FINAL REPORT
Adopt a Stream Stewardship and Education Program
Cooperative Agreement # 14-48-0001-94521
Project 94-E-4

ABSTRACT

Forks of Salmon School has implemented a highly successful watershed education project in 1994 with the help of this grant. Using Diane Higgins' curriculum- Klamath River Studies, Adopt-A-Watershed, F.O.S.S., and numerous other materials, we feel we have met and exceeded the objectives of this program to:

1) educate our 4th-8th grade students about aquatic ecosystems and watershed processes through observation journals and field-oriented studies of anadromous fish, water quality, habitat, geology, hydrology, fire, mapping and orienteering, and macroinvertebrates.

2) form ongoing cooperative relationships with the community and various organizations and agencies that relate to our watershed. By enlisting community and agency members to join us for field studies, we are encouraging their support for a cooperative approach to a healthy watershed and a healthy salmonid population.

We have learned a lot this year....about our watershed, about our visions, about our limitations, about our goals.

We have learned through our studies this year how little we know about the complexities of watershed processes, and what an on-going process it is.

We have learned that the first step we must take is to become acute observers of our surroundings, striving to understand change through learning all we can about the past, present and potential future condition of our watershed.

We have learned that we must constantly jump back and forth between the specific and the general, alternately looking at the forest and the trees, so to speak.

We have learned that using computer technology takes more time than anyone ever imagined.

We have learned a lot of specific information about the Salmon River and how it functions.

We have learned how interconnected the various facets of our watershed are, and how interdependent they are when it comes to creating and maintaining balance.

We have learned how many people in our area, both locals and agency employees, have a tremendous amount of knowledge in one field or another, and are willing to share their expertise with us.

We have learned that the classroom outside is as important as the classroom inside.

We have learned that we are at the very beginning of this process.

We would like to extend our thanks to all the people who gave their time and energy, and to the USFWS for all the help we have received in getting this project on its feet.

Susan Terence

Susan Terence
Project manager

This year we tried to get an overview of our watershed. We engaged in activities that would help students understand the location of our watershed relative to the Klamath Basin. We learned about many types of mapping, and talked about their uses in different situations. We learned about watershed processes, including landforms, erosion, hydrology, aggradation and degradation, and how the watershed changes over time. We learned about fire history and ecology in the Salmon River, and the importance of its role in shaping the landscape. We learned about the macroinvertebrates that play so many critical roles in the food chain and ecology of the area. To this end we hired John Lee for three days to do field studies and identification.We learned about salmon history, habitat, habits and population. We learned about the effects of various human activities on the health of the salmon runs, and the importance of stopping poaching on the Salmon River.

We researched and purchased a computer capable of doing GIS and obtained through a grant from ESRI the Arcview softwate. We worked with the staffs of the USFS, Fish and Game, the Karuk tribe, and HSU to help us with the expertise needed to explore GIS. We hired Larry Kuhn for two days to teach us the basics of multi-media, so that the students can put together a presentation on our watershed.

We borrowed several hobo-temps from Onset Corporation and North Coast Water Quality Control Board and did a test run on Nordheimer Creek in preparation for a full-blown temperature study in summer of '95. We have gathered imput from a number of people about study design and placement of hobo-temps so they will have maximum effectiveness.

We adopted Nordheimer Creek as our concentrated study area. While we are going to try to learn all we can about the entire Salmon River in the long run, we are focusing in particular on Nordheimer Creek.

We recieved a telecommunications grant through Adopt-a-Watershed and that gave us Clarisworks software, a modem, and networking capabilities with students in other watersheds for exchanging information.

I, as program manager, have donated 20 days above and beyond the project requirements.

This has been a very busy and productive year. We feel that the students of the Forks of Salmon School, and the community as well, have learned a lot from the hands-on approach to understanding the intricate and fragile landscape in which they are lucky enough to live. The more they understand the interconnections in the watershed in which they live, the greater the sense of stewardship and appreciation they develop. We feel that we are at the beginning of a fascinating --and infinite-- exploration into one of the most important processes of all---how to coexist in a mutually productive way with one's natural surroundings.

TASKS

Task 1: Project manager has spent over 40 days gathering, reviewing, and building upon existing curriculum and materials on watershed processes, aquatic ecosystems, and local Salmon River history. She has relied most heavily on the Klamath River Studies (Grades 4-6 and 7-8), Adopt-a-Watershed, Full Option Science System and Adopting a Stream: A Northwest Handbook, although many other curriculum materials have been gathered and referenced. (See attached expanded reference list.)

The program manager has also received training in Klamath River Studies curriculum, raising salmonids in the classroom, Adopt a Watershed curriculum, problematic science training, and several watershed-related workshops, including the Eisenhower Summer Institute, Salmon and Steelhead Restoration Federation Conference, the Klamath Basin Symposium, a watershed analysis workshop in Ruch, Or., and Watershed Restoration workshop in Gold Beach, Or.

The program manager has spent over 40 hours planning and coordinating the various participants and equipment for field studies activities for the students and interested community members. Many local and agency experts participated.

Task 2: Lesson plans for 15 classroom/outdoor days of instruction. See attachment.

Task 3: Community members have been invited to and have participated in the field studies, bringing their own expertise and questions to the process. In addition to the students' participation, from two to ten community members have participated in each of the field studies. It has been beneficial for the students and community participants to engage together in learning about their watershed. Samples of notes home to parents and community members have been included as attachments.

Task 4: More than twenty days of instruction have taken place that focused on aquatic ecosystems, watershed processes, and salmonid life history. See attached lesson plans.

Task 5: Lesson plans have been included as an appendix to this report.

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Attachment: Lesson Plans

We used Adopt a Watershed's FOSS Landforms and Geology to study the concept of watershed, change over time, structure and scale, systems and interaction. This included using the FOSS kit to engage in the following hands-on lessons:

Day 1) The students created models of our school site with plastic cubes, transfered their information from their model to a grid and drew maps of the model.

Day 2) Students set up stream tables using diatomaceous earth and sand in a tray. They ran water through the system and noticed the formation of landforms resulting from the processes of erosion and deposition. They investigated variables that affect landforms, including slope and floods.

Day 3) Students built a foam model of Mt. Shasta, then created a topo map and a profile of the mountain.

Day 4) Students were introduced to topo maps and aerial photos and compared them.

Day 5) Students looked at topos and aerial photos of Nordheimer Creek. We picked out landmarks and practiced finding elevations. We also practiced finding watershed boundaries.

Day 6) Students revisited soil erosion study and tried to draw topos and profiles of the landforms they had created.

Day 7) Students discussed natural and human influences on the process of erosion. We took a short hike and drew landforms we saw around us, discussing their possible origin.

Day 8) Students learned about soil conservation and soil as a precious resource. We hiked locally, looking for specific erosion sites and patterns in their causes.

The following lessons were gleaned from many resources:

Day 9) Students, accompanied by Juan de la Fuente of the USFS, members of the Salmon River Restoration Council, and myself, spent a day in the field studying landforms and processes of change. We drove up McNeil Creek Road, stopping to view, climb and talk about landslides along the way. We drove to an overview of the Nordheimer Creek headwaters and hiked along the watershed divide, discussing watershed processes as we went.

Day 10) We viewed and discussed a film on protection of homes from wildfire sent to us by Dan Lindley in preparation for our field study day on fire. A discussion of the history of wildfire on the Salmon River led to the list of enclosed questions, which we sent to Jay Perkins of the USFS in advance of his visit.

Day 11) Students, community members, and Jay Perkins and Dan Lindley of USFS spent the day studying wildfire and its effects on habitats and humans. Jay Perkins showed us GIS overlays of the fire history of the Salmon River and we discussed causes and effects of fire, fuel loading, hazard ratings, fire suppression, careers in fire fighting, and protection from fire. This was followed with a mock fire inspection at an elderly couple's home and an afternoon of brushing, cleaning leaves from gutters, fire line building and brush pile burning.

Day 12) Observation as a scientific tool. Students sat in circle and one by one shared observations they made in the classroom, with each student giving detailed specific observations of things they saw, heard, smelled, tasted or felt. Next they drew something they observed in the greatest detail possible. That afternoon we repeated the assignment outside. Their homework that night was to sit outside with their journals and make as many detailed observations as possible. The next night their assignment was to lie down in the same spot and make detailed observations at eye level.

Day 13) Watershed vocabulary. Students learned meanings of watershed vocabulary: velocity, stream load, aggradation, degradation, equilibrium, slope, thalweg, sub-strate, meander, floodplain, riffle, run, pool from Conservation Class Curriculum of the Feather River Watershed. Students then tried to find examples of the above on our Adopt-a-Highway hike from the 21 mile to the 19 mile on the South Fork.

Day 14) Students found and interviewed someone who had observed the '64 flood. We shared the reports orally, then discussed the causes and effects of flood.

Day 15) Students used curriculum materials from Klamath River Studies and California Creeks to gain a basic knowledge of the types and importance of macroinvertebrates in a river system. Fran Janemark of the USFS, community members, and myself went to Nordheimer Creek, our adopted stream, where we collected several samples. When we returned to class we sorted, classified, identified and graphed our collection with Fran's help.

