impacts on ecological processes as non-native trout are removed through rotenone treatment and Paiute cutthroat trout are reintroduced to its historic habitat. The chemical treatment would reduce macroinvertebrate populations and displace wildlife during implementation. Under the proposed Action, the genetic diversity of the species would be enhanced. If the action is completed, Paiute cutthroat trout populations would require less management by the Agencies in the future. In the long-term, wilderness values would be maintained as species recover. The proposed Action would also improve the ecological value of the system by restoring a native species to its historic habitat.

NATURAL

The proposed Action would impair the natural quality of wilderness. During implementation, a crew would consist of less than 50 people; however, camping and meals would concentrate around Connells Cow Camp. Workers would follow the LNT policy and low impact outdoor ethics. In the short term, workers would be highly visible to visitors using the area. Camps would be located on hardened or durable sites. Connells Cow Camp is located just upstream of the treatment area. The small cabin at this administrative site historically provided lodging for those managing livestock in the area. The site is currently used by Forest Service personnel conducting management activities in the wilderness.

During treatment, human occupation of the area would also impair the natural quality of wilderness. The Agencies would conduct the treatment over 2 to 3 years. CDFG experience indicates multiple treatments are necessary to eradicate non-native trout from streams (Finlayson et al. 2000). The treatments would occur between mid-August and mid-September beginning in 2009. Treatments would be repeated during mid-August and mid-September in 2010. If non-native trout carcasses were found during the 2010 treatment, a third year of treatment would be necessary in 2011. All or part of the chemical treatment may be applied twice in any given treatment year to assure complete non-native trout removal. Treatment is expected to occur over a week-long period (7 working days) each year.

Concentrations of rotenone would create a slight milky white color in the water immediately adjacent to the drip station but would not persist for a significant period.

UNDEVELOPED

The proposed Action would impair the undeveloped quality of wilderness as it includes the use of motorized equipment and the use of pesticides within wilderness. Tamarack Lake would be treated with rotenone dispensed by gasoline-powered pumps on two non-motorized rafts. In addition, chemical application would require the use of motorized volumetric augers powered by generators to dispense the neutralizing agent, potassium permanganate. Although small, the motorized equipment (generator and pumps) would be visible and audible to any visitors, and these sites and sounds may be associated with civilization.

A battery- or generator-powered auger at the neutralization site would be used to apply potassium permanganate at the neutralization site (refer to Figure 3-1). The auger would be operated for several hours during the treatment process and would increase the effectiveness of the neutralization in Silver King Creek, minimizing human and ecological exposure to potassium permanganate. The potassium permanganate would turn the water purple for less than 1 mile downstream of the neutralization site.

Some fencing material formerly used to manage livestock is still present in the proposed project area. The proposed Action does not include removing or altering any of these existing fences or erecting any structures. Because the proposed Action would consist only of the use of drip stations to apply rotenone and a generator-powered auger to apply potassium permanganate, the proposed Action would have less-than-significant effects on scenic integrity.

The Agencies would install signs at the trailheads to inform visitors of treatment activities as well as areas outside of the proposed project area where water is available. Most of the dead fish would be caught with block nets and disposed of quickly by burial. The proposed Action would result in no long-term visual impacts and no permanent structures would be erected during implementation of the proposed Action.

OUTSTANDING OPPORTUNITIES FOR SOLITUDE OR A PRIMITIVE AND UNCONFINED TYPE OF RECREATION

The proposed Action would be implemented within a small portion of the Carson-Iceberg Wilderness. There are numerous nearby areas within the wilderness available to visitors to provide solitude opportunities. However, during the treatment process (1 week per year over 2 to 3 years), workers would be present throughout the proposed project area, hindering the ability for visitors to experience solitude. Visitor impacts would be managed by providing visitors with alternative destinations within the wilderness. The ability for visitors to experience solitude after the proposed Action is completed would be similar to pre-treatment levels. The proposed project area currently provides anglers the opportunity to fish for non-native trout with little disturbance from other anglers or visitors. Eradication of non-native trout and reintroduction of Paiute cutthroat trout would result in short-term impacts on solitary fishing opportunities. Re-opening the area to fishing would depend on the success of restored Paiute cutthroat trout and future decisions of the California Fish and Game Commission that are not part of the proposed Action.

The proposed Action would result in a short-term reduction in angling opportunities as non-native trout are removed from Silver King Creek. After Paiute cutthroat trout are successfully reintroduced into their historic habitat (adequate numbers of all age classes represented), the California Fish and Game Commission could re-open the area to angling for native trout, which has not occurred in this area for over 50 years (prior to Wilderness designation). However, re-opening the area to fishing is not part of the proposed Action and would depend on separate decisions of the California Fish and Game Commission.

SPECIAL ECOLOGICAL VALUES

The area proposed for treatment is the historic range for Paiute cutthroat trout, which is considered among the rarest trout in North America. The subspecies is federally listed as threatened under ESA. Implementation of the proposed Action is a major component of the Revised Recovery Plan (USFWS 2004). Successful implementation of the proposed Action would likely result in delisting of the species in the near future.

The area has a rich history of livestock management and many aspen stands in the surrounding area contain arboglyphs dating back to the early 1900s. Because the proposed Action would not affect these aspen stands, no impacts on the historic value of this special feature would occur.

5.7.4.3 Alternative 3: Combined Physical Removal

Similar to the proposed Action, Alternative 3 would have short and long-term effects on wilderness character. The impacts associated with physical removal of fish on specific wilderness qualities or attributes are described below.

UNTRAMMELED

This alternative would impair the untrammeled quality of wilderness as it is an intentional human caused manipulation of ecological systems inside wilderness. This alternative would result in short to long-term impacts on ecological processes as non-native trout are removed physical methods and Paiute cutthroat trout are reintroduced to its historic habitat. Under this alternative, the genetic diversity of the species would be enhanced. If this alternative is completed, Paiute cutthroat trout populations would require less management by the Agencies in the future. In the long-term, wilderness values would be maintained as species recover. This alternative would also improve the ecological value of the system by restoring a native species to its historic habitat.

Although the trout that are present in the area are non-native, this alternative would disrupt ecological processes by removing a high proportion of trout residing in Silver King Creek and tributaries over several years. Restocking would restore ecological processes in the area to pre-treatment conditions.

NATURAL

This alternative would impair the natural quality of wilderness. Under Alternative 3, Agency personnel would electrofish approximately 6 miles of mainstem Silver King Creek and 5 miles of associated tributary streams until all non-native trout were removed from the area. Fish removal crews would consist of approximately 11 individuals. The Agencies also expect that electrofishing would continue over multiple years (at least 10 years) due to poor removal efficiency in areas with heavy aquatic vegetation, root wads, woody debris, and boulder fields. Removal activities would be undertaken between late-June or early July and mid-October due to suitable access and weather conditions. Workers would follow the LNT policy and low impact outdoor ethics. In the short term, workers would be highly visible to visitors using the area. Camps would be located on hardened or durable sites. Connells Cow Camp is located just upstream of the area to be electrofished under this alternative. The small cabin at this administrative site historically provided lodging for those managing livestock in the area. The site is currently used by Forest Service personnel conducting management activities in the wilderness.

UNDEVELOPED

Electrofishing is expected to continue over multiple years. Furthermore, generators would be required to recharge electrofishing equipment, resulting in localized noise and air quality impacts. Most of the fish stunned during electrofishing would be caught with nets and disposed of quickly through burial. No long-term visual impacts would occur.

Some fencing material formerly used to manage livestock is still present in the area. This alternative does not including removing or altering any of these existing fences or erecting any structures. Similar to the proposed Action, the Agencies would install signs at the trailheads to inform visitors of electrofishing activities. This alternative would result in no long-term visual impacts and no permanent structures would be erected during implementation.

OUTSTANDING OPPORTUNITIES FOR SOLITUDE OR A PRIMITIVE AND UNCONFINED TYPE OF RECREATION

An 11-person work crew would be present throughout the area for most of the summer season and over multiple years hindering the ability for visitors to experience solitude. However, the ability of a visitor to experience solitude would return to pre-treatment levels after this alternative is completed.

Alternative 3 would result in a reduction in angling opportunities as non-native trout are removed from Silver King Creek. Removal of non-native trout would require multiple years (at least 10 years), resulting in reduced opportunity for primitive recreation. After Paiute cutthroat trout are reintroduced to their historic habitat, the area could be re-opened to angling. However, after Paiute cutthroat trout are successfully reintroduced into their historic habitat (adequate numbers of all age classes represented), the California Fish and Game Commission could re-open the area to angling for native trout, which has not occurred in this area for over 50 years (prior to Wilderness designation). However, re-opening the area to fishing is not part of Alternative 3 and would depend on separate decisions of the California Fish and Game Commission.

SPECIAL ECOLOGICAL VALUES

If successful, this alternative would restore a federally threatened species to its native range and would likely result in the delisting of Paiute cutthroat trout.

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5.8 ECONOMIC RESOURCES

This section describes socioeconomic conditions in the treatment area and assesses potential economic impacts of the proposed Action and alternatives. The section focuses on economic resources most likely affected by the proposed Action and alternatives, namely local economic activity, related measures of economic welfare (i.e., income and employment), and recreation-based economic values. Each of these measures can be affected by changes in recreation use and visitation to the region resulting from the proposed Action. Potential impacts on population and housing, particularly growth-inducing effects are discussed in Section 6.4, Growth-Inducing Impacts.

5.8.1 Environmental Setting

The local socioeconomic conditions in the area are described in this section to provide context for analysis of potential economic impacts and to serve as the baseline against which economic impacts are measured. Socioeconomic conditions described are population and housing, economic base, and the economic role and value of recreation and tourism. For the economic analysis, the proposed treatment area (or impact region) includes Alpine County (within which Silver King Creek is located) and northern Mono County, located east of Silver King Creek. The closest communities to the area are Markleeville in Alpine County; and Walker, Coleville, and Bridgeport in northern Mono County. Information on these communities is considered where appropriate and data are available.[1]

5.8.1.1 Population

Alpine County is located along the crest of the Sierra Nevada mountain range on the California-Nevada border. It is a predominantly rural county, and with a population of 1,222 in 2008, it has the smallest population of all counties in California. Most of the population is concentrated in a few mountain communities, including Markleeville, Woodfords, Bear Valley, and Kirkwood (DOF 2008a). The nearest community to Silver King Creek in Alpine County is the town of Markleeville, approximately 14 miles northwest of the area proposed for treatment. Markleeville is a census-designated place (CDP) and the county seat of Alpine County. The 2000 population of Markleeville was 197 (U.S. Census Bureau 2000).

Mono County is situated southeast of Alpine County along the California-Nevada border. Similar to Alpine County, it is largely a rural county, with a population of 13,759 in 2008. There is one incorporated city in Mono County, the City of Mammoth Lakes, but it is not located near the proposed project area. As described above, there are several small communities in Mono County located near the treatment site, including Walker (population: 558), Coleville (population: 77), and Bridgeport (population: 794) (Mono County 2008).[2]

Silver King Creek is within the Carson-Iceberg Wilderness Area, which is public land managed by the USFS. As public land, it is not open for urban development, and accordingly, there are no permanent residents in the immediate vicinity.

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[1] Economic data for the local communities are presented wherever possible; however, certain economic data are not available for unincorporated areas.
[2] Population based on 2000 Census data. Population for individual communities tallied by census blocks.

5.8.1.2 Economic Base

The economy of Alpine County depends substantially on tourism and related recreation industries, as well as government expenditures on public lands throughout the region. In total, there are approximately 860 jobs in Alpine County (EDD 2007). The public sector represents a key source of employment in Alpine County, accounting for about 270 jobs (or nearly one-third of the job base), most of which are in state and local government. Private employment in Alpine County totals roughly 580 jobs, primarily in service-oriented industries, many of which are tied directly to tourism and recreation, which are key contributors to the Alpine County economy.

Mono County has a relatively larger employment base. In total, local industries in Mono County support about 6,920 jobs. Employment in the public sector (i.e., federal, state and local government) totals approximately 1,530 jobs (nearly one-quarter of employment). Private employment totals 5,360, with service-related industries accounting for most of the employment in Mono County with 4,710 jobs. Of this total, 2,830 jobs are in the leisure and hospitality sector.

At the community level, Markleeville is home to a mix of local, state and federal government employees, ranging from the USFS to Caltrans, as well as small businesses catering to the tourist trade and visitors to the nearby Grover Hot Springs State Park and other recreation destinations (Alpine Chamber of Commerce 2007). Likewise, local communities in northern Mono County, including Walker, Coleville and Bridgeport, are home to a range of recreation-serving business, such as recreation outfitters, local retailers, lodging, and restaurants.

5.8.1.3 Role of Recreation and Tourism in the Economy

The role of recreation and tourism in the economies of Alpine and Mono counties is significant. As indicated in Section 5.6, Recreation), the primary recreation and tourism activities in these counties are fishing, hunting, camping, hiking, rafting, skiing, snowmobiling, and other winter snow sports. The existing economic benefits of recreation in the proposed treatment area are tied to expenditures made en route and in the region, as well as permit fees. Typical recreation expenditures include gas, food, lodging, other trip costs (e.g. pack trip fees, bait and ice), as well as recreation equipment (e.g. fishing tackle and camping gear).

Total annual travel spending in Alpine County rose from $17.4 million in 1992 to $27.6 million in 2006, a 59 percent increase over the 10-year period (or an average of 3.1 percent annually) (Dean Runyon Associates 2008). Based on 2006 figures, travel spending is estimated to generate approximately $6.7 million in labor earnings and support 340 jobs in Alpine County (39 percent of total county employment), as well as produce $1.3 million in state and local tax receipts annually.

In Mono County, total annual travel spending was estimated at $394.3 million in 2006, up from $197.6 million in 1992. The economic benefits attributed to 2006 travel spending in Mono County include roughly $119.1 million in labor earnings and 5,070 jobs for local residents.[3] In addition, visitor spending also produces approximately $24.1 million annually in state and local tax revenue, part of which directly benefits local municipalities. A large portion of the economic benefits of travel spending in Mono County is attributed to the Mammoth Mountain Ski Area, which is located over 100 miles south of the proposed treatment site.

[3] This estimate of tourism-related employment appears high relative to countywide employment data published by the California Employment Development Department; however, travel spending appears to support a large proportion of employment in Mono County.

5.8.1.4 Existing Economic Benefits of Recreation in Silver King Creek Watershed

Visitors are drawn to the proposed treatment area, and therefore support the local economy, largely due to the attractions of the Carson-Iceberg Wilderness Area. Based on permit data maintained by the USFS, a conservative estimate of visitation to the Carson-Iceberg Wilderness Area indicates that approximately 3,600 overnight visitors recreated in the area during the 2007 season, which accounted for a total of nearly 8,300 visitor days (USFS 2007).[4] Information on day use visitation was unavailable. The same 2007 permit data indicate that recreation activity in the Silver King Creek area (the location of proposed fishery restoration efforts) was limited and accounted for only about 0.4% of permitted recreation in the wilderness area, with 16 overnight visitors generating 32 visitor days.

The small number of recorded visitors to the Silver King Creek area is likely due to its remote nature and lack of accessibility (motorized vehicles are not permitted in wilderness areas). Instead, visitors either backpack long distances into the area or utilize the services of a local pack station operator who transports recreational equipment and supplies by pack horse for visitors. In addition, low visitation levels can also be attributed to the lack of nearby population centers and other more accessible recreation opportunities in the region. Lastly, recreation use in the proposed treatment area could be curtailed by the current fishing closure of the 3,600 feet of stream located between Llewellyn Falls and Tamarack Creek Lake. This closure was implemented by the California Fish and Game Commission to preserve native Paiute cutthroat trout above Llewellyn Falls. However, because no survey data are available, any impacts resulting directly from the closure cannot be quantified.

The existing economic benefits of recreation in this area are based on expenditures made in local communities by visitors while traveling to and from their destination, which is typically related to the number of visitors and type of recreation activity undertaken. Recreation by activity is not directly tracked in the USFS permit data, but backpacking/hiking and fishing are likely the primary activities in the Carson-Iceberg Wilderness Area. Similarly, since no direct information is available on recreation-related expenditures made by visitors to the wilderness area, the information is inferred from other data sources. Based on information provided in the USFWS' 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, people participating in freshwater fishing activities spend approximately $60.80 per visitor day on trip and equipment related purchases (USFWS 2006). If it is assumed that all visitors to the Carson-Iceberg Wilderness Area make all of their purchases locally and engage in fishing as their principle activity,[5] then permitted recreation visitation throughout the wilderness area generates a conservative estimate of $504,000 in recreation spending annually in Alpine and Mono counties. These expenditures directly support jobs and generate income for local workers, and to the extent that inter-industry linkages exist in the region, additional indirect[6] and induced[7] economic benefits are generated. Because little data are available, these additional economic effects have not been quantified.

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[4] Because these permit data are likely incomplete and because permits are not required for day users, this estimate of the number of visitors is considered low and represents a lower-bound estimate of recreation use in the area. On average, overnight visitors stayed 2.3 days in the wilderness area.

[5] Visitors to the Carson-Iceberg Wilderness Area engage in a range of recreation uses; however, without specific information on recreation levels across activities, this assessment conservatively assumed all visitors were freshwater fishing, which typically generates higher spending levels than other wilderness activities, such as backpacking.

[6] Indirect economic effects refer to changes in output, income, and employment resulting from the iterations of businesses in some industries purchasing from businesses in other industries and initially caused by the direct economic effects.

[7] Induced economic effects refer to changes in output, income, and employment caused by the expenditures associated with new household income generated by direct and indirect economic effects.

Similarly, recreation spending by visitors to the Silver King Creek area is also unknown. Based on USFWS spending data, it is estimated that the 32 visitor days to the proposed treatment area only generates about $1,900 per year in travel spending. However, total travel spending is believed to be substantially higher for several reasons. First, the permit data are incomplete and do not account for day-use visitors, which according to a local pack station operation, represent approximately 25% of its total business (Cereghino 2008). Next, this estimate does not consider the unique characteristics and tourism draw of the Silver King Creek area. Because of the high-quality recreation opportunities this area provides, including the potential opportunity to catch Paiute cutthroat trout (below Tamarack Lake Creek), it draws visitors from outside the region, who typically have higher recreation expenditures than locals. Finally, the USFWS spending data do not account for trip-related expenditures on guide and outfitting services commonly used to access the Silver King Creek area. Accordingly, travel spending associated with recreation in the Silver King Creek area is likely to be substantially higher than the estimate above and attributed primarily to fishing activity downstream of Tamarack Lake Creek (below the existing closure area); however, the associated economic benefits are still expected to be minimal.

5.8.1.5 Other Economic Values of Recreation

In addition to regional economic benefits for local communities in jobs and income, recreation provides economic value to those individuals engaged in the recreation activity. These economic benefits are measured by consumer surplus values (or willingness-to-pay) for different types of recreation activities. Consumer surplus values capture the amount that a recreation user is willing to pay to engage in a recreation activity above and beyond what is actually paid, and are typically estimated using survey information and statistical techniques. There is no information available on the recreation-based economic value attributed specifically to the Carson-Iceberg Wilderness Area, but representative values are available from other sources. A summary of representative consumer surplus values per day for various types of recreation occurring in the proposed project area is presented below (Loomis 2005):[8]

- Backpacking: $52.10
- Camping: $104.35
- Fishing: $44.36
- Hunting: $46.92
- General Recreation: $32.35
- Hiking: $23.24
- Sightseeing: $20.27
- Wildlife Viewing: $72.48

To utilize these values to estimate the consumer surplus in the area, numerous conditions must be fulfilled according to benefits-transfer methodology. The applicability of the values requires information regarding recreation participation by activity, and numerous details regarding the types of users and their trip characteristics. Without this knowledge, which is unavailable for the area, it is difficult to estimate the consumer surplus values of recreation specific to the proposed

[8] Average consumer surplus values are for the Pacific region, and are measured on a per-person per-day basis; values in dollars (2004).

treatment area. However, assuming that these values could be applied to the this area and all recreation takes the form of fishing, recreation activity in the wilderness area is conservatively estimated to generate approximately $367,900 in consumer surplus values annually based on existing permit data, while recreation near Silver King Creek only generates an estimated $1,400 per year.

5.8.2 Regulatory Setting

NEPA recognizes that projects can result in ecological, aesthetic, historic, cultural, economic, social, or health effects (NEPA regulations, Title 40 C.F.R. § 1508.8); therefore, social and economic values need to be considered in the NEPA process. NEPA regulations (Title 40 C.F.R. § 1508.14) also state that “economic or social effects are not intended by themselves to require preparation of an environmental impact statement. When an environmental impact statement is prepared and economic, social and natural or physical environmental effects are interrelated, then the environmental impact statement will discuss all of these effects on the human environment.”

Economic considerations are treated differently under CEQA (1970). Section 15131 of the CEQA Guidelines (Guidelines) state that: “Economic or social effects of a project shall not be treated as significant effects on the environment. An EIR may trace a chain of cause and effect from a proposed decision on a project through anticipated economic or social changes resulting from the project to physical changes caused in turn by the economic or social changes. The intermediate economic or social changes need not be analyzed in any detail greater than necessary to trace the chain of cause and effect. The focus of the analysis shall be on the physical changes.” The Guidelines also state that: “Economic or social effects of a project may be used to determine the significance of physical changes caused by the project.”

5.8.3 Assessment Criteria and Methodology

5.8.3.1 Significance Thresholds

The use of significance thresholds for economic resources varies under NEPA and CEQA. For NEPA, there are no readily available significance thresholds for economic resources. Generally, the proposed economic benefits and impacts of the proposed action are evaluated independently and professional judgment is used to determine the significance of impacts. There are no CEQA significance thresholds for economic resources.

5.8.3.2 Evaluation Methods and Assumptions

The assessment of economic impacts focuses on those resources that would be potentially affected by the proposed Action and alternatives. For the proposed Action, potential economic impacts include changes in regional economic activity (e.g. economic production, income, and jobs) and recreation-based economic values. These changes are tied directly to potential changes in recreation visitation and spending in the proposed treatment area. Projected changes in recreation visitation and related economic benefits have not been quantified. However, project-related economic impacts were assessed qualitatively based on the period that the area would be closed for the treatment.

5.8.4 Environmental Impact Assessment

This section describes the potential impacts of the proposed Action and alternatives in the context of economic resources. Economic impacts are organized by alternative, and include both direct and indirect economic effects of the action.

5.8.4.1 Alternative 1: No Action

The No Action alternative would indefinitely continue the existing fishing closure along Silver King Creek from Llewellyn Falls to the confluence with Tamarack Lake Creek (approximately 3,600 feet). To the extent that current fishing restrictions have adversely affected visitation to the wilderness area, local businesses in the region that provide recreation-related goods and services to visitors would continue to realize lower revenues relative to pre-closure conditions.[9] Similarly, the economic (consumer surplus) value realized by recreationists visiting Silver King Creek would continue to be lower compared to pre-closure conditions based on the foregone recreation opportunities resulting from ongoing fishing restrictions just below Llewellyn Falls, where high-quality recreation opportunities exist. Although the magnitude of these economic impacts has not been quantified they are minor because of the small number of visitors that have historically visited the area, availability of (and demand for) alternative fishing opportunities below Tamarack Lake Creek, opportunities for visitors to recreate in other parts of the wilderness area, and the small size of the area closed to fishing.[10] Further, when considered relative to existing conditions (with fishing restrictions in place), no changes in economic activity or consumer surplus values would occur under the No Action alternative and no adverse economic impacts would result. Instead, the No Action alternative would effectively preclude any future recreation and related economic benefits associated with potential re-opening the closed portion of the area to fishing, as described below for the action alternatives. However, as described below, re-opening the proposed project area to fishing would depend on separate decisions of the California Fish and Game Commission that are not part of the proposed Action or Alternative 3.

5.8.4.2 Alternative 2: Proposed Action (Rotenone Treatment)

The proposed Action would require 1-3 years of rotenone application depending on the success of initial treatments (see Chapter 3.0, Project Alternatives). During the implementation period (i.e., approximately one week annually including mobilization, treatment, and post-treatment water quality monitoring), all visitors would be advised to avoid the treatment area. The area closed to fishing would include areas downstream of the existing closure.[11] However, visitors would still be able to access and recreate in other parts of the wilderness area.

Subsequent to treatment, Silver King Creek would be subject to extensive fishery monitoring efforts. When monitoring demonstrates eradication of non-native trout, the Agencies would restock the stream with native Paiute cutthroat trout (see Chapter 3.0, Project Alternatives).

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[9] Data are not available to determine the effect that existing fishing restrictions have had on recreation levels in the project area and recreation-related spending in the local economy.

[10] The proposed fishing closure of Silver King Creek below Llewellyn Falls was reduced from six miles (to Snodgrass Creek) to 3,600 feet (to Tamarack Lake Creek) by the Fish and Game Commission in an effort to reduce the potential economic hardship to local businesses. See the Final Statement of Reasons for Regulatory Action amending Title 14, Section 7.50(b)(178) of the California Code of Regulations.

[11] The closure area would include Silver King Creek and tributaries between Llewellyn Falls and Silver King Creek Canyon, as well as the neutralization area downstream of Snodgrass Creek. This area is substantially larger than the area subject to existing fishing restrictions.

During the restocking period, the treatment area would be open to public access, but closed to fishing. The area closed to fishing during restocking would be determined by the California Fish and Game Commission. It would likely be substantially larger than the 3,600-foot reach currently closed, and would likely extend from Llewellyn Falls downstream to Snodgrass Creek. The duration required for the Agencies to establish a self-sustaining population of Paiute cutthroat trout is unknown and would be determined by population monitoring.

The economic impacts of the proposed Action are dependent on the effect it has on recreation visitation and spending in the area, as well as action-induced expenditures during implementation. In terms of recreation-based impacts, until fishing opportunities are fully restored along Silver King Creek to existing levels, economic activity and consumer surplus values under the proposed Action may be lower than baseline conditions if there are declines in fishing activity and associated visitation to the region. More specifically, local businesses that have historically served anglers recreating in the Silver Creek King area would likely experience a decline in revenue, which could also have ripple effects throughout the local economy based on inter-industry linkages and household spending patterns. However, the magnitude of these adverse economic impacts is expected to be minimal because these recreation-serving businesses would continue to serve anglers visiting alternative fishing sites in other parts of the wilderness area (e.g. East Carson River) and Stanislaus National Forest, which are not affected by the proposed Action, and therefore, recreation activity and spending would likely remain in the region. Moreover, wilderness angling use is relatively low, and therefore, related spending impacts would be negligible from a regional perspective. Lastly, there exists few economic linkages between sectors in the local economy based on its small size and the lack of a local manufacturing base; accordingly, the potential for regional economic impacts would be low.

Conversely, the proposed Action has the potential to generate local economic benefits during implementation. Local businesses may experience an increase in revenues associated with Agency personnel and work crews travel within the region and the need for transport to and from the proposed treatment site. These expenditures would likely include gas, food, and lodging by workers in local communities, as well as payments to the local pack station operator for the transport of equipment and staff to the treatment area.

The net short-term economic effect of the proposed Action is difficult to ascertain because neither the potential adverse, nor beneficial, economic impacts of the action have been quantified. However, based on a qualitative assessment of economic resources, the proposed Action could likely result in a significant economic impact on local businesses during the period after treatment. This applies particularly to those businesses that attribute a large proportion of their business to fishing activity in the Silver King Creek basin. Short-term impacts would likely be offset by action-related expenditures that would generate revenues for many of these same businesses. In comparison, from a regional perspective, based on the small number of visitors to the proposed treatment area relative to the region and the availability of alternative recreation opportunities, the regional economic impacts of the proposed closure of Silver King Creek would be less-than-significant when compared to future No Action conditions.

In the long term, the proposed Action could result in a full re-opening of Silver King Creek to fishing after treatment and successful fishery restoration. However, potential future re-opening of the proposed project area to fishing would depend on separate decisions of the California Fish and Game Commission that are not part of the proposed Action.

If the area were re-opened to fishing, particularly with a high-quality native trout fishery, local businesses and recreationists would likely benefit from the increased visitation. Under this scenario, local economic benefits would consist of increased sales of recreation goods and services and related increases in income and jobs. Small recreation-serving businesses would realize the greatest economic benefits, including those that cater to anglers that would choose to fish Silver King Creek. Benefits to recreationists would occur in the form of increased consumer surplus values.

In summary, the proposed Action would likely result in adverse economic effects on specialized local businesses (i.e., business that rely on angling activity in the proposed treatment area) during treatment and restoration, which may be offset by the beneficial economic impacts associated with implementation of the proposed Action realized by these same businesses. However, these impacts on economic resources would not be significant when evaluated at the regional level based on the abundant recreational opportunities available in the area, including other parts of the Carson-Iceberg Wilderness Area, which would remain open to recreation use. In the long term, the proposed Action would have a beneficial regional impact on economic resources if the trout fishery were re-established, particularly with native Paiute cutthroat trout. These benefits would entail increases in business sales, jobs and income, as well as recreation-based economic values, relative to existing and future No Action conditions.

5.8.4.3 Alternative 3: Combined Physical Removal

Alternative 3, Combined Physical Removal, would be implemented over a period of multiple years (at least 10 years). Visitors would be advised of the project; however, Alternative 3 may not require closing the area to fishing during fish removal. Therefore, this alternative would not significantly reduce recreational visitation during electrofishing. However, as with the proposed Action, this alternative could result in a significant economic impact on local businesses during the restocking period when the area would be closed to fishing, particularly for businesses that attribute a large proportion of their business to fishing activity in the Silver King Creek basin. Similarly, short-term impacts would likely be offset by project-related expenditures that would generate revenues for many of these same businesses. In comparison, from a regional perspective, based on the small number of visitors to the area relative to the region and the availability of alternative recreation opportunities, the regional economic impacts of the proposed closure of Silver King Creek would be less-than-significant when compared to future No Action conditions.

In the long term, this alternative could result in a full re-opening of Silver King Creek to fishing after multiple years of electrofishing and successful fishery restoration. However, potential future re-opening of the area to fishing would depend on separate decisions of the California Fish and Game Commission that are not part of Alternative 3. As for the proposed Action, re-opening the area would likely benefit local businesses.

In summary, Alternative 3 would likely result in adverse economic effects on specialized local businesses during the multi-year electrofishing and restoration period. However, these effects may be offset by the beneficial economic impacts associated with project implementation. In addition, these impacts would be less-than-significant at the regional level based on the abundant recreational opportunities available in the area, including other parts of the Carson-Iceberg Wilderness Area, which would remain open to recreation use. In the long term, Alternative 3 would have a beneficial regional impact on economic resources if a native trout fishery were reestablished pending future California Fish and Game Commission decisions that are not part of this alternative.

5.8.5 References

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5.9 ENVIRONMENTAL JUSTICE

This section describes the existing social environment in the region around the area proposed for treatment and assesses the potential social impacts of the proposed Action and alternatives on Alpine County and the Markleeville community, as well as neighboring Mono County (refer to Figure 1-1). The focus of this section is an analysis of environmental justice, which refers to the fair and equitable treatment of individuals regardless of race, ethnicity, or income level in the development and implementation of environmental management policies and actions. Therefore, the key socioeconomic parameters addressed here are local demographics, including population and race/ethnicity, and measures of social and economic well-being, including per capita income and poverty rates.

5.9.1 Environmental Setting

This section provides a demographic overview of the local area residents, which will be used in an analysis of environmental justice impacts. The geographic scope of the information presented is Alpine County, including Markleeville (the county seat and the nearest community in proximity to the proposed Action) and Mono County.

5.9.1.1 Population Trends and Projections

Alpine County borders Nevada in northeast California and is sparsely populated. As shown in Table 5.9-1, the current population in Alpine County is 1,222 persons, ranking it the least populous county in the State (California Department of Finance [DOF] 2008a). There are no incorporated cities in Alpine County, but 4 townships in which the small population is concentrated (Markleeville, Woodfords, Bear Valley and Kirkwood). Within those areas, there are no supermarkets, emergency care facilities, or banks. Of the 727 square miles in Alpine County, 96% is under public ownership. Markleeville had a population of 197 persons in 2000 (U.S. Census Bureau 2000). The total population in Alpine County accounts for less than 0.1% of the State's total population of just over 37.6 million.

Table 5.9-1 Population and Population Growth (2000–2007)

Area	Population			Population Growth (%)	
	2000	2005	2007	2000–2005	2005–2007
Alpine County	1,208	1,243	1,261	2.9%	1.5%
Mono County	12,853	13,666	13,985	6.3%	2.3%
State of California	33,873,086	36,743,186	37,662,518	8.5%	2.5%

Sources: California Department of Finance (Demographic Research Unit) 2007a.

Mono County borders Alpine County to the southeast and is somewhat more densely populated than Alpine County. As shown in Table 5.9-1, the total population in Mono County in 2007 was 13,985 persons. There is one incorporated city in the county, Mammoth Lakes, where about half of the population is located (7,560 people in 2007) (DOF 2007a).

Population growth in the vicinity of the proposed Action has been limited over the past couple of decades. In Alpine County, population increased by a total of 2.9% between 2000 and 2005, and 1.5% between 2005 and 2007. Population trends are not available for Markleeville. In Mono

County, population increased by a total of 6.3% between 2000 and 2005, and 2.3% between 2005 and 2007. Population growth at the State level has been substantially higher than that of Alpine County and somewhat more similar to that of Mono County, increasing by over 11% cumulatively since 2000 (DOF 2007a).

Population projections through 2030 for Alpine County, Mono County, and the State of California are shown in Table 5.9-2. Population projections are not available for Markleeville. It is projected that the population in Alpine County will increase through 2030, mostly by 2020, and Mono County's population will increase steadily through 2030. More specifically, Alpine County's population is expected to increase by 8.6% between 2000 and 2010 and by 6.1% between 2010 and 2020, while Mono County's population is expected to increase by 15.4% between 2000 and 2010, by 21.9% between 2010 and 2020, and by 26.6% between 2020 and 2030 (DOF 2007b). At the State level, high growth rates are expected, with population projected to grow consistently over the next three decades, increasing by 42% cumulatively through 2030 (relative to 2000 levels).

Table 5.9-2 Population Projections (2000–2030)

Area	Population			Population Growth (%)		
	2010	2020	2030	2000–2010	2010–2020	2020– 2030
Alpine County	1,369	1,453	1,462	8.6%	6.1%	0.6%
Mono County	14,833	18,080	22,894	15.4%	21.9%	26.6%
State of California	39,246,767	43,851,741	48,110,671	15.9%	11.7%	9.7%
Sources: California Department of Finance (Demographic Research Unit) 2007b.						

5.9.1.2 Race/Ethnicity

Race (or ethnicity) is an important consideration for evaluating potential environmental justice-related effects of the action alternatives. The racial and ethnic composition of the Alpine County, Mono County, and statewide populations are presented in Table 5.9-3. Generally, the racial/ethnic makeup of the local vicinity of the proposed Action is much less diverse than statewide conditions. The predominant racial group in both Alpine and Mono counties is White (Caucasian), comprising roughly 70% of the countywide population (DOF 2007c). In Alpine County, the other racial groups, combined, represent 30% of the local population, led by American Indians/Alaska Natives (17%) and Hispanics/Latinos (9% of the total population). In Mono County, the other racial groups, combined, represent 29% of the local population, led by Hispanics/Latinos (24%). Statewide, Whites account for only 44% of total population, while Hispanics/Latinos account for about 35%.

Table 5.9-3 Race/Ethnicity (2006)

Area	Race (Percent of Total Population)						
	White	Black/ African American	American Indian/ Alaska Native	Asian	Native Hawaiian/ Pacific Islander	Multi-Race	Hispanic/ Latino
Alpine County	70%	1%	17%	0%	0%	4%	9%
Mono County	71%	0%	2%	1%	0%	2%	24%
State of California	44%	6%	1%	12%	0%	2%	35%
Sources: California Department of Finance (Demographic Research Unit) 2007c.							

5.9.1.3 Income-Related Measures of Social Well-Being

As derivatives of total personal income, per capita and median household income and poverty rates represent widely used economic indicators of social well-being. Table 5.9-4 presents these socioeconomic data for the vicinity of the proposed Action and California. In 2004, per capita personal income in Alpine County was $30,768, which is about 13% less than the statewide level of $35,219, while per capita personal income in Mono County was $35,082, roughly the same as statewide income (DOF 2007d). Based on these figures, per capita personal income in Alpine County ranked 23rd in the State and Mono County ranked 16th. The disparity between local and statewide conditions is greater in the context of median household income. Based on 2000 Census data (1999 dollars), median household incomes in Alpine County, Mono County, and the State of California were $41,875, $44,992 and $47,493, respectively. Median household income levels are not available for Markleeville. Finally, poverty rates represent the percentage of an area's total population living at or below the poverty threshold established by the U.S. Census Bureau. Based on 2000 Census data, the poverty rate was 19.5% in Alpine County, 11.5% in Mono County, and 10.6% in the State of California.

Table 5.9-4 Income and Poverty Rates

Area/Region	Per Capita Income (2004)	Median Household Income (1999)	Poverty Rate (1999)
Alpine County	$30,768	$41,875	19.5%
Mono County	$35,082	$44,992	11.5%
State of California	$35,219	$47,493	10.6%
Sources: California Department of Finance (Demographic Research Unit) 2007d.			

5.9.2 Regulatory Setting

The USEPA Office of Environmental Justice offers the following definition of environmental justice:

> *"The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic group should bear a disproportionate share of the negative environmental consequences resulting from*

industrial, municipal, and commercial operations or the execution of Federal, State, local, and tribal programs and policies."

Executive Order 12898, "*Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,*" requires each federal agency to incorporate environmental justice into its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects, including social or economic effects, of its programs, policies, and activities on minority populations and low-income populations of the United States (Council on Environmental Quality 1997). As such, environmental justice is considered part of the NEPA (1969) process.

The U.S. Department of Interior (DOI) provides direction to its agencies, including the USFWS, for integrating environmental justice considerations into their programs and activities in compliance with Executive Order 12898. The mission of DOI to environmental justice is "to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to tribes." DOI's Environmental Justice Strategic Plan (1995) contains the following four goals:

- **Goal 1.** The Department will involve minority and low-income communities as we make environmental decisions and assure public access to our environmental information.
- **Goal 2.** The Department will provide its employees environmental justice guidance and with the help of minority and low-income communities develop training which will reduce their exposure to environmental health and safety hazards.
- **Goal 3.** The Department will use and expand its science, research, and data collection capabilities on innovative solutions to environmental justice-related issues (for example, assisting in the identification of different consumption patterns of populations who rely principally on fish and/or wildlife for subsistence).
- **Goal 4.** The Department will use our public partnership opportunities with environmental and grassroots groups, business, academic, labor organizations, and Federal, Tribal, and local governments to advance environmental justice.

To achieve Goal 1, USFWS has implemented programs to reach inner-city and other indigent groups to assure public access to information. Through the USFWS' Office of Training Education, a variety of training courses are offered to USFWS managers that include elements of conflict resolution and deal specifically with inter-cultural and minority conflicts for Goal 2. For Goal 3, the USFWS conducts short-term and some long-term studies and research related to various environmental issues, such as the management of refuges, fisheries, and environmental contaminant issues. Lastly, the USFWS is involved in a variety of agreements and partnerships with other federal agencies, the states, and other non-federal entities, such as the Interorganizational Committee on Guidelines and Principles for Social Impact Assessment to implement Goal 4.

5.9.3 Assessment Criteria and Methodology

5.9.3.1 Significance Thresholds

In the following analysis, an assessment is made regarding the magnitude of changes in different economic variables. Under NEPA, an analysis of social, economic, and environmental justice effects is required; however, there is no standard set of criteria to evaluate economic impacts (see Section 5.8.2). Under CEQA, economic and social impacts are not considered significant effects on the environment. Therefore, there is no guidance in the Initial Study checklist included in the CEQA Guidelines and no "significance determinations" are made or mitigations required in the impact analyses.

5.9.3.2 Evaluation Methods and Assumptions

The main issue in the context of environmental justice is whether implementation of the proposed Action and alternatives would result in adverse environmental or economic impacts that fall disproportionately on low-income or minority populations in the proposed treatment area. For this analysis, and based on federal guidance and professional judgment, the following criteria are used to evaluate potential impacts and their magnitude (i.e., substantial or not).

- Are affected resources used by a minority or low-income community.
- Are minorities or low-income communities disproportionately subject to environmental, human health, or economic impacts.

Background material was reviewed to understand whether low-income or minority populations in Alpine and Mono Counties could be disproportionately adversely affected by the proposed Action. Using data from the U.S. Census Bureau (2000), an analysis was carried out to compare the ethnic/racial compositions and poverty levels in the communities near the proposed treatment site with those in Alpine and Mono counties. Markleeville is a CDP in Alpine County; however there were no other CDPs in the vicinity of the proposed Action or Alpine and Mono counties in the 2000 Census.

5.9.4 Environmental Impact Assessment

5.9.4.1 Alternative 1: No Action

The No Action alternative would not affect resources used by a minority or low-income community or disproportionately affect minorities or low-income communities to environmental, human health, or economic impacts, because this alternative would not change existing conditions. Therefore, this alternative would have no impact on environmental justice issues.

5.9.4.2 Alternative 2: Proposed Action (Rotenone Treatment)

As discussed in the environmental setting section of Section 5.8, Economic Resources, the nearest community to the proposed treatment area is the town of Markleeville, approximately 14 miles (22,531 meters) northeast of the treatment area. Therefore, risks to human health of the residents of Markleeville from implementation of the proposed Action are likely non-existent and would not disproportionately affect a minority or ethnic population group.

5.9.4.3 Alternative 3: Combined Physical Removal

Similar to the proposed Action, the distance from the proposed treatment area to the nearest community is approximately 14 miles (22,531 meters) to the northeast. No chemicals would be applied under this alternative and risks from fuel releases would be minor and localized and would be addressed through spill contingency planning. Therefore, potential risks to human health would not disproportionately affect a minority or ethnic population group.

5.9.5 References

Alpine County Chamber of Commerce. 2007. http://www.alpinecounty.com/recreation.

California Department of Finance (DOF). 2007a. E-4 Population Estimates for Cities, Counties and the State, 2001-2007, with 2000 Benchmark. Sacramento, California. May 2007.

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Council on Environmental Quality. 1997. Environmental Justice – Guidance under the National Environmental Policy Act. Washington, DC.

U.S. Census Bureau. 2000. Retrieved March.

U.S. Department of Interior (DOI). 1995. Environmental Justice Strategic Plan -1995. http://www.doi.gov/oepc/ej_goal1.html

5.10 COMPARISON OF THE ALTERNATIVES

This section provides an overview description of the 3 alternatives ("No Action", "Proposed Action," and "Combined Physical Removal") evaluated in the EIS/EIR. Chapter 3.0, Project Alternatives, presents a more detailed description of the proposed Action and alternatives, including a map (Figure 3-1) depicting the components of the proposed Action. This section then presents the alternatives in comparative form; defining the differences between each alternative and providing information for decision makers and the public (refer to Table 5.10-1). The alternatives comparison is based on each alternative's components and technical merit as well as the environmental, social and economic effects of implementation.

5.10.1 Overview of Alternatives

ALTERNATIVE 1: NO ACTION

The No Action alternative includes continuing the current stream and fishery management practices into the foreseeable future without implementing the Revised Recovery Plan (USFWS 2004). Under the No Action alternative, no eradication of non-native trout or reintroduction of Paiute cutthroat trout below Llewellyn Falls would be implemented, the species would not be reintroduced to its historic range, and its ESA status of threatened would likely remain unchanged. This alternative would include the continued protection of pure Paiute cutthroat trout populations in Upper Fish Valley, other tributaries in the Silver King Creek Watershed, and out-of-basin populations, including continued restrictions on recreational fishing.

ALTERNATIVE 2: PROPOSED ACTION (ROTENONE TREATMENT)

The proposed Action includes rotenone treatment of Silver King Creek and tributaries as well as Tamarack Lake if fish are present. The proposed Action would include pre-treatment removal of fish by seeking California Fish and Game Commission approval for an increase daily bag limit of 5 fish per day in the proposed treatment area in an attempt to reduce existing non-native trout populations; pre-treatment biological surveys and monitoring for amphibians and benthic macroinvertebrates; placement of signs to inform the public; water quality monitoring (during and post treatment); and post-treatment biological monitoring.

ALTERNATIVE 3: COMBINED PHYSICAL REMOVAL

This alternative includes the use of a non-chemical alternative, a combination of electrofishing, gill netting, seining, and other physical methods to address the removal of non-native trout in Silver King Creek and its tributaries, springs, and Tamarack Lake. Because this method could have low efficiency in a rocky stream environment, it would be implemented over multiple years (i.e., until no fish are found using physical removal techniques).

Conceptually, an intensive multiyear removal effort could eradicate non-native trout; however, these efforts could fail to capture small fish and could be compromised by trout moving into the proposed treatment area from untreated upstream areas. Any fish captured after the third year of physical removal would be genetically tested to ascertain its genetic heritage. If the remaining fish were hybridized, more removal would be needed. If the remaining fish were pure Paiute cutthroat trout, then recolonization efforts would begin.

5.10.2 Alternatives Comparison

The following paragraphs provide a comparison of the alternatives, including the differences between them and their technical, environmental, social and economic merits.

ALTERNATIVE 1: NO ACTION

The No Action alternative would avoid all the direct impacts associated with implementation of the proposed Action, including chemical application and impacts on non-target species and water quality. However, the No Action alternative would not accomplish the objectives of establishing Paiute cutthroat trout as the only trout species in Silver King Creek under the proposed Action. It would not further the Agencies' mandate to prevent Paiute cutthroat trout from going extinct. Specifically, it would not implement the central component of the Revised Recovery Plan (USFWS 2004). It would not provide additional protection of existing populations from transplantation of fish, would not expand its numbers and habitat size by restoring the species to its historic range, and would not reduce threats from genetic bottlenecking and stochastic events. The No Action alternative would not provide potential recreational or economic benefits should the California Fish and Game Commission make future decisions not part of the proposed Action to re-open the area to recreational fishing.

ALTERNATIVE 2: PROPOSED ACTION (ROTENONE TREATMENT)

The proposed Action would include rotenone treatment of Silver King Creek and tributaries as well as Tamarack Lake, if fish are present. The treatment would result in potential loss of rare benthic macroinvertebrate species or species unique to Silver King Creek and Tamarack Lake (i.e., endemic species). These effects would be significant and unavoidable because their intensity and duration is not easily defined and no feasible mitigation measures are readily available. They would also be cumulatively significant when considered together with past rotenone treatments in the Silver King Creek Watershed (see Chapter 6.0, Other Required Decisions). The proximity of untreated headwaters and upstream portions of tributaries and springs would reduce this impact by providing sources for recolonization.

Chemical application would result in less-than-significant impacts on stream water quality, human health, amphibians, non-native trout, terrestrial wildlife, recreation, wilderness values and management and environmental justice. Rotenone would have significant short-term and unavoidable impacts on water quality in Tamarack Lake. The potential for fishing closures could result in localized recreational and economic effects; however, should the California Fish and Game Commission make future decisions to re-open the area to fishing, the proposed Action could provide beneficial long-term recreational and economic effects through elimination of non-native trout and restoration of a unique rare trout species.

The Agencies believe the proposed rotenone treatment and restocking of pure Paiute cutthroat trout would meet all objectives of the proposed Action including establishing Paiute cutthroat trout as the only trout species in Silver King Creek, significantly reducing the probability of Paiute cutthroat trout extinction, implementing the Revised Recovery Plan, reducing the probability of inadvertent introduction of non-native trout, expanding the area occupied by Paiute cutthroat trout including restoring Paiute cutthroat trout to its historic range, and increasing the probability of long-term viability.

ALTERNATIVE 3: COMBINED PHYSICAL REMOVAL

This alternative would employ electrofishing, gill netting, seining, and other physical methods to address the removal of undesirable non-native trout species within Silver King Creek and its tributaries, springs, and Tamarack Lake. Physical removal would avoid the effects of chemical treatment but would result in other direct impacts because this method would need to be implemented over multiple years (at least 10 years, refer to Chapter 3.0, Project Alternatives). Crews would likely be in the wilderness for most of the summer for several years. The electrical current could adversely affect amphibian populations. Overall, the Agencies are concerned that this approach, while resulting in fewer environmental impacts, could ultimately be unsuccessful. Electrofishing is proven as a survey method but is not proven as a method to remove all fish. This method would likely fail to capture small fish, which would continue to populate the area proposed for treatment. In addition, trout from upstream of this area would likely move into the area during the multiple years of electrofishing and would confound effects to determine the success of fish eradication efforts.

5.10.3 Comparison of Environmental Effects of Alternatives

As specified in Chapter 4.0, Scope of the Analysis, none of the alternatives would affect aesthetics, agricultural resources, air emissions of particulates, archaeological and historic architectural resources, fire management, geological and mineral resources, groundwater, hazards and hazardous materials management and spills, wildfire, land use and management, noise, wild horses and burros, grazing, paleontological resources, population and housing public services, traffic and transportation, and utilities. Therefore, these resource areas are not evaluated in the comparative analysis presented below.

Table 5.10-1 provides a summary and comparison of the impacts of the 3 alternatives and resource areas evaluated in detail in this chapter. It shows that the proposed Action would have the greatest impact on aquatic and water resources because the chemical treatment would affect water quality objectives and stream invertebrates in Silver King Creek and Tamarack Lake, potentially resulting in the loss of individual species. In comparison, Alternative 3 would have less impact on benthic invertebrates but would result in greater impacts on terrestrial species. In addition, because Alternative 3 would take much longer than the proposed Action, it would result in more disruption of wilderness values.

The No Action alternative would have no direct environmental effects but would not achieve the objectives of the proposed Action. Alternative 3 would have greater social effects (e.g. extended effects on recreational access, diminished wilderness values); however, because these techniques may not be effective for fish eradication, this alternative may not achieve the objectives of the proposed Action. The proposed Action would have the least upland impacts and the least recreational and wilderness impacts because of the relatively short implementation time. In contrast, it would have the greatest in-stream impacts because of the chemical treatment. However, the proposed Action would achieve all objectives.

Table 5.10-1 Comparison of Environmental Effects of Silver King Creek Paiute Cutthroat Trout Restoration Project Alternatives

Affected Resource	Alternative 1 No Action		Alternative 2 Proposed Action		Alternative 3 Combined Physical Removal	
Aquatic Biological Resources (Section 5.1)	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Paiute cutthroat trout	—	Adverse	Adverse	Beneficial	Adverse	Beneficial
Non-native trout	—	—	Adverse	Adverse	Adverse	Adverse
Benthic macroinvertebrates (aquatic insects)	—	—	Adverse	Unknown	Adverse	Unknown
Riparian habitat	—	—	—	—	—	—
SUMMARY	Adverse: Paiute cutthroat trout would remain at risk of extirpation through hybridization with non-native fish.		Adverse: Mortality of Paiute cutthroat trout (if present). Potentially significant and unavoidable impacts on rare and endemic benthic macroinvertebrate species in Silver King Creek. Potentially significant impacts on invertebrate populations in Tamarack Lake. Fish transfers during Paiute cutthroat trout restocking could reduce populations in donor areas. Potential impacts on fish and benthic macroinvertebrates downstream of the neutralization station near Snodgrass Creek would be mitigated to less- than-significant. Beneficial: The proposed Action would nearly double the number of stream miles of habitat occupied by Paiute cutthroat trout over existing conditions. Unknown: Loss of undiscovered rare or endemic species would not be quantifiable.		Adverse: Mortality of non-native fish and Paiute cutthroat trout (if present). Less-than-significant impacts on benthic macroinvertebrates in Silver King Creek and Tamarack Lake. Physical disturbance by work crews would be greater than proposed Action, in duration and intensity, but less-than-significant because populations would recover rapidly. Beneficial: If successful, this alternative would nearly double the number of stream miles of habitat occupied by Paiute cutthroat trout over existing conditions. Unknown: Loss of undiscovered rare or endemic species would be less likely under the non-chemical alternative but would not be quantifiable.	
Terrestrial Biological Resources	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Wildlife (Threatened, Endangered, Candidate, Forest Sensitive, Management Indicator, and Neotropical Migratory Birds)	—	—	—	—	—	—
Amphibians	—	—	—	Beneficial	—	Beneficial
Riparian and other Sensitive Habitats	—	—	—	—	—	—

Table 5.10-1 Comparison of Environmental Effects of Silver King Creek Paiute Cutthroat Trout Restoration Project Alternatives

Affected Resource	Alternative 1 No Action		Alternative 2 Proposed Action		Alternative 3 Combined Physical Removal	
Terrestrial Biological Resources (continued)	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
SUMMARY	No effect.		Effects on terrestrial wildlife species dependent on fish or stream invertebrates as food would be less-than-significant. Rotenone toxicity to amphibians in aquatic life stages would be avoided by relocating adult and tadpole life stages out of the treatment area. Habitat disturbance by work crews would be less-than-significant. **Beneficial:** Removal of predatory non-native trout species would benefit amphibian populations.		Effects on terrestrial wildlife species dependent on fish or stream invertebrates as food would be less-than-significant. Electrofishing injury to amphibians in aquatic life stages would be avoided by relocating adult and tadpole life stages out of the treatment area. Physical disturbance by work crews would be greater than proposed Action, in duration and intensity, but less-than-significant. **Beneficial:** Removal of predatory non-native fish species would benefit amphibian populations.	
Human Toxicological Concerns	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Hazards to the Public	—	—	—	—	—	—
Hazards to the Environment	—	—	Adverse	—	—	—
SUMMARY	No effect.		Human exposure to chemicals would be less-than-significant because exposure pathways are incomplete. Rotenone application would result in temporary impacts on species composition of benthic invertebrate populations. Potassium permanganate could result in mortality in downstream fish populations.		No effect.	
Water Quality	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Silver King Creek	—	—	Adverse	—	—	—
Tamarack Lake	—	—	Adverse	—	—	—
SUMMARY	No effect.		**Adverse:** Chemical application would result in significant water quality impacts in Tamarack Lake. The proposed Action would result in less-than-significant impacts on dissolved oxygen, bacteria, turbidity and color in the treatment area.		This alternative would have less–than-significant impacts on turbidity, bacteria and dissolved oxygen concentrations.	

Table 5.10-1 Comparison of Environmental Effects of Silver King Creek Paiute Cutthroat Trout Restoration Project Alternatives

Affected Resource	Alternative 1 No Action		Alternative 2 Proposed Action		Alternative 3 Combined Physical Removal	
Greenhouse Gases and Climate Change	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
California's GHG emission reduction goal	—	—	—	—	—	—
SUMMARY	No effect.		Emissions from rotenone degradation would be less-than-significant.		Emissions from portable generators would be less-than-significant.	
Recreation Resources	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Treatment area	—	Adverse	—	—	—	—
Other recreational areas	—	—	—	—	—	—
SUMMARY	**Adverse:** Angling would remain closed above the confluence of Silver King Creek and Tamarack Lake Creek indefinitely.		Visitors would be advised to avoid the treatment area during implementation of the proposed Action. Impacts would be less-than-significant given access to alternate areas. Other local streams may experience increased use; however, the low number of diverted users would result in less-than-significant impacts on alternate sites. Physical impacts of workers would be minimized by using existing camps and trails.		Visitors would be advised to avoid the treatment area. Impacts would be less-than-significant given access to alternate areas. Other local streams may experience increased use; however, the low number of diverted users would result in less-than-significant impacts on alternate sites. Physical impacts of crews and workers would be greater than proposed Action but minimized by using existing camps and trails.	
Wilderness Values and Management	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Wilderness experience	—	—	—	—	—	—
Protection of native species	—	Adverse	Adverse	Beneficial	Adverse	Beneficial
SUMMARY	**Adverse:** The native Paiute cutthroat trout would remain at risk of extirpation through hybridization with non-native trout.		**Adverse:** Short-term use of chemicals and generators, and the presence of workers would be inconsistent with wilderness values but would be limited by using existing camps and trails. **Beneficial:** Elimination of non-native trout and restocking of a native species would be consistent with wilderness values.		**Adverse:** Extended use of generators and the presence of workers for successive years would be inconsistent with wilderness values but would be limited by using existing camps and trails. **Beneficial:** Elimination of non-native trout and restocking of a native species would be consistent with wilderness values.	

Table 5.10-1 Comparison of Environmental Effects of Silver King Creek Paiute Cutthroat Trout Restoration Project Alternatives

Affected Resource	Alternative 1 No Action		Alternative 2 Proposed Action		Alternative 3 Combined Physical Removal	
Economics	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Local and regional economic activity	—	Adverse	—	Unknown	—	Unknown
SUMMARY	Precludes potential future recreation and economic benefits from expanded fishing opportunities.		Potential short-term reduction in local angling-related economic activity would be offset by the potential increase in action-related economic activity. Unknown: Possible long-term increase in angling-related economic activity due to increased visitation by anglers seeking to catch Paiute cutthroat trout in its native habitat depending on future California Fish and Game Commission decisions not part of the proposed Action.		Potential short-term reduction in local angling-related economic activity would be offset by the potential increase in action-related economic activity. Unknown: Possible long-term increase in angling-related economic activity due to increased visitation by anglers seeking to catch Paiute cutthroat trout in its native habitat depending on future California Fish and Game Commission decisions not part of Alternative 3.	
Environmental Justice	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Minorities or low-income communities	—	—	—	—	—	—
Resources used by minority or low-income communities	—	—	—	—	—	—
SUMMARY	No effect.		No effect.		No effect	

5.10.4 Designation of the Environmentally Superior Alternative

CEQA requires the designation of the environmentally superior alternative, which is the alternative that would result in the fewest or least significant environmental impacts. However, if the No Action alternative is identified as the environmentally superior alternative, then CEQA requires that another alternative be identified as the environmentally superior alternative.

As illustrated by Table 5.10-1, the No Action alternative would be the environmentally superior alternative because it would avoid all of the potentially significant impacts of the proposed Action. However, with respect to longer-term consequences, the No Action alternative would fail to achieve the objectives of the proposed Action. The No Action would not implement the Revised Recovery Plan (USFWS 2004). Paiute cutthroat trout would not inhabit its historic range and would remain vulnerable to stochastic events and further hybridization. In addition, should non-native trout be introduced upstream of Llewellyn Falls into pure Paiute cutthroat trout populations, decades of restoration efforts would be unraveled and may result in uplisting of Paiute cutthroat trout to endangered. While the significant impacts of the proposed Action would be completely avoided in the short-term under the No Action alternative, the No Action would fail to protect and preserve the species. In comparison, Alternative 3 (Combined Physical Removal) would result in significant, direct impacts on amphibians as well as extended effects on recreation and wilderness values. The effectiveness of Alternative 3 could be difficult to verify and therefore would be challenging to implement and may not accomplish the objectives of the proposed Action. Therefore, the proposed Action is the environmentally superior alternative.

5.10.5 References

U.S. Fish and Wildlife Service (USFWS). 2004. Revised Recovery Plan for the Paiute cutthroat trout (*Oncorhynchus clarkii seleniris*). Portland, Oregon. Ix + 105 pp.

CHAPTER 6

Other Required Disclosures

6.1 RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

NEPA requires consideration of “the relationship between short-term uses of man’s environment and the maintenance and enhancement of long-term productivity” (40 CFR 1502.16). As declared by the Congress, this includes using all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans (NEPA Section 101).

The relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity of the affected resources (identified below) for the proposed Action is described below. Short-term impacts, primarily resulting from treatment with rotenone, are associated with the implementation of the proposed Action. However, the maintenance of long-term biological and economic resource productivity and the benefits for Paiute cutthroat trout populations and status outweigh short-term adverse impacts on individual resources. The short-term uses of the environment for the proposed treatment are addressed below by resource category.

6.1.1 Aquatic Resources

The proposed Action would result in the short-term loss of any Paiute cutthroat trout present in the treatment area as well as all non-native trout. However, these losses are part of the objectives of the proposed Action and would be offset by restocking Paiute cutthroat trout beginning the year after the final rotenone treatment, the long-term enhancement of ecological and other wilderness values, and the direct long-term benefit for Paiute cutthroat trout from removing hybridized fish that are incompatible with recovery.

The proposed Action would result in short-term impacts on benthic macroinvertebrate species composition and potentially long-term impacts on rare and endemic benthic macroinvertebrates. Species composition would be expected to recover substantially within 2 years of the final treatment as required by the Basin Plan rotenone policy. There are no known special-status or endemic species currently inhabiting the proposed treatment area. However, loss of any rare or endemic species would be an adverse consequence of the proposed Action with unknown and unquantifiable effects on long-term productivity.

The proposed Action would have temporary and less-than-significant impacts on riparian habitats adjacent to the stream corridor. The proposed Action would not involve use of any heavy equipment or any excavation or tree or vegetation removal. The only disturbance would be from foot traffic of workers applying treatment chemicals from the stream banks. Therefore, the proposed Action would have only minor short-term direct impacts on riparian habitat and no indirect or long-term effects on productivity or re-establishment of riparian habitat.

6.1.2 Terrestrial Resources

The proposed Action could have short-term effects on terrestrial wildlife (i.e., riparian bird species) by temporarily removing some benthic macroinvertebrate species from the proposed treatment area, thereby reducing a major food source. The temporary loss of benthic macroinvertebrates and their terrestrial forms may impact insectivorous wildlife. However, this short-term effect of the rotenone treatment would be offset by recolonizing Paiute cutthroat trout, and benthic invertebrates, from headwater and tributary areas to the proposed treatment area.

6.1.3 Human and Ecological Exposure

There would be no short-term or long-term impacts on human health due to the remoteness of the area proposed for treatment, the distance to any downstream human population, procedures employed to minimize worker exposure, and the visitor advisory that would be put in place during the treatment process (see Chapter 3.0, Project Alternatives). Human exposure pathways were considered incomplete in the risk assessment (refer to Appendix C). As described in Section 5.3, Human and Ecological Health Concerns, the proposed Action would have short-term, less-than-significant impacts on amphibians, terrestrial and avian wildlife that would not affect long-term productivity.

6.1.4 Water Resources

Short-term impacts of the proposed Action from chemical treatment, neutralization and other activities on surface water quality, hydrology and geomorphology would include potential temporary impacts of rotenone toxicity. Rotenone degrades rapidly in the presence of sunlight and warm temperatures and may persist in natural water bodies from between a few days to several weeks, making this a short-term effect. These short-term effects would have no long-term effect on the productivity of Silver King Creek.

6.1.5 Greenhouse Gases and Climate Change

Implementation of the proposed Action would result in minor greenhouse gas emissions from vehicle trips, use of generators, and degradation of rotenone in the environment. As described in Section 5.5, Greenhouse Gases and Climate Change, the carbon dioxide that would be emitted during implementation of the proposed Action would represent less than one millionth of this portion of the State's greenhouse gas emissions. Because the proposed Action would only result in emissions during rotenone treatment and would not represent an ongoing new source of greenhouse gas emissions, it would not impede the State's ability to meet its 2020 greenhouse gas emission reduction goal or have long-term impacts on ecological productivity.

6.1.6 Recreation Resources

The proposed Action would have a direct, adverse short-term impact on recreational fishing in Silver King Creek. In addition to the current closure area between Llewellyn Falls and Tamarack Lake Creek, the entire treatment area from Llewellyn Falls to Silver King Canyon would be closed to fishing during chemical treatment and subsequent restocking. Future re-opening of the area would depend on future California Fish and Game Commission decisions, not part of the proposed Action. Although potential visitors who seek this fishing opportunity would be affected during the closure, the region provides a broad range of recreational opportunities and recreation experiences similar to those provided by Silver King Creek. For example, similar opportunities exist in the East Fork Carson River, Wolf Creek, Bull Lake, Silver King Creek below the treatment area, and Poison Lake (refer to figure 5.6-2). While recreational fishing activity could be diverted to other recreation areas, the amount of use is such that it would not increase the use of other areas to a degree that substantial physical deterioration would occur or be accelerated.

6.1.7 Wilderness Values

The proposed Action would result in some short-term effects on wilderness experiences. The rotenone treatment of Silver King Creek would likely temporarily detract from the wilderness environment while the treatment is occurring. Some wilderness visitors could find the use of chemicals inconsistent with their assumptions about wilderness. In addition, chemical application would require the use of motorized volumetric augers powered by generators to dispense the neutralizing agent, potassium permanganate. Further, some visitors may view the potential loss of non-target species (specifically benthic macroinvertebrates or aquatic insects), due to the chemical treatment, as inconsistent with wilderness values. These impacts would be minimized by using the lowest effective chemical concentration and through the application of low-impact outdoor ethics. In addition, the longer-term effect of the treatment would be beneficial, resulting in elimination of non-native fish and restoration of the Paiute cutthroat trout, a native keystone predator, to its native habitat within the wilderness area.

6.1.8 Economic Resources

During the short term implementation of the proposed Action, HTNF would advise visitors to avoid the proposed treatment area, which would be closed to fishing. Local businesses that have historically served anglers recreating in the Silver Creek King area would likely experience a decline in revenue. However, the proposed Action has the potential to generate local economic benefits during implementation of the proposed Action.

Although not part of the proposed Action, future re-opening of Silver King Creek to fishing after treatment, particularly with a high-quality native trout fishery, could benefit local businesses and recreationists from increased visitation. Under this scenario, local economic benefits would consist of increased sales of recreation goods and services and related increases in income and jobs. Small recreation-serving businesses would realize the greatest economic benefits, including those that cater to anglers who choose to fish Silver King Creek. Benefits to recreationists would occur in the form of increased consumer surplus values. The long-term economic impacts of the proposed Action at Silver King Creek could be beneficial. However, future re-opening of Silver King Creek depends on separate decisions of the California Fish and Game Commission, not part of the proposed Action.

6.1.9 Environmental Justice

In the short term, there would be no health risks to the residents of Markleeville from implementation of the proposed Action. The proposed Action would not disproportionately affect a minority or ethnic population group. Also, the potential beneficial impact on local economic conditions in the long term should the treatment area be re-opened to fishing would likewise be beneficial for environmental justice factors.

6.2 UNAVOIDABLE ADVERSE EFFECTS

The following paragraphs identify the proposed Action's impacts that would be significant and unavoidable because no practicable mitigation measures were available. The No Action alternative would not result in unavoidable impacts but would not achieve the objectives of expanding Paiute cutthroat trout into its native range. Alternative 3 would not result in significant and unavoidable impacts.

- **Impacts on Potential Rare or Endemic Species in Silver King Creek (Impact AR-1).** The proposed Action could result in the loss of individual benthic macroinvertebrate taxa, potentially including rare (unquantified) and/or unidentified species endemic to Silver King Creek. Although no specific aquatic insect species that are classified as threatened, endangered or other special-status categories are known to be present in the proposed treatment area, the treatment could result in loss of rare or endemic species that may be present in Silver King Creek. However, it must be recognized that the Silver King Creek system has been treated several times in the past and therefore, some rare or endemic species present before those treatments may already be lost. Because the treatment could result in loss of rare or endemic species, this would be a significant impact. However, this impact cannot be verified. No reasonable sampling program can conclusively determine the non-existence of any endemic species. Therefore, no additional mitigation measures are available to reduce this impact to less-than-significant. This impact cannot be monitored or verified because of the variety of factors that hamper full characterization of the stream community and thus identifying or detecting the loss of rare or endemic species is infeasible. This impact would remain significant and unavoidable after mitigation.
- **Impacts on Potential Rare or Endemic Species in Tamarack Lake (Impact AR-2).** As described above for Silver King Creek, the proposed Action could result in the loss of individual benthic macroinvertebrate taxa, potentially including rare (unquantified) and/or unidentified species endemic to Tamarack Lake. This would be a significant but unverifiable impact. No reasonable sampling program can conclusively determine the non-existence of any endemic species. Therefore, no additional mitigation measures are available to reduce this impact to less-than-significant. This impact cannot be monitored or verified because of the variety of factors that hamper full characterization of the stream community and thus identifying or detecting the loss of rare or endemic species is infeasible. This impact would remain significant and unavoidable after mitigation.
- **Impacts on Chemical Residues in Tamarack Lake (WQ-1).** If rotenone formulations are applied to Tamarack Lake, breakdown residues may persist beyond the period allowed by the Basin Plan. The Basin Plan specifies that no chemical residues resulting from rotenone treatment shall be present at detectable levels within project boundaries after a two-week period has elapsed from the date that rotenone application was completed. No potassium permanganate would be used to neutralize rotenone in the lake. In addition, the lake's depth may affect the rotenone's persistence. After the 2007 rotenone treatment of Lake Davis, rotenone persisted for approximately 30 days and had a half-life of 5.6 days. Therefore, given the measured persistence of rotenone in Lake Davis, the depth of Tamarack Lake, and its colder temperatures compared with Lake Davis, residual levels of rotenone in Tamarack Lake would potentially result in significant impacts on water quality standards and beneficial

uses that would be unavoidable because no mitigation measures are available to accelerate the degradation of rotenone in the lake.

6.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

IRREVERSIBLE COMMITMENTS

Irreversible commitments are those that cause either directly or indirectly the use of natural resources so that they cannot be restored or returned to their original condition. Irreversible decisions affect renewable resources such as soils, wetlands, and waterfowl habitats. They are considered irreversible because their implementation would affect a resource that has deteriorated such that renewal takes extensive time or financial resources or because they would destroy a resource.

IRRETRIEVABLE COMMITMENTS OF NATURAL RESOURCES

Irretrievable commitments of natural resources mean the decision would result in loss of production or use of the resources. They represent opportunities forgone for a substantial period of time that the resources cannot be used.

6.3.1 Alternative 2: Proposed Action (Rotenone Treatment)

The proposed Action would not result in an irreversible commitment of resources. The proposed Action would not involve erection of any structures, loss of habitat, or removal or mining of resources. However, there would be irretrievable commitments of recreational resources.

6.3.1.1 Biological Resources

A potential irreversible loss of resources would be mortality of the non-native fish that currently occupy the 11 miles of stream reaches in the proposed treatment area (see Section 5.1, Aquatic Biological Resources). However, these fish would be replaced with pure Paiute cutthroat trout and fish populations would be restored through restocking. Therefore, because restoration of fish populations would use nearby, existing source populations, restocking would not require extensive time or financial resources, thus their loss would not constitute an irreversible loss of resources.

6.3.1.2 Energy

The proposed Action would use energy resources in the process of driving to and from the trailhead leading to the proposed treatment area and to operate the auger for dispensing the neutralization agent.

6.3.1.3 Recreation

Under the proposed Action, the treatment area would be closed to fishing during treatment and restocking. Potential re-opening would be subject to future California Fish and Game Commission decisions not part of the proposed Action. Closure of the area would constitute an irretrievable commitment of a recreational resource to non-recreational use because it represents an opportunity forgone for a substantial period during which the resource cannot be used.

6.3.2 Alternative 3: Combined Physical Removal

Similar to the proposed Action, this alternative would not result in an irreversible commitment of resources. This alternative does not involve erection of any structures, loss of habitat, or removal or mining of resources. However, there would be irretrievable commitments of recreational resources.

6.3.2.1 Biological Resources

This alternative would remove non-native trout that currently occupy the 11 miles of stream in the proposed treatment area (see Section 5.1, Aquatic Biological Resources). However, these fish would be replaced with pure Paiute cutthroat trout and fish populations would be restored through restocking.

6.3.2.2 Energy

This alternative would use energy resources in the process of driving to and from parking area and for the generators that would be used to recharge electrofishing backpack units.

6.3.2.3 Recreation

Under this alternative, the stream would be closed to fishing during the restocking period. Potential re-opening would be subject to future California Fish and Game Commission decisions not part of this alternative. Closure of the area would constitute an irretrievable commitment of a recreational resource to non-recreational use because it represents an opportunity forgone for a substantial period during which the resource cannot be used.

6.4 GROWTH-INDUCING IMPACTS

Section 21100(b)(5) of CEQA requires that an EIR discuss the growth-inducing impacts of a proposed project. This requirement is further explained in the CEQA Guidelines Section 15126(g), which states that an EIR must address "the ways in which the proposed action could foster economic or population growth, or the construction of additional housing, either directly or indirectly in the surrounding environment." Pursuant to CEQA, growth per se is not assumed to be necessarily beneficial, detrimental, or of little significance to the environment; it is the secondary, or indirect, effects of growth that can cause adverse changes to the physical environment. The indirect effects of population and/or economic growth and accompanying development can include increased demand on community services and public service infrastructure; increased traffic and noise; degradation of air and water quality; and conversion of agricultural land and open space to urban uses. Local land use plans (e.g., general plans and specific plans) establish land use development patterns and growth policies that are intended to allow for the orderly expansion of urban development supported by adequate public services, including water supply, roadway infrastructure, sewer service, and solid waste service. Local jurisdictions conduct CEQA environmental review on their general and specific plans to assess the secondary effects of their planned growth. An action that would induce growth that is inconsistent with local land use plans and policies could indirectly cause adverse environmental impacts, as well as impacts on public services, that the local land use jurisdictions have not previously addressed in the CEQA review of their land use plans and development proposals. Removing a potential obstacle to growth is considered an indirect growth-inducing impact.

Under NEPA, growth-inducing impacts are addressed as potential indirect effects. Indirect effects include those that occur later in time or that remove obstacles to population growth or encourage and facilitate other activities that could stimulate subsequent growth. In addition, CEQA requires that the direct and indirect impacts on population and housing are analyzed.

6.4.1 Environmental Setting

The local socioeconomic conditions in the proposed treatment area are described in this section to provide context for analysis of potential growth-inducing impacts, as well as to serve as the baseline against which population and housing impacts are measured. For this analysis, the proposed treatment area includes Alpine County (within which Silver King Creek is located) and northern Mono County, located east of Silver King Creek. The closest communities to this area are Markleeville in Alpine County; and Walker, Coleville, and Bridgeport in northern Mono County. Information on population is included in Section 5.8.1.1, Population; and information on population trends is outlined in Section 5.9.1.1, Population Trends and Projection. Housing information is presented below.

6.4.2 Housing

According to 2000 Census data, there were approximately 1,500 housing units in Alpine County. Of the 1,500 units, 880 were single-family homes (about 60% of the total housing stock), though only 213 (approximately 24%) were considered owner-occupied. Therefore, most of the housing stock in Alpine County consists of second homes, vacation homes and rental units (U.S. Census 2000). In Mono County, about 1,800 (approximately 40%) of the 4,600 single-family homes were owner-occupied. However, those single-family homes made up less than 40% of the total 12,000 housing units (U.S. Census 2000). Similar to Alpine County, Mono County contains more second homes, vacation homes and rental units than the United States on average (approximately 60% of the housing stock is single-family homes; 80% of which are owner-occupied).

6.4.3 Assessment Criteria and Methodology

6.4.3.1 Significance Thresholds

The CEQA Guidelines (Appendix G) outline criteria for evaluating impacts on population and housing. Specifically, the action would have a significant impact if it would:

- Induce substantial population growth in an area, either directly or indirectly.
- Displace substantial numbers of existing housing units, necessitating the construction of replacement housing elsewhere.
- Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere.

There are no specific significance thresholds under NEPA for growth-inducing or population and housing impacts; however, NEPA requires evaluation of indirect effects, which may include growth-inducing and other effects related to induced changes in the pattern of land use, population density or growth rate, and the related effects on air and water and other natural systems, including ecosystems (40 CFR Section 1508.8).

6.4.3.2 Evaluation Methods and Assumptions

The assessment of growth-inducing and population and housing impacts focuses on those resources that would be potentially affected by the proposed Action and alternatives. For the proposed Action, growth-inducing impacts could include directly constructing housing, encouraging additional jobs in the area, and removing an obstacle to growth.

6.4.4 Environmental Impact Assessment

This section describes the potential impacts of the proposed Action and alternatives in the context of growth-inducing impacts and population and housing resources. Growth-inducing impacts are organized by alternative, and include both direct and indirect effects of the action on population and housing.

6.4.4.1 Alternative 1: No Action

The No Action alternative would result in no growth-inducing or population and housing impacts because no housing would be built, no new jobs would be created, and no obstacles to growth would be removed.

6.4.4.2 Alternative 2: Proposed Action (Rotenone Treatment)

Under the proposed Action, if the proposed treatment area is to be re-opened to fishing after treatment, particularly with a high-quality native trout fishery, local economic benefits could consist of increased sales of recreation goods and services and related increases in income and jobs for the local economy. However, potential re-opening of the area to recreational fishing would be subject to future California Fish and Game Commission decisions, not part of the proposed Action.

In the context of population and housing, the proposed Action would not increase visitation to a degree that would affect population growth through an influx of workers. Because the proposed treatment area is in a wilderness area with no houses, the proposed Action would not displace housing or people. In addition, the proposed Action would not induce population growth directly or indirectly because it would not construct new homes, nor would it remove an obstacle to growth, thus no impacts would result.

6.4.4.3 Alternative 3: Combined Physical Removal

Similar to the proposed Action, Alternative 3, if successful, could result in re-opening the native trout fishery once the treatment and re-stocking period is complete. However, as described above for the proposed Action, potential re-opening of the area to recreational fishing would be subject to future California Fish and Game Commission decisions, not part of Alternative 3. This alternative would not induce population growth directly or indirectly because it would not construct new homes, create new jobs or remove an obstacle to growth and no adverse impacts would result.

6.5 CUMULATIVE EFFECTS

6.5.1 Introduction

The Council on Environmental Quality's regulations (40 CFR Sections 1500-1508) implementing the procedural provisions of NEPA of 1969, as amended (42 U.S.C. Sections 4321 et seq.), define cumulative effects as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR Section 1508.7). Pursuant to these regulations, an EIS must analyze cumulative impacts of the action.

Also, as defined in Section 15355 of the CEQA Guidelines, a cumulative impact is the impact that results from implementing a proposed action together with other projects causing related impacts. The CEQA Guidelines require that EIRs discuss the cumulative impacts of a project when the project's incremental effect is "cumulatively considerable," meaning that the project's incremental effects are significant when viewed in connection with the effects of past, present, and reasonably foreseeable (i.e., probable) future projects.

6.5.2 Approach

Based on the NEPA and CEQA Guidelines, the discussion of cumulative impacts should include either:

- A list of past, present, and probable future projects producing related or cumulative impacts, or
- A summary of projections contained in an adopted general plan or similar document, or in an adopted or certified environmental document, that described or evaluated conditions contributing to a cumulative impact.

The following discussion of cumulative impacts consists of:

- A discussion of the geographic scope of the area affected by the cumulative impact;
- A summary of the environmental impacts that would result from these projects; and
- Reasonable, feasible options for mitigating or avoiding the project's contribution to any significant cumulative impacts.

This analysis uses the list approach and addresses the direct cumulative impacts associated with the proposed Action. Projects included in the cumulative impact analysis were identified by several methods, including telephone and email correspondence with agency personnel from surrounding jurisdictions, internet research, and review of potential cumulative impacts analyses from environmental reports prepared for other projects in the same geographic area as the proposed Action. The evaluation considered projects within an approximate 20-mile radius, such that projects within Alpine County and the Carson-Iceberg Wilderness Area were considered.

Table 6-1 lists the recently completed past projects, projects currently under construction, and probable future projects that would overlap with the treatment schedule of the proposed Action and that could affect the same resources. This table provides a brief description of the projects included in the cumulative impact analysis, their locations, estimated construction schedules, access roadways and nearby waterways, and potential types of cumulative impacts that could occur in combination with those of the proposed Action. For future projects, the analysis was based on estimated construction schedules. Where construction schedules were unavailable, it was conservatively assumed that construction periods would overlap with those of the proposed Action.

6.5.3 Significance Criteria

The cumulative impact analysis evaluates whether impacts would be individually limited but cumulatively considerable. Cumulatively considerable means that the incremental effects of an action are significant when viewed in connection with the effects of past, present, and reasonably foreseeable future projects.

Impacts of the proposed Action that would be "individually limited" are based on the impact analysis presented in Chapter 5.0, Environmental Consequences. Based on that analysis, the proposed Action would have significant or less-than-significant impacts on aquatic resources, terrestrial resources, human and ecological exposure, greenhouse gas emissions, water resources, recreation, wilderness values and management, economic resources, and environmental justice.

6.5.4 Impact Analysis

This subsection evaluates the potential environmental impacts of the proposed Action when considered together with the projects listed in Table 6-1. The analysis addresses only the types of impacts that could occur as a result of the proposed Action based on the significance criteria included in each resource discussion in Chapter 5.0, Environmental Consequences. Areas where no impact would occur, as identified in Chapter 4.0, Scope of the Analysis, are not addressed because the proposed Action would not contribute to a cumulative impact (e.g. the proposed Action would not affect scenic vistas, therefore this topic is not analyzed for cumulative impacts).

The potential for the proposed Action to contribute to cumulative impacts would primarily result from the chemical treatment, including during treatment and from potential long term effects on individual benthic macroinvertebrate species. Long-term effects would include benefits for Paiute cutthroat trout populations and the potential for improved recreational and economic opportunities.

As described above, Table 6-1 lists all types of projects within 20 miles of the proposed treatment area. The Agencies were initially inclusive in identifying potential cumulative projects. However, because the proposed Action results in only in-stream impacts, most of the projects listed in Table 6-1 would not result in impacts that could occur in combination with the proposed Action. For example, development and fuel reduction projects would result in local land disturbance and storm water runoff issues that are not in the basin and would not occur in combination with the proposed Action. In contrast, although they occurred in the past, the prior treatments of Silver King Creek and its tributaries listed on Table 6-1 would result in the same types of impacts in the basin and are the focus of the cumulative impact analysis.

Table 6-1 Projects Considered in Cumulative Impacts Analysis for the Proposed Action

#	Project	Project Description	Jurisdiction / Lead Agency	Location	Nearby Waterways	Potential Cumulative Impact Issues
1	Previous Silver King Creek treatments	CDFG conducted prior rotenone treatments in the basin in 1964, 1976, 1977, 1987, 1988, 1991, 1992, and 1993.	CDFG (Trumbo et al. 2000a)	Silver King Creek	East Fork Carson River	Aquatic biological resources, water quality
2	Upper Silver King Creek	CDFG conducted prior rotenone treatments in Upper Silver King Creek (see Table 5.1-1). This area was successfully restocked with Paiute cutthroat trout but is closed to fishing.	CDFG	Upper Silver King Creek	Silver King Creek below Llewellyn Falls (the proposed treatment area)	Aquatic biological resources and water quality
3	Marine Corps Mountain Warfare Training Center	The center occupies 46,000 acres of Toiyabe National Forest. The center conducts training in mountain operations in summer and winter. Personnel live in military housing in adjacent Coleville.	USMC	Outside Coleville, California		Economic resources
5	141 Line Rebuild Project	Sierra Pacific proposes to reconstruct an existing 120 kilovolt electric transmission line on Peavine Mountain, from Lemmon Drive to the area south of Hoge Road, including the Keystone non-motorized area	USFS	Washoe County, Nevada	Truckee River	Water quality
6	Alpine County Aspen Enhancement Personal Use Fuelwood Fuels Reduction Project	USFS proposes to remove encroaching conifers on 250 acres near aspen stands along Scotts Lake Road to enhance and expand aspen and reduce fuels. Personal use fuelwood permits would be used for implementation.	USFS	Alpine County, California	Scotts Lake, Carson River	Water and terrestrial resources
7	Clear Creek Fuels Reduction and Ecosystem Enhancement Project	USFS proposes to reduce hazardous fuels and the risk of catastrophic wildland fire, improve forest health, and enhance and expand existing aspen stands by thinning trees and brush on approximately 1,500 acres.	USFS	Douglas County, Nevada (5 mi southeast of Carson City within the Clear Creek Landscape Assessment Area)	Carson River and tributaries	Water resources
8	Dog Valley Fuels Reduction and Ecosystem Enhancement Project	USFS proposes to improve timber stand and wildlife habitat on 6,000 acres, as authorized under HFRA Title 1 (Wildland-Urban interface), using mastication, mowing, hand thinning, chipping, animal grazing and prescribed fire.	USFS	Sierra County, California	Truckee River	Terrestrial resources and recreation
11	Special Use Permit Renewal – Lake Tahoe Adventures	Lake Tahoe Adventures has requested renewal of its outfitter/guide permit for guided snowmobile tours in the Hope Valley area of the Carson Ranger District. New permit would be eligible for a term of 10 years.	USFS	Alpine County, California	Carson River	Water and economic resources
12	West Carson Habitat Improvement and Fuels Reduction Project	USFS proposes to improve critical deer winter range, reduce the risk of a fast moving wildland fire, and change the fire regime by reducing cheatgrass density and allowing regrowth of native grasses and scrubs through domestic sheep grazing.	USFS	Carson City, Nevada	Carson River	Water and terrestrial resources

Table 6-1 Projects Considered in Cumulative Impacts Analysis for the Proposed Action

#	Project	Project Description	Jurisdiction / Lead Agency	Location	Nearby Waterways	Potential Cumulative Impact Issues
13	Bear Valley Village	Construct 486 lodging units (51 with lock-off units), approximately 24,400 square feet of retail floor area, 9,000 square feet of restaurant floor area, and 30,000 square feet of amenity/service space.	Alpine County	Bear Valley, Alpine County, California	Stanislaus River and tributaries	Economic resources
14	White Mountain Estates	Subdivision of a total of 70.38 acres into 45 single family residential lots, one utility lot (0.78 acres) for water and propane tanks, three lots for open space uses (1.46 acres, 3.81 acres, and 9.08 acres), and a remainder parcel (19.23 acres) that allows one single-family residence.	Mono County	Chalfant Valley, Mono County, California	Crowley Lake	Economic resources
15	Crowley Lake Estates	Construct 55 multi-family and 5 single-family homes, and develop 10,000 square feet of retail space.	Mono County	Crowley Lake, Mono County, California	Crowley Lake	Economic resources
16	Mountain Gate Fishing Access project	Create an ADA-accessible parkway for fishing, hiking, exercising, picnicking or relaxing. ADA accessible fishing and an ADA accessible trail along the West Walker River; picnic and resting spots, day use areas, therapeutic exercise stations (a "par course") for senior citizens and disabled persons, accessible restrooms, a side channel restoration, a nature trail, and an interpretive kiosk.	Mono County	Walker, CA	Walker River	Recreation and economic resources

Sources: USMC 2008; CDFG/USFS 2007; USFS 2008; SCWA Environmental Consultants 2008; Mono County 2007; Mono County 2006a; Mono County 2006b.

Notes:

ADA = Americans with Disabilities Act
CDFG = California Department of Fish and Game
HFRA = Healthy Forest Restoration Act
USFS = U.S. Forest Service
USMC = U.S. Marine Corps

6.5.4.1 Aquatic Resources

The geographic scope for the aquatic resources cumulative impact analysis encompasses areas that could be affected by the projects identified in Table 6-1. This region is appropriate because the aquatic species that would be affected by the proposed Action are part of a broader ecosystem, and the potential disturbance of individual areas has repercussions for a wider region than the immediate treatment area.

FISH

As described in detail in Section 5.1, Aquatic Biological Resources, rainbow trout and Lahontan cutthroat trout were introduced into Paiute cutthroat trout habitat above Silver King Canyon (USFWS 1985). Sometime after 1950, non-native trout were introduced into the Paiute cutthroat trout population in Silver King Creek above Llewellyn Falls (USFWS 1985). These introductions eliminated genetically pure Paiute cutthroat trout from its historic habitat. The proposed Action would not include any transfers of fish removed from Silver King Creek to other areas. Some of these fish could be removed by anglers during the pre-treatment period through increased bag limits if approved by the California Fish and Game Commission. Fish removed by other means would be gathered and buried.

Previous chemical treatments occurred between 1964 and 1993 to eradicate non-native trout in Silver King Creek and tributaries upstream of Llewellyn Falls and in Corral Valley and Coyote Valley Creeks. During these treatments, it is likely that genetically pure Paiute cutthroat trout were killed.

Genetic studies indicate that pure Paiute cutthroat trout have been successfully reintroduced into treated areas in Silver King Creek and tributaries above Llewellyn Falls, and in Corral Valley and Coyote Valley Creeks (Israel et al. 2002, Cordes et al. 2004).

The proposed Action would minimize the threat of introduction of non-native trout into areas occupied by Paiute cutthroat trout. The population of Paiute cutthroat trout would be isolated by a series of inaccessible barriers in Silver King Canyon, which would greatly reduce the likelihood of inadvertent introduction. The Agencies do not expect that the small numbers of pure Paiute cutthroat trout that could be killed during the chemical application (e.g. fish that may have come over Llewellyn Falls) or during the process of restocking would have long-term negative effects on the overall viability of Paiute cutthroat trout populations.

On a cumulative basis, implementation of the proposed Action when combined with past and reasonably foreseeable activities would result in beneficial effects that include preserving the genetic integrity of Paiute cutthroat trout populations within the Silver King Creek Watershed, restoring the species to its historic range, and the eventual recovery and delisting of a federally listed species.

MACROINVERTEBRATES

Historic impacts on benthic macroinvertebrates in the Silver King Creek basin include logging, livestock grazing, and chemical treatments. The basin was logged in the 1860s. The proposed treatment area was used as pasture for sheep in the early 1900s through the late 1930s, and for cattle from the 1940s through 1994. Previous rotenone treatments occurred between 1964 and 1993 to eradicate non-native trout from Silver King Creek upstream from Llewellyn Falls and tributaries, and in Corral Valley and Coyote Valley Creeks. Four Mile Canyon Creek was treated with rotenone from 1991 to 1993. Corral Valley Creek was treated with rotenone in 1964 and 1977. Coyote Valley Creek was treated with rotenone in 1964, 1977, and 1987 to 1988. Silver King Creek above Llewellyn Falls was treated in 1964, 1976, and 1991 to 1993. The paragraphs below address potential cumulative impacts of these treatments on benthic macroinvertebrate species composition and the potential loss of species.

SPECIES COMPOSITION

The rotenone treatments described above have likely affected benthic macroinvertebrate species composition in the Silver King Creek basin, including short-term effects on species biomass and diversity, EPT, and related water quality objectives. However, as described above, these treatments would not have affected fishless headwaters, tributaries, or neighboring watersheds that play a critical role in repopulating treated areas, potentially resulting in recovery of species abundance within months and population increases within 2 years. Given the time elapsed since these historical treatments, and based on the data presented by Vinson and Vinson (2007), there is little difference between existing benthic macroinvertebrate population (species composition) between treated and untreated reaches. The system is healthy and has returned to a high level of diversity after historic treatments.

The proposed treatment would have similar effects on species composition as historic treatments. However, as described in Section 5.1, Aquatic Biological Resources, the Agencies would use lower chemical concentrations to achieve fish eradication compared with past treatments. Although many aquatic invertebrate taxa would likely survive the proposed chemical treatment, benthic population levels would be affected in the short term, including changes in species composition and potential mortality of sensitive species (e.g. small, gilled EPT species [stoneflies, caddisflies and mayflies]). Drift from upstream areas, survival of eggs, life stages present in the hyperheos and colonizers from adjacent areas would contribute to recovery. Recent data show that historic treatments in the watershed are too far removed in time to have present-day effects that could combine with the effects of the proposed Action. Therefore, any cumulative impacts on benthic invertebrate species composition in Silver King Creek are less-than-significant. Further, because none of the historic treatments were conducted in Tamarack Lake, any treatment of the lake would have project-specific effects but no cumulative effects.

LOSS OF RARE OR ENDEMIC SPECIES

As described in Section 5.1, Aquatic Biological Resources, both the historic and proposed rotenone treatments could result in loss of species in Silver King Creek, including rare and/or endemic species. Although no such species are known to occur in Silver King Creek, they may have been present prior to historic treatments and lost as a result. Such species may still be present and could be lost as a result of the proposed Action. Although this impact cannot be described or quantified, the cumulative effect of the historic and proposed treatments would be cumulatively considerable, and could be cumulatively significant.

As described in Section 5.1, Aquatic Biological Resources, one factor that minimizes this potential cumulative effect is the limited geographic range of the treatment area. The same rare or endemic species that may inhabit the treatment area may also be present in the headwaters, tributaries and springs and would likely recolonize the area along with more common species. In addition, the Agencies would use lower rotenone concentrations than have been used previously to minimize impacts on benthic invertebrates. However, because it is beyond the scope of the EIS/EIR to determine conclusively the presence or absence of rare or endemic species, and because this may be technically infeasible, the evaluation of aquatic resources for the proposed

Action found that the treatment could result in loss of rare or endemic species. Because historic treatments may have resulted in similar impacts in Silver King Creek, this impact would be cumulatively significant. However, because none of the historic treatments were conducted in Tamarack Lake, any treatment of the lake would have project-specific effects but no cumulative effects.

Therefore, the proposed Action's effects on species composition would not be cumulatively considerable and, when viewed in combination with those of other reasonably foreseeable projects, would result in less-than-significant cumulative impacts. The proposed Action's effects on rare or endemic species could be cumulatively considerable, and because of the lack of data regarding the presence or absence of these species, this impact could be cumulatively significant.

6.5.4.2 Terrestrial Resources

The geographic scope for the terrestrial resources cumulative impact analysis encompasses areas (including wetlands and sensitive habitats) that could be affected by the projects identified in Table 6-1. This region is appropriate because the habitats and wildlife species that would be affected by the proposed Action are part of a broader ecosystem, and the potential disturbance of individual areas has repercussions for a wider region than the immediate treatment area.

The proposed Action could affect terrestrial wildlife through the physical disturbance that would result from presence of workers and their activities. The treatment could also affect terrestrial wildlife by temporarily reducing benthic macroinvertebrate populations in the stream as a food source. Insectivorous wildlife species in the proposed treatment area include, among others, yellow warbler and Williamson's sapsucker. The proposed Action would also remove all non-native trout, which could constitute an important prey base for several wildlife species and could be reduced until pre-treatment fish densities and size-class distributions are reestablished through restocking. This would not, however, be a significant impact.

The proposed Action would have less-than-significant impacts on protected species including California wolverine, fisher, bald eagle, American marten, mule deer, insectivorous birds, neotropical migratory birds, Forest Sensitive Species, and riparian habitats adjacent to the stream corridor.

Because other projects listed in Table 6-1 could affect terrestrial resources (e.g. fuel reduction, land development), these projects are localized and distant from the proposed treatment area. Furthermore, because institutional controls are in place that limits activity in the Wilderness Area, none of these projects, when viewed in combination with the proposed Action, would result in cumulative impacts on terrestrial resources.

6.5.4.3 Human and Ecological Exposure

The geographic scope for the human and ecological exposure cumulative impact analysis encompasses waterways that could be affected by the projects identified in Table 6-1. This would include Silver King Creek and the East Fork Carson River.

As described in Section 5.3, the proposed Action would have less-than-significant impacts on non-target fish species, wildlife, and human health. The wildlife impact assessment was based on estimates of surface water and other exposure of avian and terrestrial wildlife to rotenone and formulation constituents based on conservative food web modeling of doses and comparison to effects thresholds. In addition, because of the remoteness of the proposed treatment area, the distance to any downstream human population, and the controls that would be placed on human access during and after treatment (see Chapter 3.0, Project Alternatives), human exposure pathways were considered incomplete (refer to Appendix C herein). For these reasons, the application of rotenone formulations poses a less-than-significant impact on human health. None of the projects listed in Table 6-1 propose the use of chemicals that could enter area waterways, and therefore no cumulative ecological or human health exposure impacts would occur. The only projects involving rotenone application are past projects and as described in detail in Appendix C, neither rotenone, its formulation constituents nor potassium permanganate persist in the environment. The proposed Action would not therefore contribute to a cumulatively considerable impact on human or ecological health.

6.5.4.4 Greenhouse Gases and Climate Change

The geographic scope for greenhouse gases and climate change cumulative impacts encompasses the State of California, because the State has implemented greenhouse gas emissions reductions measures and because the effects of the proposed Action on global climate change would be too speculative.

The proposed Action would result in short-term emissions representing less than one millionth of the State's annual greenhouse gas emissions. This would have a less-than-significant impact on the ability of the State to meet its 2020 greenhouse gas reduction goals. Most of the projects listed in Table 6-1, as well as projects throughout California, would contribute to the State's overall greenhouse gas emissions. Although small, when viewed in combination with other projects, the proposed Action's emissions would contribute to a cumulative impact on greenhouse gas emissions and climate change.

6.5.4.5 Water Resources

The geographic scope for water resources cumulative impacts encompasses the Silver King Creek and its tributaries and springs and downstream waterways including the East Fork Carson River.

The proposed Action would result in less-than-significant water quality impacts on Silver King Creek that would not be cumulatively considerable in combination with historic treatments of area streams. However, treatments would have significant impacts on water quality in Tamarack Lake, if fish are present. However, these impacts would not be cumulatively considerable when viewed in combination with previous rotenone treatments, which have been conducted only in area streams such as Corral Valley Creek, Coyote Valley Creek and Silver King Creek above Llewellyn Falls. Because there would be no geographical overlap, any treatment of Tamarack Lake would result in cumulative water resource impacts. None of the other projects listed on Table 6-1 involve chemical treatment.

6.5.4.6 Recreation

The geographic scope for cumulative impacts on recreational resources includes areas within 20 miles of the Humboldt-Toiyabe National Forest and Carson-Iceberg Wilderness Area. This region is appropriate because the displacement of recreational uses from one area can result in the increased use of recreational facilities in another.

The proposed Action would have a direct adverse impact on recreational fishing in Silver King Creek because the proposed treatment area from Llewellyn Falls to Silver King Canyon would be closed to fishing during treatment and restocking. Re-opening thereafter would depend on future decisions of the California Fish and Game Commission not part of the proposed Action. However, existing restrictions on group size and the low number of diverted users for recreational fishing and other recreational activities (hiking, backpacking, etc.) resulting from the closure would not increase the use of other areas such that substantial physical deterioration would occur or be accelerated. The Sierra Nevada region provides a broad range of recreational opportunities and similar recreation experiences to those provided by Silver King Creek. Among the projects listed in Table 6-1, only the previous Silver King Creek treatments have resulted in restricted access to recreational areas. The Mountain Gate Fishing Access project would enhance recreational opportunities at a nearby facility. Therefore, the proposed Action would have no cumulative impact on recreational access.

6.5.4.7 Wilderness Values and Management

Under the proposed Action, the rotenone treatment of Silver King Creek would likely temporarily detract from the wilderness environment during the treatment process. However, the longer term effect of the treatment would be beneficial, resulting in the restoration of the Paiute cutthroat trout to its native habitat within the wilderness area. Wilderness experiences may be slightly diminished in the short term; however, restoration of Paiute cutthroat trout to its native habitat would have a beneficial effect on wilderness values. Projects listed on Table 6-1, including fuel reduction projects, would result in only minor, short-term access restrictions. Therefore, the proposed Action, in combination with other projects, would not result in cumulatively considerable impacts on wilderness values and management.

6.5.4.8 Economic Resources

The proposed Action is not expected to have short-term adverse effects on economic resources in the region. Much of Silver King Creek is currently closed to fishing and other parts of the wilderness area would remain open to fishing and other recreational activities. In the long term, the proposed Action could have a beneficial impact on economic resources from increased visitation to the wilderness area should the native trout fishery be restored. However, re-opening of the proposed treatment area to fishing would depend on future California Fish and Game Commission decisions not part of the proposed Action. Other cumulative projects would have similar beneficial impacts, such as the Mountain Gate Fishing Access project. Therefore, the proposed Action would not have a cumulatively considerable impact on economic resources.

6.5.4.9 Environmental Justice

The proposed Action would not disproportionately affect a minority or ethnic population group from risks to human health. Therefore, the proposed Action would not contribute to a cumulatively considerable impact on environmental justice.

6.6 REFERENCES

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CHAPTER 7

Mitigation Measures

Chapter 7 presents the avoidance and minimization measures the Agencies would employ to reduce environmental effects from implementation of the proposed Action.

7.1 AVOIDANCE AND MINIMIZATION MEASURES

This section outlines features of the proposed Action that avoid and minimize impacts. These measures may be regulatory requirement or other policies or standard measures implemented pursuant to agency policies or practices designed to avoid or minimize environmental impacts. Several of these requirements are not considered discretionary and are implemented in response to regulations or legal requirements.

7.1.1 Aquatic Resources

To reduce the number of fish lost during the treatment process, the Agencies would request that the California Fish and Game Commission increase the bag limit from 5 fish daily to 10 fish daily during the summer of 2009 prior to treatment. CDFG wardens would monitor bag limits and other restrictions.

Aquatic and water quality impacts would be minimized by limiting the treatment concentration applied and the duration of rotenone activity to the shortest time period needed to meet the fish removal objective.

Block nets would be placed at selected locations throughout the proposed treatment area to catch dead fish (refer to Figure 3-1). The nets would be maintained at a frequency adequate to minimize decomposition of captured fish.

Treatment of Tamarack Lake would be avoided if possible. The Agencies will conduct extensive surveys to determine the presence or absence of fish in the lake.

To eliminate the toxic effects of rotenone downstream of the proposed treatment area, potassium permanganate would be administered using generator-powered volumetric augers at a downstream detoxification station. The in-stream application of potassium permanganate below Silver King Canyon would ensure that no adverse effects of rotenone are experienced downstream of the treatment area.

The Agencies would monitor restocked fish populations as well as donor populations for changes in productivity and abundance that would contraindicate further transfers from donor stock.

The proposed Action would not involve treating Silver King Creek's headwaters or the upper fishless reaches of tributaries or springs. The headwaters, including Upper Fish Valley and other areas above Llewellyn Falls, have not been treated since the early 1990s. Approximately 17 miles of tributary streams would be left untreated under the proposed Action. Some of these areas have never been treated with rotenone (e.g. Fly Valley Creek). Headwater areas, upstream and outside of the proposed treatment area, including Bull Canyon Creek, Corral Valley Creek, Coyote Valley Creek, and Four Mile Canyon Creek, have never been treated with rotenone.

Headwater areas of many streams would not be treated under the proposed Action because they are above natural barriers and do not support trout populations. These areas would provide source populations of benthic macroinvertebrates for recolonizing treatment areas.

Consistent with the NPDES permit for the previously proposed treatment, the Agencies would conduct pre-treatment and post-treatment monitoring of benthic macroinvertebrate communities in the treatment areas and "control" sites. The monitoring program would be designed to assess the duration of short-term treatment impacts and long-term species composition recovery.

To educate the public regarding the Paiute Cutthroat Trout Restoration Project and prevent reintroduction of non-native fish to the area, the Agencies would erect an educational kiosk and signs at trailheads.

7.1.2 Terrestrial Resources

All personnel assisting in fish removal activities would use hardened or durable sites for camping and would be familiar with and practice the LNT principles. Crews would work in small groups (of four to six people, approximately 50 people total) spread throughout the proposed treatment area. Trails would be used whenever possible to move from one location to another to minimize soil and vegetation disturbance and to prevent the establishment of new trails.

To prevent impacts on amphibian species, the Agencies would continue to conduct annual amphibian surveys. The Agencies would also conduct amphibian surveys immediately before treatment. If adult or tadpole life stages of any threatened, endangered, sensitive, candidate or rare amphibians are found during the pre-treatment surveys, then they will be captured by nets and relocated out of the treatment area to suitable nearby habitat.

7.1.3 Human and Ecological Exposure

The rotenone application would be supervised by licensed applicators and in adherence to safety precautions identified on the product label. The application supervisor would be knowledgeable and experienced in state regulatory requirements regarding safe and legal use of the rotenone product and applicator safety. All personnel involved with the rotenone application would receive pre-treatment safety training specific to the formulated rotenone product. All personnel would be required to wear protective equipment to avoid unintended exposure to rotenone.

Prior to rotenone application, and throughout the treatment process, visitors would be advised to avoid the treatment area and the Agencies would post signs at trailheads and other strategic places.

7.1.4 Archaeological and Paleontological Resources

The Forest Archaeologist would identify suitable locations for burial of fish and placement of signs.

7.1.5 Hazardous Materials and Spills

The use of rotenone would be supervised by licensed applicators according to label directions and the MOU between CDFG and the Water Board. Transport of chemicals to the proposed treatment area would be addressed through preparation and implementation of a spill prevention, contingency and containment plan; a site safety plan; and a site security plan. Public access to the treatment area would be restricted during implementation of the proposed Action, and restrictions would be enforced by the Humboldt-Toiyabe National Forest and CDFG.

7.1.6 Wildfire

Work crews would follow all fire prevention precautions.

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CHAPTER 8

List of Preparers

8.1 AGENCY PERSONNEL

U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office
1340 Financial Boulevard, Suite 234
Reno, Nevada 89502

Field Supervisor: .... Bob Williams
Assistant Field Supervisor: .... Selena Werdon
Fisheries Biologist: .... Chad Mellison
Public Affairs Officer: .... Jeannie Stafford
Deputy Field Supervisor: .... Jody Brown
Deputy Assistant Field Supervisor: .... Kathleen Erwin

California Department of Fish and Game
1701 Nimbus Road
Rancho Cordova, California 95667

Regional Manager: .... Sandra Morey
Project Manager: .... Stafford Lehr
Program Manager: .... Kathy Hill
Information Systems: .... Treva Porter
Environmental Review: .... Julie Cunningham
Fisheries/Operations: .... William Somer
Fisheries: .... David Lentz
Fisheries: .... Kevin Thomas
Fisheries: .... Roger Bloom
Legal Counsel: .... Steve Ingram
Rotenone Use: .... Brian Finlayson

U.S. Forest Service, Intermountain Region
Humboldt-Toiyabe National Forest
Sparks, NV 89431

Forest Fisheries Biologist: .... Jim Harvey
Fisheries Biologist: .... Jason Kling

Lahontan Regional Water Quality Control Board
2501 Lake Tahoe Blvd.
South Lake Tahoe, CA 96150

Environmental Scientist: .... Bruce Warden, Ph.D.
Senior Water Resources Control Eng.: ....Doug Cushman
Supervising Water Res. Control Eng.: .... Laurie Kemper
Assistance Chief Counsel: ....Philip Wyels

8.2 EIS/EIR CONSULTANTS

ENTRIX Environmental Consultants
701 University Avenue, Suite 200
Sacramento, California 95825

MANAGEMENT STAFF

Principal-in-Charge:..Leo Lentsch
Project Manager:..Peter Boucher
Deputy Project Manager: ....Lisa Mash

KEY STAFF

Aquatic Biological Resources:...Peter Boucher
....Ramona Swenson, Ph.D.
....Michael Parton
....Lawrence Wise
.... Tom Taylor
....Lisa Mash
....Katie Ross, Ph.D.
Terrestrial Biological Resources..Richard Johnson
....Peter Boucher
Human and Ecological Exposure...Jody Kubitz, Ph.D.
....Richard Johnson
....Lawrence Wise
....Lisa Mash
Water Resources ....Peter Boucher
Air Quality – Greenhouse Gases... Alexandra Kostalas
.... Darcy Kremin, AICP
Recreation: .... William Spain
Wilderness Values .... William Spain
Economic Resources...Steve Pavich
Environmental Justice.. Darcy Kremin, AICP
Population and Housing.. Darcy Kremin, AICP
Cumulative Impacts .... Darcy Kremin, AICP
....Peter Boucher
Production Specialist/Word Processor:...Iris Eschen
....Karen Butler
Geographical Information Systems... Anna Clare
Publications/Public Outreach.. Robert Wurgler

APPENDIX A

Notice of Intent & Preparation

withhold your name or address, you must state this request prominently at the beginning of your comment. We will not, however, consider anonymous comments. To the extent consistent with applicable law, we will make all submissions from organizations or businesses, and from individuals identifying themselves as representatives or officials of organizations or businesses, available for public inspection in their entirety. Information received in response to this notice and review will be available for public inspection, by appointment, during normal business hours (see **ADDRESSES**).

Authority: This document is published under the authority of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Dated: May 19, 2006.

Wendi Weber,

Assistant Regional Director, Ecological Services, Region 3.

[FR Doc. E6–8565 Filed 6–1–06; 8:45 am]

BILLING CODE 4310–55–P

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

Preparation of an Environmental Impact Statement for the Paiute Cutthroat Trout Restoration Project, Carson-Iceberg Wilderness, Humboldt-Toiyabe National Forest, Alpine County, CA

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Notice of intent of public scoping.

SUMMARY: Pursuant to the National Environmental Policy Act (NEPA) (42 U.S.C. 4321, *et seq.*), the Fish and Wildlife Service (Service) as the lead agency, advises the public that we intend to gather information necessary to prepare, in cooperation with the United States Department of Agriculture Forest Service (Forest Service), an Environmental Impact Statement (EIS) on the proposed Paiute Cutthroat Trout Restoration Project (Project). The Forest Service is a cooperating agency because activities within designated wilderness on National Forest System lands require Forest Service approval (36 CFR 261.9f, 293.6c).

The Service provides this notice to: (1) Describe the proposed action and possible alternatives; (2) advise other Federal and State agencies, affected Tribes, and the public of our intent to prepare an EIS; (3) announce the initiation of a 30-day public scoping period; and (4) obtain suggestions and information on the scope of issues and alternatives to be included in the EIS.

DATES: A public meeting will be held on: June 19, 2006 from 4 to 7 p.m. Written comments should be received on or before July 3, 2006.

ADDRESSES: The public meeting will be held at Turtle Rock Park Community Center 17300 State Route 89 Markleeville, California 96120. Information, written comments, or questions related to the preparation of the EIS and the NEPA process should be submitted to Robert D. Williams, Field Supervisor, Fish and Wildlife Service, Nevada Fish and Wildlife Office, 1340 Financial Boulevard, Suite 234, Reno, Nevada 89502; or FAX (775) 861–6301. Comments may be submitted electronically to *fw8pctcomments@fws.gov.*

FOR FURTHER INFORMATION CONTACT: Chad Mellison (See **ADDRESSES**) at (775) 861–6300.

SUPPLEMENTARY INFORMATION:

Reasonable Accommodation

Persons needing reasonable accommodations in order to attend and participate in the public meeting should contact Chad Mellison (See **ADDRESSES**) at (775) 861–6300 as soon as possible. In order to allow sufficient time to process requests, please call no later than one week before the public meeting. Information regarding this proposed action is available in alternative formats upon request.

Authority

This action is done in accordance with Recovery implementation section 4(f)(2) of the Endangered Species Act of 1973, as amended (ESA).

Background

At the time of its original listing as endangered under the Endangered Species Protection Act of 1966, non-native trout were considered a threat to the Paiute cutthroat trout (PCT; *Oncorhynchus clarki seleniris*). In 1975, PCT were reclassified as threatened under the Endangered Species Act of 1973, and a 4(d) rule was issued to facilitate management between California Department of Fish and Game and the Service. In order to recover the subspecies, non-native trout need to be removed from their historic habitat and PCT reintroduced as specified in the 2004 Revised PCT Recovery Plan. Without this project, PCT in the Silver King drainage will continue to be at risk from an illegal introduction of non-native trout and/or stochastic (one time) events such as a large fire or flood. Recovery of the species cannot be achieved without this project and the long-term survival of the species will be in doubt.

We propose to eradicate non-native trout with the piscicide rotenone from 14.7 kilometers (9.1 miles) of historic PCT habitat, in Silver King Creek, from Llewellyn Falls downstream to Silver King Canyon as well as the accessible reaches of three small named tributaries: Tamarack Creek, Tamarack Lake Creek, the lower reaches of Coyote Valley Creek downstream of barrier falls, and Tamarack Lake.

Environmental Impact Statement

The Service has selected Entrix to prepare the EIS. Entrix will prepare the EIS under the supervision of the Service, which will be responsible for the scope and content of the NEPA document.

NEPA (42 U.S.C. 4321 *et seq.*) requires that Federal agencies conduct and environmental analysis of their proposed actions to determine if the actions may significantly affect the human environment. Under NEPA, a reasonable range of alternatives to proposed projects is developed and considered in the Services' environmental review. Alternatives considered for analysis in an EIS may include: Variations in the scope of proposed activities; variations in the location, amount, and types of conservation; variations in activity duration; or, a combination of these elements. In addition, the EIS will identify potentially significant direct, indirect, and cumulative impacts on biological resources, land use, air quality, water quality, water resources, socio-economics, and other environmental issues that could occur with the implementation of the proposed action and alternatives. For all potentially significant impacts, the EIS will identify avoidance, minimization, and mitigation measures to reduce these impacts, where feasible, to a level below significance.

The EIS will consider the proposed action, no action, and a reasonable range of alternatives. A detailed description of the impacts of the proposed action and each alternative will be included in the EIS. The alternatives to be considered for analysis in the EIS may include: Various fish removal methods; variations in timing; or, a combination of these elements.

Request for Comments

The primary purpose of the scoping process is for the public to assist the Services in developing the EIS by identifying important issues and alternatives related to the proposed action. A public meeting will be held on June 19, 2006 as noted in the **DATES** section above.

Written comments from interested parties are welcome to ensure that the full range of issues related to the proposed action are identified.

All comments and materials received, including names and addresses, will become part of the administrative record and may be released to the public.

Comments and materials received will be available for public inspection, by appointment, during normal business hours at the office listed in the **ADDRESSES** section of this notice.

The Service requests that comments be specific. In particular, we request information regarding: Direct, indirect, and cumulative impacts of implementation of the proposed action; other possible alternatives that meet the purpose and need; potential adaptive management and/or monitoring provisions; existing environmental conditions in the project area; other plans or projects that might be relevant to this proposed project; and minimization and mitigation efforts.

The environmental review of this project will be conducted in accordance with the requirements of the NEPA of 1969 as amended (42 U.S.C. 4321 *et seq.*), Council on the Environmental Quality Regulations (40 CFR parts 1500–1518), other applicable Federal laws and regulations, and applicable policies and procedures of the Services. This notice is being furnished in accordance with 40 CFR 1501.7 to obtain suggestions and information from other agencies and the public on the scope of issues and alternatives to be addressed in the EIS.

Dated: May 23, 2006.

John Engbring,

Acting Deputy Manager, California/Nevada Operations Office, Sacramento, California.

[FR Doc. 06–4918 Filed 6–1–06; 8:45 am]

BILLING CODE 4310–55–P

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

[ID 111 1610 DP 049D DBG060003]

Notice of Availability of Draft Snake River Birds of Prey National Conservation Area Resource Management Plan and Environmental Impact Statement, Idaho

AGENCY: Bureau of Land Management, Interior.

ACTION: Notice of availability.

SUMMARY: In accordance with the National Environmental Policy Act of 1969 (NEPA, 42 U.S.C. 4321 *et seq.*) and the Federal Land Policy and Management Act of 1976 (FLPMA, 43 U.S.C. 1701 *et seq.*), the Bureau of Land Management (BLM) has prepared a Draft Resource Management Plan/ Environmental Impact Statement (Draft RMP/EIS) for the Snake River Birds of Prey National Conservation Area (NCA).

DATES: To assure that they will be considered, BLM must receive written comments on the Draft RMP/EIS within 90 days following the date the Environmental Protection Agency publishes this Notice of Availability in the **Federal Register**. The BLM will announce future meetings or hearings and any other public involvement activities at least 15 days in advance through public notices, media news releases, and/or mailings.

ADDRESSES: The Draft RMP/EIS will be posted on the Internet at *http://www.id.blm.gov/planning* and will be mailed to those who have indicated that they want a hard copy or a compact disk.

You may submit comments by any of the following methods:

- E-mail: *srbp@contentanalysisgroup.com.*
- Fax: 801–397–2601.
- Mail: Snake River Birds of Prey NCA, C/O Content Analysis Group, P.O. Box 2000, Bountiful, UT 84011–2000.

FOR FURTHER INFORMATION CONTACT: John Sullivan, NCA Manager, Bureau of Land Management, Four Rivers Field Office, 3948 Development Ave., Boise, Idaho 83705, phone—208–384–3300.

SUPPLEMENTARY INFORMATION: The NCA encompasses approximately 484,000 acres of public land along 81 miles of the Snake River. The NCA was established on August 4, 1993 by Public Law 103–64 for the conservation, protection, and enhancement of raptor populations and habitats and the natural and environmental resources and values associated with the area.

Issues identified through public scoping to be addressed in the planning process include the following:

- *Vegetation:* Substantial losses of native shrub and perennial grass communities have resulted in smaller and less stable small mammal raptor prey populations, which have secondarily impacted raptor populations.
- *Fuels Management:* The landscape-scale change from perennial to annual plant communities has altered the natural fire regime, resulting in more frequent fires, and greater potential for damage to private improvements in the wildland urban interface.
- *Recreation:* The burgeoning human population and associated development in the surrounding area have increased recreation-related impacts on soils and vegetation, predominately through off-road vehicle use. In addition, unregulated recreational shooting has caused safety conflicts with military training activities.
- *National Guard:* Military activities need to be conducted in a way that reduces impacts to soils and vegetation, especially shrub communities.

Four alternative strategies are described and analyzed, as follows:

Alternative A: (No-Action) Serves as a baseline for comparison with the other three alternatives, and proposes no major changes in resource management.

Alternative B: Emphasizes a moderate level of raptor and raptor prey habitat restoration and rehabilitation, while accommodating recreation, military, and commodity uses that are compatible with the purposes of the NCA.

Alternative C: Places a heavy emphasis on restoration and rehabilitation of all non-shrub areas outside the National Guard's Orchard Training Area (OTA) to improve raptor and raptor prey habitat. Livestock grazing preference would be eliminated, and recreation and military training would be substantially restricted to support habitat restoration projects.

Alternative D: (Preferred Alternative) Places a heavy emphasis on restoration of all non-shrub areas outside the OTA to improve raptor and raptor prey habitat, with moderate restrictions on recreation, military, and commodity uses.

Decision Process: Depending on the number and types of comments on the Draft RMP/EIS, the Proposed RMP/Final EIS is expected to be published in late 2006. A Notice of Availability of the Proposed RMP/Final EIS will be published in the **Federal Register** and through local news media. A notice of an approved Record of Decision will be published in the **Federal Register** following resolution of any protests or appeals on the Proposed RMP/Final EIS. The official responsible for the decision is the BLM Idaho State Director.

Individual respondents may request confidentiality. If you wish to withhold your name or street address from public review or from disclosure under the Freedom of Information Act, you must state this prominently at the beginning of your written comment. Such requests will be honored to the extent allowed by law. All submissions from organizations and businesses, and from individuals identifying themselves as representatives or officials of organizations or businesses, will be

RECEIVED
SEP. 1 6 2008
STATE CLEARING HOUSE

NOTICE OF PREPARATION

To: Responsible Agencies and Interested Parties

Date: September 16, 2008

Subject: Notice of Preparation of Draft Environmental Impact Statement and Draft Environmental Impact Report

Project Title: **PAIUTE CUTTHROAT TROUT RESTORATION PROJECT**

Environmental review of this project is required under both the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA). Implementation of the project will require discretionary approvals from federal and state agencies. The California Department of Fish and Game (CDFG) will serve as the lead agency under CEQA, the U.S. Fish and Wildlife Service (USFWS) will serve as the lead agency under NEPA, and the U.S. Forest Service (USFS) will serve as a cooperating agency under NEPA.

To ensure coordination and to prevent duplication of efforts, CDFG, USFWS, and USFS will prepare a joint Environmental Impact Statement/Environmental Impact Report (EIS/EIR) as recommended by Title 40 section 1506.2 of the Code of Federal Regulations and CEQA Guidelines section 15222.

This Notice of Preparation (NOP) has been prepared to satisfy the requirements of CEQA. This NOP provides a description of the project, the project location, and a brief discussion of the probable environmental effects of the project.

The NOP is an important step in the environmental scoping process, which is designed to determine the range of issues to be addressed in the EIS/EIR. The objectives of scoping include:

- Ensuring agency and public involvement in the environmental review process;
- Determining which specific impacts must be evaluated in the EIS/EIR;
- Establishing a reasonable range of alternatives; and
- Identifying the scope of issues that must be discussed to adequately and accurately address the potential impacts of the project as they relate to permitting and approval authority.

We need to know the views of your agency as to the scope and content of the environmental information which is germane to your agency's statutory responsibilities in connection with the proposed project. Your agency will need to use the EIS/EIR prepared by our agency when considering your permit or other approval for the project. We will need the name for a contact person at your agency. **Your written response must be received at the earliest possible date but no later than October 31, 2008.**

Please send your written response to:

Stafford Lehr
Senior Environmental Scientist
California Department of Fish and Game
North Central Region
1701 Nimbus Road
Rancho Cordova, CA 95670
Telephone: (916) 358-2838
slehr@dfg.ca.gov

For additional information about the project or the scoping process, please use the contact information listed above.

A scoping meeting will be held on Tuesday, October 7, 2008 from 4:00-7:00 p.m. at Turtle Rock Park Community Center, 17300 Highway 89, Markleeville, California. Persons needing reasonable accommodations to attend the meeting should contact Stafford Lehr at the phone number listed above as soon as possible. Please call no later than one week before the scoping meeting.

Date: September 16, 2008

[signature] for
Stafford Lehr
Senior Environmental Scientist

Description of the Proposed Project:

The Paiute cutthroat trout (*Oncorhynchus clarki seleniris*).is a federally listed threatened species. Silver King Creek is part of the Paiute cutthroat trout's historic range but is currently populated by hybridized non-native trout that could threaten the existence of pure Paiute cutthroat trout located above Llewellyn Falls if these populations were inadvertently mixed. Hybridization with non-native fish is a primary threat to the subspecies. The fish present in reaches downstream from Llewellyn Falls to Silver King Canyon are a genetic mixture of introduced rainbow (*Oncorynchus mykiss*), Lahontan cutthroat (*Oncorynchus henshawi*), golden trout (*Oncorynchus aguabonita*), and native Paiute cutthroat trout.

The proposed project would geographically isolate pure populations of Paiute cutthroat trout. CDFG, in collaboration with USFWS and USFS, proposes to remove all non-native hybridized trout in Silver King Creek, in Alpine County, California, from Llewellyn Falls to Silver King Canyon, using the piscicide rotenone. Alternatives that will be considered include: no action, chemical treatment, various fish removal methods (e.g., mechanical removal and dewatering), combination of dewatering followed by chemical treatment.

This action is necessary to implement the Recovery Plan for the Paiute cutthroat trout (*Oncorhynchus clarki seleniris*). USFWS published a revised Recovery Plan for the Paiute Cutthroat Trout (Recovery Plan), which is available for public review at: http://ecos.fws.gov/docs/recovery_plan/040910.pdf. The first two criteria in the Recovery Plan for accomplishing the goal of delisting the species are: (1) removal of all nonnative salmonids in Silver King Creek and its tributaries downstream of Llewellyn Falls to fish barriers in Silver King Canyon; and (2) occupation by a viable population of all historic habitat in Silver King Creek and its tributaries downstream of Llewellyn Falls to the fish barriers in Silver King Canyon.

Location of the Proposed Project:

The Silver King Creek drainage is located on the eastern slope of the Sierra Nevada Range, in Alpine County, California. The drainage is a main tributary to the East Fork of the Carson River, which drains into the Lahontan Basin. The project area occurs within the Carson-Iceberg Wilderness on National Forest System lands administered by the Carson Ranger District, Humboldt-Toiyabe National Forest (See Attachment 1).

The proposed project would encompass 14.7 kilometers (9.1 miles) of historic Paiute cutthroat trout habitat in Silver King Creek, from Llewellyn Falls downstream to Silver King Canyon as well as the accessible reaches of three small named tributaries: Tamarack Creek, Tamarack Lake Creek, the lower reaches of Coyote Valley Creek downstream of barrier falls, and Tamarack Lake.

Probable Environmental Effects of the Project:

CDFG, USFWS, and USFS have determined this project could result in significant environmental impacts and/or have a significant impact on the quality of the human environment. Preparation of an EIS/EIR is thus appropriate. CDFG, USFWS, and USFS have identified the following environmental considerations as potential significant effects of the project:

- Effects on Biological Resources.

    - Effects on Paiute Cutthroat Trout. Rotenone is toxic to fish. Fish that are not removed from the water would be exposed to potentially fatal concentrations of rotenone. Any Paiute cutthroat trout present in the project area would likely be lost during the project's implementation. Mechanical removal may result in the loss of some Paiute cutthroat trout due to stress or injury. Dewatering in combination with chemical treatment may result in the loss of Paiute cutthroat trout that may remain in the project area. The EIS/EIR will evaluate any potential significant impacts on Paiute cutthroat trout.

    - Effects on Non-Target Organisms. Rotenone is toxic to fish and other gill-breathing organisms, such as aquatic invertebrate nymphs and larvae and some forms of amphibians. There may be negative effects of the project on non-target organisms, including, but not limited to aquatic invertebrates, amphibians, Management Indicator Species, Forest sensitive species, and species listed as Threatened, Endangered, or Proposed under the Endangered Species Act. Rotenone is toxic to some aquatic organisms and may affect macro-invertebrate populations. Dewatering followed by chemical treatment will have the same effects on non-target organisms as stated above. The EIS/EIR will evaluate any potential significant impacts on non-target organisms.

- <u>Hazardous Materials</u>. Rotenone is a restricted-use pesticide due to its aquatic toxicity and acute toxicity when inhaled. It may only be purchased and used by Certified Applicators or persons under their direct supervision. Although the U.S. Environmental Protection Agency has determined the use of rotenone for fish control does not present a risk of unreasonable adverse effects to humans, the EIS/EIR will analyze any potential significant impacts due to the use of rotenone. The transportation and handling of rotenone poses a potential risk of accidental spillage in route to the project site or at the project site. Potential significant impacts from an accidental spill will be analyzed in the EIS/EIR.

- <u>Effects on Hydrology and Water Quality</u>. The proposed project would require a National Pollutant Discharge Elimination System permit from the Lahontan Regional Water Quality Control Board. The application of rotenone could result in concentrations of some constituents that would temporarily exceed water quality standards. Implementation of the proposed project would require a neutralization plan. The EIS/EIR will evaluate all potentially significant impacts to both surface and groundwater quality and multiple methods of neutralization.

- <u>Effects on Recreational Fisheries</u>. Silver King Creek is used by recreational anglers. There may be potentially significant impacts on angling opportunities due to the potential long-term closure of approximately eleven (11) miles of angling waters along Silver King Creek in the Carson-Iceberg Wilderness within Alpine County, California.

NOP DISTRIBUTION:

This NOP was sent to the following agencies, organizations, and individuals:

<u>Federal</u>:

- U.S. Fish and Wildlife Service
- Advisory Council on Historic Preservation
- Federal Tribes
- U.S. Army Corps of Engineers
- U.S. Army Corps of Engineers, San Francisco Division
- U.S. Department of Agriculture
- U.S. Department of Agriculture Animal & Plant Health Inspection Service

- U.S. Department of Agriculture National Agricultural Library
- U.S. Department of Agriculture Natural Resources Conservation Service
- U.S. Department of Agriculture Office of Civil Rights
- U.S. Department of Interior, Office of Environmental Policy & Compliance
- U.S. Environmental Protection Agency
- U.S. Environmental Protection Agency, Region 9 San Francisco
- U.S. Fish and Wildlife Service
- U.S. Forest Service, Humboldt-Toiyabe National Forest
- U.S. Forest Service, Carson Ranger District

State Agencies:

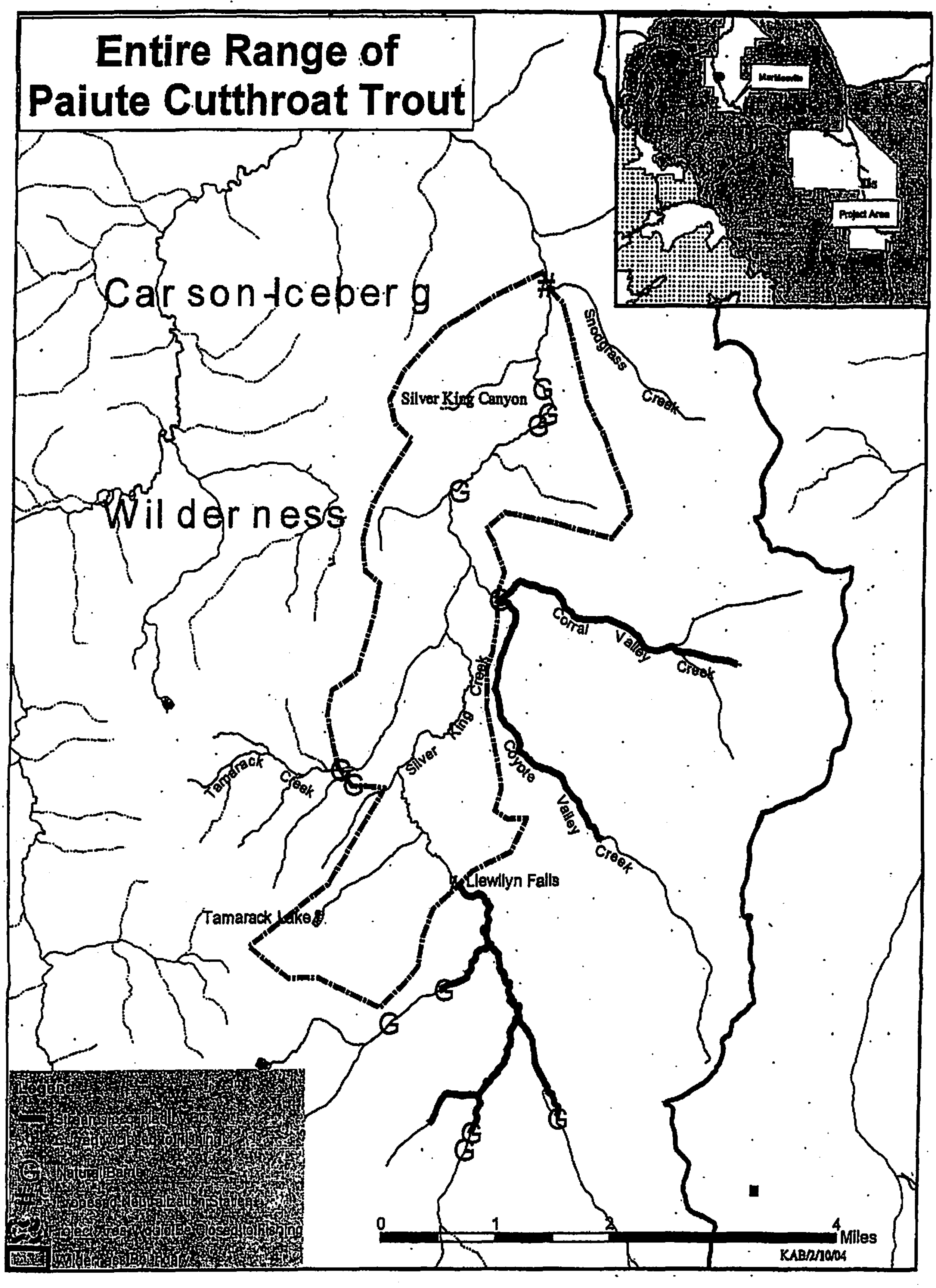
- California Department of Boating and Waterways
- California Department of Food & Agriculture
- California Department of Health Services
- California Department of Pesticide Regulation
- California Department of Toxic Substances Control
- California Department of Water Resources
- California Native American Heritage Commission
- Office of Environmental Health Hazard Assessment
- State Clearinghouse
- State Historic Preservation Officer
- State Water Resources Control Board

Regional and Local Agencies:

- Northern Sierra Air Quality Management District
- Lahontan Regional Water Quality Control Board
- Alpine County Board of Supervisors
- Alpine County Clerk
- Town of Markleeville

Individuals and other Organizations:

- Alpine County Chamber of Commerce
- Alpine County Sheriff
- Carson River Resort
- Sorensen's Resort
- Woodfords Station
- Washoe Tribe of Nevada and California
- Center for Collaborative Policy
- Nancy Erman
- Jim Crouse
- David Katz
- Mike Matuska
- John Regan
- Bob Rudden
- Judy Wickwire
- Dave Zelmer


Entire Range of
Paiute Cutthroat Trout
Carson-Iceberg
Wilderness
Snodgrass Creek
Silver King Canyon
Corral Valley Creek
Silver King Creek
Coyote Valley Creek
Tamarack Creek
Llewlyn Falls
Tamarack Lake
Project Area
Legend
Natural Barrier
0 1 2 4 Miles
KAB/2/10/04

APPENDIX B

Alternatives Formulation Report

SILVER KING CREEK
PAIUTE CUTTHROAT TROUT RESTORATION PROJECT

Alternatives Formulation Report

MARCH 2009

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TABLES

C H A P T E R 1

Introduction

The California Department of Fish and Game (CDFG) and U.S. Fish and Wildlife Service (USFWS) (collectively referred to hereafter as the Agencies) are proposing to restore Paiute cutthroat trout (*Oncorhynchus clarkii seleniris*) in Silver King Creek in the Humboldt-Toiyabe National Forest (HTNF). The Agencies propose to apply rotenone to an 11-mile reach of Silver King Creek, its tributaries and Tamarack Lake, if necessary, to eradicate non-native trout. The rotenone would be neutralized downstream of Silver King Canyon using potassium permanganate. After two to three years of treatment, the Agencies would restock pure Paiute cutthroat trout. Chapter 3.0, Project Alternatives, presents a more detailed description of the proposed Action.

The Agencies have determined this action is necessary both to restore Paiute cutthroat trout to its historic range and to isolate Paiute cutthroat trout in the Silver King Creek Watershed, protecting the restored Paiute cutthroat trout population from the introduction of other species of trout (USFWS 2004). The National Environmental Policy Act (NEPA) lead agency for this action will be the USFWS. In addition, because this action would constitute a project under the California Environmental Quality Act (CEQA), requiring discretionary action including funding and permit approvals, this action will also require preparation of an environmental impact report (EIR). CDFG is the lead agency under CEQA. Therefore, the Agencies have determined that a joint environmental impact statement/environmental impact report (EIS/EIR) will be required under federal and state laws, respectively. The proposed Action would also require permits and approvals for chemical treatment from the Lahontan Regional Water Quality Control Board (Water Board) and for chemical treatment, use of motorized equipment, and import of the required number of workers from the U.S. Forest Service (USFS) - HTNF. The Water Board is a Responsible Agency under CEQA, and the USFS is a Cooperating Agency under NEPA.

This document describes how the Agencies selected the reasonable range of alternatives for detailed evaluation in the EIS/EIR. It discusses the range of options identified through reviews of the literature on fish eradication, the comments on the USFWS Notice of Intent (Federal Register (FR 71 32125 – 32126; June 2, 2006) for the proposed Action (USFWS 2006), and public and agency comments received during the CEQA scoping process. It also considers options outlined in similar environmental documents prepared for other fish restoration projects, including the recently prepared Lake Davis Pike Eradication Project EIS/EIR (CDFG 2007).

The objective of the proposed Action is to establish the Paiute cutthroat trout as the only trout subspecies in Silver King Creek for the purpose of preventing hybridization with other trout species. This is an important and necessary step in preventing Paiute cutthroat trout from going extinct and conserving the species and restoring it to a level that would allow it to be removed from the federal threatened species list. To accomplish this objective, the Agencies would eradicate all non-native trout from the treatment area prior to restocking with pure Paiute cutthroat trout. The Agencies are also evaluating the necessity of treating Tamarack Lake at the headwaters of Tamarack Lake Creek, a tributary of Silver King Creek. Chapter 3.0, Project

Alternatives, presents the surveys the Agencies will complete to determine the presence or absence of fish and the criteria that would be used to determine whether treatment of the lake is necessary.

This report identifies and evaluates potential technologies and other strategies to meet the objectives of the proposed Action and selects technologies and combinations of strategies for further development as alternatives for evaluation in the EIS/EIR. The Water Board specifically requested that the Agencies consider combinations of technologies that would reduce the amount of chemical treatment required. The EIS/EIR provides a more detailed evaluation of the potential environmental impacts of the selected alternatives on public health, the local economy, and ecological and recreational values.

1.1 BACKGROUND

Silver King Creek, downstream from Llewellyn Falls to Silver King Canyon in Alpine County is the native range of Paiute cutthroat trout, one of the rarest trout subspecies (USFWS 1985). Indigenous only to Silver King Creek, the USFWS listed Paiute cutthroat trout as threatened under the Endangered Species Act (ESA) on July 16, 1975 (USFWS 1975). The Agencies have established out-of-basin populations of Paiute cutthroat trout in several California streams including the North Fork of Cottonwood Creek and Cabin Creek in the Inyo National Forest (Mono County) and within the Sierra National Forest, in Sharktooth Creek (Fresno County) and Stairway Creek (Madera County).

Hybridization with introduced trout species is a primary threat to the subspecies (USFWS 2004). The fish from Llewellyn Falls downstream to Silver King Canyon are a genetic mixture of introduced rainbow (*O. mykiss*), Lahontan cutthroat (*O. c. henshawi*), golden trout (*O. aquabonita sp.*), and native Paiute cutthroat trout. When associated with Lahontan cutthroat trout or rainbow trout, Paiute cutthroat trout tend to lose their distinctiveness through hybridization (USFWS 1985). Hybridized trout and genetically pure Paiute cutthroat trout are currently separated by Llewellyn Falls. Because of their proximity, hybridized fish could easily be transferred above the falls where Paiute cutthroat trout were restored by CDFG in the early 1990s.

The USFWS published a Revised Recovery Plan for Paiute cutthroat trout on August 10, 2004 (USFWS 2004). Criteria for delisting Paiute cutthroat trout and for which the proposed Action addresses include:

- Eradication of all non-native salmonids in Silver King Creek and its tributaries from downstream of Llewellyn Falls to the fish barriers in Silver King Canyon; and
- Restoration of a viable population to all historic habitat in Silver King Creek and its tributaries from downstream of Llewellyn Falls to the fish barriers in Silver King Canyon.

1.2 OPTION EVALUATION AND ALTERNATIVE FORMULATION

The technologies identified included the use of a variety of chemical agents as piscicides (fish-killing agents) with or without motorized equipment, fisheries management actions and fish eradication techniques using non-motorized methods, dewatering, and the introduction of predators. In addition to evaluating these as independent techniques, the Agencies considered combined approaches. All options were evaluated using a two-phase assessment approach. In Phase I, the options were evaluated to determine if they would effectively and, in compliance with current laws and regulations, accomplish the initial step of eradicating all non-native trout from Silver King Creek and its tributaries between Llewellyn Falls and Silver King Canyon. The options that met this criterion were then evaluated in Phase II against a second set of criteria, including protection of public health and safety; timely implementation; use of a proven, effective method; technical feasibility; minimization of environmental impacts; and cost-effectiveness. Technologies that met these criteria were selected as stand-alone measures or combined with other technologies during the formulation of alternatives for evaluation in the EIS/EIR.

1.3 ORGANIZATION OF THE ALTERNATIVES FORMULATION REPORT

Chapter 2 identifies and describes a wide-ranging suite of fish eradication technologies and combinations of these technologies and other management strategies. This section attempts to identify all the tools available to the Agencies, including technologies used worldwide, so that no possibilities are overlooked. Chapter 3 presents the Phase I and II screening of technologies, and Chapter 4 presents the alternatives selected to undergo more detailed development and evaluation in the EIS/EIR.

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CHAPTER 2

Identification and Description of Technologies

This section describes all the potential technical and management techniques identified for application in Silver King Creek. These methods were gathered from a variety of sources, including the literature on fish eradication, past environmental documents, public and agency comments on the Notice of Intent for the proposed Action, and public comments received in response to the CEQA Notice of Preparation. Public and agency comments on the recent Lake Davis Pike Eradication EIS/EIR were considered as well (CDFG 2007).

The technologies and management options fall into five categories: chemical treatment, dewatering, fisheries management, habitat management, and combined approaches. These methods are described below and are listed in Table B-1.

2.1 CHEMICAL TREATMENT

This section evaluates seven chemical agents that could be used to eradicate non-native trout in Silver King Creek. However, several piscicides or technologies described in this section are not approved for use in the State of California and others will not be used by CDFG. Nevertheless, the Agencies developed this section to discuss known piscicides currently used in fishery management and restoration projects worldwide.

2.1.1 Powdered Rotenone

The powdered form of the piscicide rotenone (produced from the roots of tropical legumes such as *Derris* spp. and *Lonchocarpus* spp.) is a proven, feasible method for eradicating fish in standing water. In areas where the source plants occur naturally, rotenone has been used as a traditional fishing method. In the United States, it has been used in fishery management since the 1930s.

Powdered rotenone can have limited effectiveness in moving water such as streams and creeks; only standing water application is described on the label. Registered for use as a piscicide with the U.S. Environmental Protection Agency (USEPA) and the California Department of Pesticide Regulation (CDPR), powdered rotenone has been tested extensively in the laboratory and the field. Rotenone biodegrades readily in water via oxidation and during daylight hours via photolysis. If used according to the explicit label instructions, both the USEPA and the CDPR have determined the product to be safe for workers and the public. However, it can be toxic to humans if inhaled. Powdered rotenone is extremely toxic to organisms that obtain oxygen through gills. However, it is not as effective as liquid rotenone formulations (see the descriptions below) in distributing horizontally and vertically in water. Powdered rotenone formulations have been historically used by CDFG; however, because of its inhalation hazards, it is the least preferred piscicide approved for use in California.

Table B-1 Potential Fish Eradication Technologies and Management Options for Silver King Creek

Chemical Treatment	Powdered rotenone Standard formulation of rotenone – non-synergized (Noxfish®) Standard formulation of rotenone – synergized (Nusyn-Noxfish®) Formulated rotenone (CFT Legumine™) Antimycin Copper sulfate Chlorine Chloramine
Dewatering	Damming of Silver King Creek above Llewellyn Falls Bypass water around project area (diversion dam, piping) Divert water to adjacent subwatershed (diversion dam, pumps, piping) Sequential dewatering of stream reaches Pump water out of residual pools with portable pumps
Fisheries Management Techniques	Physical removal (electrofishing, nets, traps or seines) Introduce predatory fish population Fish-out options (public angling, derbies, angler incentives, commercial fishing) Detonation cord, explosives Genetic swamping Sonar
Habitat Management	Use of nitrogen or carbon dioxide to deplete dissolved oxygen and asphyxiate fish Nutrient loading to deplete dissolved oxygen and asphyxiate fish Treatment of a smaller area CEQA requires consideration of a smaller project
Chemical Application Combined with Other Approaches	Dewatering with rotenone application Electrofishing with rotenone application Dewatering with electrofishing and rotenone application
Combined Non-Chemical Options	Combination of physical removal techniques Partial dewatering and physical removal techniques Physical removal techniques and genetic swamping

2.1.2 Standard Formulated Rotenone

Use of standard liquid formulations of rotenone (for example, Noxfish®, Nusyn-Noxfish®) is a proven and feasible method for eradicating fish in both standing and flowing water. Registered for use as a piscicide with the USEPA and the CDPR, Noxfish® has undergone extensive laboratory and field-testing and has explicit application directions. The formulation consists of a rotenone extract dissolved in solvents and emulsifiers, which help it mix into water and disperse both horizontally and vertically, even through thermoclines. Standard formulations of rotenone may contain other ingredients that are proprietary and, therefore, are not listed on the label. All ingredients, however, were disclosed to the USEPA and CDPR and taken into consideration when the product was registered and the label instructions developed.

In addition to containing the active ingredient rotenone, Noxfish® and Nusyn-Noxfish®, contain aromatic hydrocarbons, including naphthalene and methylated benzenes, which serve as solvents. Nusyn-Noxfish® differs from Noxfish® in that it contains a pesticide synergist, piperonyl butoxide, which adds to the rotenone's effectiveness and allows for a lower proportion of rotenone in the formulation.

Aromatic hydrocarbons are considered semi-volatile and do not remain in water for long periods, typically evaporating to concentrations below detection limits within 1 to 3 weeks. These compounds, particularly naphthalene, have a strong odor that the public has noticed following previous treatments (e.g. the 1997 treatment of Lake Davis). When Lake Davis was treated with Nusyn-Noxfish® in October 1997, the piperonyl butoxide did not biodegrade as readily as the other compounds and was detected for about seven months after the treatment at part-per-billion concentrations in the deepest part of the lake. With the exception of piperonyl butoxide, rotenone is the most persistent chemical in the standard liquid formulation. Rotenone itself readily decomposes in water through oxidation and exposure to light (photolysis). CDFG considers Noxfish® and Nusyn-Noxfish® viable options when evaluating piscicide treatments in California.

2.1.3 Alternative Formulated Rotenone

About 15 years of research and development have produced an alternative rotenone formulation that is currently being used in Europe. Its effectiveness has been demonstrated in the laboratory and in the field. This formulation contains diethylene glycol monoethyl ether (DEGEE), 1-methyl-2-pyrollidone, and a fatty acid ester to improve the rotenone's solubility in water (referred to as inactive ingredients). As with traditional rotenone formulations, the solvents and emulsifiers break down rapidly, giving the product a faint odor. CFT Legumine™ is registered by the USEPA and CDPR (#655-805-AA-75338). This formulation (see Appendix C) was used in the Lake Davis Pike Eradication Project in September 2007 (CDFG 2007).

The CFT Legumine™ formulation contains approximately 5% rotenone, 10% methyl pyrrolidone (MP), 60% DEGEE, 17% Fennodefo 99™ (Fennodefo), and 3% other compounds (CDFG 2007). The two primary inactive ingredients in CFT Legumine™ are MP and DEGEE, which comprise approximately 93% of the formulation by weight as determined by CDFG (see Appendix C, Table C-13). Both of these chemicals are infinitely soluble in water and have an estimated organic carbon partition coefficient (i.e., the "K_{oc}") of 12, indicating their water solubility and tendency not to adsorb to sediment particles (NLM 2006). Based on their low Henry's Law constants, these chemicals do not readily volatilize from surface water and neither chemical would undergo extensive hydrolysis or direct photolysis (NLM 2006).

Aerobic biodegradation is the most important mechanism for the removal of MP and DEGEE from aquatic systems (NLM 2006). The small amount of these chemicals that may volatilize into ambient air would be readily degraded by reaction with photochemically-produced hydroxyl radicals, with an atmospheric half-life of up to 12 hours (NLM 2006). The Fennodefo constituent in CFT Legumine™ facilitates emulsification and dispersion of the otherwise relatively insoluble rotenone. Two classes of constituents, polyethylene glycols (PEGs) and the solvent hexanol (alcohol), are part of the inert additive Fennodefo in CFT Legumine™, which also contains fatty acid esters. As stated in the "Screening Level Risk Analysis of Previously Unidentified Rotenone Formulation Constituents Associated with the Treatment of Lake Davis" (ENVIRON 2007), the fatty acid ester mixture in Fennodefo is likely derived from "tall oil." Tall oil has been independently reported as a mixture of naturally occurring fatty acids, resins and neutrals that are a byproduct of wood pulp, and is a common constituent of soap formulations. The fatty acids in tall oil, principally oleic and linoleic acids, are naturally occurring constituents that are also part of the building blocks that make up fats and oils (triglycerides). Highly unsaturated fatty acids, like linoleic acid, are considered essential dietary constituents in humans, as they cannot be synthesized. Polyethylene glycols (e.g. propylene glycol) are common ingredients in a variety of consumer products, including soft drink syrups (as an antioxidant), in plasticizers, suntan lotions and antifreeze, among other uses (ENVIRON 2007).

Ambient air samples were collected before and during the application of rotenone to Lake Davis in 2007 for pike elimination. The sampling methods were constructed to monitor for rotenone (the active ingredient), MP (water soluble solvent for rotenone), and naphthalene (odiferous, but minor constituent of applied technical material). Background samples were collected prior to application of the rotenone to the lake. Results of the sampling indicated that no rotenone above the detection limit (3 nanograms/meter^3 or 3 ng/m^3) occurred at any of the sample sites. In addition, no MP occurred at above the detection limit (150 ng/m^3) at any of the sites. Low levels of naphthalene were detected at the sample sites. Because naphthalene is a known combustion byproduct, particularly diesel oil combustion and other petroleum based activities, it is a known background constituent in ambient air and measurable amounts would be expected. Although some of the naphthalene levels increased after rotenone application activities began, these slightly elevated levels could be attributed to the increase of motor vehicle and boat traffic in the area. Urban levels of naphthalene, as measured by EPA, can range between 300 ng/m^3 and 700 ng/m^3. All naphthalene levels detected in the samples were below the 300 ng/m^3 level. The VOC results from the sample collected at the fire station site indicate a higher level of combustion products as compared to the other samples. The 1, 2-dichloroethane and dichloromethane concentrations were also elevated at this site in comparison with the other sample sites (Cal/EPA, Air Resources Board 2007). Overall, the monitoring data collected indicate that no appreciable increase in rotenone, MP, naphthalene, and VOC levels were attributable to activities associated with the Lake Davis rotenone project. Because of the low volume of rotenone formulation needed for this application, the small surface to be treated, and the dilution that would be achieved over a short distance, air exposures were not considered a significant exposure pathway and air concentrations of rotenone and its constituents were assumed to be zero.

Based on these data, CFT-Legumine™ is the preferred choice of approved piscicides for this project. The agencies would reserve the option of using Noxfish® or Nusyn-Noxfish® should issues arise with acquisition or approval to use CFT-Legumine™ based upon formulation approvals.

2.1.4 Antimycin

Antimycin (an antibiotic drug) has undergone extensive laboratory testing and field use as a piscicide and is both a feasible and effective method in flowing and standing waters. It has been used primarily in reservoirs up to about 15 to 20 feet deep, but not in water greater than 30 feet deep or in water with pH values of 8.5 or higher.

Antimycin is registered for use as a piscicide by the USEPA and was formerly registered in California. However, because of insufficient human health and safety data, antimycin is not currently registered with the CDPR. Re-registration of antimycin for this action would require the development of health and safety data followed by an approximately one year registration process. Emergency exemptions are possible in some cases; however, because of the expense and time requirements of the application process, antimycin is not expected to be registered for use in California in the near future.

2.1.5 Copper Sulfate

Copper sulfate is toxic to fish and a variety of other aquatic organisms including plants. It has not historically been used as a piscicide and is not registered for this use by the USEPA or CDPR. In aquatic systems, copper sulfate has been used mainly as an algaecide. It has not been tested as a pesticide in the laboratory or in the field. While highly soluble in water, it does not volatilize. Instead, copper tends to bind to sediments and persists in the environment for extended periods. In response to environmental concerns, the European Union has proposed a complete ban on all copper use.

2.1.6 Chlorine

Chlorine (in the form of hypochlorite, the same agent used in laundry bleach) is highly toxic to fish at levels that are safe for humans. It has been used since the 1900s to disinfect drinking water and treat wastewater. When chlorine is added to water with organic content, hazardous byproducts such as trihalomethanes, which are human carcinogens, are produced. Chlorine has been used in fish eradication projects, but not in the State of California. It generally dissipates from water in a few days. Chlorine is also highly toxic to crustaceans, amphibians, reptiles, mollusks, gastropods, algae, plants, and plankton. Chlorine is not registered for use as a piscicide by the USEPA or CDPR.

2.1.7 Chloramine

Chloramine, a compound formed from chlorine and ammonia, has been used for drinking water treatment since the 1930s. Chloramine does not result in the formation of as many trihalomethanes as chlorine, but is persistent in water and must be removed with carbon-activated filters. Chloramine is toxic to fish, crustaceans, amphibians, reptiles, mollusks, gastropods, algae, plants, and plankton. Literature searches completed by CDFG for Lake Davis did not reveal any cases where chloramine was used as a piscicide (CDFG 2004, 2007). Furthermore, chloramine is not registered for use as a piscicide by the USEPA or CDPR.

2.2 DEWATERING

Dewatering would involve full or partial removal of water from the creek to facilitate fish eradication. Dewatering would require construction of a diversion or check dam. Bypassing or diverting water would require pumping the water through pipes either around the proposed treatment area, to an adjacent drainage, or downstream. Dewatering of any residual pools within the treatment area would require pumping. This alternative would eliminate fish from the dewatered portion of the stream if the stream remained dewatered for a long enough period of time and any refugia for fish (i.e., residual pools, hyporheic zone) were eliminated. Because of the remote location, unique wilderness values and environmental quality of the treatment area, the construction of dams and the diversion and storage of large quantities of water on the scale necessary to accomplish fish eradication, was considered unfeasible and is not evaluated further herein.

2.3 FISHERIES MANAGEMENT TECHNIQUES

Six fisheries management techniques are evaluated below: physical removal, introducing a predator, fish-out, explosives, genetic swamping, and sonar.

2.3.1 Physical Removal using Motorized/Non-motorized Methods

2.3.1.1 Electrofishing

Electrofishing introduces an electric current into the water and is commonly used to assess fish populations (e.g. to identify types of fish, counts, aging) and as a fish removal tool. Electrofishing units, which can be gas- or electric-powered, are typically mounted on a backpack. The electricity causes an involuntary muscle contraction, attracting the fish toward the source of the electricity (electrode). Workers with long-handled nets then collect the stunned fish. Voltage, amperage, pulse frequency, and waveform are manipulated to maximize effectiveness which can be influenced by water flow and velocity, temperature, clarity, conductivity (dissolved mineral content), and substrate. Other factors influencing effectiveness include the fish size, species and behavior, presence of aquatic vegetation, time of year, and time of day. It is most effective in shallow water and is therefore most commonly used to sample fish in rivers and streams and occasionally in the shallow water zones of lakes. High elevation Sierra streams often have low conductivities, which can reduce the effectiveness of electrofishing. This can be overcome to some extent by adding salt to the stream. However, this may have other undesirable environmental effects, particularly on amphibians.

To prevent re-colonization from adjacent reaches within the treatment area, the work proposed (11 miles of stream) would have to be conducted in a single season and during the short low-flow season to maximize electrofishing efficacy. To obtain complete fish removal, the treatment area would be divided into segments isolated by nets and shocked multiple times. It may not be possible to effectively remove fish from some areas, such as in deep pools or heavily vegetated sections, beneath undercuts and rootwads, or in the substrates. Battery-powered units are less effective than gasoline-powered units and would need to be recharged frequently, requiring either constant shuttling of batteries in and out of the wilderness area or an on-site charging station. In this instance, a gasoline powered generator would be used to supply electricity to battery rechargers. Gasoline-powered electrofishing units and the use of a generator as a charging station would require authorization from USFS.

A combined physical removal method (electrofishing, seining, gill netting) that strictly uses batteries that are brought in by pack stock was also evaluated. Under this scenario, pack stock would bring in recharged batteries every 2 days over the course of 72 days per season for the projected multiple year timeframe. This method could potentially have more impacts to Wilderness character and could be substantially more costly than using a gas powered generator to recharge electrofishing unit batteries.

Electrofishing with a crew of 11 people is used annually to survey fish populations in Silver King Creek. Electrofishing with the goal of fish eradication would require a much larger number of people. It would also require a lengthy time period for shuttling people, equipment, and removing fish in and out of the treatment area on foot, via horseback or helicopter. To attempt complete removal, the area would likely require treatment for several consecutive years (approximately 10 years), each with a similar level of effort.

As described in the EIS/EIR, this method could also be compromised by colonization of the treatment area by Paiute cutthroat trout moving downstream from above Llewellyn Falls or the barriers on Coyote Valley and Corral Valley Creeks during high flows in the intervening period, and would become difficult to determine if the previous year's fish removal effort had been successful.

2.3.1.2 Gill Netting

Gill netting is a passive capture technique used to collect fish by entangling or ensnaring in nets. Both gill nets and trammel nets capture fish when they swim into the net. Nets are typically made of cotton, nylon, or monofilament fiber. Mesh sizes can range from one-quarter inch for small fish to over 5 inches for larger fish species. The method has been used successfully to remove unwanted fish from very small lakes and reservoirs (Knapp and Matthews 1998) through intensive efforts repeated over multiple years. Gillnetting requires less labor than electrofishing or other types of nets. They are light, easy to deploy, and require less maintenance than other types of nets. Gillnets would likely be checked once or twice a day.

Gill nets are more appropriate for use in reservoirs and would likely not work well in a stream where the nets would have to be oriented at an angle to the flow to prevent them from filling with debris. Success with these nets also depends on the movement of fish. Trout are territorial and may move around very little during substantial portions of the year, especially during the low-flow season when the nets would be deployed. Silver King Creek is not accessible year-round and gill net use may not be feasible during high flows, when the nets could be blown out by high flow, clogged with debris or entangled with falling trees. The nets do not effectively capture fry and require use over multiple years to capture these fish as they grow larger but before they are able to reproduce. These factors make it unlikely that this technique would be successful in completely removing fish from Silver King Creek.

The Agencies have used gill netting over the last several years, as a sampling method, to assess fish populations in Tamarack Lake. This monitoring effort, which will also include snorkeling and electrofishing, will continue as part of the proposed Action, in order to determine whether to conduct rotenone treatment of the lake.

2.3.1.3 Trap Nets

Trap nets are another passive capture technique that relies on fish movement. Fish enter the mouth of the net and then are guided into a trap box from which they cannot escape. The application would require a large number of trap nets placed throughout the Project area and maintained for prolonged periods. To maximize efficiency, nets would be positioned across the channel, a configuration which results in capturing debris as well as fish. A very small net mesh size would be required to capture fry. Small mesh nets capture debris easily and would therefore require continuous monitoring to keep them from clogging. Spacing and numbers of trap nets would depend on habitat characteristics. Because fish movement may be limited, like gill nets, these traps would not likely achieve complete fish removal.

2.3.1.4 Seining

Seining is an active netting technique used to capture fish by dragging a net through the water body. This method is most effective when applied over smooth, uniform bottoms with no obstructions to block the path of the net. Even in these situations, seining generally does not capture all fish. In stream environments, the bottom is typically rough and contains numerous obstructions (e.g. boulders, trees, and logs) and numerous places where fish can seek refuge from the net (e.g. under cobbles or boulders, along banks, or in undercuts). Therefore, this technique is unlikely to catch a substantial proportion of the fish population.

2.3.2 Introducing Predatory Fish

This technique would entail introducing into Silver King Creek and its tributaries a fish predator that would prey on non-native trout. Introduction of a new species into the Silver King Creek ecosystem would be risky, unwise and ineffective for many reasons. First of all, introducing a new predator would only increase the level of threat to native and downstream fish and wildlife resources, rather than protect them. Secondly, if the predator eliminated the non-native trout, it would need to be the target of its own fish removal project. Finally, there are no known documented cases where this technique has completely eradicated a species.

2.3.3 Fish-Out Options

Options in this category include opening the treatment area to public angling, derbies, and creating angler incentives to remove introduced trout species. Successive years of intensive fishing using combinations of the above options could depress the population of non-native trout. Case studies have shown that fish populations can be depleted by such methods. It is unlikely that anglers would catch all of the non-native trout in Silver King Creek and its tributaries. Larger trout would be caught while the smaller, more numerous fish would remain. If all larger fish were removed, the smaller fish would grow and reproduce and the population would be reestablished after a few years. If a few adults remained, repopulation would occur even sooner.

The treatment area between Llewellyn Falls and Tamarack Lake has been closed to fishing since June 2006 to help prevent the unauthorized movement of undesirable species to areas above Llewellyn Falls populated by pure Paiute cutthroat trout. Allowing public fishing in this area would increase the threat of unauthorized transport of undesirable non-native trout species above Llewellyn Falls; however, this could be managed to some degree through public education and outreach by CDFG and USFS personnel.

2.3.4 Detonation Cord, Explosives

Underwater pneumatic and percussion explosions create shock waves that can kill fish by rupturing their air bladders and inner-ear structures, causing gill and brain hemorrhages. The method is non-selective and would likely harm or kill many non-target species including invertebrates and amphibians. Similar to electrofishing, complete removal of fish from the treatment area would likely require treatment for several consecutive years, each with a similar level of effort. This method has not been determined effective at achieving complete fish removal from streams (CDFG 2007).

2.3.5 Genetic Swamping

Genetic swamping would attempt to reduce hybridization by stocking large numbers of genetically pure fish on a frequent or annual basis into areas that harbor non-native trout. This approach would gradually dilute the undesirable genetic material to a non-detectable level. This method could be enhanced if coupled with an intensive program of population suppression by removing non-native hybridized trout using the acceptable fisheries management techniques described above. However, this method would not remove the genetic introgression that has occurred in Silver King Creek and would essentially result in the extinction of Paiute cutthroat trout from their native habitat and would not be consistent with the Revised Recovery Plan (USFWS 2004).

2.3.6 Sonar

During the scoping process for the Lake Davis Pike Eradication Project, members of the public suggested using sonar to control or eradicate pike (CDFG 2007). The U.S. Navy uses high intensity sonar to detect submarines. Sonar is also used to locate petroleum resources in the marine environment. Sound waves are emitted at a minimum of 235 decibels and can affect several hundred square miles of ocean. In water, sound travels farther and can have a substantial impact on biological receptors, such as marine mammals. Information compiled by the Natural Resources Defense Council indicates that high-intensity sonar is responsible for numerous deaths of marine mammals, mainly whales, dolphins, and porpoises. It may cause internal auditory and navigational disorders such that they become disoriented and become stranded or succumb to predators. However, the CDFG found no literature describing the direct effects of sonar on fish or its use as a fish eradication method.

2.4 HABITAT MANAGEMENT/ALTERATION

Habitat management techniques involve altering the habitat within the stream to eradicate fish populations. Because fish are dependent on dissolved oxygen, the following 2 techniques focus on depleting the oxygen in the stream to kill fish.

2.4.1 Deoxygenation Using Nitrogen or Carbon Dioxide

This type of deoxygenation includes bubbling nitrogen or carbon dioxide (CO_2) from the bottom of the stream to displace oxygen within the water column, resulting in fish suffocation. Large quantities of compressed nitrogen or CO_2 would be forced through thousands of aeration manifolds or air stones placed along the stream. The precise amount of nitrogen or CO_2 required or how well, if at all, the nitrogen and CO_2 would saturate or replace the oxygenated waters is not known.

While this methodology might work in a limited area, such as small pools, it is unlikely to be successful over a large area of moving water such as Silver King Creek. Additionally, this methodology has no record of laboratory or field application, would not necessarily kill all unwanted species, and could affect non-target species, such as invertebrates and amphibians.

2.4.2 Deoxygenation through Nutrient Loading

This deoxygenation technique would increase the nutrient load in the stream by adding highly decomposable materials to the water such as corn syrup, molasses, fertilizer, or methanol. The biological oxygen demand resulting from the bacteriological breakdown of the nutrients depletes the available oxygen to lethal levels. The method has not been laboratory- or field-tested for use as a technique to eradicate fish, and thus, questions remain regarding its efficacy. These materials are not approved for use as a piscicide in California and may violate the Clean Water Act and/or Water Board regulations. In addition, the associated aesthetic, ecological, and water quality impacts would be significant.

2.5 TREATMENT OF A SMALLER AREA

Treating a smaller area is not a fish removal technology but rather a potential action alternative that could be considered in the EIS/EIR to comply with the CEQA guidelines. The concept of a smaller action could involve two approaches: 1) breaking the treatment area up into smaller treatment areas, or 2) establishing a smaller treatment area.

2.5.1 Smaller Treatment Areas

This approach would involve treating smaller portions of the proposed treatment area, with the ultimate goal of treating the entire area. Treatment of smaller areas would increase the potential effectiveness of methods such as electrofishing. Alternative 3 (Combined Physical Removal) utilizes this approach by dividing the treatment area into subreachs, which would be electrofished separately. Some benefit may be achieved by adopting this approach for Alternative 3, with the caveat that all reaches would need to be electrofished in one season, and barriers would be removed annually.

Chemical treatment of a smaller area would require a smaller amount of chemicals for the separate reaches, but would require the same amount, or more, by the time the entire treatment area was treated. No benefit would be realized by breaking up the treatment area for the purposes of chemical application. Unless all segments were treated within one season, barriers would need to be constructed to last over winter, with the consequent logistical and environmental issues discussed above and in the gill-netting section. Since no benefits would accrue using this approach, it is not evaluated in detail in the EIS/EIR.

2.5.2 Establish a Smaller Project Area

This would restore Paiute cutthroat trout to a smaller area of their historic range, between Tamarack Falls and Silver King Canyon, such as a segment of Silver King Creek or some or parts of the tributaries. Such an action would not meet one of the primary objectives of the Revised Recovery Plan to restore Paiute cutthroat trout to its historic range. Moreover, because fish can now move freely between these 2 natural barriers (Tamarack Falls and Silver King Canyon), a smaller treatment area would require the construction and maintenance of artificial barriers above Silver King Canyon to prevent the upstream movement of undesirable trout. Barriers that could withstand high spring and winter flows would require use of heavy equipment and construction of a large dam. The option would require a large workforce with the consequent logistical issues and large amounts of heavy equipment. Construction would disturb the streambed and bank areas and could result in permanent geomorphologic changes to Silver King Creek. The option is essentially infeasible and does not meet the objectives of the proposed Action and is not evaluated further in the EIS/EIR.

2.6 CHEMICAL APPLICATION COMBINED WITH OTHER APPROACHES

This section addresses potential combinations of chemical treatment with other technologies and chemical treatment with non-motorized equipment to facilitate fish removal in Silver King Creek. Several combined approaches have been considered in the past, including electrofishing combined with rotenone application. Evaluating combined approaches responds to comments received from the Water Board on the NEPA Notice of Intent. The Water Board encouraged the consideration of combinations of technologies that would limit the amount of chemical applied.

2.6.1 Dewatering with Rotenone Application

This option would entail dewatering Silver King Creek and applying rotenone. Dewatering would involve damming Silver King Creek and diverting or bypassing its flows or sequentially dewatering individual stream reaches (see Dewatering). Water remaining in residual stream pools would be treated with rotenone. Because upstream flows would be diminished or eliminated, treatment would require less rotenone. Rotenone would be applied to selected reaches along stream banks in Lower Fish Valley and Long Valley due to the complexity of riparian vegetation and springs.

While reducing the amount of chemical applied to the environment, this combination of treatments would present significant technical and logistical challenges and would result in considerable adverse environmental effects from dam and pipeline construction as well as the rotenone treatment. It would require placing a diversion or check dam just upstream of Llewellyn Falls, as well as at other locations, depending on the selected approach.

One option would involve constructing a dam near Llewellyn Falls to treat the entire 11-mile treatment area. The check dam would prevent water from spilling over Llewellyn Falls and the water would cause flooding of Upper Fish Valley. Pumps and piping would be used to pump out residual pools. The dam could be constructed with a spillway to allow a slower rate of flow but enough to disperse the rotenone as the dispensed chemical flows downstream.

This alternative would present significant technical and logistical challenges. It would require transporting a large quantity of sandbags, pumps, and piping into the project area as well as a substantial work force to build the dam, string the piping, and operate the pumps. The large stream flows would make construction of the dam very challenging.

A potential variation could involve sequentially dewatering and treating shorter stream reaches. Individual reaches would be blocked off from upstream flows, pumped out to the extent feasible, and treated with rotenone. The dams would be removed sequentially and moved downstream in a “leapfrog” fashion, ensuring that no fish move upstream. This option would present the same technical and logistical challenges as described above and would result in significant environmental impacts; thus, it is not evaluated further in the EIS/EIR.

2.6.2 Physical Removal / Fisheries Management Followed by Rotenone Application

Under this option, physical removal and fisheries management just prior to rotenone application would remove part of the fish population. Because rotenone alone is likely to achieve complete removal of fish, using physical removal methods such as electrofishing, netting and angling prior to treatment would not appreciably improve the effectiveness of the action. Physical removal programs may be useful in garnering public support and attention for the action. For example, recreational fishing organizations could hold a fishing derby. Allowing the public to gather fish for consumption could be an effective option, although current fish stocking restrictions would prohibit the transport of live fish for restocking elsewhere. Partnering with knowledgeable organizations, such as Trout Unlimited, could reduce the chance of an accidental introduction upstream of Llewellyn Falls. For the strict purpose of removing undesirable fish, physical removal followed by rotenone treatment would not be a cost-effective combination of methods for eradicating fish from Silver King Creek.

2.6.3 Dewatering Followed by Physical Removal/Fisheries Management and Rotenone Application

This option would use dewatering to increase the effectiveness of subsequent physical removal (e.g. electrofishing, fishing derbies) and rotenone treatment. Dewatering would involve damming Silver King Creek and diverting or bypassing its flows or using sequential dewatering of stream reaches (see Dewatering). Dewatering would reduce stream flows, would increase the effectiveness of methods such as electrofishing, and would allow remaining water in residual stream pools to be effectively treated with a reduced quantity of rotenone. While reducing the amount of chemical applied to the environment, this combination of treatments would present significant technical and logistical challenges and would result in environmental effects from diversion dam construction, pipeline construction, pumping, electrofishing, and rotenone treatment. It would have the added public relations benefit of using fishing to remove part of the population. There would not, however, be a significant difference in fish removal effectiveness between rotenone application alone and rotenone application preceded by dewatering, electrofishing, and angling.

2.6.4 Chemical Treatment with Non-motorized Equipment

Under this option rotenone at Tamarack Lake would be administered by hand pump and the potassium permanganate at the neutralization station would be administered via drip system. This option could result in increased human exposure to rotenone and potassium permanganate and increased potential for water quality degradation. The treatment of Tamarack Lake would also be logistically infeasible (time consuming and costly) using a non-motorized raft and equipment.

2.7 COMBINED NON-CHEMICAL OPTIONS

This section addresses potential combinations of technologies for fish removal other than chemical application. Considering combined non-chemical approaches responds to comments received on the prior USFS Environmental Assessment (2003) and on the June 2006 NEPA Notice of Intent published by the USFWS (2006).

2.7.1 Electrofishing and Gill Netting

A combination of electrofishing and gill netting could be used to remove the undesirable species. Gill nets would be used in deep pools and in Tamarack Lake where electrofishing would not be feasible. Environmental impacts would result from shuttling workers and supplies and transplanting fish (if implemented). The feasibility of removing fish in a single season is highly unlikely. As described above, removals over several successive years (approximately 10 years) would be required and could still be compromised or confounded by fish movements.

2.7.2 Dewatering and Physical Removal Techniques

This option would entail complete or partial dewatering of Silver King Creek to enhance subsequent physical removal using electrofishing and other seining and netting methods. A combination of electrofishing and gill netting would be used to remove undesirable species, using gill nets in deep pools where electrofishing would not be feasible. Reducing or eliminating upstream flows would reduce the area and depths to be electrofished, making that technique easier to implement and more effective, and might allow the effort to be completed within 1 to 3 years. However, as described above, complete removal of fish from the treatment area would likely require treatment for several consecutive years, each with a similar level of effort. Impacts associated with check dam and pipeline construction and stream dewatering by pumping would occur as described above (see Dewatering and Pumping Out Residual Water above), as would those associated with the constant shuttling of workers and equipment into the treatment area.

2.7.3 Genetic Swamping and Physical Removal Techniques

Under this scenario, a combination of electrofishing and gill netting would be used to remove as large a portion of undesirable fish as possible from Silver King Creek and its tributaries, followed by stocking large quantities of genetically pure fish in the area. By reducing the number of undesirable fish, the "swamping" effect of restocked Paiute cutthroat trout would be greater. Some hybridization would still occur, however, since the electrofishing and gill netting would not remove all of the undesirable fish. The degree of this hybridization would depend on the number of undesirable fish remaining and the number of pure Paiute cutthroat trout stocked. Because this option would not completely remove the genetic introgression, it would not be consistent with the Revised Recovery Plan and would not accomplish the objective of the proposed Action.

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CHAPTER 3

Screening and Selection of Technologies

This section describes the evaluation and screening process and describes which technologies were eliminated and which technologies or combinations of strategies were retained for potential inclusion in the alternatives in the EIS/EIR.

3.1 SCREENING PROCESS AND CRITERIA

The technologies and management options identified were evaluated using a two-phased assessment and screening approach. First, the options were reviewed to determine if they would likely be effective in accomplishing the objective of eradicating introduced fish species from the treatment area while complying with current laws and regulations. For example, any chemical agent, such as a piscicide, must be legally permitted for use in California and registered with the USEPA and the CDPR. These agencies evaluate the effectiveness of chemical agents and examine human health and safety issues. If the technology did not meet these criteria, the Agencies eliminated the option from further consideration.

If a potential technology met the objective of successful fish removal and complied with current laws and regulations, the Agencies advanced the technology to the next phase and evaluated with a second set of criteria. These criteria included protection of public health and safety; timely implementation; use of a proven, effective method; technical feasibility; minimization of environmental impacts, compatibility with rules governing designated wilderness areas; and cost-effectiveness. Using these criteria, the remaining options were ranked and used to select the proposed action as well as a reasonable range of alternatives to the proposed action for consideration in the EIS/EIR. If a technology warranted further consideration as the potential basis for a comparative alternative in the EIS/EIR, potentially in combination with other strategies, it was retained.

3.1.1 Public Health and Safety

The public heath and safety criterion addresses the safety of the public and the workers implementing the project. Protection of public health includes consideration of potential impacts to air quality, drinking water, and other exposure pathways through which people could be exposed to hazards. Any proposal to use a chemical agent would require approval of the intended use and measures to protect public health. Options that posed substantial risks to public health and safety were eliminated from further consideration.

3.1.2 Speed of Implementation

Because stochastic events or rogue introduction of non-native trout could threaten pure populations of Paiute cutthroat trout, USFWS and CDFG believe time is of the essence and has identified a 3-year schedule to remove non-native trout from Paiute cutthroat trout native habitat.

3.1.3 Proven Effective in the Laboratory and Field

The method must be proven by laboratory and field tests and be a known effective method of removing non-native salmonids in a stream environment. Because the survival of a species is at stake, any new or experimental methods were screened out. Using a method with demonstrated effectiveness dramatically increases the chance of success.

3.1.4 Technically Feasible to Implement

The technology must be technically and logistically feasible to implement. For example, it must not require a prohibitive amount of equipment or number of workers such that it would be possible to implement in a remote area.

To make accurate determinations regarding technical feasibility, site-specific data and reports regarding the habitat types present, stream dimensions, water temperature, and fish densities. Reports included cross-section surveys (CDFG 2004), unpublished data collected during fish surveys in August of 2000, and habitat assessments completed for Upper Fish Valley, Coyote Valley Creek, and Corral Valley Creek (O'Brien 1998, 1999, 2002).

3.1.5 Allowed in a Designated Wilderness

Silver King Creek lies within a designated wilderness. There are numerous restrictions on activities and equipment that can be used in wilderness areas. For example, wilderness areas restrict motor vehicles, mechanical transport, and motorized equipment. These activities would require a special use permit.

3.1.6 Potential for Environmental Impacts

The method should minimize significant adverse environmental impacts that cannot be mitigated to reduce their significance. Such impacts may include damage to archaeological resources, biological resources, or water resources, or significant noise or air quality impacts inconsistent with adjacent land uses (i.e., wilderness). This objective was not used by itself to eliminate potential technologies or management options. The EIS/EIR would analyze potential environmental impacts to determine their significance, compare the environmental consequences of the alternatives, and identify mitigation measures.

3.1.7 Cost-Effectiveness

While cost alone was not used to screen out any technology or strategy, overall cost and effectiveness was used as a balancing criterion in comparing options that were approximately equal in effectiveness or environmental impact.

3.2 TECHNOLOGY SCREENING

The following information describes the screening of the technologies and management options. The results of this evaluation are described below.

The following technologies were eliminated in Phase I because the agencies determined they would not be effective in eradicating fish from Silver King Creek or did not comply with current laws and regulations:

- Powdered rotenone was removed from further consideration based on its limited effectiveness in moving water and worker safety considerations.
- Chlorine, chloramines, copper sulfate, and antimycin were removed because they are not registered pesticides, and their use would not comply with current laws and regulations.
- Most fisheries management techniques (introduction of predatory fish, explosives, and sonar) were removed because they were not expected to achieve complete removal of introduced fish in a stream environment. Introducing a highly predatory fish to Silver King Creek was not seriously considered because it would only worsen the existing situation with non-native species. Sonar is not sufficiently developed as a fish removal technique.
- The habitat alteration options (nitrogen, CO_2, oxygen depletion) were eliminated because they are unproven and considered unlikely to be effective, particularly in moving water.
- Because of physical and logistical limitations, treatment of a smaller treatment area was removed from consideration and will not be evaluated in detail in the EIS/EIR. However, dividing the proposed treatment area into smaller treatment areas (with the goal of treating the entire area) was retained for Alternative 3 (Combined Physical Removal).
- The non-chemical combinations of strategies of dewatering followed by physical removal, and physical removal followed by genetic swamping were eliminated because they would not achieve complete removal of undesirable fish and were not consistent with the Paiute cutthroat trout Revised Recovery Plan.
- Chemical application combined with other approaches involving dewatering (e.g., diverting stream flows to an adjacent watershed), physical removal, or fisheries management (fish-out) and chemical treatment involving the use of non-motorized equipment (i.e., a hand pump) were removed from consideration because of the major technical and logistical challenges involved as well as environmental impacts. Because rotenone application would likely achieve complete removal of undesirable fish in 1 or 2 years, the options of combining rotenone treatment with dewatering, physical removal, and/or a fish-out approach would not increase removal effectiveness and thus were not included for detailed evaluation in the EIS/EIR.

The Agencies retained the following technologies and combinations of strategies as potentially effective in eradicating fish from Silver King Creek and allowed under current laws and regulations:

- Rotenone application (standard or new formulation).
- Combination of physical removal techniques, including electrofishing, gill netting, seining, and trapping.

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CHAPTER 4

Alternatives Formulation

Based on the screening-level assessment presented above, three options were selected for further evaluation as potential alternatives in the EIS/EIR. This section uses those retained options to outline the proposed Action and alternatives. The following paragraphs describe the alternatives that the Agencies will evaluate in detail in the EIS/EIR.

4.1 PROPOSED ALTERNATIVES FOR THE EIS/EIR

4.1.1 No Action Alternative

Both NEPA and CEQA require consideration of the No Action alternative. This option includes continuing the current stream and fishery management practices into the foreseeable future. Under the No Action alternative, the USFWS would not implement its Paiute cutthroat trout Revised Recovery Plan. No eradication of non-native, hybridized trout or reintroduction of Paiute cutthroat trout, below Llewellyn Falls would be implemented. Paiute cutthroat trout would not be reintroduced to its historic habitat and its ESA status of threatened would likely remain unchanged. Therefore, this alternative would include continued protection of pure Paiute cutthroat trout, populations in the Silver King Creek Watershed as well as out-of-basin populations.

4.1.2 Proposed Action (Rotenone Treatment)

The proposed Project includes varied methods of chemical application, such as the use of CFT Legumine™, Noxfish® and/or Nusyn-Noxfish®. Mini-drips and gel or sand matrices may be used on small seeps that may provide a refugia source of fresh water from treated waters. To eliminate the toxic effects of rotenone downstream of the treatment area, potassium permanganate would be administered using generator-powered volumetric augers at a downstream detoxification station. Potassium permanganate is a powerful oxidizing chemical that quickly renders rotenone harmless to aquatic organisms. The in-stream application of potassium permanganate below Silver King Canyon would ensure that no adverse effects of rotenone are experienced downstream of the treatment area. After 2o to 3 years of treatment, Paiute cutthroat trout restocking and repopulation would begin.

4.1.3 Combined Physical Removal Alternative

This report identified individual physical removal techniques as well as combinations of methods as appropriate. Because none of the techniques described would be likely to achieve complete removal as stand-alone methods, the EIS/EIR will include, as a non-chemical alternative, a combination of electrofishing, gill netting, seining, and other physical methods to address Silver

King Creek and its tributaries, springs, and Tamarack Lake. The Combined Physical Removal Alternative would not employ chemical treatment or dewatering. Because this method could have low efficiency in a rocky stream environment, it would be implemented over multiple years until fish are no longer found (approximately 10 years).

An intensive multiyear removal effort may eradicate undesirable species but not within the scheduled 3-year period anticipated under the proposed Action. Manual removal efforts, however, are not effective in capturing small fish and could be confounded by trout moving into the treatment area from untreated upstream areas.

4.2 SUMMARY

In addition to the proposed Action of rotenone application, the alternatives proposed for the EIS/EIR include No Action and Combined Physical Removal, an alternative that would be strictly limited to physical removal techniques (i.e., non-chemical alternative).

Although considered in detail as a second non-chemical option, dewatering was not selected as an alternative for detailed evaluation in the EIS/EIR, either as a stand-alone alternative or in combination with other technologies. Constructing check dams, stringing pipeline, and pumping out residual pools may be technically feasible if sufficient resources were mobilized; however, this approach would present significant technical, institutional, regulatory and economic challenges and would result in great damage to the wilderness area.

Also, at the discretion of the California Fish and Game Commission, any of the action alternatives listed above could be followed by re-opening Silver King Creek to recreational fishing following the fish eradication and restocking with pure Paiute cutthroat trout. Because Paiute cutthroat trout are a threatened species, this would be a catch-and-release fishery. The Agencies would couple any return to the previous policy of recreational fishing in the area with public education regarding protected status of Paiute cutthroat trout and the threat to the survival of the species that could result from illicit fish transfer.

CHAPTER 5

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APPENDIX C

Screening-Level Ecological and Human Health Risk Assessment

SILVER KING CREEK
PAIUTE CUTTHROAT TROUT RESTORATION PROJECT

Health Risk Assessment for the Proposed Application of Rotenone

MARCH 2009

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C.1 SUMMARY

This screening-level assessment examines the ecological risks potentially associated with the proposed use of rotenone to eradicate non-native trout throughout an 11-mile reach of Silver King Creek and its tributaries in Alpine County, California. Chapter 3.0, Project Alternatives, of the EIS/EIR provides a detailed description of the study area. This assessment uses standard ecological risk assessment guidance and protocols (USEPA 1998, ASTM 1997, Cal/EPA 1992) and follows four steps or phases including:

- Problem formulation;
- Hazard assessment;
- Exposure assessment; and
- Risk characterization.

This screening-level assessment examines only the potential toxicological impacts on ecological receptors at Silver King Creek from the use of rotenone formulations. The accompanying EIS/EIR addresses other treatment alternatives and other potential environmental impacts, such as noise, recreation, economic impacts, and other analyses required by NEPA and CEQA. The findings of this assessment are integrated into Chapter 5.0, Environmental Consequences, of the EIS/EIR as they relate to potential impacts on aquatic and terrestrial biological resources, water quality, and human exposure.

For a “screening-level” assessment, no site-specific data or in-situ toxicity tests are conducted on site receptors. Rather, risks are characterized based on modeled doses and comparison with literature values. Specifically, risks were evaluated by estimating chemical uptake (i.e., dose) in ecological receptor populations from the maximum estimated exposure point concentrations of rotenone formulation constituents expected from each complete exposure pathway. These estimated doses were then compared to published toxicity reference values (TRV) from the literature for each significant formulation constituent. These comparisons were used to predict whether the formulation constituents would pose a hazard to the receptor populations.

Screening-level evaluations are designed to be conservative estimations of hazard that overestimate potential exposures and associated risks. This approach is consistent with regulatory guidance for risk assessment which emphasizes providing agency managers with information for protecting the environment. Because this screening-level assessment uses a conservative approach, actual exposures and risks would likely be lower than those presented below. The Agencies propose to continue monitoring after the proposed treatment to assess effects on ecological receptors and the effectiveness of mitigation measures presented in the EIS/EIR and to initiate adaptive management actions to reduce residual effects to acceptable levels.

C.2 PROBLEM FORMULATION

Problem formulation is the process of defining the goals, objectives, hypotheses and methods for evaluating ecological effects are developed (USEPA 1998). This requires development of (1) risk assessment endpoints that adequately reflect management goals within the ecosystem under study, (2) conceptual site models that illustrate the key relationships between a “stressor” (i.e., the chemical(s) of potential concern) and the pathways through which selected ecological receptors in the study area could be exposed, and (3) the analysis plan (i.e., methods) by which effects from the stressor(s) will be examined. To initiate the process, risk assessors review existing information from the treatment area to scope the problem or question to be addressed, identify the receptors and potentially important exposure pathways, and develop an approach for assessing exposure risks.

C.2.1 Scope of Problem and Objective

The Paiute cutthroat trout is 1 of the 4 minor subspecies derived from the Lahontan cutthroat trout. The Paiute cutthroat trout was reclassified as threatened under the Endangered Species Act (ESA) of 1973 (USFWS 1975) to facilitate management and allow regulated angling. Although a number of transplant populations have been established outside of the Silver King Creek Watershed, it currently occupies approximately 18.6 kilometers (11.5 miles) of historically fishless stream habitat within the upper Silver King drainage, above Llewellyn Falls (USFWS 2004). The entire historic range of Paiute cutthroat trout within Silver King Creek between Llewellyn Falls and Silver King Canyon (a total of 11 miles of mainstem and tributary habitat) is occupied by non-native trout (i.e., rainbow trout, Lahontan trout and golden trout) which also pose a threat to occupied habitat above Llewellyn Falls should non-natives move into that habitat.

Hybridization with non-native trout is the primary threat to the Paiute cutthroat trout (USFWS 2004). The fish present in reaches downstream from Llewellyn Falls to Silver King Canyon are a genetic mixture of introduced rainbow, Lahontan cutthroat, golden trout, and native Paiute cutthroat trout. When associated with Lahontan cutthroat trout or rainbow trout, Paiute cutthroat trout tend to lose their distinctiveness through hybridization (USFWS 1985). Llewellyn Falls (a complete barrier to upstream migration) currently separates hybridized trout and Paiute cutthroat trout. Llewellyn Falls is easily accessed by the public, which could lead to rogue or inadvertent transfer of hybridized fish to areas above the falls. Should this occur, they would hybridize with Paiute cutthroat trout and pose a significant threat to the survival of the species.

Repatriating Paiute cutthroat trout into their historic range would isolate Paiute cutthroat trout from other trout species and greatly reduce the likelihood of an illegal introduction. There are 6 potential fish barriers in the Silver King Canyon, the 2 highest being 8 feet and 10 feet. The objective of the proposed Action is to remove all non-native trout from the Paiute cutthroat trout’s historical native range. Once accomplished, the Agencies would restock the treatment area with Paiute cutthroat trout from genetically pure populations within the watershed.

C.2.2 Historical Efforts to Restore Paiute Cutthroat Trout

Since 1964, the Agencies have made multiple efforts to restore Paiute cutthroat trout populations to Silver King Creek and its tributaries. Initial chemical treatments were conducted on upper Silver King Creek, Corral Valley Creek, and Coyote Valley Creek during 1964. A repeated chemical treatment was conducted in upper Silver King Creek, Coyote Valley and Corral Valley Creeks during 1976 and 1977 to remove hybridized trout. Electrofishing surveys following the 1977 treatment were conducted to remove surviving hybridized trout; however, these efforts showed that the initial chemical treatments of Coyote Valley Creek had failed. A repeat treatment during 1987 and 1988 appeared successful as no hybridized trout have been observed during subsequent electrofishing surveys. These results were reconfirmed by allozyme and nuclear DNA analysis of tissue samples from all populations (Israel et al. 2002).

Subsequent efforts to restore pure Paiute cutthroat trout populations above Llewellyn Falls appear to have been successful following multiple chemical treatments between 1991 and 1993, combined with removal of non-native hybridized trout using electrofishing. The 3-year chemical treatment project successfully removed non-native hybrid trout from Silver King Creek in Upper Fish Valley upstream of Llewellyn Falls. Paiute cutthroat trout populations in Fly Valley Creek have remained isolated by a barrier falls and have never been treated. Additionally, hybridized trout were removed from Four Mile Canyon Creek by electrofishing and chemical treatment during 1991 through 1993. The upper headwater areas in Silver King Creek, Fly Valley Creek, and Four Mile Canyon Creek, have never been treated with rotenone.

Prior to CDFG's successful fish removal efforts in 1991–1993 in Silver King Creek above Llewellyn Falls, hybridized trout were removed from the creek and introduced into Tamarack Lake, a presumed fishless lake. Tamarack Lake's outlet flows into Silver King Creek within the proposed treatment area. Since the introductions, Tamarack Lake was gill netted during 2001–2008, and no fish were captured or observed. This lake was last stocked during 1991, but there is spawning habitat in a small stream entering the lake (Somer, pers. comm. 2003). This potential source of fish may require rotenone treatment to ensure that there is no downstream movement of hybridized fish into the treatment area. However, if further gill netting surveys of Tamarack Lake do not indicate the presence of hybridized trout, the Agencies would not implement this component of the proposed Action.

C.2.3 Overview of Proposed Action and Alternatives

The Agencies have considered a variety of options to remove non-native hybridized trout from Silver King Creek. After completion of the alternatives screening analysis, the Agencies selected the proposed Action and another action alternative. Chapter 3.0, Project Alternatives, of the EIS/EIR presents a detailed description of these alternatives, including the No Action alternative. This appendix evaluates only the potential ecological effects of rotenone and neutralizing agents. The Agencies selected the proposed Action to meet the following objectives:

- be completed quickly,
- use a method that has been proven to be effective in laboratory and field experiments,
- use a method that is technically feasible to implement,
- be in compliance with applicable laws,
- be implemented in a manner that, protects public health and safety, and
- minimize environmental impacts during and after application.

As described in detail in Chapter 3.0, Project Alternatives, of the EIS/EIR, each rotenone treatment alternative would require neutralization with potassium permanganate ($KMnO_4$). The Agencies propose to use a rotenone application of CFT Legumine™, Noxfish® or Nusyn-Noxfish® at a concentration up to 1.0 milligrams per liter (mg/L). The concentration of potassium permanganate (the oxidizing agent) shall be applied to Silver King Creek downstream of the study area at a concentration up to 2 to 4 mg/L in the receiving waters. This step would neutralize the rotenone and prevent the effects of rotenone in downstream areas. Potential impacts/risks from neutralization with $KMnO_4$ are assessed below.

C.2.4 Project Area and Land Use

C.2.4.1 Project Area Location

The Silver King Creek drainage is located on the eastern slope of the Sierra Nevada Range, in Alpine County, California. The drainage is a tributary of the East Fork of the Carson River, which drains into the Lahontan Basin. The proposed treatment area occurs within the Carson-Iceberg Wilderness on National Forest System lands administered by the Carson Ranger District, Humboldt-Toiyabe National Forest.

The treatment area includes the area that would be affected directly by the proposed rotenone treatment of CFT Legumine™, Noxfish® or Nusyn-Noxfish® at a concentration up to 1.0 mg/L and neutralization with potassium permanganate at a concentration up to 2 to 4 mg/L. This area includes Silver King Creek, its tributaries, springs and possibly Tamarack Lake., depending on the results of gill netting surveys. Specifically, the treatment area includes the reach of Silver King Creek between Llewellyn Falls as the upstream boundary and the confluence with Snodgrass Creek at Silver King Canyon as the downstream boundary.

C.2.4.2 Land and Water Use in Project Area

The Carson-Iceberg Wilderness, within which the treatment area is located, grants permits for only certain activities, including hiking, fishing, and hunting. The USFS permitted grazing until 1995 when the grazing permit ended.

The Basin Plan defines the beneficial uses of Silver King Creek to include Municipal and Domestic Supply, Agricultural Supply; Groundwater Recharge; Water Contact Recreation; Non-contact Recreation; Commercial and Sport Fishing; Cold Freshwater Habitat; Wildlife Habitat; Rare, Threatened or Endangered Species; and Spawning, Reproduction, and Development.

C.2.5 Management Goals and Assessment Endpoints for Estimating Risk

C.2.5.1 Ecological Health

The Agencies' management goal for the proposed Action is to eradicate introduced species and reintroduce Paiute cutthroat trout to its native range while protecting the environment and non-target receptor populations from potentially adverse effects of the proposed rotenone application. This is consistent with the regulatory goals of the federal Toxic Substances Control Act (TSCA §2[b][1], Clean Water Act (304(a)CWA), and the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). It is also consistent with CDFG management goals as outlined in California Fish and Game Code Sections 1700 and 5501. The ecological goal or "assessment endpoint" for this exposure evaluation therefore is the continued existence of ecological receptor populations.

C.2.5.2 Human Health

The management goal for the human health assessment is to protect human populations from harmful exposure to rotenone formulation constituents during the proposed treatment by complying with all applicable and relevant regulatory standards, label use requirements, and site safety and health plan specifications. The human health risk assessment does not address potential worker exposure during chemical application. Worker exposure would be addressed by using protective equipment, following label use restrictions, and complying with a project-specific health and safety plan.

Human exposures to rotenone would be reduced by the following factors:

- The treatment area is located within a wilderness area (Carson-Iceberg Wilderness) located approximately 19 stream miles (or 10 air miles) from the nearest downstream human population in Markleeville, California.
- The rotenone would be neutralized chemically at the downstream end of the treatment area using potassium permanganate.
- Rotenone and its associated inert ingredients degrade rapidly in the environment.

In addition, the Agencies would (1) prevent the human consumption of fish killed by the rotenone treatment, (2) prevent the use of the treated water for irrigation purposes, and (3) prevent the release of the treated waters within one-half mile of a drinking water and/or irrigation water intake. Because the proposed Action is within a wilderness area located approximately 19 stream miles from the nearest downstream human population in Markleeville, California, this assessment assumes these goals would be satisfied.

C.2.6 Ecological Conceptual Model and Risk Hypothesis

The conceptual site model (CSM) represents the potentially complete ecological exposure pathways. It outlines: (1) all potential sources of chemical exposure; (2) chemical transport and release mechanisms; and (3) potential exposure pathways, including receptors.

Based on the description of the proposed Action and alternatives, the primary chemical exposure source would be the intentional release of rotenone formulations into Silver King Creek. Rotenone would be released at the upstream end of the study area and sprayed along the edge of the creek and tributary streams. Once released, the primary transport and release mechanisms would include:

- dissolution into surface water,
- adsorption onto sediments, and
- adsorption onto aquatic and riparian vegetation.

Thus, the “exposure points” through which non-target ecological receptors could be exposed to rotenone and its constituents would include: (1) treated surface water, (2) vegetation, (3) sediment contact and/or ingestion, (4) groundwater (drinking water), and (5) food chain bioaccumulation from consumption of dead fish. Based on these release and exposure mechanisms, risks to aquatic and terrestrial receptors are potentially significant, and the null and alternative hypotheses for this screening-level assessment follow:

- **Ho:** rotenone application from 0.5 mg-formulation/L rotenone-receiving water up to 1.0 mg-formulation/L rotenone-receiving water will result in significant exposure of non-target aquatic and terrestrial biota.
- **Ha:** rotenone application at up to 0.5 mg-formulation/L rotenone-receiving water up to 1.0 mg-formulation/L rotenone-receiving water will not result in significant exposure of non-target aquatic and terrestrial biota.

C.2.6.1 Potential Ecological Receptors

This section summarizes the species that occur within the treatment area (also see Chapter 5.0, Environmental Consequences, of the EIS/EIR). Silver King Creek flows through a narrow valley that represents a mosaic of high elevation (7,000 to 8,000 feet) forest, upland brush communities, and a mix of riparian communities including aspen, willow, and wet meadow habitats. These habitats support a variety of wildlife, including special status species. Although few data specific to the treatment area are available, wildlife observations have been documented for the larger Humboldt-Toyabe National Forest. Species that could inhabit the treatment area include over 13 species of birds, 7 mammals, 1 reptile, and 2 amphibians (see EIS/EIR Section 5.2, Terrestrial Biological Resources). These include Forest Service Management Indicator Species (MIS), Forest Sensitive Species (FSS), and federally-listed species. Potential amphibians and reptiles include Mountain yellow-legged frog (*Rana muscosa*), Yosemite toad (*Bufo canorus*), and northern sagebrush lizard (*Sceloporus graciosus graciosus*). Potential mammal species include bats (*Myotis, Euderma* and *Eumops* spp.), wolverine (*Gulo gulo luteus*), fisher (*Martes pennanti pacifica*), and Sierra Nevada red fox (*Vulpes vulpes necator*). Potential bird species include the Bald eagle (*Haliaeetus leucocephalus*), owls, (*Otus* and *Strix* spp.), Mountain quail (*Oreortyx pictus*) and the White-headed woodpecker (*Picoides albolarvatus*).

In addition to Paiute cutthroat trout, special status (federal, State, USFS, or Calfed conservation strategy) species that could occur in the treatment area include:

- Mountain yellow-legged frog (*Rana muscosa*) (Sierra Nevada distinct population segment (DPS), candidate
- Yosemite Toad (*Bufo canorus*), candidate
- Fisher (*Martes pennanti*) (West Coast DPS), candidate
- Wolverine (*Gulo gulo luteus*), CA state threatened
- Bald eagle (*Haliaeetus leucocephalus*), CA state threatened

Fish species include Paiute cutthroat trout, Lahontan cutthroat trout, golden trout, rainbow trout and hybrids. An extensive list of benthic macroinvertebrates includes stoneflies, mayflies, beetles, and caddisflies. The study area supports no known special-status aquatic invertebrate species.

Chapter 5.2 of the EIS/EIR, Terrestrial Biological Resources, summarizes the plant communities in the treatment area, which include riparian, wetland, upland, and scrub-shrub mosaic of habitats found in the northern Sierra Nevada. USEPA recently concluded during registration of rotenone that plants are not sensitive to rotenone or its formulation constituents (USEPA 2006).

The exposure assessment below focuses on surrogate species selected to represent groups of similar species or guilds. Guilds are species groups with similar life histories or niches (e.g. insectivorous birds). Surrogate species within guilds were used to estimate exposure rather than estimating exposure for each individual species. The risk calculations for a single surrogate for which reliable life history information is available and whose exposure parameters represent a conservative estimate of exposure, can be extrapolated to the entire guild. The guild that includes western toad, for example, may also include special status species such as Yosemite toad.

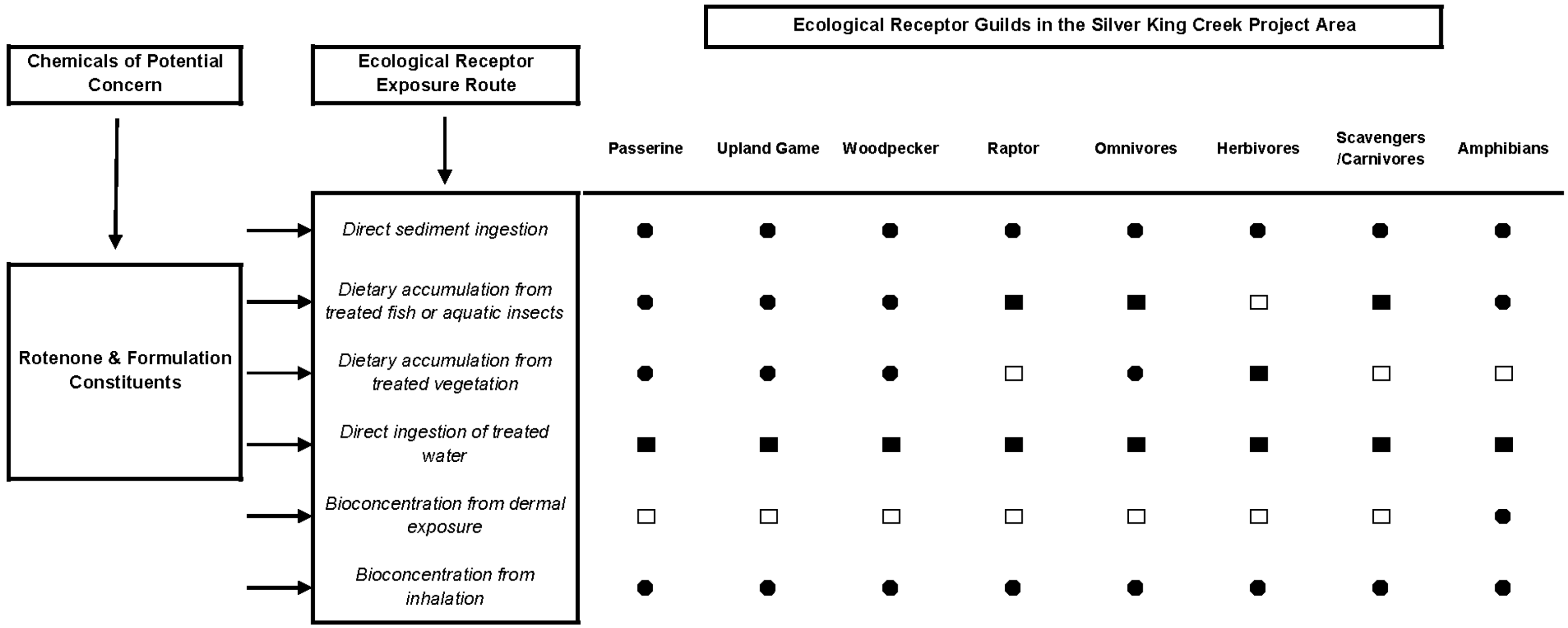
Figure C-1 presents a conceptual model for the ecological exposures that could result from the proposed Action and represents the relevant receptor guilds for Silver King Creek. Several of these are special status species as summarized in Chapter 5.0 of the EIS/EIR, Environmental Consequences. Complete exposure pathways are identified based on the receptor's habitat, life history, and association with the treatment area. Exposure pathways include ingestion, dermal contact, and inhalation routes. When fisheries managers use rotenone as a piscicide, it is applied directly to the water body - in this case Silver King Creek and its tributaries. Once applied to the water, exposures would result for non-target receptors—essentially all aquatic non-fish organisms resident to the treated waters. Fish and other aquatic receptors would likely be exposed directly and receive the highest exposure. Exposures of terrestrial receptors, such as birds and mammals, would likely be through less direct pathways and thus insensitive to rotenone compared to aquatic receptors (Ling 2003).

Figure C-1 reflects the differences in exposure pathways between the selected receptors. Closed squares indicate complete exposure pathways. Open squares indicate incomplete exposure pathways. Closed circles represent potentially complete exposure pathways but for which exposure is likely insignificant. Direct contact exposure with the treated water is a complete pathway for all aquatic organisms as well as amphibians and reptiles. The route of uptake is direct contact and bioconcentration from the water.

Exposure of terrestrial biota through dermal contact is likely complete but insignificant because of skin barriers and minimal direct skin contact that would occur during the short treatment period (<24 hours). Similarly, inhalation exposure is complete but likely insignificant because exposure would be infrequent and of short duration. Ingestion of water and food would be a complete exposure pathway for terrestrial biota.

C.2.6.2 Potential Human Receptor Populations

The proposed treatment area is within the Carson-Iceberg Wilderness on federal lands administered by the USFS, Humboldt-Toiyabe National Forest. No residences or businesses occur within the treatment area. The nearest populated area downstream of this area is Markleeville, approximately 10 miles from the neutralization station. Coleville, California, is located in Mono County approximately 5 miles from the northeastern corner of the treatment area. Coleville is upstream and has no direct access to the treatment area.



Ecological Receptor Exposure Route	Passerine	Upland Game	Woodpecker	Raptor	Omnivores	Herbivores	Scavengers /Carnivores	Amphibians
Direct sediment ingestion	●	●	●	●	●	●	●	●
Dietary accumulation from treated fish or aquatic insects	●	●	●	■	■	□	■	●
Dietary accumulation from treated vegetation	●	●	●	□	●	■	□	□
Direct ingestion of treated water	■	■	■	■	■	■	■	■
Bioconcentration from dermal exposure	□	□	□	□	□	□	□	●
Bioconcentration from inhalation	●	●	●	●	●	●	●	●

■ *Likely a complete pathway*
□ *Presumed incomplete pathway*
● *Potentially complete, but likely insignificant*

Figure C-1 Ecological Receptor Conceptual Site Model

Based on the treatment area's status as a wilderness area, restrictions on land use, the limited human activities permitted in the area, human presence in the treatment area is very limited. Human exposure pathways could include fish ingestion during or after the treatment period when rotenone and other contaminants were present. Although, the treatment area would not be closed to human access during the proposed Action, the greatest likelihood of human receptors would be workers applying the chemical formulations during the proposed Action. Worker exposure would be addressed in the project health and safety plan.

An unlikely but potential human exposure would be to an unauthorized visitor who could consume contaminated fish and or game during or after the treatment. However, this type of exposure would be minimized in the following ways. Fish killed during the rotenone application would be collected and buried to the extent practicable. The treatment area would not be restocked until any rotenone was dissipated. Fish would likely not be restocked until a year after the last treatment. Hence, newly stocked fish will not accumulate rotenone residues from the water. If dead fish were consumed, the primary health concern would be the acute illness associated with food poisoning, such as *Salmonella* sp. and other bacteria that could be present in fish tissue (Finlayson et al. 2000). Since the dead fish would have a strong foul odor, it is unlikely an unauthorized visitor would consume these dead fish.

Based on the remoteness of the treatment area, the distance to any downstream human population, and the controls that would be placed on human access during and for a period after the treatment, human exposure pathways are considered incomplete and human exposure is not addressed further in this assessment.

C.2.7 Ecological Risk Characterization Plan

This section outlines the specific methods employed to characterize ecological exposure of the receptors identified in the conceptual model. The methods focus on complete exposure pathways and ecological risks to receptors with potentially significant exposure to rotenone or rotenone formulation constituents.

C.2.7.1 Ecological Toxicity Risk Assessment Methods

The approach used in this ecological risk assessment follows the EPA guidance for conducting ecological risk assessments (USEPA 1998) as well as state guidance (Cal/EPA 1992). Briefly, the approach involves:

- identification of chemicals of potential concern (COPCs),
- selection of toxicity reference values (TRVs) for the COPCs,
- identification of habitats, biological communities, and biological receptors that could be exposed to the COPCs,
- identification of exposure parameters and exposure assessment methods (equations, calculations),
- estimation of exposures to COPCs, and
- comparison of estimated COPC doses to TRVs and estimation of risk.

Section C.3 of this appendix, the Hazard Assessment, identifies the COPCs and TRVs used. These values were developed based on a literature review of the substances that could be released from the rotenone treatment. Exposure parameters were based on review of species life histories and wildlife exposure parameter databases. Exposures were calculated using Equation [1].

EQUATION 1

$$\text{Daily intake} = CM * CR * FI * AF/BW$$

Where,

BW	=	Body Weight
CM	=	Concentration of contaminant in exposure media(s) of concern.
CR	=	Contact Rate—an estimate of the quantity of the medium consumed per day.
FI	=	Fractional Intake—The fraction of time (site use factor) spent in contact with the contaminated media (e.g., the proportion of the total diet obtained from the site, as extrapolated from information such as home range data or empirical findings).
AF	=	Absorption Fraction—the amount of contaminant contacted (e.g., consumed) that is actually assimilated into the receptor.

The contact rate may include the additive uptake from several exposure pathways (e.g. ingestion of prey tissue and aquatic sediments exposed to rotenone). The exposure assessment presented below (Section C.4) presents methods to account for exposure to multiple media as well as the exposure parameters used.

The Hazard Quotient (HQ) calculation characterizes the risks from the estimated exposure doses by dividing the dose by the TRV. For obligate aquatic species, risks were characterized by dividing the estimated concentration of rotenone and formulation constituents in the stream assuming complete mixing as the exposure point concentration (EPC) by effect concentrations from the literature – see Equation [2].

EQUATION 2

$$HQ_1 = EPC/TRV$$

Where:

EPC	=	Exposure Point Concentration (i.e., the concentration of contaminant in the exposure media), and
TRV	=	Toxicity Reference Value, as summarized by species in Section C.3.

The Risk Characterization, presented in section C.5 of this appendix, lists the resulting HQs by species and represents the combined consideration of the exposure and toxicity assessments.

C.3 TOXICITY ASSESSMENT

This section presents a review of the toxicological literature on rotenone and the most concentrated formulation constituents to identify the most appropriate TRVs from which to characterize ecological risks. This section also summarizes the fate, transport and persistence of the formulation constituents and qualitatively assesses the potential for longer-term environmental exposures to formulation constituents or their breakdown products.

C.3.1 Rotenone Origin, Synthesis and Uses

Rotenone ({2R,6aS,12aS}-1,2,6,6a,12,12a-hexahydro-2-isopropenyl-8,9-dimethoxychromeno[3,4-b]furo[2,3-h]chromen-6-one) is a naturally occurring flavonoid derived from the roots of tropical plants in the pea and bean family (*Leguminosae*), including jewel vine (*Derris* spp.) and lacepod (*Lonchocarpus* spp.) found in Australia, Oceania, southern Asia, and South America (Finlayson *et al.*, 2000 cited in USEPA 2006). Resins extracted from these plants' roots with ether or acetone may contain between 2 and 40% rotenone (Ray 1991). Rotenone is a non-specific botanical insecticide, acaricide, and piscicide and was historically used as a fishing method by indigenous tribes of South America and Malaysia. Roots containing the compound were ground up and the pulp applied to water bodies.

The use of rotenone as a pesticide was first patented in Britain in 1912. Today, because of rotenone's natural origin, toxicity to pest organisms, relatively low toxicity to birds and mammals, rapid detoxification in warm water, and low environmental persistence has made it a popular and effective organic pest management tool. It is used by gardeners, for lice and tick control on pets, and for fishery management (USEPA 2006). In the United States, rotenone is classified as a General Use Pesticide (GUP), although uses on cranberries and for fish control are restricted (Extoxnet 1996).

Rotenone is a naturally occurring chemical obtained from the roots of several tropical and subtropical plant species belonging to the genus *Lonchocarpus* or *Derris*. Rotenone can be extracted with chloroform and determined by ultraviolet spectroscopy or analyzed using high performance liquid chromatography (HPLC) with UV detection. Liquid formulations of rotenone may contain petroleum hydrocarbons as solvents and emulsifiers to disperse rotenone in water (naphthalene, methylnaphthalenes, xylenes, etc.) (Washington Dept. of Fish and Wildlife [WDFW] 2002). The proportion of these carriers varies substantially by formulation, and formulations with synergists generally contain far less petroleum-based carrier products. The potential effects on ecological receptors associated with the adjuvants and carriers in the proposed formulations are discussed below.

Rotenone is the active ingredient in the commercially available piscicides Chem-Fish®, Cuberol®, Fish Nox®, Noxfire®, Nusyn-Noxfish®, Noxfish®, powder (Cube Powder Fish Toxicant®), and CFT Legumine™. Such formulations of rotenone include crystalline preparations (approximately 95% pure), emulsified solutions (approximately 50% pure), and dusts (approximately 0.75-5% pure) (Extoxnet 1996). This risk assessment compares the potential hazards and risks from the use of CFT Legumine™, Noxfish®, and Nusyn-Noxfish® formulations.

C.3.2 Mechanism of Action of Rotenone on Fish

Historically, rotenone was believed to suppress oxygen uptake across the gills, eventually leading to death by suffocation (Schnick 1974). Recent studies, however, demonstrated that rotenone increases blood oxygen concentrations in some fish species (Fajt and Grizzle 1998). Rotenone interrupts aerobic cellular respiration by blocking electron transport in mitochondria through the inhibition of the enzyme NADH ubiquitone reductase (Singer and Ramsay 1994, Fukami et al. 1969, Lindahl and Oberg 1961) which prevents the availability of oxygen for cellular respiration. In other words, rotenone inhibits a biochemical process at the cellular level, making it impossible for fish to use the oxygen absorbed in the blood and needed for releasing of energy during respiration (Finlayson et al. 2000). In effect, rotenone causes death through tissue anoxia by blocking oxygen uptake at the cellular level and not at the water/blood interface at the gills (Ling 2003). The lack of cellular oxygen availability initiates anaerobic respiration in turn leading to increased lactic acid concentrations and dropping blood pH levels (Fajt and Grizzle 1998).

Rotenone is highly toxic to fish (Extoxnet 1996), and is ideal for the control of invasive or unwanted fish species. In the aquatic environment, rotenone is readily transmitted across the permeable membranes of the gills. Gills are highly evolved respiratory structures that maximize the uptake of oxygen ($O_{2)}$ and excretion of carbon dioxide ($CO_{2)}$ because of their large surface area, thin lamellar membrane, and efficient countercurrent exchange mechanism (Moyle and Cech 1988). Fish supplement this efficiency by actively ventilating water across the gills by controlled branchial pumping. These features make fish highly susceptible to low concentrations of rotenone. Variation in rotenone sensitivity exists between fish species; however, rotenone tolerance generally varies inversely with oxygen requirements, as would be expected for a respiratory poison (Engstrom-Heg et al. 1978).

C.3.2.1 Bioconcentration, Bioaccumulation and Metabolism

Persistence of chemicals in biological tissues is commonly characterized through bioconcentration or bioaccumulation. Bioconcentration of a chemical can occur in an organism when it accumulates chemicals in its tissues following direct exposure, at a concentration greater than that found in the exposure media (e.g. water, air). Bioaccumulation in the food chain results in higher concentrations in predators. Ney (1998) explains that bioaccumulation of organic chemicals in animals is a function of a chemical’s solubility in fat. Fat-soluble (hydrophobic, non-polar) chemicals are more prone to bioaccumulate in fatty tissues and are more slowly metabolized. Chemicals that are insoluble in lipid, exhibit polarity and are readily metabolized.

Rotenone appears to bioconcentrate in aquatic organisms at acutely toxic concentrations but is detoxified and eliminated relatively fast when exposure concentrations do not result in mortality. Rach and Gingerlich (1986) examined concentrations of rotenone and rate of breakdown in tissues in common carp *(Cyprinus carpio*), bluegill (*Lepomis macrochirus*), and yellow perch (*Perca flavescens*) following treatment. Common carp (*Cyprinus carpio*) exhibited the greatest tolerance to rotenone and contained the highest concentrations (approximately 20 times that of the ambient water). Bluegill tissue contained eight times the water concentration and yellow perch contained four times the ambient water concentration. These bioconcentration factors (BCFs) are moderate to low relative to other organic compounds that exhibit BCFs orders of magnitude greater than rotenone.

Rach and Gingerlich (1986) also found that carp quickly eliminated rotenone with rotenoid metabolites accumulating in the bile. This confirmed results reported previously by Fukami et al. (1969), who examined the detoxification of radionuclide-labeled rotenone by liver enzymes in carp. Rach and Gingerlich (1986) found that rotenone was rapidly detoxified to a variety of hydroxylated rotenoids and more water-soluble products with toxicities at least 1 to 2 orders of magnitude less than the parent rotenone. Thus the most likely route of detoxification and elimination is biliary excretion from the liver in the form of excretable metabolites.

Rotenone does not appear to bioconcentrate with prolonged exposure at sublethal doses. Rotenone is rapidly detoxified by the mixed function oxidase (MFO) system of the liver enzymes. Fish not killed by the treatment recover relatively quickly with residual effect, as shown in 30-day flow-through toxicity tests (Marking and Bills 1976).

Absorption of rotenone in the stomach and intestines in mammals is relatively slow and incomplete. If absorbed, rotenone is metabolized effectively by the liver to produce less toxic excretable metabolites (Ray 1991). Approximately 20% of the oral dose (and probably most of the absorbed dose) is excreted within 24 hours as water soluble products, with the remainder as hydroxylated rotenoids (Fukami et al. 1969). Large oral doses (200 mg/kg in pigeons and 10 mg/kg in dogs) usually stimulate vomiting (Haag 1931 *as cited in* Ling 2003). Based on a review of results from these papers and others, Ling (2003) concluded that rotenone is not easily absorbed in higher animals and does not accumulate in the body. These results also show that rotenone would not readily bioaccumulate in the food chain.

C.3.3 Environmental Fate and Chemistry

C.3.3.1 Physical Chemistry

Rotenone is a naturally occurring compound with empirical formula $C_{23}H_{22}O_6$ (Figure C-2) and a molecular weight of 394.43 (Extoxnet 1996, FAO 1970). It is derived from the roots of tropical plants (*Derris spp.*, *Lonchocarpus spp.*, and *Tephrosia spp.*) found in S. America, Australia and parts of Southern Asia (USEPA 2002). Rotenone is highly soluble in organic solvents such as alcohol and acetone, but is only slightly soluble in water: 0.2 mg/L at 20°C, 15 mg/L at 100°C (Extoxnet 1996).

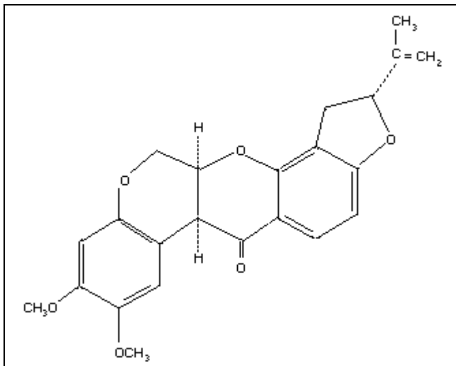


Figure C-2 Chemical Structure of Rotenone

C.3.3.2 Environmental Transport and Degradation of Rotenone

In mild temperatures, rotenone dissipates rapidly in both soil and water with a half-life between 1 and 3 days. It has a high tendency to adhere to soil particles and is unlikely to leach from soils; therefore, it is not likely to be a groundwater pollutant (Finlayson et al. 2001, Extoxnet 1996). Rotenone is considered as a “highly active but short-lived photosensitizer” (Extoxnet 1996), meaning any organism consuming rotenone and unable to metabolize it, will become highly sensitive to the sun for a short period.

Wildlife consumption of rotenone-killed fish can be a means of environmental transport into other portions of the food web. However, a literature search found no instances where birds or mammals suffered ill effects after consuming fish killed by rotenone treatment, or by drinking treated waters. As previously discussed, birds and mammals neutralize rotenone in their guts by enzymatic action, preventing adverse effects and bioaccumulation. These physiological adaptations, coupled with the minute concentrations of rotenone generally found in dead fish, limits the extent to which rotenone exposure occurs through this pathway.

Rotenone is very sensitive to light and temperature and degrades rapidly in the presence of sunlight and warm temperatures (Extoxnet 1996). Rotenone persistence in natural water bodies may vary from a few days to several weeks depending on the season (Ling 2003, Finlayson et al. 2001). Water temperature, light intensity, depth, dissolved oxygen, pH, turbidity, aquatic vegetation, and the presence of a thermocline may all affect the persistence and efficacy of rotenone.

Finlayson et al. (2001) conducted laboratory tests to record the degradation of rotenone in water at 4°C in the absence of light (Table C-1). After 6 days, 4 out of 6 samples showed significant decreases in rotenone concentration. Water with higher alkalinity (>170 mg/L $CaCO_3$) and pH (>9.0) had higher degradation rates (-24% and -25%) than water with lower alkalinity (40 mg/L $CaCO_3$) and pH (7.7) (no change to –16%). As demonstrated in Table C-1, the combination of high alkalinity and high pH did not accelerate degradation. However, there was no test condition where high alkalinity and low pH were paired in this study.

Table C-1 Mean Rotenone Concentrations (μg/L) Before and After Six Days Storage at 4°C in the Absence of Light

Alkalinity (mg/L $CaCO_3$)	pH	Rotenone Before	Rotenone After	Percent change
40	7.8	91	93	+2
180	9.2	68	52	-24*
40	7.7	31.6	28.2	-11*
40	7.7	47.8	40	-16*
40	9.3	238	238	0
172	9.6	14	10.5	-25*

*Significant changes (p>0.05) using the Kruskal-Wallis test. (Source: Finlayson et al. 2001).

Gilderhus et al. (1986) conducted a study to determine the effect of water temperature on rotenone persistence (Table C-2). Rotenone degraded much quicker in warmer water—nearly 10 times faster at 23°C than at 1°C. Rotenone treatment at 100 parts per billion (ppb) in cold water remained toxic to rainbow trout 14 days after the initial treatment, even though the concentration measured was only 6 ppb. Similar findings were reported by Finlayson et al. (2001) after measuring the half-life of rotenone in several California reservoirs: Kaweah Reservoir (20-22°C), Frenchman Lake (10-22°C) and Lake Davis (5-12°C) had rotenone half-lives of 1.7, 3.5 and 7.7 days respectively (Table C-2).

Table C-2 Persistence of Rotenone in Ponds at Two Different Temperatures

Water Temperature	Initial Treatment: Rotenone Concentration	Time to Decay to 0.02 mg/L	Half-Life of Rotenone
1°C	0.10 mg/L	11 days	83.9 hours, (3.5 days)
23°C	0.15 mg/L	48 hours (2 days)	13.9 hours, (0.5 days)

Source: Gilderhus et al. 1986
Note: Rotenone concentrations were analyzed by high performance liquid chromatography [HPLC]

Dawson et al. (1991) conducted a similar experiment in 1986 to evaluate the effects of temperature and sediment adsorption on rotenone persistence. Persistence was compared between two ponds: one lined with cement, the other with an earthen-bottom. Studies with different water temperatures were completed during the spring, summer and fall (Table C-3). Similar to the results of Gilderhus et al. (1986), rotenone degradation rate was positively correlated with increasing water temperature. In addition, for every temperature tested, rotenone disappeared two to three times quicker in the earthen pond versus the concrete lined pond, supporting the claim that rotenone tends to adhere to particles. However, while high initial sorption to the sediments was to be expected, rotenone concentrations in the sediment decreased to below limits of detection within 3 days of treatment, with water temperatures that ranged from 15 to 22°C. Dawson et al. (1991) also discovered that filtered water samples contained significantly less rotenone than the unfiltered samples, suggesting that rotenone is also readily absorbed by suspended particles in the water column.