Day 16 and 17) Students, community participants, John Lee, who has a masters degree in macroinvertebrates from HSU, and myself sampled macroinvertebrates from Knownothing Creek, McNeil Creek, Crapo Creek, Grant Creek, Butler Creek, and Somes Creek, sticking as close as possible to Fish and Game's Rapid Bioassessment Protocols. We discussed species diversity and richness, and compared our results from different creeks. John Lee then spent an additional day categorizing and identifying with more specificity.

Day 18) Where are we? Students used Klamath Basin Studies maps to locate the Klamath River and its main tributaries. We then compared this map to a California Road Map, a raised elevation Weed Sheet, satellite photos, aerial photos, a Klamath National Forest map, and a USFS transportation map. We discussed our location in relationship to the county, bio-region, state, country, ocean and mountains, Pacific Rim, etc. Students figured out how to make watershed boundaries on a mylar overlay of a Salmon River transportation map.

Day 19) Richard Van de Water of USFS brought a number of GIS maps and explained how GIS works. Students practiced reading maps, then got a lesson in orienteering. We practiced using compasses on the playground, then proceeded to Nordheimer Creek where we had orienteering exercises. Students finished the lesson with a mapping exercise (see enclosed.)

Day 20) Students discussed salmon habitat, requirements, and population decline. We read excerpts from Adopt-a-Stream and Salmon River Spring Chinook Recovery Plan, and discussed ways to support salmon recovery on the Salmon River. Next we hiked along the river, looking for habitat that would and would not be suitable for salmonids.

Day 21) Water Quality. Using Stream Scene, Klamath River Studies, and Adopt-a-Stream, students learned about water quality parameters. We discussed temperature and sediment as major limiting factors for salmonids on the Salmon River, using excerpts from the Salmon River sediment budget study that Juan de la Fuente had given us. Students took their journals down to the river on a number of subsequent days and observed its appearance as well as taking the temperature. We discussed the possibilities of getting a temperature study going with the use of hobo-temps and our new computer.

Day 22 & 23) Larry Kuhn, multi-media expert from Arcata, did an in-service on the possibilities of our computer for a student-written and executed presentation of our watershed studies on the Salmon River. We explored the possibilities and the software for videotape, quick-time movies, and camera-to-computer visuals.

Besides the above-named contributors to our project,we also received help from Dennis Maria, Mike Farmer, Jack West, Brenda Olson, Orin Dix, Robbie Van de Water, Sue Maurer, Pat & Diane Higgins, Roger Barnhardt, Terry Roeloffs, Sue Balikov, Jack Herr, Jim McGuinness, Bruce Gwynne, Jim Villaponteaux, Bob Curry, Jim Ferrara (for teaching Karuk weekly), Leif Hillman, Bob Rohde, Richard Hart, Pam Tennity, Richard Cormier, Art and Carol Fraser, Jim Hensher, and the Forks School staff and school board.

Sample of notes home

PLEASE RETURN THIS PERMISSION SLIP IMMEDIATELY!

_______________________________ has my permission to participate in the field studies program at Forks School during 1993-94. I understand that I will be informed by note of specific dates with specialists as they are arranged.

signed: ___________________________________

date: ____________________________________

Explanation follows

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****

March 21, 1994

Dear Parents,

Forks of Salmon School kids live in one of the most beautiful places on earth. It also happens to be an ideal outside laboratory for the study of geology, meteorology, zoology, botany, hydrology, mapping, math, poetry, entomology, cultural anthropology, history, ornithology, chemistry, physics and the kitchen sink. The school has undertaken watershed studies as a hands-on means to :

1) expand our knowledge in life sciences, earth sciences, physical sciences and mathematics in a memorable and meaningful way.
2) learn about the cultures and ways of life which constitute our history as a community and their relationship to the watershed.
3) retrieve as much information as we can of the fast-disappearing Karuk, Konomihu and New River Shastan history in our watershed.
4) increase awareness of, and appreciation of, our immediate surroundings.
5) write with fluency, clarity and specificity about our knowledge, thoughts and feelings regarding our surroundings.
6) try to understand what constitutes sustainability of a healthy watershed.
7) learn about specific careers which build on the skills we learn as we study the watershed.
8) take responsibility for enhancing the health and beauty of the place we live.

Although one of our goals is to become knowledgeable about the entire Salmon River watershed in which we live, we will be able to dig deeper into each of the disciplines by singling out one creek for intensive study. We chose Knownothing Creek because of its proximity to the school, its rich history, its salmonid populations, its neighborhood of private land owners, and its accessibility.

I am in the on-going process of developing a curriculum to correspond to our goals. In the past we have planted riparian vegetation, planted trees, done botanical field studies, taken water temperatures,taken numerous field trips to study one facet of the watershed or another, participated in the aquarium incubator project to raise salmon and steelhead in the classroom, participated in the Klamath Task Force poster contest, etc.

This year we have begun observation journals, written poetry books based on our observations, started a wildlife log, engaged in the FOSS landforms science module, joined the Adopt-A-Highway program (we are responsible for keeping mile 19-21 free of litter), participated in the Kidder Creek Outdoor Education Program. Five of our older children received the training for the spawning ground and carcass surveys and participated weekly in that program with Forest Service, Fish and Game, the Karuk tribe and Salmon River Restoration Council volunteers.

I have been gathering resources and ideas to implement our goals, and am considering using elements of the following programs:

Full Option Science Systems Modules (FOSS)
Adopt a Watershed
Adopt a Stream
Streamwalk -EPA
Entering the Watershed
California Creeks- An Activity Based Curriculum
Project Wild

We have been brainstorming the following possibilities to include in our curriculum:

1) WATERSHED AWARENESS:

daily news (wildlife sightings, weather, river conditions); aquatic invertebrate study, spawning surveys, stream survey, channel profile, habitat typing, ground truthing, no-trace camping field trip, vegetative typing, riparian vegetation survey, oral histories, water quality monitoring, model landform project, erosion studies, Klamath River estuary field trip, fire history study, geologic history study.

2) RESTORATION ACTIONS:

seed collection, seed and cutting propagation, school nursery of Knownothing Creek natives for planting in Knownothing watershed, riparian planting, trailwork--building, maintenance and enhancement, erosion stabilization, fire prevention around homes.

3) MAPPING

wildlife sitings, compass reading-orienteering, scale, graphing, topography, overlays, aerial photos, satellite imagery, wildlife and plant sightings, GIS (Geographic Information System)

4) COMMUNITY AWARENESS:

Salmon River calendar, Salmon River history night, leaflet on the Salmon River and its protection, photo essay, underwater salmon video essay, flood and fire dramatic production, collection of archival data, interpretive center, Forks archives, network with other schools, dioramas of restoration techniques and/or habitat types, poster campaign, community presentation of our projects.

Please contact me with any ideas you may have to add to this tentative list. Yeah, I know that this list may take ten years to finish, but the important thing is that we've started, and are committed to a successful on-going program.

At this point Forks of Salmon School has jointly received a grant with the Salmon River Restoration Council from the Klamath Task Force to develop and implement a watershed curriculum for both the school and the community. We have included in this grant fifteen days of various specialists' time (to be used in the course of a year) so that the children can benefit from the specialists' expertise as we study various aspects of the watershed. All parents and interested community members are encouraged to join us on these field studies. I expect they will be a lot of fun as well as memorable educational experiences.

I would like to get a permission slip from the parents for the entire field studies program, as it is not feasible to try to round them up for each trip. I will keep you posted as the dates become specific. To date we have three days firmed up:

April 6 - fire --Jay Perkins
May 3 - geology - Juan de la Fuente
May 5 - map & compass reading and finding latitude & longitude --Richard Van de Water

All three days will begin with an hour or so of presentation and discussion, then proceed to the field (Knownothing Creek watershed when possible, otherwise elsewhere in the Salmon River watershed).

This is all pretty exciting stuff. I hope parents jump in on these trips too, as that is always a stimulus for the children--as well as vice versa. Please contact me with any ideas and/or feedback.

Sue Terence

Sample of notes home

Tues, April 5

Dear Folks,

Tomorrow (Weds., April 6) you are all invited to join us for the day. Jay Perkins will be with us from the Supervisor's Office in Yreka. He will start the day with some background on the fire history and ecology of the Salmon River, and questions and discussion will follow. Then we will proceed to check out various fuel loadings on the ground. Following a sack lunch, we will do a thorough fire hazard reduction around the Matthewson's house preparing it for what promises to be a bone dry summer.

So bring a sack lunch, a mccloud or pulaski, and your questions and curiosity to Forks School tomorrow for a day of field studies.

Sue

P.S. Current field study schedule:
May 3 - Geology - Juan dela Fuente
May 4 - macroinvertebrates - Fran Laymark
May 5 - mapping, orienteering - Richard Vandeh

P.P.S. - We have decided to adopt Nordheimer Creek rather than Know nothing. Please keep your ears open for history (stories about Nordheimer

Teaching Curriculum

A Crow Doesn't Need a Shadow. Ferra

Adopt a Watershed.

Adopting a Stream: A Northwest Handbook. Yates. 1988.

Aquatic Project Wild: Aquatic Educational Activities Guide. 1987.

California Creeks: An Activity-Based Science Curriculum for Grades 4-8. Dept. of Fish and Game. Junge.

Field Manual for water Quality Monitoring: An Environmental Education Program for Schools. Mitchell and Stapp. 1994.

F.I.S.H. Habitat Education Program. Pacific States Marine Fisheries Commission.

Forested Landscape Assessment and Monitoring Handbook. Headwaters. 1994.