Table C-3 Effects of Temperature and Sediment Adsorption on the Half Life (in Days) of Rotenone

Pond Substrate	Half Life of Rotenone (days)		
	Spring (8°C)	Summer (22°C)	Fall (15°C)
Concrete	3.7	1.3	5.2
Earthen	1.8	0.7	1.8
Source: Dawson et al.1991			

Rotenone aging studies conducted under laboratory conditions by Marking and Bills (1976) highlight rotenone's much shorter persistence when subjected to natural conditions. Half-lives for laboratory-aged solutions of rotenone in soft water were 13 days at 17°C and 22 days at 12°C, much longer than those of Dawson et al. (1991) and Gilderhus et al. (1986) in field experiments. Furthermore, the toxicity of rotenone solutions declines in parallel with chemical decay, indicating that the breakdown products are comparatively non-toxic (Marking and Bills 1976). Cheng et al. (1972) used photodegradation to identify the breakdown products of rotenone, identifying 20 separate products, most of which were rotenoids, only one of which (6αβ, 12αβ-rotenolone) is considered toxic (Cheng et al. 1972).

Recent field studies in California by Finlayson et al. (2001) support previous findings that rotenone breaks down rapidly in the environment. Finlayson found that the estimated half-life of rotenone ranged between 0.58 and 7.7 days (mean of 2.3 days) depending on the waterbody. Rotenone half-life values measured in four reservoir systems increased with increasing water depth, supporting the hypothesis that light is an important catalyst in rotenone degradation. Kaweah Reservoir, Success Reservoir, Lake Davis, and Frenchman Lake had half-life values measured at 1.7, 2.4, 7.7 and 3.5 days respectively (average depths of 8-12m) and Percolation Reservoir 12 and Meiss Lake had respective half-lives of 0.94 and 0.83 day (average depths of 0.8-1.0m) (Table C-4). Recently, rotenone had a half-life of 5.6 days in Lake Davis in 2007 following rotenone application to Lake Davis, California in 2007 (McMillin and Finlayson 2008).

Table C-4 Rotenone Concentrations (μg/L) and Corresponding Half-Life Values in Lakes of Varying Depths

Location (Year)	Rotenone Concentrations (μg/L)				Half-life (days)	Average Depth (m)
Kaweah Reservoir (1987)	76 (1)	55 (3)	43 (5)	<2 (12)	1.7	8-12
Bravo Reservoir (1987)	254 (1)	46 (2)	<2 (6)	---	0.65	---
Lonestar Pond (1987)	310 (1)	49 (2)	24 (6)	<2 (14)	1.8	---
Percolation Reservoir 5 (1987)	370 (1)	150 (3)	120 (8)	<2 (15)	1.7	---
Percolation Reservoir 12 (1987)	200 (1)	27 (3)	<2 (8)	---	0.94	0.8-1.0
Success Reservoir (1988)	122 (1)	39 (2)	22 (6)	<2 (30)	4.6	8-12
Meiss Lake (1988)	64 (0.13)	30 (1)	8.2 (3)	<2 (6.2)	0.96	0.8-1.0
Meiss Lake (1989)	47 (0.08)	41 (0.17)	30 (0.5)	18 (1)	0.96	0.8-1.0
Meiss Lake (1990)	11 (0.04)	5.9 (2.9)	3.8 (0.92)	<2 (1.9)	0.58	0.8-1.0
Frenchman Lake (1991)	90 (1)	39 (2)	28 (3)	6 (14)	3.5	8-12
Wolf Creek Lake (1992)	16 (8)	<2 (21)	<2 (28)	<2 (51)	2.9	---
Lake Davis (1997)	44 (1)	32 (3)	29 (7)	11 (21)	7.7	8-12

Source: Finlayson et al. 2001

Due to its low Henry's Law constant (1.1 x 10^{-13} atm-m^3/mol), rotenone is not expected to volatilize appreciably from surface water. The small amount of rotenone that may volatilize into the atmosphere would be degraded readily through reactions with photochemically produced hydroxyl radicals. The half-life for this reaction is approximately 1.2 hours (NLM 2006).

C.3.4 Rotenone Toxicity to Ecological Receptors

C.3.4.1 Toxicity to Fish

The efficacy of rotenone on various aquatic organisms has been examined in controlled aquatic toxicity tests. Such tests commonly determine the LC50 value (the median water concentration of the active ingredient that kills 50% of the animals) over specified periods of time (e.g. 24 hr, 96 hr, etc.). Marking and Bills (1976) summarized rotenone toxicity data for a variety of fish species (Table C-5). The tests used to establish these values were conducted with laboratory quality water lacking the colloid and sediment load typical of field settings. These organic loads consistently increase the amount of chemical required to elicit a toxic effect. Thus, these laboratory values provide a conservative estimate of the effect that could be observed in a lake environment. However, in flowing waters, rotenone dissipates relatively quickly (less than 24 hr) due to dilution and increased rates of hydrolysis (Borriston Laboratories 1983) and photolysis (Cheng et al. 1972, Biospherics 1982) (CDFG 1994).

Table C-5 Fish Toxicity of Noxfish®, Containing 5% Rotenone, in Standardized Laboratory Tests at 12°C

Species	Lethal Concentration of Noxfish®		Lethal Concentration of Rotenone (x 0.05)	
	LC50 24h. (µg/L)	LC50 96h. (µg/L)	LC50 24h. (µg/L)	LC50 96h. (µg/L)
Northern Pike	44.9	33.0	2.3	1.7
Atlantic salmon	35.0	21.5	1.8	1.1
Brook trout	47.0	44.3	2.4	2.2
Chinook salmon	49.0	36.9	2.5	1.9
Coho salmon	71.6	62.0	3.6	3.1
Lake trout	26.9	26.9	1.4	1.4
Rainbow trout	68.9	46.0	3.5	2.3
Goldfish	---	497.0	---	24.9
Common carp	84.0	50.0	4.2	2.5
Fathead minnow	400.0	142.0	20	7.1
Channel catfish	400.0	164.0	20	8.2
Black bullhead	665.0	389.0	33.3	19.5
Smallmouth bass	93.2	79.0	4.7	4.0
Largemouth bass	200.0	142.0	10	7.1
Green sunfish	218.0	141.0	10.9	7.1
Bluegill sunfish	149.0	141.0	7.5	7.1
Yellow perch	92.0	70.0	4.6	3.5
Longnose sucker	67.2	57.0	3.4	2.9
White sucker	71.9	68.0	3.6	3.4
Bowfin	57.5	30.0	2.9	1.5

Source: Marking and Bills 1976.

Rotenone applications of commercial formulations between 1 and 3 mg/L have generally proven sufficient to eliminate all fish in the treated water body (Ling 2003). Such formulations result in active ingredient (a.i.) concentrations of rotenone (i.e., rotenone) ranging from 50 to 150 µg/L. In such aquatic exposures, the water-borne chemical enters fish by simple diffusion across the gills. Marking and Bills (1976) recorded 24hr LC50 rotenone concentrations of 1.4 µg/L to 33.3 µg/L, and 96hr LC50 concentrations of a.i. ranging from 1.1 µg/L to 24.9 µg/L. Some of the most resistant species in field and lab applications have included black bullhead (*Ictalurus melas*), channel catfish (*I. punctatus*), and fathead minnow (*Pimephales promelas*) with 24 hr LC50 rotenone concentrations of 33.3 µg/L, 20 µg/L, and 20 µg/L, respectively.

Fishery managers have exploited this range in sensitivity among fish species to remove unwanted species selectively from mixed-species communities (Bills et al. 1996). Reasons for such marked differences may be a result of differences in tissue distribution, rates of uptake, and rates of detoxification based on differences in the levels of liver enzymes responsible for rotenone breakdown and elimination, or supplemental means for oxygen uptake from air. Another possible explanation is that certain species are biochemically more successful in using alternative pathways to generate ATP (Rach and Gingerlich 1986) and are therefore still able to function at rotenone concentrations that would kill other species.

Omnivorous fish species generally demonstrate higher tolerance levels to rotenone than strict carnivores. One explanation for this elevated tolerance is that bottom-feeding omnivorous fish tend to have much higher concentrations of the mixed function oxidase (MFO) enzymes responsible for metabolizing rotenone than strict carnivores (Moyle and Cech 1988). The MFO class of enzymes metabolize foreign compounds like rotenone, and accelerate their elimination, thus increasing the tolerance of such species with high rates of MFO induction to withstand otherwise lethal rotenone concentrations.

C.3.4.1.1 EFFECTS OF PHYSICAL AND BEHAVIORAL PARAMETERS ON ROTENONE TOXICITY TO FISH

Water-temperature and contact time are perhaps the two most important variables that modulate efficacy of rotenone treatments. Guilderhus (1972) found that the time required to achieve 100% mortality (LC100) in various freshwater fish decreased approximately 2- to 3-fold for every 5-degree increase in water temperature. Additionally, fish mortality will not occur if there is inadequate contact time between the chemical and the fish. This is especially problematic for short-term exposures that typically occur in stream treatments lasting 4 to 8 hours. Some fish species demonstrate avoidance behaviors to rotenone, favoring areas with lower concentrations, or areas that are free of rotenone (Hogue 1999). Therefore, to achieve complete elimination of target species, rotenone must be dispersed throughout the fish inhabitable waters in the treatment area, including the possible treatment of Tamarack Lake should fish be present.

Furthermore, fertilized fish eggs are less susceptible to rotenone poisoning than fishes themselves because their rate of toxicant uptake is much lower (Table C-6) (Ling 2003, Marking and Bills 1976). Programs aimed at eradicating a certain fish species must conduct the treatment before the spawning season or after all eggs have hatched.

Water hardness, pH, and rotenone formulation can also modulate rotenone toxicity. Generally, rotenone is reported to be more effective when the natural body of water is somewhat acidic, with low hardness (i.e., soft water). However, Marking and Bills (1976) noted that the toxicity of rotenone to fish was not affected significantly by hardness or pH. However, toxicity to newly fertilized fish eggs *decreased* with softer water (Table C-6), suggesting, somewhat counterintuitively, that rotenone permeability through the egg chorion is diminished by softer water.

Table C-6 Toxicity of Rotenone in 12°C Water at Various Degrees of Hardness to Rainbow Trout and Rainbow Trout Eggs

Species	Median 96h LC50 (µg/L)			
	Very Soft Water	Soft Water	Hard Water	Very Hard Water
Rainbow trout (*O. mykiss*)	2.7	2.8	2.75	2.65
Newly fertilized *O.mykiss* eggs	280	221	160	125

Source: Marking and Bills 1976.

Following rotenone treatment, fish exhibit certain characteristic behaviors. In the induction stage of treatment, observed behaviors include reduced opercular ventilation coupled with erratic swimming bursts. Surfacing and a ‘gulping’ behavior or skimming at the surface film may follow before fish experience a complete loss of equilibrium. Eventually, fish sink to the bottom and die (Ling 2003, Fajt and Grizzle 1998, Rach and Gingerlich 1986).

C.3.4.2 Rotenone Toxicity to Non-target Aquatic Organisms

C.3.4.2.1 AQUATIC MACROINVERTEBRATES

With their gill-like tracheae, aquatic invertebrates are theoretically as susceptible to the toxic effects of rotenone as fish or amphibian larvae (Bradbury 1986). However, laboratory tests conducted by Chandler and Marking (1982) concluded that apart from an Ostracod (*Cypridopsis* sp.), aquatic invertebrates are much more tolerant of rotenone than most fishes and amphibian larval stages. The most resistant organisms were a snail (*Helisoma* sp.) and the Asiatic clam (*Corbicula manilensis*) for which the LC50 96 hr concentrations were 50 times greater than those reported for the black bullhead (*Ictalurus melas*) (Marking and Bills 1976), one of their most resistant fishes. Sanders and Cope (1968) also conducted lab tests examining the effect of rotenone on the nymph or naiad stage of a stonefly (*Pteronarcys californica*). They found that the LC50 24 hr was 2,900 μg/L and the LC50 96 hr was 380 μg/L. These values are an order of magnitude greater than previous findings for black bullhead (*Ictalurus melas*) (Marking and Bills 1976), indicating that aquatic invertebrates are much less sensitive to rotenone than fish. Larger, later instar naiads were less susceptible to given concentrations of toxin than were smaller, earlier instars of the same species (Sanders and Cope 1968).

Field studies examining the effect of rotenone on aquatic macroinvertebrate communities have provided varied results. Whereas some workers noticed dramatic, long-term effects (Mangum and Madrigal 1999, Binns 1967), others observed rotenone has a negligible effect on most aquatic macroinvertebrates (Demong 2001, Melaas et al. 2001, Trumbo et al. 2000a, 2000b, Whelan 2002, Vinson and Vinson 2007). In general, the rotenone effects on benthic macroinvertebrates are less pronounced and more variable on macroinvertebrates than on zooplankton. Like the range of sensitivities demonstrated by various fish species to rotenone, different species of aquatic macroinvertebrates also exhibit a range of tolerances (Mangum and Madrigal 1999, Chandler and Marking 1982, Engstrom-Heg et al. 1978), again perhaps based on their oxygen requirements (Table C-7).

Rotenone treatments in streams and rivers also cause significant loss of invertebrate fauna but effects are usually more noticeable close to rotenone application stations. Not all invertebrate losses in stream treatments are due to the death of the animals because rotenone also causes increases in invertebrate drift downstream (Morrison 1977 as cited in Ling 2003). A 5 year study of the Strawberry River, Utah, following a 48 hour treatment to remove coarse fish showed that up to 33% of the benthic invertebrate species were unaffected by the treatment. Forty-six percent of the species had recovered after 1 year but a further 21% were still missing after 5 years. Most of the species that were most sensitive to rotenone and which failed to recover were mayflies, stoneflies and caddis flies, although some members of each of these groups were also resistant to rotenone treatment. Although some species that were present before the treatment were still missing 5 years later, other species not present before the rotenone treatment had appeared and were possibly filling vacated niches (Mangum and Madrigal 1999 as cited in Ling 2003). The variable response from invertebrates is due to differences in concentration and duration of rotenone used in the stream treatment (Vinson and Vinson 2007).

Table C-7 Rotenone Toxicity Reported in Some Aquatic Invertebrates

Species Guild	Test Species	Test Endpoint	Lethal Concentration (mg/L)
Flatworm	*Catenula* sp.	LC50 24h	5.1
	Planaria sp.	LC50 24h	<0.500
Annelid worms	Leech	LC50 48h	<0.100
Copepod	*Cyclops* sp.	LC100 72h	<0.100
Branchiura	*Argulus* sp.	LC50 24h	~0.025
Cladoceran	*Daphnia pulex*	LC50 24h	0.027
	D. pulex	LC50 24h	<0.025
	Diaptomus siciloides	LC50 24h	<0.025
Ostracod	*Cypridopsis sp.*	LC50 24h	0.490
Conchostracan	*Estheria* sp.	LC50 24h	~0.050
Freshwater prawn	*Palaemonetes kadiakensis*	LC50 24h	5.15
Crayfish	*Cambarus immunis*	LC50 72h	>0.500
Dragonfly naiad	Macromia sp.	LC50 24h	4.70
Stonefly naiad	*Pteronarcys californica*	LC50 24h	2.90
Backswimmer	*Notoncta* sp.	LC50 24h	3.42
	Notonecta sp.	LC50 24h	~0.100
Caddis fly larvae	*Hydropsychye* sp.	LC50 96h	0.605
Whirligig beetle	*Gyrinus* sp.	LC50 24h	3.55
Water mite	Hydrachnidae	LC50 96h	~0.050
Snail	*Physa pomilia*	LC50 24h	6.35
	Oxytrema catenaria	LC50 96h	1.75
	Lymnaea stagnalis	LC50 96h	>1.00
Bivalve Mollusc	*Dreissena polymorpha*	LC50 48h	0.219
	Obliquaria reflexa	LC50 48h	>1.00
	Elliptio buckleyi	LC50 96h	2.95
	Elliptio complanata	LC50 96h	2.00
	Corbicula manilensis	LC50 96h	7.50

Note: as summarized by Ling 2003, from a variety of sources

C.3.4.2.2 PLANKTON

Rotenone can have significant effects on abundance and structure of the plankton community, which can have subsequent effects on fish populations that depend on plankton either directly or indirectly for nutrition. From 1954 to 1955, Hoffman and Olive (1961) conducted an experiment to document the effect of rotenone on the zooplankton community in a Colorado reservoir. They observed a complete elimination of protozoans and Entomostracans and a major reduction in the Rotifer population following treatment. Their finding agreed with previous research (Hooper 1948, Brown and Ball 1943, Hamilton 1941) and more recent findings that rotenone is highly toxic to zooplankton (Melaas et al. 2001, Beal and Anderson 1993, Neves 1975, Anderson 1970, Kiser et al. 1963), especially in acidic conditions (Kiser et al. 1963). Unlike many benthic invertebrates, which may escape the immediate effects of rotenone by burrowing into sediment, zooplankton remain in the water column for the full duration of treatment. However, some populations may recover from resistant life-stages and or eggs (Kiser et al. 1963). A full recovery of the zooplankton community may take longer however. Beal and Anderson (1993) demonstrated that some populations make take up to 8 months to recover following rotenone treatment, while Anderson (1970) noted a 3-year recovery period in 2 mountain lakes. These studies suggest that rotenone treatment and restocking of lakes must allow zooplankton communities to reestablish before restocking.

C.3.4.3 Toxicity to Terrestrial Wildlife Receptors

Rotenone can be toxic to both aquatic and terrestrial species depending on the dose, method of administration, duration of exposure, and sensitivity of the species and life stage. Table C-8 outlines chemical toxicity guidelines established by the USEPA that are used in assessments of rotenone toxicity to birds and mammals. Table C-8 lists two hazard categories: the acute oral or dermal LD50 and the acute inhalation LC50. The LD50 is the statistical derivation of a dietary or drinking water dose, predicted to cause 50% mortality. The LC50 is based on the concentration of a compound in air or water.

Table C-8 Chemical Hazard Classifications for Wildlife Risk

Hazard Category	Mammals		Avian	
	Acute Oral or Dermal LD50 (mg/kg)	Acute Inhalation LC50 (ppm)	Acute Oral or Dermal LD50 (mg/kg)	Acute Inhalation LC50 (ppm)
Very highly toxic	<10	<50	<10	<50
Highly toxic	10-50	51-500	10-50	51-500
Moderately toxic	51-500	501-1000	51-500	501-1000
Slightly toxic	501-2000	1001-5000	501-2000	1001-5000
Practically non-toxic	>2000	>5000	>2000	>5000

Source: USEPA 1998

C.3.4.3.1 ROTENONE TOXICITY TO MAMMALS

Mammalian acute oral toxicity LD50 values for rotenone range from 39.5 mg/kg for female rats to 1,500 mg/kg for rabbits. For most lab mammals, rotenone is much more toxic when administered intravenously or inhaled rather than taken orally. For example, the average oral LD50 for rats is 60 mg/kg compared with just 0.2 mg/kg for rotenone introduced directly into the bloodstream. Efficient breakdown of rotenone by the liver, oxidation of rotenone in the gut, and slow absorption in the stomach and intestines may account for this significant difference in toxicity (Narongchai et al. 2005, Ling 2003). This explanation may also account for the significant difference in rotenone sensitivity between mammals and fishes, and not from a difference in the primary site of action (Fukami et al. 1969). Indeed, USEPA considers rotenone safe to use in the presence of cattle (USEPA 1981).

C.3.4.3.2 ROTENONE TOXICITY TO BIRDS

Rotenone has a very low toxicity to wildfowl, and birds are extremely unlikely to be affected by fisheries management practices (Ling 2003). Avian acute toxicity LD50 values range from 130 mg/kg for the nestling English song sparrow (Cutcomp 1943) to 2,200 mg/kg for an adult mallard duck (USEPA 1988). In general, young birds are about 10 times more sensitive to rotenone poisoning (CDFG 1994) and, like mammals, birds have a much lower tolerance to rotenone when introduced intravenously. During rotenone treatments in California, fish-eating birds and mammals were observed foraging eradicated fish for several days following treatment. No sightings or dead birds or mammals followed (CDFG 1994).

Ling (2003) examined rotenone poisoning and sublethal toxicity in birds after consuming fish or even fish management baits. Ling concluded "rotenone is slightly toxic to wildfowl, and birds are extremely unlikely to be affected by normal fisheries management programs." For example, baits used to kill carp for management purposes have approximately 0.01 g of rotenone each. Ling calculated that a duck would need to consume approximately 200 baits to receive a fatal dose. Birds would be very unlikely to consume bait but could consume fish killed by rotenone. The concentration of rotenone in poisoned fish, however, is usually 25,000 times lower than that found in bait.

C.3.4.3.3 ROTENONE TOXICITY TO TERRESTRIAL INSECTS

Rotenone is extremely toxic to many species of insects in many different insect orders (caterpillars, beetles, flies, etc.) hence its wide popularity as an insecticide. However, the compound is considered non-toxic to bees unless used in combination with pyrethrum (Extoxnet 1996). Because rotenone would be used for fisheries management and would be applied strictly to an aquatic environment, only aquatic insects or aquatic stages of terrestrial insects would be significantly affected.

C.3.4.3.4 ROTENONE TOXICITY TO AMPHIBIANS

Rotenone is toxic to amphibians, but generally less toxic than to fish. Rotenone may be absorbed into both skin and respiratory membranes, but skin may present more of a barrier due to a greater distance for the chemical to diffuse across (Fontenot et al. 1994), and a smaller surface area relative to gill structures. Indeed, Fontenot et al. (1994) reported that amphibian larvae with gills are most sensitive to rotenone. In early 1974, African clawed frogs (*Xenopus laevis*) were discovered in some ponds located in the Santa Clara River drainage. An eradication program using rotenone to extirpate the exotic frogs was undertaken in the spring of 1974. Results indicated that all *X. laevis* tadpoles were killed but adults were unaffected and thus able to reproduce again later that spring (McCoid and Bettoli 1996).

In standard laboratory 24 hr and 96 hr aquatic rotenone toxicity tests, the LC50 values for tadpoles (*Rana sphenocephala*) and larval amphibians ranged between 5 μg/L and 580 μg/L in 24 hr tests and 25 μg/L to 500 μg/L in 96 hr tests (Fontenot et al. 1994, Chandler and Marking 1982). The adult Northern leopard frog demonstrated a much greater resistance with LC50 concentrations ranging from 240 μg/L and 1,580 μg/L (24 hr) and 240 μg/L and 920 μg/L (96 hr) (Table C-9). This suggests that tadpoles and other larval forms of amphibians that utilize gills for respiration are just as sensitive to rotenone as fishes while adult forms, which no longer utilize gills, are much less susceptible to rotenone. Larval amphibians appear to have resistance roughly equivalent to those of the most tolerant fish species.

Table C-9 Toxicity of Rotenone to Various Amphibians in Lakes

Species	Stage	Temp °C	24 hours LC50 (µg/L)	96 hours LC50 (µg/L)	Original Reference
N. Leopard frog (*Rana pipiens*)	Juvenile/ Adult	—	10	—	Haag 1931
	Tadpole	—	5	—	Hamilton 1941
	Adult	12	240	240	Farringer 1972
	Adult	12	1200	290	Farringer 1972
	Adult	12	1460	920	Farringer 1972
	Adult	12	1580	640	Farringer 1972
Tiger salamander (*Ambystoma tigrinum*)	Larvae	—	5	—	Hamilton 1941
S. Leopard frog (*Rana sphenocephala*)	Tadpole	15-17	30	25	Chandler and Marking 1982

C.3.4.3.5 ROTENONE TOXICITY TO REPTILES

Studies of rotenone toxicity to reptiles are particularly lacking (Fontenot et al. 1994). Carr (1952) and Dundee and Rossman (1989) suggested that soft-shelled turtles (*Apalone* spp.) may be affected by rotenone applications in fisheries, although neither provided supporting data. The adult green anole (*Anolis carolinensis*) was the only reptile species evaluated for acute toxicity in pre-registration testing of chemicals, including rotenone compounds (Fontenot et al. 1994). Aquatic turtle species with specialized respiratory mechanisms such as buccopharyngeal respiration (*Apalone spinifera* and *Kinosternon minor*), or modified skin and cloaca to enhance respiration (*Trachemys scripta* and *K. odoratum*) may be more susceptible to rotenone than other more terrestrial species. Turtle species in the Family Kinosternidae generally possess these special respiratory systems (Fontenot et al. 1994).

A fish population study using rotenone on Lake Conroe (Montgomery County, Texas) conducted between 1980 and 1986 indicated that aquatic turtles (*K. subrubrum*) were indeed susceptible to rotenone poisoning. At least 60 dead or dying individuals were observed around the periphery of the lake 24 to 48 hours after treatment, with the actual number of dead likely much higher because K. subrubrum tends to sink when dead (McCoid and Bettoli 1996). Freshwater aquatic snakes do not utilize aquatic respiration and absorption of rotenone through their thick skin is considered very unlikely (Fontenot et al. 1994). One study (Haque 1971), however, reported the death of an aquatic snake in a pond 48 hours after treating with rotenone, but also noted a second healthy-looking snake swimming in the same pond. The mechanism of action of uptake and toxicity of rotenone to reptiles requires further study.

C.3.4.4 Summary of Toxicity Reference Values (TRVs) Used for Ecological Risk Assessment

Table C-10 summarizes the range of acute and chronic TRVs identified for rotenone for vertebrates other than fish. Most mammal species are relatively resistant to rotenone.

The risk characterization (Section C5.1) uses these to calculate hazard quotients (HQ). Hazard quotients were evaluated using the methods presented in the USEPA ecological risk assessment for registration of rotenone (USEPA 2006). Hazard quotient standards were adjusted using several factors or “risk presumptions” to derive “Levels of Concern” (LOC) as listed in

Table C-11 and Table C-12. These values, similar to safety factors, are based on the endpoint used (i.e., acute versus chronic), frequency or duration of exposure (restricted or unrestricted site use), and the receptor's conservation status. For example, exposure of endangered species was evaluated using an LOC of 0.05 rather than a HQ of 1. If an acute toxicity value was used as the TRV, an LOC of 0.5 was used rather than an HQ of 1. In comparison, LOCs based on chronic exposure values were not adjusted.

Table C-10 Toxicity of Rotenone to Selected Mammalian and Avifauna

Animal Group	Test Endpoint	Lethal Concentration	Reference(s)
Mammals			
Human	Acute LD50 oral	300-500 mg/kg-body wt (Estimated)	Ray 1991; Gosselin et al. 1984
Rat	Acute LD50 oral	132-1500 mg/kg	Kidd and James 1991
	Acute LD50 oral	39.5 mg/kg (female)	USEPA 1988
	Acute LD50 oral	102 mg/kg (male)	USEPA 1988
	Acute LD50 I.V.	0.2 mg/kg	Hayes 1982
	Chronic LD50 oral	~10 mg/kg	Nat'l Research Council 1983
Mouse	Acute LD50 oral	350 mg/kg	Kidd and James 1991
Guinea pig	Acute LD50 oral	75 mg/kg	Haag 1931
	Acute LD50 I.P.	2 mg/kg	Haag 1931
	Acute LD50 I.M.	7 mg/kg	Haag 1931
	Acute LD50 S.C.	16 mg/kg	Haag 1931
Rabbit	Acute LD50 oral	~1.5 g/kg	Haag 1931
	Acute LD50 I.V.	~0.35 mg/kg	Haag 1931
	Acute LD50 I.M.	~5 mg/kg	Haag 1931
	Acute LD50 S.C.	~20 mg/kg	Haag 1931
Cat	Acute LD50 I.V.	~0.65 mg/kg	Haag 1931
Dog	Acute LD50 I.V.	~0.65 mg/kg	Haag 1931
	Chronic LD50 oral	~10 mg/kg (30d)	Haag 1931
	Chronic LD50 oral	>>10 mg/kg (180d)	Nat'l Research Council 1983
Birds			
Pigeon	Acute LD50 I.V.	1 mg/kg	Haag 1931
Japanese quail	Acute LD50 oral	1882 mg/kg	Hill et al. 1975
Mallard duck	Acute LD50 oral	2600-3568 mg/kg	Hill et al. 1975
Ring-necked pheasant	Acute LD50 oral	1608 mg/kg	Hill et al. 1975

Table C-11 Risk Presumptions for Aquatic Invertebrates Exposed to Rotenone Formulation Constituents from Silver King Creek Treatment

Toxicity Endpoint	Hazard Quotient (HQ) Calculation	Level of Concern (LOC) with Hazard Quotient
Acute Exposure	EPC[1]/LC50[2] *or* EC50[3]	0.5
Acute Restricted Use Exposure	EPC/LC50 or EC50	0.1
Acute Endangered Species Exposure	EPC/LC50 or EC50	0.05
Chronic Exposure	EEC/NOAEC[4]	1

Source: USEPA 1988

1. Exposure point concentration in primary media of exposure.
2. Median lethal concentration of chemical that kills 50% of the test organisms
3. Median effective concentration of chemical that elicits measurement of effect in 50% of the test organisms
4. No observable adverse effect concentration

Table C-12 Risk Presumptions for Non-Target Terrestrial Animals Exposed to Rotenone Formulation Constituents from Silver King Creek Treatment

Toxicity Endpoint	Hazard Quotient (HQ) Calculation	Level of Concern (LOL) with Hazard Quotient
Acute Exposure	EPC1/LC502 or EC503	0.5
Acute Restricted Use Exposure	EPC/LC50 or EC50	0.2
Acute Endangered Species Exposure	EPC/LC50 or EC50	0.1
Chronic Exposure	EEC/NOAEC4	1

Source: USEPA 2006

1. Exposure point concentration in primary media of exposure.
2. Median lethal concentration of chemical that kills 50% of the test organisms
3. Median effective concentration of chemical that elicits measurement of effect in 50% of the test organisms
4. No observable adverse effect concentration

C.3.5 Environmental Fate and Hazards from Formulation Ingredients and Potassium Permanganate Neutralizing Agent

Concern about risks to the environment include whether or not the chemical constituents in commercial rotenone formulations are toxic to wildlife, how rapidly they break down in the environment, and whether or not they build up in the food chain. Thus, these constituents constitute the chemicals of potential concern or COPCs for this assessment. This section also evaluates the fate and hazards of potassium permanganate, the compound used to neutralize rotenone and to protect downstream areas.

C.3.5.1 Physical and Chemical Properties of Carrier and Dispersant Ingredients in Rotenone Formulations

The manufacturer reports that formulations contain the same concentration of rotenone (5%). However, the concentrations and types of dispersant and carrier compounds in the 2 formulations differ substantially. Table C-13 summarizes some of the physical and chemical characteristics of rotenone compared to the various inert ingredients and carrier compounds present in CFT Legumine™, NoxFish®, and Nusyn-Noxfish®. The physical and chemical characteristics of a compound determine its fate in the environment. The rate and manner of the breakdown of each chemical is dependent on its solubility, volatility, tendency to adsorb to soil or sediment particles, and other factors shown in this table. As demonstrated in Table C-13, several of the components are common to both formulations, and others are unique.

C.3.5.1.1 CFT LEGUMINE™

The CFT Legumine™ formulation contains approximately 5% rotenone, 10% methyl pyrrolidone (MP), 60% diethylene glycol monoethyl ether (DEGEE), 17% Fennodefo 99™ (Fennodefo), and 3% other compounds (CDFG 2007). The 2 primary inactive carrier components in CFT Legumine™ are MP and DEGEE, which comprise approximately 93% of the formulation by weight as determined by CDFG (Table C-13). Both of these chemicals are infinitely soluble in water and have an estimated organic carbon partition coefficient (i.e., the "K_{oc}") of 12, indicating their water solubility and tendency not to adsorb to sediment particles (NLM 2006). Based on their low Henry's Law constants, these chemicals do not readily volatilize from surface water, and neither chemical is expected to undergo hydrolysis or direct photolysis (NLM 2006).

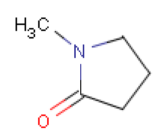
Aerobic biodegradation would be the most important mechanism for the removal of MP and DEGEE from aquatic systems (NLM 2006). The small amount of these chemicals that may volatilize into ambient air would be readily degraded by reaction with photochemically-produced hydroxyl radicals, with an atmospheric half-life of up to 12 hours (NLM 2006). The Fennodefo constituent in CFT Legumine™ facilitates emulsification and dispersion of the otherwise relatively insoluble rotenone. Two classes of constituents, polyethylene glycols (PEGs) and the solvent hexanol (alcohol), are part of the inert additive Fennodefo in CFT Legumine™, which also contains fatty acid esters. As stated in the "Screening Level Risk Analysis of Previously Unidentified Rotenone Formulation Constituents Associated with the Treatment of Lake Davis" (ENVIRON 2007), the fatty acid ester mixture in Fennodefo is likely derived from 'tall oil.' Tall oil has been independently reported as a mixture of naturally occurring fatty acids, resins and neutrals that are a by-product of wood pulp, and is a common constituent of soap formulations. The fatty acids in tall oil, principally oleic and linoleic acids, are naturally occurring constituents that are also part of the building blocks that make up fats and oils (triglycerides). Highly unsaturated fatty acids, like linoleic, are considered essential dietary constituents in humans, as they cannot be synthesized. Polyethylene glycols (e.g. propylene glycol) are common ingredients in a variety of consumer products, including soft drink syrups (as an antioxidant), in plasticizers, suntan lotions and antifreeze, among other uses (ENVIRON 2007).

The structures and oral toxicities of the two most concentrated constituents in CFT Legumine™ are summarized below.

DIETHYLENE GLYCOL MONOETHYL ETHER

- Approximate concentration in formula: 569,000 mg/L
- Toxicology: RAT ORAL LD50: 4,700-9,740 mg/kg.
- Chemical formula: C6H14O3
- Chemical structure: C2H5OCH2CH2OCH2CH2OH

1-METHYL-2-PYRROLIDINONE



- Approximate concentration in formula: 90,000 mg/L
- Toxicology: RAT ORAL LD50: 3,914 mg/kg
- Chemical formula: C5H9NO

Table C-13 Physical and Chemical Properties of Rotenone Formulation Constituents

Ingredient	Concentration in Formulation (µg/g)	Concentration in 0.5 mg/L Treatment (µg/L)[1]	Concentration in 1.0 mg/L Treatment (µg/L)[1]	MW (g/mol)	Boiling Pt (°C)	Water Solubility (mg/L @ 25°C)	Vapor Pressure (torr @ 25°C)	Vapor Density (Vd = PM/RT)[2]	Henry's Law Constant (atm-m³/mol)	Specific Gravity (g/mL)	Log Octanol/Water Partition Coefficient	Half-Lives[3]	Air Pollution Factors[4]	Odor Thresholds and Characteristics	Water Pollution Factors	Aquatic Toxicity Metrics	Toxicity to Other Receptors
CFT Legumine™																	
Rotenone	50,900 as reported in lab analyses (Fisher 2007)	25.5	50.9	394.4	210-220 / 0.5 mm	0.2 mg/L (Re-registration doc and HSDB)	6.9×10^{-10}		1.1×10^{-13}	1.27 @ 20°C	4.10	Hydrolysis: 3.2 days @ pH=7, 2 days @ pH=9 Aqueous photolysis: 21 hrs (1 cm), 191 days (2 m, well mixed) Entire pond system (water + sediment): 20 days in cold water (5°C), 1.5 days in warm water (25-27°C) Air photooxidation: 0.05 days Soil: 3 days		TOC: 0.36 mg/kg			LD50 Mice (i.p.): 2.8 mg/kg Rats (oral): 132 mg/kg-bw; (i.v.): 6 mg/kg Human: ingestion or inhalation of large doses may lead to numbness of oral mucosa, respiratory paralysis at lethal doses, tremor, tachypnea, nausea, vomiting. Chronic exposure may produce fatty changes in liver and kidney. More toxic when inhaled than ingested. Skin irritation from direct contact.
Rotenolone	7,340 as reported in lab analyses (Fisher 2007)	3.67	7.34	412.42													Oral LD50 Mice: rotenolone I, 4.1 mg/kg rotenolone II, 25 mg/kg
1-Methyl-2-pyrrolidinone (Methyl pyrrolidone)	98,900 as reported in lab analyses (Fisher 2007)	49.5	98.9	99.13	202	infinitely soluble in water	0.345	3.4	4.46×10^{-8}	< 1.0	-0.54	Air photooxidation: 5 hrs Soil: 4 days in clay, 8.7 days in loam, 11.5 days in sand	1 mg/m³ = 0.24 ppm	mild amine odor		NOEL = 5 g/L in bacteria, algae (*Scenedesmus)* and protozoa (*Colpoda)*	
Diethylene glycol monoethyl ether (Diethylene glycol ethyl ether)	610,000 as reported in lab analyses (Fisher 2007)	305	610	134.2	202	infinitely soluble in water	0.13	4.62	4.86×10^{-8}	0.99 @ 20°C / 4°C	-0.08 (USEPA RAGS E and HSDB)	Air photooxidation: 12 hrs	1 mg/m³ = 0.188 ppm	Quality: sweet, musty Hedonic tone: unpleasant to pleasant; Abs.: 0.21 ppm 50% recog: 1.10 100% recog: 1.10 O.I. recog: 600 O.I. at 20°C = 120	BOD: 0.20 NEN 3235-5.4 COD: 1.85 NEN 3235-3.3	24 hr LC50: > 5,000 mg/L (goldfish, static); 96 hr LC_{50}: > 10,000 mg/L, (*Menidia beryllina*, static)	Oral LD50 (single dose): Rat = 8.69-9.74 g/kg Guinea pig: 3.67-4.97 g/kg Cat: 1 ml/kg (lethal) Rat NOEL: 0.49 g/kg (repeat oral dose) Rabbit, cat, guinea pig, mouse inhalation—no injury w/ 12 day exposure to saturated vapor.
1-Hexanol	4,239 as reported in lab analyses (Fisher 2007)	2.12	4.24	102.2	158	5,900 mg/L @ 20°C	0.98 mm @ 20°C	3.52		0.82			1 mg/cu m=0.24 ppm 1 ppm=4.25 mg/cu m	Odor: sweet alcohol	BOD: 28% of ThOD; COD: 94% of ThOD		LED50 orally in rats: 4.59 g/kg Toxicity threshold (cell multiplication inhibition test): bacteria (Pseudomonas putida): 62 mg/l; algae
sec-Butylbenzene	3.9 [0.00055% by wt]	0.00195	0.00390	134.21	173	17	1.1 (20°C)	4.62	0.019	0.862		Aqueous volatilization: est. 3.4 hrs for model river, 4.6 days for model lake, and 88 days for model pond (includes sediment adsorption) Air photooxidation: 1.9 days	Relative chemical reactivity [RCR]: 1.31	distinctive aromatic odor			Eye irritation reactivity [EIR] in man @ 1.8
1-Butylbenzene (n-Butylbenzene)	23.9 as reported in lab analyses (Fisher 2007)	0.0120	0.0239	134.21	183	14	1	4.62	0.0883	0.860	4.03	Aqueous volatilization: est. 3.5 hrs for model river, 4.6 days for model lake, and 16 days for model pond (includes sediment adsorption) Air photooxidation: 1.8 days	RCR: 1.03		ThOD: 3.22		EIR: 6.4 (man)
1,4-diethylbenzene	500 as reported in lab analyses (Fisher 2007)	0.250	0.500	134.2	183.7	17	.92	.006646	.00755		4.06	Aqueous volatilization: est. 3.5 hrs for model river, 4.6 days for model lake	Aqueous volatilization: est. 3.5 hrs for model river, 4.6 days for model lake				

Table C-13 Physical and Chemical Properties of Rotenone Formulation Constituents

Ingredient	Concentration in Formulation (µg/g)	Concentration in 0.5 mg/L Treatment (µg/L)[1]	Concentration in 1.0 mg/L Treatment (µg/L)[1]	MW (g/mol)	Boiling Pt (°C)	Water Solubility (mg/L @ 25°C)	Vapor Pressure (torr @ 25°C)	Vapor Density (Vd = PM/RT)[2]	Henry's Law Constant (atm-m^3/mol)	Specific Gravity (g/mL)	Log Octanol/Water Partition Coefficient	Half-Lives[3]	Air Pollution Factors[4]	Odor Thresholds and Characteristics	Water Pollution Factors	Aquatic Toxicity Metrics	Toxicity to Other Receptors
1,2,4-Trimethylbenzene	34.8 as reported in lab analyses (Fisher 2007)	0.0174	0.0348	120.19	169	57	2.1	4.15	0.00616	0.8761	3.78	<u>Aqueous volatilization:</u> est. 3 hrs for model river, 4 days for model lake, <u>Air photooxidation</u>: 12 hrs	1 mg/m^3 = 0.203 ppm				
1,3,5-Trimethylbenzene (*aka* mesitylene)	4 [0.00056% by wt]	0.00200	0.00400	120.19	164.7	48.2	2.4	1.006 @ 20°C	0.147	0.865	4.00	<u>Aqueous volatilization:</u> est. 3 hrs for model river, 4 days for model lake, and 5 days for model pond (includes sediment adsorption) <u>Air photooxidation</u>: 7 hrs	1 mg/m^3 = 0.203 ppm; 0.4% of emitted hydrocarbons from diesel engines	Avg recog.: 0.027 mg/L Range: 0.00024-0.062 mg/L	BOD: 3% of Theoretical Oxygen Demand (ThOD) COD: 10% of ThOD	96 hr median threshold limit = 13 mg/L (goldfish, flow-through)	
1,2,4,5-Tetramethylbenzene	402 as reported in lab analyses (Fisher 2007)	0.201	0.402	134.2	196.8	33.9	0.118	0.000852	.00799	.84	4.0	<u>Aqueous volatilization: est. 3.5 hrs for model river, 4.6 days for model lake</u>	<u>Aqueous volatilization: est. 3.5 hrs for model river, 4.6 days for model lake</u>				
Toluene	222 as reported in lab analyses (Fisher 2007)	0.111	0.222	92.13	110.6	56.2	30	3.1	0.00664	0.8636 @ 20°C / 4°C	2.75	<u>Aqueous volatilization:</u> est. 1 hr for model river and 4 days for model lake <u>Water</u>: 4 days (aerobic), 56 days (anaerobic) <u>Uncontaminated estuarine</u>: 90 days <u>Soil biodegradation</u>: several hrs to 71 days <u>Air photooxidation</u>: 3 days	1 mg/m^3 = 0.265 ppm	water: 0.04 ppm air: 2.14 ppm			LD50 (rats) 7.53 g/kg
4-Isopropyltoluene (p-Isopropyltoluene)	5.1 [0.00072% by wt]	0.00255	0.00510	134	177	16.8	1.75	4.62	0.0183	0.8610 @ 20°C / 4°C	4.16	<u>Aqueous volatilization:</u> est. 1 hr for model river, 5 days for model lake, and 30 days for model pond (includes sediment adsorption) <u>Air photooxidation</u>: 1 day		sweet aromatic odor			
Methylnaphthalene	140 [0.0198% by wt]	0.0700	0.140	142.19	241	24.6	0.0677	4.91	5.17×10^{-4}	1.025	3.86	<u>Aqueous volatilization:</u> est. 5.5 hrs for model river, 5.3 days for model lake, and 78 days for model pond (includes sediment adsorption) <u>Air photooxidation</u>: 7.4 hrs	1 mg/m^3 = 0.17 ppm;	water: 0.023 ppm (range = 0.0025-0.17 ppm) TOC (detection) = 0.0075 mg/kg		24, 48, 72, 96-hr LC50 = 39, 9, 9, 9 mg/L in FHM (static); 48-hr LC50 in brown trout yearlings = 8.4 mg/L (static); BCF: 20 to 130 in coho salmon muscle, depending on length of exposure.	

Table C-13 Physical and Chemical Properties of Rotenone Formulation Constituents

Ingredient	Concentration in Formulation (µg/g)	Concentration in 0.5 mg/L Treatment (µg/L)[1]	Concentration in 1.0 mg/L Treatment (µg/L)[1]	MW (g/mol)	Boiling Pt (°C)	Water Solubility (mg/L @ 25°C)	Vapor Pressure (torr @ 25°C)	Vapor Density (Vd = PM/RT)[2]	Henry's Law Constant (atm-m³/mol)	Specific Gravity (g/mL)	Log Octanol/Water Partition Coefficient	Half-Lives[3]	Air Pollution Factors[4]	Odor Thresholds and Characteristics	Water Pollution Factors	Aquatic Toxicity Metrics	Toxicity to Other Receptors
Naphthalene	253 as reported in lab analyses (Fisher 2007)	0.127	0.253	128.6	217.9	31	0.23	4.42	4.83×10^{-4}		3.36	Aqueous volatilization: est. 3 hrs for model river and 5 days for model lake Aqueous photolysis: 71 hrs Aqueous biodegradation: 0.8-43 days Sediment: Degradation rates in sediment are 8-20 times higher than in the above water column. Biodegradation half-lives ranged from 2.4 weeks in sediments chronically exposed to petroleum hydrocarbons to 4.4 weeks in sediment from a pristine environment. Soil biodegradation: 2-18 days Air photooxidation: 18 hrs	1 mg/m³ = 0.191 ppm	water: 0.021 ppm air: 0.084 ppm			
Fennodefo 99™ ingredients (a mixture of tree resin components (polyethylene glycols, fatty acids and resin acids) that represents approximately 173,000 µg/g of CFT Legumine™)																	
Triethylene Glycol	326 as reported in lab analyses (Fisher 2007)	0.163	0.326	150.2	285	Easily soluble in cold water	<0.001 mm @ 20 degrees C	5.17		1.1@20C/4 C			1 ppm-6.14 mg/cu m	Practically odorless	BOD5: 0.03 NEN 3235-5.4, 1.4% of ThOD; BOD10: 0.50 std.dil.sew.; 10 days: 3.7% of ThOD; 15 days: 11.5% of ThOD; 20 days; 17.0% of ThOD: COD: 1.57 NEN 3235-5.3	LC50/ 96 hr values for fish are between 10 and 100 mg/l. Therefore, this material is expected to be slightly toxic to aquatic life.	LD 50 Oral mice, rats (g/kg): 21, 15-22; Toxicity threshold (cell multiplication inhibition test) in mg/l: bacteria (Pseudomonas putida): 320; alage (Microcystis aeruginosa): 3600; protozoa (Entosiphon sulcatum). Goldfish: 24 hr LD50=>5,000 mg/l; guppy: 7 d LC50: 62.600 ppm. Single oral doses LD50: Guinea pig: 14.6 g/kg; 7.9 ml/kg. Rat (repeated oral dose): no effect@3-4 g.kg/day, 30 days; Man: very low acute and chronic toxicity
Tetraethylene Glycol	1,304 as reported in lab analyses (Fisher 2007)	0.652	1.30	194.2	327	Fully miscible in water	0.001 mm @ 20 degrees C	6.7		1.12				Faint amine odor	BOD10: 0.50 std. dil.sew.		Rats: single oral LD50: 32.8 g/kg, and 28.9 ml/kg-1; Rabbit: skin LD 50>20,000 mg/kg
Pentaethylene Glycol	2,826 as reported in lab analyses (Fisher 2007)	1.41	2.83	238.3	338-340					1.126							
Hexaethylene Glycol	5,109 as reported in lab analyses (Fisher 2007)	2.55	5.11		217 @ 4 mm Hg	Fully miscible in water				1.127				Not determined			Oral Rat LD50: 32,000 mg/kg-1; Oral Guinea Pig: 20,000 mg/kg-1
"Tall Oil" is an byproduct of the Kraft process that is used to create pulp from wood and includes naturally-occurring fatty acids and resin acids that are widely used by the food, soap and other industries.	Unknown, butestimated to be ≤ 163,435 based on the Fennodefo 99™ content minus the summed concentration of ethyl,ene glycols	≤ 81.7	≤ 163		160-210 at 6.6 hPa	Virtually insoluble in water	Negligible at 25 deg C				4.89-5.98 at 25 deg C					Fish: Semistatic; 96 hour exposure; NOEC >=1000mg/L Invertebrates: (Crustacea); 48 hour exposure; NOEC>=1000mg/L Plants: (Algae); 72 hour exposure; NOEC>=1000mg/L	Oral: LD50, Rat @ 74000 mg/kg bw (Oleic) LD50 Rat @>3200 mg/kg bw (linoleic) LD50, Rat @ 7600 mg/kg bw (Rosin) Skin: Rabbit, Slight Irritant Eye: Rabbit, Slight irritant

Table C-13 Physical and Chemical Properties of Rotenone Formulation Constituents

Ingredient	Concentration in Formulation (µg/g)	Concentration in 0.5 mg/L Treatment (µg/L)[1]	Concentration in 1.0 mg/L Treatment (µg/L)[1]	MW (g/mol)	Boiling Pt (°C)	Water Solubility (mg/L @ 25°C)	Vapor Pressure (torr @ 25°C)	Vapor Density (Vd = PM/RT)[2]	Henry's Law Constant (atm-m^3/mol)	Specific Gravity (g/mL)	Log Octanol/Water Partition Coefficient	Half-Lives[3]	Air Pollution Factors[4]	Odor Thresholds and Characteristics	Water Pollution Factors	Aquatic Toxicity Metrics	Toxicity to Other Receptors
Abietic Acid	unknown			302.4	250 @ 9 mm Hg	insoluble											LC50 values to crustaceans: 6.2 mg/l=96 hr, *Nitocra spinipes*; LC50 values in fish: 0.56 mg/l=96 hr, *Salmo gairdneri*; 0.41 mg/l=96 hr, *Oncorhynchus kisutch*.
Beta-Pinene	unknown			136.2	167		2 mm Hg @ 20 degrees	4.7	0.049 mol/kg*bar								
Isopimaric Acid	unknown			302.5		26 mg/mL										LC50=0.4 mg/l for rainbow trout for isopimaric acid in lodgepole pine sapwood (Wang et al. 1995).	
Oleic Acid (112-80-1) <Tall Oil Partition>	unknown			282.5	360 deg C	Insoluble	1 mm Hg @ 177 deg C	9.7 (air=1)		0.895 (water=1)				Rancid odor (Lard like)		Fish: Fathead Minnow: LC50 = 205 mg/L; 96 Hr.; Static condition	LD50/LC50: Draize test, rabbit, eye: 100 mg Mild; Oral, mouse: LD50 = 28 gm/kg; Oral, rat: LD50 = 25 gm/kg; Human Skin Draize 15 mg/3D intermittent; REACTION: Moderate.
Linoleic Acid (60-33-3) <Tall Oil Partition>	unknown			280.4	229-230 deg C @ 16.00mm Hg	Insoluble				0.9020g/cm3					COD: 8.38% of ThOD BOD: 71% of ThOD	Invertebrate toxicity: EC50 (duration unspecified) purple sea urchin 0.28-1.07 mg/kg inhibited fertilization (Cherr et al. 1987).	Oral, mouse: LD50 = >50 gm/kg
Linolenic Acid (463-40-1) <Tall Oil Partition>	unknown			278.4	230-232 deg C @ 1 mm Hg	Insoluble		9.6									
Noxfish® and Nusyn Noxfish®																	
Rotenone	50,000 in Noxfish® and 25,000 in Nusyn Noxfish®	25.0	25.0														
Rotenolone	15,000	7.5	15														
Piperonyl butoxide	25,000 in Nusyn Noxfish®	Not applicable	25.0	338.45	180					1.509		Air: 3.4 hours; water 0.55 to 1.64 days; soil ≤ 4.3 days				Fish LC50 3.94 to 6.15 mg/L; Invertebrate LC50 0.23 to 0.51 mg/L	Rat oral LD50 4,570 to 12,800 mg/kg; mouse oral LD50 2,600 mg/kg; rabbit oral LD50 2,700 to 5,300 mg/kg
Trichloroethene (Trichloroethylene)	73	0.0365	0.0730	131	87	1,100	75	4.53	0.0103	1.4642 @ 20°C / 4°C	2.71	Aqueous volatilization: est. 3.5 hrs for model river, 5 days for model lake Aqueous hydrolysis: 10.7 months Air photooxidation: 7 hrs	1 mg/m^3 = 0.186 ppm	water: 10 ppm air: 50 ppm, disagreeable above 200 ppm			
Toluene	1,800	0.900	1.80	92.13	110.6	56.2	30	3.1	0.00664	0.8636 @ 20°C / 4°C	2.75	Aqueous volatilization: est. 1 hr for model river and 4 days for model lake Water: 4 days (aerobic), 56 days (anaerobic) Uncontaminated estuarine: 90 days Soil biodegradation: several hrs to 71 days Air photooxidation: 3 days	1 mg/m^3 = 0.265 ppm	water: 0.04 ppm air: 2.14 ppm			LD50 (rats) 7.53 g/kg

Table C-13 Physical and Chemical Properties of Rotenone Formulation Constituents

Ingredient	Concentration in Formulation (µg/g)	Concentration in 0.5 mg/L Treatment (µg/L)[1]	Concentration in 1.0 mg/L Treatment (µg/L)[1]	MW (g/mol)	Boiling Pt (°C)	Water Solubility (mg/L @ 25°C)	Vapor Pressure (torr @ 25°C)	Vapor Density (Vd = PM/RT)[2]	Henry's Law Constant (atm-m³/mol)	Specific Gravity (g/mL)	Log Octanol/Water Partition Coefficient	Half-Lives[3]	Air Pollution Factors[4]	Odor Thresholds and Characteristics	Water Pollution Factors	Aquatic Toxicity Metrics	Toxicity to Other Receptors
1,3- and/or 1,4-Xylene (m-/p-xylene)	610	0.305	0.610	106		185	9.5	3.7	0.00766	0.86104 @ 20°C / 4°C	3.20	*1,3-xylene* Aqueous volatilization: est. 3 hrs for model river and 4 days for model lake Air photooxidation: 16 hrs *1,4-xylene* Aqueous volatilization: est. 3 hrs for model river and 4.1 days for model lake Air photooxidation: 27 hrs	1 mg/m³ = 0.23 ppm	mixed isomers: water: 0.53 ppm air: 0.102 ppm			
1,2-Xylene (o-xylene)	76	0.0380	0.0760	106	144	178	7	3.7	0.00519	0.8801 @ 20°C / 4°C	3.13	Aqueous volatilization: est. 3.2 hrs for model river and 4.1 days for model lake Air photooxidation: 1.2 days	1 mg/m³ = 0.23 ppm	mixed isomers: water: 0.53 ppm air: 0.102 ppm			
Isopropylbenzene	52	0.0260	0.0520	120	153	61.3	4.6	4.1	0.0131	0.862 @ 20°C / 4°C	3.50	Aqueous volatilization: est. 1.2 hrs for model river and 4.4 days for model lake Air photooxidation: 2.5 days		detection: 0.008 ppm recognition: 0.047 ppm			
1-Propylbenzene (n-Propylbenzene)	310	0.155	0.310	120	158	23.4	2.5	4.14	0.00659	0.862 @ 20°C / 4°C	3.60	Aqueous volatilization: est. 1 hr for model river and 4 days for model lake Air photooxidation: 2 days					
1,3,5-Trimethylbenzene	860	0.430	0.860	120.19	164.7	48.2	2.4	1.006 @ 20°C	0.147	0.865	4.00	Aqueous volatilization: est. 3 hrs for model river, 4 days for model lake, and 5 days for model pond (includes sediment adsorption) Air photooxidation: 7 hrs	1 mg/m³ = 0.203 ppm; 0.4% of emitted hydrocarbons from diesel engines	Avg recog.: 0.027 mg/L Range: 0.00024-0.062 mg/L;	BOD: 3% of Theoretical Oxygen Demand (ThOD) COD: 10% of ThOD	96 hr median threshold limit = 13 mg/L (goldfish, flow-through)	
1,2,4-Trimethylbenzene	10,000	5.00	10.0	120	169	57	2.1	4.15	0.00616	0.8761 @ 20°C / 4°C	3.78	Aqueous volatilization: est. 3 hrs for model river and 4 days for model lake Air photooxidation: 12 hours	1 mg/m³ = 0.203 ppm				
1-Butylbenzene (n-Butylbenzene)	9,000	4.50	9.00	134	183	14	1	4.62	0.0883	0.860	4.03	Aqueous volatilization: est. 3.5 hrs for model river, 4.6 days for model lake, and 16 days for model pond (includes sediment adsorption) Air photooxidation: 1.8 days					

Table C-13 Physical and Chemical Properties of Rotenone Formulation Constituents

Ingredient	Concentration in Formulation (μg/g)	Concentration in 0.5 mg/L Treatment (μg/L)[1]	Concentration in 1.0 mg/L Treatment (μg/L)[1]	MW (g/mol)	Boiling Pt (°C)	Water Solubility (mg/L @ 25°C)	Vapor Pressure (torr @ 25°C)	Vapor Density (Vd = PM/RT)[2]	Henry's Law Constant (atm-m^3/mol)	Specific Gravity (g/mL)	Log Octanol/Water Partition Coefficient	Half-Lives[3]	Air Pollution Factors[4]	Odor Thresholds and Characteristics	Water Pollution Factors	Aquatic Toxicity Metrics	Toxicity to Other Receptors
4-Isopropyltoluene (p-Isopropyltoluene)	1,000	0.500	1.00	134	177	16.8	1.75	4.62	0.0183	0.8610 @ 20°C / 4°C	4.16	Aqueous volatilization: est. 1 hr for model river, 5 days for model lake, and 30 days for model pond (includes sediment adsorption) Air photooxidation: 1 day		sweet aromatic odor			
Naphthalene	70,000 (EPA method 8260) 28,000 (EPA method 8270)	35.0 (EPA 8260)	70.0 (EPA 8260)	128.6	217.9	31	0.23	4.42	4.83 x 10^{-4}	1.162	3.36	Aqueous volatilization: est. 3 hrs for model river and 5 days for model lake Aqueous photolysis: 71 hrs Aqueous biodegradation: 0.8-43 days Sediment: Degradation rates in sediment are 8-20 times higher than in the above water column. Biodegradation half-lives ranged from 2.4 weeks in sediments chronically exposed to petroleum hydrocarbons to 4.4 weeks in sediment from a pristine environment. Soil biodegradation: 2-18 days Air photooxidation: 18 hrs	1 mg/m^3 = 0.191 ppm	water: 0.021 ppm air: 0.084 ppm			
Potassium permanganate neutralizing compound for rotenone																	
Potassium permanganate	100% (applied at 4x rotenone concentration	2 mg/L	4 mg/L	158		64,000 (20°C)	Na	na	na	na				odorless		96-hr LC50: 3.6 mg/L (goldfish) 0.75 mg/L (channel catfish) 96-hr LD50: 2.7-3.6 mg/L (bluegill)	Oral LD50 (single dose): Guinea pig: 810 mg/kg Mouse: 750 mg/kg Rat: 750 mg/kg

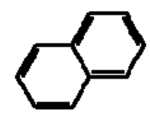
[1] CFT Legumine™ can be applied at either 0.5 mg/L or 1.0 mg/L; Noxfish® is applied only at 0.5 mg/L and Nusyn Noxfish® is applied only at 1.0 mg/L

C.3.5.1.2 NOXFISH®

In contrast to CFT Legumine™, the inert and carrier chemicals for Noxfish® consist of the PAH naphthalene, numerous alkylated benzenes, and trichloroethene. These chemicals are moderately soluble in water, with aqueous solubilities ranging from 14 to 1,100 mg/L (NLM 2006). K_{oc} values range from 94 to 3,200 L/kg, suggesting that these chemicals may also tend to adsorb to sediment particulates, thus increasing their half-lives in natural waterbodies (NLM 2006). The half-lives for these chemicals in surface water bodies range from several hours to several months, depending on the characteristics of the waterbody (i.e., temperature, flow velocity, turbulence, etc.), as well as the amount of sunlight on the water surface. With Henry's Law constants ranging from 0.00048 to 0.15 atm-m^3/mol, the primary removal mechanism from surface water for these carrier chemicals is volatilization, with direct photooxidation, hydrolysis and biodegradation contributing to a much smaller degree. Once in the ambient air, chemical vapors are readily degraded by reaction with photochemically-produced hydroxyl radicals. The chemical-specific half-lives for this reaction in air range from a few hours to a few days (NLM 2006). Naphthalene comprises slightly less than 50% of the NoxFish® formulation by weight (see Table C-13). This PAH, which gives moth balls their distinctive odor, has an odor threshold in air of 0.084 ppm, or 0.44 mg/m^3.

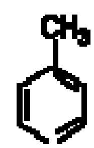
NAPHTHALENE

- Approximate concentration in Noxfish® formula: 70,000 mg/L
- Toxicology: MOUSE ORAL LD50: 533 mg/L
- Chemical formula: C10H8
- Chemical structure:



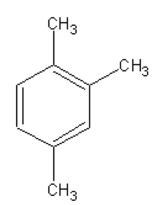
TOLUENE

- Approximate concentration in Noxfish® formula: 1,800 mg/L
- Toxicology: MOUSE ORAL LD50: 636 mg/kg
- Chemical formula: C_7H_8
- Chemical structure:



1, 2, 4-TRIMETHYLBENZENE

- Approximate concentration in Noxfish® formula: 10,000 mg/L
- Toxicology: MOUSE ORAL LD50: 5,000 mg/kg
- Chemical formula: C_9H_{12}
- Chemical structure:



C.3.5.2 Fate, Transport and Toxicity of Proposed Rotenone Formulation Constituents and Potassium Permanganate Neutralization Solution

C.3.5.2.1 REVIEW OF ROTENONE DISPERSANT FATE AND TOXICITY FROM FIELD STUDIES CONDUCTED OUTSIDE PROJECT AREA

Surface and groundwater near California lakes and streams treated with liquid and powdered rotenone formulations have been monitored after ten treatment projects since 1987 (Finlayson et al. 2001, McMillin and Finlayson 2008). They determined that all measured concentrations of dispersant ingredients were well below USEPA drinking water standards. For example, TCE concentrations never exceeded the USEPA drinking water standard (Maximum Contaminant Level [MCL]) of 5 μg/L. Similarly, xylene concentrations of xylene never exceeded the drinking water standard (Health Advisory) of 620 μg/L (WDFW 2002). No drinking water standards exist for naphthalene and methylnaphthalenes; however, these VOCs and semivolatile organic compounds (SVOCs) disappeared before rotenone dissipated, typically within one to three weeks.

The physico-chemical properties of the VOCs and SVOCs in the rotenone formulations do not promote accumulation or persistence in sediment. Finlayson et al. (2001) reported that rotenone, rotenolone and only two SVOCs (naphthalene and methylnaphthalene) were detected above detection limits (30 µg/kg-dry wt for rotenone and rotenolone, and 6 µg/kg for the VOCs and SVOCs. In standing water sediments from these nine study sites, rotenone and rotenolone were detected a maximum of 60 days, with maximum concentrations of 522 and 890 µg/kg-dry weight, respectively. No VOCs (e.g. xylene, TCE) were ever detected in either flowing or static water sediments. The only SVOCs detected in lake sediments were naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene. Detectable concentrations of these SVOCs were measured up to 180 days after treatment in standing water sediments, with maximum concentrations of 91 and 231 µg/kg for naphthalene and methylnaphthalene, respectively.

The rotenone formulation used at Lake Davis, California in 1997, contained several VOCs and SVOCs (USEPA 2006). These chemicals included naphthalene, methyl naphthalene, toluene, and xylene. Additionally, TCE, a chemical used to extract rotenone from plant tissues has also been reported. In addition to these compounds, formulated end-products may also contain varying amounts of cube root resin (rotenoloids such as rotenololone) and the extent of their toxicity is uncertain. However, toxicity testing with formulated end products suggests that, in general, co-formulants do not substantially affect the toxicity of rotenone based on reported distributions of acute 96 hr LC50 values among different species (USEPA 2006). Based on these results, the distribution of species sensitivities observed in laboratory tests represents the distribution of sensitivities likely encountered in the environment.

The Minnesota Department of Health conducted a risk assessment of the inert ingredients in Nusyn-Noxfish® for the Minnesota Department of Natural Resources. Their assessment reported August 7, 1991, stated that "There is negligible risk to human health from the contaminants found in rotenone whether the exposure is from drinking, swimming or eating fish from treated waters (as cited in WDFW 2002). In addition, they determined that treatment with rotenone will introduce contaminants into the lake, but at concentrations considerably lower than the levels that would harm human health" (WDFW 2002).

As part of the re-registration process USEPA (2006) conducted a review of the available toxicity data on all formulated products of rotenone and the formulation ingredients typically evaluated. However, only limited toxicity data were available on the inert ingredients. The evaluation of both technical grade rotenone (>95% active ingredient) and formulated end-product determined that the technical grade active ingredient is generally more toxic than formulated end-product [corrected for active ingredient] by at least a factor of 2 (USEPA 2006). These data suggest that for the formulated products tested and the toxicity endpoints measured, the dispersant ingredients do not contribute substantially to the toxicity of the active ingredient and are effectively inert.

In addition, USEPA (2006) suggested that the similarly structured rotenolones of plant resins (cube root resins) contained in varying amounts in formulated end-products also do not contribute substantially to the toxicity of rotenone. Rotenolone persists longer than rotenone, especially in cold, alpine lakes; rotenolone has been detected for as long as 6 weeks in cool water temperatures (<10°C) at high elevations (>8,000 feet). In part, this occurs because rotenone may be more susceptible to photolysis than rotenolone (Finlayson et al. 2000). However, studies have indicated that rotenolone is approximately one-tenth as lethal as rotenone (CDFG 1991 as cited in Finlayson et al. 2000). In those rare cases of rotenolone persistence, fish restocking would be delayed until both rotenone and rotenolone residues have declined to below detection limits (<2 ppb) to err on the side of safety (Finlayson et al. 2000). Table C-14 summarizes available toxicity information for the inert ingredients identified in the rotenone formulations proposed for Silver King Creek.

C.3.5.2.2 POTASSIUM PERMANGANATE NEUTRALIZING SOLUTION

Potassium permanganate ($KMnO_4$) is a strong oxidizing agent used in many industries and laboratories. It is used as a disinfectant in treating potable water. In fisheries and aquaculture, Potassium permanganate is used to treat some fish parasites. Under the proposed Action, Potassium permanganate would be used to neutralize rotenone (USEPA 2006, Ling 2003). Following rotenone application, Potassium permanganate is applied to the treated water at a ratio between two and four parts Potassium permanganate to each part of rotenone (USEPA 2006). Under the proposed Action, the potassium permanganate concentration may range from 2 to 4 mg/L depending on the organic load in the receiving water at the time of treatment.

Manganese is the principal element in the permanganate solution with potential toxicity. However, manganese is also an essential nutrient for plants and animals, and specific signs of manganese deficiency include a wide range of symptoms including nervous system disorders, bone fragility, and growth suppression (Browning 1961). Manganese comprises about 0.1% of the earth's crust and is ubiquitous in the environment (rock, soil, water). Potassium permanganate is produced by thermal oxidation of manganese dioxide (MnO_2) followed by electrolytic oxidation. The environmental chemistry and fate of manganese is controlled largely by pH. At pH values above 5.5 (approximately), colloidal manganese hydroxides generally form in water. Such colloidal forms are not generally bioavailable. As a strong oxidizing agent, permanganate is reduced when it oxidizes other substances (such as rotenone). Thus, in the process of oxidizing rotenone, Potassium permanganate is in turn reduced, liberating bioavailable oxygen in the process. This mechanism counters rotenone's respiratory toxicity. In the process, potassium ions are liberated (also an essential electrolyte), and manganese dioxide is formed. Manganese dioxide is insoluble, hence not bioavailable, and chemically similar to the MnO_2 found in the earth's crust (Vella 2006).

Table C-14 Aquatic and Terrestrial Toxicity Data for Inert Ingredients Present in Proposed Rotenone Formulations

Ingredient	Toxicity to Aquatic Receptors	Toxicity to Terrestrial Receptors			
		Acute ORAL LD50	IHL LC50 /IPR/IVN LD50	Acute Dermal LD50	Other
Rotenone	See rotenone information				
Rotenolone	Not Available	Not Available	Not Available	Not Available	Not Available
Piperonyl butoxide	Fish LC50s 3.94 to 6.12 mg/L;invertebrate LC50s 0.23 to 0.51 mg/L	Rat LD50s 4,570 to 12,800 mg/kg; Rabbit LD50s 2,700 to 5,300 mg/kg	Rat acute inhalation LD50 >5,900 mg/L	Rat LD50 7,960 to 13,500 mg/kg; rabbit LD50 2,650 to 5.300 mg/kg; mouse LD504,030 mg/kg	
Methyl pyrrolidone (*aka* n-methylpyrroli)		RAT: 3,914 mg/kg MUS: 7,725 mg/kg	IPR-RAT LD50: 2,472 mg/kg IVN-RAT LD50: 2,266 mg/kg	RBT: 8,000 mg/kg	Typical LTEL: 25 ppm. AIHA Workplace environmental exposure level: 10 ppm (8h).
Diethylene glycol ethyl ether	24h LC50: 5,000 mg/L (Goldfish, static). 96h LC50: >10,000 mg/L (*Menidia beryllina*, static)	RAT: 8,690-9,740 mg/kg GPIG: 3,670-4,970 mg/kg			CAT: 1 ml/kg (lethal) RAT NOEL: 490 mg/kg (repeat oral dose) RBT, CAT, GPIG, MUS inhalation: no injury with 12d exposure to saturated vapor.
Fennodefo 99™	As "tall oil" 96 Hr fish NOEC ≥ 1,000 mg/L; 48 hr crustacean NOEC ≥ 1,000 mg/L; algae 72 hr NOEC≥ 1,000 mg/L	Rat LD50 74,000 mg/kg (oleic acid); Rat LD50 3,200 mg/kg (linoleic acid); Rat LD50 7,600 mg/kg (rosin);		Rabbit, slight irritant	Slight irritant to rabbit eye
1,3,5 trimethylbenzene (aka mesitylene)			IHL-RAT: 24 mg/m^3 (4h)		Typical STEL: 35 ppm.
Sec-butylbenzene			IHL-RAT: >1,900 mg/kg	RBT: >13,000 mg/kg	Eye irritation reactivity [EIR] in MAN @ 1.8
n-butylbenzene	Unknown	Unknown	Unknown	Unknown	EIR in MAN: 6.4
p-isopropyltoluene (*aka* p-cymene)		RAT: 3,669-4,750 mg/kg	IHL-MUS: 19,500 mg/m^3		RBT (Moderate skin irritation): 500 mg (24h).
Methyl napthalene (*aka* 1-Methylnapthalene)	24, 48, 72, 96h LC50: 39, 9, 9, 9 mg/L in FHM (static). 48h LC50: 8.4 mg/L in B. trout yearlings (static). BCF: 20-130 in Coho salmon muscle, depending on exposure time.	RAT: 1,840 mg/kg			RBT-SKIN-LDLO (lowest recorded lethal dose): 7,500 mg/kg.

Table C-14 Aquatic and Terrestrial Toxicity Data for Inert Ingredients Present in Proposed Rotenone Formulations

Ingredient	Toxicity to Aquatic Receptors	Toxicity to Terrestrial Receptors			
		Acute ORAL LD50	IHL LC50 /IPR/IVN LD50	Acute Dermal LD50	Other
Napthalene	96h LC50: 305.2 ppm (Trout)	MUS: 533 mg/kg RBT: 3,000 mg/kg	IVN-MUS: 100 mg/kg		Rat LOAEL 10 mg/kg bw/day LDLO (lowest published lethal dose) for Child: 100 mg/kg (ORAL) LDLO for human: 29 mg/kg (unknown entry). Threshold Limit Value (TLV): 10 ppm. RBT (Mild skin irritation): 100 mg. RBT (Mild eye irritation): 495 mg.
n-methyl-2-pyrrolidone	See Toxicity data for Methyl Pyrrolidone				
Di ethyl ether		RAT: 1,215 mg/kg MAN-LDLO: 260 mg/kg	IHL-MUS: 31,000 ppm (0.5h)		Human eye irritation: 100 ppm. RBT (Mild Skin irritation): 360 mg GPIG (Severe skin irritation): 30 mg/24h.
Ethylene glycol		RAT: 4,700 mg/kg HUMAN-LDLO: 786 mg/kg	IPR-MUS: 5,614 mg/kg		
Trichloroethylene		RAT: 7,193 mg/kg HUMAN-LDLO: 7,000 mg/kg	IPR-DOG: 1,900 mg/kg IVN-MUS: 34 mg/kg IHL-HUMAN-TCLO: 6,900 mg/m^3 (10 mins) (Lowest Published Toxic Concentration). IHL-MAN-LCLO: 2,900 ppm		Typical STEL: 150 ppm Typical LTEL: 100 ppm
Toluene		RAT: 636 mg/kg RAT: 2,600-7500 mg/kg HUMAN-LDLO: 50 mg/kg	IPR-RAT: 1,332 mg/kg IPR-MUS: 59 mg/kg IHL-RAT: 8,000 ppm (4h) IHL-Unspecified Mammal species: 30 g/m^3		RBT (Mild Skin irritation): 435 mg. Human eye irritation: 300 ppm.
Ethylbenzene	LC50 (96h): Trout: 4.2 mg/L FHM: 12.1mg/L Guppy: 9.9 mg/L Bay Shrimp: 0.490 mg/L Crab: 13 mg/L	RAT: 3,500 mg/kg	IHL-GPIG-LCLO: 10,000 ppm.	RBT: 17800 mg/kg	RBT (Mild Skin irritation): 15 mg (24h).
M xylene		RAT: 5,000 mg/kg			Typical PEL (prolonged exposure limit): 100 ppm.

Table C-14 Aquatic and Terrestrial Toxicity Data for Inert Ingredients Present in Proposed Rotenone Formulations

Ingredient	Toxicity to Aquatic Receptors	Toxicity to Terrestrial Receptors			
		Acute ORAL LD50	IHL LC50 /IPR/IVN LD50	Acute Dermal LD50	Other
P xylene		RAT: 5,000 mg/kg	IPR-RAT-LDLO: 2,000 mg/kg		Typical PEL (prolonged exposure limit): 100 ppm
O xylene		RAT: 4,000 mg/kg	IPR-MUS: 1.5 ml/kg		Typical STEL: 150 ppm
Isopropyl benzene (*aka* cumene/cumol)		RAT: 1,400 mg/kg	IHL-RAT: 8,000 ppm (4h)	RBT: 12300 mg/kg	Typical TLV/TWA: 50 ppm
n-propylbenzene (*aka* propylbenzene)		RAT: 6,040 mg/kg			
1,2,4-trimethylbenzene		RAT: 5,000 mg/kg	IHL-MUS: 8,147 ppm IPN-RAT-LDLO: 2,000 mg/kg IPN-GPIG-LDLO: 1,566 mg/kg		

After treating rotenone, permanganate is reduced and does not persist in the environment. According to a recent American Water Works Association survey, permanganate is commonly used (second only to chlorine) as a pre-treatment method for removing organic contaminants such as naphthalene and tetrachloroethene (TCE) in potable groundwater wells (as cited in Vella 2006). In groundwater, it controls iron, manganese, sulfides and color, and it can also be used to reduce high concentrations of radionuclides and arsenic by forming insoluble colloids. Potassium permanganate is also used in drinking water treatment plants to control taste and odor problems.

Potassium permanganate is considered moderately to highly toxic to aquatic organisms. Like rotenone, its toxicity differs among species. It may present a hazard to aquatic vertebrates during application. USEPA (2006) reported toxicity at concentrations of 1 to 2 ppm. However, this range of concentrations is also within the therapeutic range for treating fish diseases. Indeed therapeutic doses range from 2 to 25 ppm depending on the time prescribed for treatment (i.e., prolonged bath versus dip treatments). A 4 ppm concentration is generally recommended for "permanent bath" treatments of external parasites (Cross and Needham 1988). In a permanent bath, concentrations would not be reduced by flushing and degradation would occur through natural oxidative processes—generally within 1 to 4 days. Marking and Bills (1976) demonstrated that its toxicity was inversely proportional to water temperature for both rainbow trout and channel catfish. It is more toxic in hard water, potentially due to precipitation of manganese dioxide on fish gills. Although not as well studied, potassium permanganate is also considered toxic to aquatic invertebrates and zooplankton although, as with vertebrates, there is likely to be a wide tolerance range between various freshwater invertebrates.

C.4 EXPOSURE ASSESSMENT

C.4.1 Estimated Exposure Point Concentrations (EPC)

The exposure point concentration (EPC) represents the concentration in the exposure media to which ecological receptors would be exposed in the treatment area. The EPC experienced by a receptor would differ depending on the exposure media (i.e., air, water, food, and sediment), habitat use, the amount of time spent in the available habitat, and by application rate. For the proposed Action and alternatives (excluding the No Action alternative), the Agencies propose to use a rotenone application of CFT Legumine™, Noxfish®, or Nusyn-Noxfish® at a concentration from 0.5 mg/L up to 1 mg/L. The concentration of potassium permanganate (the oxidizing agent) shall be applied to Silver King Creek downstream of the study area at a concentration up to 2 to 4 mg/L in the receiving waters.

C.4.1.1 Surface Water

To estimate EPCs in surface water, this assessment assumed that Noxfish®, CFT Legumine™, and Nusyn-Noxfish® would be applied by 5 gallon drip cans with a certain amount of diluted product that would be fully mixed in the streamflow. Estimated water concentrations of each constituent are presented in Table C-13.

C.4.1.2 Air

Ambient air samples were collected before and during the application of rotenone to Lake Davis in 2007 for pike elimination. The sampling methods were constructed to monitor for rotenone (the active ingredient), MP (water soluble solvent for rotenone), and naphthalene (odiferous, but minor constituent of applied technical material). Background samples were collected prior to application of the rotenone to the lake. Results of the sampling indicated that no rotenone above the detection limit (3 ng/m^3) was found at any of the sample sites. No MP above the detection limit (150 ng/m^3) was found at any of the sites. Low levels of naphthalene were detected at the sample sites. Since naphthalene is a known byproduct of combustion, particularly diesel oil combustion and other petroleum based activities and is known to already exist in ambient air, measureable amounts would be expected. Although some of the naphthalene levels increased after rotenone application activities began, these slightly elevated levels could be attributed to the increase of motor vehicle and boat traffic in the area. Urban levels of naphthalene, as measured by USEPA, can range between 300 ng/m^3 and 700 ng/m^3. All naphthalene levels detected in the samples were below the 300 ng/m^3 level. The VOC results from the sample collected at the fire station site indicate a higher level of combustion products as compared to the other samples. The 1,2-dichloroethane and dichloromethane concentrations were also elevated at this site in comparison with the other sample sites (Cal/EPA, Air Resources Board 2007). Overall, the monitoring data collected indicate that no appreciable increase in rotenone, MP, naphthalene, and VOC levels were attributable to activities associated with the Lake Davie rotenone project.

C.4.1.3 Groundwater

Terrestrial ecological receptors are not exposed to groundwater, thus direct exposure to groundwater or ingestion were considered incomplete pathways. Benthic macroinvertebrates may be exposed to very shallow groundwater at the sediment-water interface. However, this assessment assumed that because rotenone would be applied to the overlying surface water, any exposure from groundwater would be insignificant.

C.4.2 Ecological Exposure Estimates

This section presents the ecological exposure parameters used to estimate doses of rotenone and formulation constituents. Exposures are based on the complete and potentially significant exposure pathways identified in the conceptual model (see Figure C-1). The species selected for the exposure assessment use the treatment area for all or a portion of their life history. For the initial screening of exposure and risks, average weights, surface areas, and daily consumption rates were used to represent exposure. If the calculated HQ equaled or exceeded a level of concern (LOC) (as outlined in Table C-8) then the initial screening would be considered positive (potentially significant exposure) and a more detailed risk characterization step completed.

C.4.2.1 Ecological Receptor Exposure Factors

Table C-15 summarizes the exposure factors used to calculate estimated doses for ecological receptors, such as body weight and food ingestion rate, for the selected surrogate species. These exposure factors were obtained from the Wildlife Exposure Handbook (USEPA 1993) or from Sample et al. (1996). When species-specific data for food and water intake were not found in these compendia, allometric equations were utilized to estimate the rates of food and/or water ingestion for the receptor species in the same guild.

Allometric equations, used extensively in biological sciences, correlate food and water intake to body weight and are documented in Sample et al. (1996) and the USEPA Wildlife Exposure Factors Handbook (1993). Separate equations were used for mammals and birds, as documented below.

Food ingestion rate (mammals):

$$Y = 0.235(Wt)^{0.822}$$

Food ingestion rate (birds):

$$Y = 0.648(Wt)^{0.651}$$

Where:

Y = food ingestion rate (g/day)

Wt = representative body weight (g) of a mammalian/avian receptor.

Water ingestion rate (mammals):

$$WI = 0.099(Wt)^{0.90}$$

Water ingestion rate (birds):

$$WI = 0.059(Wt)^{0.67}$$

Where:

WI = water ingestion rate (L/d)

Wt = representative body weight (kg) of a mammalian/avian receptor.

Dosage estimates were developed in more detail by providing additional input parameters - see Equation [3].

EQUATION 3

Dose = (SUF(IR[food]*C[food]) + (IR[water]*C[water]) + (IR[sed]*C[sed]*AE))/BW   Equation [3]

Where:

SUF = Site Use Factor of Habitat Area (percent); SUF = 1 for this assessment

IR = consumption (i.e., intake) rate of [media: food, water, or sediment]

C = concentration of contaminant in [media: food, water, sediment]

AE = assimilation efficiency of contaminants in consumed soil or sediment

BW = Body Weight

Table C-15 Exposure Factors for Wildlife Used to Assess Risks from Rotenone Use in Silver King Creek Project Area

Species	Adult Body Weight (g)	Daily Food Intake (g)	Daily Water Intake (ml)	Inhalation Rate (m^3/day)	Surface Area (cm^2)	Soil and Sediment intake (% of diet)	Relevant Life History Characteristics and Dietary Preference Relevant to Exposure	Conceptual Exposure Pathways (confirmed by uptake model results)
Northern bobwhite quail	190	19.5	19	F: 0.10 M: 0.11	F: 298 M: 320	9.3	Breeding in April-July; hatching May to August; Non-migratory; annual mortality rate of approx. 80% Diet: Plants and insects. Max insects 20% in summer	Unlikely for Rotenone application, but considered surrogate for non-water dependent bird species Primary: Food & Water Secondary: Incidental soil ingestion Tertiary: Inhalation of drift
Marsh wren	11.25	8	3	-	F: 45 M: 48	0	Breed in April; hatch in May; Migration in fall and spring. Diet: Insects, spiders, mollusks, and crustaceans.	Unlikely for Rotenone application, but considered surrogate for passerine bird species. Primary: Food – aquatic insects assumed Secondary: Water Tertiary: Inhalation of drift
Hairy woodpecker	60	9.2	9	-	-	0	Diet: Insects, fruits, berries and nuts.	Has the potential to occur within project area along with Williamson's sapsucker. Primary: Food & Water Secondary: Inhalation of drift
Bald eagle	3,750	450	139	F: 1.43 M: 1.19*	F: 2,970 M: 2,530*	5.9	Diet: Fishes, waterfowl, small mammals and carrion.	Has the potential to occur within project area. Primary: Food – fish assumed Secondary: Incidental soil ingestion Tertiary: Water
Mouse	21	2.8	7	F: .025 M: 023	F: 86 M: 91	2	Breed several times during the year. Diet: Mixture of nuts, seeds, and insects	Unlikely for Rotenone application, but considered surrogate for small mammal species. Primary: Water Secondary: Food & incidental soil ingestion Tertiary: Inhalation
Pygmy rabbit	450	49	48	-	-	6.3	Breed several times during the year Diet: Herbivorous: Grasses, shrubs, woody plants	Has the potential to occur within project area. Primary: Food & Water Secondary: Incidental soil ingestion Tertiary: Inhalation
California Wolverine	18,000	725	1,350	-	-	3.0	Large home range. Sighted in the project area. Breeding occurs during June-August. Diet: Carrion and intermediate sized vertebrates	Has the potential to occur within project area. Also used as surrogate for fisher. Primary: Food – fish assumed Secondary: Water & incidental soil ingestion Tertiary: Skin contact

Table C-15 Exposure Factors for Wildlife Used to Assess Risks from Rotenone Use in Silver King Creek Project Area

Species	Adult Body Weight (g)	Daily Food Intake (g)	Daily Water Intake (ml)	Inhalation Rate (m^3/day)	Surface Area (cm^2)	Soil and Sediment intake (% of diet)	Relevant Life History Characteristics and Dietary Preference Relevant to Exposure	Conceptual Exposure Pathways (confirmed by uptake model results)
Sierra Nevada Red Fox	4,530	237	428	F: 1.7 M: 2.0	F: 2760 M: 3220	2.8	Breeding in December – February Diet: Omnivorous: mostly small mammals, birds, insects, and fruit. Plant material is common in summer and fall diet.	Has the potential to occur within project area. Primary: Water Secondary: Food Tertiary: Incidental soil ingestion
Mule deer	75,470	2400	4,800	M: 30.05* F: 17.26	M: 28,468.5* F: 18,142.4	6.8	Breeding in June. Diet: Herbivorous: leaves and twigs of trees and shrubs. Acorns, legumes and fleshy fruits	Primary: Water Secondary: Food Tertiary: Incidental soil ingestion
Black bear	128,870	3900	7,800	M: 67.05* F: 43.19	M: 54,641.8* F:38,220.6	2.8	Hibernation period: 3-4 months during winter (January-April) Diet: Omnivorous: Grasses and forbes in spring, fruits in summer, nuts and acorns in fall, insects and beetles. Carrion.	Primary: Food — fish consumed Secondary: Water & incidental soil ingestion Tertiary: Inhalation
Yosemite Toad**	20	0.2	20	-	-	25	Aquatic habitat. Diet: Plankton and plant material as juveniles; insects as adults.	Primary: Water ingestion & dermal contact Secondary: Food & incidental soil ingestion Tertiary: Inhalation with drift
Mountain yellow-legged frog**	25	0.25	25	-	-	25	Aquatic habitat. Diet: Plankton and plant material as juveniles; insects as adults – adults may predate on Yosemite toad and its own young.	Primary: Water ingestion & dermal contact Secondary: Food & incidental soil ingestion Tertiary: Inhalation with drift

* Estimated

** Tadpole stages were not considered because they are unlikely to be present during late summer, the planned time period for the treatment

For Equation [4], the food concentration of contaminant was calculated using Equation [4]:

EQUATION 4

Concentration of Contaminant in Food:

For carnivores: C[food] = C[water] * BAF_f) + C[sed] * (percent of food contaminated)

For herbivores and hairy woodpecker: C[food] = C([water] * BAF_S of 1) + C[soil] * (percent of food contaminated)

Where:

Percent of food contaminated = 100%

C[water] = concentration calculated in Table C-13

C[soil] = C[water] * BAF_S of 1 (no loss to atmosphere)

$BAF_f = K_{oc}$ * 0.05 (general bioaccumulation model for nonpolar organic compounds into aquatic animals containing 5% lipid; Mackay 1982); For Rotenone a BAF_f of 20 was used (Rach and Gingerlich 1986)

C[sed] = C[water] * K_{oc}*0.01 (general equilibrium partitioning model for sediments containing 1% organic carbon VanLeeuwen et al 1992)

$K_{oc} = K_{ow} * 10^{-0.21}$ (Karikoff et al. 1979); K_{ow} values are listed in Table C-13

For this screening-level assessment, the following conservative exposure assumptions were used:

- The BAF (20 L/kg) published by Rach and Gingerlich (1986) was used for rotenone. For the inactive ingredients, BAFs for animal dietary matter were estimated based on a general equilibrium partitioning model for nonpolar inorganic compounds, assuming the aquatic animals contained 5% lipid (Mackay 1982). For vegetable dietary matter and soils that could inadvertently receive overspray during application, BAFs = 1 were used to estimate the concentrations of all ingredients.
- The SUF was assumed to be 100% (i.e., the receptor’s home range was assumed to be the same as the treatment area). A very conservative assumption for animals with broad home ranges, such as birds and mammals).
- The assimilation efficiency of ingredients contained in food, water or adsorbed to sediment was assumed to be 100%.
- Assumed 100% of the food was contaminated for all wildlife receptors. This assumption places a high (conservative) bias into the assessment because wildlife would almost certainly eat a variety of food items, including uncontaminated food items.
- Assumed that 100% of the water consumed by all receptors was contaminated at the maximum estimated concentration in Table C-13. This assumption places a high (conservative) bias into the assessment because it ignores losses from volatilization, photodegradation and other pathways that would decrease the concentrations of ingredients in Silver King Creek.
- No additive dose from inhalation.

C.4.2.2 Mammalian Wildlife Exposures

Mammalian wildlife can be exposed to rotenone and other formulation constituents through dermal, oral (ingestion of food and/or water) or inhalation routes. For this assessment, only ingestion routes (diet, water, and soils/sediment) were considered complete and potentially significant. Dermal exposure was determined either incomplete or insignificant. Exposures were modeled for 6 mammalian species: the Sierra Nevada red fox, California wolverine, pygmy rabbit, mouse, black bear, and mule deer. These wildlife species have been documented in the treatment area or have been the foundation for much of the toxicological effects literature (e.g. mouse).

C.4.2.3 Avian Exposure

Exposure for birds may occur via the same pathways as mammals: ingestion, dermal contact, and inhalation. To represent the range of dietary habits and life histories of birds occurring in the treatment area, ingestion exposure calculations were completed for Northern bobwhite quail, marsh wren, bald eagle, and hairy woodpecker. Direct contact was considered a potentially complete pathway, but an insignificant one because of protection from feathers. Of these species, the bald eagle and hairy woodpecker have the potential to occur in the treatment area. The Northern bobwhite quail was included based on availability of toxicity values while the marsh wren was included because it was considered representative of the life history of many passerines, has the potential to occur in the treatment area, and many toxicity data are available for the species.

C.4.2.4 Aquatic Animal Exposure

Exposure of fish and aquatic invertebrates to rotenone and formulation constituents in water would be a complete pathway. This exposure assessment assumed a maximum EPC to correspond to the concentration at full mixing in the stream (see Table C-13). Rotenone was assumed to be fully diluted to 25 ppb or 0.025 ppm (with a maximum concentration of 50 ppb or 0.05 ppm for the higher potential application rate). These concentrations were then compared to aquatic exposure TRVs. Given the sensitivity to rotenone of aquatic receptors, this exposure was considered “worst case” and exposure to other formulation constituents was not evaluated. In addition, because of the degree of direct exposure to water-borne rotenone, exposure to rotenone adsorbed to sediment was considered an insignificant exposure pathway.

C.4.2.5 Amphibian Exposure

Dermal contact is the most direct exposure pathway for amphibians and/or across the gills (i.e., for juvenile amphibians). Dietary uptake was also considered a complete pathway. Amphibians in the riparian and littoral zones could be sprayed directly if chemical is administered via backpack. However, because workers would not apply chemical to riparian and littoral vegetation and would avoid spraying amphibians, this exposure pathway was considered possible but insignificant. Because rotenone can elicit toxicity through dermal exposure and gill absorption, and because juveniles with gills are the most sensitive life stage of amphibians, exposure risks to amphibians were evaluated by comparing surface water EPCs to aquatic TRVs.

C.5 RISK CHARACTERIZATION

C.5.1 Wildlife Risks from Ingestion

Table C-16 presents estimated rotenone doses based on modeled food web exposure pathways and the most concentrated constituents in the rotenone formulations. HQ values below the LOC were considered to pose little or no risk, while values equal to or exceeding the LOC were considered to indicate a potential risk (refer to Table C-17 for the HQ values).

Table C-16 Estimated Ingestion Doses of Most Concentrated Rotenone Formulation Constituents from Combined Food, Water and Sediment Intake

		Rotenone	Diethylene Glycol Monoethyl Ether	1-Methyl-2-Pyrrolidinone	Fennodefo 99™	Rotenone	Naphthalene	Toluene	1,2,4 -Trimethylbenzene
Class	Species	*CFT-Legumine™ at 0.5 mg/L*				*Noxfish® at 0.5 mg/L*			
Avian	Bald Eagle	0.058	0.012	0.019	19.3	0.057	0.23	0.0015	0.087
	Bobwhite Quail	0.0026	0.031	0.0050	0.0087	0.0025	0.0035	0.000090	0.00050
	Marsh Wren	0.37	0.087	0.014	147	0.036	1.77	0.011	0.66
	Hairy Woodpecker	0.0038	0.046	0.0074	0.013	0.0038	0.0053	0.00014	0.00075
Mammalian	Red Fox	0.032	0.029	0.0047	10.9	0.031	0.13	0.00091	0.049
	California Wolverine	0.025	0.023	0.0037	8.4	0.024	0.10	0.00070	0.038
	Mule Deer	0.0016	0.019	0.032	0.0055	0.0016	0.0022	0.000057	0.00032
	Black Bear	0.019	0.019	0.0030	6.3	0.018	0.077	0.00053	0.029
	Mouse	0.0085	0.10	0.017	0.029	0.0083	0.012	0.00030	0.0017
	Pygmy Rabbit	0.0027	0.033	0.0053	0.0092	0.0027	0.0037	0.000096	0.00053
Amphibian	Yosemite Toad	0.035	0.31	0.050	2.3	0.035	0.061	0.0011	0.015
	Mountain Yellow-Legged Frog	0.035	0.31	0.050	2.3	0.035	0.061	0.0011	0.015

Class	Species	*CFT-Legumine™ at 1.0 mg/L (ppm)*				*Nusyn-Noxfish® at 1. 0 mg/L (ppm)*			
Avian	Bald Eagle	0.12	0.024	0.038	38.5	0.057	0.46	0.0030	0.17
	Bobwhite Quail	0.0051	0.061	0.0099	0.017	0.0025	0.0070	0.00018	0.0010
	Marsh Wren	0.74	0.17	0.027	294	0.36	3.5	0.023	1.3
	Hairy Woodpecker	0.0076	0.092	0.015	0.026	0.0038	0.011	0.00027	0.0015
Mammalian	Red Fox	0.064	0.059	0.0094	21.8	0.031	0.27	0.0018	0.099
	California Wolverine	0.050	0.046	0.0075	16.8	0.024	0.21	0.0014	0.076
	Mule Deer	0.0032	0.039	0.0063	0.011	0.0016	0.0045	0.00011	0.00064
	Black Bear	0.037	0.037	0.0060	12.6	0.018	0.155	0.0011	0.057
	Mouse	0.017	0.20	0.033	0.058	0.0083	0.023	0.00060	0.0033
	Pygmy Rabbit	0.0054	0.065	0.011	0.019	0.0027	0.0075	0.00019	0.0011
Amphibian	Yosemite Toad	0.071	0.61	0.099	4.5	0.035	0.12	0.0021	0.030
	Mountain Yellow-Legged Frog	0.071	0.61	0.099	4.5	0.035	0.12	0.0021	0.030

All doses as mg ingredient/kg body weight/day

Table C-17 Wildlife Hazard Quotients from Combined Food Water and Sediment Ingestion Exposure Pathways

Class	Species	Toxicity Text	Rotenone[a]	Diethylene Glycol Monoethyl Ether[b]	1-Methyl-2-Pyrrolidinone[c]	Fennodefo 99™ [g]	Rotenone [a]	Naphthalene [d]	Toluene[e]	1,2,4 Trimethylbenzene[f]	Level of Concern
			CFT-Legumine™ at 0.5 mg/L				*Noxfish® at 0.5 mg/L*				
Avian	Bald eagle	NOAEL	0.15	2.5×10^{-5}	1.9×10^{-6}		0.14	-	4.8×10^{-6}	-	1
		LOAEL	0.029	-	-		0.029	0.023	-	-	1
		LD50	0.00045	-	-	0.0060	0.00044	-	-	1.7×10^{-5}	0.1
	Bobwhite quail	NOAEL	0.013	1.3×10^{-4}	1.0×10^{-5}		0.0066	-	6.1×10^{-7}	-	1
		LOAEL	0.0027	-	-		0.0013	0.00074	-	-	1
		LD50	4.2×10^{-5}	-	-	1.0×10^{-5}	2.0×10^{-5}	-	-	2.1×10^{-7}	0.1
	Marsh wren	NOAEL	0.92	0.00018	1.3×10^{-5}		0.91	-	3.6×10^{-5}	-	1
		LOAEL	0.18	-	-		0.18	0.18	-	-	1
		LD50	0.0028	-	-	0.046	0.0028	-	-	0.00013	0.1
	Hairy Woodpecker	NOAEL	0.019	1.9×10^{-4}	1.5×10^{-5}		0.0094	-	8.8×10^{-7}	-	1
		LOAEL	0.0039	-	-		0.0019	0.0011	-	-	1
		LD50	5.9×10^{-5}	-	-	5.3×10^{-5}	2.9×10^{-5}	-	-	3.0×10^{-7}	0.1
Mammalian	Red Fox	NOAEL	0.080	6.0×10^{-5}	4.7×10^{-6}		0.078	-	5.8×10^{-6}	-	1
		LOAEL	0.016	-	-		0.016	0.027	-	-	1
		LD50	0.00081	7.9×10^{-6}	1.2×10^{-6}	0.0034	0.00079	0.00050	2.8×10^{-6}	2.0×10^{-5}	0.1
	Wolverine	NOAEL	0.062	4.7×10^{-5}	3.7×10^{-6}		0.061	-	4.5×10^{-6}	-	1
		LOAEL	0.012	-	-		0.012	0.21	-	-	1
		LD50	0.00063	6.3×10^{-6}	9.5×10^{-7}	0.0026	0.00062	0.00039	2.2×10^{-6}	1.5×10^{-5}	0.1
	Mule Deer	NOAEL	0.0062	6.1×10^{-5}	4.8×10^{-6}		0.0030	-	2.8×10^{-7}	-	1
		LOAEL	0.0012	-	-		0.00061	0.0034	-	-	1
		LD50	6.3×10^{-5}	8.1×10^{-6}	1.2×10^{-6}	1.7×10^{-6}	3.1×10^{-5}	6.4×10^{-6}	1.4×10^{-7}	9.7×10^{-8}	0.1
	Black Bear	NOAEL	0.047	3.8×10^{-5}	3.0×10^{-6}		0.046	-	1.7×10^{-6}	-	1
		LOAEL	0.0093	-	-		0.0091	0.0077	-	-	1
		LD50	0.00047	5.1×10^{-6}	5.7×10^{-7}	0.0020	0.00046	0.00015	8.3×10^{-7}	5.7×10^{-6}	0.1
	Mouse	NOAEL	0.030	0.00029	2.3×10^{-5}		0.015	-	1.4×10^{-6}	-	1
		LOAEL	0.0060	-	-		0.0029	0.0016	-	-	1
		LD50	3.4×10^{-5}	3.9×10^{-5}	5.9×10^{-6}	4.7×10^{-4}	1.7×10^{-5}	3.1×10^{-5}	6.6×10^{-7}	4.7×10^{-7}	0.1
	Pygmy Rabbit	NOAEL	0.014	1.4×10^{-4}	1.1×10^{-5}		0.070	-	6.4×10^{-7}	-	1
		LOAEL	0.0028	-	-		0.0014	0.00078	-	-	1
		LD50	3.8×10^{-5}	1.8×10^{-6}	2.8×10^{-6}	4.1×10^{-6}	1.9×10^{-6}	1.5×10^{-5}	3.1×10^{-7}	2.2×10^{-7}	0.1

Table C-17 Wildlife Hazard Quotients from Combined Food Water and Sediment Ingestion Exposure Pathways

Class	Species	Toxicity Text	Rotenone[a]	Diethylene Glycol Monoethyl Ether[b]	1-Methyl-2-Pyrrolidinone[c]	Fennodefo 99™ [g]	Rotenone [a]	Naphthalene [d]	Toluene[e]	1,2,4 Trimethylbenzene[f]	Level of Concern
Amphibian	Yosemite Toad	NOAEL	-	0.00062	4.9 x10^{-5}		-	-	3.4 x10^{-6}	-	1
		LOAEL	-	-	-		-	0.0061	-	-	1
		LD50	0.061	-	-	0.00071	0.60	-	2.8x10^{-6}	3.0 x10^{-6}	0.1
	Mountain Yellow-Legged Frog	NOAEL	-	0.00062	4.9 x10^{-5}		-	-	3.4 x10^{-6}	-	1
		LOAEL	-	-	-		-	0.0061	-	-	1
		LD50	0.061	-	-	0.00071	0.60	-	2.8x10^{-6}	3.0 x10^{-6}	0.1
			CFT-Legumine™ at 1.0 mg/L				*Nusyn-Noxfish® at 1.0 mg/L*				
Avian	Bald eagle	NOAEL	0.29	4.9 x10^{-5}	3.7 x10^{-6}		0.14	-	9.5 x10^{-6}	-	1
		LOAEL	0.058	-	-		0.029	0.046	-	-	1
		LD50	0.00090	-	-	0.012	0.00044	-	-	3.5 x10^{-5}	0.1
	Bobwhite quail	NOAEL	0.027	2.6 x10^{-4}	2.1 x10^{-5}		0.0013	-	1.2 x10^{-6}	-	1
		LOAEL	0.0054	-	-		0.0027	0.0015	-	-	1
		LD50	8.3 x10^{-5}	-	-	2.1 x10^{-5}	4.1 x10^{-5}	-		4.2 x10^{-7}	0.1
	Marsh wren	NOAEL	1.8	0.0012	0.0001		0.92	-	7.3 x10^{-5}	-	1
		LOAEL	0.37	0.00035	2.7 x10^{-5}-		0.18	0.35	-	-	1
		LD50	0.0057	-	-	0.092	0.0028	-	-	0.00026	0.1
	Hairy Woodpecker	NOAEL	0.039	0.00038	3.0 x10^{-5}		0.0019	-	1.8 x10^{-6}	-	1
		LOAEL	0.0077	-	-		0.0038	0.0021	-	-	1
		LD50	1.2 x10^{-4}	-	-	1.1 x10^{-4}	5.8 x10^{-5}	-	-	6.1 x10^{-7}	0.1
Mammalian	Red Fox	NOAEL	0.16	0.00012	9.4 x10^{-6}		0.078	-	5.8 x10^{-6}	-	1
		LOAEL	0.032	-	-		0.016	0.027	-	-	1
		LD50	0.0016	1.6 x10^{-5}-	2.4 x10^{-6}	0.0068	0.00079	0.00050	2.8 x10^{-6}	2.0 x10^{-5}	0.1
	Wolverine	NOAEL	0.12	9.5 x10^{-5}	7.5 x10^{-6}		0.061	-	4.5 x10^{-6}	-	1
		LOAEL	0.025	-	-		0.012	0.21	-	-	1
		LD50	0.0013	1.3 x10^{-5}	1.9 x10^{-6}-	0.0052	0.00062	0.00039	2.2 x10^{-6}	1.5 x10^{-5}	0.1
	Mule Deer	NOAEL	0.012	1.2 x10^{-4}	9.6 x10^{-6}		0.0061	-	5.6 x10^{-7}	-	1
		LOAEL	0.0025	-	-		0.0012	0.00068	-	-	1
		LD50	1.3 x10^{-4}	1.6 x10^{-5}	2.5 x10^{-6}	3.4 x10^{-6}	6.2 x10^{-5}	1.3 x10^{-5}	2.8 x10^{-7}	1.9 x10^{-7}	0.1
	Black Bear	NOAEL	0.093	7.6 x10^{-5}	6.0 x10^{-6}		0.046	-	3.4 x10^{-6}	-	1
		LOAEL	0.019	-	-		0.0091	0.015	-	-	1

Table C-17 Wildlife Hazard Quotients from Combined Food Water and Sediment Ingestion Exposure Pathways

Class	Species	Toxicity Text	Rotenone[a]	Diethylene Glycol Monoethyl Ether[b]	1-Methyl-2-Pyrrolidinone[c]	Fennodefo 99™ [g]	Rotenone [a]	Naphthalene [d]	Toluene[e]	1,2,4 Trimethylbenzene[f]	Level of Concern
		LD50	0.00094	1.0 x10^{-5}	1.5 x10^{-6}	0.0039	0.00046	0.00029	1.7 x10^{-6}	1.1 x10^{-5}	0.1
	Mouse	NOAEL	0.060	0.00058	4.6 x10^{-5}		0.029	-	2.7 x10^{-6}	-	1
		LOAEL	0.012	-	-		0.00059	0.0033	-	-	1
		LD50	6.8 x10^{-5}	7.8 x10^{-5}	1.2 x10^{-5}	9.4x10^{-4}	3.4 x10^{-5}	6.2 x10^{-5}	1.3 x10^{-6}	9.4 x10^{-7}	0.1
	Pygmy Rabbit	NOAEL	0.028	2.8 x10^{-4}	2.2 x10^{-5}		0.0014	-	1.3 x10^{-6}	-	1
		LOAEL	0.0057	-	-		0.0028	0.0016	-	-	1
		LD50	7.5 x10^{-6}	3.7 x10^{-5}	5.6 x10^{-6}	8.2 x10^{-6}	3.7 x10^{-6}	2.9 x10^{-5}	6.3 x10^{-7}	4.4 x10^{-7}	0.1
Amphibian	Yosemite Toad	NOAEL	-	0.0013	9.9 x10^{-5}		-	-	6.8 x10^{-6}	-	1
		LOAEL	-	-	-		-	0.012	-	-	1
		LD50	0.12	-	-	0.0014	0.060	-	-	5.9 x10^{-6}	0.1
	Mountain Yellow-Legged Frog	NOAEL	-	0.0013	9.9 x10^{-5}		-	-	6.8 x10^{-6}	-	1
		LOAEL	-	-	-		-	0.012	-	-	1
		LD50	0.12	-	-	0.0014	0.060	-	-	5.9 x10^{-6}	0.1

NOAEL: No observable adverse effect level.

LOAEL: Lowest observable adverse effect level.

LD50: The concentration of chemical leading to a 50% mortality of the test animals within a given time period.

- No data available.

Footnotes on Toxicity Reference Values (TRVs):

[a]The rotenone NOAEL value for all mammal and bird species was 0.4 mg/kg-bw/day. This value represents the lowest NOAEL value available for separate lab-based studies on rats and dogs. The rotenone LOAEL of 2/0 mg/kg bw/day is also based on a laboratory study for rats (USEPA 1988, USFWS 1980). The rotenone LD50 of 130 mf/kg bw/day for birds is based on nestling English sparrows (Cutcomp 1943). The LD50 for mammals of 39.5 mg/kg bw/day is based on a rat study. The LD50 for mice of 350 mg/kg bw/day is based on a mouse study (Kenaga and Allison 1971). The LD50 for rabbits of 1500 mg/kg bw/day is based on a rabbit study. The rotenone LD50 value for all amphibian species was 0.58 mg/kg. This value represents the lowest LD50 value available for lab-based studies on adult and larval amphibians.

[b]The Diethylene Glycol Monoethyl Ether NOAEL value for all species was 490 mg/kg-bw/day. This value represents the lowest NOAEL value available for lab-based studies on rats (see Table C-15). No reports on studies using different animal classes were available.

[c]The 1-Methyl-2-Pyrrolidinone NOAEL value for the Norway rat was 3000 mg/kg-bw/day based on lab rats. The 1-Methyl-2-Pyrrolidinone NOAEL value for all other species was 1000 mg/kg-bw/day. This value represents the lowest available NOAEL obtained from lab-based studies on mice (MSDS Number: B&J 0304, 2001). No data was available for amphibians.

[d]The Naphthalene LOAEL value for all mammal and bird species was 10 mg/kg bw/day (NTP 1992). This value represents the lowest TRV available for lab-based studies on rats. An LD50 value of 533 mg/kg bw/day from a mouse study was used for mammalian receptors.

[e]The Toluene NOAEL value for all mammal and bird species was 312 mg/kg-bw/day (NTP 1990). This value represents the lowest TRV value available and refers to a lab-based rat study. The lowest available LD50 of 636 mg/kg bw/day from a rat study was used for mammalian receptors. No data was available for amphibians.

[f]The 1, 2, 4–Trimethylbenzene LD50 value for all mammal and bird species was 5000 mg/kg-bw. This represents the acute 24 hr LD50 value for lab-based studies on rats. No data was available for amphibians.

[g]The Fennfodefo LD50 value of 3,200 mg/kg bw/day is based on the toxicity of linoleic acid on rats. This is the lowest LD50 for a "tall oil" component.

C.5.1.1.1 CFT LEGUMINE™

ROTENONE

Risks for rotenone were based on NOAELs and LOAELs for rats and dogs, the only sublethal literature values available for terrestrial species. These values were based on chronic (6-month) studies, which are very conservative for the brief exposures proposed. The NOAEL and LOAELs from mammals were applied across all species and were more conservative than species-specific LD50 values because they represented a more protective endpoint and a lower exposure concentration.

MAMMAL RISK

As demonstrated by the Hazard Quotient (HQ) summary (refer to Table C-17), none of the doses calculated for mammals exceeded LOCs. Most of the HQs, which are based on the NOAEL, were far less than 1. This indicates that risks to mammalian receptors from rotenone or insignificant.

AVIAN RISK

Rotenone is considered slightly to non-toxic to adult birds, based on the USEPA criteria outlined above. However, some studies indicate rotenone may be moderately toxic to nestlings (Cutcomp 1943). Most HQs for birds were all below LOCs (refer to Table C-17). The NOAEL-based HQ for wrens was exceeded for CFT Legumine™ applied at the 1.0 mg/L application rate; however, the LOAEL-based HQs were all far less than 1 for the avian species. All LD50-based HQs were far less than one. These results indicate that adverse affects to birds from the proposed Action are very unlikely.

AMPHIBIAN RISK

Rotenone is considered highly toxic to amphibians, based on USEPA criteria, particularly for juveniles. If present at the time of application, juveniles could be killed by the rotenone application through exposure across the skin and gills. Adult amphibians are more mobile and would be more capable of avoiding the treatment area. Modeled doses relative to the larval LD50 value resulted in HQs just above 0.1 for both amphibian species if CFT Legumine™ were applied at the 1.0 mg/L application rate, indicating risks are bordering on significant. Because amphibians are particularly sensitive to rotenone and the uncertainty inherent in the screening-level risk assessment approach (e.g. using LD50 values), and the potential for presence of sensitive life stages, risks to amphibians could be significant.

DIETHYLENE GLYCOL MONOETHYL ETHER (DEGEE)

As with rotenone, toxicology data for DEGEE were available for only a few mammalian species. Therefore, the lowest NOAEL (490 mg/kg-bw/day for mice) was applied to all receptors.

MAMMAL RISK

DEGEE is nearly non-toxic to mammals based on the USEPA criteria. All studies show mammals with LD50s >5,000 mg/kg (IUCLID 2000). None of the HQs for DEGEE exceeded LOCs (refer to Table C-17), indicating that risks from DEGEE are insignificant.

AVIAN RISK

No data were available to demonstrate the toxicity of DEGEE to birds. Using the mammalian NOAEL value, none of the calculated exposure doses exceeded an LOC of 1 (refer to Table C-17) relative to the NOAEL, indicating risks to birds from DEGEE would be insignificant.

AMPHIBIAN RISK

No amphibian toxicity data were available for amphibians. Using the mammalian NOAEL, none of the HQs exceeded an LOC of 0.1, indicating risks to amphibians from DEGEE are insignificant.