F.O.S.S. Full Option Science Systems.

Klamath River Studies.

Mapping Fish Habitats: GEMS Lawrence Hall of Science. U.C. Berkeley. 1992.

Nature with Children of All Ages. Sisson. 1982.

Problematic Science Materials. Baurer. Mt. Shasta High School.

Rapid Bioassessment Protocols for Use in Streams and Rivers. EPA. 1989.

Science for Children. National Science Resource Center.

Small Streams and Salmonid: A Manual for Secondary Students and their Teachers Introducing Water Quality and Fishery Requirements.

Streamwalk II: Learning How to Monitor our Streams. Rabe. Idaho Water Resources Research Institute. 1992.

Volunteer Monitoring periodicals. EPA.

References:

Background Materials

A Biological Survey of Streams and Lakes in the Klamath and Shasta National Forests of California. Taft and Shapovalov. 1935.

A Proposal for Managing and Monitoring Streams for Fish Production. Sedell. 1989.

Aquatic Insects of North America. Merritt and Cummins.

Boundaries of Home. Aberley. 1993.

Elements of Recovery. Mattole Restoration Council.

Entering the Watershed. Pacific Rivers Council 1993.

Evaluation of Fish Habitat Condition and Utilization in Salmon, Scott, Shasta, and Mid-Klamath Sub-basin Tributaries. 1988-89. KNF.

Federal Agencies' Guide to Watershed Analysis.

FEMAT report. 1993.

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Monitoring Guidelines to evaluate Effects of Forest Activities on Streams in the Pacific Northwest and Alaska. EPA. University of Washington. 1990.

PACFISH Strategy. USFS. 1994.

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Salmon of the Klamath River California: Fish Bulletin No. 34. Dept. of Fish and Game. 1931.

Salmon River Sediment Analysis. USFS. 1993.

Soil Survey: Klamath National Forest. USFS. 1994.

Third National Citizens' Volunteer Water Monitoring Conference. EPA. 1992.

Trinity River Restoration Action Plan. 1994.

Volunteer Monitoring periodicals. EPA.

Local Resources

Audubon Society Field Guides.

Before the White Man Came. Graves.

Bellboy. McClain.

Everyday History of Somewhere. Raphael.

Gold Mining in Siskiyou County 1850-1900. Stumpf.

Handbook to the Klamath River Canyon. Quinn.

Hover Collection of Karuk Baskets. Clarke Memorial Museum.

Karok World Renewal. Palmer.

Klamath Knot. Wallace.

Konomihu Studies. CA-SIS-1457. Winthrop.

Land of the Grasshopper Song. Arnold and Reed.

Lore and Legends of the Klamath River Indians. Graves.

Memories from the Land of Siskiyou. KNF. Davies and Frank.

Peterson Field Guides.

Plants and the People- Ethnobotany of the Karuk. Davis.

Salmon River Sediment Analysis. USFS. 1994.

September and Fire. Pioneer Press. 1987.

Siskiyou Pioneer periodicals.

Soil Survey: Klamath National Forest. USFS. 1994.

Student Resources

A Crow Doesn't Need a Shadow. Ferra.

Audubon Society Field Guides.

Before the White Man Came. Graves.

Bellboy. McClain.

Colors from Nature. McRae.

Come Back, Salmon. Cone.

Crow and Weasel. Lopez.

Cry of the Crow. Craighead and George.

Earth Science for Every Kid. Van Cleve. 1991.

Everyday History of Somewhere. Raphael.

Gold Mining in Siskiyou County 1850-1900. Stumpf.

Handbook to the Klamath River Canyon. Quinn.

Hover Collection of Karuk Baskets. Clarke Memorial Museum.

How the Forest Grew. Jaspersohn.

Karok World Renewal. Palmer.

Konomihu Studies. CA-SIS-1457. Winthrop.

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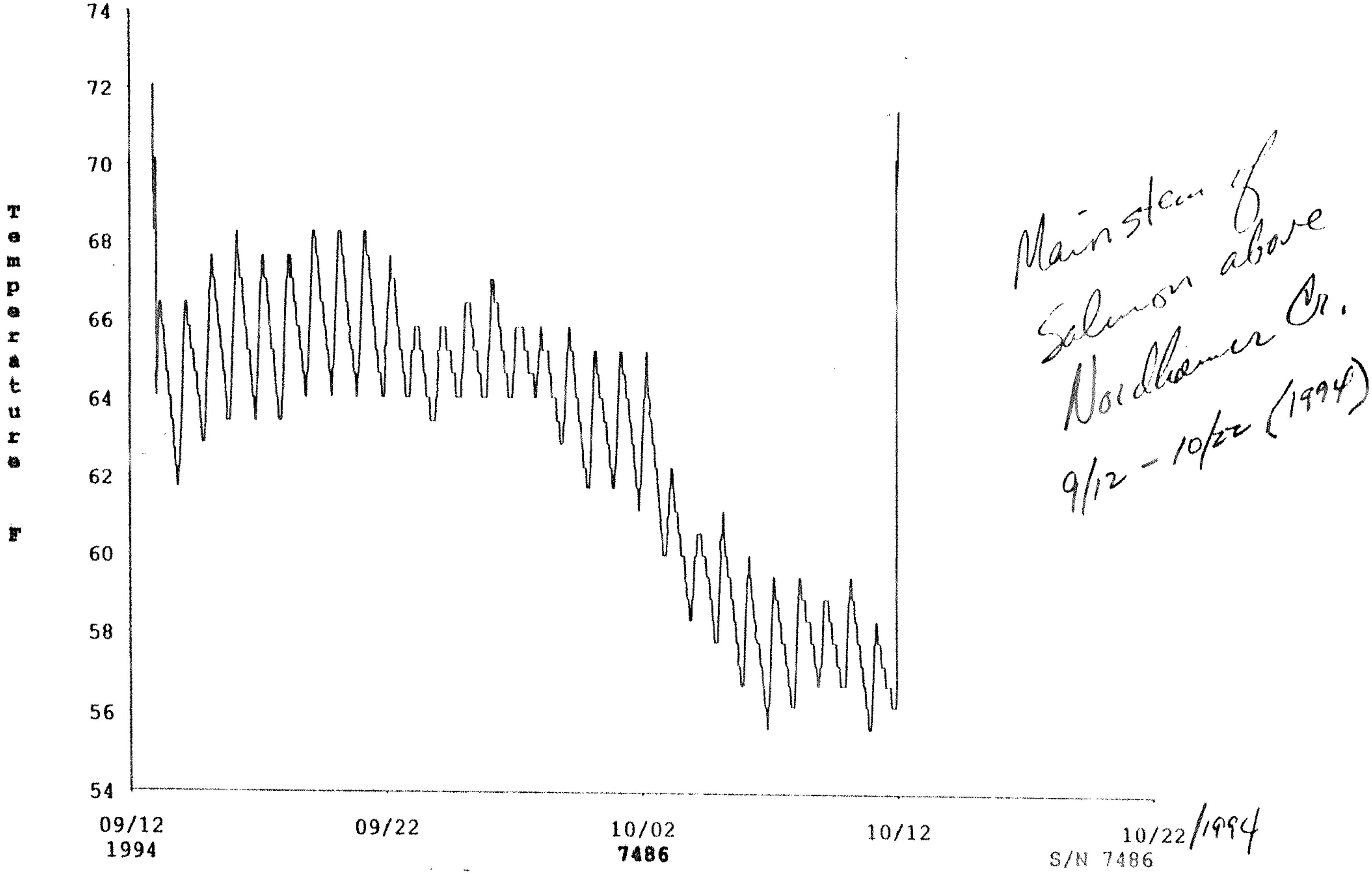