1-METHYL-2-PYRROLIDINONE (MP)

Toxicology data for MP were limited to a few mammalian species. Therefore, the lowest NOAEL value (1,000 mg/kg-bw/day for mice) for mammals was applied to all receptors.

MAMMAL RISK

MP is considered as being slightly toxic to mammals, based on the USEPA criteria, with studies showing LD50s <2,000 mg/kg (B&J 0304, 2001). None of the calculated HQs exceeded LOCs relative to the NOAEL (refer to Table C-17), indicating risks to mammals would be insignificant.

AVIAN RISK

No data were available to demonstrate the toxicity of MP to birds. Using the NOAEL value for mice, none of the HQs exceeded LOCs for any of the avian species modeled (refer to Table C-17). Therefore, risks to avian species would be insignificant risk from the proposed Action.

AMPHIBIAN RISK

No amphibian toxicity data were available for MP. Using the NOAEL value for mice, none of the HQs exceeded an LOC of 0.1 (refer to Table C-17), indicating risks to amphibians would not be significant.

FENNODEFO 99™ (FENNODEFO)

Each of the chemicals of potential concern that make up Fennodefo constituent in the CFT Legumine™ were evaluated by Jeff Fisher (ENVIRON 2007) to determine to what extent these chemicals are recognized in state and federal statutes as hazardous materials, and, if so, their regulatory criteria. In summary, no California-specific or federal regulatory screening values were identified for the protection of human or ecological health for these new chemical constituents.

Acute LD50 values from laboratory studies using rats were available for 3 constituents of Fennodefo (Table C-14). The most conservative LD50 of 3,200 mg/kg for linoleic acid was applied to all receptors.

MAMMAL RISK

As demonstrated by the HQ summary (Table C-17), none of the doses calculated for mammals exceeded LOCs. The HQs, which are based on the LD50, were far less than 0.1. This indicates that risks to mammalian receptors from Fennodefo are insignificant.

AVIAN RISK

None of the doses calculated for birds exceeded LOCs. The HQs, which are based on the LD50, were far less than 0.1. This indicates that risks to avian receptors from Fennodefo are insignificant.

AMPHIBIAN RISK

None of the doses calculated for amphibians exceeded LOCs. The HQs, which are based on the LD50, were far less than 0.1. This indicates that risks to amphibian receptors from Fennodefo are insignificant.

C.5.1.1.2 NOXFISH® AND NUSYN-NOXFISH®

ROTENONE

The concentration of rotenone in Noxfish® is the same as that of CFT Legumine™. Therefore, the HQ results are the same as those presented above for CFT Legumine™ at the 0.5 mg/L application rate, which is used for Noxfish®. Nusyn- Noxfish® is applied at 1.0 mg/L; however it contains half the rotenone of Noxfish® (or CFT Legumine™), so the exposure to rotenone is the same for both formulations. At the application rates used for Noxfish® and Nusyn- Noxfish®, rotenone risks to receptors are less-than-significant.

NAPHTHALENE

Toxicology data for naphthalene were limited to a few mammalian species. Although a NOAEL for mice was available (100 mg/kg-bw/day), a lower LOAEL for rats (10 mg/kg-bw/day) was used as the TRV for all receptors. The concentration of naphthalene is significantly higher in the Noxfish® formulations than in CFT Legumine™; however, all HQs calculated for all species were well below the LOC of 1.

MAMMAL RISK

Naphthalene is considered moderately toxic to mammals based on the USEPA criteria with studies showing LD50s < 501 mg/kg. None of the HQs exceeded LOCs, indicating risks to mammals from naphthalene exposure would be insignificant.

AVIAN RISK

Because no data were available for naphthalene toxicity in birds, the LOAEL value for rats was used to assess risks to birds. None of the HQs exceeded LOCs, indicating naphthalene exposure risks for birds would be less-than-significant.

AMPHIBIAN RISK

Because no data were available for naphthalene toxicity in amphibians, the LOAEL value for rats was used to assess amphibian risk. None of the HQs exceeded an LOC of 0.1, indicating naphthalene exposure risks for amphibians would be less-than-significant.

TOLUENE

Toxicity data for toluene were only available for rats (NOAEL of 312 mg/kg-bw/day). Therefore, the HQs for assessing toluene were based on this value.

MAMMAL RISK

Toluene is considered moderately toxic to mammals based on the USEPA criteria listed in Table C-11, with studies showing LD50s < 501 mg/kg (Neurotoxicology. Vol. 2, Pg. 567, 1981). However, none of the calculated HQs for selected mammal species exceeded the LOC of 1 relative to the NOAEL (refer to Table C-17). This result indicates risks to mammals from toluene would be insignificant.

BIRD RISK

Adopting the NOAEL value for rats as the TRV, none of the HQs exceeded LOCs, indicating risks to birds from toluene exposures are insignificant.

AMPHIBIAN RISK

Adopting the NOAEL value for rats as the TRV for amphibians, none of the HQs exceeded an LOC of 0.1, indicating risks to amphibians from toluene exposures would be insignificant for the proposed Action.

1, 2, 4-TRIMETHYLBENZENE

Toxicity data for 1, 2, 4-Trimethylbenzene were limited to an acute value for rats (LD50 of 5,000 mg/kg). Therefore, this value was used as the ingestion TRV for all species modeled.

MAMMAL RISK

1, 2, 4-trimethylbenzene is considered practically non-toxic to mammals based on USEPA criteria. Laboratory studies have derived LD50 values > 2,000 mg/kg. None of the HQs exceeded LOCs for any of the mammal species modeled relative to the LD50 (refer to Table C-17), indicating risks to mammals from 1, 2, 4-trimethyltoluene would be insignificant.

BIRD RISK

No toxicity data were available for 1, 2, 4-trimethylbenzene exposure for birds. Using the LD50 value for rats, none of the HQs exceeded LOCs for any of the avian species modeled (refer to Table C-17). This indicates risks from the proposed Action to birds would be insignificant.

AMPHIBIAN RISK

No toxicity data were available for 1, 2, 4-trimethylbenzene exposure for amphibians. Using the LD50 value for rats, none of the HQs exceeded LOCs for any of the amphibian species modeled (refer to Table C-17). This indicates risks from the proposed Action to amphibians would be insignificant.

C.5.1.2 Wildlife Ecological Receptor Risks

Because of the low volume of chemical required for the proposed Action to treat Silver King Creek during the fall with low-flow conditions and the water's limited surface area, risks to wildlife (mainly via inhalation) were considered negligible as summarized in Table C-17.

Table C-18 Terrestrial Toxicity Hazard Quotients to Rotenone

Class	Species	Surrogate Species	Rotenone TRV		HQ CFT Legumine™ at 0.5 mg/L	HQ CFT Legumine™ at 1.0 mg/L	HQ Noxfish® at 0.5 mg/L	HQ Nusyn-Noxfish® at 1.0 mg/L	Reference
			Test End Point	TRV Value (mg/kg bw/day)					
Avian	Bald Eagle	Bald Eagle	NOAELChronic 6 Month	0.4	0.15	0.29	0.14	0.14	1
			LOAELChronic 6 Month	2	0.029	0.058	0.029	0.029	1
	Great Grey Owl	Bald Eagle	NOAELChronic 6 Month	0.4	0.15	0.29	0.14	0.14	1
			LOAELChronic 6 Month	2	0.029	0.058	0.029	0.029	1
	Mountain Quail	N. Bobwhite Quail	NOAELChronic 6 Month	0.4	0.013	0.027	0.013	0.013	1
			LOAELChronic 6 Month	2	0.0027	0.0054	0.0027	0.0027	1
		Japanese Quail	LD50 5 Day	1882	2.9×10^{-6}	5.8×10^{-6}	2.9×10^{-6}	2.9×10^{-6}	2
	Willow Flycatcher	Marsh Wren	NOAELChronic 6 Month	0.4	0.92	0.013	0.91	0.91	1
			LOAELChronic 6 Month	2	0.18	0.0025	0.18	0.18	1
		English Song Sparrow (nestlings)	LD50 24h	130	0.0028	3.9×10^{-5}	0.0028	0.0028	3
	Yellow Warbler	Marsh Wren	NOAELChronic 6 Month	0.4	0.92	0.013	0.91	0.91	1
			LOAELChronic 6 Month	2	0.18	0.0025	0.18	0.18	1
		English Song Sparrow (nestlings)	LD50 24h	130	0.0028	3.9×10^{-5}	0.0028	0.0028	3
	Hairy Woodpecker	Hairy Woodpecker	NOAELChronic 6 Month	0.4	0.019	0.039	0.019	0.019	1
			LOAELChronic 6 Month	2	0.0039	0.0077	0.0038	0.0038	1
		English Song Sparrow (nestlings)	LD50 24h	130	5.9×10^{-5}	1.2×10^{-4}	5.8×10^{-5}	5.8×10^{-5}	3
	Williamson's Sapsucker	Hairy Woodpecker	NOAELChronic 6 Month	0.4	0.019	0.039	0.019	0.019	1
			LOAELChronic 6 Month	2	0.0039	0.0077	0.0038	0.0038	1
		English Song Sparrow (nestlings)	LD50 24h	130	5.9×10^{-5}	1.2×10^{-4}	5.8×10^{-5}	5.8×10^{-5}	3

Table C-18 Terrestrial Toxicity Hazard Quotients to Rotenone

Class	Species	Surrogate Species	Rotenone TRV		HQ CFT Legumine™ at 0.5 mg/L	HQ CFT Legumine™ at 1.0 mg/L	HQ Noxfish® at 0.5 mg/L	HQ Nusyn-Noxfish® at 1.0 mg/L	Reference
			Test End Point	TRV Value (mg/kg bw/day)					
Mammalian	Sierra Nevada Red Fox	Red Fox	NOAELChronic 6 Month	0.4	0.080	0.16	0.078	0.078	1
			LOAELChronic 6 Month	2	0.016	0.032	0.016	0.016	1
		Rat	LD50 24h	39.5	0.00081	0.0016	0.00079	0.00079	4
	Californian Wolverine	Californian Wolverine	NOAELChronic 6 Month	0.4	0.062	0.12	0.0061	0.0061	1
			LOAELChronic 6 Month	2	0.012	0.025	0.012	0.012	1
		Rat	LD50 24h	39.5	0.00063	0.0013	0.00062	0.00062	4
	American Marten	Californian Wolverine	NOAELChronic 6 Month	0.4	0.062	0.12	0.0061	0.0061	1
			LOAELChronic 6 Month	2	0.012	0.025	0.012	0.012	1
		Rat	LD50 24h	39.5	0.00063	0.0013	0.00062	0.00062	4
	Small Mammal	Mouse	NOAELChronic 6 Month	0.4	0.030	0.060	0.029	0.029	1
			LOAELChronic 6 Month	2	0.0060	0.012	0.0059	0.0059	1
			LD50 24h	350	3.4×10^{-5}	6.8×10^{-5}	3.4×10^{-5}	3.4×10^{-5}	5
	Small Herbivorous Mammal	Pygmy Rabbit	NOAELChronic 6 Month	0.4	0.014	0.028	0.014	0.014	1
			LOAELChronic 6 Month	2	0.0028	0.0057	0.0028	0.0028	1
			LD50 24h	1500	3.8×10^{-6}	7.5×10^{-6}	3.7×10^{-6}	3.7×10^{-6}	Unknown
	Ungulate	Mule Deer	NOAELChronic 6 Month	0.4	0.0062	0.012	0.0061	0.0061	1
			LOAELChronic 6 Month	2	0.00012	0.025	0.0012	0.0012	1
	Black Bear	Black Bear	NOAELChronic 6 Month	0.4	0.047	0.093	0.046	0.046	1
			LOAELChronic 6 Month	2	0.0093	0.0186	0.0091	0.0091	1
			LD50 24h	39.5	0.00047	0.00094	0.00046	0.00046	4

C.5.1.3 Aquatic Ecological Receptor Risks

Table C-19presents the calculated HQs based on surface water EPCs identified in Table C-13 and the aquatic TRVs identified in Table C-5 and Table C-9. As anticipated, based on their direct exposure to the treated water and/or potential presence of sensitive life stages, HQ values for larval frogs and toads and rainbow trout exceeded LOCs. However, at the proposed treatment concentrations, the proposed Action would not expose most aquatic invertebrate taxa to lethal concentrations of rotenone. Cladocerans and several other invertebrate species could be affected by the treatment.

Table C-19 Aquatic Toxicity Hazard Quotients to Rotenone

Class	Species	Surrogate Species	Rotenone TRV		HQ CFT Legumine™ at 0.5 mg/L	HQ CFT Legumine™ at 1.0 mg/L	HQ Noxfish® at 0.5 mg/L	HQ Nusyn-Noxfish® at 1.0 mg/L	Reference
			Test End Point	TRV Value (mg/kg bw/day)					
Amphibian	Mountain yellow-legged frog (adult)	Northern leopard frog (adult)	LC50 24h	240	0.11	0.21	0.10	0.10	1
	Mountain yellow-legged frog (larvae)	Northern leopard frog (tadpole)	LC50 24h	5	501	10	5.0	5.0	2
	Yosemite toad (adult)	Northern leopard frog (adult)	LC50 24h	240	0.11	0.21	0.10	0.10	1
	Yosemite toad (larvae)	Northern leopard frog (tadpole)	LC50 24h	5	5.1	10	5.0	5.0	2
Fish	Rainbow trout		LC50 24h	3.5	7.3	15	7.1	7.1	3
Macroinvertebrate	Flatworm	*Catenula* sp.	LC50 24h	5100	0.0050	0.010	0.0049	0.0049	4
		Planaria sp.	LC50 24h	<500	~0.051	~0.10	~0.050	~0.050	4
	Annelid worms	Leech	LC50 48h	<100	~0.26	~0.51	~0.25	~0.25	4
	Copepod	*Cyclops* sp.	LC100 72h	<100	~0.26	~0.51	~0.25	~0.25	4
	Branchiura	*Argulus* sp.	LC50 24h	~25	~1	~2	~1	~2	4
	Cladoceran	*Daphnia pulex*	LC50 24h	27	0.94	1.9	0.93	0.93	4
		D. pulex	LC50 24h	<25	~1	~2	~1	~2	4
		Diaptomus siciloides	LC50 24h	<25	~1	~2	~1	~2	4
	Conchostracan	*Estheria* sp.	LC50 24h	~50	~0.5	~1	~0.5	~0.5	4
	Freshwater prawn	*Palaemonetes kadiakensis*	LC50 24h	5150	0.0050	0.0099	0.0049	0.0049	4
	Crayfish	*Cambarus immunis*	LC50 72h	>500	<0.051	<0.10	<0.50	<0.50	4
	Dragonfly naiad	*Macromia* sp.	LC50 24h	4700	0.0054	0.011	0.0053	0.0053	4
	Stonefly naiad	*Pteronarcys californica*	LC50 24h	2900	0.0088	0.0176	0.0086	0.0086	4
	Backswimmer	*Notoncta* sp.	LC50 24h	3420	0.0075	0.0149	0.0073	0.0073	4
		Notoncta sp.	LC50 24h	~100	~0.26	~0.51	~0.25	~0.25	4
	Caddis fly larvae	*Hydropsychye* sp.	LC50 96h	605	0.042	0.084	0.041	0.041	4
	Whirligig	*Gyrinus* sp.	LC50 24h	3550	0.0072	0.0143	0.0070	0.0070	4
	Water mite	*Hydrachnidae*	LC50 96h	~50	~0.5	~1	~0.5	~0.5	4
	Snail	*Physa pomilia*	LC50 24h	6350	0.0040	0.0080	0.0039	0.0039	4
		Oxytrema catenaria	LC50 96h	1750	0.015	0.029	0.014	0.014	4
		Lymnaea stagnalis	LC50 96h	>1000	<0.026	<0.051	<0.025	<0.025	4
	Bivalave mollusk	*Dreissena polymorpha*	LC50 48h	2190	0.012	0.023	0.011	0.011	4
		Obliquaria reflexa	LC50 48h	>1000	<0.026	<0.051	<0.025	<0.025	4
		Elliptio buckleyi	LC50 96h	2950	0.0086	0.017	0.0085	0.0085	4
		Elliptio complanata	LC50 96h	2000	0.013	0.025	0.013	0.013	4
		Corbicula manilensis	LC50 96h	7500	0.0034	0.0068	0.0033	0.0033	4
	Ostracod	*Cypridopsis*	LC50 24h	490	0.052	0.10	0.051	0.051	4

C.5.2 Risk Assessment Uncertainties, Assumptions, and Data Gaps

C.5.2.1 Environmental Fate and Toxicity Assessment

Toxicity data are frequently unavailable for chemicals that are the subject of ecological risk assessments. This is the case for many of the selected receptors and several of the chemicals present in the rotenone formulations proposed for use under the proposed Action. In some cases, toxicity data were available for certain exposure routes (e.g. intravenous) but not for more significant exposure routes such as ingestion and dermal contact, or inhalation. When toxicity information was available for relevant exposure routes, they were not available for the receptors found near Silver King Creek. Therefore, TRVs from typical laboratory species were extrapolated to the ecological receptors selected for this assessment.

The following bullets highlight the specific data gaps identified in literature review for this assessment, and qualitatively characterize the significance of the uncertainties created by these data gaps:

1. Essentially no information was found on the toxicity of rotenone to aquatic or terrestrial plants. Given rotenone is used as an organic pesticide approved for use on over 90 organic food crops (USEPA 2006) at application rates far greater than what would be applied under the proposed Action, plant toxicity is considered extremely unlikely.

2. Chronic rotenone toxicity data for birds was lacking in the literature. Because the proposed Action includes a single, short-term treatment, and because rotenone breaks down quickly in the environment, chronic exposures were considered insignificant.

3. Essentially no information was found on the photo-degradation rate of rotenone in soil. These data could be useful in predicting wildlife exposure through incidental consumption of soils at the water's edge. The uncertainty created by this data gap in estimating dose, however, is considered minor given the chemical would be applied directly to the stream and any application to soil would be inadvertent.

4. Toxicity data for reptiles and amphibians are few for rotenone and its formulation constituents. Standard practice is to use avian toxicity data as a surrogate for these species. However, given rotenone's respiratory toxicity mechanism, such data were not considered useful.

5. Toxicity and empirical fate data for several formulant dispersants were incomplete in the literature. For example, no inhalation toxicity values for DEGEE, degradation rates for permanganate (as a covariate of organic matter), or dermal toxicity values were found for most formulation constituents. Although such data would be useful in the exposure assessment, formulation constituents and degradation products are less toxic than rotenone by at least a factor of 2 (USEPA 2006). Such results indicate that the dispersants in the end-product formulations do not contribute to rotenone's toxicity (and may actually reduce it).

C.5.2.2 Ecological Exposure Assessment

Exposure point concentrations were estimated by assuming full mixing of all chemicals in the creek. Exposure doses were calculated using the following assumptions that tend to overestimate ingestion risk, which is appropriate for this screening-level risk assessment.

1. The Site Use Factor (SUF) was assumed to be 100% for all receptors. While this assumption may be accurate for species with small home ranges, it is a very conservative assumption for larger mammals and birds.

2. Bioavailability of contaminants was assumed to be 100%. Unless a chemical is delivered intravenously, bioavailability is likely less than 100% because contaminants may adhere to food items or not be completely absorbed. Because rotenone tends to adhere to sediments and water-borne particles, this assumption is conservative. In addition, bioavailability may be affected by environmental parameters such as oxygen levels, pH, and temperature.

3. The bioaccumulation factor (BAF_f) for rotenone in fish was 20, which reflects the maximum bioaccumulation factor determined by Rach and Gingerlich (1986). The BAFs for the inert ingredients in fish were estimated based on the organic carbon partition coefficient (Koc) and an assumed lipid (organic carbon) content of 5% (Mackay 1982). The BAFs for all ingredients in sediment were estimated based on Koc and an assumed sediment organic carbon content of 1% (Van Leeuwen et al. 1992). Because of the volatility and degradability of the ingredients comprising rotenone formulations, these chemicals were considered highly unlikely to bioaccumulate in upland areas incidentally exposed to overspray and were assumed to have a BAF of 1 for vegetative matter and soil.

4. The percent of contaminated food was always assumed to be 100%, which assumed all food sources were contaminated. This is a conservative assumption as most organisms would have diverse diets.

5. Where species-specific data relating to food and water intake were not available, intake rates of food, water and air as well as surface area were estimated for each receptor using allometric equations from the Wildlife Exposure Handbook (USEPA 1993) and Sample et al. (1996). These equations us the species' average weight to determine intake rates. These values can vary by population; however, data specific to the Silver King Creek area were not available.

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APPENDIX D

Analysis of the Effects of Rotenone on Aquatic Invertebrates

AN ANALYSIS OF THE EFFECTS OF ROTENONE ON AQUATIC INVERTEBRATE ASSEMBLAGES IN THE SILVER KING CREEK BASIN, CALIFORNIA

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SUMMARY

Piscicides, namely rotenone and antimycin, have been used for more than 70 years to manage fish populations by eradicating undesirable fish species. Piscicides are intended to eradicate fish, but they are also toxic to other aquatic biota, such as aquatic invertebrates and amphibians. The impact on aquatic invertebrates is a concern because of their intrinsic values, their role in aquatic ecosystem processes and their importance as a food source for fish. The objectives of this report were to review literature on the impacts of rotenone on invertebrate assemblages, evaluate a large data set of historically collected and more recently collected aquatic invertebrate samples from the Silver King Creek Basin, Alpine County, California, and provide recommendations for sampling aquatic invertebrates prior to and after a proposed rotenone treatment in the Silver King Creek Basin that would allow for a robust assessment of the effects of this treatment on aquatic invertebrate assemblages.

Literature Review

In a review of the effects of rotenone treatments on stream invertebrates we found that overall, there have been too few published studies (ca. < 25 published studies since the 1930s) and of there was too little comparability among studies with respect to rotenone treatments and aquatic invertebrate data collection efforts to allow for any sweeping statements on the overall effects of rotenone on aquatic invertebrate assemblages in streams. Variation among treatment effects appeared related to differences in rotenone concentrations and treatment durations, physical and chemical characteristics among water bodies and the intensity of pre- and post-treatment sampling. In particular, the lack of collection of a sufficient amount of data on aquatic invertebrate assemblages prior to treatment prevents us from understanding the true effects of rotenone treatments on invertebrate assemblages. For streams, no studies have done an adequate job of describing pre-treatment assemblages. The studies we reviewed generally reported changes in the entire invertebrate assemblage, such as total taxa richness or abundance. With the exception of a few studies there has been little

reporting on the impacts of piscicides on individual invertebrate taxon or the recovery rates of individual taxon, especially rare species.

Rotenone treatments appear to act on aquatic invertebrate assemblages like a severe pulse physical disturbance. Scientific reviews of the recovery of aquatic invertebrate assemblages following pulse disturbances have suggested that impacts and recovery times appear most influenced by: 1) persistence of the impact, including the degree of change in system productivity, habitat integrity, and persistence of the stressor; 2) the relative magnitude and timing of natural disturbance regimes, 3) life history characteristics of the organisms, including generation time and propensity to disperse; 4) time of year the disturbance occurs in relation to organism life history development; 5) presence of refugia; and 6) distance to a recolonization source. These results suggest that rotenone impacts may be greatest in streams with lower frequencies of disturbance or predictable discharge patterns. Recovery will also likely be longer in streams where long reaches are treated. Increasing the distance to colonization sources will reduce the ability of species to colonize the treated reach. Treatment effects will have greater impacts if they occur during critical life stages or if they occur in the fall when lower winter drift rates and lack of winter reproduction will delay recovery until the following spring, particularly if the site will be dependent on downstream drift of larvae for recolonization.

Aquatic invertebrates have a wide range of sensitivity to rotenone with 96 hr LC50 values ranging from 0.002 to 100 ppm. A review of published laboratory toxicity tests showed the following general results: 1) there has been little rotenone toxicity work done on stream dwelling aquatic invertebrates, 2) there is a wide range of sensitivity both within and among taxonomic divisions, 3) benthic invertebrates appear less sensitive than planktonic invertebrates, 4) smaller invertebrates appear more sensitive than larger invertebrates, 5) aquatic invertebrates that use gills to extract aqueous oxygen appear more sensitive than invertebrates that acquire aqueous oxygen cutaneously, or through lamellae or spiracles, make use of respiratory pigments, or that can breathe atmospheric oxygen, 6) mortality was typically near 100% for rotenone formulation concentrations > 1 to 1.5 ppm for lotic invertebrates and > 3 ppm for many lentic or aquatic adult insect taxa (e.g., Heteroptera, Coleoptera) depending on the exposure time.

In relation to potential impacts of rotenone treatments in Silver King Creek, the available literature on rotenone impacts and disturbance ecology of aquatic invertebrates suggests that rotenone impacts to invertebrates would be initially high as rotenone effects appear to be greatest in mountain streams characterized by snowmelt dominated hydrologic regimes, cold water, and high oxygen levels, as these streams are characteristically dominated by small gilled invertebrates, namely Ephemeroptera, Plecoptera, and Trichoptera, that are not adapted to low-flow (late summer/fall/winter) disturbances. The results of three longer-term more intensively sampled studies in mountain streams suggest that common taxa will quickly recolonize treated areas and rarer taxa may be eradicated for a number of years or potentially forever. The ability of taxa to recolonize treated areas appears to be a function of treatment mortality levels, overall population sizes within the treated basin, upstream and local habitat conditions, and the dispersal abilities of individual taxon, so leaving upstream areas untreated would enhance recolonization.

Observed impacts of rotenone at Silver King Creek

The effects of previous rotenone treatments on aquatic invertebrate assemblages in the Silver King Creek Basin have been evaluated by the U.S. Forest Service and the California Department of Fish and Game. These past analyses, the analyses presented here, and future assessments of the effects on rotenone on aquatic biota in the Silver King Creek Basin are all hampered by the long history of rotenone treatments in the basin and the lack of data on aquatic invertebrate assemblages prior to the use of rotenone. Rotenone treatments first occurred in the basin in 1964. The earliest data available on aquatic invertebrate assemblages appears to be from 1984. No data on the aquatic invertebrates present before rotenone treatments are available to definitively measure changes that occurred following rotenone treatments in the basin in 1964, 1976, 1977, 1987, 1988, 1991, 1992, and 1993. Aquatic invertebrate samples were collected in the basin at six locations in 1984, 1987, 1991, 1992, 1993, 1994, 1995, and 1996, as well as several other locations during some of these years. All of these samples were processed by the USFS Aquatic Ecosystem Laboratory, Provo, Utah. Between 2003 and 2006 aquatic invertebrate samples were collected at 14 new sampling locations within the basin. These samples were all processed by the BLM National Aquatic Monitoring Center located at Utah State University. For all years the samples were collected similarly. Laboratory methods were generally similar, but the comparability between the two laboratories could not be quantified as none of the historic samples were available for comparison.

For each of the two aquatic invertebrate assemblage data sets, historic (1984 to 1996) and recent (2003 to 2006), we evaluated the following topics:

1. Differences in total genera richness, genera richness within dominant insect orders, and total assemblage abundance between sites that had been treated with rotenone and untreated sites.
2. Annual variation in total genera richness, genera richness within dominant insect orders, and total assemblage abundance.
3. Variation in total genera richness, genera richness within dominant insect orders, and total assemblage abundance among sampling locations.
4. Rarity of aquatic invertebrate genera within and among years.
5. Comparisons between historic and recent data.

For the historically collected data we found:

1. There were few measureable differences in mean aquatic invertebrate assemblage measures between sites that were treated with rotenone and two sites that were not treated. The only statistically significant difference between treatment and control sites was in the abundance of Coleoptera collected. Mean Coleoptera abundance was twice as high in control as compared to treatment sites. Two genera were collected at untreated sites that were not collected at treated sites; *Ephron* (Ephemeroptera: Polymatarcyidae) and *Dolophilodes* (Trichoptera: Philopotamidae). Twenty-seven genera were collected at treated

sites that were not collected at untreated sites; however, the sampling effort was much greater at treated sites as about four times as many individuals were collected at treated sites as compared to untreated sites. These results were similar to that found by Trumbo et al. (2000) in their more thorough analyses of these data. The large discrepancy among the number of samples and invertebrates collected in treated and untreated reaches made interpretations between the two data sets difficult.

2. Several mean aquatic invertebrate assemblage measures varied significantly among years, but no values were consistently higher or lower for any particular year, though the majority of values were higher for samples collected in the 1990s than they were for samples collected in the 1980s.
3. There were few measureable differences in mean aquatic invertebrate assemblage measures among sampling locations. Variation in all measures was high. Samples collected in Four Mile Canyon Creek, which was never treated with rotenone, were no less variable than those collected in rotenone treated reaches of Silver King Creek and in rotenone treated tributaries.
4. Rarity of individual taxa in treated and untreated sites appeared similar and based on relative abundances and occurrences in individual years and sites most taxa can be considered uncommon or rare.

For the recently collected data we found:

1. There were few measureable differences in mean aquatic invertebrate assemblage measures between sites that were treated with rotenone and the two sites that were not treated for samples collected 10 years after the last rotenone treatment in 1993. The only statistically significant difference between treatment and control sites was the mean number of Coleoptera genera and the mean abundance of Coleoptera collected. Coleoptera, primarily Elmidae, were taxonomically richer and more abundant at treatment sites. Five genera were not collected at treated sites that were collected at untreated sites; *Clinocera* (Diptera: Empididae), *Oreogeton* (Diptera: Empididae), *Pedicia* (Diptera: Tipulidae), *Moselia* (Plecoptea: Leuctridae), and *Kogotus* (Plecoptera:

Pelodidae). Forty-three genera were collected at treated sites that were not collected at untreated sites; however, the sampling effort was much greater at treated sites as nearly eight times as many individuals were collected at treated sites as compared to untreated sites. There was a strong relationship between all measures of biodiversity and organism abundance. The more samples or individuals that are collected greater increases the likelihood of capturing additional taxa. There were no differences in the mean number of taxa or genera collected at treated as compared to untreated sites.

2. Several mean aquatic invertebrate assemblage measures (6 of 15 measures) varied significantly among years. Many values were highest in 2004 and minimum values occurred in all years for different measures.
3. Four of the 15 measures varied significantly among sampling sites. All measures that were significantly different were highest in tributary streams. No measures were highest at untreated sites.
4. The majority of taxa collected between 2003 and 2006 could be considered uncommon or rare. The mean number of rare taxa collected each year was similar among years and averaged about 50% of the total taxa richness.
5. Specific comparisons between historic and recent samples to assess the long-term effects of rotenone on aquatic invertebrate assemblages in Silver King Creek were not possible because samples were not collected from the same locations during the two study periods and methodological differences between the two laboratories could not be quantified. In general terms, we did not detect a strong impact of rotenone on aquatic invertebrate assemblages in Silver King Creek based on sampling conducted since 1984. The biodiversity of aquatic invertebrate assemblages was consistently higher in recent as compared to historic samples. Recent samples had on average 9% percent more families, 30% more genera, 3% more Ephemeroptera genera, 53% more Plecoptera taxa, 42% more Trichoptera genera, 165% more Coleoptera genera, and 25% more Diptera genera than historic samples. The difference in mean total invertebrate abundance between the two sample sets was 2% greater in recent samples. The abundance of Ephemeroptera , Plecoptera, and Trichoptera (EPT) was 56%

higher in recent samples. Elmidae (Coleoptera) abundances were 21% higher in historic samples and Elmidae genera was 165% higher in recent samples. The cause of consistently higher richness in recent as compared to historic samples is not clear. The two most likely causes are improving biological conditions since the 1990s and differences in laboratory procedures between the two data sets. Evidence for improving biological conditions includes the elimination of rotenone treatments since 1993 and the elimination of livestock grazing in the Silver King Creek basin since 1996. None of the aquatic invertebrate samples remain from the historic samples, so differences due to differences in laboratory procedures, such as the number of organisms identified and taxonomic resolution cannot be evaluated.

Future study plan recommendations

A study design to detect impacts of planned rotenone treatments can take many forms depending on the level of impact that you want to detect. While the overall question may simply be, "what is the effect of rotenone on aquatic invertebrate assemblages?", the specifics of this question need to be addressed to understand the intensity of sampling required to measure the proposed impact. Will "before-after" comparisons be done with assemblage level measures only, such as total abundance, total taxa, or genera richness, or will comparisons in community composition and species or genera occurrences be evaluated as well? The specifics on where, when, how, how often, and for how long samples will be collected is dependent on knowing to the degree to which species or genera level data will be evaluated. The degree to which these data can be evaluated is also dependent on how much sampling will occur before the treatment to provide an accurate or reasonable level of information on the occurrences of taxa in the treatment area. These decisions should be made prior to conducting future sampling.

The current aquatic invertebrate sampling program in the Silver King Creek Basin can be improved by sampling a stream similar to Silver King Creek with respect to major environmental influences on aquatic invertebrate assemblages, as no pre-rotenone data on aquatic invertebrate assemblages exists for Silver King Creek. The program should also take advantage of recent predictive models that have been developed to estimate the site specific probability of collecting invertebrate taxa in Sierra Nevada streams based on a set of geographical based predictor variables.

The current sampling stations in the basin should be spread out to provide greater coverage within the basin. Consideration should be given to restoring long-term sampling sites that were historically sampled on Fly Valley Creek, Four Mile Creek, Bull Canyon Creek, and at the Silver King Creek historic sites located upstream from the sites presently sampled (Sites S5:725, S6738, S7:775, and S8:813). An equal number of control and treatment sites should be sampled for an equal period of time before and after treatment. A problem with evaluating much of the data collected to date is that vastly more samples and individuals were collected at treatment sites as compared to control sites. Taxa occurrences are highly dependent on the number of samples and individuals collected. At present, the sampling methods, annual or seasonal timing of sampling, and the duration of sampling cannot be adequately evaluated until the study design objectives are more explicitly stated.

INTRODUCTION

Piscicides, namely rotenone and antimycin, have been used for more than 70 years to manage fish populations by eradicating undesirable fish species (McClay 2000). While piscicides are intended to eradicate fish, they are also toxic to other aquatic biota, such as aquatic macroinvertebrates and amphibians. The impact on aquatic macroinvertebrates is a concern because of their intrinsic values, their role in aquatic ecosystem processes and their importance as a food source for fish. The impact to macroinvertebrate assemblages has become such a contentious issue that recent fish restoration projects using piscicides have received court ordered injunctions until issues surrounding impacts to macroinvertebrate assemblages could be addressed. The objectives of this report were to review the impacts of rotenone on invertebrate assemblages, evaluate a large data set of historically collected and more recently collected aquatic invertebrate samples from the Silver King Creek Basin, Alpine County, California, and provide recommendations for sampling aquatic invertebrates prior to and after a proposed rotenone treatment in the Silver King Creek Basin that would allow for a robust assessment of the effects of this treatment on aquatic invertebrate assemblages.

The two most commonly used piscicides are antimycin and rotenone. Antimycin is a fungicide produced by actinomycetes. Antimycin inhibits oxygen metabolism by disrupting electron transport. Antimycin is a widely used piscicide. Fish cannot detect antimycin and the effects on fish are not reversible. Most fishes are killed by concentrations of 20 ug/L or less. The effects of antimycin on aquatic invertebrates were recently reviewed by Cerreto (2004). He concluded that there was substantial variation in the effects of antimycin on aquatic invertebrate assemblages. Overall, there was little standardization in the way effects on aquatic invertebrate assemblages were measured, with respect to the amount of pre- and post-treatment data collected and the number and location of samples collected.

Rotenone is a naturally occurring compound found in many plants within the family Leguminosae. It kills fish and other aquatic organisms by inhibiting respiration at the cellular level (Horgan et al. 1968). Concentrations of 0.1 to 0.5 ppm of 5% rotenone (1 ppm rotenone formulation or 50 ppb rotenone formulation) have been most often used in lakes and rivers. In this report, unless otherwise specified rotenone formulation concentrations were presented as ppm of 5% rotenone formulation. Where possible, in data tables rotenone concentration formulations were also standardized to ppm of rotenone, e.g., 5 mg/L of 5% rotenone solution = 0.25 ppm active rotenone.

LITERATURE REVIEW

In spite of its widespread use, little specific information is known on the effects of rotenone on non-target organisms, particularly in rivers. Older literature on the effects of rotenone is pretty evenly split between studies that generally reported that rotenone treatments did not significantly affect invertebrates, usually referred to as fish food organisms (M'Goinigle and Smith 1938, Leonard 1939, Smith 1940, Brown and Ball 1943, Ball and Hayne 1952, Pintler and Johnson 1958, Zilliox and Pfeiffer 1960, Prevost 1960, and Cook and Moore 1969) and studies that found rotenone to be highly toxic to aquatic invertebrates (Davidson 1930, Ginsburg 1933, Scheuring and Heuschman 1935, Felton 1940, Cutkomp 1943, Zischkale 1952, Rudd and Genelly 1956, Lindgren 1960, Das and McIntosh 1961, Wollitz 1962, and Binns 1967). The cause of these different findings is not entirely clear, but often appears to be related to the study objective. Studies that sought to measure the effects on aquatic invertebrates in terms of fish food availability (invertebrate assemblage abundances or biomass) generally found quick recovery in these measures, whereas studies that sought to look at rotenone effects on individual invertebrate species generally found greater effects. More recent literature (Koksvik and Aagaard 1984, Rach et al. 1988, Dudgeon 1990, Reinertsen et al. 1990, Beal and Anderson 1993, Mangum and Madrigal 1999, and Melaas et al. 2001) have generally reported immediate eradication of invertebrates, quick recovery of abundances of common taxa, and longer-term recovery times for rarer taxa. The effects of differences in habitat types, such as high elevation mountain streams versus low elevation rivers have not been evaluated.

Laboratory Studies

Aquatic invertebrates have a wide range of sensitivity to rotenone with 96 hr LC50 values ranging from 0.002 to 100 ppm (Pesticide Management Education Program 2007). A review of published laboratory toxicity tests (Appendix 1) showed several general results: 1) there has been little rotenone toxicity work done on stream dwelling aquatic invertebrates, 2) there is a wide range of sensitivity both within and among taxonomic divisions (Figure 1, Appendix 1), 3) benthic invertebrates appear less sensitive than planktonic invertebrates, 4) smaller invertebrates appear more sensitive than larger invertebrates, 5) aquatic invertebrates that use gills to extract aqueous oxygen appear more sensitive than invertebrates that acquire aqueous oxygen cutaneously, through lamellae or spiracles, use respiratory pigments, or that can breathe atmospheric oxygen, 6) mortality was typically near 100% for rotenone formulation concentrations >1 to 1.5 ppm for stream invertebrates and for formulation concentrations >3 ppm for lentic invertebrates depending on the exposure time. The maximum solubility of rotenone in water is 0.20 mg/L, so concentrations > 4 mg/L of 5% rotenone formulation are likely not to increase soluble rotenone concentrations or reflect increasing sensitivity to rotenone (Finlayson, personal communication June 2007).

The following results are pertinent to Silver King Creek and other mountain cold water streams. Lethal doses for Chironomidae (Diptera) have varied from about 0.3 to 1 ppm (Zischkale 1952, Lindgren 1960). Hamilton (1941) found that lethal concentrations were 2 ppm for leeches (Annelida: Hirudinea) and 10 ppm for Amphipoda. Ruck (1966) reported 100% mortality for unspecified dragonflies (Odonata: Anisoptera) at 5.3 ppm, for Isopoda at 1.5 ppm, for Amphipoda at 2.5 ppm, and for crayfish (Decapoda) at 3.0 ppm rotenone. Based on laboratory toxicity tests, Engstom-Heg et al. (1978) reported that few immature aquatic insects could survive a 48 hour exposure to 3 ppm rotenone. Chandler and Marking (1982) reported lower sensitivity than many other studies for the invertebrates they evaluated. LC50 values for 24 hour exposures were 3.6 ppm for

Gyrinus (Coleoptera: Gyrinidae), 3.4 ppm for *Notonecta* (Coleoptera: Notonectidae), and 4.7 ppm for *Macromia* (Odonata: Macromiidae, Chandler and Marking 1982). These three genera are all relatively large and two of them breathe atmospheric air. Aquatic insects that breathe atmospheric air appear to have higher resistance to rotenone than aqueous air breathers (Engstom-Heg et al. 1978).

Data on rotenone toxicity for invertebrates known to occur in Silver King Creek was available for several taxa. *Tipula* (Diptera: Tipulidae) were unaffected by 1 ppm rotenone over 96 hours (Leonard 1939). Lindgren (1960) reported *Hydropsyche* (Trichoptera: Hydropsychidae) suffered 30% mortality at 1 ppm rotenone over 24 hours and Chandler and Marking (1982) reported LC50s of 10.7, 8.0, 3.6, and 0.6 ppm rotenone for 1, 3, 6, and 96 hour trials. Engstom-Heg et al. (1978) evaluated the toxicity of rotenone to several taxa that occur in Silver King Creek. Taxa with low tolerance of rotenone included *Baetis* (Ephemeroptera: Baetidae), Perlidae (Plecoptera), Perlodidae (Plecoptera), *Rhyacophila* (Trichoptera), *Psychomyia* (Trichoptera: Psychomyiidae), and Simuliidae (Diptera). Taxa with intermediate tolerance to rotenone included *Ephemerella* (Ephemeroptera: Ephemerellidae), Heptageniidae (Ephemeroptera), Chloroperlidae (Plecoptera), Philopotamidae (Trichoptera), Limnephilidae (Trichoptera), Antocha, and Chironomidae (Diptera). Taxa with high tolerance to rotenone included *Paraleptophlebia* (Ephemeroptera: Leptophlebiidae) Elmidae (Coleoptera), *Pteronarcys* (Plecoptera), Corydalidae (Megaloptera), *Glossosoma* (Trichoptera: Glossosomatidae), *Hydropsyche* (Trichoptera), *Cheumatopsyche* (Trichoptera), and Odontoceridae (Trichoptera). Tolerances were described in terms of rotenone exposure in ppm hours. Low tolerance was in the range of 1 to 6 ppm hours, intermediate tolerance was in the range of 6 to 16 ppm hours, and high tolerance was in the range of 16 to 24 ppm hours.

The results of laboratory studies published to date appear most useful for accessing the general rather than the specific toxicity of rotenone to invertebrates. As compared to field evaluations, laboratory studies may stress invertebrates and the natural dilution of rotenone in the environment is minimized. Also, in many of the earlier laboratory studies, rotenone formulation concentrations were not confirmed (i.e., not measured) and the exposure duration often was much longer than that used in field applications (B. Finlayson, personal communication June 2007).

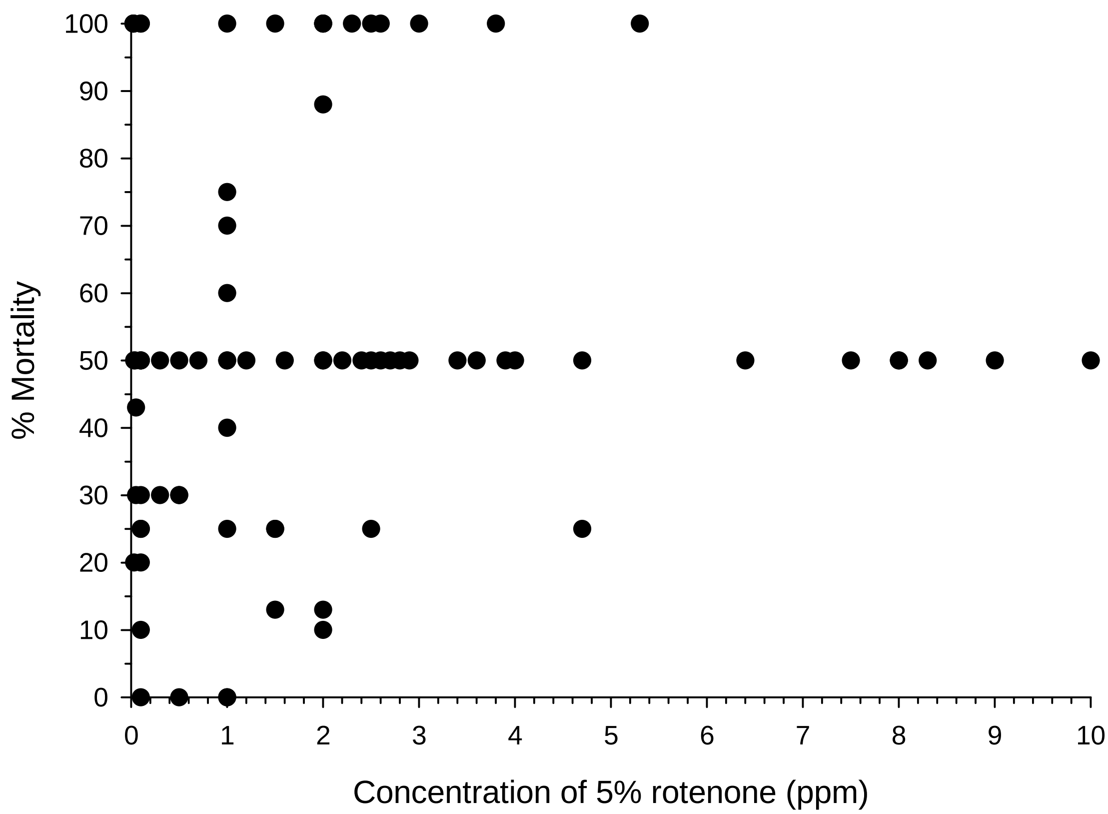

Figure 1. Toxicity of rotenone to aquatic invertebrates based on several laboratory studies. Data are provided in Appendix 1.

Field Studies

A total of 20 published field studies were evaluated as to the effects of rotenone treatments on aquatic invertebrate assemblages (Tables 1 and 2). Eleven studies were conducted in lentic systems (lakes, reservoirs, ponds, and wetlands, Table 1) and nine studies were conducted in lotic systems (rivers and streams, Table 2). The concentration of rotenone and the duration of the rotenone treatment varied widely among studies. Low level concentrations were 0.25 to 1 ppm and higher level concentrations were 3 to 5 ppm. Not all studies provided information on the concentration of rotenone used.

Lentic Studies

The effects of rotenone on invertebrates in lentic habitats have been studied since the 1940s (Table 1). Overall, the impact of rotenone on lentic invertebrates appeared to be highly variable. This variation is related to differences in the toxicity of rotenone among water bodies in response to light, oxygen, alkali, temperature, and turbidity of the water (Almquist 1959), e.g., toxicity is higher in low pH waters (Oberg 1956, cited in Almquist 1959). Some of the variation in reported effects may also be due to the intensity of pre- and post-treatment sampling. Sampling intensity varied from a single pre-treatment sample to more than a year of pre-treatment sampling. Post-treatment sampling varied from a single post-treatment sampling to up to 4 years of post-treatment sampling. Reported impacts were generally less for studies that conducted less sampling.

Short-term Impacts

More studies reported the effects on zooplankton assemblages than the effects on benthic organisms. Most studies reported that zooplankton assemblages were reduced in both number and diversity, with more studies reporting on changes in organism abundance than changes in species composition. Brown and Ball (1943) reported that 0.5 ppm killed the majority of zooplankton. Dragonflies (Odonota), leeches (Annelida: Hirudinea) and *Charoborus* (Diptera: Chaobrdiae) were affected less, but were still seriously affected. Cushing and Olive (1957) reported that 1 ppm of rotenone killed the majority of Chironomidae. Almquist (1959) concluded that most zooplankton and epiphytic and benthic organisms were killed by 0.5 to 0.6 ppm rotenone. Kiser et al. (1963) found that a 0.5 ppm treatment killed all zooplankton within 2 days. Anderson (1970) reported that 0.75 ppm rotenone reduced crustacean zooplankton densities to < 5% of pretreatment levels within 24 hours and no crustaceans were present 1 month after the treatment. In a study of benthic organisms, Koksvik and Aagaard (1984) found that 0.5 ppm rotenone caused only a negligible difference in total benthic invertebrate biomass between pre- and post-treatment samples, but the effects on Chironomidae (Diptera) species were considerable. Reinertsen et al. (1990) found similar zooplankton biomass after a 0.5 ppm rotenone treatment to that measured before the treatment, but abundances of individual species were significantly different after the treatment. Beal and Anderson (1993) found that no viable zooplankton were found in a small pond 48 hours following a treatment with 0.06 ppm of 2.5% rotenone. Melaas et al. (2001) reported on the effects of a 3 ppm rotenone treatment on wetland zooplankton and benthic invertebrates. The greatest short- and long-term declines were observed in zooplankton abundance. Effects on benthic invertebrates were less. Only abundances of Chaoborus and Hirudinoidea were significantly lower than pre-treatement levels after 3 weeks and no benthic taxa abundances were significantly different after 1 year.

Assemblage Recovery

Recovery of zooplankton assemblages following rotenone treatments was most often reported in terms of organism abundance. The rate of recovery to pre-treatment population sizes ranged from 1 month to 3 years. Brown and Ball (1943) found that Copepoda recovered to pre-treatment levels within a month and Cladocerans recovered within 5 weeks. Kiser et al. (1963) reported that all 42 species collected before a treatment that killed all zooplankton were present within 5 months. Anderson (1970) found that crustacean zooplankton were absent from two Alberta Lakes for 6 months following rotenone treatment, whereas rotifers never completely disappeared. All but one crustacean species returned to pre-treatment population numbers within about 3 years. Beal and Anderson (1993) reported that recovery began with Copepoda within a month of treatment, Cladocera within about 6 months and full recovery to pre-treatment levels occurred within 8 months. Melaas et al. (2001) reported complete recovery of a prairie wetland zooplankton and benthic invertebrate assemblages within 1 year of treatment.

Table 1. Field studies on the effects of rotenone on lentic invertebrates.

Location	Study Year	Rotenone Concentration	Pre-treatment Sampling	Post-treatment Sampling	Observed Change in Aquatic Invertebrate Assemblages	Citation
Third Sister Lake, MI	1943	0.5 ppm		Bimonthly		Brown & Ball 1943
Reservoir 4 & Smith Lake, CO	1954	1 mg/L 5% rotenone solution = 0.5 ppm	4 Ekman dredge samples, 2 weeks prior	Biweekly Ekman dredge samples for 1 yr	Few negative effects to Chironomidae	Cushing & Olive 1957
Salbo & Holm Lakes, Sweden	1958 1956	0.5 – 0.6 mg/L 5% rotenone solution = 0.25 – 0.3 ppm	Immediately prior	Immediately after	Most zooplankton & benthic fauna were killed	Almquist 1959
Fern Lake, WA	1960	0.5 mg/L 5% rotenone solution = 0.25 ppm	Biweekly for 2 yrs prior	Frequently for 6 months after	Complete zooplankton assemblage kill 2 days after; all 42 species found before treatment found within 5 months	Kiser et al. 1963
Patricia & Celestine Lakes, Alberta, Canada	1966	0.75 mg/L 5% rotenone solution = 0.4 ppm	1 sample 2 months prior	3 yrs after	Near complete recovery in 3 yrs	Anderson 1970
Lake Haugatjern, Norway	1980	0.5 mg/L 5% rotenone solution = 0.25 ppm	7 samples 1 yr prior	3 yrs & 4 yrs after	Small effect on zooplankton species composition & biomass	Reinertsen et al. 1990
Lake Haugatjern, Norway	1980	0.5 mg/L 5% rotenone solution = 0.25 ppm	Monthly, 6 months prior	Seasonal, 2 yrs	Little change overall in benthic assemblages, except to Chironomidae fauna, *Chironomus* in particular	Koksvik & Aagaard 1984
Lake Christina, MN	1987	3 mg/L 5% rotenone solution = 0.15 ppm	Seasonal 2 yrs prior	Seasonal 3 yrs	Large change in zooplankton assemblages attributed to change in fish assemblage	Hason & Butler 1994
Golf Course Ponds, IL	1991	0.6 mg/L 2.5% rotenone solution = 0.15 ppm	15 min. prior	6 months	Full recovery in 6-8 months	Beal & Anderson 1993
Unnamed Pond, MN	1998	3 mg/L 5% rotenone solution = 0.15 ppm	2 samples 6 months Prior	1 yr	Large short-term effect on zooplankton, no effect after 1 yr	Melaas et al. 2001
Lake Davis, CA	2006	Estimated to be 2 mg/L 5% rotenone solution = 0.1 ppm	3 months & 18 days prior	1 week, 9 months & 22 months after	Zooplankton abundance decreased 57% after & was 58% & 61% lower after 1 & 2 yrs. Taxa richness not affected	CA Fish & Game 2006

Lotic studies

The impacts of piscicides on aquatic invertebrates in rivers have been studied since the 1960s. The majority of these studies have been of short duration with little or no pre-treatment sampling and a year or less of post-treatment sampling (Binns 1967, Cook and Moore 1969, Koksvik and Aagaard 1984, Dudgeon 1990, Mangum and Madrigal 1999, Whelan 2002). Among the river studies we evaluated, three studies collected no pre-treatment data, four studies collected samples just prior to the treatment, and one study collected data a year before treatment. Post-treatment sampling was similarly variable with few studies collecting samples for more than a year following treatment. Exceptions to this were Mangum and Madrigal (1999), Whelan (2002) and Darby et al. (2004). Mangum and Madrigal (1999), Whelan (2002), and Darby et al. (2004) collected several years of post-rotenone data and Darby et al. collected samples a year prior to treatment.

Short-term Impacts

The immediate and short-term response of aquatic invertebrates to typical rotenone treatments in streams has been the rapid eradication of many if not all members of the assemblage (Binns 1967, Cook and Moore 1969, Engstrom-Heg et al. 1978). Binns (1967) reported that in the Green River, Wyoming, aquatic invertebrate populations were nearly completely eliminated following rotenone treatement. Mangum and Madrigal's (1999) study of the Strawberry River in north eastern Utah, reported at four stations, after two rotenone treatments, of 3 ppm for 48 hours, Ephemeroptera richness was reduced by 67-100%, Plecoptera richness by 67-100%, and Trichoptera richness by 61-100%. In Great Basin National Park, Ephemeroptera, Plecoptera, and Trichoptera (EPT) abundances were reduced by 99% of pre-treatment levels one month following treatment. Total assemblage taxa richness declined from a pre-treatment average of 46.8 taxa to 3.8 and 2.3 taxa, 1 day and 1 week following rotenone treatment. Average EPT group taxa numbers declined from 27 taxa to 0.25 taxa, 1 day and 1 week following rotenone treatment. Average EPT group taxa numbers declined from 26 taxa to 0.3 taxa at one-day post-treatment and 0 taxa by one-week. Taxa most resistant to rotenone were from the Coleoptera, Diptera and Amphipoda orders. Specimens from these orders were collected at all three time periods: one-day, one-week and one-month post-treatment. One-month following treatment, total assemblage taxa richness had increased to 14.8 taxa (31% of pre-treatment values) and EPT taxa richness had increased to 3.8 taxa (14% of pre-treatment values).

Assemblage Recovery

The time needed for aquatic invertebrate assemblages to recover following rotenone treatment across studies have varied from a few months to 3 years or more depending on the measure of recovery and study length. Overall aquatic invertebrate assemblage abundances generally return to pre-treatment levels quicker than measures of biodiversity or community composition. Assemblage abundances typically return to pre-application levels within a few months to a year (Binns 1967, Cook and Moore 1969, Beal and Anderson 1993, Mangum and Madrigal 1999, Melaas et al. 2001, Whelan 2002). Mangum and Madgrial (1999) found that the total abundance of invertebrates returned to pre-application levels in 1 to 36 months across their sampling sites. In Great Basin National Park, total abundance recovered to an average of 1,167 individuals m^{-2} (-34% of pre-treatment average) after 2 years. EPT group abundance recovery was slower being only 362.5 individuals m^{-2} (-57% of pre-treatment average) after 2 years. Only one sample site had total abundances that exceeded pre-treatment levels over the 3 year sampling period.

The recovery times for biodiversity and community composition measures have been longer and have exceeded 2 years in some studies (Binns 1967, Whelan 2002) and more than 5 years for individual species (Mangum and Madrigal 1999). Unfortunately, longer-term (2 or more years of post-treatment sampling) studies of aquatic invertebrate assemblage recovery following rotenone treatments are limited to four studies; Binn's (1967) study of the Green River, Wyoming, Mangum and Madgrial's (1999) study of the Strawberry River, Utah, Whelan's (2002) study of Manning Creek, Utah, and Darby et al. (2004) study of Snake Creek in Great Basin National Park.

Binns (1967) reported that 2 years after treatment the patterns of dominant invertebrate groups were still different from pre-treatment assemblages. Two genera, Pentagenia (Ephemeroptera: Ephemeridae) and Hexagenia (Ephemeroptera: Ephemeridae) did not reappear 2 years after treatment.

In the Strawberry River, Utah, Mangum and Madrigal (1999) found that 46% of the taxa were found 1 year after two rotenone treatments. Five years after the treatments, 79% of the pre-treatment taxa were collected. Of the 19 taxa that were not collected 5 years after the rotenone treatments, 47% were Trichoptera, 21% were Ephemeroptera, 16% were Plecoptera, 11% were Coleoptera, and 5% were Megaloptera. The number of taxa missing after 5 years at four sampling sites varied from 6 taxa at Station 1, 8 taxa at Station 2, 5 taxa at Station 3, and 4 taxa at Station 4. Seven years following the treatments, 8 additional pre-treatment taxa (2 Ephemeroptera: *Cinygmula, Drunella grandis*, 5 Trichoptera: *Rhyacophila acropedes*, *Micrasema, Ochrotrichia, Glossosoma, Oligophlebodes*, and 1 Coleoptera, Hydaticus) were collected, leaving 11 pre-treatment collected taxa (8%) missing 7 years after treatment (Mangum, personal communication to Jim Harvey, USFS Fisheries Biologist, Humboldt-Toyiabe National Forest, March 2007).

In Manning Creek, Utah, Whelan (2002) reported that about 50% of the taxa were found both pre-and post treatment, 21% (11 taxa) were collected only pre-treatment, and 30% were found only post-treatment. The most impacted orders of aquatic insects were Trichoptera, with about 10% of the taxa missing after 3 years.

In Snake Creek, Great Basin National Park, EPT abundances never returned to pre-treatment levels after 3 years (Darby et al. 2004). Overall taxa numbers recovered to an average of 42 taxa by the second year which was 91% of the average pre-treatment richness. The number of EPT taxa recovered to an average of 20 taxa by the second year which was 77% of the mean pre-treatment richness. After three years, 96% of the pre-treatment taxa were present. The 2 taxa that were not collected were *Baetis* (Ephemeroptera: Baetidae) and *Antocha* (Diptera: Tipulidae).

Table 2. Field studies on the effects of rotenone on lotic invertebrates.

Location	Study Year	Rotenone Concentration	Pre-treatment Sampling	Post-treatment Sampling	Observed Change in Aquatic Invertebrate Assemblages	Citation
Robinson Creek, CA	1963	5% rotenone active, unknown concentration	None, treated/ untreated comparison	8 months	10-50% reduction in abundance	Cook & Moore 1969
Green River, UT	1963	2.5 - 9.4 mg/L 5% rotenone solution = 0.125 – 0.5 ppm	2 weeks prior	2 yrs after	Immediate reduction in abundance of nearly all species. Hydrosychidae (Trichoptera) recovered after 2 yrs, Pentagenia & Hexagenia (Ephemeroptera) were extirpated	Binns 1967
Strawberry River, UT	1990	3 mg/L 5% rotenone solution = 0.15 ppm 48 hr	1 week prior	Annually 5 yrs	54% decrease in taxa richness after 1 yr, 21% decrease in taxa richness after 5 yrs	Mangum & Madrigal 1999
Steams, Papua, New Guinea	1990	Unknown	Immediately prior	Immediately after & then up to 2 hours	Significant declines in Dixidae & Hydropsychidae, no change in Leptophlebiide or in total abundance	Dudgeon 1990
Silver King Creek, CA	1964-1996	Treatments were done in 1964, 1976, 1977, 1991, & 1993. Treatments ranged from high doses of unknown concentrations and durations to lower doses of 0.025 ppm for 4 - 6 hours in 1991 & 1993 (see Table 3)	None	Multiple times 1984 to 2006	Slight reduction in total, Ephemeroptera, Plecoptera, and Trichoptera taxa richness and change in percent dominant taxa	Trumbo et al. 2000, Finlayson and Somer personal communication June 2007
Manning Creek, UT	1995	0.5 - 1.5 mg/L 5% rotenone solution = 0.25-0.75 ppm for 12-18 hours	1 month prior	1 yr & 3 yrs	13% decrease in taxa richness after 3 yrs	Whelan 2002
River Ogna, Norway	2001	Unknown	Just prior	2 months	Rapid recolonization of common taxa, a few taxa disappeared	Kjaerstad & Arnekleiv 2003
Strawberry Creek, Great Basin NP	2000	5 mg/L 5% rotenone solution = 0.25 ppm for 1 hour & 2 mg/L 5% rotenone	1 yr & 1 day prior	1 month, 9 months, 10 months, 11 months, 1 yr, 2 yrs & 3 yrs	Abundance & taxa richness did not return to pre-treatment levels after 3 yrs, 5 taxa	Darby et al. 2004

		solution = 0.1 ppm for 7 hours			not found after 1 yr, 2 taxa not found after 3 yrs	
Virgin River, UT	2001 to 2005	11 treatments between 1988 & 2005, unknown concentrations prior to 2004. In 2004 & 2005, 3 ppm rotenone for 3-8 hours.	None	1 yr	little to no change following 2004 & 2005 treatments, study complicated by lack of pre-data & >20 yrs of rotenone treatment	Vinson & Dinger 2006

Conclusion

Overall, there have been too few published studies and of these studies there is little comparability with respect to rotenone treatments and aquatic invertebrate data collection efforts to allow for any sweeping statements on the overall effects of rotenone on aquatic invertebrate assemblages in streams. Variation among treatment effects are likely related to differences among water bodies in response to light, oxygen, pH, temperature, and turbidity of the water (Almquist 1959). Much of the variation in reported effects also appears due to the intensity of pre- and post-treatment sampling. In particular, the lack of collection of a sufficient amount of data on aquatic invertebrate assemblages prior to treatment prevents us from understanding the true effects of rotenone treatments on invertebrate assemblages. The same is not as true for lakes where the number of studies is greater and the design of many of the studies has been more rigorous than it has been for stream studies. For streams, no studies have done an adequate job of describing pre-treatment assemblages. In general, once the immediate effects and recovery of assemblage abundances are documented, funding is generally unavailable to continue long-term studies of these systems (Niemi et al. 1990).

Based on toxicity tests and field observations, smaller invertebrates that use gills to acquire aqueous oxygen appear more sensitive than larger invertebrates that acquire aqueous oxygen cutaneously, through lamellae or spiracles, use respiratory pigments, or that can breathe atmospheric oxygen. This suggests that rotenone impacts to invertebrates will be greatest in mountain streams characterized by cold water and high oxygen levels, as these streams are characteristically dominated by small gilled invertebrates, namely Ephemeroptera, Plecoptera, and Trichoptera.

The studies we reviewed generally reported changes in the entire invertebrate assemblage, such as total taxa richness or abundance. With the exception of a few studies there has been little reporting on the impacts of piscicides on individual invertebrate taxon or the recovery rates of individual taxon, especially rare species. The results of the three longer-term more intensively sampled studies suggest that while some taxa can quickly recolonize treated areas, other taxa may be eradicated for a number of years or potentially forever. The ability of taxa to recolonize treated areas is likely a function of their overall population sizes within the basin, upstream and local habitat conditions, and the dispersal abilities of individual taxon.

Rotenone as a disturbance

Natural physical disturbances in stream environments include floods, droughts, and fire. Biological disturbances can include nuisance invasive species, such as New Zealand mud snails (*Potamopyrgus antipodarum*) or the introduction of sport fishes, like rainbow trout (*Oncorhynchus mykiss*). Biological disturbances can be sustained pressures on the environment, whereas physical disturbances are relatively discrete events that remove organisms and create conditions for recolonization. In this way, rotenone appears to act like a physical disturbance and probably most like a high intense streamflow event.

The immediate impact of higher than normal streamflows is a drastic reduction in community diversity and abundance (Lepori and Hjerdt 2006). Estimates on the loss of invertebrate diversity and abundance ranged from to 2 to 10% of pre-flood conditions (e.g., Fisher et al. 1982, Giller et al. 1991, Cobb et al. 1992). Recovery by aquatic invertebrates following floods has generally been reported to occur within weeks to months to years following the flood event (Niemi et al. 1990, Mackay 1992). This variation in recovery time appears highly dependent on the flood regime and habitat complexity (Lepori and Hjerdt 2006). Slower recovery occurs following unpredictable floods, i.e., floods that occur during the wrong time of year (Giller et al. 1991), which suggests that invertebrates have adapted to the flood regimes they are typically subject to (Resh et al. 1988). Recovery of assemblages is also slower following floods with greater magnitude (Scrimgeour et al. 1988), which suggests that the effectiveness of small scale refugia decreases with increasing flood magnitude and the sources of colonization become further apart.

The effects of rotenone on stream invertebrates appear similar to a large unpredictable flood. Rotenone is typically applied during low flow periods. In Silver King Creek in 1991 to 1993 it was applied in August and September – an unnatural time for a large disturbance in this region, where high flow events are typically caused by snowmelt in late spring and early summer. The impact of rotenone on aquatic invertebrates is typically extensive with respect to the extent of the disturbance. Historical rotenone treatments in Silver King Creek appeared to treat 5 or more miles of stream during each treatment, which would likely make it more difficult for invertebrates to reach treated areas. There are intermittent tributaries and fishless headwater tributary streams along much of Silver King Creek that may supply invertebrates into the treatment area. The degree to which these invertebrates will provide colonization reserves for Silver King Creek should be evaluated.

The rate of recovery after floods is also determined by intrinsic biological characteristics of the invertebrates themselves. Invertebrates adapted to living in unpredictable stream environments, e.g., desert streams, have different behavioral and physiological traits than invertebrates adapted to more predictable streams (Townsend and Hildrew 1994), which allows them to better deal with unpredictable disturbances. Aquatic invertebrate adaptations to frequently or unpredictably disturbed environments include rapid growth and development, lack of diapause or resting stages, small size, flexible life histories, high adult mobility and longevity, and the near year-around presence of adults available for post-flood oviposition (Gray 1981, Fisher et al. 1982, Lake et al. 1986, Williams and Feltmate 1992, Townsend et al. 1997a, 1997b).

In a review of 150 case studies of aquatic ecosystem recovery from disturbance, (15 of which were in response to rotenone treatments), Niemi et al. (1990) found that most recovery times were less than 3 years. Recovery of macroinvertebrate assemblages to 85% of pre-disturbance densities after pulse disturbances (including rotenone) occurred in less than 18 months. Recovery times were slightly quicker for low order (1 to 3) streams than they were for larger rivers (4^{th} to 5^{th} order). They summarized that rates of recovery of aquatic invertebrate assemblages were influenced most by: 1) persistence of the impact, including changes in system productivity, habitat integrity, and persistence of the stressor; 2) life history of the organism, including generation time, and propensity to disperse; 3) time of year the disturbance occurs; 4) presence of refugia; and 5) distance to the recolonization source. They found that assemblage densities recovered much quicker than individual taxon. Times of recovery for common insect orders following pulse disturbances that did not affect physical habitat characteristics (mostly rotenone and DDT) were Diptera < Ephemeroptera < Trichoptera < Plecoptera. Coleoptera was not represented in enough studies, but they felt that Coleoptera likely recovered more slowly than Trichoptera and Plecoptera. Assemblage recovery times were about 60% after 2 years for Trichoptera and Plecoptera, 70% for Ephemeroptera after 1 year, and near 80% for Diptera after 1 year. They speculated that recovery time was primarily related to generation time, propensity to drift, and distance from colonization source. Downstream drift from unimpacted upstream areas was the critical factor in determining the recovery times for stream ecosystems following pulse disturbances that do not impact the physical characteristics of the habitat.

These results suggest that rotenone impacts may be greatest in streams with lower frequency of disturbance or predictable discharge patterns. Recovery will also likely be longer in streams where long reaches are treated. Increasing the distance to colonization sources will reduce the ability of species to colonize the treated reach. Disturbance events will have greater impacts if they occur during critical life stages or if they occur in the fall when lower winter drift rates and lack of winter reproduction will delay recovery until the following spring, particularly if the site will be dependent on downstream drift of larvae for recolonization.

SILVER KING CREEK

Overview

The Silver King Creek basin is located on the eastern slope of the Sierra Nevada Range, in Alpine County, California. It is a major tributary to the East Fork of the Carson River, which drains into the Lahontan Basin. It is home to Paiute cutthroat trout (*Oncorhynchus clarki seleniris*). The Paiute cutthroat trout is listed as threatened under the Endangered Species Act of 1973. One of the Paiute cutthroat trout recovery plan's criteria is to remove all nonnative salmonids from Silver King Creek and its tributaries downstream of Llewellyn Falls to fish barriers in Silver King Canyon. The use of the piscicide rotenone has been historically used in Silver King Creek to remove nonnative fishes and it has been proposed for future use. The purpose of this report was to evaluate the effects of previous rotenone treatments on aquatic invertebrate assemblages in the Silver King Creek Basin. This analysis and future assessments of the effects on rotenone on aquatic biota in the Silver King Creek Basin are hampered by the long history of rotenone treatments in the basin, the lack of data on aquatic invertebrate assemblages prior to the use of rotenone, and prior land use practices, such as logging and sheep and cattle grazing, that have substantially improved over the last 20 or more years. The oldest data available on aquatic invertebrate assemblages in this analysis was from 1984. Thus we lack necessary pre-treatment samples to definitively measure changes that occurred following rotenone treatments in the basin in 1964, 1976, and 1977. There were also significant differences between the two sets of aquatic invertebrate samples that were collected between 1984 and 1996 (hereafter referred to as historic) and 2003 and 2006 (hereafter referred to as recent) that limited our ability to quantify changes in invertebrate assemblages back to 1984.

Study Area

Silver King Creek is a tributary to the East Fork Carson River, which drains into the Lahontan Basin. The entire Silver King Creek basin occurs within the Humboldt-Toiyabe National Forest in Alpine County, California. The creek originates at 2,926 meters (9,600 feet) elevation and flows north through three distinct valleys for approximately 22.5 kilometers (14 miles) where it meets the East Fork Carson River (Figure 2). Between the headwaters and the confluence with the East Fork Carson River, eight tributaries, three above and five below Llewellyn Falls, join Silver King Creek. Llewellyn Falls is located at the head of Lower Fish Valley (2,438 meters, 8,000 feet elevation) about 16.2 kilometers (10 miles) above the confluence with the East Fork Carson River. Habitat characteristics were described by Ryan and Nicola (1976). From its source, Silver King Creek flows swiftly for 3.2 kilometers (2.0 miles) before beginning a gradual descent to Upper Fish Valley in an area of washed-out beaver ponds just above the mouth of Fly Valley Creek. For 2.4 kilometers (1.5 miles), through Upper Fish Valley, Silver King Creek is a typical meandering meadow creek, averaging 3.7 meters (12 feet) wide and 0.3 meter (1 foot) deep in the summer. From the southeast, Four Mile Canyon Creek enters 2.0 kilometers (1.2 miles) above Llewellyn Falls. Bull Canyon Creek joins Silver King Creek from the west 0.8 kilometer (0.5 miles) above Llewellyn Falls. At the lower end of Upper Fish Valley, the stream gradient increases through a sparsely forested section before reaching Llewellyn Falls. The vertical drop of Llewellyn Falls is approximately 6.1 meters (20 feet). Within the 2.8-kilometer (1.7-miles) length of Lower Fish Valley, two small tributaries enter the mainstem from the west: Tamarack Lake Creek, located 1.2 kilometers (0.7 miles) below Llewellyn Falls, and a short, unnamed tributary downstream another 1.2 kilometers (0.7 miles). Silver King next flows through Long Valley, which is only 1.5 kilometers (0.9 miles) long and is the shortest of the three valleys. No tributaries enter Silver King Creek in Long Valley. Between Lower Fish Valley and Long Valley the gradient increases. Tamarack Creek enters Silver King Creek from the west 0.6 kilometer (0.4 miles) below Long Valley, and Coyote Valley Creek enters from the east 1 kilometer (0.6 miles) farther downstream. Approximately 2.8 kilometers (1.7 miles) below the mouth of Coyote Valley Creek, Silver King Creek descends through Silver King Canyon and emerges from the canyon in the vicinity of Snodgrass Creek. Upstream from Snodgrass Creek, in the canyon, a series of falls present a fish barrier to nonnative trout and nonsalmonid native fish species that occur downstream. No tributary of significance enters Silver King Creek from Snodgrass Creek downstream for 5.4 kilometers (3.4 miles) until its confluence with the East Fork Carson River.

All of the sampling locations on Silver King Creek were located in stream reaches classified as “C” channels following Rosgen (1996). "C" stream types are typically located in narrow to wide valleys, have a well developed but slightly entrenched floodplain, are relatively sinuous with a channel slope of 2% or less and a bedform morphology indicative of a riffle/pool configuration. The "C" stream type exhibits a sequencing of steeps (riffles) and flats (pools), that are linked to the meander geometry of the river where the riffle/pool sequence or spacing is on the average one-half a meander wavelength or approximately 5-7 bankfull channel widths. The average gradient of Silver King Creek is 4.1 percent, which is less than any of its tributaries. However, the portion of Silver King Creek between Fly Valley and Corral Valley Creeks has an average gradient of 1.6 percent. Stream bottom substrates in Silver King Creek riffles, where aquatic invertebrate collections were made, consist primarily of gravels and cobbles (Table 3) and appear to have changed little between samples collected in 1984 and 1990.

Table 3. Stream bottom sediment particle sizes presented as the percent of each sample > 6.35 mm (medium gravel) for samples collected in 1984 and 1990. Positive % difference values indicate a coarsening of the substrate, whereas negative values indicate more fine (< 6.35 mm) sediment accumulation.

		% >6.35 mm		
Location	Station	1984	1990	% Difference Between 1984 and 1990
Silver King Creek	S2:640	64.3	60.3	-6.6
Silver King Creek	S3:641	61.8	53.4	-15.7
Silver King Creek	S4:700	57.0	61.5	7.3
Silver King Creek	S5:725	57.3	59.0	2.9
Silver King Creek	S6:738	59.3	68.6	13.6
Silver King Creek	S7:775	64.8	57.6	-12.5
Silver King Creek	S8:813	60.0	64.2	6.5
Bull Canyon Creek	S1:040	62.9	61.0	-3.1
Fly Valley Creek	S1:500	62.9	67.9	7.4
Four Mile Creek	S1:250	69.6	72.4	3.9
Coyote Valley Creek	S2:467	32.2	41.0	21.5
Coyote Valley Creek	S3:500	44.5	52.1	14.6
Corral Valley Creek	S1:571	51.8	51.0	-1.6
Corral Valley Creek	S2:574	45.7	46.9	2.6

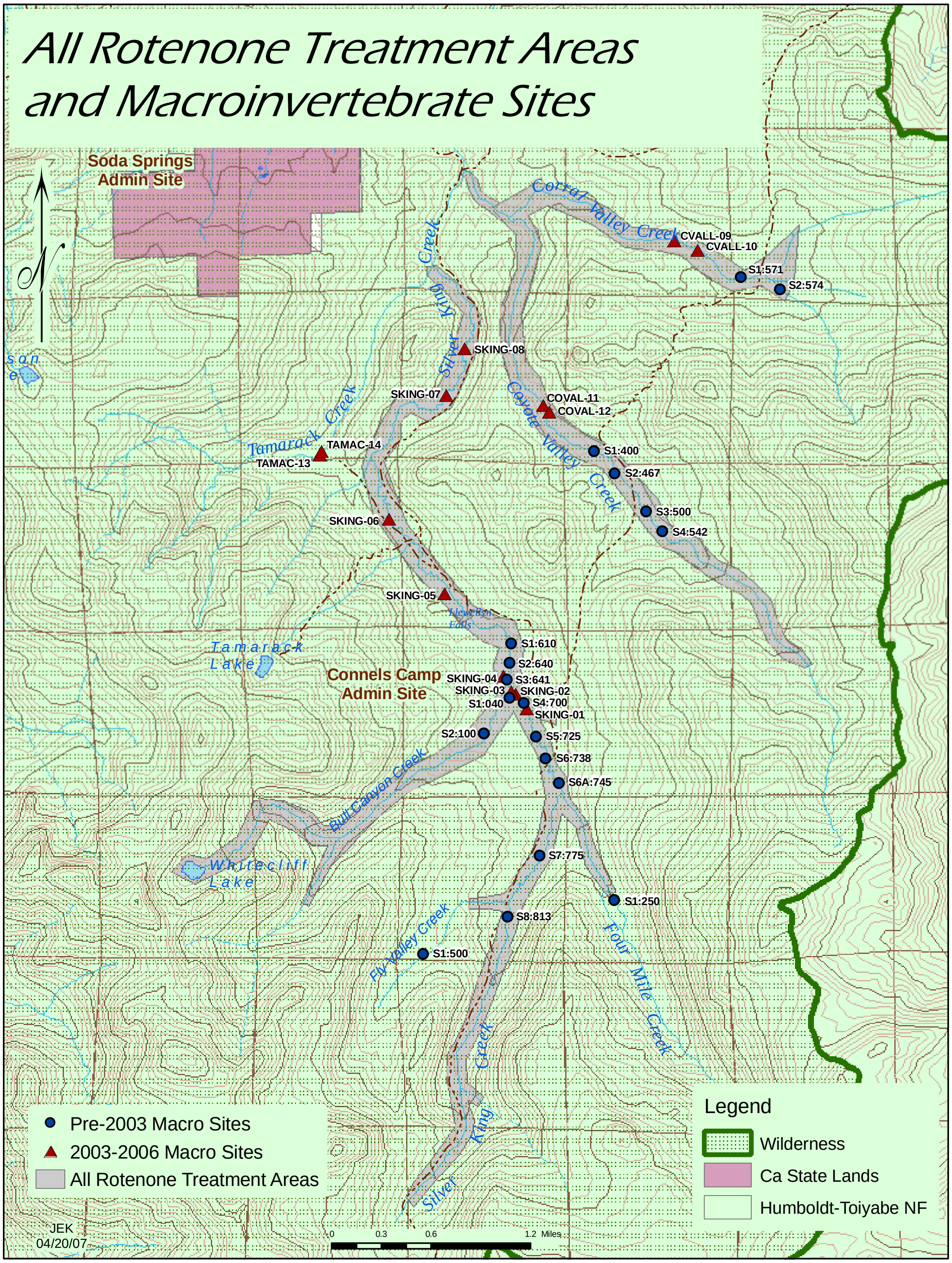

Figure 2. Map of study area.

Aquatic invertebrate samples were collected in several streams that are tributaries of Silver King Creek. These include Corral Valley Creek, Coyote Valley Creek, Four Mile Canyon Creek, and Fly Valley Creek (Figure 2). Except for Fly Valley Creek, these tributaries were all classified as ”C” channels with similar habitat characteristics as Silver King Creek. Fly Valley was classified as a B2/B3 channel. "B" stream types are moderately entrenched, have a cross-section width/depth ratio (greater than 12), display a low channel sinuosity, and exhibit rapids dominated bed morphology. Pool-to-pool spacing is generally four to five bankfull widths, decreasing with an increase in slope gradient. Meander width ratios (belt width/bankfull width) are generally low which reflect low rates of lateral extension. "B" stream types occur primarily on moderately steep to gently sloped terrain, with the predominant landform seen as a narrow and moderately sloping basin.

Rotenone Treatments

Rotenone treatments were conducted in the Silver King Creek Basin between 1964 and 1993 (Table 3). Silver King Creek was treated in 1964, 1976, 1991, 1992, and 1993. Corral Valley Creek was treated with rotenone in 1964 and 1977. Coyote Valley Creek was treated with rotenone in 1964, 1977, 1987, and 1988. Four Mile Canyon Creek and Fly Valley Creek were never treated with rotenone upstream from the aquatic invertebrate sampling locations (USFS and California Fish and Game personnel communication, 9 March 2007). The concentration and duration of rotenone application varied among treatments and among the streams treated (Table 3).

Table 3. Rotenone formula, concentration, and duration for treatments conducted in the Silver King Creek Basin between 1964 and 1993. ppm is parts per million, ppb is parts per billion. Information in the Table for 1991 to 1993 is from Trumbo et al. (2000) and are maximum rotenone formulation concentrations. The notes below the Table[b] are from Finlayson (personal communication June 2007) and are mean rotenone formulation concentrations.

Year	Silver King Creek & Lower Bull Canyon Creek	Corral Valley Creek	Coyote Valley Creek
1964	1 ppm pro-noxfish, 5 hours	1 ppm pro-noxfish, 5 hours	1 ppm pro-noxfish, 5 hours
1976	10 ppb Fintrol, 8 hours, followed by 1 ppm pro-noxfish, 5 hours		
1977		4 ppm unknown formulation, 8 hours followed by 1 ppm unknown formulation 3 hours	4 ppm unknown formulation, 8 hours followed by 1 ppm unknown formulation 3 hours
1987			1 ppm pro-noxfish, 4 hours
1988			0.6 ppm Noxfish, 4 hours
1991	1 ppm Nusyn-noxfish[a] (0.025 mg/L rotenone formulation concentration) 19 and 23 hours a day for 2 consecutive days[b]		
1992	1 ppm Nusyn-noxfish[a], 19 to 23 hours a day for 2 days separated by 1 day[b]		
1993	1 ppm Nusyn-noxfish[a], 24 and 22 hours a day for 2 consecutive days[b]		

[a]Nusyn-Noxfish contains 2.5% rotenone, 5% other rotenoid compounds, 2.5% of the synergist piperonyl butoxide, and 90% not-rotenoid organic compounds. A 1 ppm concentration of Nusyn-noxfish would equal 0.25 ppm rotenone.
[b]Silver King Creek was treated at 0.025 mg/L rotenone for 4 to 6 hours, no more than twice a year in 1991-1993. California Department of Fish and Game monitoring data suggest that the average rotenone concentration was 0.010 mg/L, not 0.020 mg/L, for a period of approximately 8 to 10 hours.

Sample Collection Methods

A list of collections sites and years when samples were collected are presented in Table 4 and 5, respectively. Aquatic invertebrates were collected similarly in all years. Samples were collected using a Surber net (0.09 m^2). Samplers used prior to 2003 most likely had a 280 micron mesh net. The exact mesh is unknown, but most USFS offices were supplied with Surber nets by the USFS Aquatic Ecosystem Laboratory with a 280 micron mesh net. Samplers used since 2003 have a 500 micron mesh net. Samples were collected by disturbing the area within the square sampling frame with hands and scrubbing individual substrate particles within the sampling area and allowing the invertebrates and detritus to wash downstream into the net. Three samples were collected at different locations within a single riffle. The three samples were kept separate in the field and preserved in 90% ethanol.

Table 4. Aquatic invertebrate sampling locations. Station IDs are those used on the map shown in Figure 1. Station IDs for historic sampling locations were from the original aquatic invertebrate monitoring reports prepared by the USFS Aquatic Ecosystem Laboratory. Additional information on rotenone treatments is shown in Table 3.

Sampling Location	Station ID	Latitude North	Longitude West	Rotenone Treatment or Control Site
Bull Canyon Creek, downstream site, Station 1	S1:040	35.4529	119.6000	Treated
Bull Canyon Creek, 300 feet upstream from fence, Station 2	S2:100	36.4499	119.6029	Control
Corral Valley Creek, downstream from trail	S1:571	34.4894	119.5742	Treated
Corral Valley Creek, upstream from trail	S2:574	34.4883	119.5699	Treated
Corral Valley Creek, Lower Site	CVALL-09	38.4931	119.5822	Treated
Corral Valley Creek, Upper Site	CVALL-10	38.4914	119.5790	Treated
Coyote Creek, downstream from crossing, Station 2	S2:467	35.4724	119.5883	Treated
Coyote Valley Creek, upstream site	S4:452	34.4674	119.5830	Treated
Coyote Creek, upstream from large meadow rock, Station 3	S3:500	35.4691	119.5847	Treated
Coyote Valley Creek, Lower Site	COVAL-11	38.4768	119.6024	Treated
Coyote Valley Creek, Upper Site	COVAL-12	38.4777	119.5956	Treated
Fly Valley Creek, Station 1	S1:500	36.4308	119.6098	Control
Four-mile Canyon Creek, middle meadow, Station 1	S1:250	35.4354	119.5884	Control
Silver King Creek, 300 yards upstream from 4-Mile Creek, Station 7	S7:775	35.4392	119.5968	Treated
Silver King Creek, lower exclosure near Cow Cabin, Station 2	S2:640	35.4559	119.6000	Treated
Silver King Creek, near middle exclosure, Station 3	S3:641	36.4545	119.6003	Treated
Silver King Creek, Station 1	S1:610	35.4576	119.5998	Treated
Silver King Creek, Upper Valley, Site 1	SKING-01	38.4519	119.5981	Treated
Silver King Creek, Upper valley, Site 2	SKING-02	38.4697	119.5878	Treated
Silver King Creek, Upper Valley, Site 3	SKING-03	38.4536	119.5997	Treated
Silver King Creek, Upper Valley, Site 4	SKING-04	38.4547	119.6008	Treated
Silver King Creek, upstream from exclosure, Station 4	S4:700	35.4524	119.5984	Treated
Silver King Creek, upstream from Fly Valley Creek, Station 8	S8:813	36.4339	119.6003	Treated
Silver King Creek, mid meadow upstream from cabin, Station 5	S5:725	35.4495	119.5971	Treated
Silver King Creek, upper meadow upstream from cabin, Station 6	S6:738	35.4476	119.5960	Treated
Silver King Creek, Station 6A	S6A:745	35.4455	119.5946	Treated
Silver King Creek, Long Valley, Site 7	SKING-07	38.4792	119.6069	Treated
Silver King Creek, Long Valley, Site 8	SKING-08	38.4831	119.6047	Treated
Silver King Creek, Lower Valley, Site 5	SKING-05	38.4619	119.6072	Treated
Silver King Creek, Lower Valley, Site 6	SKING-06	38.4686	119.6133	Treated
Tamarack Creek, Lower Site	TAMAC-14	38.4750	119.6208	Control
Tamarack Creek, Upper Site	TAMAC-13	38.4743	119.6207	Control

Table 5. Aquatic invertebrate sample availability.

Sampling Location	Station ID	Samples Obtained	Years Obtained	Years Known to be Missing
Bull Canyon Creek, downstream site, Station 1	S1:040	0	None	unknown
Bull Canyon Creek, 300 feet upstream from fence, Station 2	S2:100	2	1984, 87	none
Corral Valley Creek, downstream from trail	S1:571	2	1984, 87	1977
Corral Valley Creek, upstream from trail	S2:574	0	None	unknown
Corral Valley Creek, Lower Site	CVALL-09	4	2003, 04,05,06	none
Corral Valley Creek, Upper Site	CVALL-10	4	2003, 04,05,06	none
Coyote Valley Creek, upstream site	S1:400	0	None	unknown
Coyote Valley Creek, downstream from crossing, Station 2	S2:467	2	1984, 87	none
Coyote Valley Creek, Lower Site	COVAL-11	4	2003, 04,05,06	none
Coyote Valley Creek, Upper Site	COVAL-12	4	2003, 04,05,06	none
Coyote Valley Creek, upstream from large meadow rock, Station 3	S3:500	2	1984, 87	none
Coyote Valley Creek, upstream site	S4:452	0	None	unknown
Fly Valley Creek, Station 1	S1:500	2	1984, 87	none
Four-mile Canyon Creek, middle meadow, Station 1	S1:250	11	1984,87,91,92,93,94,95,96	1977,78,83,90
Silver King Creek, 300 yds upstream from 4-Mile Creek, Station 7	S7:775	11	1984,87,91,92,93,94,95,96	1990
Silver King Creek, Long Valley, Site 7	SKING-07	4	2003, 04,05,06	None
Silver King Creek, Long Valley, Site 8	SKING-08	4	2003, 04,05,06	None
Silver King Creek, lower exclosure near Cow Cabin, Station 2	S2:640	11	1984,87,91,92,93,94,95,96	1990
Silver King Creek, Lower Valley, Site 5	SKING-05	4	2003, 04,05,06	None
Silver King Creek, Lower Valley, Site 6	SKING-06	4	2003, 04,05,06	None
Silver King Creek, mid meadow upstream from cabin, Station 5	S5:725	2	1984, 87	1990
Silver King Creek, near middle exclosure, Station 3	S3:641	11	1984,87,91,92,93,94,95,96	1977,78,83,90
Silver King Creek, Station 1	S1:610	0	None	Unknown
Silver King Creek, upper meadow upstream from cabin, Station 6	S6:738	11	1984,87,91,92,93,94,95,96	1990
Silver King Creek, Station 6A	S6A:745	0	None	Unknown
Silver King Creek, Upper Valley, Site 1	SKING-01	4	2003, 04,05,06	None
Silver King Creek, Upper valley, Site 2	SKING-02	4	2003, 04,05,06	None
Silver King Creek, Upper Valley, Site 3	SKING-03	4	2003, 04,05,06	None
Silver King Creek, Upper Valley, Site 4	SKING-04	4	2003, 04,05,06	None
Silver King Creek, upstream from exclosure, Station 4	S4:700	2	1984, 87	1977,78,83,90
Silver King Creek, upstream from Fly Valley Creek, Station 8	S8:813	11	1984,87,91,92,93,94,95,96	1990
Tamarack Creek, Lower Site, never treated	TAMAC-14	4	2003, 04,05,06	None
Tamarack Creek, Upper Site, never treated	TAMAC-13	4	2003, 04,05,06	none

Laboratory Methods

Historic samples collected between 1984 and 1996 were processed by the USFS Aquatic Ecosystem Analysis Laboratory in Provo, Utah. Recent samples collected annually between 2003 and 2006 were processed by the National Aquatic Monitoring Center (The BugLab) operated by the U.S. Bureau of Land Management and Utah

State University in Logan, Utah. At the USFS Laboratory in Provo, Utah, samples were sub-sampled using an automated sub-sampler containing eight pans with fine mesh bottoms. The actual mesh size of the subsample is unknown, but was likely 280 microns, which was the mesh provided on Surber samplers used by most USFS offices between 1970 and the 2000. Samples were placed in a 1 L beaker that was attached above the pans. The pans were then rotated on a phonograph turntable as the material in the beaker was flushed out of the beaker with a stream of water delivered to the bottom of the beaker. The invertebrates in the sub-sample pans were then removed under a dissecting microscope at 10-30 power. A total of 250 to 300 organisms were removed from each sample and identified. All organisms removed during the sorting process were then identified using appropriate identification keys. Invertebrates were generally identified to the genus level. Chironomidae were identified to family or sub-family. Non-insects were identified to Phylum, Class, or Order depending on the availability of identification keys. The previous description of the methods used by the USFS Laboratory was from Trumbo et al. (2000). The percentage of each sample processed was unknown.

Recent samples were processed by the BugLab following methods recommended by the United States Geological Survey (Cuffney et al. 1993). These methods are described in greater detail and rationalized in Vinson and Hawkins (1996). All samples were processed in their entirety, i.e., all invertebrates from each sample were removed. All the organisms removed during the sorting process were separated into Orders then identified. Once the data had been entered into a computer and checked, the unsorted portion of the sample (i.e. detritus) was discarded. The identified portion of the sample was placed in 70% ethanol, given a catalog number, and was retained.

Data Processing

Historic Samples

Individual sample data for historic samples processed by the USFS Laboratory were originally entered in a computer program developed by the USFS Aquatic Ecosystem

Analysis Laboratory. Data for each of the three replicate samples collected at each sampling location on each sampling date were entered separately. The data were then summarized and tables were printed that listed the mean number of individuals collected for each taxon among the three replicate samples. The original data sources, (either the taxonomist's original bench sheets or the computerized data for each replicate sample) are no longer available. We were provided with copies of the paper reports that appeared to be prepared annually by the USFS Aquatic Ecosystem Analysis Laboratory. These reports contained a list of taxa and the estimated mean number of individuals per square meter collected among the three replicate samples from each sampling location on each sampling date. These data, the taxon names and mean number of individuals per square meter, were entered into the BugLab's computer data base. The estimated abundances per square meter for each taxon were then converted to counts by multiplying the estimated number of individuals per square meter times the sample area, 0.279 m^2. Rounding errors occurred when these data were converted from densities per square meter to whole number counts. These differences, when the counts were then converted back to densities amounted to no more than 1% of the total abundance for individual samples. The data were converted to counts to improve our ability to make comparisons between historic and more recently collected data. We did not know the percentage of each sample that was processed by the USFS laboratory, so the number of individuals identified in each sample is overestimated for those samples that were not processed in their entirety. The taxonomy for all taxa was updated as required to reflect the most recent taxonomic nomenclature for each taxon. For example, *Ephemerella doddsi, Ephemerella spinifera,* and *Ephemerella hystrix* were changed to *Drunella doddsi, Drunella spinifera,* and *Caudatella hystrix.* We also used experience we gained from processing 210 samples from the Silver King Creek Basin between 2003 and 2006 to clean up some of the taxonomy from samples identified prior to 2003. We believe these somewhat subjective changes – as we did not have the actual specimens identified by the USFS laboratory – were appropriate based on our taxonomic experience and improved the consistency in taxonomy between the two laboratories. Taxa lists with estimated abundances for each taxon for each sample are provided in Appendix 12.

Recent Samples

Data for recent samples processed by the BugLab were from individual Surber samples. These data were entered into the BugLab's computer program. The data from the three Surber samples collected at each site on each sampling date were then composited into a single sample with a sampling area of 0.279 m^2, making them equivalent with respect to sampling area as the samples collected prior to 2003. All recent samples were processed in their entirety, so the number of individuals for each three sample composite was equal to the number of individuals collected at each site. Taxa lists with estimated abundances for each taxon for each sample are provided in Appendix 12.

Data Analysis

Ecological summaries were calculated for each composite sample collected at each site on each sampling date. The sample summaries presented were picked to be representative of the entire aquatic invertebrate assemblage, a major taxonomic group of aquatic invertebrates, or a measure of rarity. Measures of the total assemblage included total taxa richness (OTUs – operational taxonomic units, i.e., individuals were identified to a variety of taxonomic levels), total genera richness, genera richness for the dominant orders of aquatic insects, total sample abundance, presented as the number of individuals per square meter, and the number of taxa (OTUs) with abundances less than 1% of the total assemblage abundance. The Type I experiment wise error rate was managed by setting the critical alpha value to 0.05 for all ANOVAs and by using the Ryan-Einot-Gabriel-Welsch multiple range test (SAS 1988), which controls the Type I error for multiple comparisons. This test was used to determine all significant pair-wise differences between categories. Additional measures of rarity were tabulated and evaluated based on the taxa collected at site or group of sites (Appendices 2 – 10) or computed using EstimateS, version 8.0 (Colwell 2005). We used the Chao 2 estimator (Chao 1987) in EstimateS to estimate overall biodiversity. This estimator was chosen because it was developed for presence/absence data which we feel was most appropriate for our data (Colwell and Coddington 1994). Use of smoothed accumulation curves and estimators requires the assumption that all sampling efforts were similar in duration and area. For the both sets of data, historic and recent, the sampling and laboratory procedures and most of the laboratory personnel were constant. The Chao 2 estimator predicts the number of taxa by using the observed species collected, plus a correction factor based on taxa rarity as calculated by counting the number of taxa only occurring in one or two samples (singletons and doubletons, Colwell 2005). To reduce variability we limited our analyses and interpretations to the genera level, thus taxon identified to the species level were reduced to genus and taxon identified to family or higher levels were excluded from the data set.

The topics we evaluated in our analyses were:

1. Annual variation in total genera richness, genera richness within dominant insect orders, and total assemblage abundance.
2. Variation in total genera richness, genera richness within dominant insect orders, and total assemblage abundance among sampling locations.
3. Differences in total genera richness, genera richness within dominant insect orders, and total assemblage abundance between sites that had been treated with rotenone and untreated sites.
4. Rarity of aquatic invertebrate genera within and among years.

Results

Historic Samples

Data on a total of 75,974 individuals were extracted from the USFS annual monitoring reports from 13 sampling locations (Table 5, Appendix 2). Samples were collected between 1984 and 1996. Eleven samples were collected at six sites and two samples were collected at the other seven sites in 1984 and 1986. Of the 75,974 individuals for which data were obtained, 44,194 individuals (58%) were identified to genus or species. For all samples collected in all years, a total of 75 genera were identified (Appendix 3).

Treated Versus Untreated Sites

For samples collected between 1984 and 1996, there were few measureable differences in mean aquatic invertebrate assemblage measures between sites that were treated with rotenone and the two sites that were not treated (Table 6). The mean number of individuals collected, total assemblage abundance, total taxa richness, total genera richness, and genera richness within all but one of the major insect orders were all statistically similar between treated and untreated sampling locations. The only statistically significant difference between treatment and control sites was in the abundance of Coleoptera collected. Mean Coleoptera abundance was twice as high in control (433.6±352.7) as compared to treatment sites (206.7±241.9, Table 6). These results contrast Darby et al. (2004) who found Coleoptera (Elmidae) to be one of the more resilient insect groups to rotenone. There was no difference in the mean number of rare taxa collected between treated and untreated sites. Two genera were not collected at treated sites that were collected at untreated sites; *Ephron* (Ephemeroptera: Polymatarcyidae) and *Dolophilodes* (Trichoptera: Philopotamidae). Twenty-seven genera were collected at treated sites that were not collected at untreated sites; however, about four times as many individuals were collected at treated sites as compared to untreated sites. This large discrepancy among the number of samples collected in treated and untreated reaches makes comparison between the two difficult.

Several taxa that Engstom-Heg et al. (1978) found to be sensitive to rotenone were collected at treated sites following treatment (Appendices 3, 4, and 6). These included *Baetis* (Ephemeroptera: Baetidae), Perlidae (Plecoptera), Perlodidae (Plecoptera), *Rhyacophila* (Trichoptera) and Simuliidae (Diptera). Taxa with intermediate tolerance to rotenone that were collected at treatment sites included *Ephemerella* (Ephemeroptera: Ephemerellidae), Heptageniidae (Ephemeroptera), Chloroperlidae (Plecoptera), Limnephilidae (Trichoptera), Antocha, and Chironomidae (Diptera).

Table 6. Mean + SD and results of ANOVA to evaluate differences in aquatic invertebrate assemblage measures among rotenone treated and control stations for historic samples collected between 1984 and 1996. Sample sizes were 67 for treatment and 13 for control sites.

	Treatment		Control			
Measure	**Mean**	**SD**	**Mean**	**SD**	**F-value**	**Pr > F**
Number of individuals per sample	923.8	474.9	1083.0	471.4	1.23	0.2716
Total abundance	3241.9	1796.5	3838.1	1761.0	0.01	0.9089
Taxa richness	30.0	6.1	30.2	6.3	1.21	0.2755
Genera richness	28.0	5.4	28.3	5.2	0.04	0.8515
Ephemeroptera genera	7.1	2.0	7.4	1.5	0.26	0.6126
Ephemeroptera abundance	1071.3	930.7	938.3	572.6	0.25	0.6213
Plecoptera genera	2.4	1.4	2.7	1.3	0.64	0.4245
Plecoptera abundance	272.3	371.8	254.5	199.1	0.03	0.8673
Trichoptera genera	3.1	1.5	3.6	2.1	1.28	0.2614
Trichoptera abundance	163.7	196.0	159.6	158.8	0.01	0.9430
Coleoptera genera	0.7	0.6	0.6	0.6	0.24	0.6223
Coleoptera abundance	206.7	241.9	433.6	352.7	8.16	0.0055
Diptera genera	3.7	1.6	3.6	2.1	0.00	0.9629
Diptera abundance	1380.4	962.1	1778.0	1089.1	1.78	0.1859
Rare taxa, <1% of total abundance	15.9	4.3	15.5	4.6	0.09	0.7620

Annual Variation

There was considerable annual variation in ecological measures, as mean annual values were statistically different for all measures (Tables 7 and 8) among years. Overall, this was not surprising given that natural climatic differences occurred among these years as well as several rotenone treatments. Values were not consistently higher or lower for any particular year, though the majority of values were higher in the 1990s than they were in the 1980s samples. Samples collected in Four Mile Canyon Creek (Appendix 5), which was never treated with rotenone, were no less variable than those collected in Silver King Creek and rotenone treated tributaries (Appendix 6). The impact of rotenone was not apparent in this analysis and these results are similar to that reported by Trumbo et al. (2000) in their more comprehensive analysis of these data.

Table 7. Mean + SD of aquatic invertebrate assemblage measures among years for historic samples collected between 1984 and 1996.

	1984		1987		1991		1992		1993		1994		1995		1996	
Measure	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Sample size	13		13		12		12		12		6		6		6	
Number of individuals per sample	993.5	338.1	1504.2	407.3	506.5	282.9	1224.2	272.1	662.3	352.3	1203.0	426.2	445.2	129.2	816.5	155.6
Total abundance	3561.1	1211.8	5391.5	1460.0	1605.1	1188.5	4387.9	975.4	2273.0	1387.0	4312.0	1527.2	1350.0	593.8	2926.7	557.7
Taxa richness	29.2	4.9	26.3	5.2	28.5	6.1	26.3	5.1	32.4	4.9	30.7	3.6	40.0	2.2	35.2	5.1
Genera richness	28.2	4.6	25.5	4.8	26.3	5.7	24.4	4.3	30.5	4.7	28.3	3.5	35.5	2.8	32.3	4.2
Ephemeroptera genera	6.3	1.4	8.1	1.6	7.1	1.8	6.7	1.7	6.3	2.6	7.5	2.0	9.5	0.8	8.0	0.6
Ephemeroptera abundance	1575.3	856.5	1751.6	1112.4	432.6	539.7	1118.5	681.9	519.0	433.0	1098.0	1123.2	469.5	362.1	1080.3	227.4
Plecoptera genera	3.8	1.2	2.5	1.3	2.8	1.8	2.3	0.9	1.7	1.4	1.7	1.0	1.7	0.8	2.3	1.4
Plecoptera abundance	473.1	365.8	511.9	562.9	117.4	205.8	167.7	219.9	112.8	118.1	242.0	243.2	51.8	35.2	369.2	280.3
Trichoptera genera	3.4	1.6	4.0	2.2	3.3	1.2	1.8	1.4	2.2	0.8	3.5	1.0	4.3	0.8	4.7	1.4
Trichoptera abundance	214.2	208.9	332.3	309.9	52.7	59.5	118.2	130.2	97.1	84.0	137.3	75.3	138.2	81.0	179.2	179.4
Coleoptera genera	0.0	0.0	0.0	0.0	1.1	0.3	1.1	0.3	1.1	0.3	1.2	1.0	1.5	0.5	1.2	0.4
Coleoptera abundance	72.9	109.6	270.1	310.8	201.4	238.0	454.8	338.5	286.1	283.9	291.3	357.2	125.2	102.0	204.3	127.3
Diptera genera	1.5	1.2	2.1	0.8	4.0	0.7	4.7	0.9	5.4	1.1	4.7	0.8	4.3	1.2	4.7	0.8
Diptera abundance	1125.8	655.2	2282.0	986.4	712.4	902.7	2335.8	724.3	1112.3	660.3	2121.0	634.5	477.5	171.7	964.8	461.2
Rare taxa, <1% of total abundance	14.8	2.7	13.3	4.0	15.9	3.9	13.6	4.4	15.7	3.0	17.7	2.9	24.3	2.0	18.3	1.8

Table 8. Results of ANOVA to evaluate differences in aquatic invertebrate assemblage measures among years. Significant pairwise differences between categories were determined by the Ryan-Einot-Gabriel-Welsch multiple range test with the critical alpha value set to 0.05. The degrees of freedom for all tests were 7, 72.

			Significantly Different Means	
Measure	**F Value**	**Pr > F**	**Maximum**	**Minimum**
Number of individuals	14.05	<0.0001	1987	1995
Abundance	14.52	<0.0001	1987	1995
Taxa richness	6.91	<0.0001	1995	1992
Genera richness	5.40	<0.0001	1995	1992
Ephemeroptera genera	3.31	0.0042	1995	1993
Ephemeroptera abundance	5.00	0.0001	1987	1991
Plecoptera genera	3.48	0.0029	1984	1994
Plecoptera abundance	3.33	0.0040	1987	1995
Trichoptera genera	4.56	0.0003	1996	1992
Trichoptera abundance	2.98	0.0083	1987	1991
Coleoptera genera	24.93	<0.0001	1995	1987
Coleoptera abundance	2.28	0.0374	1992	1984
Diptera genera	25.14	<0.0001	1993	1984
Diptera abundance	9.74	<0.0001	1992	1995
Rare taxa, <1% of total abundance	7.94	<0.0001	1995	1987

Variation Among Sampling Stations

There were few measureable differences in mean aquatic invertebrate assemblage measures among sampling locations (Table 9 and 10). The mean number of individuals collected, total assemblage abundance, total richness, total genera richness, and genera richness within all but one of the major insect orders were all statistically similar between sites. The only statistically significant difference between treatment and control sites was in the abundance of Coleoptera collected. Coleoptera abundance was highest at site S1:250 an untreated site on Four-mile Canyon Creek and lowest at site S8:813 a rotenone treated site on Silver King Creek. These results are consistent with Darby et al. (2004) who found Coleoptera (Elmidae) to be one of the more resilient insect groups to rotenone.

Table 9. Mean + SD of aquatic invertebrate assemblage measures among sites located on Silver King Creek. Samples were collected between 1984 and 1996.

	S1:250		S2:640		S3:641		S6:738		S7:775		S8:813	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Sample size	11		11		11		11		11		11	
Number of individuals	1119.0	505.7	795.5	488.1	887.6	357.3	880.1	460.6	899.5	396.9	775.2	557.4
Abundance	3959.2	1896.0	2755.1	1860.9	3161.2	1310.4	3051.8	1796.7	3150.8	1557.5	2649.6	2113.7
Taxa richness	30.8	6.4	31.1	6.6	30.7	5.2	28.5	6.0	29.5	7.8	32.0	6.5
Genera richness	28.7	5.3	29.4	6.2	28.7	4.8	26.4	4.8	27.4	6.8	29.6	5.6
Ephemeroptera genera	7.5	1.6	8.1	1.4	7.5	1.6	7.0	2.7	6.7	1.8	6.6	2.3
Ephemeroptera abundance	981.8	616.4	759.7	664.1	1029.1	656.0	945.5	948.5	867.6	707.1	929.8	1263.3
Plecoptera genera	2.7	1.2	1.8	1.2	2.0	1.3	2.2	1.1	2.4	1.3	2.3	2.0
Plecoptera abundance	230.8	184.7	165.6	216.1	149.5	186.4	255.1	308.4	150.0	154.7	177.7	234.1
Trichoptera genera	3.6	2.3	3.1	1.7	3.5	1.3	2.7	1.7	3.3	1.6	3.0	1.0
Trichoptera abundance	146.3	158.0	133.9	151.6	115.6	166.4	99.3	99.0	142.8	105.7	211.4	253.4
Coleoptera genera	0.8	0.6	1.1	0.7	0.9	0.5	0.7	0.5	1.2	0.8	0.9	0.5
Coleoptera abundance	510.9	326.4	338.8	311.2	356.8	325.7	188.4	168.4	103.5	116.2	65.0	50.2
Diptera genera	4.3	1.8	4.1	1.2	4.0	1.2	4.0	1.5	4.0	1.8	4.4	1.8
Diptera abundance	1806.9	1125.2	1243.1	967.5	1355.5	723.6	1447.2	1043.1	1750.5	1183.5	1136.6	869.9
Rare taxa, <1% of total abundance	16.4	4.5	15.9	5.5	16.2	3.5	15.5	4.0	15.5	5.0	17.8	4.4

Table 10. Results of ANOVA to evaluate differences in aquatic invertebrate assemblage measures among sampling locations. Only sites that were sampled in multiple years, 1984, 1987, 1991, 1992, 1994, 1995, 1996 were included in the analysis. Significant pairwise differences between categories were determined by the Ryan-Einot-Gabriel-Welsch multiple range test with the critical alpha value set to 0.05. The degrees of freedom were 5, 60 for all comparisons.

			Significantly Different Means	
Measure	**F Value**	**Pr > F**	**Maximum**	**Minimum**
Number of individuals	0.76	0.5480		
Abundance	0.74	0.5932		
Taxa richness	0.40	0.8503		
Genera richness	0.55	0.7382		
Ephemeroptera genera	0.91	0.4805		
Ephemeroptera abundance	0.14	0.9824		
Plecoptera genera	0.59	0.7082		
Plecoptera abundance	0.45	0.8115		
Trichoptera genera	0.47	0.7950		
Trichoptera abundance	0.61	0.6935		
Coleoptera genera	0.85	0.5183		
Coleoptera abundance	5.45	0.0003	S1:250	S8:813
Diptera genera	0.11	0.9890		
Diptera abundance	0.81	0.5457		
Rare taxa, <1% of total abundance	0.40	0.8480		

Rarity

Contrary to mean assemblage values which were fairly similar among sites and even treated and untreated sites, rarity of individual taxa was high. Based on relative abundances and occurrences in individual years and site, the majority of taxa collected could be considered uncommon or rare. Three genera, *Pericoma* (Diptera: Psychodidae), *Baetis* (Ephemeroptera: Baetidae), and *Drunella* (Ephemeroptera: Ephemerellidae) accounted for 50% of all genera identified. Fourteen genera (19% of the total genera) accounted for 90% of the total number of genera identified and 42 other genera accounted for only 1% of the total number of individuals identified to genera (Figure 3). Of the 44,194 individuals identified to 75 unique genera, 26 genera (35%) were represented by < 10 individuals, 27 genera (36%) were represented by > 100 individuals, 14 genera were represented by 500 or more individuals (19%), 11 genera were represented by 1000 or more individuals (15%), and two genera were represented by 5,000 or more individuals (3%). The mean number of rare taxa, as measured by the number of taxa whose individual abundances were less than 1% of the total sample abundance, was similar among sampling locations (Table 9) and rotenone treatment and control and sites (Table 5), but did vary significantly among years (Table 7). The highest numbers of rare taxa were collected in 1995 and the fewest in 1987.