Temperature F
74
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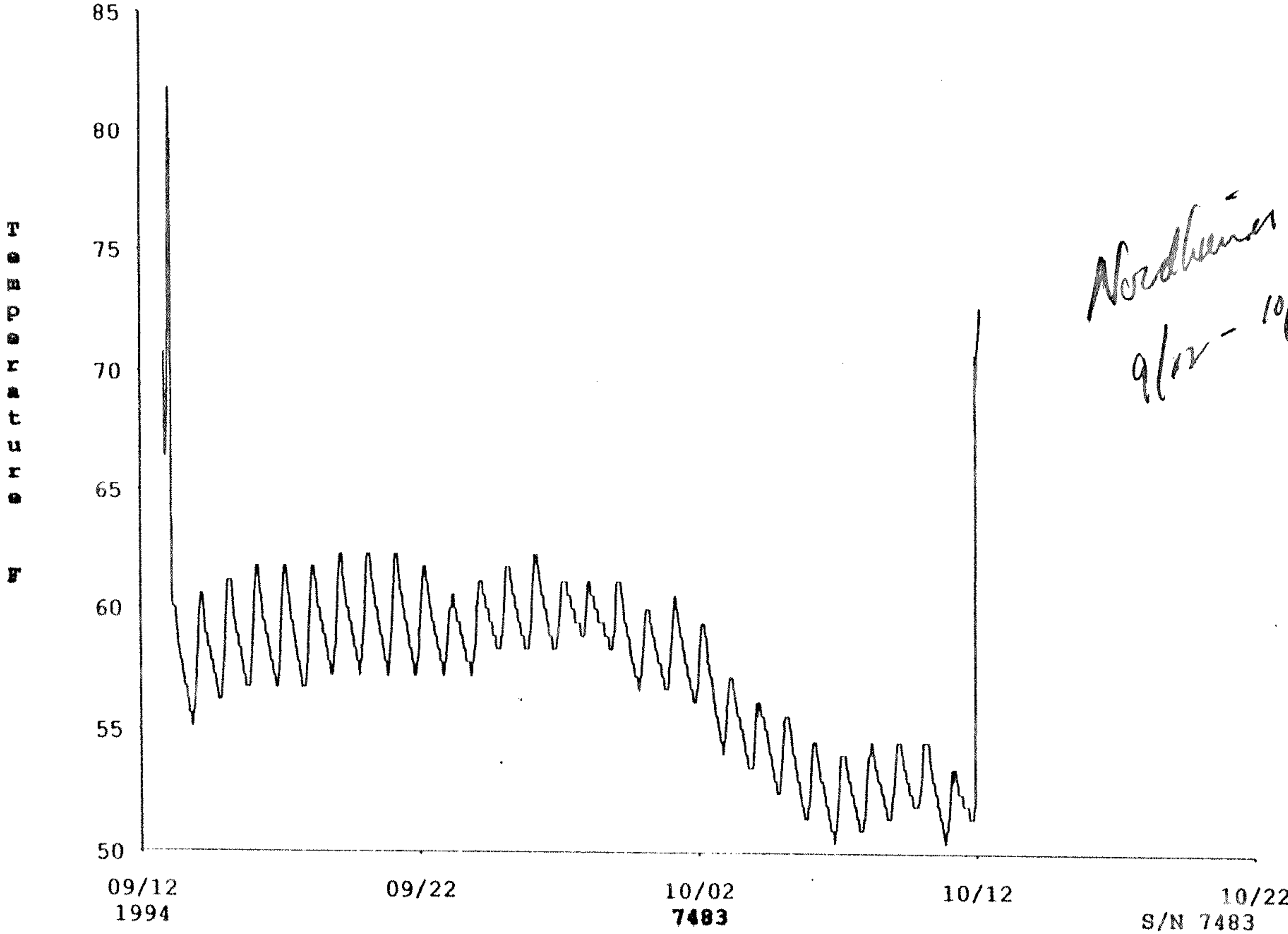
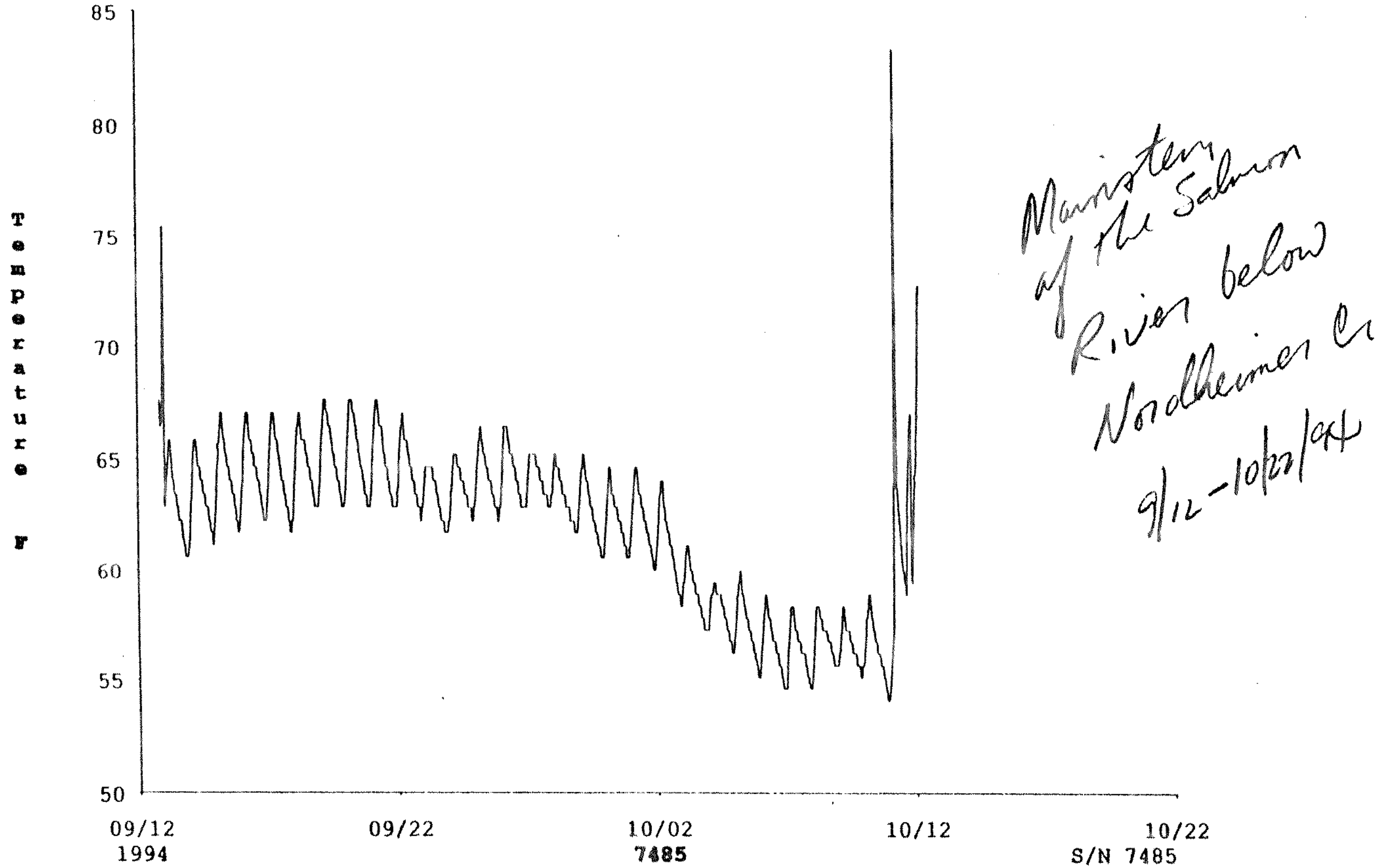
66
64
62
60
58
56
54
09/12
1994
09/22
10/02
7486
10/12
10/22/1994
S/N 7486
Mainstem of Salmon above Nordheimer Cr.
9/12 - 10/22 (1994)



Nordheimer Cr.
9/12 - 10/22/94


Temperature F
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09/12
1994
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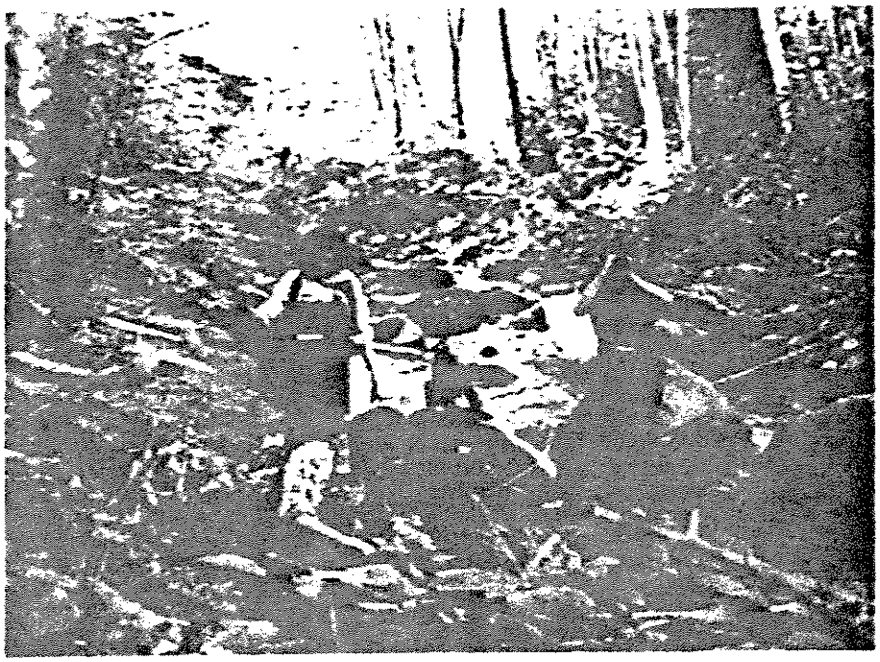
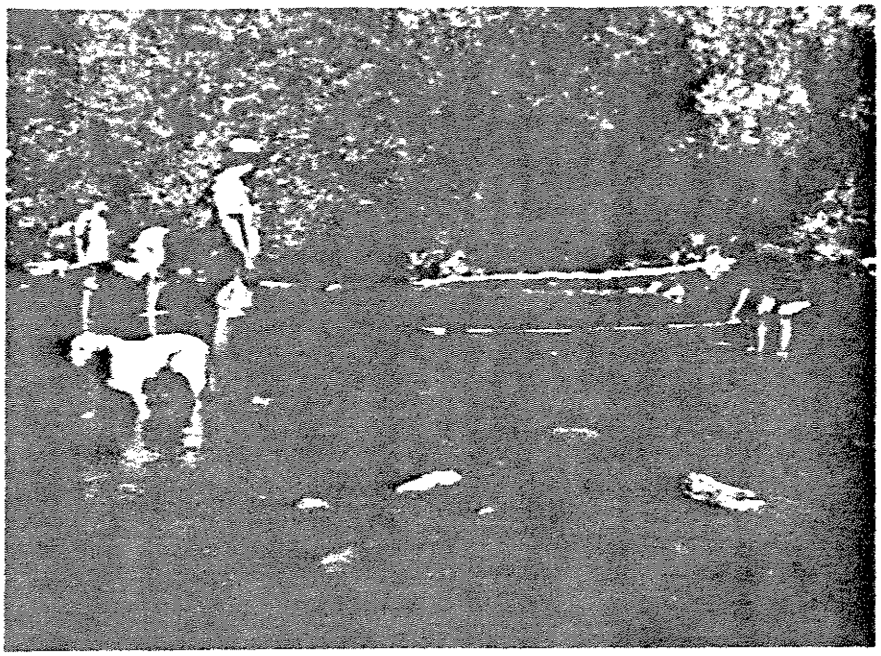
S/N 7485
Mainstem of the Salmon River below Nordheimer Cr.
9/12-10/22/94

Shredders at work
Jeremiah



Macroinvertebrate survey
Butler Creek



Velocity measurement
at the mouth of Knownothing

Checking out substrate

Underwater shot at
Teacherage Hole
Main Stem Salmon

Student-generated geology questions for Juan de la Fuente

What is the main thing that formed this watershed?