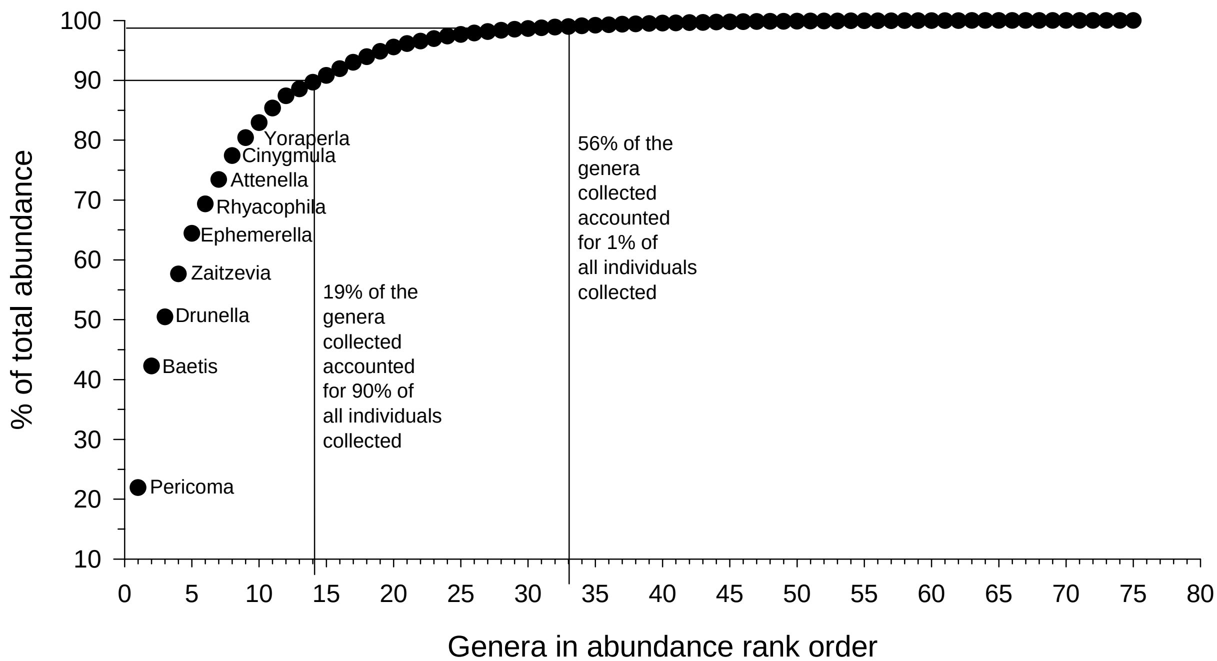

Figure 3. Genera abundance curve for historic data.

The number of genera present in individual years in Silver King Creek was about half of the 65 total genera collected in Silver King Creek over all years (Appendix 4). For example in 1984 and 1987, 30 genera were collected and 35 were missing. In 1991, 37 genera were collected and 28 were missing. In 1992, 35 genera were collected and 30 were missing. In 1993, 39 genera were collected and 26 were missing. In 1994, 37 genera were collected and 28 were missing. In 1995 36 genera were present and 29 were missing. In 1996, 33 genera were present and 32 were missing. The number of genera collected at each site each was generally similar except for site S4:700, where genera richness was about 70% of the total number of genera collected in Silver King

Creek. Of the 65 total genera collected in Silver King Creek, 45 genera were collected at site S7:775, 48 genera were collected at site S6:738, 23 genera were collected at site S4:700, 47 genera were collected at site S3:641, and 49 genera were collected at site S2:640.

At all sites that were sampled in Silver King Creek over 8 years between 1984 and 1996, about an equal number of genera could be considered rare, common, or somewhere in between. Nineteen genera (29%) were found in only 1 year, eight genera (12%), were found in 2 years, four genera (6%) were found in 3 years, three genera (5%) were found in 4 years, two genera (3%) were found in 5 years, 10 genera (15%) were found in 6 years, four genera (6%) were found in 7 years, and 15 genera (23%) were found in all 8 years of sampling (Appendix 6). Fifty-two percent of the genera were found in 4 or fewer years and 47% were found in 5 or more years.

The same general pattern of genera occurrence was seen at the single site sampled in Four Mile Canyon Creek over 8 years between 1984 and 1996 (Appendix 5). Overall, there were fewer total genera collected in Four Mile Creek, but the relative occurrence of genera among years was similar. Nine genera (19%) were found in only 1 year, four genera (9%), were found in 2 years, eight genera (17%) were found in 3 years, three genera (6%) were found in 4 years, seven genera (15%) were found in 5 years, seven genera (15%) were found in 6 years, five genera (11%) were found in 7 years, and four genera (9%) were found in all 8 years of sampling. Fifty-one percent of the genera were found in 4 or fewer years and 49% were found in 5 or more years.

Recent Samples

A total of 54,906 organisms were collected among 14 sampling locations between 2003 and 2006 (Appendix 2). The total number of individuals identified to genus or species was 35,706 (65%, Appendix 8). Total genera richness was 85 across all years. Observed genera accumulation curves had a similar shape each year (Figure 4), but were steeper in some years than others reflecting greater overall diversity in some years. Differences among years for Chao 1 genera estimate curves were slightly different than the observed genera curves. Chao 1 genera richness estimates were much higher in 2006 than in 2005, and both of these years were higher than 2003 and 2004 which had similar end values (Figure 5). These results reflect the large number of genera collected in 2005 and 2006 that only occurred in a few samples or were represented by just a few individuals (Appendix 8).

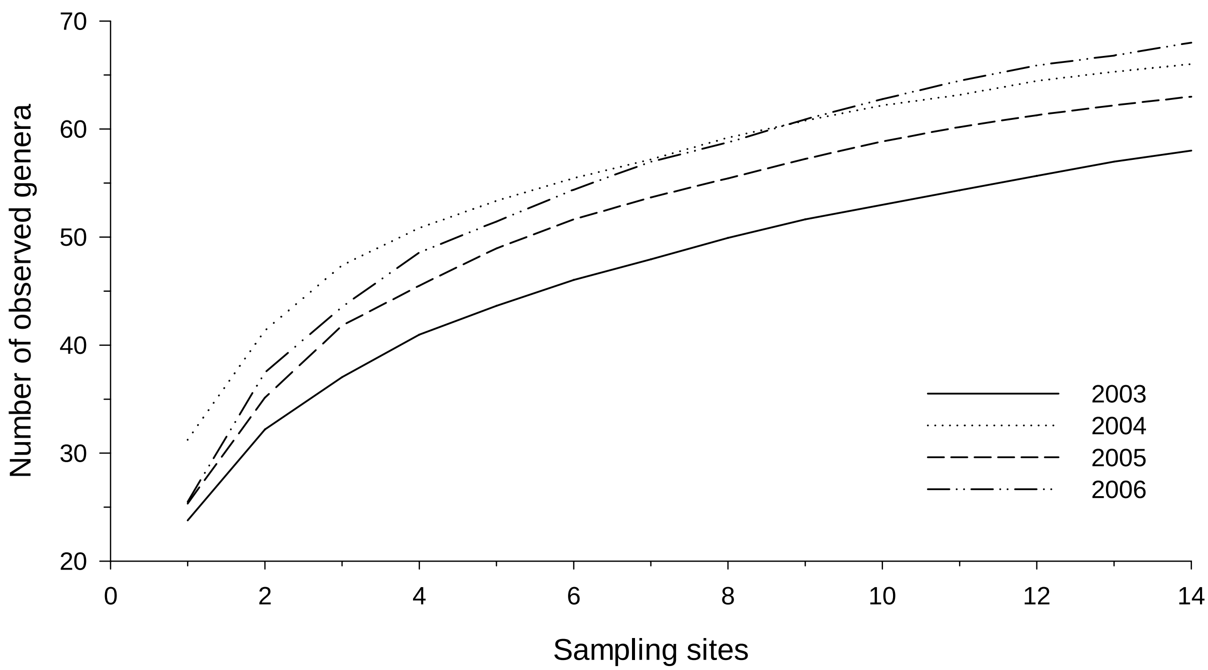

Figure 4. Genera accumulation curves showing the number of observed genera collected each year among all sampling locations for samples collected between 2003 and 2006.

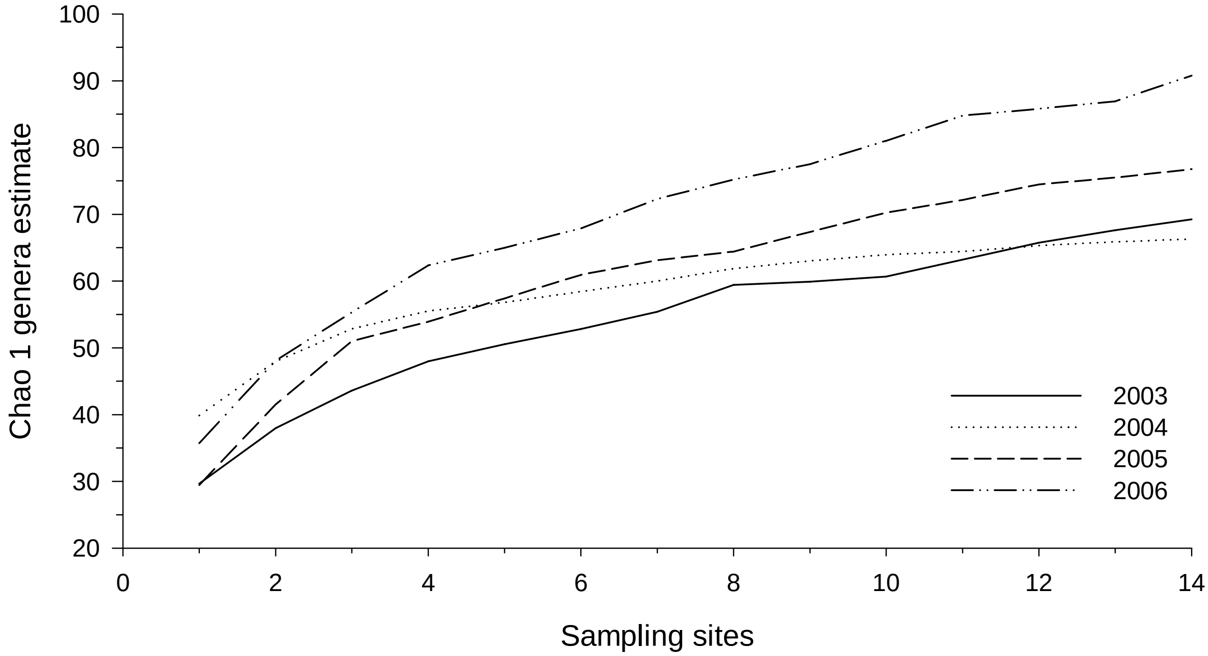

Figure 5. Chao 1 genera richness estimation curves for samples collected among all sampling locations between 2003 and 2006.

Treated Versus Untreated Sites

There were few measureable differences in mean aquatic invertebrate assemblage measures between sites that were treated with rotenone and the two sites that were not treated (Table 11) for samples collected 10 years after the last rotenone treatment in 1993. The mean number of individuals collected, total assemblage abundance, total taxa richness, total genera richness, and genera richness within all but one of the major insect orders were all statistically similar between treated and untreated sampling locations. The only statistically significant difference between treatment and control sites was the number of Coleoptera genera and the abundance of Coleoptera collected. Coleoptera, primarily Elmidae were taxonomically richer and more abundant at treatment sites. This result was opposite to that observed in the historic data set. The reason for this is unknown. Darby et al. (2004) found Coleoptera abundances, primarily Elmidae, recovered quickly following rotenone treatment. There was no difference in the mean number of rare taxa collected between treated and untreated sites. Five genera were not collected at treated sites that were collected at untreated sites;

Clinocera (Diptera: Empididae), *Oreogeton* (Diptera: Empididae), *Pedicia* (Diptera: Tipulidae), *Moselia* (Plecoptea: Leuctridae), and *Kogotus* (Plecoptera: Pelodidae). Forty-three genera were collected at treated sites that were not collected at untreated sites; however, nearly eight times as many individuals were collected at treated sites as compared to untreated sites (Appendix 9).

Table 11. Results of ANOVA to evaluate differences in aquatic invertebrate assemblage measures among rotenone treated and control stations for historic sample collected between 2003 and 2006. Sample sizes were 48 for treatment and 8 for control sites. The degrees of freedom for all tests were 1, 54.

	Treatment		Control			
	Mean	**SD**	**Mean**	**SD**	**F- Value**	**Pr > F**
Number of individuals	1017.0	618.0	759.5	426.3	1.28	0.2634
Abundance	3553.8	2223.3	2625.2	1624.0	1.27	0.2624
Taxa richness	41.3	6.0	39.7	4.8	0.51	0.4787
Genera richness	37.0	5.1	34.7	3.6	1.39	0.2430
Ephemeroptera genera	7.4	1.7	7.1	0.6	0.20	0.6595
Ephemeroptera abundance	1383.1	874.7	913.3	587.5	2.13	0.1503
Plecoptera genera	3.8	1.7	3.8	1.1	0.00	0.9744
Plecoptera abundance	521.2	632.1	858.0	623.0	1.95	0.1679
Trichoptera genera	4.8	1.7	3.8	0.6	2.53	0.1173
Trichoptera abundance	343.0	420.7	107.8	31.0	2.46	0.1227
Coleoptera genera	2.3	1.1	1.1	0.3	8.82	0.0044
Coleoptera abundance	306.0	363.5	24.8	23.4	4.71	0.0344
Diptera genera	4.5	1.3	5.2	1.6	1.76	0.1899
Diptera abundance	819.2	780.5	658.3	557.0	0.31	0.5793
Rare taxa, <1% of total abundance	23.8	5.2	23.7	4.5	0.00	0.9583

Annual Variation

The total number of individuals collected and identified to genera each year varied from 6,280 in 2005 to 13,618 in 2004 (Appendix 10). The total number of genera collected among all years was 85. The total number of genera collected each year at all sites ranged from 59 to 68 and the number of genera not present in a single year ranged from 17 to 26 (Appendix 10). Six of the 15 ecological measures varied significantly among years (Tables 12 and 13). The mean number of individuals per sample, total sample abundance, Ephemeroptera genera and abundance, Plecoptera genera, and Diptera abundance varied significantly among years. These were all higher in 2004, except Diptera abundance which was highest in 2003. Minimum values for these measures occurred in 2003, 2004, and 2005. The mean number of rare taxa collected each year was similar among years and averaged about 50% of the total taxa richness.

Table 12. Mean + SD of aquatic invertebrate assemblage measures among years for samples collected between 2003 and 2006.

	2003		2004		2005		2006	
Measure	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Number of individuals	1101.6	569.5	1490.6	675.5	635.2	275.3	693.5	379.8
Total abundance	3860.4	2040.6	5253.9	2358.7	2175.4	1116.5	2394.9	1463.5
Taxa richness	39.1	4.1	42.5	4.6	41.2	5.8	41.7	8.2
Genera richness	36.3	3.3	38.6	4.0	35.9	5.6	35.9	6.5
Ephemeroptera genera	6.2	1.0	8.1	2.2	7.4	1.4	7.8	1.0
Ephemeroptera abundance	1316.9	839.4	2119.5	887.2	771.8	443.2	1055.9	541.6
Plecoptera genera	2.8	1.0	4.7	1.9	4.3	1.1	3.6	1.9
Plecoptera abundance	383.4	354.1	947.7	865.0	495.4	544.5	450.9	575.4
Trichoptera genera	4.9	1.7	4.6	1.8	4.6	1.3	4.8	2.0
Trichoptera abundance	412.4	436.4	398.4	601.6	209.0	144.1	218.0	238.1
Coleoptera genera	2.0	0.9	2.3	1.4	2.0	1.0	2.3	1.2
Coleoptera abundance	260.6	248.3	457.0	527.9	164.4	184.3	181.6	295.7
Diptera genera	5.1	1.4	4.7	1.1	4.4	1.7	4.3	1.4
Diptera abundance	1174.9	912.8	1079.3	953.9	513.9	289.6	416.9	274.1
Rare taxa, <1% of total abundance	22.7	4.0	24.9	4.1	24.4	6.7	23.3	5.6

Table 13. Results of ANOVA to evaluate differences in aquatic invertebrate assemblage measures among years for samples collected between 2003 and 2006. Significant pairwise differences between categories were determined by the Ryan-Einot-Gabriel-Welsch multiple range test with the critical alpha value set to 0.05. The degrees of freedom for all tests were 3, 52.

			Significantly Different Means	
Measure	**F Value**	**Pr > F**	**Maximum**	**Minimum**
Number of individuals pre sample	8.89	<0.0001	2004	2005
Total abundance	8.76	<0.0001	2004	2005
Taxa richness	0.87	0.4619		
Genera richness	0.90	0.4479		
Ephemeroptera genera	4.38	0.0080	2004	2003
Ephemeroptera abundance	9.51	<0.0001	2004	2005
Plecoptera genera	4.09	0.0111	2004	2003
Plecoptera abundance	2.45	0.0736		
Trichoptera genera	0.12	0.9478		
Trichoptera abundance	1.09	0.3596		
Coleoptera genera	0.29	0.8306		
Coleoptera abundance	2.18	0.1013		
Diptera genera	1.01	0.3953		
Diptera abundance	4.39	0.0079	2003	2006
Rare taxa, <1% of total abundance	0.53	0.6622		

Variation Among Sampling Stations

There were few measureable differences in mean aquatic invertebrate assemblage measures between sampling locations (Tables 14, 15, and 16). Four of the 15 measures were significantly different among sites. Plecoptera abundance, Trichoptera genera, and Coleoptera genera and abundance were significantly different among sampling locations. All measures that were significantly different were highest in tributary streams. No measures were highest, suggesting better condition, at untreated sites. The mean number of Coleoptera genera collected was significantly lower at an untreated site on Tamarack Creek (TAMAC-13).

Table 14. Mean + SD of aquatic invertebrate assemblage measures among sites located on tributary streams. Samples were collected between 2003 and 2006. Sample size was 4 for all sites.

Sample size	COVAL-11		COVAL-12		CVALL-09		CVALL-10		TAMAC-13		TAMAC-14	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Number of individuals	1478.8	375.7	1574.3	605.4	1481.5	990.2	1610.8	732.9	815.8	290.8	703.3	575.5
Abundance	5246.3	1285.9	5522.0	2029.1	5242.5	3488.1	5623.0	2422.9	2906.8	1069.0	2343.8	2190.9
Taxa richness	46.3	6.6	41.3	6.2	45.3	8.1	45.0	2.4	40.0	6.4	39.5	3.9
Genera richness	41.8	3.9	38.5	5.2	39.5	4.5	39.5	1.3	35.3	3.6	34.3	4.2
Ephemeroptera genera	7.8	1.9	6.5	1.7	6.3	1.0	5.5	1.7	7.0	0.8	7.3	0.5
Ephemeroptera abundance	1633.8	773.5	1918.3	705.6	1611.0	1102.4	1310.3	643.3	946.5	371.3	880.3	815.2
Plecoptera genera	5.5	1.0	5.0	2.4	4.5	1.3	5.5	1.7	4.0	1.4	3.8	1.0
Plecoptera abundance	1408.0	844.6	867.8	595.7	816.0	492.3	1454.8	972.8	994.0	655.0	722.0	653.7
Trichoptera genera	5.3	1.5	4.3	0.5	5.5	2.5	7.3	2.1	3.8	0.5	4.0	0.8
Trichoptera abundance	676.0	258.4	420.8	313.5	246.3	151.3	824.5	1030.4	98.3	14.3	117.5	42.4
Coleoptera genera	3.8	1.3	3.8	0.5	2.5	0.6	1.8	0.5	1.0	0.0	1.3	0.5
Coleoptera abundance	334.5	195.8	945.3	571.9	454.8	561.4	519.5	329.9	18.5	13.8	31.3	31.4
Diptera genera	4.8	1.0	4.8	1.3	5.0	0.8	4.0	1.6	6.3	1.7	4.3	1.0
Diptera abundance	637.5	202.7	973.5	750.7	1639.3	1542.7	1216.8	1456.8	767.0	441.1	549.8	705.6
Rare taxa, <1% of total abundance	26.3	5.1	24.5	5.4	26.3	5.6	26.5	5.6	24.0	5.2	23.5	4.7

Table 15. Mean ± SD of aquatic invertebrate assemblage measures among sites located on Silver King Creek. Samples were collected between 2003 and 2006. Sample size was 4 for all sites.

	SKING-01		SKING-02		SKING-03		SKING-04		SKING-05		SKING-06		SKING-07		SKING-08	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Number of individuals	972.5	628.6	1037.5	583.2	855.5	334.3	690.8	488.1	475.0	308.5	770.5	209.8	480.3	197.9	777.0	354.4
Abundance	3475.0	2233.1	3718.8	2089.9	3066.5	1198.0	2331.5	1906.5	1397.8	1310.7	2761.8	752.2	1555.3	909.2	2705.8	1390.2
Taxa Richness	39.5	4.8	41.0	5.4	42.0	3.2	40.0	7.1	42.0	5.4	41.5	4.4	35.0	7.7	37.5	6.6
Genera richness	36.3	3.9	37.0	3.9	37.5	2.6	35.5	6.7	36.8	5.6	36.8	4.6	32.0	8.3	33.0	6.5
Ephemeroptera genera	7.3	1.0	8.5	2.1	8.8	1.3	7.3	1.3	8.3	1.3	8.5	1.9	7.5	1.3	6.8	2.1
Ephemeroptera abundance	1652.3	1300.6	1805.3	1441.1	1561.3	839.7	941.3	699.0	766.5	930.9	929.8	370.6	864.8	555.6	1603.3	778.0
Plecoptera genera	3.3	0.5	3.0	1.8	3.3	1.3	2.3	0.5	3.5	2.1	3.3	1.3	3.5	2.1	3.8	2.4
Plecoptera abundance	211.0	125.5	390.8	531.7	368.3	104.6	115.8	69.5	160.8	183.9	262.0	133.2	71.3	34.1	128.5	104.4
Trichoptera genera	5.0	1.6	4.3	0.5	4.3	1.0	4.0	1.4	6.3	2.2	5.5	1.3	3.0	0.8	4.0	1.4
Trichoptera abundance	193.5	87.1	210.0	77.4	198.8	82.7	98.5	54.5	218.0	146.8	629.8	761.9	111.3	96.1	289.0	211.1
Coleoptera genera	1.8	1.0	2.0	1.6	2.8	1.0	2.0	0.8	1.8	1.0	3.0	0.0	1.3	0.5	1.5	0.6
Coleoptera abundance	410.3	285.2	243.8	256.4	263.8	292.5	248.8	234.4	48.3	8.4	152.3	22.7	13.3	18.6	38.8	27.1
Diptera genera	4.5	1.0	5.3	1.0	5.0	1.2	5.3	1.7	4.0	1.8	3.3	1.0	3.8	2.1	5.0	1.4
Diptera abundance	948.5	687.1	991.0	715.8	610.0	192.0	881.5	925.7	185.5	96.5	710.5	321.7	424.0	222.4	613.0	523.1
Rare taxa, <1% of total abundance	22.3	4.4	23.3	6.2	24.3	4.5	22.8	6.0	22.5	5.8	25.8	4.6	17.8	7.5	24.3	2.8

Table 16. Results of ANOVA to evaluate differences in aquatic invertebrate assemblage measures among sampling locations for recent samples collected between 2003 and 2006. Significant pairwise differences between categories were determined by the Ryan-Einot-Gabriel-Welsch multiple range test with the critical alpha value set to 0.05. The degrees of freedom for all tests were 13, 42.

			Significantly Different Means	
Measure	F Value	Pr > F	Maximum	Minimum
Number of individuals	2.30	0.0208		
Abundance	2.39	0.0167		
Taxa richness	1.08	0.4004		
Genera richness	1.15	0.3466		
Ephemeroptera genera	1.59	0.1260		
Ephemeroptera abundance	0.90	0.5626		
Plecoptera genera	1.42	0.1893		
Plecoptera abundance	3.64	0.0007	CVALL-10	SKING-07
Trichoptera genera	2.43	0.0148	CVALL-10	SKING-07
Trichoptera abundance	1.62	0.1166		
Coleoptera genera	4.71	<0.0001	CVALL-11	TAMAC-13
Coleoptera abundance	3.51	0.0010	COVAL-12	SKING-07
Diptera genera	1.22	0.2990		
Diptera abundance	0.88	0.5770		
Rare taxa, <1% of total abundance	0.72	0.7372		

Rarity

The majority of taxa collected between 2003 and 2006 could be considered uncommon or rare. A total of 85 genera were collected between 2003 and 2006. Of these 85 genera, 47 genera (55%) were collected in all 4 sampling years, 7 genera (8%) were collected in 3 of the years, 16 genera (19%) were collected in 2 of the years, and 15 genera (18%) were collected in only 1 year (Appendix 9). Genera abundance accumulation plots were similar among years (Figure 6) and showed that a few taxa were abundant while most could be considered uncommon or rare. For all samples collected between 2003 and 2006, the individual abundances of 17 common genera (20% of the total number of genera) accounted for 90% of all individuals collected, 21 (25%) other genera accounted for 9% of the total number of individuals collected, and 47 rare genera (45%) accounted for only 1% of all individuals collected (Figure 7). For 53 genera where 10 or more individuals were collected over the 4 years, 46 were found in all 4 years of collections, 4 were found in 3 years, and two were found in only 2 years, and one was found in a single year. The opposite was generally true for less abundant taxa. For 32 taxa that fewer than 10 individuals were collected over 4 years of sampling, *Lepidostoma* (Trichoptera: Lepidostomatidae) was collected in all 4 years. *Hyalella* (Amphipoda: Hyalellidae), *Moselia* (Plecoptera: Leuctridae), and *Psychoglypha* (Trichoptera: Limnephilidae) were collected in 3 years, 14 other genera were collected in 2 years, and 14 other genera were collected in only a single year (Appendix 9). Three genera, *Baetis* (Ephemeroptera: Baetidae), *Yoraperla* (Plecoptera: Peltoperlidae), and *Drunella* (Ephemeroptera: Ephemerellidae) accounted for about 50% of all genera identified.

Of the 35,706 individuals identified to 85 unique genera (Appendix 10); 32 genera (38%) were represented by < 10 individuals (0.02% relative occurrence), 27 genera (32%) were represented by > 100 individuals (0.2% relative occurrence), 15 genera were represented by 500 individuals (18% relative occurrence), 9 genera were represented by 1000 individuals (11% relative occurrence), and 2 genera were represented by 5,000 individuals (2% relative occurrence). The mean number of rare taxa, as measured by the number of taxa whose individual abundances were less than 1% of the total sample abundance, was similar among sampling locations (Table 15), rotenone treatment and control sites (Table 10), and among years (Table 12).

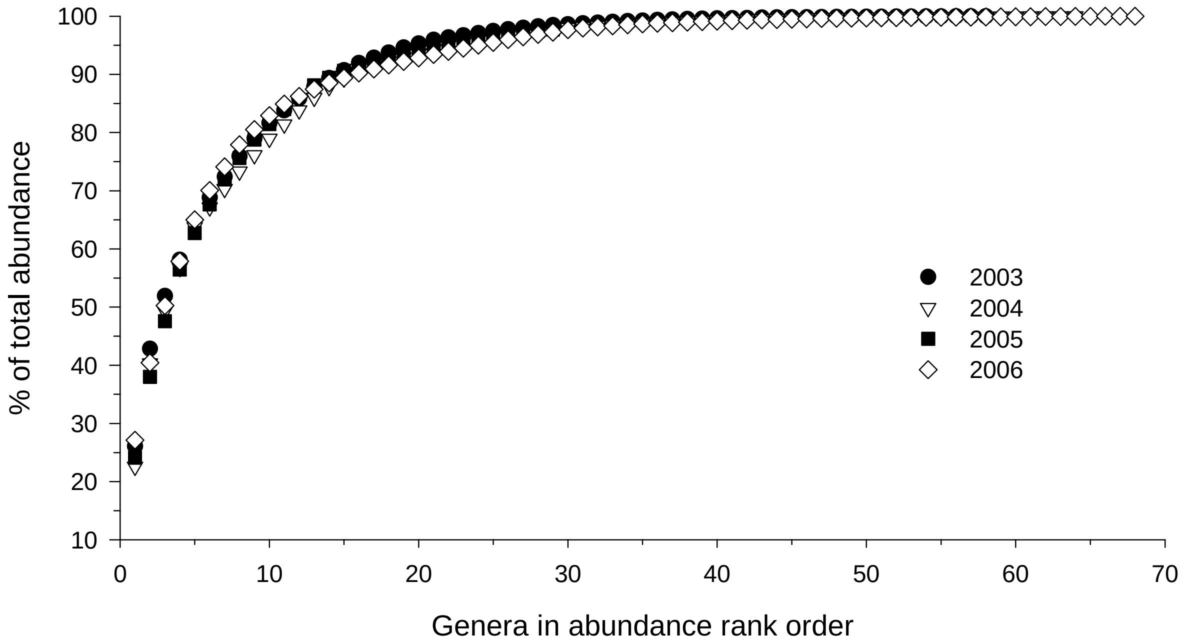

Figure 6. Genera abundance accumulation plots for each year. Data points represent the abundance contribution of individual genera.

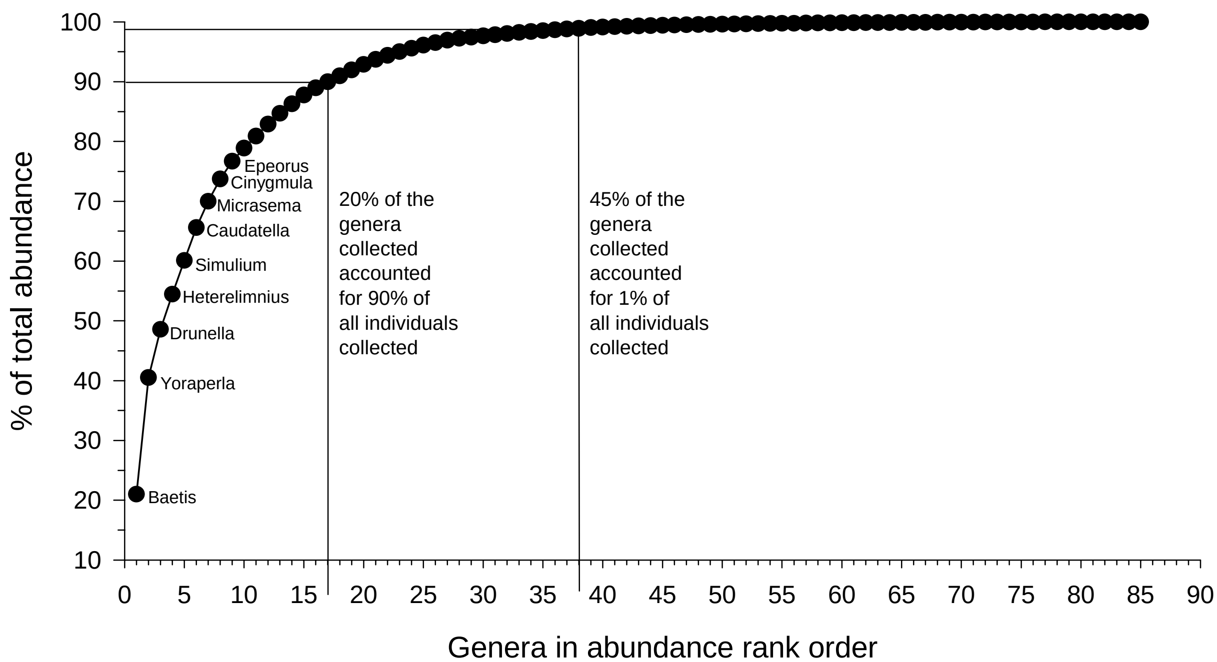

Figure 7. Genera abundance accumulation plot for all samples collected between 2003 and 2006. Symbols represent the abundance contribution of individual genera.

Differences Between Historic and Recent Samples

Pre-analysis of the data was done to evaluate differences between historic and recent samples. Comparisons between data sets collected in different decades can be problematic. Obvious problems can stem from differences in sampling locations, sampling methods, and laboratory techniques. Less obvious problems are often associated with environmental changes that may have occurred along with changes in the primary variable of interest, rotenone in this study.

Sampling intensity and difference in laboratory procedures are known to influence taxa richness estimates (Vinson and Hawkins 1998) and assemblage composition. Taxa richness typically increases with sampling effort as measured by sampling area, the number and type of habitats sampled, and the number of individuals identified (Vinson and Hawkins 1996). There were several commonalities between the two data sets that should reduce biases. The same numbers of samples were collected with the same sampling device in riffle habitats during the same time of year. Two complicating factors were that most of the samples were not collected from the same locations in the basin (Figure 1) and that the samples were identified by two different aquatic macroinvertebrate processing laboratories.

The topics we evaluated in this analysis were:

1. Overall differences in the taxa collected and identified between historic and recent samples.
2. Differences between assemblages collected historically at two untreated sites on Four Mile Canyon Creek and Fly Valley Creek and recent data collected at two untreated sites on Tamarack Creek.
3. Differences between assemblages collected recently at historic treated sites and assemblages collected recently at untreated sites.

Comparisons between the two data sets included evaluating taxa accumulation curves, mean differences in individual samples, and an evaluation of all taxa collected during each study period. To reduce differences due to recent changes in the availability of better taxonomic resources we limited our analyses and interpretations to the genera level, thus taxon identified to the species level were reduced to genus and taxon identified to family or higher levels were excluded from the data set. We felt that filtering the data this way improved our capacity to make comparisons.

Overall Assemblage Differences

There was no relationship between the number of individuals collected and genera richness for historic samples (includes both treated and untreated sites, Figure 8), whereas there was a significant relationship between the number of individuals collected in each sample and genera richness for recent samples (includes both treated and untreated sites). To reduce this effect, a random subsample of 500 individuals was selected from each sample. Of the 136 samples, only 28 had less than 500 individuals. For these samples, all individuals were included in the analyses. There was no relationship between genera richness and the estimated number of individuals per square meter for this data set. However, genera richness was still consistently higher in recent samples (Figure 9 and 10).

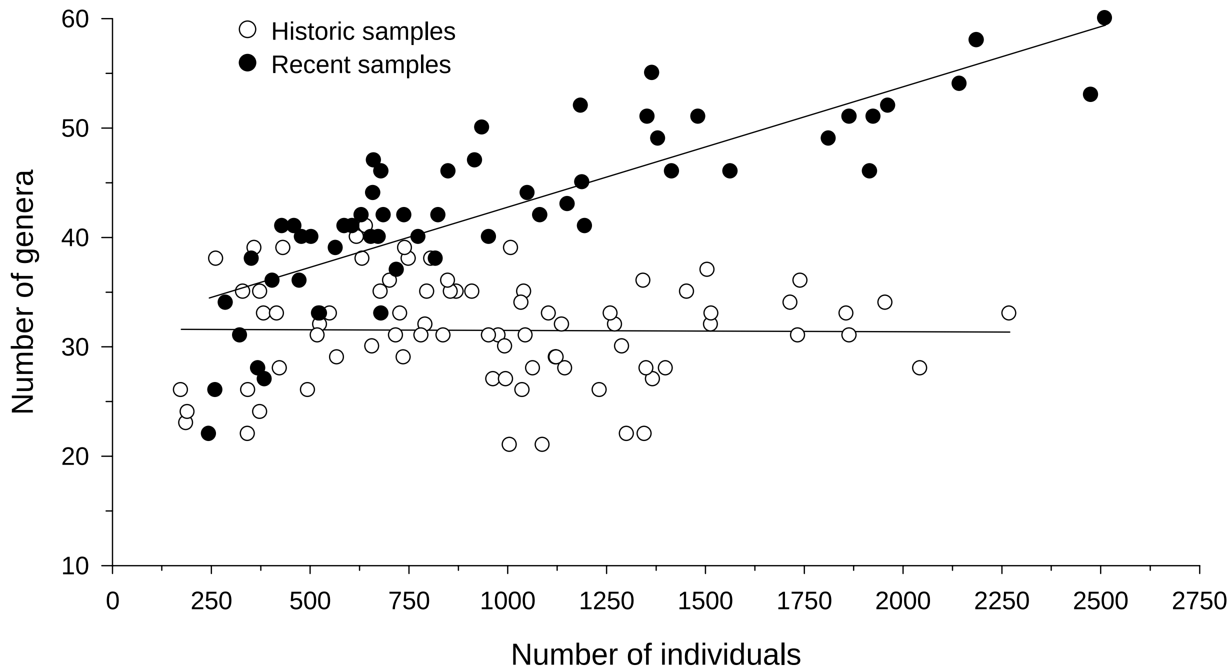

Figure 8. Relationship between genera richness and the number of individuals collected in each sample. r^2 for the post 2003 samples was 0.68.

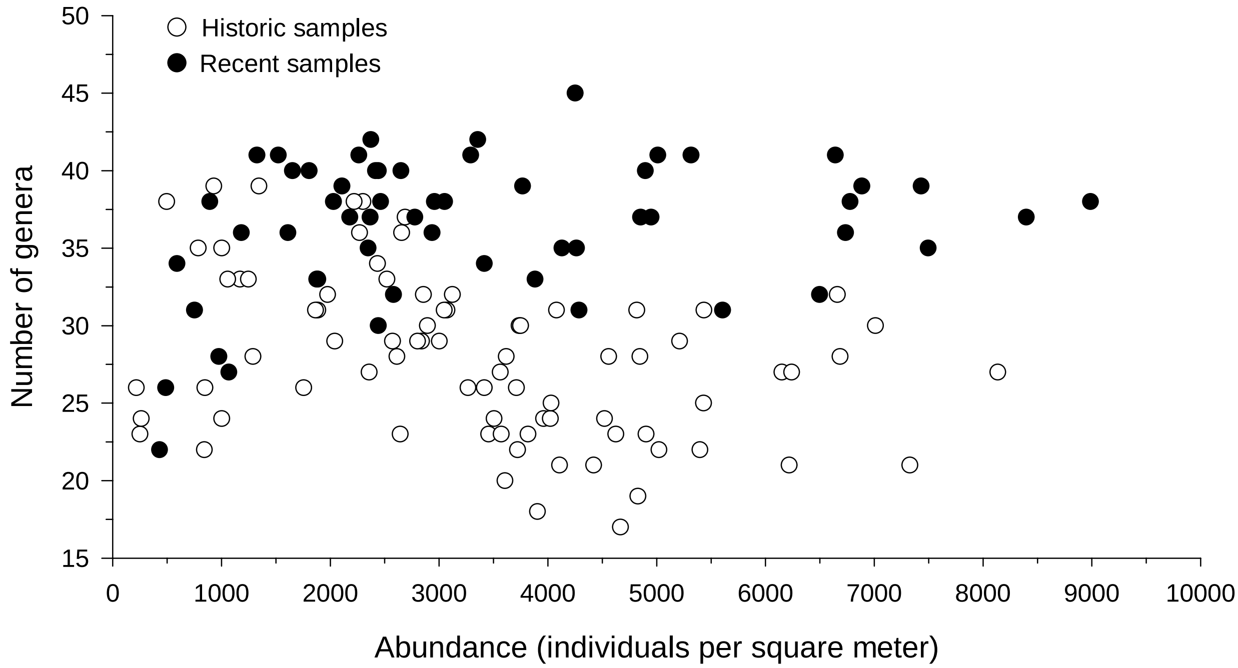

Figure 9. Relationship between genera richness and the number of individuals per square meter. Samples were standardized for 500 randomly selected individuals per sample. Density estimates are based on the number of individuals in the original sample.

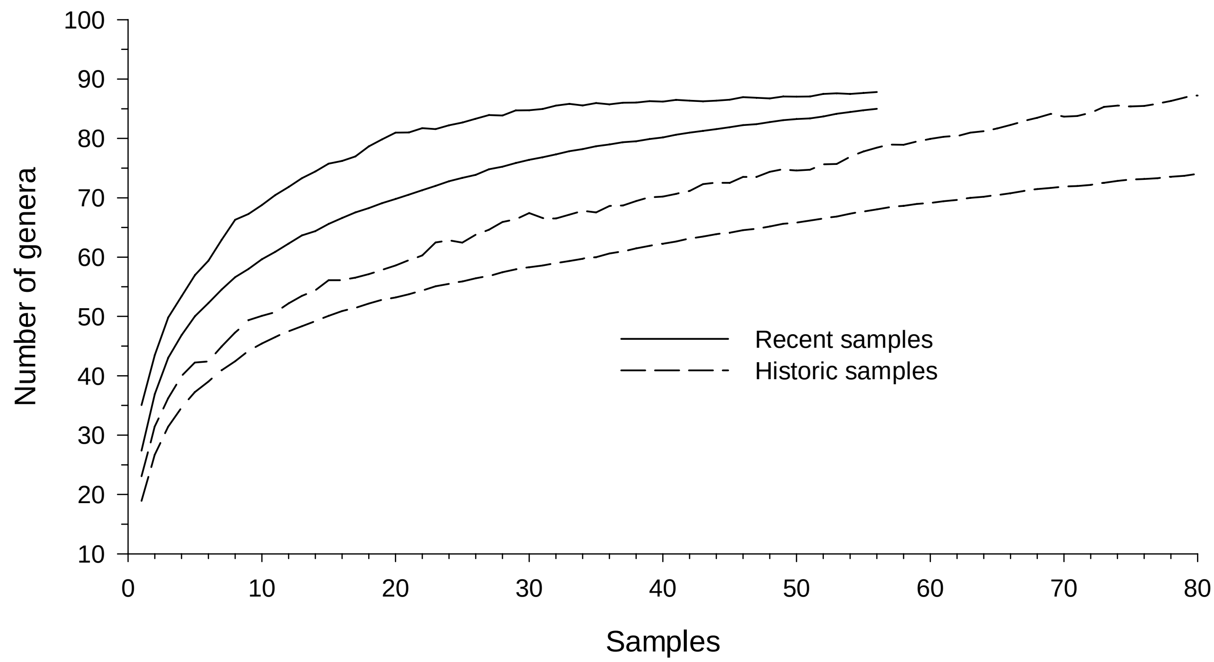

Figure 10. Genera accumulation curves for observed and Chao 1 genera estimates for historic and recent samples. The lower lines for both data sets are the observed number genera and the upper lines are the Chao 1 estimates.

Comparisons of mean per sample values between the two sample sets revealed several significant differences in taxonomic richness between the two data sets (Table 17, Figure 11). Recent samples had on average of 9% percent more families, 30% more genera, 3% more Ephemeroptera genera, 53% more Plecoptera taxa, 42% more Trichoptera genera, 165% more Coleoptera genera, and 25% Diptera genera. Differences were not limited to taxonomic richness measures, as there were differences in total invertebrate abundances and the abundances of some groups as well. The difference in mean total invertebrate abundance between the two sample sets was 2% greater in recent samples. The abundance of EPT was 56% higher in recent samples. An interesting difference between the two sample sets was that Elmidae (Coleoptera) abundances were 21% less in recent samples, but Elmidae genera richness was 165% higher.

Differences in the complete list of genera collected by each sampling period again showed a greater number of genera found in recent samples for nearly all orders and families. There were 49 families and 75 genera identified in the historic samples and 46 families and 83 genera found in the recent samples (Appendix 7). Of the 32 families where genera were identified by both labs, in 10 cases more genera were identified in the recent samples and in 5 cases more genera were identified in the historic samples.

The cause of consistently higher richness in recent as compared to historic samples is not clear. The two most likely causes are improving biological conditions or differences in laboratory procedures between the two data sets. Evidence for improving biological conditions includes the elimination of rotenone treatments since 1993 and the elimination of livestock grazing in the Silver King Creek basin since 1996. None of the aquatic invertebrate samples remain from the historic samples, so differences due to differences in laboratory procedures, such as the number of organisms identified and taxonomic resolution cannot be evaluated.

Table 17. ANOVA results to evaluate differences in aquatic invertebrate assemblage measures between historic and recent samples. Sample sizes were 80 for historic and 56 for recent samples. The degrees of freedom for all tests were 1, 134.

	Historic		Recent			
Assemblage measure	**Mean**	**SD**	**Mean**	**SD**	**F - value**	**Pr > p**
Number of individuals	949.7	475.1	980.2	598.2	0.11	0.7408
Abundance	3338.9	1793.5	3421.2	2160.4	110.68	<0.0001
Taxa richness	30.1	6.2	41.1	5.9	0.06	0.8091
Genera richness	28.1	5.4	36.7	5.0	87.45	<0.0001
Ephemeroptera genera	7.2	1.9	7.4	1.6	0.21	0.6439
Ephemeroptera abundance	1049.7	880.9	1316.0	851.6	3.09	0.0809
Plecoptera genera	2.5	1.4	3.9	1.7	26.45	<0.0001
Plecoptera abundance	269.5	348.6	569.3	636.4	12.45	0.0006
Trichoptera genera	3.2	1.7	4.7	1.7	27.23	<0.0001
Trichoptera abundance	163.1	189.6	309.4	397.9	8.19	0.0049
Coleoptera genera	0.8	0.7	2.1	1.1	80.33	<0.0001
Coleoptera abundance	243.6	273.7	265.9	350.5	0.17	0.6783
Diptera genera	3.7	1.7	4.6	1.4	11.40	0.0010
Diptera abundance	1445.1	987.6	796.3	750.6	17.20	<0.0001
Rare taxa, <1% of total abundance	15.9	4.3	23.8	5.2	95.03	<0.0001

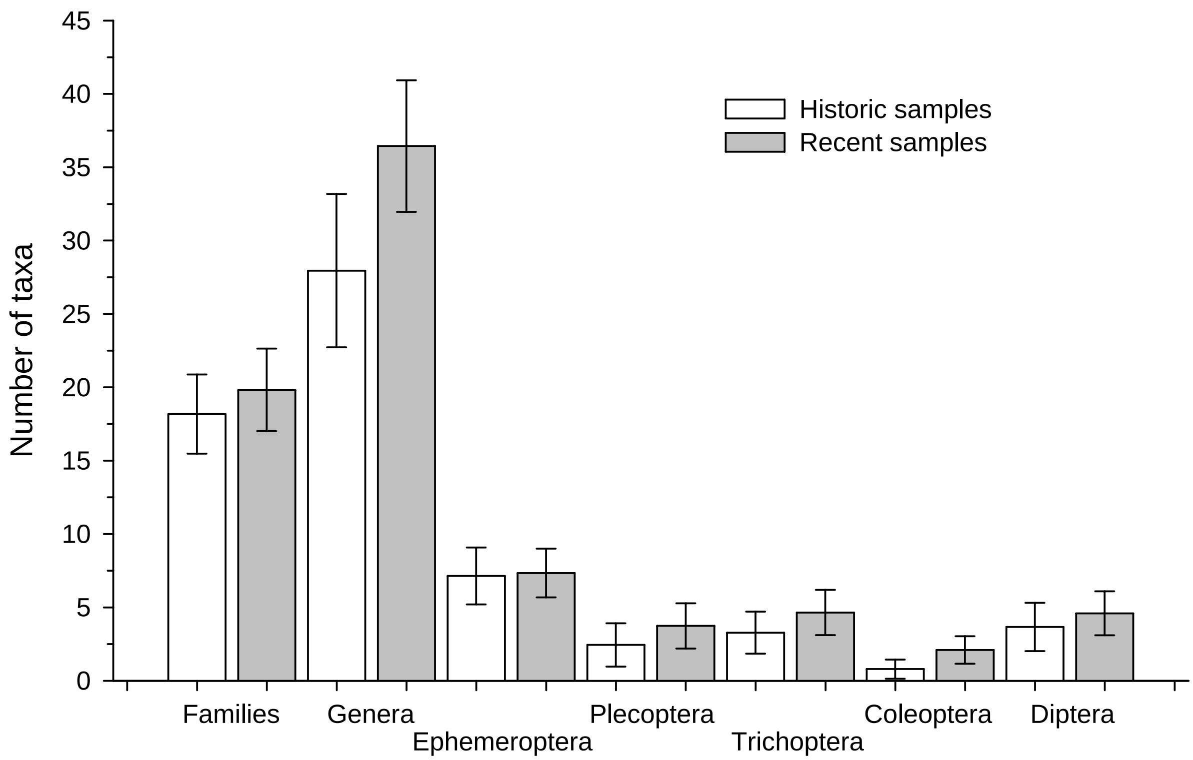

Figure 11. Differences in the number of families, total genera, and genera for individual insect orders between samples collected between 1984 and 1987, and samples collected between 2003 and 2006.

Differences Between Treated and Untreated Sites

To evaluate changes due to the elimination of rotenone, we compared historic data collected on Four Mile Canyon Creek and Fly Valley Creek to recent data collected on Tamarack Creek. None of these streams were treated with rotenone. Similar values between these sites would suggest that the differences observed between historic and recent samples (Table 17 and Figure 11) may be attributed to rotenone, and not field or laboratory methods or other environmental changes, as these streams were never treated with rotenone. Conversely differences between untreated streams suggest that sampling methodology or changes in other environmental factors likely play a role in explaining the observed changes between historic and recent samples (Table 16 and Figure 11). Aquatic invertebrate data were available for Four Mile Canyon Creek from 1984, 1987, 1991, 1992, 1993, 1995, and 1996. Data were available from Fly Valley

Creek from 1984 and 1986. Data were collected annually at two sites on Tamarack Creek between 2003 and 2006.

Comparisons of mean per sample values between the two sample sets revealed similar significant differences in taxonomic richness between the two data sets as we found when comparing the data from all sampling locations (Figure 12). These results suggest that the elimination of rotenone was not the sole cause of the observed differences in aquatic invertebrate assemblages between the two data sets. If all other factors, namely habitat conditions or laboratory procedures, were similar we should not have observed these differences between the historic and recent samples collected at untreated locations. These data suggest that factors in addition to rotenone are responsible for the observed changes. Alternatively, Tamarack Creek may have inherently higher biotic richness than Four Mile Canyon Creek or Fly Valley Creek. We have no way of testing this as recent samples were not collected at Four Mile Canyon Creek or Fly Valley Creek.

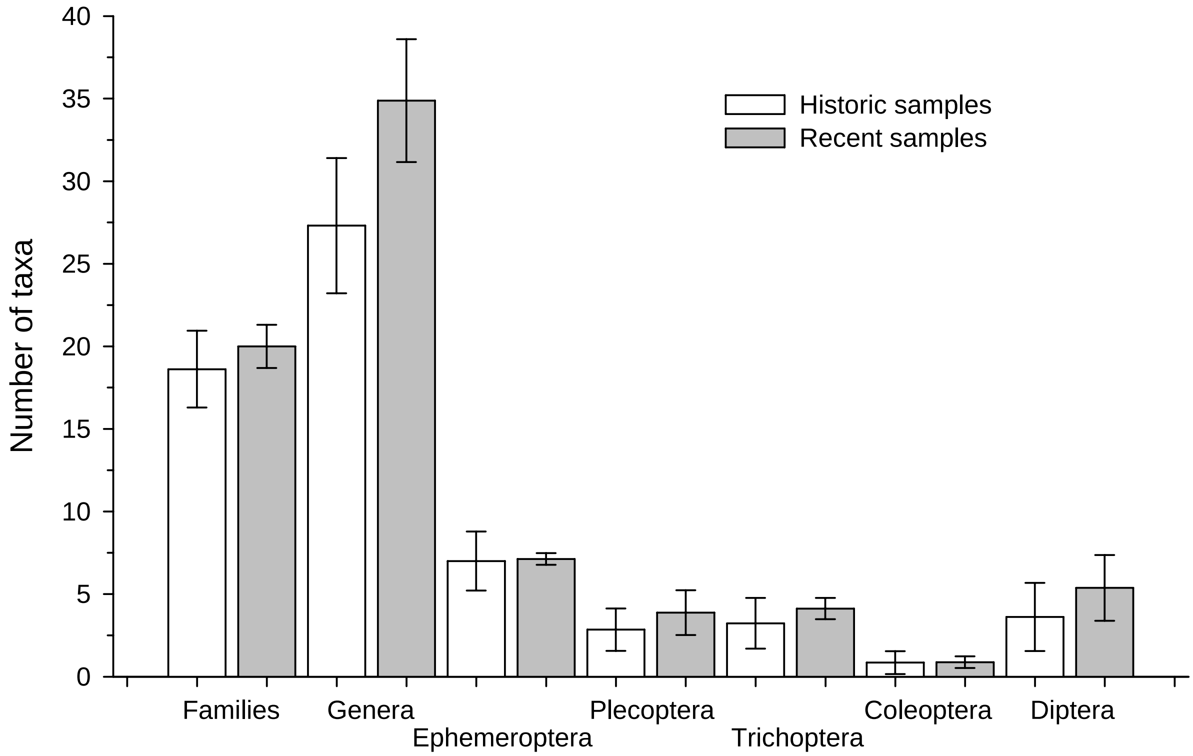

Figure 12. Differences in the number of families, total genera, and genera for individual insect orders between samples collected at the untreated Four Mile Canyon Creek and Fly Valley Creek between 1984 and 1987 and samples collected in the untreated Tamarack Creek between 2003 and 2006.

Differences Between Treated and Untreated Sites in Recent Samples

Differences in aquatic invertebrate assemblages between untreated sites on Tamarack Creek and the treated sites located on Coyote Valley Creek were overall less than that observed between historic and recent samples. The largest observed differences were in total genera richness between Coyote Valley Creek and Tamarack Creek (Figure 13), Corral Valley Creek (Figure 14), and Silver King Creek (Figure 15). These results suggest that if the assemblages present in these streams are comparable; than there have been no lasting effects of rotenone on mean aquatic invertebrate assemblage measures in Coyote Valley Creek.

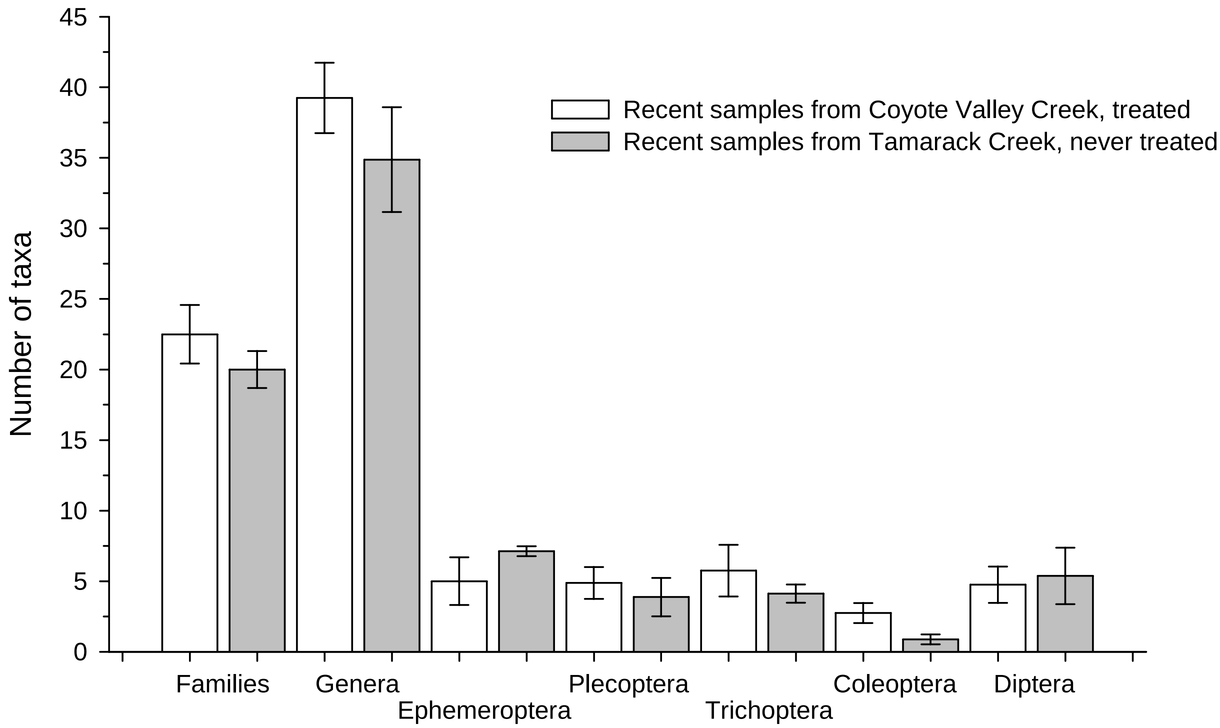

Figure 13. Differences in the number of families, total genera, and genera for individual insect orders between samples collected in Coyote Valley and Tamarack Creek. Samples were collected annually between 2003 and 2006. Coyote Valley was treated with rotenone. Tamarack Creek was never treated.

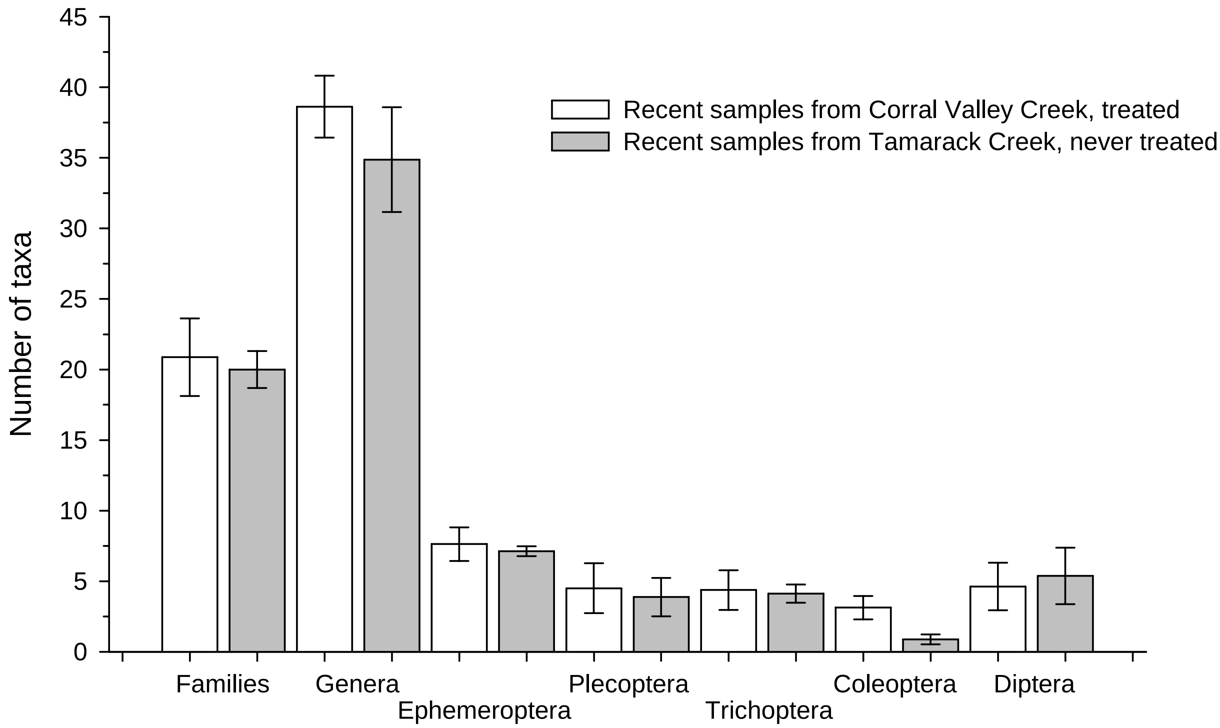

Figure 14 Differences in the number of families, total genera, and genera for individual insect orders between samples collected in Corral Valley and Tamarack Creek. Samples were collected annually between 2003 and 2006. Corral Valley was treated with rotenone. Tamarack Creek was never treated.

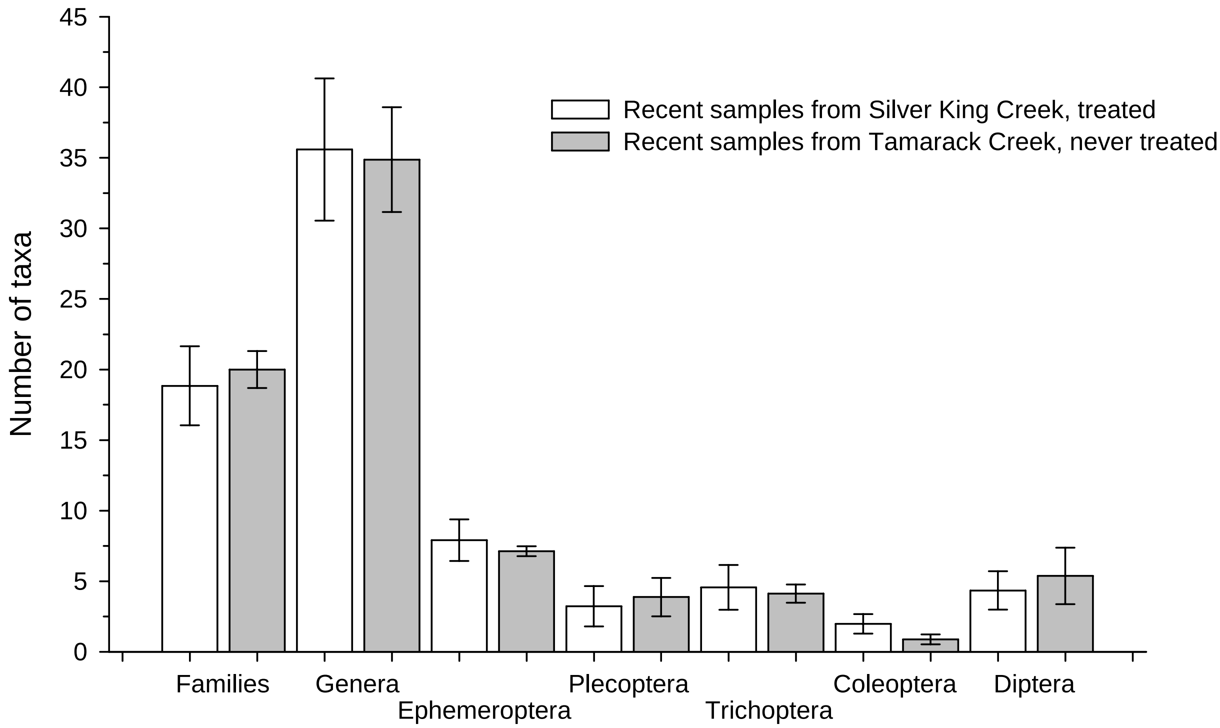

Figure 15. Differences in the number of families, total genera, and genera for individual insect orders between samples collected in Silver King Creek and Tamarack Creek. Samples were collected annually between 2003 and 2006. Silver King Creek was treated with rotenone and Tamarack Creek was untreated.

Conclusions

The cause of consistently higher richness in recent as compared to historic samples is not clear. Potential causes include, 1) the elimination of rotenone treatments since 1993 (Table 3), 2) the elimination of livestock grazing in the Silver King Creek basin since 1996 (Kling, Jason USFS personal communication), 3) differences in aquatic invertebrate sample collection methods, and 4) differences in aquatic invertebrate laboratory procedures and taxonomic resolution. Several problems exist that make it difficult to tease apart the role each of these may play in the observed changes; 1) little information is available on changes in habitat conditions between 1996 when livestock grazing was eliminated and the last samples were collected and processed by the USFS laboratory and 2003 when the samples identified by the BugLab were first collected, 2) none of the exact same sites sampled between 1984 and 1996 were sampled between 2003 and 2006, 3) only a single control (untreated with rotenone) site, Four Mile Canyon Creek, was sampled more than twice in the early dataset and this stream was not sampled between 2003 and 2006, 4) none of the aquatic invertebrate samples remain from the early samples, so the taxonomic quality of these samples can be evaluated, and 5) none of the raw data exists in terms of the percentage of each sample processed or the individual counts of the number of organisms identified in each sample.

One obvious change was the elimination of rotenone treatments. Rotenone was first used in the basin in 1964 and was used in several other years up until 1993 (Table 2). Ten years of recovery from these rotenone treatments may account for some of these differences. Future sampling in Four Mile Canyon Creek, where rotenone was never applied, would help address this problem. If few differences between historic and present samples were found, this would suggest that the elimination of rotenone may explain the current observed differences between historic and recent samples, as all of the differences can be considered positive or improving. The elimination of livestock grazing has also likely led to improved habitat conditions that have benefited aquatic invertebrate assemblages. Unfortunately, with the data provided, we cannot separate these factors.

These overall results of these comparisons are that despite our best efforts to standardize the data generated by the two laboratories, large differences in aquatic invertebrate assemblage measures and the occurrence of individual taxa remained between the two data sets. These differences prevent us from being able to further evaluate changes between the two sample sets as we cannot separate the effects of rotenone from methodological differences and other environmental changes.   We believe these differences and the unanswered questions concerning the historic data made it inappropriate to evaluate changes in taxa occurrences over time using the historic data set.

Based on the data collected between 2003 and 2006, annual and spatial variability in mean aquatic invertebrate assemblage measures were generally low. The coefficient of variation (CV) among years was 36% for aquatic invertebrate abundance and 6% for genera richness, which suggest that differences in these values would likely be detectable following a rotenone treatment. The opposite was true for genera level occurrences where the CV ranged from 12 to 200% and the mean was 101%. This finding, while typical for stream invertebrate studies, has serious consequences for detecting impacts of rotenone on specific genera or species. The low abundances, i.e., rarity, of most genera and species makes it even problematic that they would be collected in the future using the current methods if their populations were less than those collected between 2003 and 2006.

Rarity is broadly defined as something unusual or occurring infrequently. In ecology, there is no current accepted definition of rarity, but measures of rarity most often center on organism abundance, habitat occupancy and range size. Species can be considered rare based on one or more these criteria and they can be rare at different spatial and temporal scales. Abundances among species vary widely; some species are abundant and some or most are not. At local scales, local abundance can vary based on the amount of preferred habitat, while at broad scales, local abundance is generally higher near the center of a species' range (Poff 1997). Following disturbance events, like rotenone treatments, floods or fires, rarity will be related to both organism dispersal rates and community succession that occurs during the colonization phase. Poor dispersers will have slow colonization rates and will thus have lower incidences of occupancy and be difficult to collect. These are basic ecological reasons why species can be rare.

Ecologists have debated the role of rare taxa in detecting and quantifying ecological impairment. This debate has often centered on their role in ecosystems and the ability to accurately assess them. Minimally-disturbed sites often support more rare taxa than disturbed sites. Intentionally removing rare taxa from analyses or effectively removing them by using a small sampling effort may therefore affect the characterization of richness and assemblage structure more strongly at minimally or least-disturbed sites than impaired sites, therefore introducing bias into assessments (Cao et al. 1998, 2002a, 2002b). In theory, rare taxa are typically associated with restricted distributions and habitat specificity, where as abundant taxa have wider geographic ranges and environmental preferences (Cao et al. 1999). Extinction risk increases with decreasing population size, so rare taxa should have a higher probability of extinction. However, empirical evidence supporting this relationship is scarce, particularly for freshwater ecosystems, and it has also been observed that rare aquatic invertebrate taxa may often increase in abundance in response to disturbance (Hawkins et al. 2000). It is likely that the sensitivity of specific taxa differs with the type and magnitude of disturbances and the colonization source and distance to that source.

For stream invertebrates, rarity is a common phenomenon. Stream environments are very diverse both in terms of habitat complexity and in the number of invertebrate species they support. There have been no complete inventories of invertebrates of any body of freshwater, but several studies to date have documented that local – stream reach level – faunas contain hundreds to thousands of species. A total of 1122 species have been reported from the Danube River, Austria and 1044 species from the Breitenbach, Germany (Strayer 2006). Vinson (unpublished data) has sampled the same location on the Logan River, Utah each month for 7 years. His results are similar to that presented here for Silver King Creek. Namely, there is little variation in the number of species or genera that are collected each month, but the occurrences of individual genera and species is very unpredictable. To date, more than 60 genera have been collected at the site, but the number of individual genera collected each month is only about 40% of the total genera found in the stream reach. On average a new genera is collected about every 2 months (Figure 16) and the genera accumulation curve shows little inclination for flattening out.

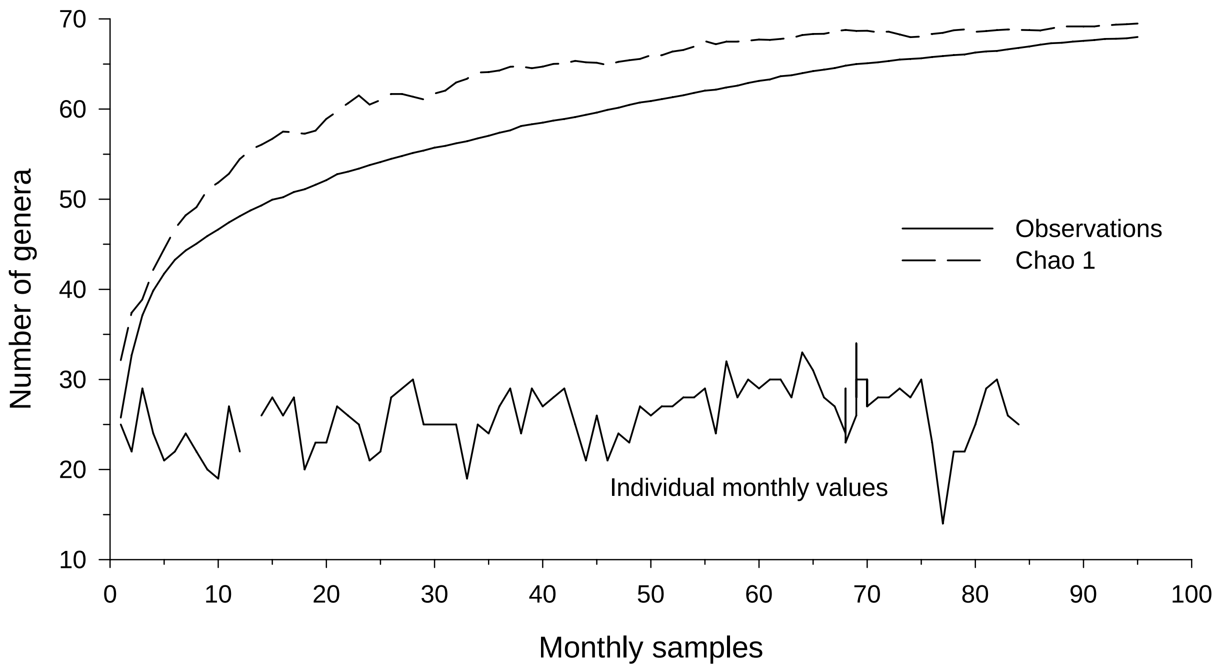

Figure 16. Genera accumulation curves for the Logan River, Cache County, Utah. Lines are individual monthly values and cumulative observations and Chao 1 estimates.

Few species are generally found sharing the same place and the same species are rarely found in similar habitats at similar abundances. These spatial patterns result from either microenvironmental variation in which one habitat is favored over another or from behavioral interactions that may cause individuals to aggregate independently of environmental factors (Resh 1979). These aggregate distributions lead to high variability among samples in terms of both individual abundances and species occurrences. In Needham and Usinger's (1956) classic work to address the problem of precision in sampling stream invertebrates, they concluded that 73 replicate samples were required for a precise estimate of mean total numbers and 194 replicates for mean wet weight. Chutter and Noble (1966) corrected Needham and Usinger's estimate and showed that the problem was even worse than originally thought, if one accepts that 95% CL $\pm$ 5% of the mean is the necessary level of precision. Resh (1979) reanalyzed these data, as well as some of his own, and basically confirmed Needham and Usinger (1956) to say, "We then can conclude from these data that purely quantitative routine sampling in streams to determine weights and numerical data is impractical."

FUTURE SAMPLING CONSIDERATIONS

A study design to detect impacts of rotenone on stream invertebrates can take many forms depending on the level of impact that you want to detect. While the overall question may simply be, "what is the effect of rotenone on aquatic invertebrate assemblages?" The specifics of this question need to be addressed to understand the intensity of sampling required to measure the proposed impact. Will "before-after" comparisons be done with assemblage level measures only, such as total abundance or total taxa or genera richness, or will comparisons in community composition and species or genera occurrences be evaluated as well? The specifics on where, when, how, how often, and for how long samples will be collected is dependent on knowing to the degree to which species or genera level data will be evaluated. The degree to which these data can be evaluated is also dependent on how much sampling will occur before the treatment to provide an accurate or reasonable level of information on the occurrences of taxa in the treatment area.

Where to sample

Presently no information is available on what aquatic invertebrates were present in Silver King Creek prior to the rotenone treatments that began in 1964. Additional effort should be put into locating the missing data for which references are made in USFS monitoring reports. The most valuable data would be pre-1964 before rotenone treatments. To help understand what taxa may have been lost, a stream similar to Silver King Creek with respect to major environmental influences on aquatic invertebrate assemblages, namely latitude, elevation, water chemistry, discharge water temperature regimes, land cover, and livestock grazing history, that has never been treated with rotenone should be sampled. This stream should be sampled with a similar number of sites as Silver King Creek. Sites should be located at similar elevations and positions in the basin as the sites sampled on Silver King Creek.

Consideration should be given to restoring long-term sampling sites that were historically sampled on Fly Valley Creek, Four Mile Creek, Bull Canyon Creek, and at the historic sites that were sampled in Silver King Creek that are located upstream from the sites presently sampled (Sites S5:725, S6738, S7:775, and S8:813). Sampling these sites would provide additional information on historic assemblages. The issue with these data though is that they are not easily comparable to data presently collected.

The recent sampling locations on Silver King Creek upstream of Llewellyn Falls, on Coyote Valley Creek, Corral Valley Creek, and Tamarack Creek appear to be too close together to provide information on invertebrate assemblages living throughout these streams. These sites should be spread out along each stream. For streams tributary to Silver King Creek, sampling stations should be located at historically sampled locations and at the up and downstream ends of the basins. On Silver King Creek, sampling locations upstream of Llewellyn Falls should be spread out and be placed at or near historic sampling locations.

An equal number of control and treatment sites should be sampled for an equal period of time before and after treatment. A problem with evaluating much of the data collected to date is that there are vastly more treatment sites than control sites. Taxa occurrences are highly dependent on the number of samples and individuals collected.

When to sample

To continue with comparisons of previously collected samples, samples should continue to be collected in late summer, August to September. The majority of past samples collected in the Silver King Creek Basin were collected during these months. In terms of aquatic invertebrate abundance, richness, and organism maturity this is a good time to sample. Collecting samples during other times of the year would likely increase the total number of different taxa collected. These data would be valuable for taxonomic questions related to what genera or species live in the basin. However, these data would not be readily comparable to historic or recently collected data.

How to sample

A Surber sampler has been historically used to collect samples in the Silver King Basin is an adequate sampling device for collecting invertebrates in this type of stream, especially where information on relative densities in desired. The number of samples to be collected and the area sampled for each sample is a difficult question to answer. Recent samples collected between 2003 and 2006 were sampled similar to the way samples were collected historically, 1984 to 1996, (three individual Surber samples per riffle at each site on each sampling date). Individual Surber samples were collected and analyzed separately. Samples collected in the future using this technique would be comparable to previous samples. The problem with this sampling technique is that fewer individuals are collected as compared to more current techniques (Hawkins et al. 2003) used by much of the USFS. Much of the USFS now collects eight Surber samples per sampling site and composites these into a single sample. The use of this technique would allow for the use of RIVPAC analyses (Hawkins et al. 2000, see also Western Center for Monitoring and Assessment of Freshwater Ecosystems 2007) which allows for the prediction of what taxa should occur at a site in the absence of anthropogenic actions and factors in the probability of occurrences for all individual taxa.

A complete census is never done for any environmental assessment. In general, the number of taxa that we collect at a site will increase with increasing sampling effort (e.g., Figure 8 and 16). Collections therefore always contain a subset of the taxa that actually occur at a site. Furthermore, random sampling error ensures that replicate collections will seldom be identical in either the number of individuals or the specific taxa collected. For any single sample, we are more likely to collect an abundant taxon than a rare one. The collection of qualitative samples in addition to quantitative samples would increase the likelihood of collecting taxa with low relative abundances, i.e., rare taxa. Qualitative samples could be collected using a kicknet with a 500 micron mesh net and by hand picking invertebrates from woody debris and large boulders. All major habitat types (e.g., riffles, pools, backwaters, aquatic macrophyte beds) should be sampled and all samples composited to form a single sample from each site for each sampling date. The occurrence of adult insects in riparian habitats could be sampled as well. Sampling for adult aquatic insects could be as simple as sampling riparian vegetation with terrestrial insect nets at the same time that benthic samples are collected or could be more involved by using ultraviolet and black lights at dusk. A study plan that we are currently using to do a thorough census of the aquatic insects of the Logan River in Cache County, Utah during summer 2007 is presented in Appendix 11).

Sample processing

For historic samples, the percentage of each sample processed is unknown. For recent samples, each sample was processed in its entirety. If future samples are separate Surber samples, these should be processed in their entirety. If multiple Suber samples are collected in each stream reach and composited, these samples will need to be sub-sampled. If a minimum of 500 organisms are removed and the samples are searched for rare taxa following sub-sampling, the probability of collecting rarer taxa will increase. Qualitative samples should be processed in their entirety.

It takes increasing time and money to identify organisms to increasingly higher levels of taxonomic resolution. Many studies conducted in the 1960-70s have shown that variation in assemblage composition along strong, large-scale environmental gradients can be detected with coarser (generally family level) taxonomy, subsets of the assemblage, or abundant taxa only. Other studies which have examined how taxonomic resolution affected the relationships between assemblage structure and stress measures (e.g., heavy metals, pH, nutrients, land use) or environmental variables (e.g., stream width, substrate, and slope) and have demonstrated that species-genus level data yielded stronger correlations between similarity matrices derived from biological and environmental data (Hill et al. 2001, King and Richardson 2002, and Waite et al. 2004). For general ecology and biodiversity conservation studies, Lenat and Resh (2001) discussed the importance of genus-species level resolution, because the biology and environmental requirements of different species in the same family can differ greatly. Genus-species level data provides more information about the assemblage of interest and their environments than family-level data and is certainly required to detect impacts to individual genera and species. We recommend that taxa be identified to the lowest taxonomic resolution possible based on the organisms collected. For larval insects this is generally genus level, with some species and family level identifications occurring for certain taxa during certain times of the year. The collection of adult insects would greatly facilitate our knowledge of species present in the Silver King Creek Basin, which would assist in the routine identification of larval insects. The practicality of these collections and the more time consuming identifications of adult specimens will obviously need to be weighed with the other objectives of the project.

How to determine sampling adequacy

Information on the adequacy of sampling with respect to how much of the Silver King Creek fauna has been collected prior to treatment can be assessed using rarefaction and species accumulation curves (Colwell and Coddington 1994, Colwell 2005). These techniques provide information on the adequacy of sampling done to date and on the relative number of taxa that may be present but are yet uncollected. These same methods can be used following treatment to evaluate assemblage recovery.

To evaluate where we are in terms of accumulating biodiversity at Silver King Creek we calculated a genus level collection curve for the Silver King Creek data collected between 2003 and 2005 (Figure 17). Compared to the theoretical maximum richness (Chao 1 estimator), about 90% of the genera have been collected to date. The shape of the collector curve can also be evaluated to determine if the rate of increase is starting to level off. In Silver King Creek the slope of the accumulation curve is still fairly steep, suggesting several additional genera will be collected in the future.

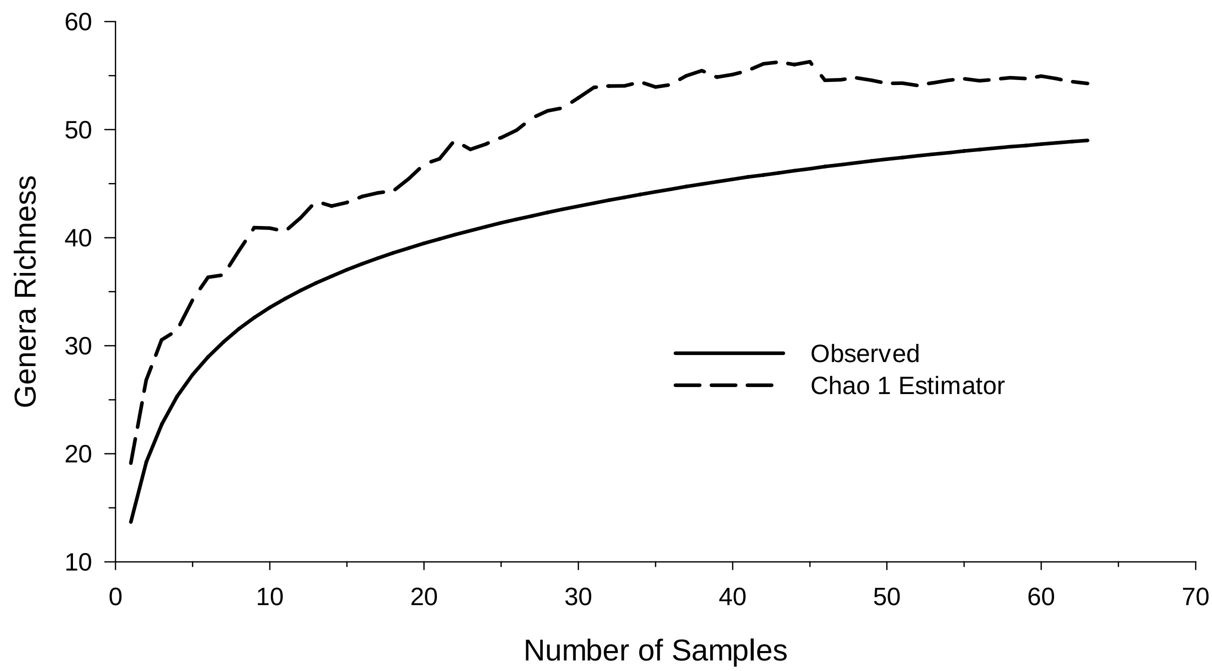

Figure 17 Genera accumulation curve for samples collected betweeen 2003 and 2006 within the Silver King Creek Basin.

For comparison, we also calculated a species accumulation curve for a sampling location we have been sampling monthly for 8 years on the Logan River in Cache County, Utah (Figure 18). After 8 years of sampling the same place each month, we continue to collect new genera. To date, the predicted genera richness for this site is about 10% higher than our observed richness. Conversely, if you look at the number of genera collected each month (the lower line in Figure 18), it varies very little. This means that the number of species at a site fairly constant, but who those individual species are changes considerably from month to month.

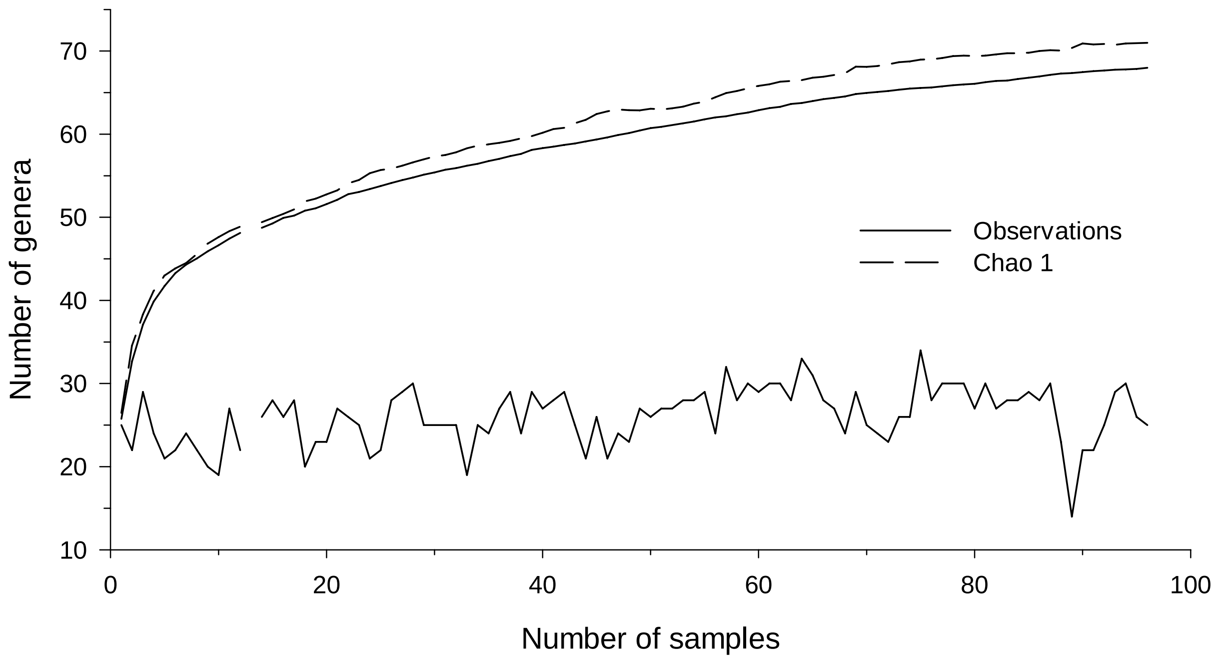

Figure 18 Genera accumulation curve for samples collected between 2000 and 2007 in the Logan River at Wood Camp Campground, Cache County, Utah.

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LIST OF APPENDICES

Appendix 1. Sensitivity of invertebrates to rotenone in laboratory studies, modified from Lindgren (1960) and Schnick (1974). Rotenone concentration is presented as the concentration of 5% rotenone.

Group & Species	Duration (hrs)	Concentration (ppm)	Mortality (%)	Source
Amphipoda Gammarus pulex	72	0.1	0	Meadows 1973
Amphipoda Gammarus pulex	144	0.5	0	Meadows 1973
Amphipoda Gammarus pulex	144	2.0	10	Meadows 1973
Amphipoda Gammarus pulex	40	1.0	100	Lindgren 1960
Amphipoda Gammaridae	24	1.5	13	Ruck 1966
Amphipoda Gammaridae	24	2.0	88	Ruck 1966
Amphipoda Gammaridae	24	2.5	100	Ruck 1966
Bivalvia: Unionidae Elliptio buckleyi	96	2.9	50	Chandler and Marking 1982
Bivalvia: Unionidae Elliptio complanata	96	2.0	50	Chandler and Marking 1982
Bivalvia: Corbiculidae Corbicula manilensis	96	7.5	50	Chandler and Marking 1982
Coleoptera: Gyrinidae Gyrinus	1	47.5	50	Chandler and Marking 1982
Coleoptera: Gyrinidae Gyrinus	3	8.3	50	Chandler and Marking 1982
Coleoptera: Gyrinidae Gyrinus	6	8.0	50	Chandler and Marking 1982
Coleoptera: Gyrinidae Gyrinus	24	3.6	50	Chandler and Marking 1982
Coleoptera: Gyrinidae Gyrinus	96	0.7	50	Chandler and Marking 1982
Decapoda	24	2.5	50	Ruck 1966
Decapoda	24	3.0	100	Ruck 1966
Diplostraca: Daphnia	3	0.025	100	Hamilton 1941
Diplostraca: Daphnia pulex	1	0.1	50	Chandler and Marking 1982
Diplostraca: Daphnia pulex	3	0.1	50	Chandler and Marking 1982
Diplostraca: Daphnia pulex	6	0.04	50	Chandler and Marking 1982
Diplostraca: Daphnia pulex	24	0.03	50	Chandler and Marking 1982
Diplostraca: Leotodora kindtii	3	0.025	100	Hamilton 1941
Diptera: Ceratopogonidae Palpomyia	23	1.0	40	Lindgren 1960
Diptera: Chironomidae Chironomus plumosus	46	0.3	30	Lindgren 1960
Diptera: Chironomidae Chironomus plumosus	46	1.0	50	Lindgren 1960
Diptera: Chironomidae Chironomus plumosus	48	0.1	25	Zischkale 1952
Diptera: Chironomidae unspecified species	61	0.03	20	Lindgren 1960
Diptera: Culicidae Culex	48	1.5	25	Zischkale 1952
Diptera: Culicidae: Aedes	48	1.0	25	Zischkale 1952
Diptera: Culicidae: Anopheles	48	1.5	25	Zischkale 1952
Diptera: Tipulidae Tipula	96	1.0	0	Leonard 1939
Ephemeroptera: Caenidae Caenis	35	1.0	60	Lindgren 1960
Ephemeroptera: Siphlonuridae Siphlonurus	48	1.2	50	Claffey and Ruck 1967
Ephemeroptera: Siphlonuridae Siphlonurus	48	2.6	100	Claffey and Ruck 1967
Gastropoda: Helisoma	3	33.5	50	Chandler and Marking 1982
Gastropoda: Helisoma	6	33.5	50	Chandler and Marking 1982
Gastropoda: Helisoma	24	30	50	Chandler and Marking 1982
Gastropoda: Helisoma	96	8.0	50	Chandler and Marking 1982
Gastropoda: Lymnaea stagnalis	84	0.5	30	Hamilton 1941
Gastropoda: Lymnaea stagnalis	84	1.0	70	Hamilton 1941
Gastropoda: Physa	96	1.0	0	Leonard 1939
Gastropoda: Physa halei	36	0.1	20	Hamliton 1941
Gastropoda: Physa pomilia	24	6.4	50	Chandler and Marking 1982
Gastropoda: Physa pomilia	96	4.0	50	Chandler and Marking 1982
Hemiptera: Notonectidae Notonecta	1	10.0	50	Chandler and Marking 1982
Hemiptera: Notonectidae Notonecta	3	2.0	50	Chandler and Marking 1982
Hemiptera: Notonectidae Notonecta	6	9.0	50	Chandler and Marking 1982
Hemiptera: Notonectidae Notonecta	24	3.4	50	Chandler and Marking 1982
Hemiptera: Notonectidae Notonecta	96	1.6	50	Chandler and Marking 1982
Hemiptera: Notonectidae Notonecta species	40	0.1	30	Lindgren 1960
Hemiptera: Notonectidae unspecified species	24	0.1	50	Hamilton 1941
Hemiptera: Notonectidae Notonecta species	40	2.0	100	Lindgren 1960
Hirudinea: Unspecified species	50	0.1	100	Hamilton 1941
Hydracarina	96	0.05	43	Hamilton 1941
Hydracarina	65	0.05	30	Hamilton 1941
Isopoda: Asellus aquaticus	144	2.0	100	Meadows 1973
Isopoda: Asellus aquaticus[2]	144	0.1	10	Meadows 1973
Isopoda: Asellus aquaticus[2]	144	0.5	30	Meadows 1973
Isopoda	24	1.0	75	Ruck 1966
Isopoda	24	1.5	100	Ruck 1966
Maxillipoda: Cyclopodidae Cyclops	72	0.1	100	Meadows 1973

Maxillipoda: Diaptomus siciloides	3	0.025	100	Hamilton 1941
Odonata: Anisoptera	24	4.7	25	Ruck 1966
Odonata: Anisoptera	24	5.3	100	Ruck 1966
Odonata: Aeschnidae Anax	48	2.4	50	Claffey and Ruck 1967
Odonata: Aeschnidae Anax	48	3.9	50	Claffey and Ruck 1967
Odonata: Coenagrionidae Agrion = Calopteryx	48	2.7	50	Claffey and Ruck 1967
Odonata: Coenagrionidae Agrion = Calopteryx	48	3.8	100	Claffey and Ruck 1967
Odonata: Macromiidae Macromia	3	275	50	Chandler and Marking 1982
Odonata: Macromiidae Macromia	6	34	50	Chandler and Marking 1982
Odonata: Macromiidae Macromia	24	4.7	50	Chandler and Marking 1982
Odonata: Macromiidae Macromia	96	1.0	50	Chandler and Marking 1982
Odonata: Zygoptera	24	2.5	25	Ruck 1966
Oligochaeta: Stylaria lacustris	14	2.0	13	Lindgren 1960
Ostracoda: Cypridopsis	1	2.8	50	Chandler and Marking 1982
Ostracoda: Cypridopsis	3	2.6	50	Chandler and Marking 1982
Ostracoda: Cypridopsis	6	2.2	50	Chandler and Marking 1982
Ostracoda: Cypridopsis	24	0.5	50	Chandler and Marking 1982
Ostracoda: Cypridopsis	96	0.3	50	Chandler and Marking 1982
Ostracoda: Cypris	7	2.0	100	Lindgren 1960
Ostracoda: Eucypris	48	0.1	25	Zischkale 1952
Trichoptera: Phryganeidae Phryganea	48	2.3	100	Claffey and Ruck 1967

Appendix 2. List of aquatic invertebrate taxa and abundances collected in historic, 1984 to 1996, and recent, 2003 to 2006, samples.

Phylum	Class	Order	Family	Subfamily or genus	Species	Historic	Recent	Total
Annelida	Clitellata	Haplotaxida	Tubificidae			247	0	247
Annelida	Clitellata	Lumbriculida	Lumbriculidae			3	0	3
Annelida	Clitellata Subclass Oligochaeta					112	399	511
Arthropoda	Arachnida	Trombidiformes				2766	1962	4728
Arthropoda	Branchiopoda	Diplostraca	Daphniidae	Daphnia		1	0	1
Arthropoda	Insecta	Coleoptera	Carabidae			3	0	3
Arthropoda	Insecta	Coleoptera	Curculionidae			0	2	2
Arthropoda	Insecta	Coleoptera	Dytiscidae	Laccophilus		1	0	1
Arthropoda	Insecta	Coleoptera	Dytiscidae	Oreodytes		0	3	3
Arthropoda	Insecta	Coleoptera	Dytiscidae	Stictotarsus		0	1	1
Arthropoda	Insecta	Coleoptera	Dytiscidae			3	1	4
Arthropoda	Insecta	Coleoptera	Elmidae	Cleptelmis	addenda	0	567	567
Arthropoda	Insecta	Coleoptera	Elmidae	Heterlimnius	corpulentus	0	177	177
Arthropoda	Insecta	Coleoptera	Elmidae	Heterlimnius	koebelei	0	1	1
Arthropoda	Insecta	Coleoptera	Elmidae	Heterlimnius		0	1855	1855
Arthropoda	Insecta	Coleoptera	Elmidae	Lara		0	5	5
Arthropoda	Insecta	Coleoptera	Elmidae	Narpus	concolor	0	38	38
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	divergens/pecosensis	0	31	31
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	quadrimaculatus	0	230	230
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus		1105	686	1791
Arthropoda	Insecta	Coleoptera	Elmidae	Zaitzevia		3159	0	3159
Arthropoda	Insecta	Coleoptera	Elmidae			2479	547	3026
Arthropoda	Insecta	Coleoptera	Helophoridae	Helophorus		0	4	4
Arthropoda	Insecta	Coleoptera	Hydraenidae	Hydraena		0	6	6
Arthropoda	Insecta	Coleoptera	Hydraenidae	Ochthebius		0	10	10
Arthropoda	Insecta	Coleoptera	Hydrophilidae			1	3	4
Arthropoda	Insecta	Coleoptera				0	1	1
Arthropoda	Insecta	Diptera	Athericidae	Atherix	pachypus	2	67	69
Arthropoda	Insecta	Diptera	Ceratopogonidae	Atrichopogon/Forcipomyia		0	1	1
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia		491	2	493
Arthropoda	Insecta	Diptera	Ceratopogonidae	Forcipomyia		0	2	2
Arthropoda	Insecta	Diptera	Ceratopogonidae	Probezzia		0	200	200
Arthropoda	Insecta	Diptera	Ceratopogonidae			162	10	172
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae		0	3083	3083
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		7847	5288	13135
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae		534	94	628
Arthropoda	Insecta	Diptera	Chironomidae			9604	340	10903
Arthropoda	Insecta	Diptera	Dixidae	Dixa		4	1	5
Arthropoda	Insecta	Diptera	Dixidae			4	0	4
Arthropoda	Insecta	Diptera	Empididae	Chelifera		316	155	471
Arthropoda	Insecta	Diptera	Empididae	Clinocera		0	2	2
Arthropoda	Insecta	Diptera	Empididae	Hemerodromia		7	0	7
Arthropoda	Insecta	Diptera	Empididae	Oreogeton		0	4	4
Arthropoda	Insecta	Diptera	Empididae			211	10	221
Arthropoda	Insecta	Diptera	Ephydridae			2	0	2
Arthropoda	Insecta	Diptera	Pelecorhynchidae	Glutops		193	208	401
Arthropoda	Insecta	Diptera	Psychodidae	Maruina		1	0	1
Arthropoda	Insecta	Diptera	Psychodidae	Pericoma		9689	640	10329

Arthropoda	Insecta	Diptera	Psychodidae			191	0	191
Arthropoda	Insecta	Diptera	Simuliidae	Prosimulium		0	54	54
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	tuberosum complex	0	1	1
Arthropoda	Insecta	Diptera	Simuliidae	Simulium		15	1784	1799
Arthropoda	Insecta	Diptera	Simuliidae			1203	60	1263
Arthropoda	Insecta	Diptera	Stratiomyidae	Nemotelus		2	0	2
Arthropoda	Insecta	Diptera	Stratiomyidae			3	0	3
Arthropoda	Insecta	Diptera	Tipulidae	Antocha	monticola	6	0	6
Arthropoda	Insecta	Diptera	Tipulidae	Antocha		113	94	207
Arthropoda	Insecta	Diptera	Tipulidae	Dicranota		22	18	40
Arthropoda	Insecta	Diptera	Tipulidae	Hexatoma		250	48	298
Arthropoda	Insecta	Diptera	Tipulidae	Holorusia		1	0	1
Arthropoda	Insecta	Diptera	Tipulidae	Limnophila		0	3	3
Arthropoda	Insecta	Diptera	Tipulidae	Ormosia		11	0	11
Arthropoda	Insecta	Diptera	Tipulidae	Pedicia		0	1	1
Arthropoda	Insecta	Diptera	Tipulidae	Rhabdomastix		0	12	12
Arthropoda	Insecta	Diptera	Tipulidae	Tipula		3	0	3
Arthropoda	Insecta	Diptera	Tipulidae			1	4	5
Arthropoda	Insecta	Diptera				34	0	34
Arthropoda	Insecta	Ephemeroptera	Ameletidae	Ameletus		46	186	232
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis		8980	6629	15609
Arthropoda	Insecta	Ephemeroptera	Baetidae	Diphetor	hageni	0	41	41
Arthropoda	Insecta	Ephemeroptera	Baetidae			0	218	218
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	attenuata group	0	3	3
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	delantala	1430	507	1937
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	margarita	365	0	365
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella		18	1	19
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella	heterocaudata	0	8	8
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella	hystrix	900	58	958
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella		0	1732	1732
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	coloradensis/flavilinea	82	122	204
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	doddsi	1769	2539	4308
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	grandis/spinifera	1783	1834	3617
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella		0	213	213
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	inermis/dorothea	2997	5	3002
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella	tibialis	91	17	108
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella		0	51	51
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae			31	3126	3157
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula		1757	1175	2932
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus		482	942	1424
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptagenia		414	0	414
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Ironodes		0	63	63
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena		500	460	960
Arthropoda	Insecta	Ephemeroptera	Heptageniidae			4	418	422
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	minutus	52	1	53
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae			0	23	23
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia		1082	627	1709
Arthropoda	Insecta	Ephemeroptera	Polymitarcyidae	Ephoron	album	12	0	12
Arthropoda	Insecta	Ephemeroptera				299	2	301
Arthropoda	Insecta	Megaloptera	Corydalidae			0	6	6
Arthropoda	Insecta	Megaloptera	Sialidae	Sialis		1	3	4

Arthropoda	Insecta	Odonata	Coenagrionidae			1	0	1
Arthropoda	Insecta	Plecoptera	Capniidae			185	2	187
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Plumiperla	diversa	5	0	5
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Suwallia		181	52	233
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa		43	294	337
Arthropoda	Insecta	Plecoptera	Chloroperlidae			1679	856	2535
Arthropoda	Insecta	Plecoptera	Leuctridae	Moselia	infuscata	0	5	5
Arthropoda	Insecta	Plecoptera	Leuctridae			169	23	192
Arthropoda	Insecta	Plecoptera	Nemouridae	Malenka		4	263	267
Arthropoda	Insecta	Plecoptera	Nemouridae	Podmosta		1	0	1
Arthropoda	Insecta	Plecoptera	Nemouridae	Visoka	cataractae	1	19	20
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	cinctipes	42	37	79
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	columbiana	0	136	136
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	oregonensis	79	0	79
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	oregonensis group	0	11	11
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada		271	232	503
Arthropoda	Insecta	Plecoptera	Nemouridae			29	81	110
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Yoraperla		1331	6157	7488
Arthropoda	Insecta	Plecoptera	Peltoperlidae			2	107	109
Arthropoda	Insecta	Plecoptera	Perlidae	Calineuria	californica	17	2	19
Arthropoda	Insecta	Plecoptera	Perlidae	Claassenia	sabulosa	0	6	6
Arthropoda	Insecta	Plecoptera	Perlidae	Doroneuria	baumanni	18	132	150
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla	hoguei	0	18	18
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla	pacifica	15	65	80
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla		22	7	29
Arthropoda	Insecta	Plecoptera	Perlidae			85	159	244
Arthropoda	Insecta	Plecoptera	Perlodidae	Cultus		5	0	5
Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperla		38	0	38
Arthropoda	Insecta	Plecoptera	Perlodidae	Kogotus	nonus	0	1	1
Arthropoda	Insecta	Plecoptera	Perlodidae	Kogotus		25	0	25
Arthropoda	Insecta	Plecoptera	Perlodidae	Megarcys		0	2	2
Arthropoda	Insecta	Plecoptera	Perlodidae	Oroperla	barbara	0	11	11
Arthropoda	Insecta	Plecoptera	Perlodidae	Perlinodes	aurea	1	4	5
Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	americana	20	0	20
Arthropoda	Insecta	Plecoptera	Perlodidae			37	305	342
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcella	regularis	7	17	24
Arthropoda	Insecta	Plecoptera	Pteronarcyidae			0	1	1
Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Taenionema		512	0	512
Arthropoda	Insecta	Plecoptera	Taeniopterygidae			0	2	2
Arthropoda	Insecta	Plecoptera				709	36	745
Arthropoda	Insecta	Trichoptera	Apataniidae	Apatania		2	61	63
Arthropoda	Insecta	Trichoptera	Apataniidae	Pedomoecus	sierra	44	36	80
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	americanus	28	309	337
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus		78	15	93
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema		185	1392	1577
Arthropoda	Insecta	Trichoptera	Brachycentridae			1	0	1
Arthropoda	Insecta	Trichoptera	Calamoceratidae	Heteroplectron	californicum	0	2	2
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Anagapetus		0	20	20
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma		495	323	818
Arthropoda	Insecta	Trichoptera	Glossosomatidae			0	547	547
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	californica	0	7	7

Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	grandis	29	12	41
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche		78	36	114
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche		4	0	4
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche		80	2	82
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche	almota	0	1	1
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche	elsis	1	44	45
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche		29	11	40
Arthropoda	Insecta	Trichoptera	Hydropsychidae			0	140	140
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Leucotrichia		1	0	1
Arthropoda	Insecta	Trichoptera	Hydroptilidae			0	4	4
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma		46	8	54
Arthropoda	Insecta	Trichoptera	Leptoceridae	Oecetis		1	0	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Chyranda	centralis	1	0	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Cryptochia		1	2	3
Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus		4	10	14
Arthropoda	Insecta	Trichoptera	Limnephilidae	Ecclisomyia		10	0	10
Arthropoda	Insecta	Trichoptera	Limnephilidae	Homophylax		0	1	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Psychoglypha		0	3	3
Arthropoda	Insecta	Trichoptera	Limnephilidae			11	11	22
Arthropoda	Insecta	Trichoptera	Philopotamidae	Dolophilodes		2	310	312
Arthropoda	Insecta	Trichoptera	Philopotamidae	Wormaldia		0	2	2
Arthropoda	Insecta	Trichoptera	Philopotamidae			12	50	62
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropus		4	5	9
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	alberta group	0	1	1
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	angelita group	0	23	23
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	arnaudi	0	34	34
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	betteni group	0	172	172
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	brunnea/vemna groups	295	384	679
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	coloradensis	5	0	5
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	hyalinata	691	0	691
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	sibirica group	0	44	44
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	sibirica group A	0	18	18
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	sibirica group C	0	3	3
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	vagrita	281	3	284
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	verrula group	0	10	10
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	vofixa group	0	176	176
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila		901	439	1340
Arthropoda	Insecta	Trichoptera	Rhyacophilidae			0	16	16
Arthropoda	Insecta	Trichoptera	Uenoidae	Farula		0	1	1
Arthropoda	Insecta	Trichoptera	Uenoidae	Neophylax	splendens	0	2	2
Arthropoda	Insecta	Trichoptera	Uenoidae	Neophylax		0	29	29
Arthropoda	Insecta	Trichoptera	Uenoidae	Neothremma		19	47	66
Arthropoda	Insecta	Trichoptera	Uenoidae	Oligophlebodes		25	13	38
Arthropoda	Insecta	Trichoptera	Uenoidae			0	2	2
Arthropoda	Insecta	Trichoptera				186	185	371
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	Hyalella	azteca	0	9	9
Arthropoda	Maxillopoda, Subclass Copepoda					139	0	139
Arthropoda	Ostracoda					1321	159	1480
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium		63	87	150
Mollusca	Gastropoda					0	2	2
Nemata						275	61	336

Nematomorpha			2	0	2
Platyhelminthes	Turbellaria		234	854	1088
		Total individuals collected	75974	54906	130880
		Taxa present, count > 0	132	163	204
		Taxa absent, count =0	72	41	0
		Taxa with count >0 and <10	42	57	70
		Taxa with count >10	90	106	134
		Taxa with count >100	52	54	83
		Taxa with count >500	25	23	40
		Taxa with count >1000	18	13	27

Appendix 3. List of genera and abundances historically collected at treated and untreated sites. Samples were collected in1984, 1987, 1991, 1992, 1993, 1995, and 1996.

Phylum	Class	Order	Family	Genus	Treated sites	Untreated sites	Total
Arthropoda	Branchiopoda	Diplostraca	Daphniidae	Daphnia	1	0	1
Arthropoda	Insecta	Coleoptera	Dytiscidae	Laccophilus	1	0	1
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	571	534	1105
Arthropoda	Insecta	Coleoptera	Elmidae	Zaitzevia	2170	989	3159
Arthropoda	Insecta	Diptera	Athericidae	Atherix	2	0	2
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia	422	69	491
Arthropoda	Insecta	Diptera	Dixidae	Dixa	1	3	4
Arthropoda	Insecta	Diptera	Empididae	Chelifera	276	40	316
Arthropoda	Insecta	Diptera	Empididae	Hemerodromia	7	0	7
Arthropoda	Insecta	Diptera	Pelecorhynchidae	Glutops	132	61	193
Arthropoda	Insecta	Diptera	Psychodidae	Maruina	1	0	1
Arthropoda	Insecta	Diptera	Psychodidae	Pericoma	7798	1891	9689
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	8	7	15
Arthropoda	Insecta	Diptera	Stratiomyidae	Nemotelus	2	0	2
Arthropoda	Insecta	Diptera	Tipulidae	Antocha	92	27	119
Arthropoda	Insecta	Diptera	Tipulidae	Dicranota	21	1	22
Arthropoda	Insecta	Diptera	Tipulidae	Hexatoma	228	22	250
Arthropoda	Insecta	Diptera	Tipulidae	Holorusia	1	0	1
Arthropoda	Insecta	Diptera	Tipulidae	Ormosia	11	0	11
Arthropoda	Insecta	Diptera	Tipulidae	Tipula	2	1	3
Arthropoda	Insecta	Ephemeroptera	Ameletidae	Ameletus	40	6	46
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	7367	1613	8980
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	1553	260	1813
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella	789	111	900
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	3001	633	3634
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	2615	382	2997
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella	89	2	91
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	1468	289	1757
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	416	66	482
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptagenia	346	68	414
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	428	72	500
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	52	0	52
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	983	99	1082
Arthropoda	Insecta	Ephemeroptera	Polymitarcyidae	Ephoron	0	12	12
Arthropoda	Insecta	Megaloptera	Sialidae	Sialis	1	0	1
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Plumiperla	5	0	5
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Suwallia	145	36	181
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	29	14	43
Arthropoda	Insecta	Plecoptera	Nemouridae	Malenka	4	0	4
Arthropoda	Insecta	Plecoptera	Nemouridae	Podmosta	1	0	1
Arthropoda	Insecta	Plecoptera	Nemouridae	Visoka	1	0	1
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	253	139	392
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Yoraperla	1107	224	1331
Arthropoda	Insecta	Plecoptera	Perlidae	Calineuria	17	0	17
Arthropoda	Insecta	Plecoptera	Perlidae	Doroneuria	11	7	18
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla	24	13	37
Arthropoda	Insecta	Plecoptera	Perlodidae	Cultus	5	0	5

Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperla	24	14	38
Arthropoda	Insecta	Plecoptera	Perlodidae	Kogotus	20	5	25
Arthropoda	Insecta	Plecoptera	Perlodidae	Perlinodes	1	0	1
Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	19	1	20
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcella	7	0	7
Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Taenionema	448	64	512
Arthropoda	Insecta	Trichoptera	Apataniidae	Apatania	2	0	2
Arthropoda	Insecta	Trichoptera	Apataniidae	Pedomoecus	33	11	44
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	93	13	106
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema	163	22	185
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma	400	95	495
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	55	52	107
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	4	0	4
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	80	0	80
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche	24	6	30
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Leucotrichia	1	0	1
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	27	19	46
Arthropoda	Insecta	Trichoptera	Leptoceridae	Oecetis	1	0	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Chyranda	1	0	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Cryptochia	1	0	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus	3	1	4
Arthropoda	Insecta	Trichoptera	Limnephilidae	Ecclisomyia	4	6	10
Arthropoda	Insecta	Trichoptera	Philopotamidae	Dolophilodes	0	2	2
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropus	4	0	4
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	1832	341	2173
Arthropoda	Insecta	Trichoptera	Uenoidae	Neothremma	6	13	19
Arthropoda	Insecta	Trichoptera	Uenoidae	Oligophlebodes	25	0	25
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium	42	21	63
				Total individuals collected	35817	8377	44194
				Genera present, count >0	73	48	75
				Genera absent, count =0	2	27	0
				Genera with count >0 and <10	28	13	26
				Genera with count >=10	45	35	49
				Genera with count >=100	24	12	27
				Genera with count >=500	12	5	14
				Genera with count >=1000	9	2	11
				Genera with count >=5000	2	0	2

Appendix 4. List of genera and abundances collected in Four Mile Canyon Creek and at five sites on Silver King Creek in 1984, 1987, 1991, 1992, 1993, 1995, and 1996. Four Mile Canyon was never treated with rotenone. Silver King Creek was treated with rotenone in 1964, 1976, 1991, 1992, and 1993.