How were the mountains of the Salmon River formed?

How long ago?

How long ago was this whole area under water?

How long do you think it took for these mountains to form?

Are these mountains still forming?

How long did it take for the river to carve the canyon?

Is there a chronology of the geological history of this area anyplace? Where could we find it?

Were there ever volcanic eruptions in the Salmon River watershed?

Why are all the volcanos east of here and not here?

Is there a possibility that there could be an eruption here? In the near future? In the distant future?

What effects do you think earthquakes have had on this watershed?

Have you found any evidence that big earthquakes have triggered massive landslides here in the past?

What effect would a major earthquake on the coast have on the topography of this watershed?

Are there any earthquake faults in the Salmon River? Where?

If not, where are the nearest faults?

How long has it been since the Orleans Fault has been active? Do you think it has any chance of being active in our lifetime?

Is there a certain season when the earth's plates seem more active?

How do you figure out how old a mountain is?

What is the highest place in the Salmon River watershed?

What is the deepest spot in the Salmon River?

Why is there so much granite around here?

What kind of rocks are the most common in the Salmon River watershed?

What do the different types of rocks mean in different places?

How does a rock form?

Why is there sand by the river in some places, and cobbles and big rocks in other places by the river?

What makes good planting soil?

Where is the best planting soil around the Salmon River?

How do you go about finding good planting soil?

Why is there red dirt in some places?

How long would it take for a granite rock 12" in diameter to turn into dust if it's not in the river? How about if it is in the river?

Where does the gold tend to be? Why? How about the platinum?

Are there any other precious metals in this watershed?

How do people affect geology here?

What causes land or rock slides?

How many gallons of water pass from the Salmon River each day?

When does a river meander?

What determines where a spring might pop up from under the ground?

How did glaciers affect stuff around here, or did they? Do you think we will ever have glaciers again?

Do fires affect the geology of the Salmon River?

How much erosion slides into the river each year in the Salmon River watershed?

Where in the SR is the worst erosion? Why?

What could be done to help stop this?

Why were the road put where they are?

How many miles of road are in the SR watershed?

How do you think a flood the same size as the '64 flood would affect the Salmon River today?

Is there any way to predict floods?

Is there any way to predict landslides?

How do trees affect the amount of erosion?

Which species of trees hold the soil in the best?

How long after they're dead do the roots of a tree hold the soil in?

At the rate of erosion now, what do you think this watershed will look like in 200 years? 2000 years? 200,000 years?

Why did you become a geologist? What first got you interested?

How old were you when you decided to become a geologist?

How long did you have to go to school to become a geologist?

If you were doing it again would you still become a geologist?

Student-generated questions re: FIRE

What determines where fire hits, and are certain places more vulnerable?

Have any major fires in the Salmon River been human caused? Have there ever been any arson fires in the Salmon River?

Why do fires burn faster going upslope? When do they burn downslope?

Do fires burn more on certain slopes? Why?

When did they start using fire suppression on the Salmon River?

How has it worked?

If fire suppression had never started here, would you start it now? Why or why not?

Is there any way to get the watershed back to a more natural state now that it is the way it is?

How is Yellowstone looking now where they let it burn?

How do you think backfiring worked on the '87 fires? Did it save ground or lose ground in the end?

Why don't you do more controlled burning?

Do trees in riparian areas survive fire better?

What species are hit hardest by fire? What age trees are hit hardest by fire?

What do you think should happen in the Salmon River to keep fires

like the Hog Fire and the '87 fires from happening again?

Do you like your job? Why or why not?

Do you think the fires affect the climate? Does less rain come when there aren't as many trees?

What does the fire season look like for this year? Do you have enough people to fight the fires?

How old do you have to be to fight fires?

Orienteering Quiz

1) What is the bearing and distance from Forks of Salmon School to the Kramer Mine?

2) Our class went to Nordheimer Flat for the afternoon. I forgot my lunch! I hailed a passing helicopter and asked if he would fly me to school so I could get my lunch. He doesn't know where Forks of Salmon School is, and asks for a compass bearing. What is the compass bearing from Nordheimer Flat to the school?

a) We rise into the air above Nordheimer Flat and the pilot reports that his compass has gone haywire. What topographic feature (feature of the landscape) can you tell the pilot to follow to get to Forks of Salmon?

3) I stayed late fishing at Picayune Lake and by the time I started walking the ridge back to Forks of Salmon, it was getting dark. I intend to stay on the main ridge (Blue Ridge) to get back to the Forks, but I'll have to be careful not to veer off on any spur ridges in the dark. What approximate compass bearing should I be following? About how far is it from Picayune Lake to the Forks?

4) You are walking on the trail up Horn Cr. drainage and realize you're about out of water. You'd like to refill your canteen at Acorn Spring. Having reached the ridge below Acorn Spring, how far is it up the ridge to the spring (in feet)? What is the approximate difference in elevation?

5) The lightning has been popping like crazy around the Forks, and most of the Forest Service firefighters are on fires in Southern California. The Forest Service calls your mom and asks her if you and she could serve as lookouts on the peak near Kramer Mine at elevation 4305. After you arrive there, you begin reporting the bearings to a couple of smokes you have spotted.

a) One smoke is down on the river at a bearing of 185 degrees. Where is this fire?

b) Another smoke is on the top of Blue Ridge at a bearing of 130 degrees. Mark this spot on your map. What is the elevation at this spot?

c) You spot a smoke across the river at a bearing of 200 degrees. Another lookout has been posted on Blue Ridge near Picayune Lake at elevation 3750. She reports the fire at 258 degrees. By triangulation, you can fix the location of this fire. Mark the location on your map with an "X". What is the approximate elevation at this location?

d) The only other smoke you spot is in a tributary on the west side of the main stem of the Salmon (below the Forks) at a bearing of 227 degrees. What is the name of this creek?

5) What is the difference in elevation between your lookout point (elev. 4305) and Forks of Salmon?

6) What is the name of the gulch just north of Forks of Salmon School? Use your pencil to draw in some drainages/draws that might flow water during intense storms that are not shown as streams on the map.

7) What Township, Range & Section is the Forks located in?

8) How many tributary streams does Murderers Gulch have?

9) What is the approximate elevation of the Codfish Hill Mine (near Quail Flat & Nordheimer Flat)?

MAP & COMPASS

Clip out each course. Distribute one course to each patrol. The patrol starts at an assigned numbered stake. When the patrol completes its course, it places another numbered stake marked "end" where the course ends. The instructor then checks for permissible error using a tape measure and compass. The correct finish for the courses is on the next page.

COURSE 1

From the start, go 125 feet on a compass reading of 94 degrees, then:

Go 137 feet on a compass reading of 213 degrees, then:

Go 140 feet on a compass reading of 340 degrees.

COURSE 2

From the start, go 95 feet on a compass reading of 214 degrees, then:

Go 80 feet on a compass reading of 320 degrees, then:

Go 90 feet on a compass reading of 69 degrees.

COURSE 3

From the start, go 120 feet at a compass reading of 48 degrees, then:

Go 95 feet at a compass reading of 185 degrees, then:

Go 160 feet at a compass reading of 280 degrees.

COURSE 4

From the start, go 140 feet on a compass reading of 160 degrees, then:

Go 137 feet on a compass reading of 33 degrees, then:

Go 125 feet on a compass reading of 274 degrees.

COURSE 5

From the start, go 90 feet on a compass reading of 249 degrees, then:

Go 80 feet on a compass reading of 140 degrees, then:

Go 95 feet on a compass reading of 34 degrees.

COURSE 6

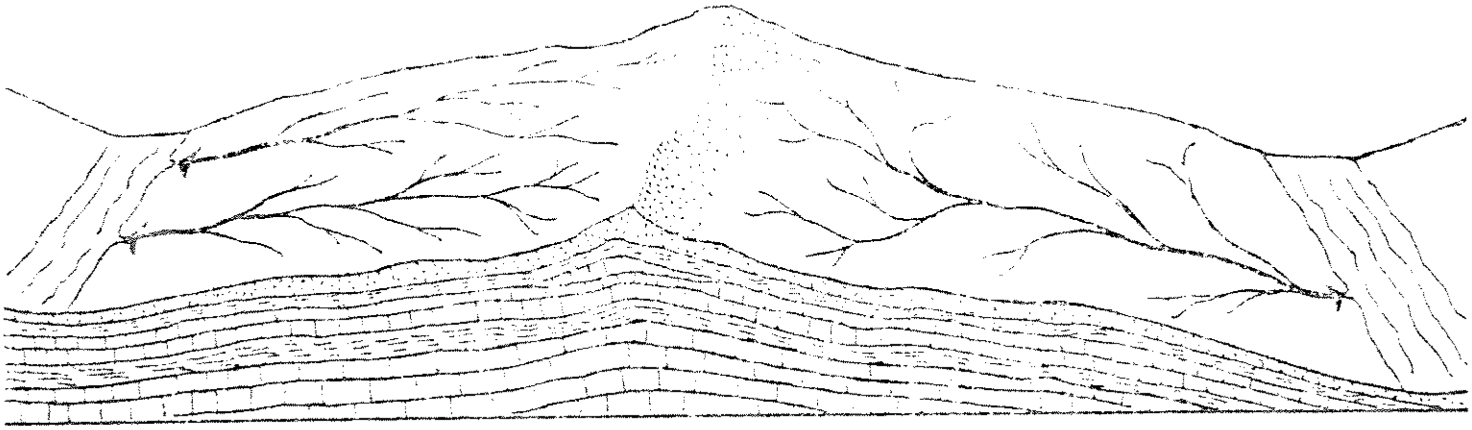
From the start, go 160 feet on a compass readiong of 100 degrees, then:

Go 95 feet on a compass reading of 5 degrees, then:

Go 120 feet on a compass reading of 228 degrees.

Permissible Errors for Map & Compass Courses

Course	Closure to Starting Position	Permissible Error
COURSE 1	10' at 23 degrees	20'1"
COURSE 2	25'6" at 309 degrees	13'3"
COURSE 3	78' at 280 degrees	18'9"
COURSE 4	10' at 203 degrees	20'1"
COURSE 5	25'6" at 129 degrees	13'3"
COURSE 6	78' at 100 degrees	18'9"



divide: a line or zone of higher ground between two adjacent streams or drainage basins; (an imaginary line dividing two watersheds).
watershed: an area of land which drains into a body of water.
channel: the bed of a stream or waterway; the lowest part of the landscape.

Moisture from rainfall and other forms of precipitation is pulled from high ground to low ground by the force of gravity. Land on one side of a ridge or divide drains into one channel while water from land on the other side drains into another channel. The area between the divide and the channel is called the watershed. As water drains over the slopes, it collects in geographic irregularities in the landscape. These tiny streams are called rills. Drainage streams join other drainage streams and typically become larger as the water progresses downhill.

A watershed is covered by a combination of landforms and streams. The number and size of the streams depends partially on rainfall and degree of slope. The ideal watershed, a watershed that stores the greatest percentage of precipitated moisture, is one with a dense network of slow moving rills and streams. In addition to rainfall and slope, the quality and quantity of water provided by a watershed depends on both natural vegetation and on the crops grown by man. Other integral components of a watershed include wild and domestic animals, the soil, and man and his structures.

1. Discuss how each item below might effect a watershed.

   thick growth of plants (grass, shrubs, trees) ______________________________

   ____

   burrowing animals ____

   extensive farming on sloping land ______________________________

   massive systems of cities and superhighways ____________________

   strip mining ____

   extensive lumbering ____

2. Be prepared to discuss other factors that affect a watershed.

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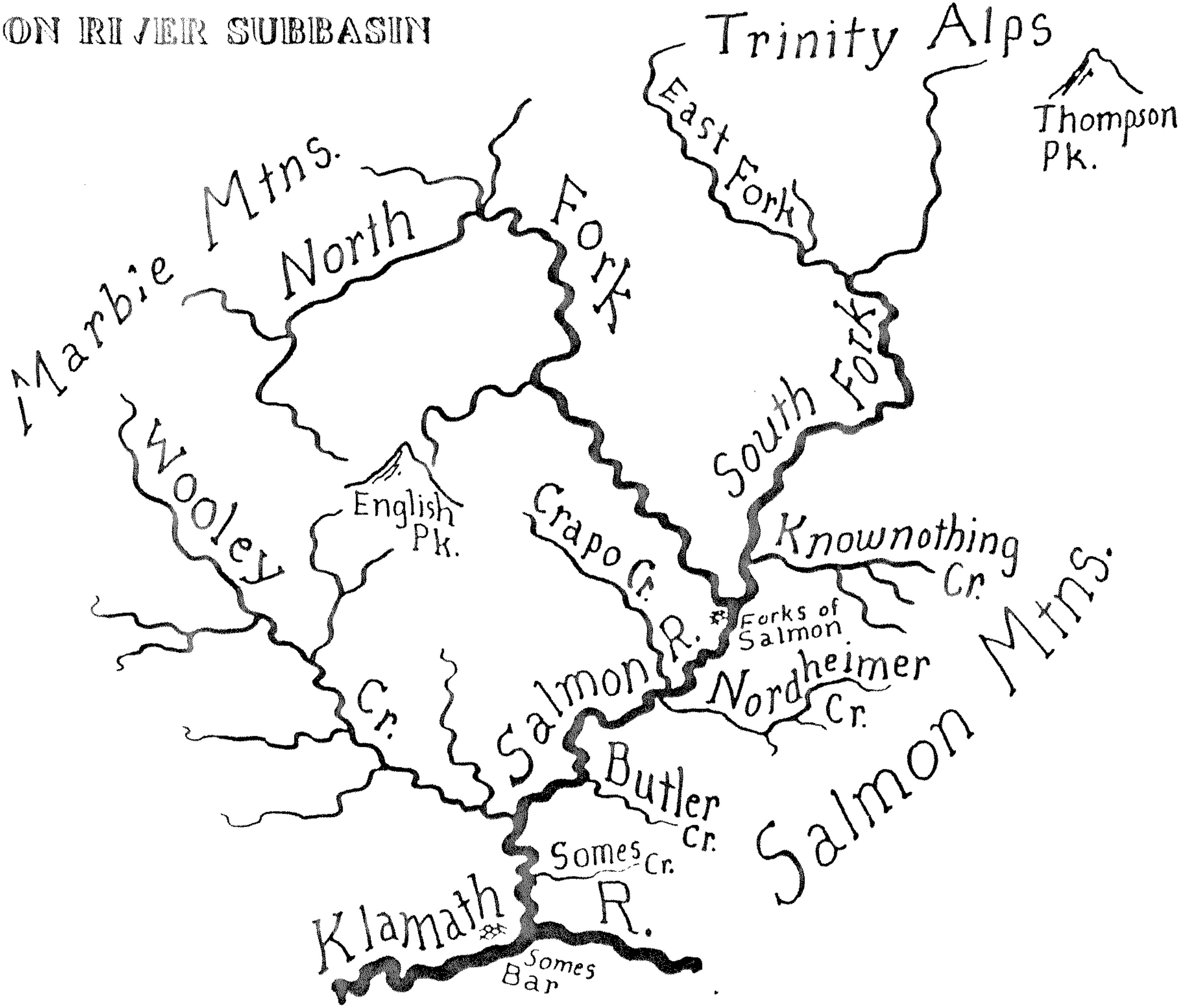
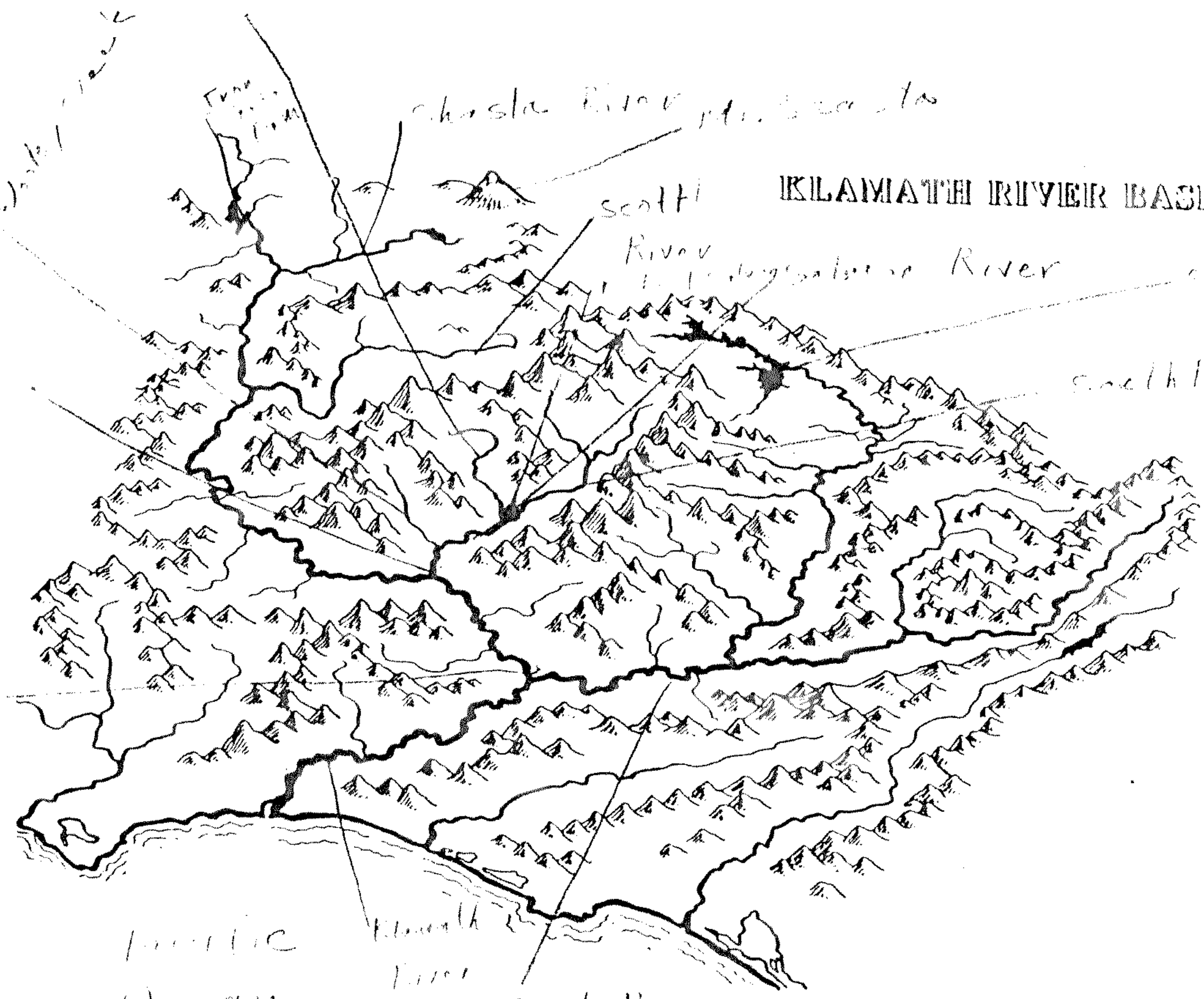
SALMON RIVER SUBBASIN