						Silver King Creek					
Phylum	Class	Order	Family	Genus	Four Mile	S7:775	S6:738	S4:700	S3:641	S2:640	Silver King Total
Arthropoda	Insecta	Ephemeroptera	Ameletidae	Ameletus	6	4	5	1	5	19	34
Arthropoda	Branchiopoda	Diplostraca	Daphniidae	Daphnia	0	0	0	0	0	1	1
Arthropoda	Insecta	Coleoptera	Dytiscidae	Laccophilus	0	0	0	0	0	1	1
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	534	43	159	0	4	308	514
Arthropoda	Insecta	Coleoptera	Elmidae	Zaitzevia	989	185	370	0	721	752	2028
Arthropoda	Insecta	Diptera	Athericidae	Atherix	0	0	0	0	1	1	2
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia	69	51	181	0	86	49	367
Arthropoda	Insecta	Diptera	Dixidae	Dixa	3	0	1	0	0	0	1
Arthropoda	Insecta	Diptera	Empididae	Chelifera	40	37	16	0	44	153	250
Arthropoda	Insecta	Diptera	Empididae	Hemerodromia	0	2	1	0	4	0	7
Arthropoda	Insecta	Diptera	Pelecorhynchidae	Glutops	61	36	7	0	2	18	63
Arthropoda	Insecta	Diptera	Psychodidae	Maruina	0	0	1	0	0	0	1
Arthropoda	Insecta	Diptera	Psychodidae	Pericoma	1880	1503	1599	165	1356	1632	6255
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	7	0	0	0	0	0	0
Arthropoda	Insecta	Diptera	Tipulidae	Antocha	27	3	23	3	26	26	81
Arthropoda	Insecta	Diptera	Tipulidae	Dicranota	1	1	0	0	3	0	4
Arthropoda	Insecta	Diptera	Tipulidae	Hexatoma	21	72	19	9	42	43	185
Arthropoda	Insecta	Diptera	Tipulidae	Ormosia	0	0	11	0	0	0	11
Arthropoda	Insecta	Diptera	Tipulidae	Tipula	1	0	2	0	0	0	2
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	1339	1084	1194	314	974	709	4275
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	260	218	475	39	198	233	1163
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella	92	64	52	50	234	94	494
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	611	642	426	48	471	340	1927
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	369	307	406	173	626	386	1898
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella	2	2	22	0	8	2	34
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	257	174	174	100	152	236	836
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	37	91	64	5	74	71	305
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptagenia	62	52	169	0	27	70	318
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	63	32	10	7	23	33	105
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	0	8	0	0	44	0	52
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	98	46	140	20	183	128	517
Arthropoda	Insecta	Ephemeroptera	Polymitarcyidae	Ephoron	12	0	0	0	0	0	0
Arthropoda	Insecta	Megaloptera	Sialidae	Sialis	0	0	0	0	0	1	1
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Plumiperla	0	0	2	0	0	0	2
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Suwallia	36	52	15	0	37	15	119
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	14	8	0	0	12	5	25
Arthropoda	Insecta	Plecoptera	Nemouridae	Malenka	0	0	0	0	4	0	4
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	70	69	36	1	25	43	174
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Yoraperla	213	32	136	20	103	90	381
Arthropoda	Insecta	Plecoptera	Perlidae	Calineuria	0	1	0	2	2	5	10
Arthropoda	Insecta	Plecoptera	Perlidae	Doroneuria	7	3	2	0	3	1	9
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla	8	0	7	0	8	0	15
Arthropoda	Insecta	Plecoptera	Perlodidae	Cultus	0	0	1	1	0	0	2
Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperla	12	1	1	1	3	1	7
Arthropoda	Insecta	Plecoptera	Perlodidae	Kogotus	5	12	1	0	1	3	17
Arthropoda	Insecta	Plecoptera	Perlodidae	Perlinodes	0	1	0	0	0	0	1

Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	0	3	1	0	3	2	9
Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Taenionema	60	27	51	17	16	20	131
Arthropoda	Insecta	Trichoptera	Apataniidae	Pedomoecus	11	6	1	0	8	9	24
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	13	11	13	8	23	16	71
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema	18	30	26	3	27	42	128
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma	85	49	35	13	26	33	156
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	32	13	5	0	11	3	32
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	0	0	2	0	0	2	4
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche	6	10	1	0	4	1	16
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Leucotrichia	0	0	0	0	0	1	1
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	4	3	1	0	5	5	14
Arthropoda	Insecta	Trichoptera	Leptoceridae	Oecetis	0	0	1	0	0	0	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Chyranda	0	0	1	0	0	0	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Cryptochia	0	1	0	0	0	0	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus	1	0	0	0	0	2	2
Arthropoda	Insecta	Trichoptera	Limnephilidae	Ecclisomyia	6	2	0	0	0	1	3
Arthropoda	Insecta	Trichoptera	Philopotamidae	Dolophilodes	2	0	0	0	0	0	0
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropus	0	0	0	0	0	4	4
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	256	387	252	34	202	225	1100
Arthropoda	Insecta	Trichoptera	Uenoidae	Neothremma	9	0	0	0	4	0	4
Arthropoda	Insecta	Trichoptera	Uenoidae	Oligophlebodes	0	0	0	0	7	2	9
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium	21	1	8	0	16	6	31
			Total individuals collected		7730	5379	6126	1034	5858	5843	24240
			Genera present, count >0		47	45	48	23	47	49	65
			Genera absent, count =0		21	23	20	45	21	19	3
			Genera with count >0 and <10		15	17	21	11	19	22	26
			Genera with count >=10		32	28	27	12	28	27	39
			Genera with count >=100		10	8	13	4	11	11	23
			Genera with count >=500		5	3	2	0	4	3	10
			Genera with count >=1000		2	2	2	0	1	1	7
			Genera with count >=5000		0	0	0	0	0	0	1

Appendix 5. List of aquatic invertebrate genera and abundances collected in Four Mile Canyon Creek in 1984, 1987, 1991, 1992, 1993, 1994, 1995, and 1996. Four Mile Canyon Creek was never treated with rotenone.

Phylum	Class	Order	Family	Genus	1984	1987	1991	1992	1993	1994	1995	1996	Total
Arthropoda	Insecta	Ephemeroptera	Ameletidae	Ameletus	0	0	0	6	0	0	0	0	6
Arthropoda	Insecta	Diptera	Tipulidae	Antocha	0	11	1	2	7	6	0	0	27
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	2	15	0	0	0	0	0	15	32
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	2	6	60	97	16	78	1	0	260
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	196	241	104	364	184	130	15	105	1339
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia	0	0	8	32	20	4	3	2	69
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	2	0	1	4	5	0	0	1	13
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella	49	35	2	0	1	0	0	5	92
Arthropoda	Insecta	Diptera	Empididae	Chelifera	0	0	3	18	9	2	2	6	40
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	13	21	27	92	65	0	1	38	257
Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus	0	0	0	0	0	0	1	0	1
Arthropoda	Insecta	Diptera	Tipulidae	Dicranota	0	0	1	0	0	0	0	0	1
Arthropoda	Insecta	Diptera	Dixidae	Dixa	0	1	0	0	2	0	0	0	3
Arthropoda	Insecta	Trichoptera	Philopotamidae	Dolophilodes	0	0	1	0	0	0	0	1	2
Arthropoda	Insecta	Plecoptera	Perlidae	Doroneuria	2	0	0	0	3	0	0	2	7
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	52	43	52	210	118	23	16	97	611
Arthropoda	Insecta	Trichoptera	Limnephilidae	Ecclisomyia	0	4	1	0	1	0	0	0	6
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	9	7	7	9	3	0	2	0	37
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	0	42	12	250	22	17	16	10	369
Arthropoda	Insecta	Ephemeroptera	Polymitarcyidae	Ephoron	0	0	0	0	0	0	0	12	12
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma	9	61	2	0	0	2	1	10	85
Arthropoda	Insecta	Diptera	Pelecorhynchidae	Glutops	0	0	17	0	17	15	1	11	61
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptagenia	0	0	8	9	11	22	12	0	62
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla	0	8	0	0	0	0	0	0	8
Arthropoda	Insecta	Diptera	Tipulidae	Hexatoma	0	0	3	8	5	2	1	2	21
Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperla	0	0	2	7	0	2	1	0	12
Arthropoda	Insecta	Plecoptera	Perlodidae	Kogotus	1	0	2	0	2	0	0	0	5
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	2	0	0	0	0	1	0	1	4
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema	9	7	0	0	0	0	0	2	18
Arthropoda	Insecta	Trichoptera	Uenoidae	Neothremma	7	1	0	0	0	0	1	0	9
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	0	0	0	219	303	11	1	0	534
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	18	30	9	15	22	2	1	1	98
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche	2	4	0	0	0	0	0	0	6
Arthropoda	Insecta	Trichoptera	Apataniidae	Pedomoecus	0	0	2	2	6	1	0	0	11
Arthropoda	Insecta	Diptera	Psychodidae	Pericoma	0	277	99	373	283	702	9	137	1880
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium	0	0	1	2	7	0	1	10	21
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	18	8	2	31	0	0	2	2	63
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	27	68	19	17	38	15	26	46	256
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella	0	0	0	0	2	0	0	0	2
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	0	0	0	7	0	0	0	0	7
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Suwallia	0	0	0	36	0	0	0	0	36
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	0	0	10	4	0	0	0	0	14
Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Taenionema	48	0	0	4	0	0	0	8	60
Arthropoda	Insecta	Diptera	Tipulidae	Tipula	0	0	0	0	1	0	0	0	1
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Yoraperla	4	37	37	29	56	15	0	35	213
Arthropoda	Insecta	Coleoptera	Elmidae	Zaitzevia	0	0	338	103	153	236	37	122	989
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	11	27	3	16	0	0	0	13	70

Total individuals collected	483	954	834	1966	1362	1286	151	694	7730
Genera present, count >0	21	22	30	28	28	20	22	26	47
Genera absent, count =0	26	25	17	19	19	27	25	21	0
Genera with count >0 and <10	12	9	19	12	14	9	16	12	15
Genera with count >=10	9	13	11	16	14	11	6	14	32
Genera with count >=100	1	2	2	6	5	3	0	3	10
Genera with count >=500	0	0	0	0	0	1	0	0	5
Genera with count >=1000	0	0	0	0	0	0	0	0	2
Genera with count >=5000	0	0	0	0	0	0	0	0	0

Appendix 6. List of aquatic invertebrate genera and abundances collected among five sites on Silver King Creek in 1984, 1987, 1991, 1992, 1993, 1994, 1995, and 1996. Silver King Creek was treated in 1964, 1976, 1991, 1992, and 1993.

Phylum	Class	Order	Family	Genus	1984	1987	1991	1992	1993	1994	1995	1996	Total
Arthropoda	Branchiopoda	Diplostraca	Daphniidae	Daphnia	0	0	0	0	0	0	1	0	1
Arthropoda	Insecta	Coleoptera	Dytiscidae	Laccophilus	0	0	1	0	0	0	0	0	1
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	0	0	0	408	88	7	9	2	514
Arthropoda	Insecta	Coleoptera	Elmidae	Zaitzevia	0	0	414	737	256	366	54	201	2028
Arthropoda	Insecta	Diptera	Athericidae	Atherix	0	0	0	0	2	0	0	0	2
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia	0	0	31	101	132	78	14	11	367
Arthropoda	Insecta	Diptera	Dixidae	Dixa	1	0	0	0	0	0	0	0	1
Arthropoda	Insecta	Diptera	Empididae	Chelifera	0	0	23	65	89	55	6	12	250
Arthropoda	Insecta	Diptera	Empididae	Hemerodromia	0	0	0	2	5	0	0	0	7
Arthropoda	Insecta	Diptera	Pelecorhynchidae	Glutops	0	0	7	35	8	7	1	5	63
Arthropoda	Insecta	Diptera	Psychodidae	Maruina	0	0	0	0	1	0	0	0	1
Arthropoda	Insecta	Diptera	Psychodidae	Pericoma	32	1809	418	2113	884	850	5	144	6255
Arthropoda	Insecta	Diptera	Tipulidae	Antocha	1	22	19	15	4	15	2	3	81
Arthropoda	Insecta	Diptera	Tipulidae	Dicranota	2	0	0	0	1	0	0	1	4
Arthropoda	Insecta	Diptera	Tipulidae	Hexatoma	15	10	21	43	33	50	5	8	185
Arthropoda	Insecta	Diptera	Tipulidae	Ormosia	0	0	0	0	0	0	11	0	11
Arthropoda	Insecta	Diptera	Tipulidae	Tipula	0	0	2	0	0	0	0	0	2
Arthropoda	Insecta	Ephemeroptera	Ameletidae	Ameletus	0	1	8	3	5	13	2	2	34
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	1072	701	617	673	340	74	313	485	4275
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	18	52	112	446	3	494	35	3	1163
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella	158	146	14	19	27	6	16	108	494
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	200	188	118	513	228	225	195	260	1927
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	23	593	113	479	294	230	29	137	1898
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella	8	6	6	2	7	0	5	0	34
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	113	366	59	86	48	17	58	89	836
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	32	47	26	50	36	3	38	73	305
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptagenia	0	9	11	74	9	124	4	87	318
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	47	40	4	0	6	4	4	0	105
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	0	0	0	2	50	0	0	0	52
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	33	58	107	94	53	159	5	8	517
Arthropoda	Insecta	Megaloptera	Sialidae	Sialis	0	0	1	0	0	0	0	0	1
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Plumiperla	0	0	2	0	0	0	0	0	2
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Suwallia	0	0	0	119	0	0	0	0	119
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	0	0	21	2	1	1	0	0	25
Arthropoda	Insecta	Plecoptera	Nemouridae	Malenka	0	0	0	0	0	4	0	0	4
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	18	26	34	56	17	3	1	19	174
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Yoraperla	13	51	217	77	5	4	4	10	381
Arthropoda	Insecta	Plecoptera	Perlidae	Calineuria	0	9	1	0	0	0	0	0	10
Arthropoda	Insecta	Plecoptera	Perlidae	Doroneuria	1	1	0	0	5	0	0	2	9
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla	11	4	0	0	0	0	0	0	15
Arthropoda	Insecta	Plecoptera	Perlodidae	Cultus	2	0	0	0	0	0	0	0	2
Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperla	0	1	3	0	1	0	2	0	7
Arthropoda	Insecta	Plecoptera	Perlodidae	Kogotus	0	0	0	7	2	3	1	4	17
Arthropoda	Insecta	Plecoptera	Perlodidae	Perlinodes	0	0	0	0	0	1	0	0	1
Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	0	0	0	3	0	4	0	2	9
Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Taenionema	130	1	0	0	0	0	0	0	131
Arthropoda	Insecta	Trichoptera	Apataniidae	Pedomoecus	0	0	3	10	1	6	3	1	24

Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	14	42	7	4	0	2	2	0	71
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema	6	64	15	2	3	4	3	31	128
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma	36	59	10	11	0	18	10	12	156
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	1	2	0	6	1	7	2	13	32
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	0	0	1	0	2	1	0	0	4
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche	11	4	0	0	1	0	0	0	16
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Leucotrichia	0	0	0	0	0	0	1	0	1
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	1	0	3	3	2	2	0	3	14
Arthropoda	Insecta	Trichoptera	Leptoceridae	Oecetis	0	0	0	0	0	0	1	0	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Chyranda	0	0	0	0	0	0	0	1	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Cryptochia	0	1	0	0	0	0	0	0	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus	1	0	0	0	0	0	1	0	2
Arthropoda	Insecta	Trichoptera	Limnephilidae	Ecclisomyia	0	0	1	0	0	2	0	0	3
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropus	0	4	0	0	0	0	0	0	4
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	98	166	96	170	179	129	117	145	1100
Arthropoda	Insecta	Trichoptera	Uenoidae	Neothremma	4	0	0	0	0	0	0	0	4
Arthropoda	Insecta	Trichoptera	Uenoidae	Oligophlebodes	0	0	0	0	0	3	0	6	9
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium	0	0	4	11	2	5	8	1	31
			Total individuals collected		2102	4483	2550	6441	2831	2976	968	1889	24240
			Genera present, count >0		30	30	37	35	39	37	36	33	65
			Genera absent, count =0		35	35	28	30	26	28	29	32	0
			Genera with count >0 and <10		11	12	16	11	23	21	24	16	26
			Genera with count >=10		19	18	21	24	16	16	12	17	39
			Genera with count >=100		5	7	8	10	7	8	3	7	23
			Genera with count >=500		1	3	1	4	1	1	0	0	10
			Genera with count >=1000		1	1	0	1	0	0	0	0	7
			Genera with count >=5000		0	0	0	0	0	0	0	0	1

Appendix 7. List of aquatic invertebrate genera and abundances collected in historic, 1984 to 1996, and recent 2003 to 2006 samples.

Phylum	Class	Order	Family	Genus	Historic	Recent	Total
Arthropoda	Branchiopoda	Diplostraca	Daphniidae	Daphnia	1	0	1
Arthropoda	Insecta	Coleoptera	Dytiscidae	Laccophilus	1	0	1
Arthropoda	Insecta	Coleoptera	Dytiscidae	Oreodytes	0	3	3
Arthropoda	Insecta	Coleoptera	Dytiscidae	Stictotarsus	0	1	1
Arthropoda	Insecta	Coleoptera	Elmidae	Cleptelmis	0	567	567
Arthropoda	Insecta	Coleoptera	Elmidae	Heterlimnius	0	2033	2033
Arthropoda	Insecta	Coleoptera	Elmidae	Lara	0	5	5
Arthropoda	Insecta	Coleoptera	Elmidae	Narpus	0	38	38
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	1105	947	2052
Arthropoda	Insecta	Coleoptera	Elmidae	Zaitzevia	3159	0	3159
Arthropoda	Insecta	Coleoptera	Helophoridae	Helophorus	0	4	4
Arthropoda	Insecta	Coleoptera	Hydraenidae	Hydraena	0	6	6
Arthropoda	Insecta	Coleoptera	Hydraenidae	Ochthebius	0	10	10
Arthropoda	Insecta	Diptera	Athericidae	Atherix	2	67	69
Arthropoda	Insecta	Diptera	Ceratopogonidae	Atrichopogon/Forcipomyia	0	1	1
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia	491	2	493
Arthropoda	Insecta	Diptera	Ceratopogonidae	Forcipomyia	0	2	2
Arthropoda	Insecta	Diptera	Ceratopogonidae	Probezzia	0	200	200
Arthropoda	Insecta	Diptera	Dixidae	Dixa	4	1	5
Arthropoda	Insecta	Diptera	Empididae	Chelifera	316	155	471
Arthropoda	Insecta	Diptera	Empididae	Clinocera	0	2	2
Arthropoda	Insecta	Diptera	Empididae	Hemerodromia	7	0	7
Arthropoda	Insecta	Diptera	Empididae	Oreogeton	0	4	4
Arthropoda	Insecta	Diptera	Pelecorhynchidae	Glutops	193	208	401
Arthropoda	Insecta	Diptera	Psychodidae	Maruina	1	0	1
Arthropoda	Insecta	Diptera	Psychodidae	Pericoma	9689	640	10329
Arthropoda	Insecta	Diptera	Simuliidae	Prosimulium	0	54	54
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	15	1785	1800
Arthropoda	Insecta	Diptera	Stratiomyidae	Nemotelus	2	0	2
Arthropoda	Insecta	Diptera	Tipulidae	Antocha	119	94	213
Arthropoda	Insecta	Diptera	Tipulidae	Dicranota	22	18	40
Arthropoda	Insecta	Diptera	Tipulidae	Hexatoma	250	48	298
Arthropoda	Insecta	Diptera	Tipulidae	Holorusia	1	0	1
Arthropoda	Insecta	Diptera	Tipulidae	Limnophila	0	3	3
Arthropoda	Insecta	Diptera	Tipulidae	Ormosia	11	0	11
Arthropoda	Insecta	Diptera	Tipulidae	Pedicia	0	1	1
Arthropoda	Insecta	Diptera	Tipulidae	Rhabdomastix	0	12	12
Arthropoda	Insecta	Diptera	Tipulidae	Tipula	3	0	3
Arthropoda	Insecta	Ephemeroptera	Ameletidae	Ameletus	46	186	232
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	8980	6629	15609
Arthropoda	Insecta	Ephemeroptera	Baetidae	Diphetor	0	41	41
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	1813	511	2324
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella	900	1798	2698
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	3634	4708	8342
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	2997	5	3002
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella	91	68	159
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	1757	1175	2932
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	482	942	1424

Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Heptagenia	414	0	414
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Ironodes	0	63	63
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	500	460	960
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	52	1	53
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	1082	627	1709
Arthropoda	Insecta	Ephemeroptera	Polymitarcyidae	Ephoron	12	0	12
Arthropoda	Insecta	Megaloptera	Sialidae	Sialis	1	3	4
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Plumiperla	5	0	5
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Suwallia	181	52	233
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	43	294	337
Arthropoda	Insecta	Plecoptera	Leuctridae	Moselia	0	5	5
Arthropoda	Insecta	Plecoptera	Nemouridae	Malenka	4	263	267
Arthropoda	Insecta	Plecoptera	Nemouridae	Podmosta	1	0	1
Arthropoda	Insecta	Plecoptera	Nemouridae	Visoka	1	19	20
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	392	416	808
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Yoraperla	1331	6157	7488
Arthropoda	Insecta	Plecoptera	Perlidae	Calineuria	17	2	19
Arthropoda	Insecta	Plecoptera	Perlidae	Claassenia	0	6	6
Arthropoda	Insecta	Plecoptera	Perlidae	Doroneuria	18	132	150
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla	37	90	127
Arthropoda	Insecta	Plecoptera	Perlodidae	Cultus	5	0	5
Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperla	38	0	38
Arthropoda	Insecta	Plecoptera	Perlodidae	Kogotus	25	1	26
Arthropoda	Insecta	Plecoptera	Perlodidae	Megarcys	0	2	2
Arthropoda	Insecta	Plecoptera	Perlodidae	Oroperla	0	11	11
Arthropoda	Insecta	Plecoptera	Perlodidae	Perlinodes	1	4	5
Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	20	0	20
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcella	7	17	24
Arthropoda	Insecta	Plecoptera	Taeniopterygidae	Taenionema	512	0	512
Arthropoda	Insecta	Trichoptera	Apataniidae	Apatania	2	61	63
Arthropoda	Insecta	Trichoptera	Apataniidae	Pedomoecus	44	36	80
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	106	324	430
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema	185	1392	1577
Arthropoda	Insecta	Trichoptera	Calamoceratidae	Heteroplectron	0	2	2
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Anagapetus	0	20	20
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma	495	323	818
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	107	55	162
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	4	0	4
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	80	2	82
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche	30	56	86
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Leucotrichia	1	0	1
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	46	8	54
Arthropoda	Insecta	Trichoptera	Leptoceridae	Oecetis	1	0	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Chyranda	1	0	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Cryptochia	1	2	3
Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus	4	10	14
Arthropoda	Insecta	Trichoptera	Limnephilidae	Ecclisomyia	10	0	10
Arthropoda	Insecta	Trichoptera	Limnephilidae	Homophylax	0	1	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Psychoglypha	0	3	3
Arthropoda	Insecta	Trichoptera	Philopotamidae	Dolophilodes	2	310	312
Arthropoda	Insecta	Trichoptera	Philopotamidae	Wormaldia	0	2	2

Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropus	4	5	9
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	2173	1307	3480
Arthropoda	Insecta	Trichoptera	Uenoidae	Farula	0	1	1
Arthropoda	Insecta	Trichoptera	Uenoidae	Neophylax	0	31	31
Arthropoda	Insecta	Trichoptera	Uenoidae	Neothremma	19	47	66
Arthropoda	Insecta	Trichoptera	Uenoidae	Oligophlebodes	25	13	38
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	Hyalella	0	9	9
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium	63	87	150
				Total individuals collected	44194	35706	79900
				Genera present, count >0	75	85	107
				Genera absent, count =0	32	22	0
				Genera with count >0 and <10	26	32	39
				Genera with count >=10	49	53	68
				Genera with count >=100	27	27	39
				Genera with count >=500	14	15	21
				Genera with count >=1000	11	9	16
				Genera with count >=5000	2	2	4

Appendix 8. List of taxa and the number of individuals collected between 2003 and 2006.

Phylum	Class	Order	Family	Subfamily of genus	species	2003	2004	2005	2006	All Years
Annelida	Clitellata Subclass Oligochaeta					248	85	46	20	399
Arthropoda	Arachnida	Trombidiformes				695	850	250	167	1962
Arthropoda	Insecta	Coleoptera	Curculionidae			2	0	0	0	2
Arthropoda	Insecta	Coleoptera	Dytiscidae	Oreodytes		0	2	1	0	3
Arthropoda	Insecta	Coleoptera	Dytiscidae	Stictotarsus		0	0	0	1	1
Arthropoda	Insecta	Coleoptera	Dytiscidae			0	1	0	0	1
Arthropoda	Insecta	Coleoptera	Elmidae	Cleptelmis	addenda	158	280	70	59	567
Arthropoda	Insecta	Coleoptera	Elmidae	Heterlimnius	corpulentus	27	48	65	37	177
Arthropoda	Insecta	Coleoptera	Elmidae	Heterlimnius	koebelei	0	0	1	0	1
Arthropoda	Insecta	Coleoptera	Elmidae	Heterlimnius		390	829	355	281	1855
Arthropoda	Insecta	Coleoptera	Elmidae	Lara		2	3	0	0	5
Arthropoda	Insecta	Coleoptera	Elmidae	Narpus	concolor	1	20	5	12	38
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	divergens/pecosensis	5	10	3	13	31
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	quadrimaculatus	52	81	25	72	230
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus		65	333	151	137	686
Arthropoda	Insecta	Coleoptera	Elmidae			266	158	56	67	547
Arthropoda	Insecta	Coleoptera	Helophoridae	Helophorus		0	2	2	0	4
Arthropoda	Insecta	Coleoptera	Hydraenidae	Hydraena		0	0	0	6	6
Arthropoda	Insecta	Coleoptera	Hydraenidae	Ochthebius		0	0	8	2	10
Arthropoda	Insecta	Coleoptera	Hydrophilidae			0	1	2	0	3
Arthropoda	Insecta	Coleoptera				0	0	0	1	1
Arthropoda	Insecta	Diptera	Athericidae	Atherix	pachypus	22	26	0	19	67
Arthropoda	Insecta	Diptera	Ceratopogonidae	Atrichopogon/Forcipomyia		0	1	0	0	1
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia		0	0	1	1	2
Arthropoda	Insecta	Diptera	Ceratopogonidae	Forcipomyia		0	0	1	1	2
Arthropoda	Insecta	Diptera	Ceratopogonidae	Probezzia		62	62	39	37	200
Arthropoda	Insecta	Diptera	Ceratopogonidae			1	1	0	8	10
Arthropoda	Insecta	Diptera	Chironomidae	Chironominae		1081	1264	380	358	3083
Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		1978	1899	843	568	5288
Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae		31	36	14	13	94
Arthropoda	Insecta	Diptera	Chironomidae			83	94	98	65	340
Arthropoda	Insecta	Diptera	Dixidae	Dixa		0	0	0	1	1
Arthropoda	Insecta	Diptera	Empididae	Chelifera		49	49	24	33	155
Arthropoda	Insecta	Diptera	Empididae	Clinocera		0	2	0	0	2
Arthropoda	Insecta	Diptera	Empididae	Oreogeton		3	0	0	1	4
Arthropoda	Insecta	Diptera	Empididae			0	3	5	2	10
Arthropoda	Insecta	Diptera	Pelecorhynchidae	Glutops		27	85	54	42	208
Arthropoda	Insecta	Diptera	Psychodidae	Pericoma		218	352	21	49	640
Arthropoda	Insecta	Diptera	Simuliidae	Prosimulium		4	12	10	28	54
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	tuberosum complex	0	0	1	0	1
Arthropoda	Insecta	Diptera	Simuliidae	Simulium		380	372	502	530	1784
Arthropoda	Insecta	Diptera	Simuliidae			17	11	29	3	60
Arthropoda	Insecta	Diptera	Tipulidae	Antocha		25	14	13	42	94
Arthropoda	Insecta	Diptera	Tipulidae	Dicranota		8	2	4	4	18
Arthropoda	Insecta	Diptera	Tipulidae	Hexatoma		14	24	4	6	48
Arthropoda	Insecta	Diptera	Tipulidae	Limnophila		0	2	1	0	3
Arthropoda	Insecta	Diptera	Tipulidae	Pedicia		1	0	0	0	1

Arthropoda	Insecta	Diptera	Tipulidae	Rhabdomastix		3	2	4	3	12
Arthropoda	Insecta	Diptera	Tipulidae			1	1	1	1	4
Arthropoda	Insecta	Ephemeroptera	Ameletidae	Ameletus		9	130	12	35	186
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis		1872	2091	784	1882	6629
Arthropoda	Insecta	Ephemeroptera	Baetidae	Diphetor	hageni	8	17	5	11	41
Arthropoda	Insecta	Ephemeroptera	Baetidae			10	114	91	3	218
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	attenuata group	0	0	3	0	3
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	delantala	88	92	145	182	507
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella		0	1	0	0	1
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella	heterocaudata	0	4	2	2	8
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella	hystrix	0	35	23	0	58
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella		0	1058	178	496	1732
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	coloradensis/flavilinea	18	33	37	34	122
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	doddsi	446	873	541	679	2539
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	grandis/spinifera	584	914	128	208	1834
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella		59	1	47	106	213
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	inermis/dorothea	0	2	3	0	5
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella	tibialis	5	10	1	1	17
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella		0	39	12	0	51
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae			1487	1173	281	185	3126
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula		255	293	277	350	1175
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus		255	215	208	264	942
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Ironodes		9	16	5	33	63
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena		97	261	42	60	460
Arthropoda	Insecta	Ephemeroptera	Heptageniidae			33	232	36	117	418
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	minutus	0	0	0	1	1
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae			0	23	0	0	23
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia		112	403	21	91	627
Arthropoda	Insecta	Ephemeroptera				0	0	2	0	2
Arthropoda	Insecta	Megaloptera	Corydalidae			2	1	0	3	6
Arthropoda	Insecta	Megaloptera	Sialidae	Sialis		0	0	1	2	3
Arthropoda	Insecta	Plecoptera	Capniidae			0	1	1	0	2
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Suwallia		2	17	25	8	52
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa		47	124	84	39	294
Arthropoda	Insecta	Plecoptera	Chloroperlidae			133	399	181	143	856
Arthropoda	Insecta	Plecoptera	Leuctridae	Moselia	infuscata	0	2	2	1	5
Arthropoda	Insecta	Plecoptera	Leuctridae			5	7	7	4	23
Arthropoda	Insecta	Plecoptera	Nemouridae	Malenka		20	172	25	46	263
Arthropoda	Insecta	Plecoptera	Nemouridae	Visoka	cataractae	3	3	6	7	19
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	cinctipes	0	37	0	0	37
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	columbiana	10	44	8	74	136
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	oregonensis group	0	0	0	11	11
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada		1	204	6	21	232
Arthropoda	Insecta	Plecoptera	Nemouridae			32	34	5	10	81
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Yoraperla		1205	2663	1363	926	6157
Arthropoda	Insecta	Plecoptera	Peltoperlidae			0	67	40	0	107
Arthropoda	Insecta	Plecoptera	Perlidae	Calineuria	californica	0	2	0	0	2
Arthropoda	Insecta	Plecoptera	Perlidae	Claassenia	sabulosa	5	0	1	0	6
Arthropoda	Insecta	Plecoptera	Perlidae	Doroneuria	baumanni	29	49	25	29	132
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla	hoguei	9	0	1	8	18
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla	pacifica	5	27	23	10	65

Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla		2	0	0	5	7
Arthropoda	Insecta	Plecoptera	Perlidae			28	60	34	37	159
Arthropoda	Insecta	Plecoptera	Perlodidae	Kogotus	nonus	0	0	1	0	1
Arthropoda	Insecta	Plecoptera	Perlodidae	Megarcys		1	1	0	0	2
Arthropoda	Insecta	Plecoptera	Perlodidae	Oroperla	barbara	1	7	0	3	11
Arthropoda	Insecta	Plecoptera	Perlodidae	Perlinodes	aurea	0	4	0	0	4
Arthropoda	Insecta	Plecoptera	Perlodidae			61	84	45	115	305
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcella	regularis	4	7	0	6	17
Arthropoda	Insecta	Plecoptera	Pteronarcyidae			0	1	0	0	1
Arthropoda	Insecta	Plecoptera	Taeniopterygidae			2	0	0	0	2
Arthropoda	Insecta	Plecoptera				8	6	8	14	36
Arthropoda	Insecta	Trichoptera	Apataniidae	Apatania		25	9	12	15	61
Arthropoda	Insecta	Trichoptera	Apataniidae	Pedomoecus	sierra	1	7	16	12	36
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	americanus	191	58	32	28	309
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus		12	1	1	1	15
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema		651	331	243	167	1392
Arthropoda	Insecta	Trichoptera	Calamoceratidae	Heteroplectron	californicum	2	0	0	0	2
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Anagapetus		0	14	0	6	20
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma		64	78	147	34	323
Arthropoda	Insecta	Trichoptera	Glossosomatidae			218	211	87	31	547
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	californica	0	6	1	0	7
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	grandis	1	9	0	2	12
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche		2	34	0	0	36
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche		0	0	1	1	2
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche	almota	0	0	0	1	1
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche	elsis	0	34	6	4	44
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche		10	0	0	1	11
Arthropoda	Insecta	Trichoptera	Hydropsychidae			86	41	3	10	140
Arthropoda	Insecta	Trichoptera	Hydroptilidae			1	1	0	2	4
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma		1	2	4	1	8
Arthropoda	Insecta	Trichoptera	Limnephilidae	Cryptochia		1	0	0	1	2
Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus		1	4	2	3	10
Arthropoda	Insecta	Trichoptera	Limnephilidae	Homophylax		0	0	0	1	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Psychoglypha		0	1	1	1	3
Arthropoda	Insecta	Trichoptera	Limnephilidae			1	3	2	5	11
Arthropoda	Insecta	Trichoptera	Philopotamidae	Dolophilodes		145	80	44	41	310
Arthropoda	Insecta	Trichoptera	Philopotamidae	Wormaldia		1	0	0	1	2
Arthropoda	Insecta	Trichoptera	Philopotamidae			9	1	23	17	50
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropus		0	0	5	0	5
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	alberta group	0	0	0	1	1
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	angelita group	0	0	18	5	23
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	arnaudi	6	15	1	12	34
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	betteni group	54	68	15	35	172
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	brunnea/vemna groups	142	83	73	86	384
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	sibirica group	44	0	0	0	44
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	sibirica group A	0	1	14	3	18
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	sibirica group C	0	0	0	3	3
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	vagrita	0	0	3	0	3
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	verrula group	0	6	2	2	10
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	vofixa group	0	81	65	30	176
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila		51	151	125	112	439

Arthropoda	Insecta	Trichoptera	Rhyacophilidae			11	5	0	0	16
Arthropoda	Insecta	Trichoptera	Uenoidae	Farula		0	0	1	0	1
Arthropoda	Insecta	Trichoptera	Uenoidae	Neophylax	splendens	0	0	1	1	2
Arthropoda	Insecta	Trichoptera	Uenoidae	Neophylax		12	5	10	2	29
Arthropoda	Insecta	Trichoptera	Uenoidae	Neothremma		17	19	7	4	47
Arthropoda	Insecta	Trichoptera	Uenoidae	Oligophlebodes		0	13	0	0	13
Arthropoda	Insecta	Trichoptera	Uenoidae			2	0	0	0	2
Arthropoda	Insecta	Trichoptera				72	83	19	11	185
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	Hyalella	azteca	1	4	0	4	9
Arthropoda	Ostracoda					13	139	7	0	159
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium		22	40	20	5	87
Mollusca	Gastropoda					1	0	0	1	2
Nemata						49	3	9	0	61
Platyhelminthes	Turbellaria					625	167	8	54	854
				Total individuals collected		15426	20878	8893	9709	54906
				Taxa present, count > 0		108	124	118	122	163
				Taxa absent, count = 0		55	39	45	41	0
				Taxa with count >0 and <10		44	46	54	55	57
				Taxa with count >10		64	78	64	67	106
				Taxa with count >100		24	31	19	21	54
				Taxa with count >500		9	10	5	5	23
				Taxa with count >1000		5	6	1	1	13

Appendix 9. List of genera and abundances historically collected at treated and untreated sites. Samples were collected annually between 2003 and 2006.

Phylum	Class	Order	Family	Genus	Treated sites	Untreated sites	Total
Arthropoda	Insecta	Coleoptera	Dytiscidae	Oreodytes	3	0	3
Arthropoda	Insecta	Coleoptera	Dytiscidae	Stictotarsus	1	0	1
Arthropoda	Insecta	Coleoptera	Elmidae	Cleptelmis	567	0	567
Arthropoda	Insecta	Coleoptera	Elmidae	Heterlimnius	1996	37	2033
Arthropoda	Insecta	Coleoptera	Elmidae	Lara	5	0	5
Arthropoda	Insecta	Coleoptera	Elmidae	Narpus	38	0	38
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	945	2	947
Arthropoda	Insecta	Coleoptera	Helophoridae	Helophorus	4	0	4
Arthropoda	Insecta	Coleoptera	Hydraenidae	Hydraena	6	0	6
Arthropoda	Insecta	Coleoptera	Hydraenidae	Ochthebius	10	0	10
Arthropoda	Insecta	Diptera	Athericidae	Atherix	67	0	67
Arthropoda	Insecta	Diptera	Ceratopogonidae	Atrichopogon/Forcipomyia	1	0	1
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia	2	0	2
Arthropoda	Insecta	Diptera	Ceratopogonidae	Forcipomyia	2	0	2
Arthropoda	Insecta	Diptera	Ceratopogonidae	Probezzia	182	18	200
Arthropoda	Insecta	Diptera	Dixidae	Dixa	1	0	1
Arthropoda	Insecta	Diptera	Empididae	Chelifera	124	31	155
Arthropoda	Insecta	Diptera	Empididae	Clinocera	0	2	2
Arthropoda	Insecta	Diptera	Empididae	Oreogeton	0	4	4
Arthropoda	Insecta	Diptera	Pelecorhynchidae	Glutops	153	55	208
Arthropoda	Insecta	Diptera	Psychodidae	Pericoma	639	1	640
Arthropoda	Insecta	Diptera	Simuliidae	Prosimulium	18	36	54
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	1582	203	1785
Arthropoda	Insecta	Diptera	Tipulidae	Antocha	94	0	94
Arthropoda	Insecta	Diptera	Tipulidae	Dicranota	16	2	18
Arthropoda	Insecta	Diptera	Tipulidae	Hexatoma	47	1	48
Arthropoda	Insecta	Diptera	Tipulidae	Limnophila	2	1	3
Arthropoda	Insecta	Diptera	Tipulidae	Pedicia	0	1	1
Arthropoda	Insecta	Diptera	Tipulidae	Rhabdomastix	12	0	12
Arthropoda	Insecta	Ephemeroptera	Ameletidae	Ameletus	180	6	186
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	6251	378	6629
Arthropoda	Insecta	Ephemeroptera	Baetidae	Diphetor	36	5	41
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	497	14	511
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella	1751	47	1798
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	4334	374	4708
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	5	0	5
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella	68	0	68
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	758	417	1175
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	781	161	942
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Ironodes	63	0	63
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	400	60	460
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	1	0	1
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	598	29	627
Arthropoda	Insecta	Megaloptera	Sialidae	Sialis	3	0	3
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Suwallia	52	0	52
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	280	14	294
Arthropoda	Insecta	Plecoptera	Leuctridae	Moselia	0	5	5
Arthropoda	Insecta	Plecoptera	Nemouridae	Malenka	261	2	263

Arthropoda	Insecta	Plecoptera	Nemouridae	Visoka	3	16	19
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	302	114	416
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Yoraperla	4312	1845	6157
Arthropoda	Insecta	Plecoptera	Perlidae	Calineuria	2	0	2
Arthropoda	Insecta	Plecoptera	Perlidae	Claassenia	6	0	6
Arthropoda	Insecta	Plecoptera	Perlidae	Doroneuria	122	10	132
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla	90	0	90
Arthropoda	Insecta	Plecoptera	Perlodidae	Kogotus	0	1	1
Arthropoda	Insecta	Plecoptera	Perlodidae	Megarcys	2	0	2
Arthropoda	Insecta	Plecoptera	Perlodidae	Oroperla	11	0	11
Arthropoda	Insecta	Plecoptera	Perlodidae	Perlinodes	4	0	4
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcella	17	0	17
Arthropoda	Insecta	Trichoptera	Apataniidae	Apatania	60	1	61
Arthropoda	Insecta	Trichoptera	Apataniidae	Pedomoecus	16	20	36
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	324	0	324
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema	1384	8	1392
Arthropoda	Insecta	Trichoptera	Calamoceratidae	Heteroplectron	2	0	2
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Anagapetus	20	0	20
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma	321	2	323
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	55	0	55
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	2	0	2
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche	51	5	56
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	8	0	8
Arthropoda	Insecta	Trichoptera	Limnephilidae	Cryptochia	1	1	2
Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus	9	1	10
Arthropoda	Insecta	Trichoptera	Limnephilidae	Homophylax	1	0	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Psychoglypha	3	0	3
Arthropoda	Insecta	Trichoptera	Philopotamidae	Dolophilodes	310	0	310
Arthropoda	Insecta	Trichoptera	Philopotamidae	Wormaldia	2	0	2
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropus	5	0	5
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	1037	270	1307
Arthropoda	Insecta	Trichoptera	Uenoidae	Farula	1	0	1
Arthropoda	Insecta	Trichoptera	Uenoidae	Neophylax	23	8	31
Arthropoda	Insecta	Trichoptera	Uenoidae	Neothremma	33	14	47
Arthropoda	Insecta	Trichoptera	Uenoidae	Oligophlebodes	13	0	13
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	Hyalella	9	0	9
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium	87	0	87
			Total individuals collected		31484	4222	35706
			Genera present, count >0		80	42	85
			Genera absent, count =0		5	43	0
			Genera with count >0 and <10		29	20	32
			Genera with count >=10		51	22	53
			Genera with count >=100		27	8	27
			Genera with count >=500		14	1	15
			Genera with count >=1000		8	1	9
			Genera with count >=5000		1	0	2

Appendix 10. List of genera and number of individuals collected among all sampling locations for each year between 2003 and 2006.

Phylum	Class	Order	Family	Genus	2003	2004	2005	2006	Total	Years present
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium	22	40	20	5	87	4
Arthropoda	Insecta	Coleoptera	Dytiscidae	Oreodytes	0	2	1	0	3	2
Arthropoda	Insecta	Coleoptera	Dytiscidae	Stictotarsus	0	0	0	1	1	1
Arthropoda	Insecta	Coleoptera	Elmidae	Cleptelmis	158	280	70	59	567	4
Arthropoda	Insecta	Coleoptera	Elmidae	Heterlimnius	417	877	421	318	2033	4
Arthropoda	Insecta	Coleoptera	Elmidae	Lara	2	3	0	0	5	2
Arthropoda	Insecta	Coleoptera	Elmidae	Narpus	1	20	5	12	38	4
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	122	424	179	222	947	4
Arthropoda	Insecta	Coleoptera	Helophoridae	Helophorus	0	2	2	0	4	2
Arthropoda	Insecta	Coleoptera	Hydraenidae	Hydraena	0	0	0	6	6	1
Arthropoda	Insecta	Coleoptera	Hydraenidae	Ochthebius	0	0	8	2	10	2
Arthropoda	Insecta	Diptera	Athericidae	Atherix	22	26	0	19	67	3
Arthropoda	Insecta	Diptera	Ceratopogonidae	Atrichopogon/Forcipomyia	0	1	0	0	1	1
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia	0	0	1	1	2	2
Arthropoda	Insecta	Diptera	Ceratopogonidae	Forcipomyia	0	0	1	1	2	2
Arthropoda	Insecta	Diptera	Ceratopogonidae	Probezzia	62	62	39	37	200	4
Arthropoda	Insecta	Diptera	Dixidae	Dixa	0	0	0	1	1	1
Arthropoda	Insecta	Diptera	Empididae	Chelifera	49	49	24	33	155	4
Arthropoda	Insecta	Diptera	Empididae	Clinocera	0	2	0	0	2	1
Arthropoda	Insecta	Diptera	Empididae	Oreogeton	3	0	0	1	4	2
Arthropoda	Insecta	Diptera	Pelecorhynchidae	Glutops	27	85	54	42	208	4
Arthropoda	Insecta	Diptera	Psychodidae	Pericoma	218	352	21	49	640	4
Arthropoda	Insecta	Diptera	Simuliidae	Prosimulium	4	12	10	28	54	4
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	380	372	503	530	1785	4
Arthropoda	Insecta	Diptera	Tipulidae	Antocha	25	14	13	42	94	4
Arthropoda	Insecta	Diptera	Tipulidae	Dicranota	8	2	4	4	18	4
Arthropoda	Insecta	Diptera	Tipulidae	Hexatoma	14	24	4	6	48	4
Arthropoda	Insecta	Diptera	Tipulidae	Limnophila	0	2	1	0	3	2
Arthropoda	Insecta	Diptera	Tipulidae	Pedicia	1	0	0	0	1	1
Arthropoda	Insecta	Diptera	Tipulidae	Rhabdomastix	3	2	4	3	12	4
Arthropoda	Insecta	Ephemeroptera	Ameletidae	Ameletus	9	130	12	35	186	4
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	1872	2091	784	1882	6629	4
Arthropoda	Insecta	Ephemeroptera	Baetidae	Diphetor	8	17	5	11	41	4
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Attenella	88	93	148	182	511	4
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Caudatella	0	1097	203	498	1798	3
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	1107	1821	753	1027	4708	4
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	0	2	3	0	5	2
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Serratella	5	49	13	1	68	4
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	255	293	277	350	1175	4
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	255	215	208	264	942	4
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Ironodes	9	16	5	33	63	4
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	97	261	42	60	460	4
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	0	0	0	1	1	1
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	112	403	21	91	627	4
Arthropoda	Insecta	Megaloptera	Sialidae	Sialis	0	0	1	2	3	2
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Suwallia	2	17	25	8	52	4
Arthropoda	Insecta	Plecoptera	Chloroperlidae	Sweltsa	47	124	84	39	294	4
Arthropoda	Insecta	Plecoptera	Leuctridae	Moselia	0	2	2	1	5	3

Arthropoda	Insecta	Plecoptera	Nemouridae	Malenka	20	172	25	46	263	4
Arthropoda	Insecta	Plecoptera	Nemouridae	Visoka	3	3	6	7	19	4
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	11	285	14	106	416	4
Arthropoda	Insecta	Plecoptera	Peltoperlidae	Yoraperla	1205	2663	1363	926	6157	4
Arthropoda	Insecta	Plecoptera	Perlidae	Calineuria	0	2	0	0	2	1
Arthropoda	Insecta	Plecoptera	Perlidae	Claassenia	5	0	1	0	6	2
Arthropoda	Insecta	Plecoptera	Perlidae	Doroneuria	29	49	25	29	132	4
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla	16	27	24	23	90	4
Arthropoda	Insecta	Plecoptera	Perlodidae	Kogotus	0	0	1	0	1	1
Arthropoda	Insecta	Plecoptera	Perlodidae	Megarcys	1	1	0	0	2	2
Arthropoda	Insecta	Plecoptera	Perlodidae	Oroperla	1	7	0	3	11	3
Arthropoda	Insecta	Plecoptera	Perlodidae	Perlinodes	0	4	0	0	4	1
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcella	4	7	0	6	17	3
Arthropoda	Insecta	Trichoptera	Apataniidae	Apatania	25	9	12	15	61	4
Arthropoda	Insecta	Trichoptera	Apataniidae	Pedomoecus	1	7	16	12	36	4
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	203	59	33	29	324	4
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema	651	331	243	167	1392	4
Arthropoda	Insecta	Trichoptera	Calamoceratidae	Heteroplectron	2	0	0	0	2	1
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Anagapetus	0	14	0	6	20	2
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma	64	78	147	34	323	4
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Arctopsyche	3	49	1	2	55	4
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	0	0	1	1	2	2
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Parapsyche	10	34	6	6	56	4
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	1	2	4	1	8	4
Arthropoda	Insecta	Trichoptera	Limnephilidae	Cryptochia	1	0	0	1	2	2
Arthropoda	Insecta	Trichoptera	Limnephilidae	Dicosmoecus	1	4	2	3	10	4
Arthropoda	Insecta	Trichoptera	Limnephilidae	Homophylax	0	0	0	1	1	1
Arthropoda	Insecta	Trichoptera	Limnephilidae	Psychoglypha	0	1	1	1	3	3
Arthropoda	Insecta	Trichoptera	Philopotamidae	Dolophilodes	145	80	44	41	310	4
Arthropoda	Insecta	Trichoptera	Philopotamidae	Wormaldia	1	0	0	1	2	2
Arthropoda	Insecta	Trichoptera	Polycentropodidae	Polycentropus	0	0	5	0	5	1
Arthropoda	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	297	405	316	289	1307	4
Arthropoda	Insecta	Trichoptera	Uenoidae	Farula	0	0	1	0	1	1
Arthropoda	Insecta	Trichoptera	Uenoidae	Neophylax	12	5	11	3	31	4
Arthropoda	Insecta	Trichoptera	Uenoidae	Neothremma	17	19	7	4	47	4
Arthropoda	Insecta	Trichoptera	Uenoidae	Oligophlebodes	0	13	0	0	13	1
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	Hyalella	1	4	0	4	9	3
				Total individuals collected	8134	13618	6280	7674	35706	
				Genera present, count >0	59	66	63	68	85	
				Genera absent, count =0	26	19	22	17	0	
				Genera with count >0 and <10	25	23	27	32	32	
				Genera with count >=10	34	43	36	36	53	
				Genera with count >=100	15	19	13	13	27	
				Genera with count >=500	4	5	4	4	15	
				Genera with count >=1000	3	4	1	2	9	
				Genera with count >=5000	0	0	0	0	2	

Appendix 11. Logan River Basin Aquatic Invertebrate Collection Plan for summer 2007

Version: 10 May 2007
Prepared by: Eric Dinger, PhD and Mark Vinson, PhD, The BugLab, Logan, Utah
Purpose: To try and collect as many different taxa as possible from the Logan River Basin. Specimens will be indentified to the lowest level practical and archived for genetic analysis.

Sampling schedule

- Twice weekly, sample a habitat location in the Logan River watershed
  - Personnel: Stephanie Peterson and one additional assistant, occasionally a taxonomist
  - Locations to be determined by Eric , Mark, and others
- Things to remember
  - USE ONLY 95% Ethanol! – standard BugLab juice is only 75% Ethanol

Sampling protocol

1. Upon arrival, record Site Name, Lat/Long with GPS, Date/Time, Site description
   a. Site Description should be in as much detail as possible – e.g. how long it took to walk to site, weather (esp. cloud cover), Moon phase, rise (get from website: www.wunderground.com – Logan, UT forecast or from GPS), vegetation - in as much detail as possible, basic flow estimate (high, low, trickle, etc.), Size of habitat, etc. Take photographs
2. Measure and record water temperature, air temperature, alkalinity, specific conductance, pH.
3. Three separate types of samples:
   a. Aquatic qualitative (min time: 2 hours, or an estimated 500 individuals)
      - Intensively sample all habitats (including “microhabitats” – e.g. aquatic vegetation, filamentous algae, littoral zone, cobbles, boulders, sand/silt, backwaters, water/air interface, etc.) Leave no habitats un-sampled.
      - As you sample, periodically sort out aquatic insects with BioQuip forceps – preserve in medium sized sample vial with 95% Ethanol. Note that some sample processing (i.e., elutriation, washing leaf litter) may speed up the picking portion.
      - Label outside of sample vial with paper tape with site name and date, place paper label inside with site name, date, lat/long, type of sample (aquatic qualitative)
   b. Terrestrial sweep netting (min time: 1 hour)
      - With heavy duty sweep net, vigorously beat all riparian vegetation, sweeping grasses, willows, tree branches, etc.
      - After 5 minutes of sweeping, sweep air rapidly to collate all debris and insects in bottom of net.
      - Expose bottom portion of net, and pull out terrestrial stages with BioQuip forceps, or with aspirator (for midges), place in small vial with 95% Ethanol.
      - Repeat, repeat, repeat.
      - Note, if sampling in bright sun pay particular attention to shaded, near stream vegetation. If cloudy, or during dusk – insects may be in flight more and sweeping higher branches may be more productive.
      - With green, extendable net, sweep above the stream channel (up to 8 ft high) to collect swarming insects (especially mayflies). Avoid using the green delicate net to sweep riparian vegetation (it will rip).
      - Label vials identical to aquatic qualitative (with different sample type, of course)
   c. Light traps
      - As dusk approaches, start setting out light traps

- Over a 150 meter stream reach, pond perimeter, spring area – lay out 12 pairs of lights, each with their own Rubbermaid tray/trap. (one each of blacklight & ultraviolet light, separated by ~1m), place close to stream (a couple can be set off in open areas)
- In bottom of each Rubbermaid tray, pour ~1 cm of 95% Ethanol.
- Make sure Laminated Sheet is underneath each sampling pair.
- Sample Collection: 2 options
  1. Hang out and wait two hours post-dusk to collect
  2. Return next morning to collect
- To collect:
  - Filter all insects in 95% ethanol through fine-mesh aquarium nets
  - Invert net into sample vial, use 95% ethanol to wash out net into vial (all traps can be consolidated into one large sample vial)
- Label vial identical to above vials

Upon return to BugLab, hand off samples to taxonomist, recharge batteries (if using rechargeable batteries), download photographs to computer. Repeat for the remainder of the summer. Tell Eric of any sampling problems.

<u>Equipment list:</u>

Field Pack
Forceps (4 pairs – 2 with leashes)
95% Ethanol (2 liters)
Sample vials (2 small vials, 1 medium, 1 large)
Paper labels
Sharpies
GPS
Alkalinity kit
pH meter
Conductivity meter
2 or 3 sweep nets (1 extendable net (with 4 sections), 1 or 2 heavy duty sweep nets)
1 kicknet
Sorting trays
Headlamps
Field book
Pencils
Blacklights & ultraviolet lights (24 total) with Rubbermaid trays and laminated sheets)
Spare bulbs (2 of each type)
Extra AA Batteries for all powered equipment
Thermometer
Watch
Waders/Gloves as needed
Digital Camera
Aspirator
Aquarium net
Area Maps

Appendix 12. Individual taxa lists and abundances for the samples used in the analyses.

Taxonomic list and abundances of aquatic invertebrates collected 13 August 1984 at station S2:640, Silver King Creek, lower exclosure near Cow Cabin, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128274. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 642 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			93	
Class: Insecta				
Coleoptera	Dytiscidae		4	
Coleoptera	Elmidae		108	
Diptera	Ceratopogonidae		4	
Diptera	Chironomidae		946	
Diptera	Empididae		11	
Diptera	Psychodidae		18	
Diptera	Simuliidae		93	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Hexatoma	11	
Ephemeroptera			86	
Ephemeroptera	Baetidae	Baetis	39	
Ephemeroptera	Ephemerellidae	Attenella delantala	11	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	93	
Ephemeroptera	Ephemerellidae	Drunella doddsi	100	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	14	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	18	
Ephemeroptera	Heptageniidae	Cinygmula	158	
Ephemeroptera	Heptageniidae	Epeorus	29	
Ephemeroptera	Heptageniidae	Rhithrogena	72	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	39	
Plecoptera			4	
Plecoptera	Capniidae		4	
Plecoptera	Chloroperlidae		75	
Plecoptera	Nemouridae	Zapada	18	
Plecoptera	Peltoperlidae	Yoraperla	7	
Plecoptera	Perlidae		4	
Plecoptera	Taeniopterygidae	Taenionema	72	
Trichoptera			11	
Trichoptera	Brachycentridae	Brachycentrus	4	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Glossosomatidae	Glossosoma	39	
Trichoptera	Hydropsychidae	Arctopsyche	4	
Trichoptera	Hydropsychidae	Parapsyche	4	
Trichoptera	Lepidostomatidae	Lepidostoma	4	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Rhyacophilidae	Rhyacophila	47	
Class: Maxillopoda, subclass copepoda			4	
Class: Ostracoda			14	
Phylum: Nemata			7	
Phylum: Platyhelminthes				
Class: Turbellaria			18	

Total: 42 OTU taxa			2301 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 13 August 1984 at station S3:641, Silver King Creek, near middle exclosure, Station 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128275. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1344 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			118	
Class: Insecta				
Coleoptera	Elmidae		154	
Diptera			7	
Diptera	Ceratopogonidae		14	
Diptera	Chironomidae		1394	
Diptera	Empididae		65	
Diptera	Psychodidae		72	
Diptera	Psychodidae	Pericoma	32	
Diptera	Simuliidae		154	
Diptera	Stratiomyidae		7	
Diptera	Tipulidae	Dicranota	7	
Diptera	Tipulidae	Hexatoma	25	
Ephemeroptera			104	
Ephemeroptera	Baetidae	Baetis	1039	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	437	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	222	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	65	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	65	
Ephemeroptera	Heptageniidae	Cinygmula	79	
Ephemeroptera	Heptageniidae	Epeorus	25	
Ephemeroptera	Heptageniidae	Rhithrogena	65	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	39	
Plecoptera	Chloroperlidae		176	
Plecoptera	Nemouridae	Zapada	25	
Plecoptera	Peltoperlidae	Yoraperla	32	
Plecoptera	Perlidae		7	
Plecoptera	Perlidae	Hesperoperla	14	
Plecoptera	Taeniopterygidae	Taenionema	57	
Trichoptera			14	
Trichoptera	Brachycentridae	Brachycentrus	25	
Trichoptera	Glossosomatidae	Glossosoma	25	
Trichoptera	Hydropsychidae	Parapsyche	14	
Trichoptera	Rhyacophilidae	Rhyacophila	161	
Trichoptera	Uenoidae	Neothremma	14	
Class: Ostracoda			14	
Phylum: Nemata			7	
Phylum: Platyhelminthes				
Class: Turbellaria			32	

Total: 38 OTU taxa			4817 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 15 August 1984 at station S4:700, Silver King Creek, upstream from exclosure, Station 4, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128276. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 871 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			104	
Class: Insecta				
Coleoptera	Elmidae		100	
Diptera			7	
Diptera	Ceratopogonidae		14	
Diptera	Chironomidae		903	
Diptera	Empididae		65	
Diptera	Psychodidae		82	
Diptera	Psychodidae	Pericoma	82	
Diptera	Simuliidae		197	
Diptera	Tipulidae	Hexatoma	11	
Ephemeroptera			82	
Ephemeroptera	Baetidae	Baetis	771	
Ephemeroptera	Ephemerellidae	Attenella delantala	47	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	7	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	11	
Ephemeroptera	Ephemerellidae	Drunella doddsi	39	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	22	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	4	
Ephemeroptera	Heptageniidae	Cinygmula	118	
Ephemeroptera	Heptageniidae	Epeorus	7	
Ephemeroptera	Heptageniidae	Rhithrogena	22	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	39	
Plecoptera			18	
Plecoptera	Capniidae		7	
Plecoptera	Chloroperlidae		68	
Plecoptera	Leuctridae		4	
Plecoptera	Nemouridae	Zapada	4	
Plecoptera	Peltoperlidae	Yoraperla	4	
Plecoptera	Perlidae		4	
Plecoptera	Perlodidae	Cultus	4	
Plecoptera	Taeniopterygidae	Taenionema	57	
Trichoptera			97	
Trichoptera	Brachycentridae	Brachycentrus	7	
Trichoptera	Glossosomatidae	Glossosoma	32	
Trichoptera	Rhyacophilidae	Rhyacophila	32	
Class: Ostracoda			14	
Phylum: Nemata			22	
Phylum: Platyhelminthes				
Class: Turbellaria			14	

Total: 37 OTU taxa			3122	individuals

Taxonomic list and abundances of aquatic invertebrates collected 14 August 1984 at station S5:725, Silver King Creek, mid meadow upstream from cabin, Station 5, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128277. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 658 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			4	
Class: Insecta				
Coleoptera	Elmidae		82	
Diptera	Chironomidae		462	
Diptera	Empididae		29	
Diptera	Psychodidae		36	
Diptera	Simuliidae		312	
Diptera	Stratiomyidae		4	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera			29	
Ephemeroptera	Baetidae	Baetis	946	
Ephemeroptera	Ephemerellidae	Attenella delantala	11	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	57	
Ephemeroptera	Ephemerellidae	Drunella doddsi	79	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	11	
Ephemeroptera	Heptageniidae	Epeorus	22	
Ephemeroptera	Heptageniidae	Rhithrogena	7	
Plecoptera			4	
Plecoptera	Chloroperlidae		61	
Plecoptera	Nemouridae	Zapada	4	
Plecoptera	Peltoperlidae	Yoraperla	4	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Taeniopterygidae	Taenionema	11	
Trichoptera			4	
Trichoptera	Brachycentridae	Brachycentrus	7	
Trichoptera	Hydropsychidae	Arctopsyche	4	
Trichoptera	Hydropsychidae	Parapsyche	7	
Trichoptera	Lepidostomatidae	Lepidostoma	43	
Trichoptera	Rhyacophilidae	Rhyacophila	90	
Trichoptera	Uenoidae	Neothremma	4	
Phylum: Nemata			18	

Total: 31 OTU taxa			2358 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 15 August 1984 at station S6:738, Silver King Creek, upper meadow upstream from cabin, Sta. 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128278. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 782 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			65	
Class: Insecta				
Coleoptera	Elmidae		90	
Diptera	Ceratopogonidae		11	
Diptera	Chironomidae		900	
Diptera	Dixidae	Dixa	4	
Diptera	Empididae		68	
Diptera	Psychodidae		133	
Diptera	Simuliidae		133	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera			22	
Ephemeroptera	Baetidae	Baetis	642	
Ephemeroptera	Ephemerellidae	Attenella delantala	7	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	29	
Ephemeroptera	Ephemerellidae	Drunella doddsi	29	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	36	
Ephemeroptera	Ephemerellidae	Serratella tibialis	29	
Ephemeroptera	Heptageniidae	Cinygmula	29	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Plecoptera			36	
Plecoptera	Chloroperlidae		168	
Plecoptera	Peltoperlidae	Yoraperla	4	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlidae	Hesperoperla	25	
Plecoptera	Perlodidae	Cultus	4	
Plecoptera	Taeniopterygidae	Taenionema	183	
Trichoptera			11	
Trichoptera	Brachycentridae	Brachycentrus	14	
Trichoptera	Glossosomatidae	Glossosoma	29	
Trichoptera	Hydropsychidae	Parapsyche	4	
Trichoptera	Rhyacophilidae	Rhyacophila	61	
Class: Ostracoda			4	
Phylum: Nemata			25	

Total: 32 OTU taxa			2803 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 15 August 1984 at station S7:775, Silver King Creek, 300 yds upstream from 4-Mile Creek, Sta 7, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128279. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1146 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			97	
Class: Insecta				
Coleoptera	Elmidae		14	
Diptera			4	
Diptera	Ceratopogonidae		47	
Diptera	Chironomidae		1688	
Diptera	Empididae		65	
Diptera	Psychodidae		32	
Diptera	Simuliidae		108	
Ephemeroptera			115	
Ephemeroptera	Baetidae	Baetis	1351	
Ephemeroptera	Ephemerellidae	Drunella doddsi	86	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	82	
Ephemeroptera	Heptageniidae	Cinygmula	22	
Ephemeroptera	Heptageniidae	Epeorus	54	
Ephemeroptera	Heptageniidae	Rhithrogena	7	
Plecoptera			68	
Plecoptera	Chloroperlidae		25	
Plecoptera	Leuctridae		7	
Plecoptera	Nemouridae	Zapada	18	
Plecoptera	Perlidae		18	
Plecoptera	Taeniopterygidae	Taenionema	97	
Trichoptera			4	
Trichoptera	Brachycentridae	Micrasema	18	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Hydropsychidae	Parapsyche	18	
Trichoptera	Limnephilidae		4	
Trichoptera	Rhyacophilidae	Rhyacophila	50	
Class: Maxillopoda, subclass copepoda			4	
Class: Ostracoda			4	

Total: 29 OTU taxa			4108 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 15 August 1984 at station S8:813, Silver King Creek, upstream from Fly Valley Creek, Station 8, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128280. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 964 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			186	
Class: Insecta				
Coleoptera	Elmidae		14	
Diptera	Ceratopogonidae		14	
Diptera	Chironomidae		423	
Diptera	Empididae		14	
Diptera	Psychodidae		7	
Diptera	Psychodidae	Pericoma	7	
Diptera	Simuliidae		32	
Ephemeroptera			54	
Ephemeroptera	Baetidae	Baetis	1749	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	29	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	7	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	14	
Ephemeroptera	Heptageniidae	Cinygmula	22	
Ephemeroptera	Heptageniidae	Epeorus	54	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Plecoptera			7	
Plecoptera	Capniidae		22	
Plecoptera	Chloroperlidae		129	
Plecoptera	Leuctridae		22	
Plecoptera	Nemouridae	Zapada	7	
Plecoptera	Perlodidae	Cultus	7	
Plecoptera	Taeniopterygidae	Taenionema	448	
Trichoptera	Glossosomatidae	Glossosoma	25	
Trichoptera	Rhyacophilidae	Rhyacophila	147	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Platyhelminthes				
Class: Turbellaria			4	

Total: 28 OTU taxa			3455 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 14 August 1984 at station S2:100, Bull Canyon Creek, 300 feet upstream from fence, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128281. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 526 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			39	
Class: Insecta				
Coleoptera	Elmidae		7	
Diptera	Ceratopogonidae		11	
Diptera	Chironomidae		459	
Diptera	Empididae		4	
Diptera	Psychodidae		4	
Diptera	Simuliidae	Simulium	29	
Diptera	Tipulidae	Dicranota	14	
Diptera	Tipulidae	Holorusia	4	
Ephemeroptera			14	
Ephemeroptera	Baetidae	Baetis	366	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	47	
Ephemeroptera	Ephemerellidae	Drunella doddsi	125	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	32	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	18	
Ephemeroptera	Heptageniidae	Cinygmula	115	
Ephemeroptera	Heptageniidae	Epeorus	29	
Ephemeroptera	Heptageniidae	Rhithrogena	11	
Plecoptera			179	
Plecoptera	Capniidae		47	
Plecoptera	Chloroperlidae		4	
Plecoptera	Nemouridae	Visoka cataractae	4	
Plecoptera	Nemouridae	Zapada	14	
Plecoptera	Peltoperlidae	Yoraperla	4	
Plecoptera	Perlidae	Hesperoperla	4	
Plecoptera	Perlodidae	Isoperla	4	
Plecoptera	Taeniopterygidae	Taenionema	39	
Trichoptera			18	
Trichoptera	Rhyacophilidae	Rhyacophila	115	
Class: Maxillopoda, subclass copepoda			4	
Class: Ostracoda			4	
Phylum: Nemata			118	

Total: 33 OTU taxa			1885 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 16 August 1984 at station S1:500, Fly Valley Creek, Station 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128282. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 792 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			358	
Class: Insecta				
Coleoptera	Elmidae		14	
Diptera			4	
Diptera	Ceratopogonidae		57	
Diptera	Chironomidae		806	
Diptera	Empididae		14	
Diptera	Simuliidae		104	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera			25	
Ephemeroptera	Baetidae	Baetis	452	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	36	
Ephemeroptera	Ephemerellidae	Drunella doddsi	25	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	7	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	18	
Ephemeroptera	Heptageniidae	Cinygmula	22	
Ephemeroptera	Heptageniidae	Epeorus	68	
Ephemeroptera	Heptageniidae	Rhithrogena	29	
Plecoptera			39	
Plecoptera	Capniidae		14	
Plecoptera	Chloroperlidae		61	
Plecoptera	Leuctridae		194	
Plecoptera	Nemouridae	Zapada	129	
Plecoptera	Peltoperlidae	Yoraperla	32	
Plecoptera	Perlidae	Hesperoperla	14	
Plecoptera	Perlodidae	Isoperla	7	
Plecoptera	Taeniopterygidae	Taenionema	14	
Trichoptera			14	
Trichoptera	Glossosomatidae	Glossosoma	14	
Trichoptera	Lepidostomatidae	Lepidostoma	54	
Trichoptera	Rhyacophilidae	Rhyacophila	172	
Trichoptera	Uenoidae	Neothremma	11	
Class: Ostracoda			4	
Phylum: Nemata			22	

Total: 33 OTU taxa			2839 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 17 August 1984 at station S1:250, Four-mile Canyon Creek, middle meadow, Station 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128283. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1042 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			186	
Class: Insecta				
Coleoptera	Elmidae		351	
Diptera	Ceratopogonidae		36	
Diptera	Chironomidae		588	
Diptera	Empididae		32	
Diptera	Psychodidae		272	
Diptera	Simuliidae		93	
Ephemeroptera			57	
Ephemeroptera	Baetidae	Baetis	703	
Ephemeroptera	Ephemerellidae	Attenella delantala	7	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	176	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	176	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	4	
Ephemeroptera	Heptageniidae	Cinygmula	47	
Ephemeroptera	Heptageniidae	Epeorus	32	
Ephemeroptera	Heptageniidae	Rhithrogena	65	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	65	
Plecoptera			240	
Plecoptera	Capniidae		7	
Plecoptera	Chloroperlidae		22	
Plecoptera	Leuctridae		7	
Plecoptera	Nemouridae	Zapada	39	
Plecoptera	Peltoperlidae	Yoraperla	14	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Plecoptera	Perlodidae	Kogotus	4	
Plecoptera	Taeniopterygidae	Taenionema	172	
Trichoptera			18	
Trichoptera	Brachycentridae	Brachycentrus	7	
Trichoptera	Brachycentridae	Micrasema	32	
Trichoptera	Glossosomatidae	Glossosoma	32	
Trichoptera	Hydropsychidae	Arctopsyche grandis	7	
Trichoptera	Hydropsychidae	Parapsyche	7	
Trichoptera	Lepidostomatidae	Lepidostoma	7	
Trichoptera	Rhyacophilidae	Rhyacophila	97	
Trichoptera	Uenoidae	Neothremma	25	
Class: Ostracoda			93	

Total: 37 OTU taxa			3735 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 18 August 1984 at station S2:467, Coyote Valley Creek, downstream from crossing, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128284. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1368 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			115	
Class: Insecta				
Coleoptera	Elmidae		308	
Diptera			14	
Diptera	Ceratopogonidae		47	
Diptera	Chironomidae		502	
Diptera	Psychodidae		22	
Diptera	Simuliidae		29	
Diptera	Tipulidae	Hexatoma	14	
Ephemeroptera			72	
Ephemeroptera	Baetidae	Baetis	1713	
Ephemeroptera	Ephemerellidae	Drunella doddsi	32	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	631	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	7	
Ephemeroptera	Heptageniidae	Cinygmula	233	
Ephemeroptera	Heptageniidae	Epeorus	7	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	18	
Plecoptera			36	
Plecoptera	Capniidae		25	
Plecoptera	Chloroperlidae		760	
Plecoptera	Nemouridae		4	
Plecoptera	Nemouridae	Zapada	7	
Plecoptera	Peltoperlidae	Yoraperla	68	
Plecoptera	Perlidae	Hesperoperla	7	
Plecoptera	Taeniopterygidae	Taenionema	97	
Trichoptera	Brachycentridae	Brachycentrus	7	
Trichoptera	Limnephilidae		4	
Trichoptera	Rhyacophilidae	Rhyacophila	118	
Phylum: Nemata			7	

Total: 28 OTU taxa			4903 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 18 August 1984 at station S3:500, Coyote Valley Creek, upstream from large meadow rock, Sta. 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128285. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1065 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			72	
Class: Insecta				
Coleoptera	Elmidae		208	
Diptera	Ceratopogonidae		14	
Diptera	Chironomidae		581	
Diptera	Psychodidae		7	
Diptera	Simuliidae		32	
Diptera	Tipulidae	Dicranota	7	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera			68	
Ephemeroptera	Baetidae	Baetis	588	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	133	
Ephemeroptera	Ephemerellidae	Drunella doddsi	36	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	448	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	247	
Ephemeroptera	Heptageniidae	Cinygmula	487	
Ephemeroptera	Heptageniidae	Epeorus	14	
Plecoptera			39	
Plecoptera	Capniidae		39	
Plecoptera	Chloroperlidae		323	
Plecoptera	Nemouridae		14	
Plecoptera	Peltoperlidae	Yoraperla	72	
Plecoptera	Perlidae		7	
Plecoptera	Perlidae	Hesperoperla	14	
Plecoptera	Perlodidae	Kogotus	7	
Plecoptera	Taeniopterygidae	Taenionema	297	
Trichoptera			11	
Trichoptera	Rhyacophilidae	Rhyacophila	22	
Class: Ostracoda			14	
Phylum: Nemata			4	

Total: 29 OTU taxa			3817 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 18 August 1984 at station S5:NOMAP, Coyote Creek, top of upper meadow, Station 5, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128286. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1127 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			11	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			165	
Class: Insecta				
Coleoptera	Dytiscidae		4	
Coleoptera	Elmidae		136	
Diptera	Ceratopogonidae		47	
Diptera	Chironomidae		735	
Diptera	Empididae		14	
Diptera	Psychodidae		158	
Diptera	Simuliidae		470	
Diptera	Tipulidae	Dicranota	7	
Ephemeroptera			72	
Ephemeroptera	Baetidae	Baetis	1240	
Ephemeroptera	Ephemerellidae	Attenella delantala	25	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	29	
Ephemeroptera	Ephemerellidae	Drunella doddsi	68	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	25	
Ephemeroptera	Heptageniidae	Cinygmula	25	
Ephemeroptera	Heptageniidae	Epeorus	43	
Ephemeroptera	Heptageniidae	Rhithrogena	47	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	18	
Plecoptera			54	
Plecoptera	Capniidae		129	
Plecoptera	Capniidae		22	
Plecoptera	Chloroperlidae		57	
Plecoptera	Nemouridae	Zapada	14	
Plecoptera	Peltoperlidae	Yoraperla	125	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlodidae	Cultus	4	
Plecoptera	Perlodidae	Skwala americana	25	
Trichoptera			22	
Trichoptera	Brachycentridae	Micrasema	14	
Trichoptera	Glossosomatidae	Glossosoma	14	
Trichoptera	Hydropsychidae	Arctopsyche	22	
Trichoptera	Hydropsychidae	Parapsyche	18	
Trichoptera	Philopotamidae		7	
Trichoptera	Rhyacophilidae	Rhyacophila	115	
Trichoptera	Uenoidae	Neothremma	32	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae		7	
Phylum: Nemata			14	

Total: 39 OTU taxa			4039 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 19 August 1984 at station S1:571, Corral Valley Creek, downstream from trail, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128287. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1716 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			14	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			269	
Class: Insecta				
Coleoptera	Elmidae		695	
Diptera	Ceratopogonidae		25	
Diptera	Chironomidae		2186	
Diptera	Empididae		7	
Diptera	Psychodidae	Pericoma	14	
Diptera	Simuliidae		79	
Diptera	Tipulidae	Dicranota	25	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera			312	
Ephemeroptera	Baetidae	Baetis	692	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	176	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	75	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	434	
Ephemeroptera	Ephemerellidae	Serratella tibialis	186	
Ephemeroptera	Heptageniidae	Cinygmula	65	
Ephemeroptera	Heptageniidae	Epeorus	25	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	32	
Plecoptera	Capniidae		57	
Plecoptera	Chloroperlidae		57	
Plecoptera	Leuctridae		25	
Plecoptera	Nemouridae		7	
Plecoptera	Nemouridae	Zapada	14	
Plecoptera	Peltoperlidae	Yoraperla	14	
Plecoptera	Perlodidae	Cultus	4	
Plecoptera	Perlodidae	Isoperla	22	
Plecoptera	Pteronarcyidae	Pteronarcella regularis	7	
Trichoptera			151	
Trichoptera	Glossosomatidae	Glossosoma	32	
Trichoptera	Hydropsychidae	Arctopsyche	7	
Trichoptera	Rhyacophilidae	Rhyacophila	186	
Class: Maxillopoda, subclass copepoda			39	
Class: Ostracoda			186	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	7	

Total: 36 OTU taxa			6151 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 18 August 1987 at station S2:640, Silver King Creek, lower exclosure near Cow Cabin, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128296. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1865 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			136	
Class: Insecta				
Coleoptera	Elmidae		136	
Coleoptera	Elmidae		330	
Diptera	Ceratopogonidae		14	
Diptera	Chironomidae		1577	
Diptera	Psychodidae	Pericoma	1832	
Diptera	Simuliidae		111	
Diptera	Tipulidae	Antocha	39	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera	Baetidae	Baetis	584	
Ephemeroptera	Ephemerellidae	Attenella margarita	7	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	118	
Ephemeroptera	Ephemerellidae	Drunella doddsi	104	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	39	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	545	
Ephemeroptera	Ephemerellidae	Serratella tibialis	7	
Ephemeroptera	Heptageniidae	Cinygmula	416	
Ephemeroptera	Heptageniidae	Epeorus	7	
Ephemeroptera	Heptageniidae	Heptagenia	32	
Ephemeroptera	Heptageniidae	Rhithrogena	32	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	129	
Plecoptera	Chloroperlidae		65	
Plecoptera	Leuctridae		7	
Plecoptera	Nemouridae	Zapada	32	
Plecoptera	Peltoperlidae	Yoraperla	39	
Plecoptera	Perlidae	Calineuria californica	14	
Trichoptera	Brachycentridae	Brachycentrus	47	
Trichoptera	Brachycentridae	Micrasema	118	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Philopotamidae		14	
Trichoptera	Polycentropodidae	Polycentropus	14	
Trichoptera	Rhyacophilidae	Rhyacophila	97	
Phylum: Nemata			25	

Total: 32 OTU taxa			6685 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 18 August 1987 at station S3:641, Silver King Creek, near middle exclosure, Station 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128297. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1401 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			265	
Class: Insecta				
Coleoptera	Elmidae		513	
Diptera	Chironomidae		753	
Diptera	Empididae		47	
Diptera	Psychodidae	Pericoma	2011	
Diptera	Simuliidae		25	
Diptera	Tipulidae	Antocha	25	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera	Baetidae	Baetis	297	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	97	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	47	
Ephemeroptera	Ephemerellidae	Drunella doddsi	97	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	25	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	276	
Ephemeroptera	Ephemerellidae	Serratella tibialis	14	
Ephemeroptera	Heptageniidae	Cinygmula	104	
Ephemeroptera	Heptageniidae	Epeorus	25	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	25	
Plecoptera			7	
Plecoptera	Chloroperlidae		57	
Plecoptera	Nemouridae		14	
Plecoptera	Peltoperlidae	Yoraperla	57	
Plecoptera	Perlidae	Calineuria californica	7	
Plecoptera	Perlidae	Hesperoperla pacifica	14	
Trichoptera	Brachycentridae	Brachycentrus	39	
Trichoptera	Brachycentridae	Micrasema	47	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Rhyacophilidae	Rhyacophila	79	
Class: Ostracoda			32	
Phylum: Nemata			7	

Total: 30 OTU taxa			5022 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 18 August 1987 at station S4:700, Silver King Creek, upstream from exclosure, Station 4, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128298. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1046 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			75	
Class: Insecta				
Coleoptera	Elmidae		613	
Diptera	Ceratopogonidae		25	
Diptera	Chironomidae		573	
Diptera	Empididae		11	
Diptera	Psychodidae	Pericoma	509	
Diptera	Simuliidae		14	
Diptera	Tipulidae	Antocha	11	
Diptera	Tipulidae	Hexatoma	22	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	355	
Ephemeroptera	Ephemerellidae	Attenella margarita	93	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	172	
Ephemeroptera	Ephemerellidae	Drunella doddsi	65	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	32	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	620	
Ephemeroptera	Heptageniidae	Cinygmula	240	
Ephemeroptera	Heptageniidae	Epeorus	11	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	32	
Plecoptera	Chloroperlidae		22	
Plecoptera	Peltoperlidae	Yoraperla	68	
Plecoptera	Perlidae	Calineuria californica	7	
Plecoptera	Perlodidae	Isoperla	4	
Plecoptera	Taeniopterygidae	Taenionema	4	
Trichoptera	Brachycentridae	Brachycentrus	22	
Trichoptera	Brachycentridae	Micrasema	11	
Trichoptera	Glossosomatidae	Glossosoma	14	
Trichoptera	Rhyacophilidae	Rhyacophila	90	
Class: Maxillopoda, subclass copepoda			7	
Class: Ostracoda			11	
Phylum: Nemata			11	

Total: 32 OTU taxa			3749 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 18 August 1987 at station S5:725, Silver King Creek, mid meadow upstream from cabin, Station 5, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128299. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1454 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			147	
Class: Insecta				
Coleoptera	Elmidae		351	
Diptera	Ceratopogonidae		25	
Diptera	Chironomidae		1057	
Diptera	Empididae		39	
Diptera	Psychodidae	Pericoma	505	
Diptera	Simuliidae		22	
Diptera	Stratiomyidae	Nemotelus	7	
Ephemeroptera	Baetidae	Baetis	882	
Ephemeroptera	Ephemerellidae	Attenella margarita	97	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	384	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	47	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	39	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	412	
Ephemeroptera	Ephemerellidae	Serratella tibialis	4	
Ephemeroptera	Heptageniidae	Cinygmula	254	
Ephemeroptera	Heptageniidae	Epeorus	11	
Ephemeroptera	Heptageniidae	Rhithrogena	297	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	47	
Plecoptera	Chloroperlidae		147	
Plecoptera	Leuctridae		7	
Plecoptera	Nemouridae	Zapada	7	
Plecoptera	Peltoperlidae	Yoraperla	97	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Calineuria californica	7	
Plecoptera	Perlodidae	Isoperla	4	
Plecoptera	Perlodidae	Skwala americana	7	
Trichoptera	Brachycentridae	Brachycentrus	36	
Trichoptera	Brachycentridae	Micrasema	65	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Hydropsychidae	Parapsyche	22	
Trichoptera	Philopotamidae		29	
Trichoptera	Rhyacophilidae	Rhyacophila	90	
Class: Maxillopoda, subclass copepoda			22	
Class: Ostracoda			4	
Phylum: Nemata			25	

Total: 37 OTU taxa			5211 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 18 August 1987 at station S6:738, Silver King Creek, upper meadow upstream from cabin, Sta. 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128300. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1347 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			208	
Class: Insecta				
Coleoptera	Elmidae		208	
Diptera	Ceratopogonidae		7	
Diptera	Chironomidae		713	
Diptera	Empididae		14	
Diptera	Psychodidae	Pericoma	1466	
Diptera	Simuliidae		47	
Ephemeroptera	Baetidae	Baetis	713	
Ephemeroptera	Ephemerellidae	Attenella margarita	47	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	72	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	104	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	25	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	480	
Ephemeroptera	Heptageniidae	Cinygmula	330	
Ephemeroptera	Heptageniidae	Epeorus	65	
Plecoptera			7	
Plecoptera	Chloroperlidae		65	
Plecoptera	Nemouridae	Zapada	7	
Plecoptera	Peltoperlidae	Yoraperla	14	
Plecoptera	Perlidae		7	
Trichoptera	Brachycentridae	Brachycentrus	14	
Trichoptera	Glossosomatidae	Glossosoma	47	
Trichoptera	Rhyacophilidae	Rhyacophila	161	

Total: 24 OTU taxa			4828 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 19 August 1987 at station S7:775, Silver King Creek, 300 yds upstream from 4-Mile Creek, Sta 7, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128301. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1105 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			247	
Class: Insecta				
Coleoptera	Elmidae		25	
Diptera	Ceratopogonidae		11	
Diptera	Chironomidae		857	
Diptera	Empididae		22	
Diptera	Psychodidae	Pericoma	667	
Diptera	Simuliidae		65	
Diptera	Tipulidae	Antocha	4	
Ephemeroptera	Baetidae	Baetis	563	
Ephemeroptera	Ephemerellidae	Attenella margarita	39	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	65	
Ephemeroptera	Ephemerellidae	Drunella doddsi	72	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	57	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	204	
Ephemeroptera	Heptageniidae	Cinygmula	222	
Ephemeroptera	Heptageniidae	Epeorus	61	
Ephemeroptera	Heptageniidae	Rhithrogena	108	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	22	
Plecoptera			4	
Plecoptera	Capniidae		4	
Plecoptera	Chloroperlidae		133	
Plecoptera	Nemouridae	Zapada	54	
Plecoptera	Peltoperlidae	Yoraperla	4	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Calineuria californica	4	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Trichoptera	Brachycentridae	Brachycentrus	29	
Trichoptera	Brachycentridae	Micrasema	54	
Trichoptera	Glossosomatidae	Glossosoma	136	
Trichoptera	Hydropsychidae	Arctopsyche	7	
Trichoptera	Hydropsychidae	Parapsyche	14	
Trichoptera	Limnephilidae	Cryptochia	4	
Trichoptera	Rhyacophilidae	Rhyacophila	168	
Class: Ostracoda			32	

Total: 34 OTU taxa			3961 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 19 August 1987 at station S8:813, Silver King Creek, upstream from Fly Valley Creek, Station 8, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128302. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 2270 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			337	
Class: Insecta				
Coleoptera	Elmidae		47	
Diptera	Chironomidae		1602	
Diptera	Empididae		47	
Diptera	Psychodidae	Pericoma	842	
Diptera	Simuliidae		7	
Diptera	Tipulidae	Antocha	14	
Ephemeroptera	Baetidae	Baetis	1695	
Ephemeroptera	Ephemerellidae	Attenella margarita	168	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	168	
Ephemeroptera	Ephemerellidae	Drunella doddsi	168	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	935	
Ephemeroptera	Ephemerellidae	Serratella tibialis	7	
Ephemeroptera	Heptageniidae	Cinygmula	376	
Ephemeroptera	Heptageniidae	Epeorus	32	
Ephemeroptera	Heptageniidae	Rhithrogena	39	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	32	
Plecoptera			14	
Plecoptera	Chloroperlidae		201	
Plecoptera	Leuctridae		32	
Plecoptera	Nemouridae	Zapada	47	
Plecoptera	Peltoperlidae	Yoraperla	25	
Plecoptera	Perlodidae	Skwala americana	7	
Plecoptera	Taeniopterygidae	Taenionema	79	
Trichoptera			39	
Trichoptera	Brachycentridae	Micrasema	7	
Trichoptera	Glossosomatidae	Glossosoma	670	
Trichoptera	Hydropsychidae	Arctopsyche	14	
Trichoptera	Rhyacophilidae	Rhyacophila	233	
Class: Ostracoda			129	
Phylum: Nemata			65	
Phylum: Platyhelminthes				
Class: Turbellaria			47	

Total: 33 OTU taxa			8136 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 18 August 1987 at station S2:100, Bull Canyon Creek, 300 feet upstream from fence, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128303. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1272 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			29	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			186	
Class: Insecta				
Coleoptera	Elmidae		11	
Diptera	Ceratopogonidae		22	
Diptera	Chironomidae		1581	
Diptera	Empididae		39	
Diptera	Psychodidae	Pericoma	516	
Diptera	Simuliidae		111	
Diptera	Tipulidae	Hexatoma	25	
Ephemeroptera	Ameletidae	Ameletus	7	
Ephemeroptera	Baetidae	Baetis	276	
Ephemeroptera	Ephemerellidae	Attenella margarita	57	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	39	
Ephemeroptera	Ephemerellidae	Drunella doddsi	108	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	29	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	75	
Ephemeroptera	Heptageniidae	Cinygmula	29	
Ephemeroptera	Heptageniidae	Epeorus	39	
Ephemeroptera	Heptageniidae	Rhithrogena	505	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	47	
Plecoptera	Capniidae		14	
Plecoptera	Chloroperlidae		100	
Plecoptera	Leuctridae		25	
Plecoptera	Nemouridae	Zapada	32	
Plecoptera	Perlidae		54	
Plecoptera	Perlidae	Calineuria californica	14	
Plecoptera	Perlodidae	Isoperla	22	
Trichoptera	Glossosomatidae	Glossosoma	93	
Trichoptera	Hydropsychidae	Arctopsyche	29	
Trichoptera	Limnephilidae		4	
Trichoptera	Rhyacophilidae	Rhyacophila	344	
Class: Ostracoda			72	
Phylum: Nemata			25	

Total: 33 OTU taxa			4559	individuals

Taxonomic list and abundances of aquatic invertebrates collected 19 August 1987 at station S1:500, Fly Valley Creek, Station 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128304. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 978 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			14	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			90	
Class: Insecta				
Diptera	Chironomidae		1720	
Diptera	Empididae		7	
Diptera	Psychodidae	Pericoma	39	
Diptera	Simuliidae		140	
Ephemeroptera	Baetidae	Baetis	530	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	32	
Ephemeroptera	Ephemerellidae	Drunella doddsi	39	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	7	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	29	
Ephemeroptera	Heptageniidae	Cinygmula	93	
Ephemeroptera	Heptageniidae	Epeorus	36	
Ephemeroptera	Heptageniidae	Heptagenia	22	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera			7	
Plecoptera	Capniidae		129	
Plecoptera	Chloroperlidae		43	
Plecoptera	Leuctridae		50	
Plecoptera	Nemouridae	Zapada	118	
Plecoptera	Peltoperlidae	Yoraperla	7	
Plecoptera	Perlidae	Hesperoperla pacifica	4	
Plecoptera	Perlodidae	Skwala americana	4	
Trichoptera	Brachycentridae	Micrasema	14	
Trichoptera	Glossosomatidae	Glossosoma	22	
Trichoptera	Hydropsychidae	Arctopsyche	72	
Trichoptera	Rhyacophilidae	Rhyacophila	133	
Trichoptera	Uenoidae	Neothremma	4	
Class: Ostracoda			7	
Phylum: Nemata			29	
Phylum: Platyhelminthes				
Class: Turbellaria			57	

Total: 32 OTU taxa			3505 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 19 August 1987 at station S1:250, Four-mile Canyon Creek, middle meadow, Station 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128305. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1515 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			272	
Class: Insecta				
Coleoptera	Elmidae		358	
Diptera	Ceratopogonidae		29	
Diptera	Chironomidae		1065	
Diptera	Dixidae	Dixa	4	
Diptera	Empididae		79	
Diptera	Psychodidae	Pericoma	993	
Diptera	Simuliidae		25	
Diptera	Tipulidae	Antocha	39	
Ephemeroptera	Baetidae	Baetis	864	
Ephemeroptera	Ephemerellidae	Attenella margarita	22	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	125	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	140	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	11	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	151	
Ephemeroptera	Heptageniidae	Cinygmula	75	
Ephemeroptera	Heptageniidae	Epeorus	25	
Ephemeroptera	Heptageniidae	Rhithrogena	29	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	108	
Plecoptera	Capniidae		36	
Plecoptera	Chloroperlidae		4	
Plecoptera	Leuctridae		136	
Plecoptera	Nemouridae	Zapada	97	
Plecoptera	Peltoperlidae	Yoraperla	133	
Plecoptera	Perlidae	Hesperoperla pacifica	29	
Trichoptera	Brachycentridae	Micrasema	25	
Trichoptera	Glossosomatidae	Glossosoma	219	
Trichoptera	Hydropsychidae	Arctopsyche	54	
Trichoptera	Hydropsychidae	Parapsyche	14	
Trichoptera	Limnephilidae	Ecclisomyia	14	
Trichoptera	Rhyacophilidae	Rhyacophila	244	
Trichoptera	Uenoidae	Neothremma	4	
Class: Ostracoda			7	

Total: 34 OTU taxa			5430 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 21 August 1987 at station S1:571, Corral Valley Creek, downstream from trail, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128306. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1956 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			136	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			384	
Class: Insecta				
Coleoptera	Elmidae		1570	
Diptera	Ceratopogonidae		25	
Diptera	Chironomidae		2355	
Diptera	Empididae		47	
Diptera	Psychodidae	Pericoma	47	
Diptera	Simuliidae		65	
Ephemeroptera	Ameletidae	Ameletus	7	
Ephemeroptera	Baetidae	Baetis	233	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	39	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	65	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	104	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	215	
Ephemeroptera	Heptageniidae	Cinygmula	129	
Ephemeroptera	Heptageniidae	Epeorus	14	
Ephemeroptera	Heptageniidae	Rhithrogena	32	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	416	
Plecoptera	Capniidae		14	
Plecoptera	Chloroperlidae		90	
Plecoptera	Nemouridae	Zapada	32	
Plecoptera	Peltoperlidae	Yoraperla	305	
Plecoptera	Perlodidae	Isoperla	7	
Plecoptera	Pteronarcyidae	Pteronarcella regularis	14	
Trichoptera	Apataniidae	Apatania	7	
Trichoptera	Brachycentridae	Brachycentrus	14	
Trichoptera	Brachycentridae	Micrasema	39	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Hydropsychidae	Arctopsyche	25	
Trichoptera	Hydropsychidae	Cheumatopsyche	14	
Trichoptera	Hydropsychidae	Hydropsyche	272	
Trichoptera	Rhyacophilidae	Rhyacophila	72	
Class: Maxillopoda, subclass copepoda			65	
Class: Ostracoda			129	
Phylum: Platyhelminthes				
Class: Turbellaria			14	

Total: 36 OTU taxa			7011 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 20 August 1987 at station S2:467, Coyote Valley Creek, downstream from crossing, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128307. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 2044 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			29	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			118	
Class: Insecta				
Coleoptera	Elmidae		505	
Diptera	Ceratopogonidae		75	
Diptera	Chironomidae		1366	
Diptera	Dixidae		14	
Diptera	Psychodidae	Pericoma	577	
Diptera	Simuliidae		36	
Diptera	Tipulidae	Hexatoma	36	
Ephemeroptera	Baetidae	Baetis	186	
Ephemeroptera	Ephemerellidae	Attenella margarita	778	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	36	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	118	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	39	
Ephemeroptera	Heptageniidae	Cinygmula	118	
Ephemeroptera	Heptageniidae	Epeorus	14	
Ephemeroptera	Heptageniidae	Rhithrogena	244	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	186	
Plecoptera			4	
Plecoptera	Chloroperlidae		1237	
Plecoptera	Nemouridae	Zapada	25	
Plecoptera	Peltoperlidae	Yoraperla	1419	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Hesperoperla pacifica	7	
Plecoptera	Perlodidae	Skwala americana	22	
Trichoptera	Brachycentridae	Micrasema	7	
Trichoptera	Rhyacophilidae	Rhyacophila	43	
Class: Ostracoda			61	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	14	

Total: 30 OTU taxa			7326 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 20 August 1987 at station S3:500, Coyote Valley Creek, upstream from large meadow rock, Sta. 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128308. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1302 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			32	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			183	
Class: Insecta				
Coleoptera	Elmidae		753	
Diptera	Ceratopogonidae		39	
Diptera	Chironomidae		1047	
Diptera	Psychodidae	Pericoma	82	
Diptera	Simuliidae		82	
Diptera	Tipulidae	Dicranota	7	
Diptera	Tipulidae	Hexatoma	22	
Ephemeroptera	Baetidae	Baetis	32	
Ephemeroptera	Ephemerellidae	Drunella doddsi	32	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	75	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	4	
Ephemeroptera	Heptageniidae	Cinygmula	262	
Ephemeroptera	Heptageniidae	Rhithrogena	14	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	771	
Plecoptera	Chloroperlidae		530	
Plecoptera	Nemouridae	Zapada	65	
Plecoptera	Peltoperlidae	Yoraperla	538	
Trichoptera			7	
Trichoptera	Rhyacophilidae	Rhyacophila	72	
Class: Ostracoda			4	
Phylum: Nemata			14	

Total: 23 OTU taxa			4667 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 20 August 1987 at station S5:NOMAP, Coyote Creek, top of upper meadow, Station 5, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128309. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1520 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			168	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			330	
Class: Insecta				
Coleoptera	Elmidae		358	
Diptera	Ceratopogonidae		165	
Diptera	Chironomidae		495	
Diptera	Empididae		11	
Diptera	Psychodidae	Pericoma	1315	
Diptera	Simuliidae		183	
Diptera	Tipulidae	Antocha	7	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Ameletidae	Ameletus	7	
Ephemeroptera	Baetidae	Baetis	65	
Ephemeroptera	Ephemerellidae	Attenella margarita	158	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	72	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	25	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	29	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	36	
Ephemeroptera	Heptageniidae	Cinygmula	47	
Ephemeroptera	Heptageniidae	Epeorus	4	
Ephemeroptera	Heptageniidae	Rhithrogena	65	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	54	
Plecoptera	Capniidae		14	
Plecoptera	Chloroperlidae		287	
Plecoptera	Leuctridae		7	
Plecoptera	Nemouridae		7	
Plecoptera	Nemouridae	Zapada	14	
Plecoptera	Peltoperlidae	Yoraperla	961	
Plecoptera	Perlidae		14	
Plecoptera	Perlidae	Doroneuria baumanni	14	
Plecoptera	Perlidae	Hesperoperla pacifica	25	
Trichoptera	Glossosomatidae	Glossosoma	161	
Trichoptera	Hydropsychidae	Arctopsyche	7	
Trichoptera	Lepidostomatidae	Lepidostoma	7	
Trichoptera	Polycentropodidae	Polycentropus	115	
Trichoptera	Rhyacophilidae	Rhyacophila	104	
Class: Maxillopoda, subclass copepoda			7	
Class: Ostracoda			57	
Phylum: Nemata			32	
Phylum: Platyhelminthes			4	

Total: 40 OTU taxa			5448 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 26 July 1991 at station S1:250, Four-mile Canyon Creek, middle meadow, Station 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128310. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 424 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			72	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	487	
Diptera	Ceratopogonidae	Bezzia	29	
Diptera	Chironomidae		280	
Diptera	Empididae	Chelifera	11	
Diptera	Pelecorhynchidae	Glutops	25	
Diptera	Simuliidae		143	
Diptera	Tipulidae	Antocha	4	
Ephemeroptera	Baetidae	Baetis	151	
Ephemeroptera	Ephemerellidae	Attenella delantala	11	
Ephemeroptera	Ephemerellidae	Drunella doddsi	79	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	29	
Ephemeroptera	Heptageniidae	Cinygmula	36	
Ephemeroptera	Heptageniidae	Epeorus	14	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	7	
Plecoptera	Chloroperlidae		11	
Plecoptera	Chloroperlidae	Sweltsa	7	
Plecoptera	Leuctridae		4	
Plecoptera	Peltoperlidae	Yoraperla	39	
Plecoptera	Perlodidae	Isoperla	7	
Plecoptera	Perlodidae	Kogotus	4	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Limnephilidae		7	
Trichoptera	Limnephilidae	Ecclisomyia	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	22	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	18	
Class: Ostracoda			4	

Total: 30 OTU taxa			1520 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 28 August 1991 at station S1:250, Four-mile Canyon Creek, middle meadow, Station 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128311. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 718 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			11	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			125	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	724	
Diptera			4	
Diptera	Chironomidae		391	
Diptera	Pelecorhynchidae	Glutops	36	
Diptera	Psychodidae	Pericoma	355	
Diptera	Simuliidae		22	
Diptera	Tipulidae	Dicranota	4	
Diptera	Tipulidae	Hexatoma	11	
Ephemeroptera	Baetidae	Baetis	222	
Ephemeroptera	Ephemerellidae	Attenella delantala	204	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	7	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	11	
Ephemeroptera	Ephemerellidae	Drunella doddsi	97	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	14	
Ephemeroptera	Heptageniidae	Cinygmula	61	
Ephemeroptera	Heptageniidae	Epeorus	11	
Ephemeroptera	Heptageniidae	Heptagenia	29	
Ephemeroptera	Heptageniidae	Rhithrogena	7	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	25	
Plecoptera	Chloroperlidae	Sweltsa	29	
Plecoptera	Nemouridae	Zapada	11	
Plecoptera	Peltoperlidae	Yoraperla	93	
Plecoptera	Perlodidae	Kogotus	4	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Philopotamidae	Dolophilodes	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	14	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	7	
Class: Maxillopoda, subclass copepoda			4	
Class: Ostracoda			25	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	

Total: 34 OTU taxa			2573 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 25 July 1991 at station S2:640, Silver King Creek, lower exclosure near Cow Cabin, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128312. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 404 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			50	
Class: Insecta				
Coleoptera	Carabidae		4	
Coleoptera	Dytiscidae	Laccophilus	4	
Coleoptera	Elmidae	Zaitzevia	186	
Diptera	Ceratopogonidae	Bezzia	4	
Diptera	Chironomidae		222	
Diptera	Empididae	Chelifera	14	
Diptera	Simuliidae		4	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera	Ameletidae	Ameletus	22	
Ephemeroptera	Baetidae	Baetis	409	
Ephemeroptera	Ephemerellidae	Attenella delantala	57	
Ephemeroptera	Ephemerellidae	Drunella doddsi	11	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	47	
Ephemeroptera	Heptageniidae	Cinygmula	43	
Ephemeroptera	Heptageniidae	Epeorus	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Megaloptera	Sialidae	Sialis	4	
Plecoptera			4	
Plecoptera	Capniidae		7	
Plecoptera	Chloroperlidae		32	
Plecoptera	Chloroperlidae	Sweltsa	14	
Plecoptera	Peltoperlidae	Yoraperla	29	
Plecoptera	Perlidae	Calineuria californica	4	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Hydropsychidae	Hydropsyche	4	
Trichoptera	Limnephilidae	Ecclisomyia	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	29	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	36	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			4	
Phylum: Platyhelminthes				
Class: Turbellaria			172	

Total: 35 OTU taxa			1448 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 25 July 1991 at station S3:641, Silver King Creek, near middle exclosure, Station 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128313. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 737 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			104	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	369	
Diptera	Chironomidae		509	
Diptera	Empididae	Chelifera	4	
Diptera	Simuliidae		72	
Diptera	Tipulidae	Antocha	14	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Baetidae	Baetis	699	
Ephemeroptera	Ephemerellidae	Attenella delantala	22	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	143	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	39	
Ephemeroptera	Ephemerellidae	Serratella tibialis	4	
Ephemeroptera	Heptageniidae	Cinygmula	57	
Ephemeroptera	Heptageniidae	Epeorus	14	
Ephemeroptera	Heptageniidae	Heptagenia	14	
Ephemeroptera	Heptageniidae	Rhithrogena	14	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	36	
Plecoptera	Chloroperlidae		36	
Plecoptera	Chloroperlidae	Sweltsa	43	
Plecoptera	Nemouridae		14	
Plecoptera	Nemouridae	Zapada oregonensis	29	
Plecoptera	Peltoperlidae	Yoraperla	244	
Plecoptera	Perlodidae	Isoperla	11	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Brachycentridae	Micrasema	11	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Lepidostomatidae	Lepidostoma	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	47	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	25	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	43	

Total: 32 OTU taxa			2642 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 25 July 1991 at station S3:S3A, Silver King Creek, near exclosure, Station 3A, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128314. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 169 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			29	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	133	
Diptera	Ceratopogonidae	Bezzia	4	
Diptera	Chironomidae		133	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Baetidae	Baetis	129	
Ephemeroptera	Ephemerellidae	Attenella delantala	11	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	29	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	22	
Ephemeroptera	Heptageniidae	Cinygmula	11	
Ephemeroptera	Heptageniidae	Epeorus	7	
Ephemeroptera	Heptageniidae	Heptagenia	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	11	
Plecoptera	Chloroperlidae		29	
Plecoptera	Nemouridae	Zapada oregonensis	4	
Plecoptera	Peltoperlidae	Yoraperla	22	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	14	

Total: 20 OTU taxa			606 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 26 July 1991 at station S7:775, Silver King Creek, 300 yds upstream from 4-Mile Creek, Sta 7, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128315. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 174 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			61	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	25	
Diptera	Ceratopogonidae	Bezzia	11	
Diptera	Chironomidae		168	
Diptera	Empididae		4	
Diptera	Empididae	Chelifera	11	
Diptera	Pelecorhynchidae	Glutops	14	
Diptera	Simuliidae		4	
Diptera	Tipulidae	Hexatoma	11	
Ephemeroptera	Baetidae	Baetis	29	
Ephemeroptera	Ephemerellidae	Attenella delantala	39	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	7	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	4	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	61	
Ephemeroptera	Heptageniidae	Cinygmula	39	
Ephemeroptera	Heptageniidae	Epeorus	36	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera			4	
Plecoptera	Chloroperlidae		22	
Plecoptera	Chloroperlidae	Sweltsa	4	
Plecoptera	Leuctridae		4	
Plecoptera	Nemouridae	Zapada oregonensis	11	
Plecoptera	Peltoperlidae	Yoraperla	7	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	29	
Class: Ostracoda			7	

Total: 28 OTU taxa			624 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 26 July 1991 at station S8:813, Silver King Creek, upstream from Fly Valley Creek, Station 8, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128316. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 263 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			86	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	47	
Diptera	Ceratopogonidae	Bezzia	22	
Diptera	Chironomidae		254	
Diptera	Empididae		4	
Diptera	Empididae	Chelifera	11	
Diptera	Pelecorhynchidae	Glutops	29	
Diptera	Simuliidae		11	
Diptera	Tipulidae	Antocha	7	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Baetidae	Baetis	129	
Ephemeroptera	Ephemerellidae	Attenella delantala	72	
Ephemeroptera	Ephemerellidae	Drunella doddsi	4	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	11	
Ephemeroptera	Heptageniidae	Cinygmula	25	
Ephemeroptera	Heptageniidae	Epeorus	18	
Ephemeroptera	Heptageniidae	Heptagenia	4	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera			7	
Plecoptera	Chloroperlidae		4	
Plecoptera	Chloroperlidae	Suwallia	4	
Plecoptera	Chloroperlidae	Sweltsa	14	
Plecoptera	Leuctridae		4	
Plecoptera	Nemouridae	Podmosta	4	
Plecoptera	Peltoperlidae	Yoraperla	11	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Calineuria californica	4	
Plecoptera	Perlodidae	Isoperla	4	
Plecoptera	Pteronarcyidae	Pteronarcella regularis	4	
Trichoptera			4	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila coloradensis	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	43	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	47	
Class: Ostracoda			4	
Phylum: Nemata			22	
Phylum: Platyhelminthes				
Class: Turbellaria			4	

Total: 41 OTU taxa			943 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 29 August 1991 at station S2:640, Silver King Creek, lower exclosure near Cow Cabin, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128317. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 187 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			50	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	165	
Diptera	Ceratopogonidae	Bezzia	7	
Diptera	Chironomidae		136	
Diptera	Empididae	Chelifera	22	
Diptera	Psychodidae	Pericoma	151	
Diptera	Simuliidae		4	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera	Baetidae	Baetis	4	
Ephemeroptera	Ephemerellidae	Attenella delantala	39	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	4	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	11	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	4	
Ephemeroptera	Heptageniidae	Heptagenia	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	14	
Plecoptera			4	
Plecoptera	Chloroperlidae		4	
Plecoptera	Peltoperlidae	Yoraperla	4	
Trichoptera			4	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	22	
Phylum: Nemata			4	
Phylum: Platyhelminthes				
Class: Turbellaria			4	

Total: 24 OTU taxa			670	individuals

Taxonomic list and abundances of aquatic invertebrates collected 29 August 1991 at station S3:641, Silver King Creek, near middle exclosure, Station 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128318. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 495 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			14	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			79	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	341	
Diptera	Ceratopogonidae	Bezzia	25	
Diptera	Chironomidae		588	
Diptera	Empididae	Chelifera	25	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	319	
Diptera	Tipulidae	Hexatoma	11	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	14	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	11	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	32	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	93	
Ephemeroptera	Ephemerellidae	Serratella tibialis	7	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	111	
Plecoptera			14	
Plecoptera	Chloroperlidae		4	
Plecoptera	Nemouridae	Zapada	4	
Plecoptera	Peltoperlidae	Yoraperla	22	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Lepidostomatidae	Lepidostoma	4	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	14	
Class: Maxillopoda, subclass copepoda			7	
Class: Ostracoda			14	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			4	

Total: 28 OTU taxa			1774 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 28 August 1991 at station S7:775, Silver King Creek, 300 yds upstream from 4-Mile Creek, Sta 7, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128319. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1006 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			315	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	29	
Diptera	Ceratopogonidae	Bezzia	29	
Diptera	Chironomidae		1835	
Diptera	Pelecorhynchidae	Glutops	7	
Diptera	Psychodidae	Pericoma	882	
Diptera	Tipulidae	Hexatoma	29	
Ephemeroptera	Ameletidae	Ameletus	7	
Ephemeroptera	Ephemerellidae	Attenella delantala	104	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	25	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	25	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	54	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	79	
Ephemeroptera	Heptageniidae	Cinygmula	7	
Plecoptera			7	
Plecoptera	Chloroperlidae	Sweltsa	14	
Plecoptera	Nemouridae	Zapada cinctipes	7	
Plecoptera	Peltoperlidae	Yoraperla	54	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	32	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	11	
Class: Ostracoda			36	

Total: 24 OTU taxa			3606 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 25 July 1991 at station S6:738, Silver King Creek, upper meadow upstream from cabin, Sta. 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128320. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 953 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			183	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	219	
Diptera	Ceratopogonidae	Bezzia	7	
Diptera	Chironomidae		609	
Diptera	Empididae	Chelifera	7	
Diptera	Simuliidae		82	
Diptera	Tipulidae	Antocha	54	
Diptera	Tipulidae	Hexatoma	7	
Diptera	Tipulidae	Tipula	4	
Ephemeroptera	Baetidae	Baetis	1072	
Ephemeroptera	Ephemerellidae	Attenella delantala	43	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	32	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	47	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	68	
Ephemeroptera	Ephemerellidae	Serratella tibialis	11	
Ephemeroptera	Heptageniidae	Cinygmula	65	
Ephemeroptera	Heptageniidae	Epeorus	39	
Ephemeroptera	Heptageniidae	Heptagenia	22	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	165	
Plecoptera	Chloroperlidae		29	
Plecoptera	Chloroperlidae	Plumiperla diversa	7	
Plecoptera	Nemouridae	Zapada	39	
Plecoptera	Nemouridae	Zapada cinctipes	32	
Plecoptera	Peltoperlidae	Yoraperla	405	
Trichoptera	Brachycentridae	Brachycentrus americanus	11	
Trichoptera	Brachycentridae	Micrasema	32	
Trichoptera	Glossosomatidae	Glossosoma	25	
Trichoptera	Lepidostomatidae	Lepidostoma	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	7	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	32	
Class: Ostracoda			32	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			7	

Total: 35 OTU taxa			3416 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 29 August 1991 at station S6:738, Silver King Creek, upper meadow upstream from cabin, Sta. 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128321. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 343 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			61	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			158	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	151	
Diptera	Ceratopogonidae	Bezzia	29	
Diptera	Chironomidae		430	
Diptera	Psychodidae	Pericoma	147	
Diptera	Tipulidae	Tipula	4	
Ephemeroptera	Ephemerellidae		4	
Ephemeroptera	Ephemerellidae	Attenella delantala	93	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	7	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	7	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	14	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	50	
Plecoptera			7	
Plecoptera	Chloroperlidae		4	
Plecoptera	Peltoperlidae	Yoraperla	14	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	11	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	4	
Class: Maxillopoda, subclass copepoda			4	
Class: Ostracoda			14	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			4	