KLAMATH RIVER BASIN



SALMON RIVER SUBBASIN

sample of an
observation of a
10' square area

Miles
Alayna
Amber
Erica

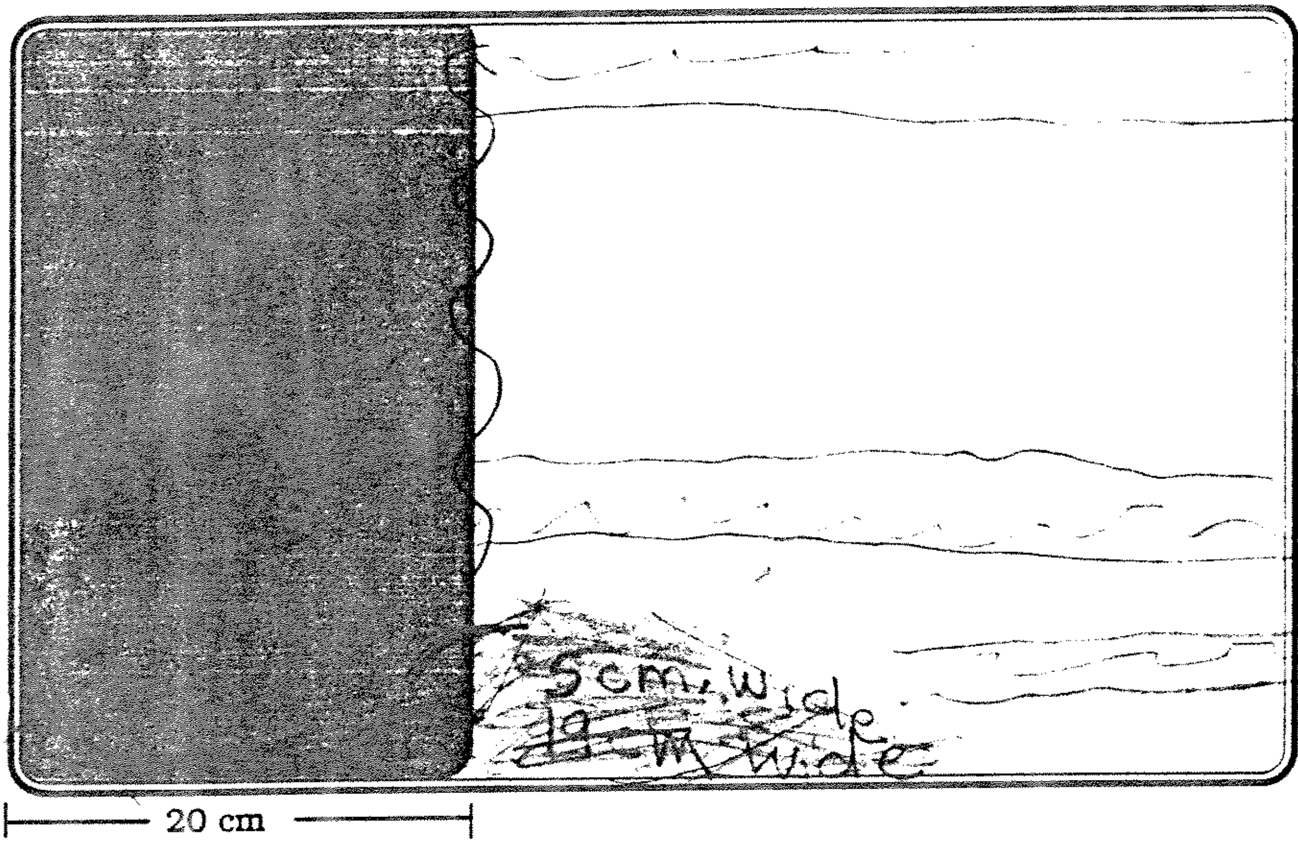
White oak unhealthy, mistletoe
grass
porcupine
Wild flower
[illegible]
Shale
[illegible]
[illegible]
dirty [illegible]
lichen
rocks
weeds
groundsquirrel hole
half flat / half sloped
plantain
Dead leaves moss
Sticks
lots of kinds of grass
There
Dried leaves under horehound
Lots of queen anne's lace
lush grass, very green
tallest horehound 30
Some sorre, going to seed
Dry horehound seeds
Oak tree is very mossy
bare circle around oak lots of dry leaves
more vegetation on the west side
[illegible] on north side
Shorter grass on [illegible]
dead horehound that someone pulled
Clover
Butter cup

Name Erica Date 2/8/14

sample of a F.O.S.S. experiment

STREAM TABLE MAP

This is an investigation of Standard.



Key	
▓	Sand/diatomaceous earth mixture
⁘	Sand
~	Diatomaceous earth

Elapsed time (minutes after start)	Important events
41	Delta
40	channel at sid
220	channel completley c
50	erosion near channel
don't know	Water cutting chann
3	pool being made

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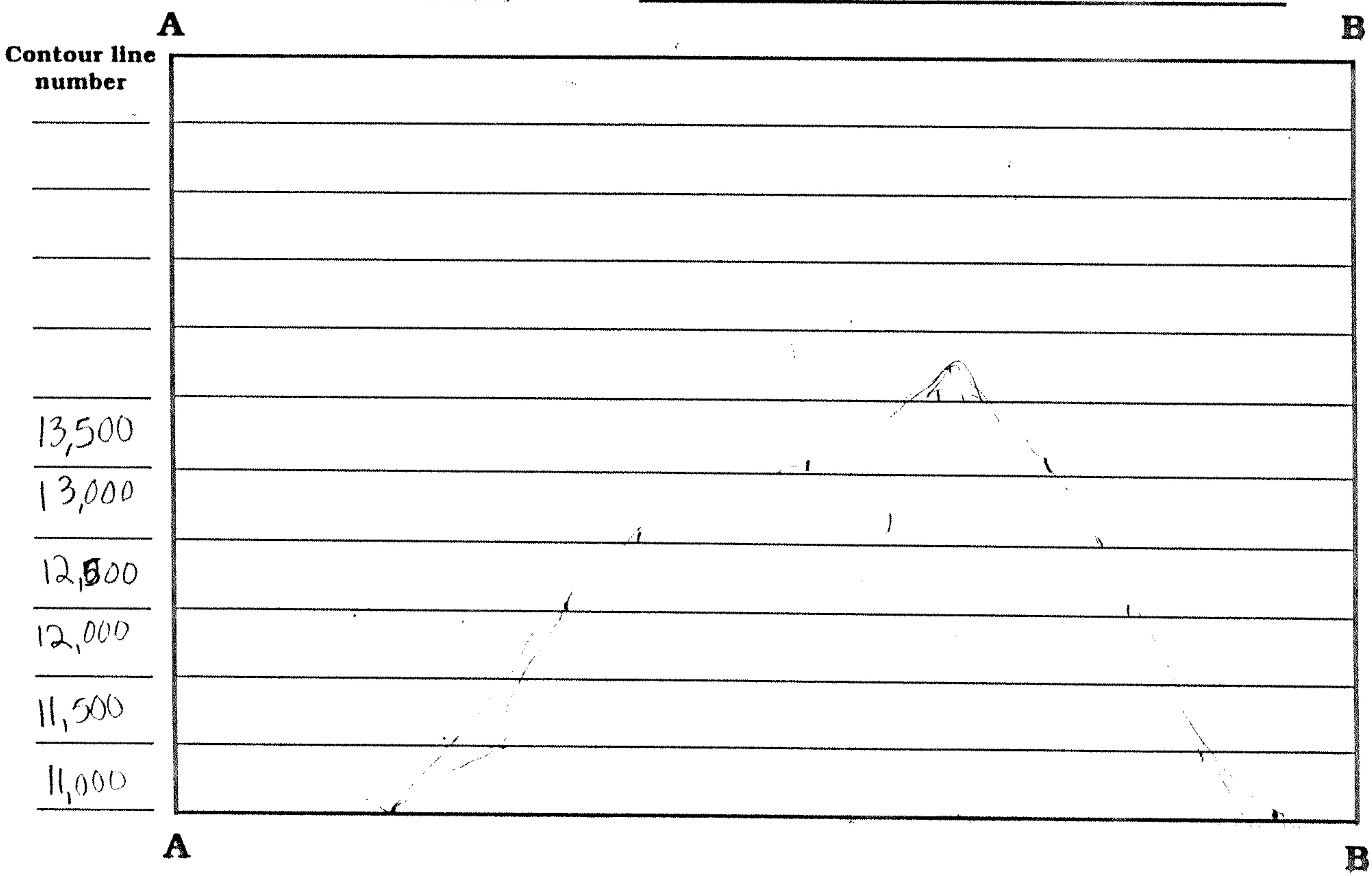
Name Erica Date 4/8/94