Total: 24 OTU taxa			1229 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 28 August 1991 at station S8:813, Silver King Creek, upstream from Fly Valley Creek, Station 8, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128322. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 374 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			22	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			57	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	54	
Diptera	Ceratopogonidae	Bezzia	14	
Diptera	Chironomidae		437	
Diptera	Empididae	Chelifera	11	
Diptera	Pelecorhynchidae	Glutops	14	
Diptera	Psychodidae	Pericoma	509	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera	Baetidae	Baetis	4	
Ephemeroptera	Ephemerellidae		32	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	14	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	25	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera			4	
Plecoptera	Capniidae		4	
Plecoptera	Chloroperlidae		7	
Plecoptera	Chloroperlidae	Plumiperla diversa	11	
Trichoptera			4	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	29	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	47	
Phylum: Nemata			11	
Phylum: Platyhelminthes				
Class: Turbellaria			7	

Total: 26 OTU taxa			1341 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 7 August 1992 at station S1:250, Four-mile Canyon Creek, middle meadow, Station 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128323. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1858 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		254	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			151	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	369	
Diptera	Ceratopogonidae	Bezzia	90	
Diptera	Chironomidae		25	
Diptera	Chironomidae		222	
Diptera	Chironomidae	Orthocladiinae	1104	
Diptera	Empididae	Chelifera	65	
Diptera	Psychodidae	Pericoma	828	
Diptera	Simuliidae	Simulium	25	
Diptera	Tipulidae	Hexatoma	14	
Ephemeroptera	Ameletidae	Ameletus	14	
Ephemeroptera	Baetidae	Baetis	971	
Ephemeroptera	Ephemerellidae	Attenella delantala	237	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	129	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	505	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	896	
Ephemeroptera	Heptageniidae	Cinygmula	201	
Ephemeroptera	Heptageniidae	Epeorus	25	
Ephemeroptera	Heptageniidae	Rhithrogena	111	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	47	
Plecoptera			72	
Plecoptera	Chloroperlidae	Suwallia	90	
Plecoptera	Chloroperlidae	Sweltsa	14	
Plecoptera	Nemouridae	Zapada oregonensis	25	
Plecoptera	Perlodidae		25	
Plecoptera	Perlodidae	Isoperla	25	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Brachycentridae	Brachycentrus americanus	14	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	25	
Class: Maxillopoda, subclass copepoda			11	
Class: Ostracoda			14	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	7	
Phylum: Nemata			39	

Total: 35 OTU taxa			6660 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 September 1992 at station S1:250, Four-mile Canyon Creek, middle meadow, Station 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128324. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1290 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		165	
Lumbriculida	Lumbriculidae		4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			82	
Class: Insecta				
Coleoptera	Elmidae	Optioservus	785	
Diptera	Ceratopogonidae	Bezzia	25	
Diptera	Chironomidae		57	
Diptera	Chironomidae		176	
Diptera	Chironomidae	Orthocladiinae	1703	
Diptera	Psychodidae	Pericoma	509	
Diptera	Simuliidae		25	
Diptera	Tipulidae	Antocha	7	
Diptera	Tipulidae	Hexatoma	14	
Ephemeroptera	Ameletidae	Ameletus	7	
Ephemeroptera	Baetidae	Baetis	333	
Ephemeroptera	Ephemerellidae	Attenella delantala	111	
Ephemeroptera	Ephemerellidae	Drunella doddsi	82	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	29	
Ephemeroptera	Heptageniidae	Cinygmula	129	
Ephemeroptera	Heptageniidae	Epeorus	7	
Ephemeroptera	Heptageniidae	Heptagenia	32	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	7	
Plecoptera	Chloroperlidae	Suwallia	39	
Plecoptera	Nemouridae	Zapada oregonensis	32	
Plecoptera	Peltoperlidae	Yoraperla	104	
Plecoptera	Perlidae		7	
Plecoptera	Perlodidae		7	
Plecoptera	Taeniopterygidae	Taenionema	14	
Trichoptera			7	
Trichoptera	Limnephilidae		7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	32	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	4	
Class: Ostracoda			79	

Total: 32 OTU taxa			4624 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 7 August 1992 at station S2:640, Silver King Creek, lower exclosure near Cow Cabin, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128325. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1352 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			151	
Class: Insecta				
Coleoptera	Elmidae	Optioservus	1082	
Diptera	Ceratopogonidae	Bezzia	14	
Diptera	Chironomidae	Orthocladiinae	1265	
Diptera	Empididae	Chelifera	14	
Diptera	Pelecorhynchidae	Glutops	57	
Diptera	Psychodidae	Pericoma	649	
Diptera	Simuliidae		47	
Diptera	Tipulidae	Hexatoma	14	
Ephemeroptera	Baetidae	Baetis	330	
Ephemeroptera	Ephemerellidae	Attenella delantala	104	
Ephemeroptera	Ephemerellidae	Drunella doddsi	194	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	72	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	72	
Ephemeroptera	Heptageniidae	Cinygmula	111	
Ephemeroptera	Heptageniidae	Epeorus	39	
Ephemeroptera	Heptageniidae	Heptagenia	47	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	14	
Plecoptera			7	
Plecoptera	Chloroperlidae	Suwallia	32	
Plecoptera	Leuctridae		7	
Plecoptera	Nemouridae	Zapada oregonensis	90	
Plecoptera	Peltoperlidae	Yoraperla	233	
Trichoptera			14	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	47	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	7	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	32	
Class: Ostracoda			72	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	14	

Total: 31 OTU taxa			4846 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 7 August 1992 at station S3:641, Silver King Creek, near middle exclosure, Station 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128326. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1261 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		32	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			208	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	609	
Diptera	Ceratopogonidae	Bezzia	65	
Diptera	Chironomidae		7	
Diptera	Chironomidae		358	
Diptera	Chironomidae	Orthocladiinae	609	
Diptera	Empididae	Chelifera	82	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	584	
Diptera	Simuliidae		151	
Diptera	Tipulidae	Antocha	39	
Diptera	Tipulidae	Hexatoma	14	
Ephemeroptera	Baetidae	Baetis	584	
Ephemeroptera	Ephemerellidae	Attenella delantala	7	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	47	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	194	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	369	
Ephemeroptera	Heptageniidae	Epeorus	72	
Ephemeroptera	Heptageniidae	Heptagenia	25	
Ephemeroptera	Leptohyphidae	Tricorythodes minutus	7	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	32	
Plecoptera	Capniidae		14	
Plecoptera	Chloroperlidae	Suwallia	129	
Plecoptera	Nemouridae	Zapada oregonensis	25	
Plecoptera	Perlodidae		39	
Plecoptera	Perlodidae	Skwala americana	4	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Brachycentridae	Brachycentrus americanus	7	
Trichoptera	Brachycentridae	Micrasema	7	
Trichoptera	Hydropsychidae	Arctopsyche grandis	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	57	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	25	
Class: Maxillopoda, subclass copepoda			7	
Class: Ostracoda			79	

Total: 37 OTU taxa			4520 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 7 August 1992 at station S6:738, Silver King Creek, upper meadow upstream from cabin, Sta. 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128327. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1138 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			108	
Class: Insecta				
Coleoptera	Carabidae		4	
Coleoptera	Elmidae	Zaitzevia	380	
Diptera	Ceratopogonidae	Bezzia	32	
Diptera	Chironomidae	Orthocladiinae	1366	
Diptera	Chironomidae	Tanypodinae	29	
Diptera	Empididae	Chelifera	22	
Diptera	Psychodidae	Pericoma	254	
Diptera	Simuliidae		7	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Ameletidae	Ameletus	7	
Ephemeroptera	Baetidae	Baetis	900	
Ephemeroptera	Ephemerellidae	Attenella delantala	143	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	68	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	97	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	183	
Ephemeroptera	Ephemerellidae	Serratella tibialis	7	
Ephemeroptera	Heptageniidae	Cinygmula	57	
Ephemeroptera	Heptageniidae	Epeorus	39	
Ephemeroptera	Heptageniidae	Heptagenia	129	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	39	
Plecoptera	Chloroperlidae		7	
Plecoptera	Chloroperlidae	Suwallia	25	
Plecoptera	Nemouridae	Zapada cinctipes	7	
Plecoptera	Nemouridae	Zapada oregonensis	14	
Plecoptera	Peltoperlidae	Yoraperla	7	
Plecoptera	Perlidae		7	
Plecoptera	Perlodidae	Skwala americana	4	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	7	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	11	
Class: Maxillopoda, subclass copepoda			7	
Class: Ostracoda			75	

Total: 36 OTU taxa			4079 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 6 August 1992 at station S7:775, Silver King Creek, 300 yds upstream from 4-Mile Creek, Sta 7, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128328. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1516 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			161	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	201	
Diptera	Ceratopogonidae	Bezzia	14	
Diptera	Chironomidae		14	
Diptera	Chironomidae		43	
Diptera	Chironomidae	Orthocladiinae	2111	
Diptera	Chironomidae	Tanypodinae	39	
Diptera	Empididae	Chelifera	25	
Diptera	Empididae	Hemerodromia	7	
Diptera	Pelecorhynchidae	Glutops	14	
Diptera	Psychodidae	Pericoma	910	
Diptera	Simuliidae		32	
Diptera	Tipulidae	Hexatoma	25	
Ephemeroptera	Baetidae	Baetis	584	
Ephemeroptera	Ephemerellidae		11	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	140	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	351	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	90	
Ephemeroptera	Heptageniidae	Cinygmula	140	
Ephemeroptera	Heptageniidae	Epeorus	25	
Ephemeroptera	Heptageniidae	Heptagenia	61	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	14	
Plecoptera			14	
Plecoptera	Chloroperlidae	Suwallia	161	
Plecoptera	Chloroperlidae	Sweltsa	7	
Plecoptera	Nemouridae		14	
Plecoptera	Nemouridae	Zapada cinctipes	14	
Plecoptera	Nemouridae	Zapada oregonensis	7	
Plecoptera	Perlodidae	Kogotus	25	
Plecoptera	Perlodidae	Skwala americana	4	
Trichoptera	Glossosomatidae	Glossosoma	11	
Trichoptera	Hydropsychidae	Arctopsyche grandis	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	14	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	68	
Class: Ostracoda			57	
Phylum: Nemata			7	

Total: 37 OTU taxa			5434 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 6 August 1992 at station S8:813, Silver King Creek, upstream from Fly Valley Creek, Station 8, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128329. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 797 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		18	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			75	
Class: Insecta				
Coleoptera	Elmidae	Optioservus	75	
Diptera	Ceratopogonidae	Bezzia	25	
Diptera	Chironomidae		65	
Diptera	Chironomidae		179	
Diptera	Chironomidae	Orthocladiinae	649	
Diptera	Chironomidae	Tanypodinae	11	
Diptera	Empididae	Chelifera	18	
Diptera	Pelecorhynchidae	Glutops	72	
Diptera	Psychodidae	Pericoma	473	
Diptera	Simuliidae		11	
Diptera	Tipulidae	Antocha	7	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	373	
Ephemeroptera	Ephemerellidae		4	
Ephemeroptera	Ephemerellidae	Attenella delantala	54	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	111	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	68	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	100	
Ephemeroptera	Heptageniidae	Cinygmula	43	
Ephemeroptera	Heptageniidae	Epeorus	22	
Ephemeroptera	Heptageniidae	Heptagenia	25	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	14	
Plecoptera			14	
Plecoptera	Chloroperlidae	Suwallia	57	
Plecoptera	Nemouridae	Zapada cinctipes	4	
Plecoptera	Perlodidae		4	
Trichoptera			7	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	90	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	29	
Class: Ostracoda			97	
Phylum: Nemata			11	
Phylum: Platyhelminthes				
Class: Turbellaria			29	

Total: 39 OTU taxa			2857 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 September 1992 at station S2:640, Silver King Creek, lower exclosure near Cow Cabin, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128330. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1089 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			93	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	860	
Diptera	Ceratopogonidae	Bezzia	25	
Diptera	Chironomidae		4	
Diptera	Chironomidae	Orthocladiinae	373	
Diptera	Chironomidae	Tanypodinae	36	
Diptera	Empididae	Chelifera	72	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	1563	
Diptera	Simuliidae		4	
Diptera	Tipulidae	Hexatoma	39	
Ephemeroptera	Baetidae	Baetis	7	
Ephemeroptera	Ephemerellidae	Attenella delantala	505	
Ephemeroptera	Ephemerellidae	Drunella doddsi	14	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	61	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	125	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	32	
Plecoptera	Chloroperlidae	Suwallia	22	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	4	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	39	
Class: Maxillopoda, subclass copepoda			4	
Class: Ostracoda			11	

Total: 23 OTU taxa			3903 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 September 1992 at station S3:641, Silver King Creek, near middle exclosure, Station 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128331. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1122 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		14	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			43	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	441	
Diptera	Ceratopogonidae	Bezzia	72	
Diptera	Chironomidae		452	
Diptera	Chironomidae	Orthocladiinae	828	
Diptera	Chironomidae	Tanypodinae	22	
Diptera	Empididae	Chelifera	11	
Diptera	Psychodidae	Pericoma	749	
Diptera	Simuliidae		7	
Diptera	Tipulidae	Antocha	11	
Diptera	Tipulidae	Hexatoma	14	
Ephemeroptera	Baetidae	Baetis	4	
Ephemeroptera	Ephemerellidae	Attenella delantala	251	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	43	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	4	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	97	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	581	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	143	
Plecoptera	Chloroperlidae	Suwallia	4	
Plecoptera	Leuctridae		4	
Plecoptera	Peltoperlidae	Yoraperla	7	
Trichoptera	Apataniidae	Pedomoecus sierra	11	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Lepidostomatidae	Lepidostoma	11	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	22	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	7	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	4	
Class: Maxillopoda, subclass copepoda			11	
Class: Ostracoda			79	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	25	
Phylum: Nemata			32	

Total: 32 OTU taxa			4022 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 September 1992 at station S6:738, Silver King Creek, upper meadow upstream from cabin, Sta. 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128332. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1038 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			262	
Class: Insecta				
Coleoptera	Elmidae	Optioservus	262	
Diptera	Ceratopogonidae	Bezzia	129	
Diptera	Chironomidae		11	
Diptera	Chironomidae		176	
Diptera	Chironomidae	Orthocladiinae	756	
Diptera	Pelecorhynchidae	Glutops	14	
Diptera	Psychodidae	Pericoma	1287	
Diptera	Simuliidae		7	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	4	
Ephemeroptera	Ephemerellidae	Attenella delantala	444	
Ephemeroptera	Ephemerellidae	Drunella doddsi	43	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	125	
Ephemeroptera	Heptageniidae	Epeorus	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	7	
Plecoptera	Capniidae		7	
Plecoptera	Chloroperlidae	Suwallia	29	
Plecoptera	Nemouridae	Zapada cinctipes	4	
Plecoptera	Nemouridae	Zapada oregonensis	7	
Plecoptera	Peltoperlidae	Yoraperla	25	
Trichoptera			4	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Hydropsychidae	Arctopsyche grandis	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	11	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	4	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	4	
Class: Ostracoda			72	

Total: 30 OTU taxa			3720 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 September 1992 at station S7:775, Silver King Creek, 300 yds upstream from 4-Mile Creek, Sta 7, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128333. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1233 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			430	
Class: Insecta				
Coleoptera	Elmidae	Optioservus	118	
Coleoptera	Elmidae	Zaitzevia	151	
Diptera	Ceratopogonidae	Bezzia	11	
Diptera	Chironomidae		233	
Diptera	Chironomidae	Orthocladiinae	548	
Diptera	Chironomidae	Tanypodinae	39	
Diptera	Empididae		7	
Diptera	Empididae	Chelifera	7	
Diptera	Pelecorhynchidae	Glutops	32	
Diptera	Psychodidae	Pericoma	1577	
Diptera	Tipulidae	Hexatoma	39	
Ephemeroptera	Ephemerellidae	Attenella delantala	143	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	39	
Ephemeroptera	Ephemerellidae	Drunella doddsi	82	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	197	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	297	
Ephemeroptera	Heptageniidae	Heptagenia	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	54	
Plecoptera	Chloroperlidae	Suwallia	25	
Plecoptera	Nemouridae	Zapada oregonensis	32	
Plecoptera	Peltoperlidae	Yoraperla	4	
Trichoptera	Brachycentridae	Brachycentrus americanus	7	
Trichoptera	Glossosomatidae	Glossosoma	14	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	229	
Class: Ostracoda			79	
Phylum: Nemata			14	

Total: 28 OTU taxa			4419 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 September 1992 at station S8:813, Silver King Creek, upstream from Fly Valley Creek, Station 8, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128334. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 996 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		22	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			186	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	100	
Diptera	Ceratopogonidae	Bezzia	22	
Diptera	Chironomidae	Orthocladiinae	1204	
Diptera	Chironomidae	Tanypodinae	4	
Diptera	Empididae	Chelifera	7	
Diptera	Pelecorhynchidae	Glutops	32	
Diptera	Psychodidae	Pericoma	749	
Diptera	Simuliidae		11	
Diptera	Tipulidae	Hexatoma	14	
Ephemeroptera	Baetidae	Baetis	111	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	100	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	29	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	11	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	394	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	25	
Ephemeroptera	Heptageniidae	Epeorus	11	
Ephemeroptera	Heptageniidae	Heptagenia	29	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	7	
Plecoptera			32	
Plecoptera	Chloroperlidae	Suwallia	32	
Plecoptera	Nemouridae	Zapada oregonensis	11	
Plecoptera	Peltoperlidae	Yoraperla	7	
Trichoptera			7	
Trichoptera	Brachycentridae	Brachycentrus	4	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	22	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	158	
Class: Ostracoda			194	
Phylum: Platyhelminthes				
Class: Turbellaria			25	

Total: 30 OTU taxa			3570 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 17 September 1993 at station S1:250, Four-mile Canyon Creek, middle meadow, Station 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128335. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1506 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		14	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			111	
Class: Insecta				
Coleoptera	Elmidae		4	
Coleoptera	Elmidae	Optioservus	1086	
Diptera			7	
Diptera	Ceratopogonidae	Bezzia	29	
Diptera	Chironomidae		25	
Diptera	Chironomidae		25	
Diptera	Chironomidae	Orthocladiinae	1670	
Diptera	Dixidae	Dixa	7	
Diptera	Empididae	Chelifera	11	
Diptera	Pelecorhynchidae	Glutops	32	
Diptera	Psychodidae	Pericoma	606	
Diptera	Simuliidae		47	
Diptera	Tipulidae	Antocha	14	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Baetidae	Baetis	477	
Ephemeroptera	Ephemerellidae	Attenella delantala	57	
Ephemeroptera	Ephemerellidae	Drunella doddsi	276	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	61	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	79	
Ephemeroptera	Ephemerellidae	Serratella tibialis	7	
Ephemeroptera	Heptageniidae	Cinygmula	161	
Ephemeroptera	Heptageniidae	Epeorus	11	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	79	
Plecoptera			36	
Plecoptera	Capniidae		11	
Plecoptera	Chloroperlidae		65	
Plecoptera	Peltoperlidae	Yoraperla	97	
Plecoptera	Perlidae		39	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlodidae	Kogotus	7	
Trichoptera	Apataniidae	Pedomoecus sierra	14	
Trichoptera	Brachycentridae	Brachycentrus americanus	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	61	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	7	
Class: Ostracoda			104	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	25	
Phylum: Platyhelminthes				
Class: Turbellaria			22	

Total: 39 OTU taxa			5398 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 26 September 1993 at station S1:250, Four-mile Canyon Creek, middle meadow, Station 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128336. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 838 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		36	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			61	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	548	
Diptera	Ceratopogonidae	Bezzia	43	
Diptera	Chironomidae		68	
Diptera	Chironomidae		32	
Diptera	Chironomidae	Orthocladiinae	1054	
Diptera	Empididae	Chelifera	22	
Diptera	Pelecorhynchidae	Glutops	29	
Diptera	Psychodidae	Pericoma	409	
Diptera	Simuliidae		4	
Diptera	Tipulidae	Antocha	11	
Diptera	Tipulidae	Hexatoma	14	
Diptera	Tipulidae	Tipula	4	
Ephemeroptera	Baetidae	Baetis	183	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	4	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	82	
Ephemeroptera	Heptageniidae	Cinygmula	72	
Ephemeroptera	Heptageniidae	Heptagenia	39	
Plecoptera			14	
Plecoptera	Chloroperlidae		22	
Plecoptera	Peltoperlidae	Yoraperla	104	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Plecoptera	Perlodidae		7	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Brachycentridae	Brachycentrus americanus	11	
Trichoptera	Limnephilidae	Ecclisomyia	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	29	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	39	
Class: Ostracoda			14	
Phylum: Nemata			25	
Phylum: Platyhelminthes				
Class: Turbellaria			4	

Total: 33 OTU taxa			3004	individuals

Taxonomic list and abundances of aquatic invertebrates collected 17 September 1993 at station S2:640, Silver King Creek, lower exclosure near Cow Cabin, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128337. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 679 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		29	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			39	
Class: Insecta				
Coleoptera	Elmidae		104	
Coleoptera	Elmidae	Zaitzevia	183	
Diptera			7	
Diptera	Athericidae	Atherix pachypus	4	
Diptera	Ceratopogonidae	Bezzia	29	
Diptera	Chironomidae		36	
Diptera	Chironomidae	Orthocladiinae	305	
Diptera	Chironomidae	Tanypodinae	29	
Diptera	Empididae	Chelifera	57	
Diptera	Psychodidae	Pericoma	491	
Diptera	Simuliidae		4	
Diptera	Tipulidae	Antocha	7	
Diptera	Tipulidae	Hexatoma	18	
Ephemeroptera	Ameletidae	Ameletus	18	
Ephemeroptera	Baetidae	Baetis	405	
Ephemeroptera	Ephemerellidae		14	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	29	
Ephemeroptera	Ephemerellidae	Drunella doddsi	50	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	65	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	100	
Ephemeroptera	Heptageniidae	Cinygmula	7	
Ephemeroptera	Heptageniidae	Epeorus	61	
Ephemeroptera	Heptageniidae	Rhithrogena	7	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	14	
Plecoptera			22	
Plecoptera	Chloroperlidae		57	
Plecoptera	Nemouridae		4	
Plecoptera	Perlidae		4	
Trichoptera			7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	86	
Class: Ostracoda			90	
Phylum: Nemata			11	
Phylum: Platyhelminthes				
Class: Turbellaria			39	

Total: 36 OTU taxa			2434 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 26 September 1993 at station S2:640, Silver King Creek, lower exclosure near Cow Cabin, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128338. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 520 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		25	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			61	
Class: Insecta				
Coleoptera	Elmidae		4	
Coleoptera	Elmidae	Optioservus	7	
Coleoptera	Elmidae	Zaitzevia	315	
Diptera			4	
Diptera	Ceratopogonidae	Bezzia	72	
Diptera	Chironomidae		4	
Diptera	Chironomidae		43	
Diptera	Chironomidae	Orthocladiinae	412	
Diptera	Chironomidae	Tanypodinae	54	
Diptera	Empididae	Chelifera	194	
Diptera	Psychodidae	Pericoma	315	
Diptera	Simuliidae		7	
Diptera	Tipulidae	Hexatoma	22	
Ephemeroptera	Baetidae	Baetis	25	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	11	
Ephemeroptera	Ephemerellidae	Drunella doddsi	14	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	25	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	90	
Ephemeroptera	Heptageniidae	Cinygmula	22	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	7	
Plecoptera			11	
Plecoptera	Capniidae		4	
Plecoptera	Chloroperlidae		11	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Lepidostomatidae	Lepidostoma	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	25	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	11	
Class: Maxillopoda, subclass copepoda			11	
Class: Ostracoda			32	
Phylum: Nemata			14	

Total: 33 OTU taxa			1864 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 17 September 1993 at station S3:641, Silver King Creek, near middle exclosure, Station 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128339. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 569 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		36	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			29	
Class: Insecta				
Coleoptera	Elmidae		194	
Coleoptera	Elmidae	Zaitzevia	93	
Diptera	Ceratopogonidae	Bezzia	57	
Diptera	Chironomidae		75	
Diptera	Chironomidae	Orthocladiinae	208	
Diptera	Chironomidae	Tanypodinae	61	
Diptera	Empididae	Chelifera	18	
Diptera	Psychodidae	Pericoma	333	
Diptera	Simuliidae		18	
Diptera	Tipulidae	Hexatoma	25	
Ephemeroptera	Baetidae	Baetis	226	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	61	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	32	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	362	
Ephemeroptera	Heptageniidae	Cinygmula	39	
Ephemeroptera	Heptageniidae	Epeorus	29	
Ephemeroptera	Heptageniidae	Heptagenia	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	39	
Plecoptera			11	
Plecoptera	Chloroperlidae		18	
Plecoptera	Nemouridae	Zapada cinctipes	4	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	22	
Class: Ostracoda			7	
Phylum: Nemata			11	
Phylum: Platyhelminthes				
Class: Turbellaria			7	

Total: 31 OTU taxa			2039 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 26 September 1993 at station S3:641, Silver King Creek, near middle exclosure, Station 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128340. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 551 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		36	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			68	
Class: Insecta				
Coleoptera	Elmidae		57	
Coleoptera	Elmidae	Zaitzevia	172	
Diptera	Athericidae	Atherix pachypus	4	
Diptera	Ceratopogonidae	Bezzia	39	
Diptera	Chironomidae		22	
Diptera	Chironomidae		47	
Diptera	Chironomidae	Orthocladiinae	513	
Diptera	Chironomidae	Tanypodinae	11	
Diptera	Empididae	Hemerodromia	14	
Diptera	Psychodidae	Pericoma	380	
Diptera	Simuliidae		25	
Diptera	Tipulidae	Hexatoma	14	
Ephemeroptera	Baetidae	Baetis	25	
Ephemeroptera	Ephemerellidae	Drunella doddsi	14	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	4	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	39	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	143	
Ephemeroptera	Heptageniidae	Cinygmula	11	
Ephemeroptera	Heptageniidae	Epeorus	11	
Ephemeroptera	Leptohyphidae	Tricorythodes minutus	151	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	29	
Plecoptera			22	
Plecoptera	Capniidae		4	
Plecoptera	Chloroperlidae		11	
Plecoptera	Nemouridae	Zapada cinctipes	4	
Plecoptera	Peltoperlidae	Yoraperla	4	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	32	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	18	
Class: Maxillopoda, subclass copepoda			4	
Class: Ostracoda			29	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			11	
Phylum: Platyhelminthes				
Class: Turbellaria			4	

Total: 35 OTU taxa			1975 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 16 September 1993 at station S6:738, Silver King Creek, upper meadow upstream from cabin, Sta. 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128341. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1035 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		43	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			118	
Class: Insecta				
Coleoptera	Elmidae		39	
Coleoptera	Elmidae	Optioservus	308	
Diptera	Ceratopogonidae	Bezzia	186	
Diptera	Chironomidae		7	
Diptera	Chironomidae	Orthocladiinae	674	
Diptera	Empididae	Chelifera	4	
Diptera	Empididae	Hemerodromia	4	
Diptera	Ephydridae		7	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	1161	
Diptera	Simuliidae		29	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Baetidae	Baetis	287	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	161	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	97	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	7	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	79	
Ephemeroptera	Ephemerellidae	Serratella tibialis	25	
Ephemeroptera	Heptageniidae	Cinygmula	39	
Ephemeroptera	Heptageniidae	Epeorus	7	
Ephemeroptera	Heptageniidae	Rhithrogena	14	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	54	
Odonata	Coenagrionidae		4	
Plecoptera			82	
Plecoptera	Chloroperlidae		43	
Plecoptera	Nemouridae	Zapada cinctipes	7	
Plecoptera	Perlidae		11	
Trichoptera			7	
Trichoptera	Hydropsychidae	Hydropsyche	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	32	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	93	
Class: Ostracoda			36	
Phylum: Nemata			14	
Phylum: Platyhelminthes				
Class: Turbellaria			14	

Total: 36 OTU taxa			3710 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 25 September 1993 at station S6:738, Silver King Creek, upper meadow upstream from cabin, Sta. 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128342. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 191 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			79	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	125	
Diptera	Ceratopogonidae	Bezzia	39	
Diptera	Chironomidae		4	
Diptera	Chironomidae	Orthocladiinae	258	
Diptera	Empididae	Chelifera	7	
Diptera	Psychodidae	Maruina	4	
Diptera	Psychodidae	Pericoma	11	
Diptera	Simuliidae		14	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	4	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	4	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	4	
Plecoptera	Chloroperlidae		14	
Plecoptera	Peltoperlidae	Yoraperla	4	
Plecoptera	Perlidae		7	
Plecoptera	Perlodidae		4	
Trichoptera			4	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Hydropsychidae	Hydropsyche	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	29	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	39	
Class: Ostracoda			4	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			4	
Phylum: Platyhelminthes				
Class: Turbellaria			4	

Total: 27 OTU taxa			685 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 16 September 1993 at station S7:775, Silver King Creek, 300 yds upstream from 4-Mile Creek, Sta 7, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128343. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 750 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		32	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			82	
Class: Insecta				
Coleoptera	Elmidae		22	
Coleoptera	Elmidae	Zaitzevia	22	
Diptera			25	
Diptera	Ceratopogonidae	Bezzia	29	
Diptera	Chironomidae		47	
Diptera	Chironomidae		140	
Diptera	Chironomidae	Orthocladiinae	448	
Diptera	Empididae		7	
Diptera	Empididae	Chelifera	29	
Diptera	Pelecorhynchidae	Glutops	14	
Diptera	Psychodidae	Pericoma	391	
Diptera	Simuliidae		11	
Diptera	Tipulidae	Dicranota	4	
Diptera	Tipulidae	Hexatoma	25	
Ephemeroptera	Baetidae	Baetis	247	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	25	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	93	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	115	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	265	
Ephemeroptera	Heptageniidae	Cinygmula	39	
Ephemeroptera	Heptageniidae	Epeorus	22	
Ephemeroptera	Heptageniidae	Heptagenia	29	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	32	
Plecoptera			65	
Plecoptera	Chloroperlidae		32	
Plecoptera	Chloroperlidae	Sweltsa	4	
Plecoptera	Nemouridae	Zapada cinctipes	47	
Plecoptera	Peltoperlidae	Yoraperla	4	
Plecoptera	Perlodidae	Isoperla	4	
Plecoptera	Perlodidae	Kogotus	7	
Trichoptera			7	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Limnephilidae		4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	147	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	11	
Class: Ostracoda			136	
Phylum: Nemata			11	
Phylum: Platyhelminthes				
Class: Turbellaria			11	

Total: 41 OTU taxa			2688 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 25 September 1993 at station S7:775, Silver King Creek, 300 yds upstream from 4-Mile Creek, Sta 7, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128344. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 331 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			47	
Class: Insecta				
Coleoptera	Elmidae		129	
Coleoptera	Elmidae	Zaitzevia	7	
Diptera	Ceratopogonidae	Bezzia	22	
Diptera	Chironomidae		7	
Diptera	Chironomidae	Orthocladiinae	462	
Diptera	Chironomidae	Tanypodinae	14	
Diptera	Empididae		4	
Diptera	Empididae	Chelifera	11	
Diptera	Pelecorhynchidae	Glutops	11	
Diptera	Psychodidae	Pericoma	86	
Diptera	Simuliidae		36	
Diptera	Tipulidae	Antocha	7	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera			32	
Ephemeroptera	Baetidae	Baetis	4	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	29	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	22	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	14	
Ephemeroptera	Heptageniidae	Cinygmula	14	
Ephemeroptera	Leptohyphidae	Tricorythodes minutus	29	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	14	
Plecoptera			7	
Plecoptera	Capniidae		4	
Plecoptera	Chloroperlidae		29	
Plecoptera	Leuctridae		4	
Plecoptera	Peltoperlidae	Yoraperla	7	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Trichoptera			4	
Trichoptera	Hydropsychidae	Arctopsyche grandis	4	
Trichoptera	Hydropsychidae	Parapsyche elsis	4	
Trichoptera	Limnephilidae		4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	50	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	43	
Class: Ostracoda			4	
Phylum: Nemata			11	

Total: 36 OTU taxa			1186 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 16 September 1993 at station S8:813, Silver King Creek, upstream from Fly Valley Creek, Station 8, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128345. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 633 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			82	
Class: Insecta				
Coleoptera	Elmidae		7	
Coleoptera	Elmidae	Zaitzevia	68	
Diptera			36	
Diptera	Ceratopogonidae	Bezzia	39	
Diptera	Chironomidae		4	
Diptera	Chironomidae		108	
Diptera	Chironomidae	Orthocladiinae	627	
Diptera	Chironomidae	Tanypodinae	11	
Diptera	Empididae	Chelifera	4	
Diptera	Pelecorhynchidae	Glutops	25	
Diptera	Psychodidae	Pericoma	104	
Diptera	Simuliidae		4	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Dicranota	4	
Ephemeroptera	Baetidae	Baetis	258	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	68	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	47	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	82	
Ephemeroptera	Heptageniidae		14	
Ephemeroptera	Heptageniidae	Cinygmula	47	
Ephemeroptera	Heptageniidae	Epeorus	22	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	29	
Plecoptera			4	
Plecoptera	Capniidae		4	
Plecoptera	Chloroperlidae		14	
Plecoptera	Nemouridae	Zapada cinctipes	11	
Plecoptera	Perlidae		22	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlodidae		11	
Plecoptera	Taeniopterygidae	Taenionema	4	
Trichoptera			14	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Hydropsychidae	Arctopsyche grandis	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	176	
Class: Ostracoda			122	
Phylum: Nemata			14	
Phylum: Platyhelminthes				
Class: Turbellaria			154	

Total: 41 OTU taxa			2269 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 25 September 1993 at station S8:813, Silver King Creek, upstream from Fly Valley Creek, Station 8, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128346. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 344 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		14	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			39	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	82	
Diptera	Ceratopogonidae	Bezzia	50	
Diptera	Chironomidae		65	
Diptera	Chironomidae	Orthocladiinae	534	
Diptera	Chironomidae	Tanypodinae	36	
Diptera	Empididae	Chelifera	11	
Diptera	Pelecorhynchidae	Glutops	25	
Diptera	Psychodidae	Pericoma	108	
Diptera	Simuliidae		4	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Dicranota	4	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Baetidae	Baetis	7	
Ephemeroptera	Heptageniidae	Cinygmula	4	
Plecoptera	Chloroperlidae		14	
Plecoptera	Nemouridae		4	
Plecoptera	Perlidae		4	
Trichoptera			14	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	115	
Class: Ostracoda			47	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			7	
Phylum: Platyhelminthes				
Class: Turbellaria			29	

Total: 27 OTU taxa			1233 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 28 August 1995 at station S1:250, Four-mile Canyon Creek, middle meadow, Station 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128347. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 374 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			50	
Class: Insecta				
Coleoptera	Elmidae		301	
Coleoptera	Elmidae	Optioservus	4	
Coleoptera	Elmidae	Zaitzevia	133	
Diptera	Ceratopogonidae	Bezzia	11	
Diptera	Chironomidae	Orthocladiinae	337	
Diptera	Chironomidae	Tanypodinae	4	
Diptera	Empididae	Chelifera	7	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	32	
Diptera	Simuliidae		22	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Baetidae	Baetis	54	
Ephemeroptera	Ephemerellidae		4	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	50	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	4	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	57	
Ephemeroptera	Heptageniidae	Cinygmula	4	
Ephemeroptera	Heptageniidae	Epeorus	7	
Ephemeroptera	Heptageniidae	Heptagenia	43	
Ephemeroptera	Heptageniidae	Rhithrogena	7	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera			7	
Plecoptera	Capniidae		11	
Plecoptera	Chloroperlidae		7	
Plecoptera	Perlidae		4	
Plecoptera	Perlodidae		4	
Plecoptera	Perlodidae	Isoperla	4	
Trichoptera			4	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	82	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	4	
Trichoptera	Uenoidae	Neothremma	4	
Class: Ostracoda			47	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	

Total: 39 OTU taxa			1340 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 29 August 1995 at station S2:640, Silver King Creek, lower exclosure near Cow Cabin, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128348. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 360 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			22	
Class: Branchiopoda				
Diplostraca	Daphniidae	Daphnia	4	
Class: Insecta				
Coleoptera	Carabidae		4	
Coleoptera	Dytiscidae		4	
Coleoptera	Elmidae		47	
Coleoptera	Elmidae	Zaitzevia	54	
Diptera	Chironomidae	Orthocladiinae	280	
Diptera	Chironomidae	Tanypodinae	18	
Diptera	Empididae	Chelifera	11	
Diptera	Psychodidae	Pericoma	4	
Diptera	Simuliidae		65	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	251	
Ephemeroptera	Ephemerellidae	Attenella	11	
Ephemeroptera	Ephemerellidae	Attenella delantala	39	
Ephemeroptera	Ephemerellidae	Drunella doddsi	79	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	39	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	25	
Ephemeroptera	Heptageniidae	Cinygmula	50	
Ephemeroptera	Heptageniidae	Epeorus	32	
Ephemeroptera	Heptageniidae	Heptagenia	11	
Ephemeroptera	Heptageniidae	Rhithrogena	7	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera	Capniidae		4	
Plecoptera	Chloroperlidae		7	
Plecoptera	Peltoperlidae	Yoraperla	4	
Plecoptera	Perlodidae		4	
Plecoptera	Perlodidae	Isoperla	4	
Trichoptera			4	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Hydroptilidae	Leucotrichia	4	
Trichoptera	Limnephilidae		4	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Rhyacophilidae	Rhyacophila	14	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	82	
Class: Maxillopoda, subclass copepoda			11	
Class: Ostracoda			47	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			14	

Total: 43 OTU taxa			1290 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 29 August 1995 at station S3:641, Silver King Creek, near middle exclosure, Station 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128349. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 433 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		4	
Lumbriculida	Lumbriculidae		7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			11	
Class: Insecta				
Coleoptera	Elmidae		72	
Coleoptera	Elmidae	Optioservus	11	
Coleoptera	Elmidae	Zaitzevia	65	
Coleoptera	Hydrophilidae		4	
Diptera	Ceratopogonidae	Bezzia	4	
Diptera	Chironomidae	Orthocladiinae	530	
Diptera	Chironomidae	Tanypodinae	72	
Diptera	Empididae	Chelifera	4	
Diptera	Psychodidae	Pericoma	4	
Diptera	Simuliidae		50	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	211	
Ephemeroptera	Ephemerellidae	Attenella delantala	32	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	36	
Ephemeroptera	Ephemerellidae	Drunella doddsi	90	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	47	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	14	
Ephemeroptera	Ephemerellidae	Serratella tibialis	4	
Ephemeroptera	Heptageniidae	Cinygmula	50	
Ephemeroptera	Heptageniidae	Epeorus	18	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	11	
Plecoptera	Chloroperlidae		18	
Plecoptera	Nemouridae		4	
Plecoptera	Peltoperlidae	Yoraperla	4	
Trichoptera			7	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Glossosomatidae	Glossosoma	29	
Trichoptera	Rhyacophilidae	Rhyacophila	11	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	36	
Class: Maxillopoda, subclass copepoda			11	
Class: Ostracoda			25	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	7	
Phylum: Nemata			22	

Total: 42 OTU taxa			1552 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 29 August 1995 at station S6:738, Silver King Creek, upper meadow upstream from cabin, Sta. 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128350. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 384 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			7	
Class: Insecta				
Coleoptera	Elmidae		50	
Coleoptera	Elmidae	Zaitzevia	43	
Diptera	Ceratopogonidae	Bezzia	22	
Diptera	Chironomidae	Orthocladiinae	513	
Diptera	Chironomidae	Tanypodinae	11	
Diptera	Empididae	Chelifera	4	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	11	
Diptera	Simuliidae		22	
Diptera	Tipulidae	Hexatoma	4	
Diptera	Tipulidae	Ormosia	39	
Ephemeroptera	Baetidae	Baetis	165	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	22	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	61	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	22	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	54	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	11	
Ephemeroptera	Ephemerellidae	Serratella tibialis	7	
Ephemeroptera	Heptageniidae	Cinygmula	22	
Ephemeroptera	Heptageniidae	Epeorus	7	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Plecoptera	Chloroperlidae		82	
Plecoptera	Nemouridae	Zapada	4	
Plecoptera	Peltoperlidae	Yoraperla	4	
Plecoptera	Perlodidae		4	
Plecoptera	Perlodidae	Isoperla	4	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Leptoceridae	Oecetis	4	
Trichoptera	Rhyacophilidae	Rhyacophila	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	11	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	100	
Class: Ostracoda			22	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	18	
Phylum: Nemata			4	

Total: 37 OTU taxa			1376 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 29 August 1995 at station S7:775, Silver King Creek, 300 yds upstream from 4-Mile Creek, Sta 7, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128351. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 703 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			82	
Class: Insecta				
Coleoptera	Elmidae		39	
Coleoptera	Elmidae	Optioservus	22	
Coleoptera	Elmidae	Zaitzevia	32	
Diptera	Ceratopogonidae		7	
Diptera	Ceratopogonidae	Bezzia	25	
Diptera	Chironomidae	Orthocladiinae	749	
Diptera	Chironomidae	Tanypodinae	32	
Diptera	Empididae	Chelifera	4	
Diptera	Simuliidae		7	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera	Baetidae	Baetis	495	
Ephemeroptera	Ephemerellidae	Attenella	39	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	186	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	4	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	108	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	54	
Ephemeroptera	Ephemerellidae	Serratella tibialis	7	
Ephemeroptera	Heptageniidae	Cinygmula	86	
Ephemeroptera	Heptageniidae	Epeorus	79	
Ephemeroptera	Heptageniidae	Heptagenia	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera			7	
Plecoptera	Chloroperlidae		29	
Plecoptera	Nemouridae		14	
Plecoptera	Peltoperlidae	Yoraperla	4	
Plecoptera	Perlidae		11	
Plecoptera	Perlodidae	Kogotus	4	
Trichoptera			7	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Brachycentridae		4	
Trichoptera	Brachycentridae	Micrasema	7	
Trichoptera	Hydropsychidae	Arctopsyche grandis	7	
Trichoptera	Rhyacophilidae	Rhyacophila	25	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	25	
Trichoptera	Rhyacophilidae	Rhyacophila coloradensis	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	75	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	18	
Class: Maxillopoda, subclass copepoda			7	
Class: Ostracoda			183	
Phylum: Nemata			4	

Total: 42 OTU taxa			2520 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 29 August 1995 at station S8:813, Silver King Creek, upstream from Fly Valley Creek, Station 8, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128352. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 417 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			61	
Class: Insecta				
Coleoptera	Elmidae	Optioservus	108	
Diptera	Ceratopogonidae	Bezzia	4	
Diptera	Chironomidae		240	
Diptera	Chironomidae	Tanypodinae	254	
Diptera	Empididae	Chelifera	11	
Diptera	Pelecorhynchidae	Glutops	14	
Diptera	Simuliidae		43	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	176	
Ephemeroptera	Ephemerellidae		36	
Ephemeroptera	Ephemerellidae	Attenella	14	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	57	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	14	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	7	
Ephemeroptera	Heptageniidae	Cinygmula	18	
Ephemeroptera	Heptageniidae	Epeorus	25	
Ephemeroptera	Heptageniidae	Heptagenia	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	11	
Plecoptera			14	
Plecoptera	Chloroperlidae		18	
Plecoptera	Leuctridae		11	
Plecoptera	Nemouridae		4	
Plecoptera	Peltoperlidae	Yoraperla	39	
Trichoptera			93	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	82	
Trichoptera	Rhyacophilidae	Rhyacophila coloradensis	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	39	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	14	
Trichoptera	Uenoidae	Oligophlebodes	4	
Class: Ostracoda			43	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Platyhelminthes				
Class: Turbellaria			4	

Total: 39 OTU taxa			1495 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 4 September 1996 at station S1:250, Four-mile Canyon Creek, middle meadow, Station 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128353. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1009 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		14	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			111	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	437	
Diptera	Ceratopogonidae	Bezzia	7	
Diptera	Chironomidae	Orthocladiinae	695	
Diptera	Chironomidae	Tanypodinae	7	
Diptera	Empididae	Chelifera	22	
Diptera	Pelecorhynchidae	Glutops	39	
Diptera	Psychodidae	Pericoma	491	
Diptera	Simuliidae		65	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera	Baetidae	Baetis	376	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	18	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	323	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	11	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	36	
Ephemeroptera	Heptageniidae	Cinygmula	136	
Ephemeroptera	Heptageniidae	Rhithrogena	7	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Ephemeroptera	Polymitarcyidae	Ephoron album	43	
Plecoptera			97	
Plecoptera	Capniidae		61	
Plecoptera	Chloroperlidae		36	
Plecoptera	Leuctridae		7	
Plecoptera	Nemouridae		4	
Plecoptera	Nemouridae	Zapada	47	
Plecoptera	Peltoperlidae	Yoraperla	125	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Plecoptera	Taeniopterygidae	Taenionema	29	
Trichoptera			7	
Trichoptera	Brachycentridae	Brachycentrus	4	
Trichoptera	Brachycentridae	Micrasema	7	
Trichoptera	Glossosomatidae	Glossosoma	36	
Trichoptera	Hydropsychidae	Arctopsyche	54	
Trichoptera	Lepidostomatidae	Lepidostoma	4	
Trichoptera	Philopotamidae	Dolophilodes	4	
Trichoptera	Rhyacophilidae	Rhyacophila	14	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	29	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	108	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	14	
Class: Ostracoda			22	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	36	

Total: 44 OTU taxa			3616	individuals

Taxonomic list and abundances of aquatic invertebrates collected 5 September 1996 at station S2:640, Silver King Creek, lower exclosure near Cow Cabin, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128354. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 741 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			36	
Class: Insecta				
Coleoptera	Dytiscidae		4	
Coleoptera	Elmidae	Zaitzevia	366	
Diptera	Ceratopogonidae	Bezzia	7	
Diptera	Chironomidae	Orthocladiinae	523	
Diptera	Chironomidae	Tanypodinae	165	
Diptera	Empididae	Chelifera	25	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	54	
Diptera	Simuliidae		47	
Diptera	Tipulidae	Antocha	11	
Diptera	Tipulidae	Hexatoma	11	
Ephemeroptera	Baetidae	Baetis	444	
Ephemeroptera	Ephemerellidae	Attenella delantala	11	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	75	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	115	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	54	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	172	
Ephemeroptera	Heptageniidae	Cinygmula	39	
Ephemeroptera	Heptageniidae	Epeorus	79	
Ephemeroptera	Heptageniidae	Heptagenia	43	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	7	
Plecoptera			39	
Plecoptera	Chloroperlidae		22	
Plecoptera	Nemouridae	Zapada	7	
Plecoptera	Nemouridae	Zapada cinctipes	4	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlodidae	Kogotus	11	
Plecoptera	Perlodidae	Skwala americana	7	
Trichoptera			11	
Trichoptera	Brachycentridae	Micrasema	25	
Trichoptera	Glossosomatidae	Glossosoma	22	
Trichoptera	Hydropsychidae	Arctopsyche	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	22	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	111	
Class: Maxillopoda, subclass copepoda			14	
Class: Ostracoda			4	
Phylum: Nemata			32	
Phylum: Nematomorpha			7	
Phylum: Platyhelminthes				
Class: Turbellaria			4	

Total: 43 OTU taxa			2656 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 5 September 1996 at station S3:641, Silver King Creek, near middle exclosure, Station 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128355. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 994 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		25	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			79	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	204	
Diptera	Ceratopogonidae	Bezzia	11	
Diptera	Chironomidae	Orthocladiinae	713	
Diptera	Chironomidae	Tanypodinae	61	
Diptera	Empididae	Chelifera	11	
Diptera	Psychodidae	Pericoma	93	
Diptera	Simuliidae		563	
Diptera	Tipulidae	Dicranota	4	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera	Baetidae	Baetis	380	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	240	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	11	
Ephemeroptera	Ephemerellidae	Drunella doddsi	158	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	90	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	14	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	290	
Ephemeroptera	Heptageniidae	Cinygmula	201	
Ephemeroptera	Heptageniidae	Epeorus	72	
Ephemeroptera	Heptageniidae	Heptagenia	29	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	7	
Plecoptera			68	
Plecoptera	Chloroperlidae		7	
Trichoptera	Brachycentridae	Micrasema	25	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Hydropsychidae	Arctopsyche grandis	32	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	25	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	47	
Trichoptera	Uenoidae	Oligophlebodes	22	
Class: Maxillopoda, subclass copepoda			4	
Class: Ostracoda			4	
Phylum: Nemata			22	
Phylum: Platyhelminthes				
Class: Turbellaria			39	

Total: 33 OTU taxa			3563 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 4 September 1996 at station S6:738, Silver King Creek, upper meadow upstream from cabin, Sta. 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128356. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 729 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			136	
Class: Insecta				
Coleoptera	Elmidae		11	
Coleoptera	Elmidae	Zaitzevia	79	
Diptera	Ceratopogonidae	Bezzia	11	
Diptera	Chironomidae	Orthocladiinae	201	
Diptera	Chironomidae	Tanypodinae	43	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	219	
Diptera	Simuliidae		287	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Baetidae	Baetis	315	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	25	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	29	
Ephemeroptera	Ephemerellidae	Drunella doddsi	79	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	25	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	29	
Ephemeroptera	Heptageniidae	Cinygmula	25	
Ephemeroptera	Heptageniidae	Epeorus	61	
Ephemeroptera	Heptageniidae	Heptagenia	176	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera			487	
Plecoptera	Chloroperlidae		97	
Plecoptera	Leuctridae		4	
Plecoptera	Peltoperlidae	Yoraperla	4	
Plecoptera	Perlidae		7	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlodidae	Kogotus	4	
Trichoptera	Brachycentridae	Micrasema	39	
Trichoptera	Glossosomatidae	Glossosoma	11	
Trichoptera	Hydropsychidae	Arctopsyche	4	
Trichoptera	Limnephilidae	Chyranda centralis	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila coloradensis	7	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	158	
Class: Ostracoda			4	
Phylum: Nemata			4	
Phylum: Platyhelminthes				
Class: Turbellaria			11	

Total: 37 OTU taxa			2613 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 4 September 1996 at station S7:775, Silver King Creek, 300 yds upstream from 4-Mile Creek, Sta 7, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128357. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 807 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			154	
Class: Insecta				
Coleoptera	Elmidae		50	
Coleoptera	Elmidae	Optioservus	7	
Coleoptera	Elmidae	Zaitzevia	72	
Diptera	Ceratopogonidae	Bezzia	11	
Diptera	Chironomidae	Orthocladiinae	219	
Diptera	Chironomidae	Tanypodinae	54	
Diptera	Empididae	Chelifera	7	
Diptera	Pelecorhynchidae	Glutops	11	
Diptera	Psychodidae	Pericoma	151	
Diptera	Simuliidae		165	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera	Ameletidae	Ameletus	7	
Ephemeroptera	Baetidae	Baetis	599	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	47	
Ephemeroptera	Ephemerellidae	Drunella doddsi	276	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	75	
Ephemeroptera	Heptageniidae	Cinygmula	54	
Ephemeroptera	Heptageniidae	Epeorus	50	
Ephemeroptera	Heptageniidae	Heptagenia	65	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	11	
Plecoptera			448	
Plecoptera	Chloroperlidae		39	
Plecoptera	Leuctridae		7	
Plecoptera	Nemouridae		4	
Plecoptera	Nemouridae	Zapada	54	
Plecoptera	Nemouridae	Zapada cinctipes	4	
Plecoptera	Peltoperlidae	Yoraperla	32	
Plecoptera	Perlidae		4	
Plecoptera	Perlodidae		4	
Trichoptera			4	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Brachycentridae	Micrasema	22	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Hydropsychidae	Arctopsyche	4	
Trichoptera	Hydropsychidae	Arctopsyche grandis	4	
Trichoptera	Lepidostomatidae	Lepidostoma	11	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	36	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	100	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	7	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			7	

Total: 43 OTU taxa			2892 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 4 September 1996 at station S8:813, Silver King Creek, upstream from Fly Valley Creek, Station 8, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128358. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 619 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			90	
Class: Insecta				
Coleoptera	Elmidae	Zaitzevia	118	
Diptera	Ceratopogonidae		7	
Diptera	Ceratopogonidae	Bezzia	11	
Diptera	Chironomidae	Orthocladiinae	244	
Diptera	Chironomidae	Tanypodinae	57	
Diptera	Empididae	Chelifera	11	
Diptera	Pelecorhynchidae	Glutops	11	
Diptera	Psychodidae	Pericoma	97	
Diptera	Simuliidae		4	
Ephemeroptera	Baetidae	Baetis	613	
Ephemeroptera	Ephemerellidae		7	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	115	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	50	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	25	
Ephemeroptera	Heptageniidae	Cinygmula	39	
Ephemeroptera	Heptageniidae	Epeorus	39	
Ephemeroptera	Heptageniidae	Heptagenia	25	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	29	
Plecoptera			82	
Plecoptera	Capniidae		54	
Plecoptera	Chloroperlidae		11	
Plecoptera	Leuctridae		14	
Plecoptera	Nemouridae	Zapada	4	
Plecoptera	Perlidae		4	
Plecoptera	Perlodidae		14	
Plecoptera	Perlodidae	Kogotus	4	
Plecoptera	Taeniopterygidae	Taenionema	161	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Limnephilidae		4	
Trichoptera	Limnephilidae	Ecclisomyia	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	125	
Trichoptera	Uenoidae	Neothremma	4	
Class: Maxillopoda, subclass copepoda			4	
Class: Ostracoda			22	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			25	
Phylum: Platyhelminthes				
Class: Turbellaria			68	

Total: 42 OTU taxa			2219 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 23 September 1994 at station S1:250, Four-mile Canyon Creek, middle meadow, Station 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128359. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1735 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			133	
Class: Insecta				
Coleoptera	Elmidae	Optioservus	39	
Coleoptera	Elmidae	Zaitzevia	846	
Diptera			4	
Diptera	Ceratopogonidae	Bezzia	14	
Diptera	Chironomidae		97	
Diptera	Chironomidae	Orthocladiinae	319	
Diptera	Empididae		7	
Diptera	Empididae	Chelifera	7	
Diptera	Pelecorhynchidae	Glutops	54	
Diptera	Psychodidae	Pericoma	2516	
Diptera	Tipulidae	Antocha monticola	22	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera	Baetidae	Baetis	466	
Ephemeroptera	Ephemerellidae	Attenella delantala	280	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	43	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	25	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	61	
Ephemeroptera	Heptageniidae	Heptagenia	79	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	7	
Plecoptera			7	
Plecoptera	Capniidae		22	
Plecoptera	Chloroperlidae		7	
Plecoptera	Leuctridae		4	
Plecoptera	Peltoperlidae	Yoraperla	54	
Plecoptera	Perlodidae	Isoperla	7	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Lepidostomatidae	Lepidostoma	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	43	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	4	
Class: Ostracoda			996	
Phylum: Nemata			14	

Total: 35 OTU taxa			6219	individuals

Taxonomic list and abundances of aquatic invertebrates collected 22 September 1994 at station S2:640, Silver King Creek, lower exclosure near Cow Cabin, Station 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128360. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 911 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			61	
Class: Insecta				
Coleoptera	Elmidae		4	
Coleoptera	Elmidae	Optioservus	14	
Coleoptera	Elmidae	Zaitzevia	566	
Diptera	Ceratopogonidae	Bezzia	18	
Diptera	Chironomidae	Orthocladiinae	151	
Diptera	Chironomidae	Tanypodinae	204	
Diptera	Empididae	Chelifera	140	
Diptera	Psychodidae	Pericoma	792	
Diptera	Tipulidae	Antocha	29	
Diptera	Tipulidae	Hexatoma	14	
Ephemeroptera	Ameletidae	Ameletus	25	
Ephemeroptera	Baetidae	Baetis	43	
Ephemeroptera	Ephemerellidae	Attenella delantala	43	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	32	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	115	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	186	
Ephemeroptera	Heptageniidae	Epeorus	4	
Ephemeroptera	Heptageniidae	Heptagenia	115	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	194	
Plecoptera			4	
Plecoptera	Chloroperlidae		147	
Plecoptera	Chloroperlidae	Sweltsa	4	
Plecoptera	Nemouridae	Zapada cinctipes	4	
Plecoptera	Peltoperlidae	Yoraperla	7	
Plecoptera	Perlidae		22	
Trichoptera	Apataniidae	Pedomoecus sierra	11	
Trichoptera	Glossosomatidae	Glossosoma	47	
Trichoptera	Hydropsychidae	Arctopsyche grandis	4	
Trichoptera	Hydropsychidae	Hydropsyche	4	
Trichoptera	Lepidostomatidae	Lepidostoma	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	14	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	72	
Trichoptera	Uenoidae	Oligophlebodes	7	
Class: Maxillopoda, subclass copepoda			47	
Class: Ostracoda			111	

Total: 37 OTU taxa			3265 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 22 September 1994 at station S3:641, Silver King Creek, near middle exclosure, Station 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128361. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 857 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		18	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			32	
Class: Insecta				
Coleoptera	Elmidae		43	
Coleoptera	Elmidae	Optioservus	4	
Coleoptera	Elmidae	Zaitzevia	290	
Diptera	Ceratopogonidae	Bezzia	36	
Diptera	Chironomidae		781	
Diptera	Chironomidae	Tanypodinae	143	
Diptera	Empididae	Chelifera	4	
Diptera	Psychodidae	Pericoma	355	
Diptera	Tipulidae		4	
Diptera	Tipulidae	Hexatoma	25	
Ephemeroptera	Ameletidae	Ameletus	14	
Ephemeroptera	Baetidae	Baetis	25	
Ephemeroptera	Ephemerellidae	Attenella delantala	391	
Ephemeroptera	Ephemerellidae	Drunella doddsi	4	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	75	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	4	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	11	
Ephemeroptera	Heptageniidae	Cinygmula	4	
Ephemeroptera	Heptageniidae	Heptagenia	25	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	183	
Plecoptera			14	
Plecoptera	Capniidae		7	
Plecoptera	Chloroperlidae		72	
Plecoptera	Leuctridae		4	
Plecoptera	Nemouridae	Malenka	14	
Plecoptera	Perlodidae	Kogotus	4	
Plecoptera	Perlodidae	Skwala americana	7	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Glossosomatidae	Glossosoma	14	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	25	
Trichoptera	Uenoidae	Oligophlebodes	4	
Class: Maxillopoda, subclass copepoda			183	
Class: Ostracoda			183	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	18	
Phylum: Nemata			43	

Total: 37 OTU taxa			3072 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 23 September 1994 at station S6:738, Silver King Creek, upper meadow upstream from cabin, Sta. 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128362. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1741 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			161	
Class: Insecta				
Coleoptera	Elmidae		32	
Coleoptera	Elmidae	Zaitzevia	330	
Diptera	Ceratopogonidae	Bezzia	194	
Diptera	Chironomidae	Orthocladiinae	1072	
Diptera	Chironomidae	Tanypodinae	72	
Diptera	Empididae	Chelifera	14	
Diptera	Psychodidae	Pericoma	1176	
Diptera	Simuliidae		7	
Diptera	Tipulidae	Antocha	25	
Diptera	Tipulidae	Hexatoma	32	
Ephemeroptera	Ameletidae	Ameletus	7	
Ephemeroptera	Baetidae	Baetis	183	
Ephemeroptera	Ephemerellidae	Attenella delantala	921	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	176	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	161	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	591	
Ephemeroptera	Heptageniidae	Cinygmula	57	
Ephemeroptera	Heptageniidae	Epeorus	7	
Ephemeroptera	Heptageniidae	Heptagenia	280	
Ephemeroptera	Heptageniidae	Rhithrogena	14	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	183	
Plecoptera			32	
Plecoptera	Capniidae		7	
Plecoptera	Chloroperlidae		233	
Plecoptera	Leuctridae		14	
Plecoptera	Nemouridae	Zapada	7	
Plecoptera	Peltoperlidae	Yoraperla	7	
Plecoptera	Perlidae		14	
Trichoptera	Brachycentridae	Brachycentrus americanus	7	
Trichoptera	Brachycentridae	Micrasema	14	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Hydropsychidae	Arctopsyche grandis	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	57	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	39	
Class: Ostracoda			47	
Phylum: Nemata			32	

Total: 39 OTU taxa			6240 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 23 September 1994 at station S7:775, Silver King Creek, 300 yds upstream from 4-Mile Creek, Sta 7, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128363. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1124 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			186	
Class: Insecta				
Coleoptera	Elmidae		65	
Coleoptera	Elmidae	Optioservus	7	
Coleoptera	Elmidae	Zaitzevia	125	
Diptera	Ceratopogonidae	Bezzia	32	
Diptera	Chironomidae	Orthocladiinae	1172	
Diptera	Chironomidae	Tanypodinae	280	
Diptera	Empididae	Chelifera	39	
Diptera	Pelecorhynchidae	Glutops	25	
Diptera	Psychodidae	Pericoma	724	
Diptera	Simuliidae		4	
Diptera	Tipulidae	Hexatoma	108	
Ephemeroptera	Baetidae	Baetis	14	
Ephemeroptera	Ephemerellidae	Attenella delantala	416	
Ephemeroptera	Ephemerellidae	Drunella doddsi	43	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	197	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	36	
Ephemeroptera	Heptageniidae	Heptagenia	25	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	11	
Plecoptera	Chloroperlidae		54	
Plecoptera	Perlidae		11	
Plecoptera	Perlodidae	Kogotus	7	
Plecoptera	Perlodidae	Perlinodes aurea	4	
Plecoptera	Perlodidae	Skwala americana	7	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Hydropsychidae	Arctopsyche grandis	14	
Trichoptera	Limnephilidae	Ecclisomyia	7	
Trichoptera	Rhyacophilidae	Rhyacophila	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	222	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	7	
Class: Ostracoda			161	
Phylum: Nemata			7	

Total: 33 OTU taxa			4029 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 23 September 1994 at station S8:813, Silver King Creek, upstream from Fly Valley Creek, Station 8, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.279 square meters. The sample identification number is 128364. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 850 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata				
Haplotaxida	Tubificidae		7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			39	
Class: Insecta				
Coleoptera	Elmidae		47	
Coleoptera	Elmidae	Optioservus	22	
Coleoptera	Elmidae	Zaitzevia	39	
Diptera	Ceratopogonidae	Bezzia	11	
Diptera	Chironomidae	Orthocladiinae	728	
Diptera	Chironomidae	Tanypodinae	43	
Diptera	Empididae	Chelifera	11	
Diptera	Pelecorhynchidae	Glutops	25	
Diptera	Psychodidae	Pericoma	900	
Diptera	Simuliidae		7	
Diptera	Tipulidae	Hexatoma	11	
Ephemeroptera	Baetidae	Baetis	54	
Ephemeroptera	Ephemerellidae	Attenella delantala	143	
Ephemeroptera	Ephemerellidae	Drunella doddsi	14	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	61	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	204	
Ephemeroptera	Heptageniidae	Heptagenia	14	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	25	
Plecoptera			57	
Plecoptera	Capniidae		22	
Plecoptera	Chloroperlidae		25	
Plecoptera	Peltoperlidae		7	
Plecoptera	Perlidae		4	
Plecoptera	Perlodidae		7	
Trichoptera			25	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Glossosomatidae	Glossosoma	14	
Trichoptera	Lepidostomatidae	Lepidostoma	4	
Trichoptera	Rhyacophilidae	Rhyacophila	32	
Trichoptera	Rhyacophilidae	Rhyacophila hyalinata	18	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	4	
Trichoptera	Uenoidae	Oligophlebodes	54	
Class: Maxillopoda, subclass copepoda			7	
Class: Ostracoda			312	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			36	

Total: 39 OTU taxa			3047 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 6 August 2003 at station COVAL-11, Coyote Valley Creek, Lower Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129065. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1416 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			161	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			484	
Class: Insecta				
Coleoptera	Elmidae		47	
Coleoptera	Elmidae	Cleptelmis addenda	154	
Coleoptera	Elmidae	Heterlimnius	7	
Coleoptera	Elmidae	Heterlimnius corpulentus	11	
Coleoptera	Elmidae	Lara	4	
Coleoptera	Elmidae	Optioservus	22	
Coleoptera	Elmidae	Optioservus quadrimaculatus	36	
Diptera	Ceratopogonidae	Probezzia	4	
Diptera	Chironomidae		25	
Diptera	Chironomidae	Chironominae	183	
Diptera	Chironomidae	Orthocladiinae	606	
Diptera	Chironomidae	Tanypodinae	7	
Diptera	Pelecorhynchidae	Glutops	11	
Diptera	Psychodidae	Pericoma	79	
Diptera	Simuliidae	Simulium	140	
Diptera	Tipulidae	Dicranota	4	
Ephemeroptera	Baetidae	Baetis	663	
Ephemeroptera	Ephemerellidae		950	
Ephemeroptera	Ephemerellidae	Drunella doddsi	22	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	133	
Ephemeroptera	Heptageniidae		29	
Ephemeroptera	Heptageniidae	Cinygmula	22	
Ephemeroptera	Heptageniidae	Epeorus	4	
Ephemeroptera	Heptageniidae	Ironodes	7	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	57	
Megaloptera	Corydalidae		7	
Plecoptera	Chloroperlidae		68	
Plecoptera	Chloroperlidae	Sweltsa	47	
Plecoptera	Nemouridae		79	
Plecoptera	Nemouridae	Malenka	65	
Plecoptera	Peltoperlidae	Yoraperla	222	
Plecoptera	Perlidae		14	
Plecoptera	Perlidae	Hesperoperla pacifica	7	
Plecoptera	Perlodidae		7	
Trichoptera	Brachycentridae	Brachycentrus	43	
Trichoptera	Brachycentridae	Micrasema	75	
Trichoptera	Calamoceratidae	Heteroplectron californicum	7	
Trichoptera	Glossosomatidae		115	
Trichoptera	Hydropsychidae		7	
Trichoptera	Philopotamidae	Dolophilodes	197	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	25	
Trichoptera	Uenoidae	Neophylax	11	
Trichoptera	Uenoidae	Neothremma	4	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			36	
Phylum: Platyhelminthes				
Class: Turbellaria			165	

Total: 49 OTU taxa			5075 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 2 August 2004 at station COVAL-11, Coyote Valley Creek, Lower Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129066. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1965 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			111	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			889	
Class: Insecta				
Coleoptera	Elmidae		18	
Coleoptera	Elmidae	Cleptelmis addenda	161	
Coleoptera	Elmidae	Heterlimnius	36	
Coleoptera	Elmidae	Lara	7	
Coleoptera	Elmidae	Narpus concolor	4	
Coleoptera	Elmidae	Optioservus	68	
Coleoptera	Elmidae	Optioservus quadrimaculatus	61	
Diptera	Ceratopogonidae	Probezzia	4	
Diptera	Chironomidae		14	
Diptera	Chironomidae	Chironominae	22	
Diptera	Chironomidae	Orthocladiinae	226	
Diptera	Chironomidae	Tanypodinae	14	
Diptera	Pelecorhynchidae	Glutops	129	
Diptera	Psychodidae	Pericoma	93	
Diptera	Simuliidae	Simulium	29	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera	Baetidae	Baetis	330	
Ephemeroptera	Ephemerellidae		251	
Ephemeroptera	Ephemerellidae	Caudatella	419	
Ephemeroptera	Ephemerellidae	Drunella doddsi	54	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	265	
Ephemeroptera	Ephemerellidae	Serratella	72	
Ephemeroptera	Heptageniidae		100	
Ephemeroptera	Heptageniidae	Cinygmula	25	
Ephemeroptera	Heptageniidae	Epeorus	18	
Ephemeroptera	Heptageniidae	Ironodes	14	
Ephemeroptera	Heptageniidae	Rhithrogena	54	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	323	
Plecoptera			4	
Plecoptera	Chloroperlidae		233	
Plecoptera	Chloroperlidae	Suwallia	22	
Plecoptera	Chloroperlidae	Sweltsa	172	
Plecoptera	Nemouridae	Malenka	129	
Plecoptera	Nemouridae	Zapada	480	
Plecoptera	Peltoperlidae	Yoraperla	1545	
Plecoptera	Perlidae		25	
Plecoptera	Perlidae	Doroneuria baumanni	14	
Plecoptera	Perlidae	Hesperoperla pacifica	25	
Plecoptera	Perlodidae		7	
Plecoptera	Perlodidae	Oroperla barbara	4	
Plecoptera	Pteronarcyidae	Pteronarcella regularis	11	
Trichoptera			7	
Trichoptera	Brachycentridae	Micrasema	140	
Trichoptera	Glossosomatidae		79	
Trichoptera	Glossosomatidae	Anagapetus	22	
Trichoptera	Hydropsychidae	Parapsyche elsis	7	
Trichoptera	Philopotamidae	Dolophilodes	129	
Trichoptera	Rhyacophilidae	Rhyacophila	18	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	25	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	29	
Trichoptera	Uenoidae	Neothremma	4	
Class: Ostracoda			79	
Phylum: Platyhelminthes				
Class: Turbellaria			14	

Total: 56 OTU taxa			7043 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 8 August 2005 at station COVAL-11, Coyote Valley Creek, Lower Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129067. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1051 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			79	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			312	
Class: Insecta				
Coleoptera	Elmidae		11	
Coleoptera	Elmidae	Cleptelmis addenda	79	
Coleoptera	Elmidae	Heterlimnius	14	
Coleoptera	Elmidae	Heterlimnius corpulentus	4	
Coleoptera	Elmidae	Optioservus	50	
Coleoptera	Elmidae	Optioservus divergens/pecosensis	4	
Coleoptera	Elmidae	Optioservus quadrimaculatus	32	
Coleoptera	Hydrophilidae		4	
Diptera	Ceratopogonidae	Probezzia	7	
Diptera	Chironomidae		11	
Diptera	Chironomidae	Chironominae	140	
Diptera	Chironomidae	Orthocladiinae	398	
Diptera	Pelecorhynchidae	Glutops	11	
Diptera	Psychodidae	Pericoma	25	
Diptera	Simuliidae	Simulium	57	
Diptera	Tipulidae	Antocha	7	
Diptera	Tipulidae	Dicranota	4	
Ephemeroptera	Baetidae		39	
Ephemeroptera	Baetidae	Baetis	620	
Ephemeroptera	Baetidae	Diphetor hageni	4	
Ephemeroptera	Ephemerellidae		194	
Ephemeroptera	Ephemerellidae	Caudatella	111	
Ephemeroptera	Ephemerellidae	Drunella	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	158	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	36	
Ephemeroptera	Ephemerellidae	Serratella	22	
Ephemeroptera	Heptageniidae		7	
Ephemeroptera	Heptageniidae	Cinygmula	25	
Ephemeroptera	Heptageniidae	Epeorus	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	29	
Plecoptera	Chloroperlidae		147	
Plecoptera	Chloroperlidae	Sweltsa	18	
Plecoptera	Nemouridae	Malenka	36	
Plecoptera	Nemouridae	Zapada	11	
Plecoptera	Peltoperlidae	Yoraperla	484	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	11	
Plecoptera	Perlidae	Hesperoperla pacifica	39	
Plecoptera	Perlodidae		14	
Trichoptera			11	
Trichoptera	Brachycentridae	Micrasema	211	
Trichoptera	Philopotamidae		29	
Trichoptera	Philopotamidae	Dolophilodes	136	
Trichoptera	Rhyacophilidae	Rhyacophila	7	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	11	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	68	
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group a	7	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	4	
Trichoptera	Uenoidae	Neothremma	11	
Class: Ostracoda			4	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 129067.

Order	Family	Subfamily/Genus/species	Life	Abundance	Notes
Phylum: Nemata				7	

Total: 53 OTU taxa				3767 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 10 August 2006 at station COVAL-11, Coyote Valley Creek, Lower Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129068. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1483 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			61	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			211	
Class: Insecta				
Coleoptera	Elmidae		4	
Coleoptera	Elmidae	Cleptelmis addenda	75	
Coleoptera	Elmidae	Heterlimnius	18	
Coleoptera	Elmidae	Heterlimnius corpulentus	29	
Coleoptera	Elmidae	Narpus concolor	11	
Coleoptera	Elmidae	Optioservus	65	
Coleoptera	Elmidae	Optioservus divergens/pecosensis	14	
Coleoptera	Elmidae	Optioservus quadrimaculatus	36	
Diptera	Ceratopogonidae		4	
Diptera	Chironomidae		4	
Diptera	Chironomidae	Chironominae	154	
Diptera	Chironomidae	Orthocladiinae	355	
Diptera	Pelecorhynchidae	Glutops	25	
Diptera	Psychodidae	Pericoma	47	
Diptera	Simuliidae	Simulium	287	
Diptera	Tipulidae	Dicranota	4	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	882	
Ephemeroptera	Baetidae	Diphetor hageni	14	
Ephemeroptera	Ephemerellidae		72	
Ephemeroptera	Ephemerellidae	Caudatella	710	
Ephemeroptera	Ephemerellidae	Drunella doddsi	211	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	32	
Ephemeroptera	Heptageniidae		65	
Ephemeroptera	Heptageniidae	Cinygmula	22	
Ephemeroptera	Heptageniidae	Epeorus	229	
Ephemeroptera	Heptageniidae	Ironodes	68	
Ephemeroptera	Heptageniidae	Rhithrogena	25	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	208	
Megaloptera	Corydalidae		11	
Plecoptera			4	
Plecoptera	Chloroperlidae		68	
Plecoptera	Chloroperlidae	Sweltsa	39	
Plecoptera	Leuctridae		4	
Plecoptera	Nemouridae		22	
Plecoptera	Nemouridae	Malenka	65	
Plecoptera	Nemouridae	Zapada	50	
Plecoptera	Nemouridae	Zapada columbiana	4	
Plecoptera	Peltoperlidae	Yoraperla	516	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlidae	Hesperoperla	14	
Plecoptera	Perlidae	Hesperoperla hoguei	11	
Plecoptera	Perlidae	Hesperoperla pacifica	14	
Plecoptera	Perlodidae		39	
Trichoptera	Brachycentridae	Micrasema	290	
Trichoptera	Glossosomatidae		54	
Trichoptera	Hydropsychidae		4	
Trichoptera	Hydropsychidae	Hydropsyche	4	
Trichoptera	Hydropsychidae	Parapsyche elsis	4	
Trichoptera	Hydroptilidae		7	
Trichoptera	Limnephilidae	Homophylax	4	
Trichoptera	Philopotamidae		11	
Trichoptera	Philopotamidae	Dolophilodes	25	
Trichoptera	Rhyacophilidae	Rhyacophila	11	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	11	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	79	
Phylum: Platyhelminthes				
Class: Turbellaria			4	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 129068.

Total:	60 OTU taxa	------ 5315 individuals

Taxonomic list and abundances of aquatic invertebrates collected 6 August 2003 at station COVAL-12, Coyote Valley Creek, Upper Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129069. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1918 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			111	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			599	
Class: Insecta				
Coleoptera	Elmidae		251	
Coleoptera	Elmidae	Cleptelmis addenda	151	
Coleoptera	Elmidae	Heterlimnius	179	
Coleoptera	Elmidae	Optioservus	11	
Diptera	Ceratopogonidae	Probezzia	25	
Diptera	Chironomidae		14	
Diptera	Chironomidae	Chironominae	115	
Diptera	Chironomidae	Orthocladiinae	842	
Diptera	Pelecorhynchidae	Glutops	7	
Diptera	Psychodidae	Pericoma	125	
Diptera	Simuliidae		18	
Diptera	Simuliidae	Simulium	233	
Diptera	Tipulidae	Dicranota	11	
Diptera	Tipulidae	Hexatoma	11	
Ephemeroptera	Baetidae	Baetis	710	
Ephemeroptera	Baetidae	Diphetor hageni	29	
Ephemeroptera	Ephemerellidae		1487	
Ephemeroptera	Ephemerellidae	Attenella delantala	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	61	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	29	
Ephemeroptera	Heptageniidae		11	
Ephemeroptera	Heptageniidae	Cinygmula	14	
Ephemeroptera	Heptageniidae	Epeorus	22	
Ephemeroptera	Heptageniidae	Ironodes	22	
Ephemeroptera	Heptageniidae	Rhithrogena	11	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	75	
Plecoptera			22	
Plecoptera	Chloroperlidae		100	
Plecoptera	Nemouridae	Malenka	4	
Plecoptera	Peltoperlidae	Yoraperla	538	
Plecoptera	Perlidae		11	
Plecoptera	Perlidae	Hesperoperla	4	
Plecoptera	Perlidae	Hesperoperla hoguei	29	
Plecoptera	Perlidae	Hesperoperla pacifica	4	
Plecoptera	Perlodidae		4	
Plecoptera	Pteronarcyidae	Pteronarcella regularis	14	
Trichoptera			7	
Trichoptera	Brachycentridae	Micrasema	502	
Trichoptera	Glossosomatidae		32	
Trichoptera	Philopotamidae	Dolophilodes	194	
Trichoptera	Rhyacophilidae	Rhyacophila	4	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	79	
Trichoptera	Uenoidae	Neophylax	7	
Trichoptera	Uenoidae	Neothremma	22	
Class: Malacostraca				
Amphipoda	Hyalellidae	Hyalella azteca	4	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	7	
Phylum: Nemata			4	
Phylum: Platyhelminthes				
Class: Turbellaria			104	

Total: 51 OTU taxa			6875 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 2 August 2004 at station COVAL-12, Coyote Valley Creek, Upper Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129070. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 2188 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			43	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			599	
Class: Insecta				
Coleoptera	Elmidae		122	
Coleoptera	Elmidae	Cleptelmis addenda	326	
Coleoptera	Elmidae	Heterlimnius	168	
Coleoptera	Elmidae	Lara	4	
Coleoptera	Elmidae	Narpus concolor	22	
Coleoptera	Elmidae	Optioservus	391	
Coleoptera	Elmidae	Optioservus quadrimaculatus	25	
Diptera	Ceratopogonidae	Probezzia	14	
Diptera	Chironomidae		11	
Diptera	Chironomidae	Chironominae	25	
Diptera	Chironomidae	Orthocladiinae	613	
Diptera	Empididae	Chelifera	4	
Diptera	Pelecorhynchidae	Glutops	32	
Diptera	Psychodidae	Pericoma	168	
Diptera	Simuliidae	Prosimulium	4	
Diptera	Simuliidae	Simulium	133	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Dicranota	4	
Diptera	Tipulidae	Hexatoma	14	
Ephemeroptera	Baetidae		125	
Ephemeroptera	Baetidae	Baetis	559	
Ephemeroptera	Ephemerellidae		1351	
Ephemeroptera	Ephemerellidae	Attenella	4	
Ephemeroptera	Ephemerellidae	Attenella delantala	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	25	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	133	
Ephemeroptera	Heptageniidae		47	
Ephemeroptera	Heptageniidae	Cinygmula	14	
Ephemeroptera	Heptageniidae	Epeorus	7	
Ephemeroptera	Heptageniidae	Ironodes	43	
Ephemeroptera	Heptageniidae	Rhithrogena	50	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	122	
Megaloptera	Corydalidae		4	
Plecoptera			7	
Plecoptera	Chloroperlidae		330	
Plecoptera	Chloroperlidae	Suwallia	4	
Plecoptera	Chloroperlidae	Sweltsa	39	
Plecoptera	Nemouridae		22	
Plecoptera	Nemouridae	Malenka	122	
Plecoptera	Nemouridae	Zapada	29	
Plecoptera	Nemouridae	Zapada cinctipes	43	
Plecoptera	Peltoperlidae		29	
Plecoptera	Peltoperlidae	Yoraperla	1204	
Plecoptera	Perlidae		11	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Plecoptera	Perlidae	Hesperoperla pacifica	36	
Plecoptera	Perlodidae		32	
Plecoptera	Perlodidae	Perlinodes aurea	14	
Plecoptera	Pteronarcyidae		4	
Plecoptera	Pteronarcyidae	Pteronarcella regularis	4	
Trichoptera	Brachycentridae	Micrasema	294	
Trichoptera	Glossosomatidae		129	
Trichoptera	Glossosomatidae	Glossosoma	22	
Trichoptera	Limnephilidae		4	
Trichoptera	Philopotamidae	Dolophilodes	68	
Trichoptera	Rhyacophilidae	Rhyacophila	25	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	11	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 129070.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	72	
Trichoptera	Uenoidae	Neothremma	39	
Class: Malacostraca				
Amphipoda	Hyalellidae	Hyalella azteca	14	
Phylum: Nemata			4	
Phylum: Platyhelminthes				
Class: Turbellaria			11	

Total: 64 OTU taxa			7842 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 8 August 2005 at station COVAL-12, Coyote Valley Creek, Upper Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129071. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 825 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			29	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			93	
Class: Insecta				
Coleoptera	Elmidae		18	
Coleoptera	Elmidae	Cleptelmis addenda	154	
Coleoptera	Elmidae	Heterlimnius	147	
Coleoptera	Elmidae	Heterlimnius corpulentus	97	
Coleoptera	Elmidae	Heterlimnius koebelei	4	
Coleoptera	Elmidae	Narpus concolor	4	
Coleoptera	Elmidae	Optioservus	168	
Diptera	Ceratopogonidae	Bezzia	4	
Diptera	Chironomidae	Chironominae	22	
Diptera	Chironomidae	Orthocladiinae	75	
Diptera	Pelecorhynchidae	Glutops	7	
Diptera	Psychodidae	Pericoma	14	
Diptera	Simuliidae	Simulium	108	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera			4	
Ephemeroptera	Baetidae	Baetis	323	
Ephemeroptera	Ephemerellidae		541	
Ephemeroptera	Ephemerellidae	Attenella delantala	7	
Ephemeroptera	Ephemerellidae	Caudatella	50	
Ephemeroptera	Ephemerellidae	Drunella doddsi	108	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	72	
Ephemeroptera	Heptageniidae		4	
Ephemeroptera	Heptageniidae	Cinygmula	29	
Ephemeroptera	Heptageniidae	Ironodes	14	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	7	
Megaloptera	Sialidae	Sialis	4	
Plecoptera	Chloroperlidae		86	
Plecoptera	Chloroperlidae	Suwallia	11	
Plecoptera	Chloroperlidae	Sweltsa	190	
Plecoptera	Nemouridae		14	
Plecoptera	Nemouridae	Malenka	4	
Plecoptera	Nemouridae	Zapada	4	
Plecoptera	Peltoperlidae	Yoraperla	204	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlidae	Hesperoperla pacifica	43	
Plecoptera	Perlodidae		29	
Trichoptera			4	
Trichoptera	Brachycentridae	Micrasema	161	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Philopotamidae		7	
Trichoptera	Philopotamidae	Dolophilodes	7	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	68	

Total: 46 OTU taxa			2957 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 10 August 2006 at station COVAL-12, Coyote Valley Creek, Upper Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129072. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1366 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			29	
Class: Insecta				
Coleoptera	Elmidae		61	
Coleoptera	Elmidae	Cleptelmis addenda	75	
Coleoptera	Elmidae	Heterlimnius	197	
Coleoptera	Elmidae	Heterlimnius corpulentus	43	
Coleoptera	Elmidae	Narpus concolor	25	
Coleoptera	Elmidae	Optioservus	204	
Coleoptera	Elmidae	Optioservus divergens/pecosensis	29	
Coleoptera	Elmidae	Optioservus quadrimaculatus	122	
Coleoptera	Hydraenidae	Hydraena	4	
Diptera	Ceratopogonidae		4	
Diptera	Ceratopogonidae	Bezzia	4	
Diptera	Ceratopogonidae	Probezzia	7	
Diptera	Ceratopogonidae	Forcipomyia	4	
Diptera	Chironomidae		11	
Diptera	Chironomidae	Chironominae	54	
Diptera	Chironomidae	Orthocladiinae	147	
Diptera	Empididae	Chelifera	4	
Diptera	Pelecorhynchidae	Glutops	18	
Diptera	Psychodidae	Pericoma	36	
Diptera	Simuliidae	Prosimulium	7	
Diptera	Simuliidae	Simulium	423	
Diptera	Tipulidae	Dicranota	4	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Ameletidae	Ameletus	18	
Ephemeroptera	Baetidae	Baetis	978	
Ephemeroptera	Baetidae	Diphetor hageni	4	
Ephemeroptera	Ephemerellidae		437	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Caudatella	477	
Ephemeroptera	Ephemerellidae	Drunella doddsi	122	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	79	
Ephemeroptera	Heptageniidae		86	
Ephemeroptera	Heptageniidae	Cinygmula	7	
Ephemeroptera	Heptageniidae	Epeorus	100	
Ephemeroptera	Heptageniidae	Ironodes	50	
Ephemeroptera	Heptageniidae	Rhithrogena	18	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	50	
Plecoptera	Chloroperlidae		233	
Plecoptera	Chloroperlidae	Sweltsa	47	
Plecoptera	Nemouridae		7	
Plecoptera	Nemouridae	Malenka	32	
Plecoptera	Nemouridae	Zapada	4	
Plecoptera	Peltoperlidae	Yoraperla	269	
Plecoptera	Perlidae		36	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlidae	Hesperoperla	4	
Plecoptera	Perlidae	Hesperoperla hoguei	14	
Plecoptera	Perlidae	Hesperoperla pacifica	11	
Plecoptera	Perlodidae		29	
Plecoptera	Perlodidae	Oroperla barbara	4	
Plecoptera	Pteronarcyidae	Pteronarcella regularis	7	
Trichoptera	Brachycentridae	Micrasema	100	
Trichoptera	Glossosomatidae		7	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Philopotamidae		18	
Trichoptera	Philopotamidae	Dolophilodes	18	
Trichoptera	Philopotamidae	Wormaldia	4	
Trichoptera	Rhyacophilidae	Rhyacophila	18	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	72	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 129072.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Class: Malacostraca				
Amphipoda	Hyalellidae	Hyalella azteca	11	
Phylum: Mollusca				
Class: Gastropoda			4	

Total: 62 OTU taxa			4896 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 6 August 2003 at station CVALL-09, Corral Valley Creek, Lower Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129073. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 2145 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			229	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			437	
Class: Insecta				
Coleoptera	Curculionidae		4	
Coleoptera	Elmidae		168	
Coleoptera	Elmidae	Cleptelmis addenda	168	
Coleoptera	Elmidae	Heterlimnius	39	
Coleoptera	Elmidae	Heterlimnius corpulentus	7	
Coleoptera	Elmidae	Lara	4	
Coleoptera	Elmidae	Optioservus	115	
Coleoptera	Elmidae	Optioservus divergens/pecosensis	18	
Coleoptera	Elmidae	Optioservus quadrimaculatus	22	
Diptera	Ceratopogonidae	Probezzia	32	
Diptera	Chironomidae		36	
Diptera	Chironomidae	Chironominae	401	
Diptera	Chironomidae	Orthocladiinae	1100	
Diptera	Chironomidae	Tanypodinae	18	
Diptera	Empididae	Chelifera	11	
Diptera	Pelecorhynchidae	Glutops	36	
Diptera	Psychodidae	Pericoma	247	
Diptera	Simuliidae	Simulium	115	
Diptera	Tipulidae	Antocha	22	
Diptera	Tipulidae	Dicranota	11	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	642	
Ephemeroptera	Ephemerellidae		634	
Ephemeroptera	Ephemerellidae	Attenella delantala	7	
Ephemeroptera	Ephemerellidae	Drunella	211	
Ephemeroptera	Ephemerellidae	Drunella doddsi	29	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	763	
Ephemeroptera	Heptageniidae	Cinygmula	68	
Ephemeroptera	Heptageniidae	Epeorus	4	
Ephemeroptera	Heptageniidae	Ironodes	4	
Ephemeroptera	Heptageniidae	Rhithrogena	14	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	47	
Plecoptera	Chloroperlidae		82	
Plecoptera	Chloroperlidae	Sweltsa	25	
Plecoptera	Nemouridae		25	
Plecoptera	Peltoperlidae	Yoraperla	749	
Plecoptera	Perlidae		18	
Plecoptera	Perlidae	Claassenia sabulosa	14	
Plecoptera	Perlidae	Doroneuria baumanni	29	
Plecoptera	Perlidae	Hesperoperla	4	
Plecoptera	Perlidae	Hesperoperla pacifica	7	
Plecoptera	Perlodidae		18	
Trichoptera			29	
Trichoptera	Apataniidae	Apatania	61	
Trichoptera	Brachycentridae	Micrasema	47	
Trichoptera	Glossosomatidae		108	
Trichoptera	Hydropsychidae		29	
Trichoptera	Hydropsychidae	Parapsyche	11	
Trichoptera	Hydroptilidae		4	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Philopotamidae	Dolophilodes	7	
Trichoptera	Rhyacophilidae	Rhyacophila	7	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	65	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	61	
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group	50	
Trichoptera	Uenoidae		7	
Trichoptera	Uenoidae	Neophylax	7	
Trichoptera	Uenoidae	Neothremma	22	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 129073.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	11	
Phylum: Nemata			18	
Phylum: Platyhelminthes				
Class: Turbellaria			505	

Total: 63 OTU taxa			7688 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 2 August 2004 at station CVALL-09, Corral Valley Creek, Lower Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129074. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 2512 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			25	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			484	
Class: Insecta				
Coleoptera	Dytiscidae		4	
Coleoptera	Elmidae		136	
Coleoptera	Elmidae	Cleptelmis addenda	459	
Coleoptera	Elmidae	Heterlimnius	22	
Coleoptera	Elmidae	Heterlimnius corpulentus	14	
Coleoptera	Elmidae	Narpus concolor	4	
Coleoptera	Elmidae	Optioservus	387	
Coleoptera	Elmidae	Optioservus divergens/pecosensis	7	
Coleoptera	Elmidae	Optioservus quadrimaculatus	50	
Diptera	Ceratopogonidae	Atrichopogon/Forcipomyia	4	
Diptera	Ceratopogonidae	Probezzia	32	
Diptera	Chironomidae		65	
Diptera	Chironomidae	Chironominae	362	
Diptera	Chironomidae	Orthocladiinae	1509	
Diptera	Chironomidae	Tanypodinae	32	
Diptera	Empididae	Chelifera	4	
Diptera	Pelecorhynchidae	Glutops	61	
Diptera	Psychodidae	Pericoma	344	
Diptera	Simuliidae	Simulium	158	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Ameletidae	Ameletus	22	
Ephemeroptera	Baetidae	Baetis	140	
Ephemeroptera	Baetidae	Diphetor hageni	7	
Ephemeroptera	Ephemerellidae		606	
Ephemeroptera	Ephemerellidae	Attenella delantala	7	
Ephemeroptera	Ephemerellidae	Caudatella	369	
Ephemeroptera	Ephemerellidae	Drunella doddsi	7	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	581	
Ephemeroptera	Heptageniidae		4	
Ephemeroptera	Heptageniidae	Cinygmula	18	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	111	
Plecoptera	Chloroperlidae		133	
Plecoptera	Chloroperlidae	Sweltsa	4	
Plecoptera	Nemouridae		82	
Plecoptera	Nemouridae	Malenka	18	
Plecoptera	Nemouridae	Zapada	54	
Plecoptera	Peltoperlidae		39	
Plecoptera	Peltoperlidae	Yoraperla	1731	
Plecoptera	Perlidae		11	
Plecoptera	Perlidae	Calineuria californica	7	
Plecoptera	Perlidae	Doroneuria baumanni	18	
Plecoptera	Perlidae	Hesperoperla pacifica	25	
Plecoptera	Perlodidae		32	
Plecoptera	Pteronarcyidae	Pteronarcella regularis	4	
Trichoptera			14	
Trichoptera	Apataniidae	Apatania	22	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Brachycentridae	Micrasema	39	
Trichoptera	Glossosomatidae		47	
Trichoptera	Glossosomatidae	Glossosoma	104	
Trichoptera	Hydropsychidae	Parapsyche elsis	22	
Trichoptera	Limnephilidae		4	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Limnephilidae	Psychoglypha	4	
Trichoptera	Rhyacophilidae	Rhyacophila	47	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	61	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	18	
Trichoptera	Uenoidae	Neophylax	4	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 129074.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Trichoptera	Uenoidae	Neothremma	11	
Class: Ostracoda			358	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	11	
Phylum: Nemata			4	
Phylum: Platyhelminthes				
Class: Turbellaria			32	

Total: 66 OTU taxa			9004 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 8 August 2005 at station CVALL-09, Corral Valley Creek, Lower Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129075. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 588 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			118	
Class: Insecta				
Coleoptera	Elmidae		14	
Coleoptera	Elmidae	Cleptelmis addenda	11	
Coleoptera	Elmidae	Heterlimnius	115	
Coleoptera	Elmidae	Heterlimnius corpulentus	18	
Coleoptera	Elmidae	Optioservus	72	
Coleoptera	Elmidae	Optioservus divergens/pecosensis	4	
Coleoptera	Elmidae	Optioservus quadrimaculatus	25	
Diptera	Ceratopogonidae	Probezzia	29	
Diptera	Chironomidae		47	
Diptera	Chironomidae	Chironominae	161	
Diptera	Chironomidae	Orthocladiinae	222	
Diptera	Chironomidae	Tanypodinae	14	
Diptera	Pelecorhynchidae	Glutops	97	
Diptera	Psychodidae	Pericoma	25	
Diptera	Simuliidae	Simulium	50	
Diptera	Tipulidae	Antocha	14	
Ephemeroptera	Ameletidae	Ameletus	29	
Ephemeroptera	Baetidae		262	
Ephemeroptera	Baetidae	Baetis	97	
Ephemeroptera	Ephemerellidae	Attenella delantala	11	
Ephemeroptera	Ephemerellidae	Drunella	108	
Ephemeroptera	Heptageniidae	Cinygmula	22	
Plecoptera	Capniidae		4	
Plecoptera	Chloroperlidae		111	
Plecoptera	Chloroperlidae	Sweltsa	11	
Plecoptera	Nemouridae		4	
Plecoptera	Nemouridae	Malenka	7	
Plecoptera	Peltoperlidae	Yoraperla	151	
Plecoptera	Perlidae		25	
Plecoptera	Perlidae	Doroneuria baumanni	11	
Plecoptera	Perlidae	Hesperoperla hoguei	4	
Plecoptera	Perlodidae		11	
Trichoptera			14	
Trichoptera	Apataniidae	Apatania	39	
Trichoptera	Glossosomatidae		11	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Hydropsychidae	Parapsyche elsis	7	
Trichoptera	Limnephilidae		4	
Trichoptera	Rhyacophilidae	Rhyacophila	39	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	22	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	4	
Trichoptera	Uenoidae	Neophylax	18	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	22	
Phylum: Nemata			14	

Total: 46 OTU taxa			2108 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 8 August 2006 at station CVALL-09, Corral Valley Creek, Lower Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129076. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 681 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			61	
Class: Insecta				
Coleoptera	Elmidae		11	
Coleoptera	Elmidae	Cleptelmis addenda	32	
Coleoptera	Elmidae	Heterlimnius	79	
Coleoptera	Elmidae	Optioservus	75	
Coleoptera	Elmidae	Optioservus divergens/pecosensis	4	
Coleoptera	Elmidae	Optioservus quadrimaculatus	32	
Diptera	Ceratopogonidae		4	
Diptera	Ceratopogonidae	Probezzia	36	
Diptera	Chironomidae		4	
Diptera	Chironomidae	Chironominae	47	
Diptera	Chironomidae	Orthocladiinae	122	
Diptera	Chironomidae	Tanypodinae	18	
Diptera	Pelecorhynchidae	Glutops	39	
Diptera	Psychodidae	Pericoma	7	
Diptera	Simuliidae	Simulium	14	
Diptera	Tipulidae	Antocha	47	
Diptera	Tipulidae	Hexatoma	11	
Ephemeroptera	Ameletidae	Ameletus	65	
Ephemeroptera	Baetidae	Baetis	771	
Ephemeroptera	Baetidae	Diphetor hageni	11	
Ephemeroptera	Ephemerellidae		32	
Ephemeroptera	Ephemerellidae	Attenella delantala	7	
Ephemeroptera	Ephemerellidae	Drunella	68	
Ephemeroptera	Ephemerellidae	Drunella doddsi	32	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	172	
Ephemeroptera	Heptageniidae		14	
Ephemeroptera	Heptageniidae	Cinygmula	93	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera	Chloroperlidae		57	
Plecoptera	Chloroperlidae	Sweltsa	22	
Plecoptera	Nemouridae	Malenka	32	
Plecoptera	Nemouridae	Zapada	4	
Plecoptera	Nemouridae	Zapada oregonensis group	4	
Plecoptera	Peltoperlidae	Yoraperla	129	
Plecoptera	Perlidae		7	
Plecoptera	Perlidae	Doroneuria baumanni	14	
Plecoptera	Perlidae	Hesperoperla hoguei	4	
Plecoptera	Perlidae	Hesperoperla pacifica	11	
Plecoptera	Perlodidae		29	
Trichoptera			18	
Trichoptera	Apataniidae	Apatania	4	
Trichoptera	Apataniidae	Pedomoecus sierra	11	
Trichoptera	Glossosomatidae	Anagapetus	4	
Trichoptera	Hydropsychidae	Parapsyche almota	4	
Trichoptera	Hydropsychidae	Parapsyche elsis	4	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Limnephilidae	Psychoglypha	4	
Trichoptera	Philopotamidae		14	
Trichoptera	Rhyacophilidae	Rhyacophila	32	
Trichoptera	Rhyacophilidae	Rhyacophila alberta group	4	
Trichoptera	Rhyacophilidae	Rhyacophila arnaudi	18	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	32	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	54	
Trichoptera	Uenoidae	Neophylax	4	
Trichoptera	Uenoidae	Neothremma	4	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	7	

Total: 57 OTU taxa			2441 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 6 August 2003 at station CVALL-10, Corral Valley Creek, Upper Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129077. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1927 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			32	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			473	
Class: Insecta				
Coleoptera	Elmidae		201	
Coleoptera	Elmidae	Cleptelmis addenda	39	
Coleoptera	Elmidae	Heterlimnius	39	
Coleoptera	Elmidae	Heterlimnius corpulentus	39	
Coleoptera	Elmidae	Optioservus	47	
Coleoptera	Elmidae	Optioservus quadrimaculatus	129	
Diptera	Ceratopogonidae		4	
Diptera	Ceratopogonidae	Probezzia	65	
Diptera	Chironomidae		86	
Diptera	Chironomidae	Chironominae	563	
Diptera	Chironomidae	Orthocladiinae	1075	
Diptera	Chironomidae	Tanypodinae	32	
Diptera	Pelecorhynchidae	Glutops	7	
Diptera	Psychodidae	Pericoma	226	
Diptera	Simuliidae		4	
Diptera	Simuliidae	Simulium	72	
Diptera	Tipulidae	Antocha	18	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera	Ameletidae	Ameletus	7	
Ephemeroptera	Baetidae	Baetis	333	
Ephemeroptera	Ephemerellidae		505	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	47	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	595	
Ephemeroptera	Heptageniidae	Cinygmula	14	
Ephemeroptera	Heptageniidae	Rhithrogena	22	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	158	
Plecoptera	Chloroperlidae		104	
Plecoptera	Chloroperlidae	Sweltsa	18	
Plecoptera	Nemouridae		7	
Plecoptera	Nemouridae	Malenka	4	
Plecoptera	Peltoperlidae	Yoraperla	430	
Plecoptera	Perlidae		22	
Plecoptera	Perlidae	Claassenia sabulosa	4	
Plecoptera	Perlidae	Doroneuria baumanni	47	
Plecoptera	Perlodidae		14	
Trichoptera			197	
Trichoptera	Apataniidae	Apatania	29	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Brachycentridae	Micrasema	43	
Trichoptera	Glossosomatidae		140	
Trichoptera	Glossosomatidae	Glossosoma	11	
Trichoptera	Hydropsychidae		93	
Trichoptera	Hydropsychidae	Parapsyche	22	
Trichoptera	Philopotamidae		4	
Trichoptera	Philopotamidae	Dolophilodes	29	
Trichoptera	Rhyacophilidae	Rhyacophila	4	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	108	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	86	
Trichoptera	Uenoidae	Neophylax	11	
Trichoptera	Uenoidae	Neothremma	4	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	47	
Phylum: Nemata			18	
Phylum: Platyhelminthes				
Class: Turbellaria			570	

Total: 56 OTU taxa			6907 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 2 August 2004 at station CVALL-10, Corral Valley Creek, Upper Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129078. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 2479 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			39	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			487	
Class: Insecta				
Coleoptera	Dytiscidae	Oreodytes	7	
Coleoptera	Elmidae		68	
Coleoptera	Elmidae	Cleptelmis addenda	29	
Coleoptera	Elmidae	Heterlimnius	233	
Coleoptera	Elmidae	Heterlimnius corpulentus	14	
Coleoptera	Elmidae	Narpus concolor	11	
Coleoptera	Elmidae	Optioservus	283	
Coleoptera	Elmidae	Optioservus divergens/pecosensis	29	
Coleoptera	Elmidae	Optioservus quadrimaculatus	115	
Diptera	Ceratopogonidae	Probezzia	39	
Diptera	Chironomidae		65	
Diptera	Chironomidae	Chironominae	538	
Diptera	Chironomidae	Orthocladiinae	1634	
Diptera	Empididae	Chelifera	4	
Diptera	Pelecorhynchidae	Glutops	22	
Diptera	Psychodidae	Pericoma	530	
Diptera	Simuliidae	Simulium	197	
Diptera	Tipulidae	Antocha	11	
Diptera	Tipulidae	Hexatoma	11	
Ephemeroptera	Baetidae	Baetis	39	
Ephemeroptera	Baetidae	Diphetor hageni	4	
Ephemeroptera	Ephemerellidae		427	
Ephemeroptera	Ephemerellidae	Caudatella	11	
Ephemeroptera	Ephemerellidae	Drunella doddsi	4	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	538	
Ephemeroptera	Heptageniidae		32	
Ephemeroptera	Heptageniidae	Cinygmula	18	
Ephemeroptera	Leptohyphidae		82	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	201	
Plecoptera	Capniidae		4	
Plecoptera	Chloroperlidae		75	
Plecoptera	Chloroperlidae	Sweltsa	65	
Plecoptera	Nemouridae		14	
Plecoptera	Nemouridae	Malenka	100	
Plecoptera	Nemouridae	Zapada	143	
Plecoptera	Nemouridae	Zapada cinctipes	90	
Plecoptera	Peltoperlidae	Yoraperla	1143	
Plecoptera	Perlidae		29	
Plecoptera	Perlidae	Doroneuria baumanni	47	
Plecoptera	Perlidae	Hesperoperla pacifica	7	
Plecoptera	Perlodidae		7	
Plecoptera	Pteronarcyidae	Pteronarcella regularis	7	
Trichoptera			168	
Trichoptera	Apataniidae	Apatania	7	
Trichoptera	Brachycentridae	Micrasema	50	
Trichoptera	Glossosomatidae		448	
Trichoptera	Glossosomatidae	Anagapetus	29	
Trichoptera	Glossosomatidae	Glossosoma	129	
Trichoptera	Hydropsychidae		47	
Trichoptera	Hydropsychidae	Parapsyche elsis	72	
Trichoptera	Philopotamidae	Dolophilodes	36	
Trichoptera	Rhyacophilidae	Rhyacophila	54	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	86	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	61	
Trichoptera	Uenoidae	Neophylax	7	
Trichoptera	Uenoidae	Oligophlebodes	47	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 129078.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	86	
Phylum: Platyhelminthes				
Class: Turbellaria			108	

Total: 60 OTU taxa			8885 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 10 August 2005 at station CVALL-10, Corral Valley Creek, Upper Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129079. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 851 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			11	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			65	
Class: Insecta				
Coleoptera	Elmidae		39	
Coleoptera	Elmidae	Cleptelmis addenda	7	
Coleoptera	Elmidae	Heterlimnius	229	
Coleoptera	Elmidae	Heterlimnius corpulentus	18	
Coleoptera	Elmidae	Optioservus	240	
Coleoptera	Elmidae	Optioservus quadrimaculatus	32	
Coleoptera	Hydrophilidae		4	
Diptera	Ceratopogonidae	Probezzia	11	
Diptera	Chironomidae		4	
Diptera	Chironomidae	Chironominae	240	
Diptera	Chironomidae	Orthocladiinae	229	
Diptera	Chironomidae	Tanypodinae	18	
Diptera	Empididae	Chelifera	4	
Diptera	Psychodidae	Pericoma	7	
Diptera	Simuliidae	Simulium	93	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Dicranota	7	
Ephemeroptera			4	
Ephemeroptera	Baetidae	Baetis	168	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Drunella	11	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	22	
Ephemeroptera	Ephemerellidae	Drunella doddsi	36	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	65	
Ephemeroptera	Heptageniidae		32	
Ephemeroptera	Heptageniidae	Cinygmula	36	
Ephemeroptera	Heptageniidae	Epeorus	7	
Ephemeroptera	Heptageniidae	Ironodes	4	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera	Chloroperlidae		143	
Plecoptera	Chloroperlidae	Suwallia	32	
Plecoptera	Chloroperlidae	Sweltsa	7	
Plecoptera	Nemouridae	Malenka	18	
Plecoptera	Nemouridae	Zapada	7	
Plecoptera	Peltoperlidae	Yoraperla	860	
Plecoptera	Perlidae		39	
Plecoptera	Perlidae	Doroneuria baumanni	36	
Trichoptera	Apataniidae	Apatania	4	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Glossosomatidae		11	
Trichoptera	Hydropsychidae	Hydropsyche	4	
Trichoptera	Hydropsychidae	Parapsyche elsis	14	
Trichoptera	Limnephilidae	Psychoglypha	4	
Trichoptera	Philopotamidae		39	
Trichoptera	Philopotamidae	Dolophilodes	4	
Trichoptera	Rhyacophilidae	Rhyacophila	65	
Trichoptera	Rhyacophilidae	Rhyacophila angelita group	25	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	22	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	43	
Trichoptera	Uenoidae	Neophylax	4	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	11	

Total: 54 OTU taxa			3050 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 8 August 2006 at station CVALL-10, Corral Valley Creek, Upper Site, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129080. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1186 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			125	
Class: Insecta				
Coleoptera	Elmidae		43	
Coleoptera	Elmidae	Cleptelmis addenda	7	
Coleoptera	Elmidae	Heterlimnius	108	
Coleoptera	Elmidae	Heterlimnius corpulentus	14	
Coleoptera	Elmidae	Narpus concolor	4	
Coleoptera	Elmidae	Optioservus	115	
Coleoptera	Elmidae	Optioservus quadrimaculatus	50	
Diptera	Ceratopogonidae	Probezzia	57	
Diptera	Chironomidae	Chironominae	147	
Diptera	Chironomidae	Orthocladiinae	97	
Diptera	Chironomidae	Tanypodinae	14	
Diptera	Pelecorhynchidae	Glutops	7	
Diptera	Psychodidae	Pericoma	82	
Diptera	Simuliidae	Simulium	32	
Diptera	Tipulidae	Dicranota	7	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Ameletidae	Ameletus	11	
Ephemeroptera	Baetidae	Baetis	581	
Ephemeroptera	Ephemerellidae		18	
Ephemeroptera	Ephemerellidae	Caudatella	36	
Ephemeroptera	Ephemerellidae	Drunella	143	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	65	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	229	
Ephemeroptera	Heptageniidae		36	
Ephemeroptera	Heptageniidae	Cinygmula	297	
Ephemeroptera	Heptageniidae	Epeorus	43	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	14	
Plecoptera			4	
Plecoptera	Chloroperlidae		54	
Plecoptera	Chloroperlidae	Suwallia	14	
Plecoptera	Chloroperlidae	Sweltsa	7	
Plecoptera	Leuctridae		4	
Plecoptera	Nemouridae	Malenka	32	
Plecoptera	Nemouridae	Visoka cataractae	4	
Plecoptera	Nemouridae	Zapada	7	
Plecoptera	Nemouridae	Zapada columbiana	43	
Plecoptera	Nemouridae	Zapada oregonensis group	36	
Plecoptera	Peltoperlidae	Yoraperla	1118	
Plecoptera	Perlidae		7	
Plecoptera	Perlidae	Doroneuria baumanni	25	
Plecoptera	Perlodidae		97	
Plecoptera	Pteronarcyidae	Pteronarcella regularis	14	
Trichoptera	Apataniidae	Apatania	50	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Glossosomatidae		14	
Trichoptera	Glossosomatidae	Anagapetus	18	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Hydropsychidae		7	
Trichoptera	Hydropsychidae	Parapsyche elsis	4	
Trichoptera	Lepidostomatidae	Lepidostoma	4	
Trichoptera	Limnephilidae		7	
Trichoptera	Limnephilidae	Cryptochia	4	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Philopotamidae		14	
Trichoptera	Philopotamidae	Dolophilodes	97	
Trichoptera	Rhyacophilidae	Rhyacophila	18	
Trichoptera	Rhyacophilidae	Rhyacophila angelita group	7	
Trichoptera	Rhyacophilidae	Rhyacophila arnaudi	11	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	57	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	61	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 129080.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	7	

Total: 63 OTU taxa			4251 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 5 August 2003 at station SKING-01, Silver King Creek, Upper Valley, Site 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129081.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 953 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			29	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			50	
Class: Insecta				
Coleoptera	Elmidae		22	
Coleoptera	Elmidae	Heterlimnius	301	
Diptera	Chironomidae		4	
Diptera	Chironomidae	Chironominae	265	
Diptera	Chironomidae	Orthocladiinae	609	
Diptera	Chironomidae	Tanypodinae	11	
Diptera	Empididae	Chelifera	43	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	32	
Diptera	Simuliidae		11	
Diptera	Simuliidae	Simulium	25	
Diptera	Tipulidae	Antocha	7	
Diptera	Tipulidae	Rhabdomastix	4	
Ephemeroptera	Ameletidae	Ameletus	7	
Ephemeroptera	Baetidae	Baetis	337	
Ephemeroptera	Ephemerellidae		283	
Ephemeroptera	Ephemerellidae	Attenella delantala	18	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	11	
Ephemeroptera	Ephemerellidae	Drunella doddsi	186	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	122	
Ephemeroptera	Heptageniidae		18	
Ephemeroptera	Heptageniidae	Cinygmula	172	
Ephemeroptera	Heptageniidae	Epeorus	140	
Ephemeroptera	Heptageniidae	Rhithrogena	39	
Plecoptera	Chloroperlidae		32	
Plecoptera	Chloroperlidae	Sweltsa	11	
Plecoptera	Leuctridae		4	
Plecoptera	Peltoperlidae	Yoraperla	122	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Trichoptera			4	
Trichoptera	Brachycentridae	Brachycentrus americanus	7	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Glossosomatidae		75	
Trichoptera	Glossosomatidae	Glossosoma	39	
Trichoptera	Rhyacophilidae	Rhyacophila	36	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	32	
Class: Ostracoda			11	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			18	
Phylum: Platyhelminthes				
Class: Turbellaria			258	

Total: 43 OTU taxa			3416 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 4 August 2004 at station SKING-01, Silver King Creek, Upper Valley, Site 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129082.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1867 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			54	
Class: Insecta				
Coleoptera	Elmidae		65	
Coleoptera	Elmidae	Cleptelmis addenda	4	
Coleoptera	Elmidae	Heterlimnius	810	
Coleoptera	Elmidae	Heterlimnius corpulentus	29	
Coleoptera	Elmidae	Narpus concolor	11	
Diptera	Ceratopogonidae	Probezzia	22	
Diptera	Chironomidae		29	
Diptera	Chironomidae	Chironominae	538	
Diptera	Chironomidae	Orthocladiinae	351	
Diptera	Chironomidae	Tanypodinae	22	
Diptera	Empididae	Chelifera	32	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	72	
Diptera	Simuliidae		4	
Diptera	Simuliidae	Simulium	47	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Hexatoma	11	
Diptera	Tipulidae	Limnophila	4	
Ephemeroptera	Ameletidae	Ameletus	32	
Ephemeroptera	Baetidae		39	
Ephemeroptera	Baetidae	Baetis	1287	
Ephemeroptera	Ephemerellidae		262	
Ephemeroptera	Ephemerellidae	Attenella delantala	36	
Ephemeroptera	Ephemerellidae	Caudatella	609	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	330	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	394	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	7	
Ephemeroptera	Heptageniidae		201	
Ephemeroptera	Heptageniidae	Cinygmula	258	
Ephemeroptera	Heptageniidae	Epeorus	43	
Ephemeroptera	Heptageniidae	Rhithrogena	61	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	194	
Plecoptera	Chloroperlidae		82	
Plecoptera	Leuctridae		4	
Plecoptera	Nemouridae	Malenka	90	
Plecoptera	Nemouridae	Zapada columbiana	22	
Plecoptera	Peltoperlidae	Yoraperla	258	
Plecoptera	Perlidae		25	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Plecoptera	Perlodidae		11	
Trichoptera			43	
Trichoptera	Brachycentridae	Brachycentrus americanus	39	
Trichoptera	Brachycentridae	Micrasema	32	
Trichoptera	Glossosomatidae		4	
Trichoptera	Hydropsychidae		11	
Trichoptera	Hydropsychidae	Parapsyche elsis	7	
Trichoptera	Lepidostomatidae	Lepidostoma	4	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Philopotamidae	Dolophilodes	29	
Trichoptera	Rhyacophilidae	Rhyacophila	90	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila verrula group	11	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	7	
Phylum: Platyhelminthes				
Class: Turbellaria			25	

Total: 57 OTU taxa			6692 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 10 August 2005 at station SKING-01, Silver King Creek, Upper Valley, Site 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129083.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 504 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			7	
Class: Insecta				
Coleoptera	Elmidae		22	
Coleoptera	Elmidae	Heterlimnius	143	
Coleoptera	Elmidae	Heterlimnius corpulentus	14	
Coleoptera	Elmidae	Narpus concolor	4	
Diptera	Ceratopogonidae	Probezzia	7	
Diptera	Chironomidae		11	
Diptera	Chironomidae	Chironominae	111	
Diptera	Chironomidae	Orthocladiinae	133	
Diptera	Empididae	Chelifera	14	
Diptera	Simuliidae		14	
Diptera	Simuliidae	Simulium	54	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Rhabdomastix	4	
Ephemeroptera	Baetidae		22	
Ephemeroptera	Baetidae	Baetis	226	
Ephemeroptera	Ephemerellidae		18	
Ephemeroptera	Ephemerellidae	Attenella delantala	108	
Ephemeroptera	Ephemerellidae	Caudatella	18	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	211	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	39	
Ephemeroptera	Heptageniidae		11	
Ephemeroptera	Heptageniidae	Cinygmula	108	
Ephemeroptera	Heptageniidae	Epeorus	82	
Ephemeroptera	Heptageniidae	Rhithrogena	18	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera	Chloroperlidae		22	
Plecoptera	Chloroperlidae	Suwallia	7	
Plecoptera	Chloroperlidae	Sweltsa	7	
Plecoptera	Leuctridae		4	
Plecoptera	Nemouridae	Malenka	4	
Plecoptera	Peltoperlidae	Yoraperla	50	
Plecoptera	Perlidae		14	
Plecoptera	Perlodidae		4	
Trichoptera	Brachycentridae	Brachycentrus americanus	14	
Trichoptera	Brachycentridae	Micrasema	14	
Trichoptera	Glossosomatidae		65	
Trichoptera	Glossosomatidae	Glossosoma	140	
Trichoptera	Lepidostomatidae	Lepidostoma	4	
Trichoptera	Philopotamidae	Dolophilodes	4	
Trichoptera	Polycentropodidae	Polycentropus	4	
Trichoptera	Rhyacophilidae	Rhyacophila	36	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	7	

Total: 44 OTU taxa			1806 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 August 2006 at station SKING-01, Silver King Creek, Upper Valley, Site 1, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129084.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 566 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			14	
Class: Insecta				
Coleoptera	Elmidae		39	
Coleoptera	Elmidae	Heterlimnius	165	
Coleoptera	Elmidae	Heterlimnius corpulentus	14	
Coleoptera	Elmidae	Optioservus quadrimaculatus	4	
Coleoptera	Hydraenidae	Ochthebius	4	
Diptera	Ceratopogonidae		4	
Diptera	Chironomidae		14	
Diptera	Chironomidae	Chironominae	204	
Diptera	Chironomidae	Orthocladiinae	90	
Diptera	Chironomidae	Tanypodinae	4	
Diptera	Empididae	Chelifera	18	
Diptera	Simuliidae		4	
Diptera	Simuliidae	Simulium	14	
Diptera	Tipulidae	Antocha	4	
Ephemeroptera	Ameletidae	Ameletus	7	
Ephemeroptera	Baetidae	Baetis	355	
Ephemeroptera	Ephemerellidae		7	
Ephemeroptera	Ephemerellidae	Attenella delantala	219	
Ephemeroptera	Ephemerellidae	Caudatella	36	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	172	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	50	
Ephemeroptera	Heptageniidae		54	
Ephemeroptera	Heptageniidae	Cinygmula	172	
Ephemeroptera	Heptageniidae	Epeorus	47	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Plecoptera	Chloroperlidae		14	
Plecoptera	Chloroperlidae	Suwallia	11	
Plecoptera	Chloroperlidae	Sweltsa	11	
Plecoptera	Peltoperlidae	Yoraperla	50	
Plecoptera	Perlidae		11	
Plecoptera	Perlodidae		32	
Trichoptera			4	
Trichoptera	Apataniidae	Pedomoecus sierra	11	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Brachycentridae	Micrasema	7	
Trichoptera	Glossosomatidae	Glossosoma	22	
Trichoptera	Limnephilidae		4	
Trichoptera	Rhyacophilidae	Rhyacophila	57	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	11	
Phylum: Platyhelminthes				
Class: Turbellaria			57	

Total: 43 OTU taxa			2029 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 5 August 2003 at station SKING-02, Silver King Creek, Upper valley, Site 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129085.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1152 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			29	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			22	
Class: Insecta				
Coleoptera	Elmidae		143	
Coleoptera	Elmidae	Heterlimnius	380	
Coleoptera	Elmidae	Heterlimnius corpulentus	18	
Coleoptera	Elmidae	Narpus concolor	4	
Diptera	Ceratopogonidae	Probezzia	4	
Diptera	Chironomidae		29	
Diptera	Chironomidae	Chironominae	588	
Diptera	Chironomidae	Orthocladiinae	742	
Diptera	Empididae	Chelifera	18	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	39	
Diptera	Simuliidae		4	
Diptera	Simuliidae	Simulium	25	
Diptera	Tipulidae	Antocha	11	
Diptera	Tipulidae	Hexatoma	14	
Ephemeroptera	Baetidae	Baetis	577	
Ephemeroptera	Ephemerellidae		366	
Ephemeroptera	Ephemerellidae	Attenella delantala	133	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	11	
Ephemeroptera	Ephemerellidae	Drunella doddsi	86	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	36	
Ephemeroptera	Heptageniidae		7	
Ephemeroptera	Heptageniidae	Cinygmula	158	
Ephemeroptera	Heptageniidae	Epeorus	97	
Ephemeroptera	Heptageniidae	Rhithrogena	11	
Plecoptera	Chloroperlidae		7	
Plecoptera	Chloroperlidae	Sweltsa	39	
Plecoptera	Peltoperlidae	Yoraperla	36	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Plecoptera	Perlodidae		14	
Trichoptera			7	
Trichoptera	Brachycentridae	Brachycentrus americanus	36	
Trichoptera	Brachycentridae	Micrasema	29	
Trichoptera	Glossosomatidae		104	
Trichoptera	Glossosomatidae	Glossosoma	57	
Trichoptera	Hydropsychidae		22	
Trichoptera	Philopotamidae		7	
Trichoptera	Philopotamidae	Dolophilodes	11	
Trichoptera	Rhyacophilidae	Rhyacophila	18	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	11	
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group	14	
Class: Ostracoda			18	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Nemata			14	
Phylum: Platyhelminthes				
Class: Turbellaria			118	

Total: 48 OTU taxa			4129 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 4 August 2004 at station SKING-02, Silver King Creek, Upper valley, Site 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129086.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1813 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			14	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			29	
Class: Insecta				
Coleoptera	Elmidae		47	
Coleoptera	Elmidae	Heterlimnius	670	
Coleoptera	Elmidae	Heterlimnius corpulentus	36	
Coleoptera	Elmidae	Narpus concolor	4	
Coleoptera	Elmidae	Optioservus	4	
Coleoptera	Elmidae	Optioservus quadrimaculatus	4	
Diptera	Ceratopogonidae	Probezzia	11	
Diptera	Chironomidae		22	
Diptera	Chironomidae	Chironominae	1140	
Diptera	Chironomidae	Orthocladiinae	308	
Diptera	Chironomidae	Tanypodinae	25	
Diptera	Empididae	Chelifera	39	
Diptera	Psychodidae	Pericoma	11	
Diptera	Simuliidae		4	
Diptera	Simuliidae	Simulium	122	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Ameletidae	Ameletus	25	
Ephemeroptera	Baetidae	Baetis	1129	
Ephemeroptera	Baetidae	Diphetor hageni	18	
Ephemeroptera	Ephemerellidae		61	
Ephemeroptera	Ephemerellidae	Attenella delantala	82	
Ephemeroptera	Ephemerellidae	Caudatella	337	
Ephemeroptera	Ephemerellidae	Caudatella heterocaudata	7	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	61	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	240	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	297	
Ephemeroptera	Ephemerellidae	Serratella	39	
Ephemeroptera	Ephemerellidae	Serratella tibialis	4	
Ephemeroptera	Heptageniidae		68	
Ephemeroptera	Heptageniidae	Cinygmula	237	
Ephemeroptera	Heptageniidae	Epeorus	93	
Ephemeroptera	Heptageniidae	Rhithrogena	25	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	208	
Plecoptera	Chloroperlidae		79	
Plecoptera	Chloroperlidae	Sweltsa	111	
Plecoptera	Nemouridae		4	
Plecoptera	Nemouridae	Malenka	75	
Plecoptera	Nemouridae	Zapada columbiana	11	
Plecoptera	Peltoperlidae	Yoraperla	358	
Plecoptera	Perlidae		32	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlodidae		7	
Trichoptera			14	
Trichoptera	Brachycentridae	Brachycentrus americanus	25	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Glossosomatidae		4	
Trichoptera	Hydropsychidae		4	
Trichoptera	Hydropsychidae	Arctopsyche	25	
Trichoptera	Hydropsychidae	Arctopsyche californica	11	
Trichoptera	Hydropsychidae	Arctopsyche grandis	7	
Trichoptera	Rhyacophilidae		7	
Trichoptera	Rhyacophilidae	Rhyacophila	25	
Trichoptera	Rhyacophilidae	Rhyacophila arnaudi	25	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila verrula group	4	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	14	
Class: Ostracoda			32	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 129086.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	11	
Phylum: Platyhelminthes				
Class: Turbellaria			176	

Total: 62 OTU taxa			6498 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 10 August 2005 at station SKING-02, Silver King Creek, Upper valley, Site 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129087.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 662 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			7	
Class: Insecta				
Coleoptera	Elmidae		22	
Coleoptera	Elmidae	Heterlimnius	133	
Coleoptera	Elmidae	Heterlimnius corpulentus	7	
Coleoptera	Elmidae	Narpus concolor	4	
Coleoptera	Helophoridae	Helophorus	7	
Coleoptera	Hydraenidae	Ochthebius	4	
Diptera	Ceratopogonidae	Probezzia	4	
Diptera	Chironomidae		14	
Diptera	Chironomidae	Chironominae	50	
Diptera	Chironomidae	Orthocladiinae	190	
Diptera	Chironomidae	Tanypodinae	4	
Diptera	Empididae	Chelifera	4	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Simuliidae		4	
Diptera	Simuliidae	Simulium	136	
Diptera	Tipulidae	Hexatoma	4	
Diptera	Tipulidae	Rhabdomastix	4	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	283	
Ephemeroptera	Ephemerellidae		14	
Ephemeroptera	Ephemerellidae	Attenella delantala	140	
Ephemeroptera	Ephemerellidae	Caudatella	222	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	18	
Ephemeroptera	Ephemerellidae	Drunella doddsi	215	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	54	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	4	
Ephemeroptera	Heptageniidae		4	
Ephemeroptera	Heptageniidae	Cinygmula	75	
Ephemeroptera	Heptageniidae	Epeorus	90	
Ephemeroptera	Heptageniidae	Rhithrogena	22	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera			11	
Plecoptera	Chloroperlidae		4	
Plecoptera	Chloroperlidae	Suwallia	4	
Plecoptera	Chloroperlidae	Sweltsa	7	
Plecoptera	Nemouridae	Malenka	11	
Plecoptera	Peltoperlidae		4	
Plecoptera	Peltoperlidae	Yoraperla	75	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Trichoptera	Brachycentridae	Brachycentrus americanus	47	
Trichoptera	Brachycentridae	Micrasema	22	
Trichoptera	Glossosomatidae		93	
Trichoptera	Glossosomatidae	Glossosoma	229	
Trichoptera	Hydropsychidae		4	
Trichoptera	Rhyacophilidae	Rhyacophila	29	
Trichoptera	Rhyacophilidae	Rhyacophila angelita group	32	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	14	
Class: Ostracoda			11	
Phylum: Nemata			4	
Phylum: Platyhelminthes				
Class: Turbellaria			14	

Total: 53 OTU taxa			2373 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 August 2006 at station SKING-02, Silver King Creek, Upper valley, Site 2, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129088.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 523 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			7	
Class: Insecta				
Coleoptera			4	
Coleoptera	Elmidae		50	
Coleoptera	Elmidae	Heterlimnius	90	
Coleoptera	Elmidae	Heterlimnius corpulentus	4	
Coleoptera	Elmidae	Optioservus quadrimaculatus	4	
Diptera	Ceratopogonidae	Probezzia	4	
Diptera	Chironomidae		54	
Diptera	Chironomidae	Chironominae	136	
Diptera	Chironomidae	Orthocladiinae	100	
Diptera	Empididae	Chelifera	29	
Diptera	Simuliidae		4	
Diptera	Simuliidae	Prosimulium	11	
Diptera	Simuliidae	Simulium	129	
Ephemeroptera	Baetidae	Baetis	247	
Ephemeroptera	Baetidae	Diphetor hageni	4	
Ephemeroptera	Ephemerellidae		43	
Ephemeroptera	Ephemerellidae	Attenella delantala	122	
Ephemeroptera	Ephemerellidae	Caudatella	65	
Ephemeroptera	Ephemerellidae	Drunella	29	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	315	
Ephemeroptera	Heptageniidae		4	
Ephemeroptera	Heptageniidae	Cinygmula	36	
Ephemeroptera	Heptageniidae	Epeorus	18	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Plecoptera	Chloroperlidae		29	
Plecoptera	Nemouridae		4	
Plecoptera	Peltoperlidae	Yoraperla	161	
Trichoptera			4	
Trichoptera	Brachycentridae	Brachycentrus americanus	18	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Glossosomatidae		18	
Trichoptera	Glossosomatidae	Glossosoma	25	
Trichoptera	Rhyacophilidae	Rhyacophila	43	
Phylum: Platyhelminthes				
Class: Turbellaria			57	

Total: 36 OTU taxa			1875	individuals

Taxonomic list and abundances of aquatic invertebrates collected 5 August 2003 at station SKING-03, Silver King Creek, Upper Valley, Site 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129089.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 674 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			29	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			75	
Class: Insecta				
Coleoptera	Elmidae		61	
Coleoptera	Elmidae	Cleptelmis addenda	4	
Coleoptera	Elmidae	Heterlimnius	97	
Diptera	Chironomidae		22	
Diptera	Chironomidae	Chironominae	186	
Diptera	Chironomidae	Orthocladiinae	312	
Diptera	Chironomidae	Tanypodinae	14	
Diptera	Empididae	Chelifera	25	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	11	
Diptera	Simuliidae	Simulium	18	
Diptera	Tipulidae		4	
Diptera	Tipulidae	Hexatoma	11	
Diptera	Tipulidae	Rhabdomastix	4	
Ephemeroptera	Baetidae	Baetis	136	
Ephemeroptera	Ephemerellidae		208	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	211	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	22	
Ephemeroptera	Heptageniidae		11	
Ephemeroptera	Heptageniidae	Cinygmula	39	
Ephemeroptera	Heptageniidae	Epeorus	43	
Ephemeroptera	Heptageniidae	Rhithrogena	18	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	43	
Plecoptera			4	
Plecoptera	Chloroperlidae	Sweltsa	14	
Plecoptera	Peltoperlidae	Yoraperla	369	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlodidae		11	
Trichoptera			4	
Trichoptera	Brachycentridae	Brachycentrus americanus	50	
Trichoptera	Brachycentridae	Micrasema	50	
Trichoptera	Glossosomatidae		54	
Trichoptera	Glossosomatidae	Glossosoma	68	
Trichoptera	Hydropsychidae		4	
Trichoptera	Philopotamidae	Dolophilodes	4	
Trichoptera	Rhyacophilidae	Rhyacophila	4	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	29	
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group	25	
Class: Ostracoda			7	
Phylum: Platyhelminthes				
Class: Turbellaria			104	

Total: 44 OTU taxa			2416 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 4 August 2004 at station SKING-03, Silver King Creek, Upper Valley, Site 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129090.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1354 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			39	
Class: Insecta				
Coleoptera	Elmidae		36	
Coleoptera	Elmidae	Heterlimnius	280	
Coleoptera	Elmidae	Heterlimnius corpulentus	36	
Coleoptera	Elmidae	Narpus concolor	4	
Coleoptera	Helophoridae	Helophorus	4	
Coleoptera	Hydrophilidae		4	
Diptera	Ceratopogonidae	Probezzia	11	
Diptera	Chironomidae		29	
Diptera	Chironomidae	Chironominae	258	
Diptera	Chironomidae	Orthocladiinae	122	
Diptera	Chironomidae	Tanypodinae	4	
Diptera	Empididae	Chelifera	11	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Simuliidae	Simulium	158	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Hexatoma	11	
Diptera	Tipulidae	Rhabdomastix	4	
Ephemeroptera	Baetidae		36	
Ephemeroptera	Baetidae	Baetis	817	
Ephemeroptera	Baetidae	Diphetor hageni	7	
Ephemeroptera	Ephemerellidae		100	
Ephemeroptera	Ephemerellidae	Attenella delantala	11	
Ephemeroptera	Ephemerellidae	Caudatella	738	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	753	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	100	
Ephemeroptera	Heptageniidae		43	
Ephemeroptera	Heptageniidae	Cinygmula	72	
Ephemeroptera	Heptageniidae	Epeorus	161	
Ephemeroptera	Heptageniidae	Rhithrogena	68	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	39	
Plecoptera	Chloroperlidae		50	
Plecoptera	Chloroperlidae	Sweltsa	11	
Plecoptera	Leuctridae		4	
Plecoptera	Nemouridae	Malenka	4	
Plecoptera	Nemouridae	Zapada columbiana	7	
Plecoptera	Peltoperlidae	Yoraperla	398	
Plecoptera	Perlidae		25	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Plecoptera	Perlodidae		29	
Trichoptera			25	
Trichoptera	Brachycentridae	Brachycentrus americanus	50	
Trichoptera	Brachycentridae	Micrasema	47	
Trichoptera	Glossosomatidae		25	
Trichoptera	Glossosomatidae	Glossosoma	14	
Trichoptera	Hydropsychidae		4	
Trichoptera	Hydropsychidae	Arctopsyche californica	4	
Trichoptera	Hydropsychidae	Parapsyche elsis	4	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Philopotamidae		4	
Trichoptera	Philopotamidae	Dolophilodes	11	
Trichoptera	Rhyacophilidae	Rhyacophila	86	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	22	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	50	

Total: 57 OTU taxa			4853 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 10 August 2005 at station SKING-03, Silver King Creek, Upper Valley, Site 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129091.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 739 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			39	
Class: Insecta				
Coleoptera	Elmidae		14	
Coleoptera	Elmidae	Heterlimnius	147	
Coleoptera	Hydraenidae	Ochthebius	25	
Diptera	Ceratopogonidae	Probezzia	11	
Diptera	Chironomidae		61	
Diptera	Chironomidae	Chironominae	140	
Diptera	Chironomidae	Orthocladiinae	265	
Diptera	Empididae	Chelifera	7	
Diptera	Simuliidae	Prosimulium	4	
Diptera	Simuliidae	Simulium	61	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	204	
Ephemeroptera	Ephemerellidae		118	
Ephemeroptera	Ephemerellidae	Attenella delantala	36	
Ephemeroptera	Ephemerellidae	Caudatella	158	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	4	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	11	
Ephemeroptera	Ephemerellidae	Drunella doddsi	333	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	32	
Ephemeroptera	Ephemerellidae	Ephemerella inermis/dorothea	7	
Ephemeroptera	Heptageniidae		4	
Ephemeroptera	Heptageniidae	Cinygmula	65	
Ephemeroptera	Heptageniidae	Epeorus	65	
Ephemeroptera	Heptageniidae	Rhithrogena	29	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera	Chloroperlidae		18	
Plecoptera	Chloroperlidae	Sweltsa	11	
Plecoptera	Leuctridae		11	
Plecoptera	Nemouridae	Malenka	11	
Plecoptera	Nemouridae	Visoka cataractae	4	
Plecoptera	Peltoperlidae		4	
Plecoptera	Peltoperlidae	Yoraperla	455	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Plecoptera	Perlodidae		14	
Trichoptera			4	
Trichoptera	Brachycentridae	Brachycentrus americanus	11	
Trichoptera	Brachycentridae	Micrasema	75	
Trichoptera	Glossosomatidae		7	
Trichoptera	Glossosomatidae	Glossosoma	29	
Trichoptera	Philopotamidae		7	
Trichoptera	Rhyacophilidae	Rhyacophila	57	
Trichoptera	Rhyacophilidae	Rhyacophila arnaudi	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	14	
Trichoptera	Rhyacophilidae	Rhyacophila vagrita	4	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	39	
Trichoptera	Uenoidae	Neophylax splendens	4	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	11	

Total: 49 OTU taxa			2649 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 August 2006 at station SKING-03, Silver King Creek, Upper Valley, Site 3, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129092.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 655 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			4	
Class: Insecta				
Coleoptera	Dytiscidae	Stictotarsus	4	
Coleoptera	Elmidae		14	
Coleoptera	Elmidae	Heterlimnius	104	
Coleoptera	Hydraenidae	Hydraena	4	
Coleoptera	Hydraenidae	Ochthebius	4	
Diptera	Ceratopogonidae	Probezzia	4	
Diptera	Chironomidae		22	
Diptera	Chironomidae	Chironominae	179	
Diptera	Chironomidae	Orthocladiinae	72	
Diptera	Chironomidae	Tanypodinae	4	
Diptera	Empididae	Chelifera	54	
Diptera	Pelecorhynchidae	Glutops	7	
Diptera	Psychodidae	Pericoma	4	
Diptera	Simuliidae	Prosimulium	7	
Diptera	Simuliidae	Simulium	32	
Diptera	Tipulidae		4	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	344	
Ephemeroptera	Baetidae	Diphetor hageni	4	
Ephemeroptera	Ephemerellidae		7	
Ephemeroptera	Ephemerellidae	Attenella delantala	61	
Ephemeroptera	Ephemerellidae	Caudatella	65	
Ephemeroptera	Ephemerellidae	Drunella	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	720	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	29	
Ephemeroptera	Heptageniidae		43	
Ephemeroptera	Heptageniidae	Cinygmula	54	
Ephemeroptera	Heptageniidae	Epeorus	61	
Ephemeroptera	Heptageniidae	Rhithrogena	79	
Plecoptera	Chloroperlidae		4	
Plecoptera	Chloroperlidae	Sweltsa	4	
Plecoptera	Leuctridae		4	
Plecoptera	Nemouridae		4	
Plecoptera	Peltoperlidae	Yoraperla	165	
Plecoptera	Perlidae	Doroneuria baumanni	14	
Plecoptera	Perlodidae		7	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Glossosomatidae	Glossosoma	36	
Trichoptera	Rhyacophilidae	Rhyacophila	39	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	11	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	7	
Phylum: Platyhelminthes				
Class: Turbellaria			39	

Total: 45 OTU taxa			2348 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 5 August 2003 at station SKING-04, Silver King Creek, Upper Valley, Site 4, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129093.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 660 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			11	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			39	
Class: Insecta				
Coleoptera	Elmidae		22	
Coleoptera	Elmidae	Heterlimnius	147	
Diptera	Ceratopogonidae	Probezzia	4	
Diptera	Chironomidae		7	
Diptera	Chironomidae	Chironominae	229	
Diptera	Chironomidae	Orthocladiinae	351	
Diptera	Chironomidae	Tanypodinae	11	
Diptera	Empididae	Chelifera	36	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	4	
Diptera	Simuliidae		7	
Diptera	Simuliidae	Simulium	14	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Baetidae		29	
Ephemeroptera	Baetidae	Baetis	290	
Ephemeroptera	Ephemerellidae		179	
Ephemeroptera	Ephemerellidae	Attenella delantala	75	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	211	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	43	
Ephemeroptera	Heptageniidae		4	
Ephemeroptera	Heptageniidae	Cinygmula	68	
Ephemeroptera	Heptageniidae	Epeorus	50	
Ephemeroptera	Heptageniidae	Rhithrogena	7	
Plecoptera			4	
Plecoptera	Chloroperlidae		7	
Plecoptera	Chloroperlidae	Sweltsa	7	
Plecoptera	Nemouridae	Zapada columbiana	4	
Plecoptera	Peltoperlidae	Yoraperla	122	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Plecoptera	Perlodidae		22	
Trichoptera	Brachycentridae	Brachycentrus americanus	18	
Trichoptera	Brachycentridae	Micrasema	29	
Trichoptera	Glossosomatidae		68	
Trichoptera	Glossosomatidae	Glossosoma	39	
Trichoptera	Hydropsychidae		4	
Trichoptera	Hydropsychidae	Parapsyche	4	
Trichoptera	Philopotamidae		4	
Trichoptera	Philopotamidae	Dolophilodes	4	
Trichoptera	Rhyacophilidae	Rhyacophila	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	54	
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group	18	
Class: Ostracoda			11	
Phylum: Nemata			25	
Phylum: Platyhelminthes				
Class: Turbellaria			54	

Total: 48 OTU taxa			2366 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 3 August 2004 at station SKING-04, Silver King Creek, Upper Valley, Site 4, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129094.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1381 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			18	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			36	
Class: Insecta				
Coleoptera	Elmidae	Heterlimnius	427	
Coleoptera	Elmidae	Heterlimnius corpulentus	18	
Coleoptera	Elmidae	Narpus concolor	4	
Coleoptera	Helophoridae	Helophorus	4	
Diptera	Ceratopogonidae	Probezzia	22	
Diptera	Chironomidae		14	
Diptera	Chironomidae	Chironominae	1004	
Diptera	Chironomidae	Orthocladiinae	459	
Diptera	Chironomidae	Tanypodinae	18	
Diptera	Empididae		4	
Diptera	Empididae	Chelifera	47	
Diptera	Psychodidae	Pericoma	29	
Diptera	Simuliidae		4	
Diptera	Simuliidae	Simulium	18	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Hexatoma	7	
Ephemeroptera	Ameletidae	Ameletus	269	
Ephemeroptera	Baetidae	Baetis	871	
Ephemeroptera	Baetidae	Diphetor hageni	14	
Ephemeroptera	Ephemerellidae		43	
Ephemeroptera	Ephemerellidae	Attenella delantala	90	
Ephemeroptera	Ephemerellidae	Caudatella	86	
Ephemeroptera	Ephemerellidae	Drunella doddsi	258	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	197	
Ephemeroptera	Heptageniidae		32	
Ephemeroptera	Heptageniidae	Cinygmula	93	
Ephemeroptera	Heptageniidae	Epeorus	22	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	122	
Plecoptera	Chloroperlidae		136	
Plecoptera	Chloroperlidae	Suwallia	11	
Plecoptera	Nemouridae	Malenka	36	
Plecoptera	Peltoperlidae	Yoraperla	154	
Plecoptera	Perlidae		7	
Plecoptera	Perlidae	Doroneuria baumanni	18	
Plecoptera	Perlodidae		50	
Trichoptera			11	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Brachycentridae	Brachycentrus	4	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Glossosomatidae		14	
Trichoptera	Hydropsychidae		22	
Trichoptera	Hydropsychidae	Arctopsyche grandis	4	
Trichoptera	Limnephilidae		4	
Trichoptera	Philopotamidae	Dolophilodes	4	
Trichoptera	Rhyacophilidae	Rhyacophila	47	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	47	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	32	
Phylum: Nemata			4	
Phylum: Platyhelminthes				
Class: Turbellaria			104	

Total: 53 OTU taxa			4950 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 10 August 2005 at station SKING-04, Silver King Creek, Upper Valley, Site 4, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129095.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 461 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			11	
Class: Insecta				
Coleoptera	Elmidae	Heterlimnius	122	
Coleoptera	Elmidae	Heterlimnius corpulentus	57	
Coleoptera	Elmidae	Narpus concolor	4	
Diptera	Ceratopogonidae	Probezzia	7	
Diptera	Chironomidae		47	
Diptera	Chironomidae	Chironominae	115	
Diptera	Chironomidae	Orthocladiinae	161	
Diptera	Chironomidae	Tanypodinae	7	
Diptera	Empididae		4	
Diptera	Empididae	Chelifera	22	
Diptera	Simuliidae		18	
Diptera	Simuliidae	Prosimulium	4	
Diptera	Simuliidae	Simulium	22	
Diptera	Tipulidae	Antocha	7	
Diptera	Tipulidae	Hexatoma	4	
Diptera	Tipulidae	Rhabdomastix	4	
Ephemeroptera	Baetidae	Baetis	161	
Ephemeroptera	Ephemerellidae		18	
Ephemeroptera	Ephemerellidae	Attenella delantala	93	
Ephemeroptera	Ephemerellidae	Caudatella	32	
Ephemeroptera	Ephemerellidae	Drunella	22	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	276	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	25	
Ephemeroptera	Heptageniidae	Cinygmula	29	
Ephemeroptera	Heptageniidae	Epeorus	18	
Ephemeroptera	Heptageniidae	Rhithrogena	7	
Plecoptera			4	
Plecoptera	Chloroperlidae		4	
Plecoptera	Chloroperlidae	Sweltsa	7	
Plecoptera	Leuctridae		4	
Plecoptera	Peltoperlidae	Yoraperla	97	
Plecoptera	Perlidae		11	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Trichoptera			4	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Brachycentridae	Brachycentrus	4	
Trichoptera	Brachycentridae	Brachycentrus americanus	7	
Trichoptera	Brachycentridae	Micrasema	7	
Trichoptera	Glossosomatidae		11	
Trichoptera	Glossosomatidae	Glossosoma	32	
Trichoptera	Rhyacophilidae	Rhyacophila	57	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	43	
Class: Ostracoda			11	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	22	

Total: 48 OTU taxa			1652 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 August 2006 at station SKING-04, Silver King Creek, Upper Valley, Site 4, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129096.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 261 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			4	
Class: Insecta				
Coleoptera	Elmidae	Heterlimnius	68	
Coleoptera	Elmidae	Heterlimnius corpulentus	4	
Coleoptera	Hydraenidae	Hydraena	4	
Diptera	Chironomidae		11	
Diptera	Chironomidae	Chironominae	79	
Diptera	Chironomidae	Orthocladiinae	36	
Diptera	Dixidae	Dixa	4	
Diptera	Empididae		4	
Diptera	Simuliidae	Prosimulium	14	
Diptera	Simuliidae	Simulium	36	
Ephemeroptera	Baetidae	Baetis	151	
Ephemeroptera	Ephemerellidae	Attenella delantala	104	
Ephemeroptera	Ephemerellidae	Caudatella	4	
Ephemeroptera	Ephemerellidae	Drunella	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	140	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	4	
Ephemeroptera	Heptageniidae	Cinygmula	32	
Ephemeroptera	Heptageniidae	Epeorus	29	
Ephemeroptera	Heptageniidae	Rhithrogena	18	
Plecoptera	Chloroperlidae		4	
Plecoptera	Leuctridae		4	
Plecoptera	Peltoperlidae	Yoraperla	32	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Plecoptera	Perlodidae		7	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Brachycentridae	Brachycentrus americanus	29	
Trichoptera	Glossosomatidae	Glossosoma	11	
Trichoptera	Rhyacophilidae	Rhyacophila	36	
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group a	4	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	47	

Total: 31 OTU taxa			935 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 5 August 2003 at station SKING-05, Silver King Creek, Lower Valley, Site 5, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129097.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 353 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			36	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			18	
Class: Insecta				
Coleoptera	Elmidae		4	
Coleoptera	Elmidae	Heterlimnius	68	
Coleoptera	Elmidae	Optioservus	4	
Diptera	Ceratopogonidae	Probezzia	32	
Diptera	Chironomidae	Chironominae	29	
Diptera	Chironomidae	Orthocladiinae	100	
Diptera	Pelecorhynchidae	Glutops	4	
Diptera	Psychodidae	Pericoma	4	
Diptera	Simuliidae	Simulium	4	
Diptera	Tipulidae	Antocha	4	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	194	
Ephemeroptera	Ephemerellidae		7	
Ephemeroptera	Ephemerellidae	Attenella delantala	36	
Ephemeroptera	Ephemerellidae	Drunella doddsi	43	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	39	
Ephemeroptera	Heptageniidae		4	
Ephemeroptera	Heptageniidae	Cinygmula	50	
Ephemeroptera	Heptageniidae	Epeorus	22	
Ephemeroptera	Heptageniidae	Rhithrogena	11	
Plecoptera	Chloroperlidae		4	
Plecoptera	Peltoperlidae	Yoraperla	104	
Plecoptera	Perlidae		4	
Plecoptera	Perlodidae		11	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Brachycentridae	Brachycentrus americanus	287	
Trichoptera	Brachycentridae	Micrasema	36	
Trichoptera	Glossosomatidae		29	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Hydropsychidae		7	
Trichoptera	Hydropsychidae	Arctopsyche grandis	4	
Trichoptera	Lepidostomatidae	Lepidostoma	4	
Trichoptera	Philopotamidae	Dolophilodes	7	
Trichoptera	Philopotamidae	Wormaldia	4	
Trichoptera	Rhyacophilidae		4	
Trichoptera	Rhyacophilidae	Rhyacophila	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	11	
Phylum: Platyhelminthes				
Class: Turbellaria			25	

Total: 40 OTU taxa			1265 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 3 August 2004 at station SKING-05, Silver King Creek, Lower Valley, Site 5, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129098.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 936 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			50	
Class: Insecta				
Coleoptera	Elmidae		39	
Coleoptera	Elmidae	Cleptelmis addenda	4	
Coleoptera	Elmidae	Heterlimnius	165	
Coleoptera	Elmidae	Heterlimnius corpulentus	14	
Coleoptera	Elmidae	Narpus concolor	7	
Coleoptera	Elmidae	Optioservus	7	
Coleoptera	Elmidae	Optioservus quadrimaculatus	18	
Diptera	Athericidae	Atherix pachypus	11	
Diptera	Ceratopogonidae	Probezzia	43	
Diptera	Chironomidae		4	
Diptera	Chironomidae	Chironominae	7	
Diptera	Chironomidae	Orthocladiinae	237	
Diptera	Chironomidae	Tanypodinae	7	
Diptera	Psychodidae	Pericoma	4	
Diptera	Simuliidae	Simulium	32	
Diptera	Tipulidae	Hexatoma	7	
Diptera	Tipulidae	Rhabdomastix	4	
Ephemeroptera	Ameletidae	Ameletus	115	
Ephemeroptera	Baetidae		133	
Ephemeroptera	Baetidae	Baetis	717	
Ephemeroptera	Ephemerellidae		36	
Ephemeroptera	Ephemerellidae	Attenella delantala	54	
Ephemeroptera	Ephemerellidae	Caudatella	186	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	244	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	312	
Ephemeroptera	Ephemerellidae	Serratella	7	
Ephemeroptera	Heptageniidae		100	
Ephemeroptera	Heptageniidae	Cinygmula	75	
Ephemeroptera	Heptageniidae	Epeorus	25	
Ephemeroptera	Heptageniidae	Rhithrogena	151	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	7	
Plecoptera	Chloroperlidae		36	
Plecoptera	Chloroperlidae	Suwallia	22	
Plecoptera	Chloroperlidae	Sweltsa	14	
Plecoptera	Nemouridae	Malenka	14	
Plecoptera	Peltoperlidae		4	
Plecoptera	Peltoperlidae	Yoraperla	108	
Plecoptera	Perlidae		18	
Plecoptera	Perlidae	Doroneuria baumanni	11	
Plecoptera	Perlodidae		25	
Plecoptera	Perlodidae	Oroperla barbara	11	
Trichoptera	Brachycentridae	Brachycentrus americanus	47	
Trichoptera	Brachycentridae	Micrasema	86	
Trichoptera	Glossosomatidae		4	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Hydropsychidae		18	
Trichoptera	Hydropsychidae	Arctopsyche	39	
Trichoptera	Hydropsychidae	Arctopsyche californica	7	
Trichoptera	Hydropsychidae	Arctopsyche grandis	11	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Philopotamidae	Dolophilodes	7	
Trichoptera	Rhyacophilidae		7	
Trichoptera	Rhyacophilidae	Rhyacophila	7	
Trichoptera	Rhyacophilidae	Rhyacophila arnaudi	22	
Trichoptera	Rhyacophilidae	Rhyacophila verrula group	4	
Class: Ostracoda			4	

Total: 58 OTU taxa			3355 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 August 2005 at station SKING-05, Silver King Creek, Lower Valley, Site 5, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129099.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 287 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			4	
Class: Insecta				
Coleoptera	Elmidae	Heterlimnius	82	
Coleoptera	Elmidae	Heterlimnius corpulentus	14	
Diptera	Ceratopogonidae	Probezzia	11	
Diptera	Chironomidae		11	
Diptera	Chironomidae	Chironominae	18	
Diptera	Chironomidae	Orthocladiinae	204	
Diptera	Chironomidae	Tanypodinae	7	
Diptera	Simuliidae	Simulium	18	
Ephemeroptera	Baetidae	Baetis	32	
Ephemeroptera	Ephemerellidae		4	
Ephemeroptera	Ephemerellidae	Attenella delantala	72	
Ephemeroptera	Ephemerellidae	Caudatella	11	
Ephemeroptera	Ephemerellidae	Drunella	18	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	90	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	25	
Ephemeroptera	Ephemerellidae	Serratella	7	
Ephemeroptera	Heptageniidae		4	
Ephemeroptera	Heptageniidae	Cinygmula	14	
Ephemeroptera	Heptageniidae	Epeorus	36	
Ephemeroptera	Heptageniidae	Rhithrogena	7	
Plecoptera			4	
Plecoptera	Chloroperlidae		22	
Plecoptera	Chloroperlidae	Suwallia	7	
Plecoptera	Chloroperlidae	Sweltsa	4	
Plecoptera	Peltoperlidae	Yoraperla	54	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlodidae		4	
Trichoptera	Brachycentridae	Brachycentrus americanus	14	
Trichoptera	Brachycentridae	Micrasema	29	
Trichoptera	Glossosomatidae		47	
Trichoptera	Glossosomatidae	Glossosoma	47	
Trichoptera	Hydropsychidae		7	
Trichoptera	Philopotamidae	Dolophilodes	7	
Trichoptera	Rhyacophilidae	Rhyacophila	47	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	11	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	22	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	7	

Total: 40 OTU taxa			1029 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 8 August 2006 at station SKING-05, Silver King Creek, Lower Valley, Site 5, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129100.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 324 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			14	
Class: Insecta				
Coleoptera	Elmidae		7	
Coleoptera	Elmidae	Heterlimnius	36	
Coleoptera	Elmidae	Heterlimnius corpulentus	14	
Diptera	Athericidae	Atherix pachypus	4	
Diptera	Ceratopogonidae		7	
Diptera	Ceratopogonidae	Probezzia	11	
Diptera	Chironomidae		7	
Diptera	Chironomidae	Chironominae	25	
Diptera	Chironomidae	Orthocladiinae	111	
Diptera	Chironomidae	Tanypodinae	4	
Diptera	Simuliidae	Simulium	39	
Ephemeroptera	Baetidae	Baetis	301	
Ephemeroptera	Baetidae	Diphetor hageni	4	
Ephemeroptera	Ephemerellidae		7	
Ephemeroptera	Ephemerellidae	Attenella delantala	47	
Ephemeroptera	Ephemerellidae	Caudatella	7	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	18	
Ephemeroptera	Ephemerellidae	Drunella doddsi	183	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	7	
Ephemeroptera	Heptageniidae		14	
Ephemeroptera	Heptageniidae	Cinygmula	54	
Ephemeroptera	Heptageniidae	Epeorus	32	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Plecoptera	Chloroperlidae	Suwallia	4	
Plecoptera	Peltoperlidae	Yoraperla	72	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Plecoptera	Perlodidae		14	
Trichoptera	Brachycentridae	Brachycentrus americanus	22	
Trichoptera	Brachycentridae	Micrasema	7	
Trichoptera	Philopotamidae	Dolophilodes	7	
Trichoptera	Rhyacophilidae	Rhyacophila	36	
Trichoptera	Rhyacophilidae	Rhyacophila angelita group	4	
Trichoptera	Rhyacophilidae	Rhyacophila arnaudi	7	
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group c	11	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	7	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	

Total: 38 OTU taxa			1161 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 5 August 2003 at station SKING-06, Silver King Creek, Lower Valley, Site 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129101.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1083 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			18	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			65	
Class: Insecta				
Coleoptera	Elmidae		11	
Coleoptera	Elmidae	Cleptelmis addenda	39	
Coleoptera	Elmidae	Heterlimnius	97	
Coleoptera	Elmidae	Heterlimnius corpulentus	18	
Coleoptera	Elmidae	Optioservus	11	
Diptera	Ceratopogonidae	Probezzia	7	
Diptera	Chironomidae		11	
Diptera	Chironomidae	Chironominae	577	
Diptera	Chironomidae	Orthocladiinae	366	
Diptera	Empididae	Chelifera	11	
Diptera	Psychodidae	Pericoma	7	
Diptera	Simuliidae	Simulium	82	
Diptera	Tipulidae	Antocha	11	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	548	
Ephemeroptera	Ephemerellidae		158	
Ephemeroptera	Ephemerellidae	Attenella delantala	18	
Ephemeroptera	Ephemerellidae	Drunella doddsi	158	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	90	
Ephemeroptera	Heptageniidae		4	
Ephemeroptera	Heptageniidae	Cinygmula	39	
Ephemeroptera	Heptageniidae	Epeorus	61	
Ephemeroptera	Heptageniidae	Rhithrogena	18	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera	Chloroperlidae		14	
Plecoptera	Peltoperlidae	Yoraperla	254	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlodidae		14	
Trichoptera	Brachycentridae	Brachycentrus americanus	280	
Trichoptera	Brachycentridae	Micrasema	509	
Trichoptera	Glossosomatidae		36	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Hydropsychidae		129	
Trichoptera	Hydropsychidae	Arctopsyche	7	
Trichoptera	Philopotamidae		4	
Trichoptera	Philopotamidae	Dolophilodes	32	
Trichoptera	Rhyacophilidae	Rhyacophila	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	57	
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group	18	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Class: Gastropoda			4	
Phylum: Nemata			4	
Phylum: Platyhelminthes				
Class: Turbellaria			68	

Total: 46 OTU taxa			3882 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 2 August 2004 at station SKING-06, Silver King Creek, Lower Valley, Site 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129102.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 687 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			43	
Class: Insecta				
Coleoptera	Elmidae		7	
Coleoptera	Elmidae	Cleptelmis addenda	7	
Coleoptera	Elmidae	Heterlimnius	97	
Coleoptera	Elmidae	Heterlimnius corpulentus	7	
Coleoptera	Elmidae	Narpus concolor	4	
Coleoptera	Elmidae	Optioservus	7	
Diptera	Chironomidae	Chironominae	165	
Diptera	Chironomidae	Orthocladiinae	179	
Diptera	Empididae	Chelifera	7	
Diptera	Simuliidae		4	
Diptera	Simuliidae	Prosimulium	11	
Diptera	Simuliidae	Simulium	93	
Diptera	Tipulidae	Dicranota	4	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	452	
Ephemeroptera	Baetidae	Diphetor hageni	4	
Ephemeroptera	Ephemerellidae		61	
Ephemeroptera	Ephemerellidae	Attenella delantala	7	
Ephemeroptera	Ephemerellidae	Caudatella	179	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	61	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	29	
Ephemeroptera	Ephemerellidae	Drunella doddsi	176	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	104	
Ephemeroptera	Ephemerellidae	Serratella tibialis	7	
Ephemeroptera	Heptageniidae		43	
Ephemeroptera	Heptageniidae	Cinygmula	54	
Ephemeroptera	Heptageniidae	Epeorus	36	
Ephemeroptera	Heptageniidae	Rhithrogena	72	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	22	
Plecoptera	Chloroperlidae		57	
Plecoptera	Chloroperlidae	Sweltsa	4	
Plecoptera	Nemouridae	Malenka	7	
Plecoptera	Nemouridae	Zapada	4	
Plecoptera	Nemouridae	Zapada columbiana	14	
Plecoptera	Peltoperlidae	Yoraperla	25	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlodidae		22	
Trichoptera	Brachycentridae	Brachycentrus americanus	39	
Trichoptera	Brachycentridae	Micrasema	161	
Trichoptera	Hydropsychidae		29	
Trichoptera	Hydropsychidae	Arctopsyche	57	
Trichoptera	Hydropsychidae	Arctopsyche grandis	4	
Trichoptera	Philopotamidae	Dolophilodes	4	
Trichoptera	Rhyacophilidae		4	
Trichoptera	Rhyacophilidae	Rhyacophila	22	
Trichoptera	Rhyacophilidae	Rhyacophila arnaudi	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	43	
Phylum: Platyhelminthes				
Class: Turbellaria			4	

Total: 51 OTU taxa			2462 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 August 2005 at station SKING-06, Silver King Creek, Lower Valley, Site 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129103.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 631 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			14	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			11	
Class: Insecta				
Coleoptera	Elmidae		39	
Coleoptera	Elmidae	Heterlimnius	111	
Coleoptera	Elmidae	Heterlimnius corpulentus	4	
Coleoptera	Elmidae	Narpus concolor	4	
Coleoptera	Elmidae	Optioservus	7	
Coleoptera	Elmidae	Optioservus divergens/pecosensis	4	
Diptera	Ceratopogonidae	Probezzia	11	
Diptera	Chironomidae		22	
Diptera	Chironomidae	Chironominae	194	
Diptera	Chironomidae	Orthocladiinae	254	
Diptera	Simuliidae		7	
Diptera	Simuliidae	Simulium	409	
Diptera	Tipulidae	Antocha	4	
Diptera	Tipulidae	Rhabdomastix	4	
Ephemeroptera	Baetidae		4	
Ephemeroptera	Baetidae	Baetis	18	
Ephemeroptera	Ephemerellidae		14	
Ephemeroptera	Ephemerellidae	Attenella delantala	7	
Ephemeroptera	Ephemerellidae	Caudatella	4	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	29	
Ephemeroptera	Ephemerellidae	Drunella doddsi	240	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	79	
Ephemeroptera	Ephemerellidae	Serratella	11	
Ephemeroptera	Heptageniidae		4	
Ephemeroptera	Heptageniidae	Cinygmula	7	
Ephemeroptera	Heptageniidae	Epeorus	61	
Ephemeroptera	Heptageniidae	Rhithrogena	7	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	7	
Plecoptera			7	
Plecoptera	Chloroperlidae		18	
Plecoptera	Chloroperlidae	Suwallia	7	
Plecoptera	Chloroperlidae	Sweltsa	7	
Plecoptera	Leuctridae		4	
Plecoptera	Peltoperlidae	Yoraperla	219	
Trichoptera			22	
Trichoptera	Brachycentridae	Brachycentrus americanus	18	
Trichoptera	Brachycentridae	Micrasema	240	
Trichoptera	Glossosomatidae		32	
Trichoptera	Glossosomatidae	Glossosoma	22	
Trichoptera	Lepidostomatidae	Lepidostoma	11	
Trichoptera	Polycentropodidae	Polycentropus	14	
Trichoptera	Rhyacophilidae	Rhyacophila	4	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	36	
Trichoptera	Uenoidae	Farula	4	
Phylum: Nemata			4	

Total: 48 OTU taxa			2262 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 8 August 2006 at station SKING-06, Silver King Creek, Lower Valley, Site 6, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129104.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 681 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			22	
Class: Insecta				
Coleoptera	Elmidae	Cleptelmis addenda	7	
Coleoptera	Elmidae	Heterlimnius	104	
Coleoptera	Elmidae	Heterlimnius corpulentus	7	
Coleoptera	Elmidae	Narpus concolor	4	
Coleoptera	Hydraenidae	Hydraena	7	
Diptera	Ceratopogonidae	Probezzia	4	
Diptera	Chironomidae		25	
Diptera	Chironomidae	Chironominae	54	
Diptera	Chironomidae	Orthocladiinae	384	
Diptera	Simuliidae	Simulium	548	
Diptera	Tipulidae	Antocha	14	
Diptera	Tipulidae	Rhabdomastix	4	
Ephemeroptera	Baetidae	Baetis	380	
Ephemeroptera	Ephemerellidae		7	
Ephemeroptera	Ephemerellidae	Attenella delantala	32	
Ephemeroptera	Ephemerellidae	Caudatella	204	
Ephemeroptera	Ephemerellidae	Drunella	39	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	136	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	25	
Ephemeroptera	Heptageniidae	Cinygmula	7	
Ephemeroptera	Heptageniidae	Epeorus	50	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Megaloptera	Sialidae	Sialis	4	
Plecoptera			4	
Plecoptera	Chloroperlidae		11	
Plecoptera	Nemouridae	Zapada	7	
Plecoptera	Peltoperlidae	Yoraperla	90	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Plecoptera	Perlodidae		36	
Trichoptera	Brachycentridae	Brachycentrus americanus	25	
Trichoptera	Brachycentridae	Micrasema	111	
Trichoptera	Glossosomatidae	Glossosoma	11	
Trichoptera	Hydropsychidae	Arctopsyche grandis	7	
Trichoptera	Philopotamidae		4	
Trichoptera	Rhyacophilidae	Rhyacophila	18	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	18	

Total: 39 OTU taxa			2441 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 5 August 2003 at station SKING-07, Silver King Creek, Long Valley, Site 7, Alpine County, California . The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129105. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 720 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			50	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			43	
Class: Insecta				
Coleoptera	Curculionidae		4	
Coleoptera	Elmidae	Heterlimnius	14	
Coleoptera	Elmidae	Optioservus	7	
Diptera	Athericidae	Atherix pachypus	25	
Diptera	Ceratopogonidae	Probezzia	11	
Diptera	Chironomidae		7	
Diptera	Chironomidae	Chironominae	265	
Diptera	Chironomidae	Orthocladiinae	186	
Diptera	Simuliidae		7	
Diptera	Simuliidae	Simulium	29	
Diptera	Tipulidae	Antocha	4	
Ephemeroptera	Baetidae	Baetis	814	
Ephemeroptera	Ephemerellidae		97	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	215	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	68	
Ephemeroptera	Ephemerellidae	Serratella tibialis	7	
Ephemeroptera	Heptageniidae		18	
Ephemeroptera	Heptageniidae	Cinygmula	4	
Ephemeroptera	Heptageniidae	Epeorus	262	
Ephemeroptera	Heptageniidae	Rhithrogena	104	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera	Chloroperlidae		29	
Plecoptera	Chloroperlidae	Suwallia	7	
Plecoptera	Nemouridae		4	
Plecoptera	Peltoperlidae	Yoraperla	29	
Plecoptera	Perlodidae		4	
Plecoptera	Perlodidae	Oroperla barbara	4	
Trichoptera	Brachycentridae	Micrasema	118	
Trichoptera	Glossosomatidae		18	
Trichoptera	Hydropsychidae		11	
Trichoptera	Philopotamidae		14	
Trichoptera	Philopotamidae	Dolophilodes	29	
Trichoptera	Rhyacophilidae	Rhyacophila	7	
Phylum: Nemata			11	
Phylum: Platyhelminthes				
Class: Turbellaria			36	

Total: 39 OTU taxa			2581 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 2 August 2004 at station SKING-07, Silver King Creek, Long Valley, Site 7, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129106. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 430 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			50	
Class: Insecta				
Coleoptera	Elmidae	Optioservus	7	
Diptera	Athericidae	Atherix pachypus	32	
Diptera	Ceratopogonidae	Probezzia	4	
Diptera	Chironomidae		7	
Diptera	Chironomidae	Chironominae	140	
Diptera	Chironomidae	Orthocladiinae	75	
Diptera	Simuliidae		4	
Diptera	Simuliidae	Simulium	7	
Diptera	Tipulidae		4	
Diptera	Tipulidae	Antocha	11	
Diptera	Tipulidae	Hexatoma	4	
Diptera	Tipulidae	Limnophila	4	
Ephemeroptera	Baetidae		36	
Ephemeroptera	Baetidae	Baetis	265	
Ephemeroptera	Ephemerellidae		36	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Caudatella	215	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	18	
Ephemeroptera	Ephemerellidae	Drunella doddsi	151	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	29	
Ephemeroptera	Ephemerellidae	Serratella	4	
Ephemeroptera	Heptageniidae		54	
Ephemeroptera	Heptageniidae	Cinygmula	4	
Ephemeroptera	Heptageniidae	Epeorus	93	
Ephemeroptera	Heptageniidae	Rhithrogena	100	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	18	
Plecoptera	Chloroperlidae		36	
Plecoptera	Chloroperlidae	Sweltsa	4	
Plecoptera	Nemouridae	Malenka	4	
Plecoptera	Nemouridae	Visoka cataractae	4	
Plecoptera	Peltoperlidae	Yoraperla	4	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlodidae		4	
Plecoptera	Perlodidae	Megarcys	4	
Trichoptera			4	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Brachycentridae	Micrasema	50	
Trichoptera	Hydropsychidae		14	
Trichoptera	Hydropsychidae	Arctopsyche grandis	4	
Trichoptera	Rhyacophilidae	Rhyacophila	11	
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group a	4	
Phylum: Platyhelminthes				
Class: Turbellaria			11	

Total: 44 OTU taxa			1541 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 August 2005 at station SKING-07, Silver King Creek, Long Valley, Site 7, Alpine County, California . The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129107. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 245 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			14	
Class: Insecta				
Coleoptera	Dytiscidae	Oreodytes	4	
Diptera	Chironomidae	Chironominae	25	
Diptera	Chironomidae	Orthocladiinae	18	
Diptera	Simuliidae	Simulium	419	
Ephemeroptera	Baetidae	Baetis	54	
Ephemeroptera	Ephemerellidae		11	
Ephemeroptera	Ephemerellidae	Attenella attenuata group	11	
Ephemeroptera	Ephemerellidae	Attenella delantala	29	
Ephemeroptera	Ephemerellidae	Caudatella	18	
Ephemeroptera	Ephemerellidae	Caudatella heterocaudata	4	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	4	
Ephemeroptera	Ephemerellidae	Drunella doddsi	61	
Ephemeroptera	Heptageniidae		7	
Ephemeroptera	Heptageniidae	Epeorus	43	
Ephemeroptera	Heptageniidae	Rhithrogena	7	
Plecoptera	Chloroperlidae		22	
Plecoptera	Chloroperlidae	Suwallia	14	
Plecoptera	Chloroperlidae	Sweltsa	4	
Plecoptera	Peltoperlidae	Yoraperla	25	
Plecoptera	Perlidae	Claassenia sabulosa	4	
Trichoptera	Brachycentridae	Micrasema	47	
Trichoptera	Glossosomatidae		11	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Rhyacophilidae	Rhyacophila	11	
Trichoptera	Rhyacophilidae	Rhyacophila angelita group	7	

Total: 26 OTU taxa			878 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 8 August 2006 at station SKING-07, Silver King Creek, Long Valley, Site 7, Alpine County, California . The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129108. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 526 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			22	
Class: Insecta				
Coleoptera	Elmidae	Cleptelmis addenda	7	
Coleoptera	Hydraenidae	Hydraena	4	
Diptera	Athericidae	Atherix pachypus	57	
Diptera	Chironomidae		43	
Diptera	Chironomidae	Chironominae	32	
Diptera	Chironomidae	Orthocladiinae	237	
Diptera	Chironomidae	Tanypodinae	4	
Diptera	Simuliidae	Prosimulium	4	
Diptera	Simuliidae	Simulium	283	
Diptera	Tipulidae	Antocha	22	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	566	
Ephemeroptera	Ephemerellidae		18	
Ephemeroptera	Ephemerellidae	Attenella delantala	32	
Ephemeroptera	Ephemerellidae	Caudatella	57	
Ephemeroptera	Ephemerellidae	Caudatella heterocaudata	7	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	29	
Ephemeroptera	Ephemerellidae	Drunella doddsi	161	
Ephemeroptera	Ephemerellidae	Serratella tibialis	4	
Ephemeroptera	Heptageniidae		11	
Ephemeroptera	Heptageniidae	Cinygmula	4	
Ephemeroptera	Heptageniidae	Epeorus	68	
Ephemeroptera	Leptohyphidae	Tricorythodes minutus	4	
Plecoptera	Chloroperlidae		7	
Plecoptera	Peltoperlidae	Yoraperla	82	
Plecoptera	Perlodidae		25	
Plecoptera	Perlodidae	Oroperla barbara	4	
Trichoptera			7	
Trichoptera	Brachycentridae	Micrasema	32	
Trichoptera	Glossosomatidae		4	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Hydropsychidae		4	
Trichoptera	Rhyacophilidae	Rhyacophila	4	
Trichoptera	Rhyacophilidae	Rhyacophila angelita group	7	
Trichoptera	Rhyacophilidae	Rhyacophila arnaudi	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Phylum: Platyhelminthes				
Class: Turbellaria			18	

Total: 38 OTU taxa			1885 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 5 August 2003 at station SKING-08, Silver King Creek, Long Valley, Site 8, Alpine County, California . The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129109. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1196 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			50	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			18	
Class: Insecta				
Coleoptera	Elmidae		22	
Coleoptera	Elmidae	Cleptelmis addenda	11	
Coleoptera	Elmidae	Heterlimnius	18	
Coleoptera	Elmidae	Heterlimnius corpulentus	4	
Coleoptera	Elmidae	Optioservus	14	
Diptera	Athericidae	Atherix pachypus	54	
Diptera	Ceratopogonidae	Probezzia	25	
Diptera	Chironomidae		7	
Diptera	Chironomidae	Chironominae	262	
Diptera	Chironomidae	Orthocladiinae	409	
Diptera	Psychodidae	Pericoma	7	
Diptera	Simuliidae		4	
Diptera	Simuliidae	Simulium	262	
Diptera	Tipulidae	Antocha	14	
Diptera	Tipulidae	Hexatoma	4	
Diptera	Tipulidae	Rhabdomastix	4	
Ephemeroptera	Baetidae		4	
Ephemeroptera	Baetidae	Baetis	1240	
Ephemeroptera	Ephemerellidae		333	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	190	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	72	
Ephemeroptera	Ephemerellidae	Serratella tibialis	11	
Ephemeroptera	Heptageniidae		11	
Ephemeroptera	Heptageniidae	Cinygmula	4	
Ephemeroptera	Heptageniidae	Epeorus	122	
Ephemeroptera	Heptageniidae	Rhithrogena	57	
Plecoptera	Chloroperlidae		7	
Plecoptera	Chloroperlidae	Sweltsa	4	
Plecoptera	Peltoperlidae	Yoraperla	43	
Plecoptera	Perlidae		11	
Plecoptera	Perlodidae	Megarcys	4	
Trichoptera			4	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Brachycentridae	Micrasema	885	
Trichoptera	Glossosomatidae		4	
Trichoptera	Hydropsychidae		4	
Trichoptera	Philopotamidae	Dolophilodes	7	
Trichoptera	Rhyacophilidae	Rhyacophila arnaudi	22	
Phylum: Nemata			11	
Phylum: Platyhelminthes				
Class: Turbellaria			32	

Total: 44 OTU taxa			4287 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 2 August 2004 at station SKING-08, Silver King Creek, Long Valley, Site 8, Alpine County, California . The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129110. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 918 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			36	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			29	
Class: Insecta				
Coleoptera	Elmidae		4	
Coleoptera	Elmidae	Cleptelmis addenda	14	
Coleoptera	Elmidae	Heterlimnius	7	
Coleoptera	Elmidae	Heterlimnius corpulentus	4	
Coleoptera	Elmidae	Optioservus	36	
Coleoptera	Elmidae	Optioservus quadrimaculatus	18	
Diptera	Athericidae	Atherix pachypus	50	
Diptera	Ceratopogonidae		4	
Diptera	Ceratopogonidae	Probezzia	18	
Diptera	Chironomidae		7	
Diptera	Chironomidae	Chironominae	161	
Diptera	Chironomidae	Orthocladiinae	158	
Diptera	Psychodidae	Pericoma	11	
Diptera	Simuliidae	Simulium	57	
Diptera	Tipulidae	Antocha	11	
Ephemeroptera	Baetidae		25	
Ephemeroptera	Baetidae	Baetis	391	
Ephemeroptera	Baetidae	Diphetor hageni	4	
Ephemeroptera	Ephemerellidae		186	
Ephemeroptera	Ephemerellidae	Caudatella	477	
Ephemeroptera	Ephemerellidae	Caudatella heterocaudata	7	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	18	
Ephemeroptera	Ephemerellidae	Drunella doddsi	380	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	65	
Ephemeroptera	Ephemerellidae	Serratella	18	
Ephemeroptera	Ephemerellidae	Serratella tibialis	25	
Ephemeroptera	Heptageniidae		79	
Ephemeroptera	Heptageniidae	Epeorus	172	
Ephemeroptera	Heptageniidae	Rhithrogena	244	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	50	
Plecoptera	Chloroperlidae		25	
Plecoptera	Chloroperlidae	Suwallia	4	
Plecoptera	Chloroperlidae	Sweltsa	14	
Plecoptera	Nemouridae	Malenka	11	
Plecoptera	Nemouridae	Zapada	4	
Plecoptera	Peltoperlidae	Yoraperla	50	
Plecoptera	Perlidae		14	
Plecoptera	Perlidae	Doroneuria baumanni	11	
Plecoptera	Perlodidae		7	
Plecoptera	Perlodidae	Oroperla barbara	11	
Trichoptera			4	
Trichoptera	Brachycentridae	Brachycentrus americanus	4	
Trichoptera	Brachycentridae	Micrasema	265	
Trichoptera	Glossosomatidae		4	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Hydropsychidae	Arctopsyche grandis	4	
Trichoptera	Lepidostomatidae	Lepidostoma	4	
Trichoptera	Rhyacophilidae	Rhyacophila	4	
Class: Ostracoda			4	
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae	Pisidium	4	
Phylum: Platyhelminthes				
Class: Turbellaria			79	

Total: 53 OTU taxa			3290 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 9 August 2005 at station SKING-08, Silver King Creek, Long Valley, Site 8, Alpine County, California . The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129111. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 386 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			4	
Class: Insecta				
Coleoptera	Elmidae		7	
Coleoptera	Elmidae	Optioservus	4	
Diptera	Ceratopogonidae	Probezzia	7	
Diptera	Ceratopogonidae	Forcipomyia	4	
Diptera	Chironomidae		7	
Diptera	Chironomidae	Chironominae	11	
Diptera	Chironomidae	Orthocladiinae	158	
Diptera	Simuliidae	Simulium	294	
Diptera	Simuliidae	Simulium tuberosum complex	4	
Diptera	Tipulidae		4	
Diptera	Tipulidae	Antocha	7	
Ephemeroptera	Baetidae	Baetis	294	
Ephemeroptera	Ephemerellidae		4	
Ephemeroptera	Ephemerellidae	Attenella delantala	4	
Ephemeroptera	Ephemerellidae	Caudatella	14	
Ephemeroptera	Ephemerellidae	Caudatella heterocaudata	4	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	79	
Ephemeroptera	Ephemerellidae	Drunella	7	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	11	
Ephemeroptera	Ephemerellidae	Drunella doddsi	154	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	7	
Ephemeroptera	Ephemerellidae	Serratella	4	
Ephemeroptera	Ephemerellidae	Serratella tibialis	4	
Ephemeroptera	Heptageniidae	Epeorus	143	
Ephemeroptera	Heptageniidae	Rhithrogena	14	
Plecoptera	Chloroperlidae		14	
Plecoptera	Chloroperlidae	Suwallia	7	
Plecoptera	Peltoperlidae	Yoraperla	11	
Trichoptera			7	
Trichoptera	Brachycentridae	Micrasema	57	
Trichoptera	Glossosomatidae		25	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Hydropsychidae	Arctopsyche californica	4	

Total: 34 OTU taxa			1384 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 8 August 2006 at station SKING-08, Silver King Creek, Long Valley, Site 8, Alpine County, California . The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129112. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 608 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			39	
Class: Insecta				
Coleoptera	Elmidae		4	
Coleoptera	Elmidae	Cleptelmis addenda	7	
Coleoptera	Elmidae	Heterlimnius	7	
Coleoptera	Elmidae	Optioservus	32	
Coleoptera	Elmidae	Optioservus quadrimaculatus	11	
Diptera	Athericidae	Atherix pachypus	7	
Diptera	Chironomidae		4	
Diptera	Chironomidae	Chironominae	90	
Diptera	Chironomidae	Orthocladiinae	165	
Diptera	Simuliidae	Simulium	39	
Diptera	Tipulidae	Antocha	65	
Diptera	Tipulidae	Rhabdomastix	7	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae		11	
Ephemeroptera	Baetidae	Baetis	889	
Ephemeroptera	Ephemerellidae		14	
Ephemeroptera	Ephemerellidae	Attenella delantala	25	
Ephemeroptera	Ephemerellidae	Caudatella	118	
Ephemeroptera	Ephemerellidae	Drunella	86	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	32	
Ephemeroptera	Ephemerellidae	Drunella doddsi	100	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	4	
Ephemeroptera	Heptageniidae		36	
Ephemeroptera	Heptageniidae	Cinygmula	11	
Ephemeroptera	Heptageniidae	Epeorus	79	
Ephemeroptera	Heptageniidae	Rhithrogena	22	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Megaloptera	Sialidae	Sialis	4	
Plecoptera	Chloroperlidae		29	
Plecoptera	Nemouridae	Malenka	4	
Plecoptera	Peltoperlidae	Yoraperla	90	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	11	
Plecoptera	Perlodidae		7	
Plecoptera	Perlodidae	Oroperla barbara	4	
Trichoptera			7	
Trichoptera	Brachycentridae	Brachycentrus	4	
Trichoptera	Brachycentridae	Micrasema	43	
Trichoptera	Glossosomatidae		14	
Trichoptera	Glossosomatidae	Glossosoma	7	
Trichoptera	Hydropsychidae		22	
Trichoptera	Rhyacophilidae	Rhyacophila	14	
Class: Malacostraca				
Amphipoda	Hyalellidae	Hyalella azteca	4	
Phylum: Platyhelminthes				
Class: Turbellaria			4	

Total: 45 OTU taxa			2179 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 7 August 2003 at station TAMAC-13, Tamarack Creek, Upper Site, never treated, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129113.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 819 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			50	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			100	
Class: Insecta				
Coleoptera	Elmidae	Optioservus	4	
Diptera	Ceratopogonidae	Probezzia	14	
Diptera	Chironomidae		25	
Diptera	Chironomidae	Chironominae	97	
Diptera	Chironomidae	Orthocladiinae	244	
Diptera	Chironomidae	Tanypodinae	7	
Diptera	Empididae	Chelifera	25	
Diptera	Empididae	Oreogeton	11	
Diptera	Pelecorhynchidae	Glutops	7	
Diptera	Simuliidae		7	
Diptera	Simuliidae	Prosimulium	14	
Diptera	Simuliidae	Simulium	308	
Diptera	Tipulidae	Dicranota	4	
Diptera	Tipulidae	Pedicia	4	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	136	
Ephemeroptera	Ephemerellidae		118	
Ephemeroptera	Ephemerellidae	Drunella doddsi	39	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	43	
Ephemeroptera	Heptageniidae	Cinygmula	97	
Ephemeroptera	Heptageniidae	Epeorus	11	
Ephemeroptera	Heptageniidae	Rhithrogena	4	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	7	
Plecoptera	Chloroperlidae		7	
Plecoptera	Nemouridae	Visoka cataractae	7	
Plecoptera	Nemouridae	Zapada columbiana	32	
Plecoptera	Peltoperlidae	Yoraperla	1100	
Plecoptera	Perlodidae		65	
Plecoptera	Taeniopterygidae		7	
Trichoptera			7	
Trichoptera	Brachycentridae	Micrasema	7	
Trichoptera	Limnephilidae	Cryptochia	4	
Trichoptera	Rhyacophilidae		11	
Trichoptera	Rhyacophilidae	Rhyacophila	47	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	43	
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group	32	
Trichoptera	Uenoidae	Neothremma	7	
Phylum: Nemata			18	
Phylum: Platyhelminthes				
Class: Turbellaria			161	

Total: 41 OTU taxa			2935 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 4 August 2004 at station TAMAC-13, Tamarack Creek, Upper Site, never treated, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129114.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 775 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			4	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			86	
Class: Insecta				
Coleoptera	Elmidae		4	
Coleoptera	Elmidae	Heterlimnius	18	
Diptera	Ceratopogonidae	Probezzia	4	
Diptera	Chironomidae		36	
Diptera	Chironomidae	Chironominae	82	
Diptera	Chironomidae	Orthocladiinae	104	
Diptera	Empididae		4	
Diptera	Empididae	Chelifera	4	
Diptera	Pelecorhynchidae	Glutops	11	
Diptera	Simuliidae	Simulium	168	
Ephemeroptera	Baetidae	Baetis	194	
Ephemeroptera	Baetidae	Diphetor hageni	4	
Ephemeroptera	Ephemerellidae		154	
Ephemeroptera	Ephemerellidae	Attenella delantala	22	
Ephemeroptera	Ephemerellidae	Caudatella	136	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	312	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	111	
Ephemeroptera	Heptageniidae		4	
Ephemeroptera	Heptageniidae	Cinygmula	75	
Ephemeroptera	Heptageniidae	Epeorus	47	
Ephemeroptera	Heptageniidae	Rhithrogena	65	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	4	
Plecoptera			11	
Plecoptera	Chloroperlidae		7	
Plecoptera	Chloroperlidae	Sweltsa	7	
Plecoptera	Leuctridae		11	
Plecoptera	Nemouridae	Malenka	7	
Plecoptera	Nemouridae	Zapada	14	
Plecoptera	Nemouridae	Zapada columbiana	11	
Plecoptera	Peltoperlidae	Yoraperla	835	
Plecoptera	Perlidae		4	
Plecoptera	Perlidae	Doroneuria baumanni	4	
Plecoptera	Perlodidae		32	
Trichoptera	Apataniidae	Pedomoecus sierra	4	
Trichoptera	Brachycentridae	Micrasema	11	
Trichoptera	Hydropsychidae	Parapsyche elsis	4	
Trichoptera	Hydroptilidae		4	
Trichoptera	Rhyacophilidae	Rhyacophila	47	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	39	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila verrula group	4	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	43	
Trichoptera	Uenoidae	Neophylax	4	
Trichoptera	Uenoidae	Neothremma	7	

Total: 47 OTU taxa			2778 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 8 August 2005 at station TAMAC-13, Tamarack Creek, Upper Site, never treated, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129115.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1189 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			14	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			197	
Class: Insecta				
Coleoptera	Elmidae		14	
Coleoptera	Elmidae	Heterlimnius	14	
Diptera	Ceratopogonidae	Probezzia	32	
Diptera	Chironomidae		93	
Diptera	Chironomidae	Chironominae	97	
Diptera	Chironomidae	Orthocladiinae	627	
Diptera	Empididae		14	
Diptera	Empididae	Chelifera	29	
Diptera	Pelecorhynchidae	Glutops	50	
Diptera	Psychodidae	Pericoma	4	
Diptera	Simuliidae		57	
Diptera	Simuliidae	Prosimulium	25	
Diptera	Simuliidae	Simulium	65	
Diptera	Tipulidae	Dicranota	4	
Diptera	Tipulidae	Limnophila	4	
Ephemeroptera	Baetidae	Baetis	194	
Ephemeroptera	Baetidae	Diphetor hageni	14	
Ephemeroptera	Ephemerellidae		68	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	11	
Ephemeroptera	Ephemerellidae	Drunella doddsi	43	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	18	
Ephemeroptera	Heptageniidae		25	
Ephemeroptera	Heptageniidae	Cinygmula	308	
Ephemeroptera	Heptageniidae	Epeorus	79	
Ephemeroptera	Heptageniidae	Rhithrogena	25	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	18	
Plecoptera			4	
Plecoptera	Chloroperlidae		32	
Plecoptera	Chloroperlidae	Sweltsa	22	
Plecoptera	Leuctridae	Moselia infuscata	7	
Plecoptera	Nemouridae	Visoka cataractae	14	
Plecoptera	Nemouridae	Zapada columbiana	18	
Plecoptera	Peltoperlidae		136	
Plecoptera	Peltoperlidae	Yoraperla	1613	
Plecoptera	Perlidae		14	
Plecoptera	Perlidae	Doroneuria baumanni	7	
Plecoptera	Perlodidae		57	
Trichoptera			4	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Brachycentridae	Micrasema	7	
Trichoptera	Rhyacophilidae	Rhyacophila	61	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	11	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	11	
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group a	25	
Trichoptera	Rhyacophilidae	Rhyacophila verrula group	4	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	43	
Trichoptera	Uenoidae	Neophylax	7	
Trichoptera	Uenoidae	Neothremma	7	
Phylum: Nemata			4	
Phylum: Platyhelminthes				
Class: Turbellaria			4	

Total: 52 OTU taxa			4262 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 8 August 2006 at station TAMAC-13, Tamarack Creek, Upper Site, never treated, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129116.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 480 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			7	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			39	
Class: Insecta				
Coleoptera	Elmidae		4	
Coleoptera	Elmidae	Heterlimnius	7	
Coleoptera	Elmidae	Heterlimnius corpulentus	4	
Diptera	Ceratopogonidae		7	
Diptera	Ceratopogonidae	Probezzia	11	
Diptera	Chironomidae		36	
Diptera	Chironomidae	Chironominae	72	
Diptera	Chironomidae	Orthocladiinae	72	
Diptera	Empididae	Chelifera	11	
Diptera	Empididae	Oreogeton	4	
Diptera	Pelecorhynchidae	Glutops	14	
Diptera	Simuliidae		4	
Diptera	Simuliidae	Prosimulium	18	
Diptera	Simuliidae	Simulium	14	
Diptera	Tipulidae	Hexatoma	4	
Ephemeroptera	Ameletidae	Ameletus	7	
Ephemeroptera	Baetidae	Baetis	168	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	43	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	86	
Ephemeroptera	Heptageniidae		47	
Ephemeroptera	Heptageniidae	Cinygmula	280	
Ephemeroptera	Heptageniidae	Epeorus	93	
Ephemeroptera	Heptageniidae	Rhithrogena	11	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	32	
Plecoptera			25	
Plecoptera	Chloroperlidae		4	
Plecoptera	Chloroperlidae	Sweltsa	4	
Plecoptera	Leuctridae	Moselia infuscata	4	
Plecoptera	Nemouridae	Visoka cataractae	22	
Plecoptera	Nemouridae	Zapada	4	
Plecoptera	Nemouridae	Zapada columbiana	108	
Plecoptera	Peltoperlidae	Yoraperla	254	
Plecoptera	Perlidae		54	
Plecoptera	Perlidae	Doroneuria baumanni	11	
Plecoptera	Perlodidae		29	
Trichoptera	Hydropsychidae	Parapsyche	4	
Trichoptera	Limnephilidae		7	
Trichoptera	Rhyacophilidae	Rhyacophila	29	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	11	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	4	
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group a	7	
Trichoptera	Rhyacophilidae	Rhyacophila verrula group	4	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	11	
Trichoptera	Uenoidae	Neophylax	4	
Trichoptera	Uenoidae	Neothremma	11	
Phylum: Platyhelminthes				
Class: Turbellaria			14	

Total: 49 OTU taxa			1720	individuals

Taxonomic list and abundances of aquatic invertebrates collected 7 August 2003 at station TAMAC-14, Tamarack Creek, Lower Site, never treated, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129117.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 406 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Annelida				
Class: Clitellata subclass oligochaeta			54	
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			68	
Class: Insecta				
Coleoptera	Elmidae		4	
Coleoptera	Elmidae	Heterlimnius	11	
Diptera	Chironomidae		25	
Diptera	Chironomidae	Chironominae	115	
Diptera	Chironomidae	Orthocladiinae	147	
Diptera	Chironomidae	Tanypodinae	11	
Diptera	Empididae	Chelifera	7	
Diptera	Pelecorhynchidae	Glutops	11	
Diptera	Simuliidae	Simulium	36	
Ephemeroptera	Baetidae		4	
Ephemeroptera	Baetidae	Baetis	90	
Ephemeroptera	Ephemerellidae		4	
Ephemeroptera	Ephemerellidae	Attenella delantala	7	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	100	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	39	
Ephemeroptera	Heptageniidae		4	
Ephemeroptera	Heptageniidae	Cinygmula	165	
Ephemeroptera	Heptageniidae	Epeorus	79	
Ephemeroptera	Heptageniidae	Rhithrogena	29	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	7	
Plecoptera	Chloroperlidae		14	
Plecoptera	Chloroperlidae	Sweltsa	4	
Plecoptera	Leuctridae		14	
Plecoptera	Nemouridae	Visoka cataractae	4	
Plecoptera	Nemouridae	Zapada	4	
Plecoptera	Peltoperlidae	Yoraperla	201	
Plecoptera	Perlidae		7	
Plecoptera	Perlodidae		32	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Limnephilidae		4	
Trichoptera	Rhyacophilidae		25	
Trichoptera	Rhyacophilidae	Rhyacophila	39	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	14	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	22	
Trichoptera	Uenoidae	Neophylax	4	
Trichoptera	Uenoidae	Neothremma	4	
Phylum: Platyhelminthes				
Class: Turbellaria			39	

Total: 40 OTU taxa			1455 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 3 August 2004 at station TAMAC-14, Tamarack Creek, Lower Site, never treated, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129118.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 1564 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			172	
Class: Insecta				
Coleoptera	Elmidae		22	
Coleoptera	Elmidae	Heterlimnius	39	
Coleoptera	Elmidae	Optioservus	4	
Diptera	Chironomidae		36	
Diptera	Chironomidae	Chironominae	90	
Diptera	Chironomidae	Orthocladiinae	832	
Diptera	Chironomidae	Tanypodinae	7	
Diptera	Empididae		4	
Diptera	Empididae	Chelifera	25	
Diptera	Empididae	Clinocera	7	
Diptera	Pelecorhynchidae	Glutops	39	
Diptera	Simuliidae		22	
Diptera	Simuliidae	Prosimulium	29	
Diptera	Simuliidae	Simulium	115	
Ephemeroptera	Baetidae		14	
Ephemeroptera	Baetidae	Baetis	305	
Ephemeroptera	Ephemerellidae		631	
Ephemeroptera	Ephemerellidae	Attenella delantala	11	
Ephemeroptera	Ephemerellidae	Caudatella	29	
Ephemeroptera	Ephemerellidae	Caudatella hystrix	4	
Ephemeroptera	Ephemerellidae	Drunella	4	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	14	
Ephemeroptera	Ephemerellidae	Drunella doddsi	197	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	151	
Ephemeroptera	Heptageniidae		25	
Ephemeroptera	Heptageniidae	Cinygmula	108	
Ephemeroptera	Heptageniidae	Epeorus	54	
Ephemeroptera	Heptageniidae	Rhithrogena	39	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	25	
Plecoptera	Chloroperlidae		151	
Plecoptera	Leuctridae		7	
Plecoptera	Leuctridae	Moselia infuscata	7	
Plecoptera	Nemouridae	Visoka cataractae	7	
Plecoptera	Nemouridae	Zapada	4	
Plecoptera	Nemouridae	Zapada columbiana	93	
Plecoptera	Peltoperlidae		168	
Plecoptera	Peltoperlidae	Yoraperla	1731	
Plecoptera	Perlidae		11	
Plecoptera	Perlidae	Doroneuria baumanni	14	
Plecoptera	Perlodidae		36	
Trichoptera			7	
Trichoptera	Apataniidae	Apatania	4	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Brachycentridae	Micrasema	4	
Trichoptera	Glossosomatidae	Glossosoma	4	
Trichoptera	Hydropsychidae	Parapsyche elsis	7	
Trichoptera	Rhyacophilidae	Rhyacophila	61	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	11	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	72	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	86	
Trichoptera	Uenoidae	Neothremma	7	
Class: Ostracoda			22	
Phylum: Platyhelminthes				
Class: Turbellaria			36	

Total: 54 OTU taxa			5606 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 8 August 2005 at station TAMAC-14, Tamarack Creek, Lower Site, never treated, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129119.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 474 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			14	
Class: Insecta				
Coleoptera	Elmidae	Heterlimnius	14	
Diptera	Ceratopogonidae	Probezzia	4	
Diptera	Chironomidae		25	
Diptera	Chironomidae	Chironominae	39	
Diptera	Chironomidae	Orthocladiinae	86	
Diptera	Empididae	Chelifera	7	
Diptera	Pelecorhynchidae	Glutops	25	
Diptera	Simuliidae		4	
Diptera	Simuliidae	Prosimulium	4	
Diptera	Simuliidae	Simulium	14	
Ephemeroptera	Ameletidae	Ameletus	7	
Ephemeroptera	Baetidae	Baetis	136	
Ephemeroptera	Ephemerellidae		4	
Ephemeroptera	Ephemerellidae	Attenella delantala	11	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	7	
Ephemeroptera	Ephemerellidae	Drunella doddsi	14	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	7	
Ephemeroptera	Heptageniidae		29	
Ephemeroptera	Heptageniidae	Cinygmula	276	
Ephemeroptera	Heptageniidae	Epeorus	118	
Ephemeroptera	Heptageniidae	Rhithrogena	11	
Plecoptera	Chloroperlidae		7	
Plecoptera	Chloroperlidae	Sweltsa	7	
Plecoptera	Leuctridae		4	
Plecoptera	Nemouridae	Visoka cataractae	4	
Plecoptera	Nemouridae	Zapada columbiana	11	
Plecoptera	Peltoperlidae	Yoraperla	588	
Plecoptera	Perlidae		11	
Plecoptera	Perlodidae		29	
Plecoptera	Perlodidae	Kogotus nonus	4	
Trichoptera	Apataniidae	Pedomoecus sierra	47	
Trichoptera	Limnephilidae		4	
Trichoptera	Limnephilidae	Dicosmoecus	4	
Trichoptera	Rhyacophilidae	Rhyacophila	36	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group a	18	
Trichoptera	Rhyacophilidae	Rhyacophila verrula group	4	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	29	
Trichoptera	Uenoidae	Neophylax	7	
Trichoptera	Uenoidae	Neothremma	7	
Phylum: Platyhelminthes				
Class: Turbellaria			11	

Total: 43 OTU taxa			1699 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 8 August 2006 at station TAMAC-14, Tamarack Creek, Lower Site, never treated, Alpine County, California. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was unspecified. The sample identification number is 129120.

The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 369 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. OTU = operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Abundance	Notes
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			7	
Class: Insecta				
Coleoptera	Elmidae		4	
Coleoptera	Elmidae	Heterlimnius	25	
Diptera	Chironomidae	Chironominae	11	
Diptera	Chironomidae	Orthocladiinae	50	
Diptera	Empididae		4	
Diptera	Empididae	Chelifera	4	
Diptera	Pelecorhynchidae	Glutops	39	
Diptera	Simuliidae	Prosimulium	39	
Diptera	Simuliidae	Simulium	7	
Ephemeroptera	Ameletidae	Ameletus	4	
Ephemeroptera	Baetidae	Baetis	133	
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	11	
Ephemeroptera	Ephemerellidae	Drunella doddsi	32	
Ephemeroptera	Ephemerellidae	Drunella grandis/spinifera	29	
Ephemeroptera	Heptageniidae		11	
Ephemeroptera	Heptageniidae	Cinygmula	186	
Ephemeroptera	Heptageniidae	Epeorus	97	
Ephemeroptera	Heptageniidae	Rhithrogena	32	
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	11	
Plecoptera			14	
Plecoptera	Chloroperlidae	Sweltsa	7	
Plecoptera	Nemouridae	Zapada columbiana	111	
Plecoptera	Peltoperlidae	Yoraperla	290	
Plecoptera	Perlidae		7	
Plecoptera	Perlodidae		61	
Trichoptera	Apataniidae	Pedomoecus sierra	7	
Trichoptera	Hydropsychidae	Parapsyche elsis	4	
Trichoptera	Rhyacophilidae	Rhyacophila	47	
Trichoptera	Rhyacophilidae	Rhyacophila betteni group	7	
Trichoptera	Rhyacophilidae	Rhyacophila brunnea/vemna groups	7	
Trichoptera	Rhyacophilidae	Rhyacophila verrula group	4	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	18	
Trichoptera	Uenoidae	Neophylax splendens	4	

Total: 34 OTU taxa			1323 individuals	

APPENDIX E

Aquatic Invertebrates Interagency Monitoring Plan

Aquatic Invertebrate
Interagency Monitoring Plan

Prepared by:
Humboldt-Toiyabe National Forest,
U.S. Forest Service, Sparks NV

Date:
July 2007

Silver King Creek Macroinvertebrate Monitoring
August 2007-2015

Background

The US Fish and Wildlife Service propose to treat Silver King Creek basin with rotenone during the late summer of 2009, 2010, and possibly 2011. The goal of this project is to restore Paiute cutthroat trout (*Oncorhynchus clarkii seleniris*), a federally listed threatened species, to its historic habitat**.**

While rotenone is intended to eradicate non-native trout, it is also toxic to some aquatic macroinvertebrates. Rotenone was first used in the Silver King Creek basin in 1964, and on various occasions and locations up to 1993. Macroinvertebrate sampling within the basin began in 1984 and has occurred periodically up to 2007.

This monitoring study differs from the June 15, 2003, Interagency Study Proposal in that it incorporates more sampling stations throughout the basin as well as additional "control" and "treatment" sites. The sampling methodology is also changed to allow for additional analyses such as the River Invertebrate Prediction and Classification System (RIVPACS) analysis model (Hawkins et al. 2000).

Objectives

The primary objectives of this study are to: 1) analyze changes in macroinvertebrate assemblages and taxa from the use of rotenone during Paiute cutthroat trout recovery activities, 2) collect and identify taxa from the Silver King Creek basin, and 3) reestablish historic collection sites in selected streams.

Study Design

Twenty-three quantitative and 5 qualitative sampling site locations were established during August 2007 (Table 1). This study design differs from the June 15, 2003, Interagency Study Proposal in that it incorporates more sampling stations throughout the basin as well as additional "control" and "treatment" sites (nine pairs) (Figures 1 and 2). Five qualitative sampling sites were established within the area to be treated to increase the likelihood of collecting taxa with low relative abundances, i.e. rare taxa (Figure 3). The sampling methodology is also changed to allow for additional analyses.

Past analyses to evaluate the effects of rotenone on aquatic biota are hampered by the lack of data on aquatic invertebrate assemblages prior to the use of rotenone (Vinson and Vinson 2007). This monitoring effort includes five quantitative sampling sites (SKC Site 1 & 2, Tamarack Sites 1-3) and 3 qualitative sampling sites (SKC Site 1, Tamarack Sites

1 & 2) in areas that have never been treated with rotenone which are expected to be treated in the future.

Pre-treatment sampling will be conducted at all sites during mid-August 2007, and 2008. Further pre-treatment sampling will also be conducted at all sites during mid-August 2009, immediately prior to treatment. Post-treatment monitoring will be conducted during mid-August the first, second, third, and fifth year post-treatment.

Table 1. Sample type and locations within the Silver King Creek basin.

Stream	**Site Number**	**Sample Type**	**Site Type**	**UTM North**	**UTM East**	**Elev. (m)**
Bull Creek	Bull Site 1	Quantitative		4259066	273218	2457
Corral Creek	Corral Site 1	Quantitative		4263805	274123	2424
Corral Creek	Corral Site 2	Quantitative		4263251	275248	2510
Coyote Creek	Coyote Site 1	Quantitative	Control	4262687	273342	2411
Coyote Creek	Coyote Site 2	Quantitative	Control	4261839	273608	2481
Coyote Creek	Coyote Site 3	Quantitative	Control	4260799	274522	2492
Fly Valley Creek	Fly Site 1	Quantitative		4256568	272140	2653
Four Mile Creek	Four Mile Site 1	Quantitative		4257098	274165	2560
Silver King Creek	SKC Site 1	Quantitative	Treatment	4264901	272645	2333
Silver King Creek	SKC Site 2	Quantitative	Treatment	4263842	272756	2345
Silver King Creek	SKC Site 3	Quantitative	Treatment	4262456	272874	2376
Silver King Creek	SKC Site 4	Quantitative	Treatment	4262005	272675	2383
Silver King Creek	SKC Site 5	Quantitative	Treatment	4260832	272085	2416
Silver King Creek	SKC Site 6	Quantitative	Treatment	4260099	272602	2426
Silver King Creek	SKC Site 7	Quantitative	Control	4259608	273247	2456
Silver King Creek	SKC Site 8	Quantitative	Control	4259289	273140	2460
Silver King Creek	SKC Site 9	Quantitative	Control	4258963	273359	2462
Silver King Creek	SKC Site 10	Quantitative	Control	4258354	273562	2473
Silver King Creek	SKC Site 11	Quantitative	Control	4257651	273471	2503
Silver King Creek	SKC Site 12	Quantitative	Control	4257022	273187	2506
Tamarack Creek	Tamarack Site 2	Quantitative	Treatment	4261479	271383	2422
Tamarack Creek	Tamarack Site 1	Quantitative	Treatment	4262448	271943	2400
Tamarack Creek	Tamarack Site 3	Quantitative	Treatment	4261437	270915	2443
Silver King Creek	SKC Site 1	Qualitative		4264901	272645	2333
Silver King Creek	SKC Site 2	Qualitative		4260655	272242	2416
Silver King Creek	SKC Site 3	Qualitative		4259883	272755	2425
Tamarack Creek	Tamarack Site 1	Qualitative		4261873	271653	2411
Tamarack Creek	Tamarack Site 2	Qualitative		4261457	270972	2439

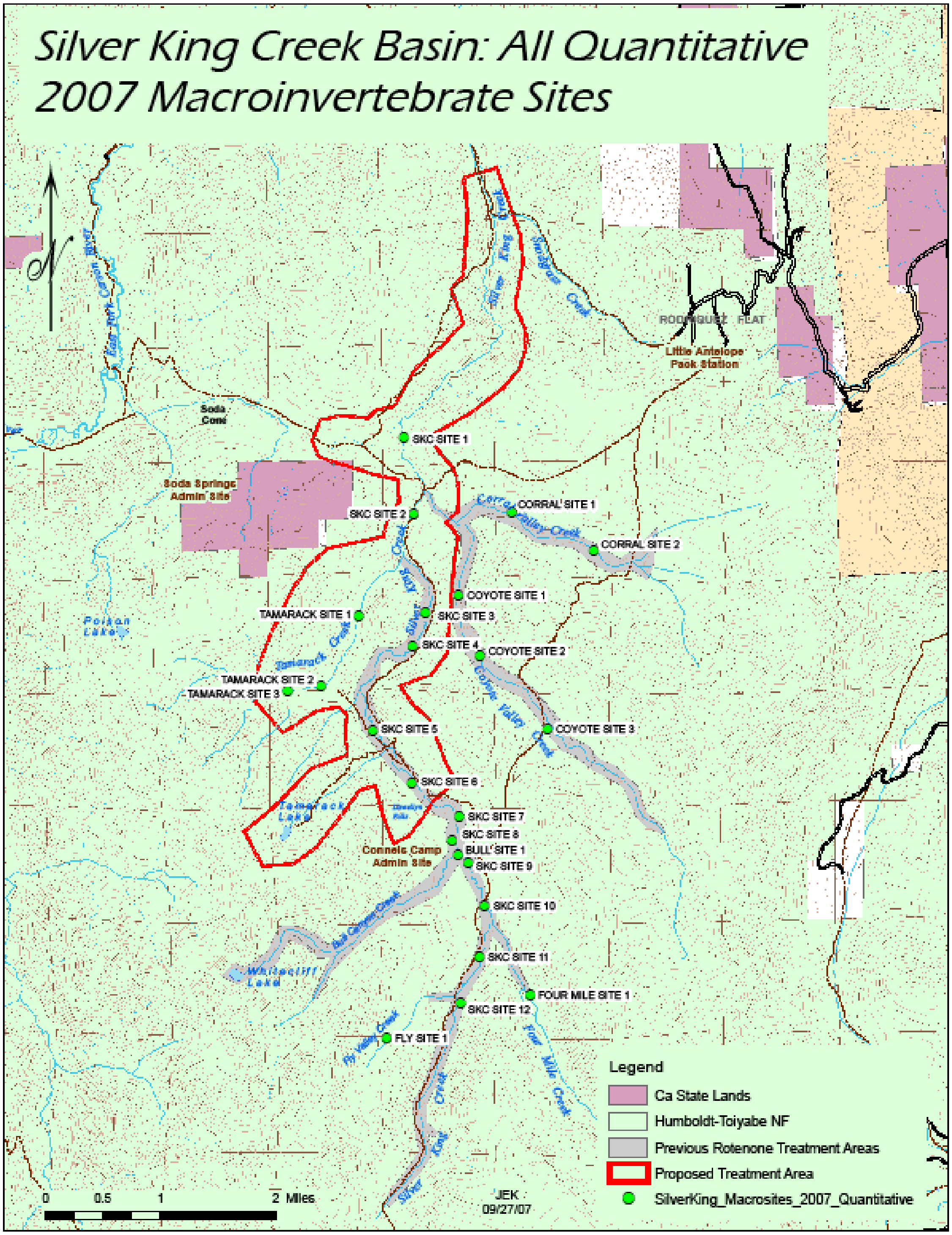

Figure 1. Quantitative sampling sites within the Silver King Creek basin.

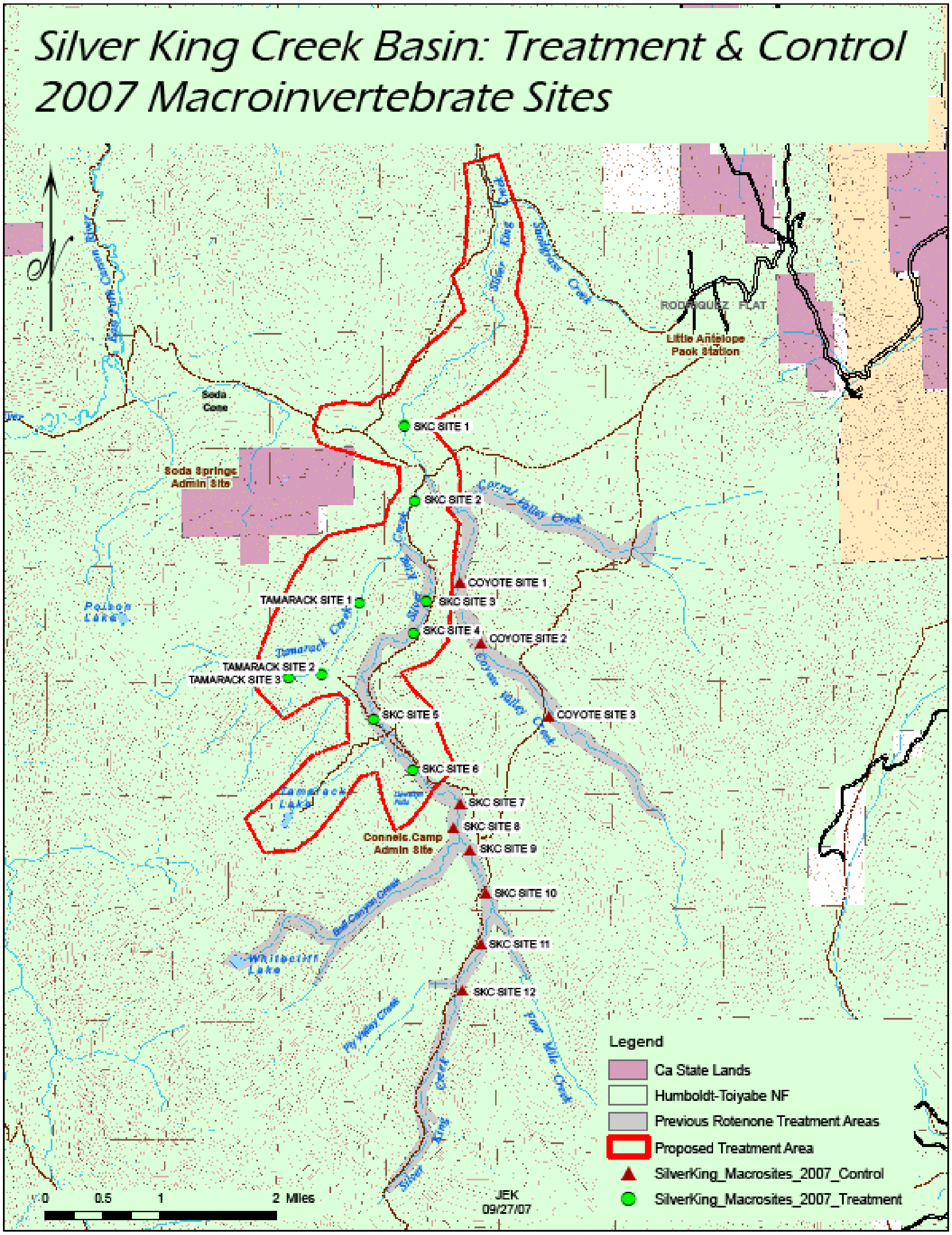

Figure 2. Quantitative sampling “control” and “treatment” sites within the Silver King Creek basin.

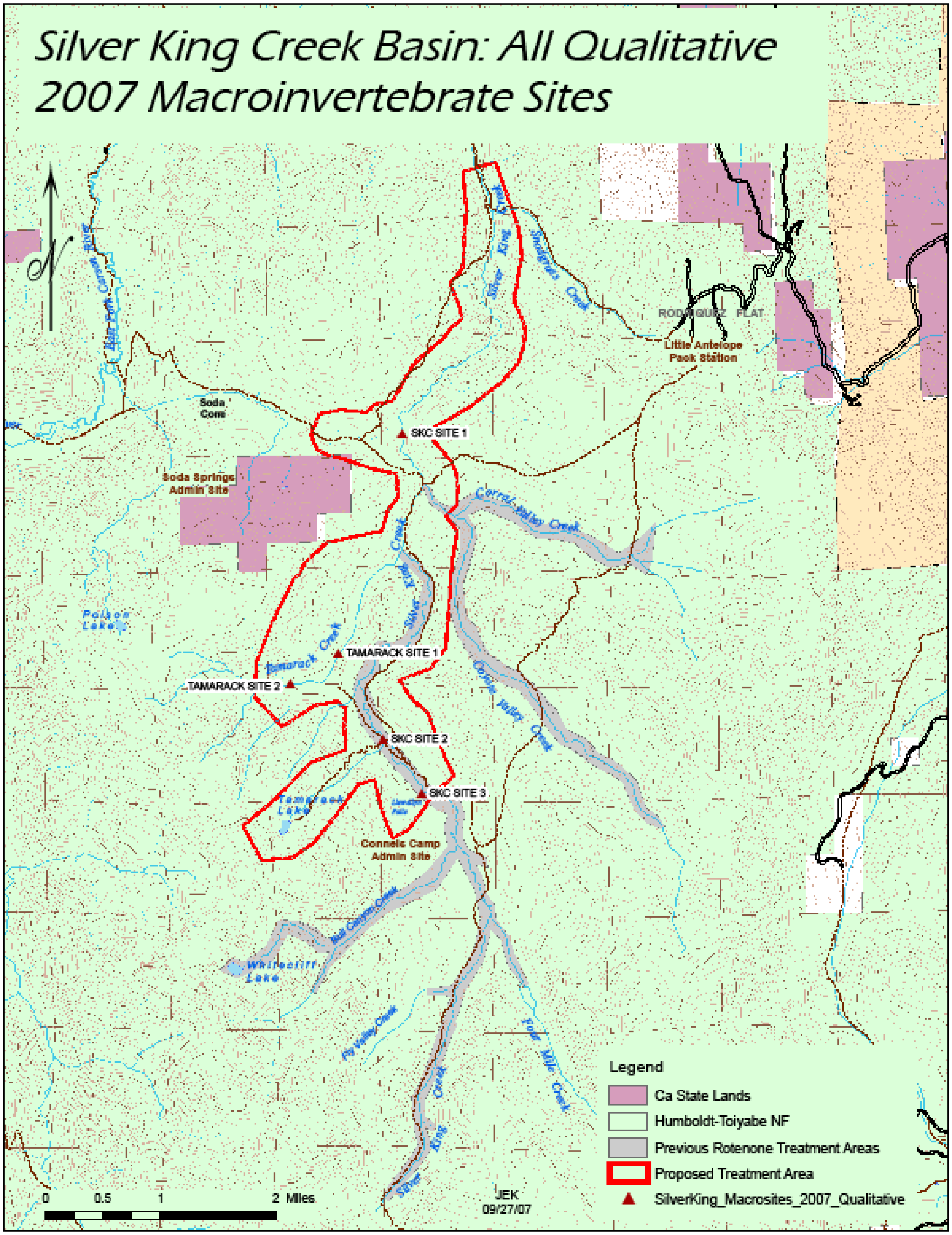

Figure 3. Qualitative sampling sites within the Silver King Creek basin.

Sampling Methods

Stream Invertebrate Collection Procedures as described by the National Aquatic Monitoring Center at Utah State University, Logan, Utah (www.usu.edu/buglab/) will be followed. Samples will be sent to the National Aquatic Monitoring Center at Utah State University, Logan, Utah for processing (see www.usu.edu/buglab/ for laboratory methods). Table 2 provides the normal taxonomic resolution of processed samples.

Fixed Area Quantitative Samples

The objective of quantitative invertebrate sampling is to collect the more common invertebrates at a site and estimate their relative abundances. Quantitative samples are collected using a Surber net (0.09 m^2) with a 500 micron mesh net. Eight samples are collected in 4 different riffles (2 samples from each riffle) and composited to make a single sample of approximately 0.74 m^2 for each location on each sampling date.

Qualitative Invertebrate Collections

The objective of qualitative invertebrate collections is to collect as many different kinds of invertebrates living at a site as possible. Samples are collected with a Surber net or a kicknet (457 x 229 mm) with a 500 micron mesh net and by hand picking invertebrates from woody debris and large boulders. All major habitat types (e.g., riffles, pools, back waters, macrophyte beds) are sampled and all samples are composited to form a single sample from each site.

Table 2. Normal taxonomic resolution provided by the National Aquatic Monitoring Center.

Taxon or Taxa group	**BugLab's Current Standard Taxonomic Level**	**Northwest Bioassessment Work Group Minimum Standard Taxonomic Effort**
Annelida		
Hirudinea	Genus/species	Genus
Oligochaeta	Order	Family
Arthropoda		
Hydracarina	Family/Genus/species	Order
Crustacea		
Anostraca	Genus/species	Genus/species
Cladocera	Genus/species	
Copepoda	Genus/species	
Decapoda	Genus/species	Genus
Ostracoda	Order/Family/Genus	

Table 2. Continued.		
Taxon or Taxa group	**BugLab's Current Standard Taxonomic Level**	**Northwest Bioassessment Work Group Minimum Standard Taxonomic Effort**
Arthropoda		
Crustacea		
Amphipoda	Genus/species	Genus
Isopoda	Genus	Genus
Collembola	Order	
Insecta		
Coleoptera	Genus/species	Genus
Except Curculionidae, Heteroceridae, Ptiliidae	Family	Family
Diptera		
Atherceridae	Genus/species	Genus
Blephariceridae	Genus/species	Genus
Ceratopogonidae	Genus	Subfamily
Chaoboridae	Genus	
Chironomidae	Subfamily	Genus
Culicidae	Genus	
Deuterophlebiidae	Genus/species	Genus
Dixidae	Genus	Genus
Dolichopodidae	Family	Family
Empididae	Genus	Genus
Ephydridae	Family	Family
Muscidae	Family	Family
Pelecorhynchidae	Genus	Genus
Psychodidae	Genus	Genus
Ptychopteridae	Genus	Genus
Sciomyzidae	Family	
Simuliidae	Genus	Genus
Stratiomyidae	Genus	Genus
Tabanidae	Genus	Family
Tanyderidae	Genus	Genus
Thaumaleidae	Genus	Genus
Tipulidae	Genus	Genus
Ephemeroptera	Genus/species	Genus
Ephemerellidae	species	species
Hemiptera	Genus/species	Genus

Table 2. Continued.		
Taxon or Taxa group	**BugLab's Current Standard Taxonomic Level**	**Northwest Bioassessment Work Group Minimum Standard Taxonomic Effort**
Arthropoda		
Lepidoptera	Genus	Genus
Megaloptera	Genus/species	Genus
Odonata	Genus/species	Genus
Plecoptera	Genus/species	Genus
Pteronarcyidae	species	species
Taeniopterygidae	Family/Genus	Family
Trichoptera	Genus/species	
Coelenterata	Class	Class/Order
Mollusca		
Gastropoda	Family/Genus/species	Genus
Pelecypoda	Order/Family/Genus	Genus
Sphaeriidae	Genus/species	Family/Genus
Nematoda	Phylum	Phylum
Nematophora	Phylum	Phylum
Porifera	Phylum	Phylum
Turbellaria	Class	Class

Data summarization

As part of the National Aquatic Monitoring Center standard reporting, the following metrics or ecological summaries are provided for each sampling station:

- Taxa richness, Genera richness
- EPT
- Percent taxon or family dominance
- Biotic indices - Hilsenhoff Biotic Index
- USFS Community tolerant quotient
- Shredders
- Collector-filterers
- Predators
- Clinger taxa
- Abundance
- Number of families
- Shannon Diversity Index
- Evenness
- Functional feeding group measures
- Scrapers
- Collector-gatherers
- Unknown feeding group
- Long-live taxa

Additional information on the metrics and how they are calculated can be found at www.usu.edu/buglab/.

Statistical analyses

An equal number (nine pairs) of control and treatment sites will sampled before and after the treatment with rotenone. Pre-treatment sampling will occur in 2007, 2008, and 2009; post-treatment monitoring will be conducted during mid-August the first, second, third, and fifth year post-treatment. This will allow for a BACI (Before-After-Control-Impact) analysis to be used to detect treatment effects to biological metrics. BACI analyses will follow 2 methodologies, designed to detect both short and long-term impacts. The first method is the standard BACI, where the time scale is constrained to the sampling period immediately before and after treatment. A 2-way ANOVA on selected metrics (e.g. abundance, tolerance values) with Time (Before/After) and Site (Control/Impact) is then performed, with rotenone effects assessed using the interaction term (Green 1979). Long-term effects will be analyzed using a BACIPS (Before-After-Control-Impact Paired Series) (Stewart-Oaten 1996). In this, an average metric value for each sampling period for Control sites and Treatment sites are determined, and the difference between the averages is the response variable analyzed statistically. The differences in pre-treatment versus post-treatments are then analyzed using a basic *t*-test. Metrics to be analyzed may also include aquatic invertebrate abundance and taxa richness (genera) which Vinson and Vinson 2007 suggest that differences would be detectable following a rotenone treatment. ANOVA may be also used to evaluate differences in aquatic invertebrate assemblage measures between pre-treatment and post-samples to detect treatment effects. Simple graphs of before and after comparisons will be used to evaluate differences in invertebrate assemblage measures and diversity indices between pre-treatment and post-treatment periods (Vinson and Dinger 2006).

RIVPAC analysis will also be conducted. This analysis allows for the prediction of what taxa should occur at a site in the absence of anthropogenic actions and factors in the probability of occurrences for all individual.

Accumulation curves will be used to provide information on the adequacy of sampling and on the relative number of taxa that may be present but are yet uncollected. These methods will be used following treatment to evaluate assemblage recovery. Rare taxa, (those whose individual abundances are less than 1% of the total sample abundance) will be identified in pre-treatment sampling and tracked post-treatment to detect treatment effects. Of particular interest will be sampling sites, Tamarack 1-3 and Silver King 1 & 2, which are areas that haven't been treated with rotenone.

Historic Site monitoring

Long-term sampling sites have been reestablished on Fly Valley Creek, Four-mile Creek, Bull Canyon, and at upstream historic sites in Silver King Creek. Although this monitoring study uses a different sampling design from those used historically, sampling these sites could provide additional information on historic assemblages. The Fly Valley and Four-mile creeks sites are in areas that were never chemically treated and will not be treated.

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