PROFILE

Title ____________________



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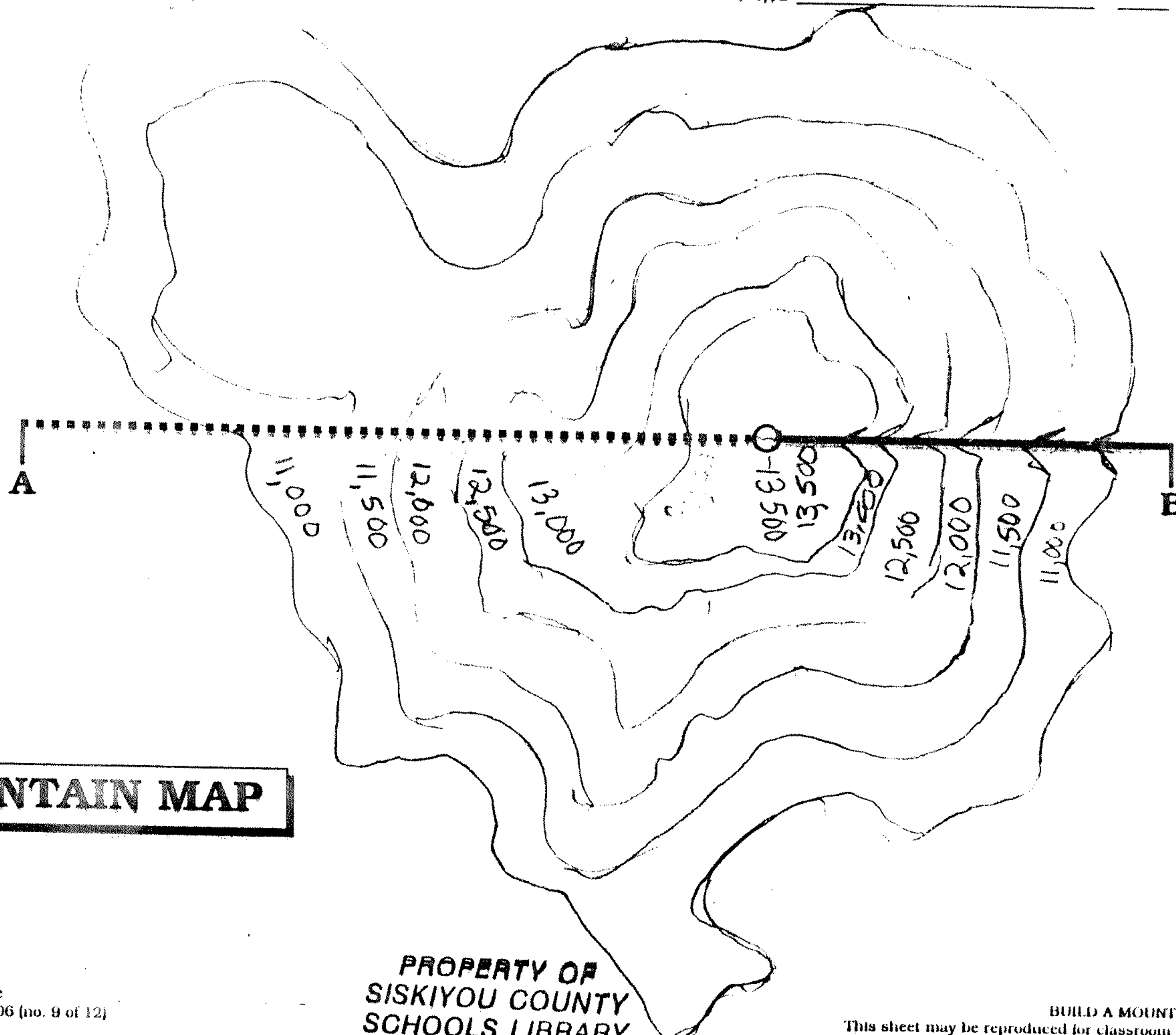
Name Erica ______ Date ______

MOUNTAIN MAP



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35163

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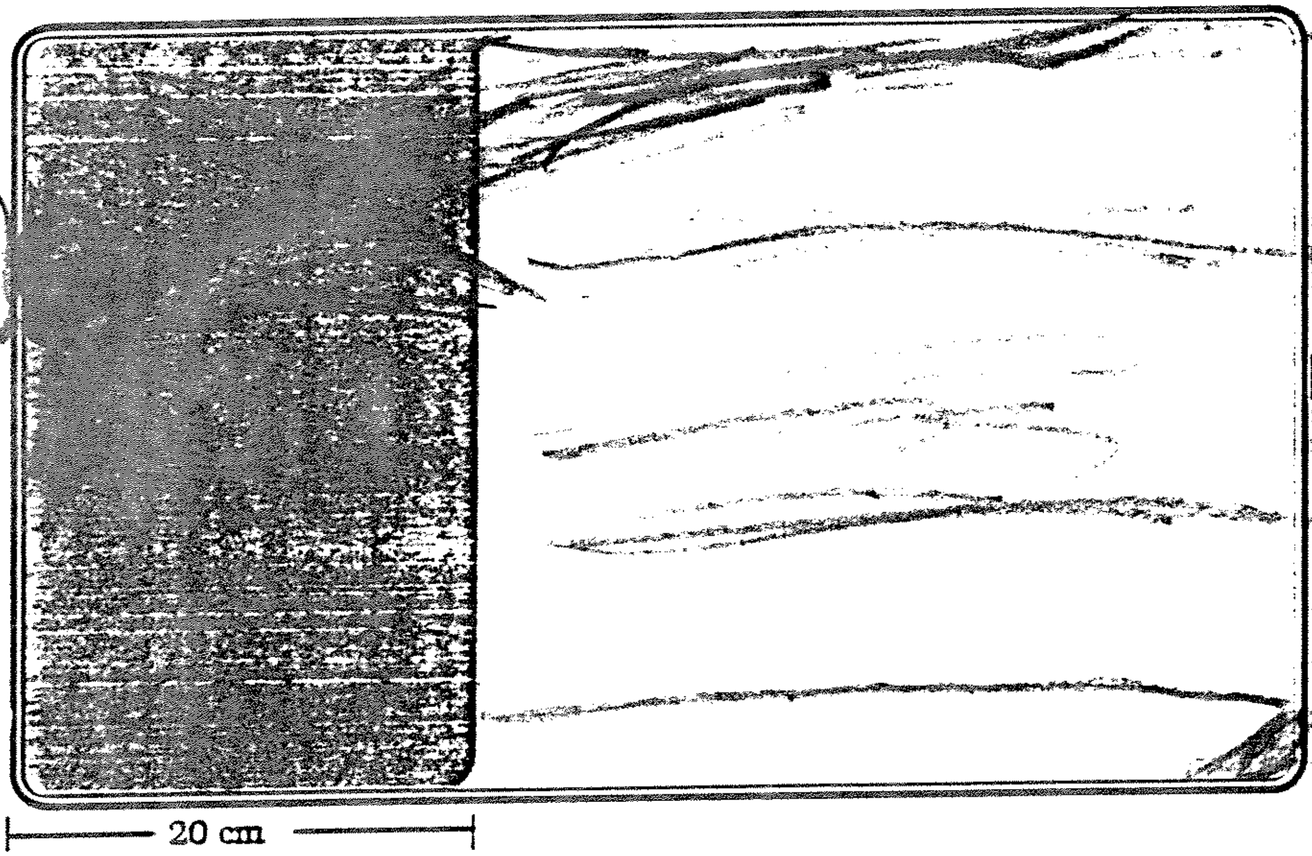
Name Erica Date 5-1-4

STREAM TABLE MAP

This is an investigation of Flood.



Key	
	Sand/diatomaceous earth mixture
	Sand
	Diatomaceous earth
	Delta

Elapsed time (minutes after start)	Important events
3	flooding
~~[illegible]~~	erosion 5 sec
10	2 main Channels
35	Only 1 trail
40	Delta at bottom of tra
3 min 20 sec	Water stopped

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Comparing Insects in Different Streams

Concept

Insects can be indicators of stream health. Healthy habitat may have certain species or greater diversity of species than unhealthy habitat. Populations of insects change in a given stream seasonally.

Objectives

Students will:

•observe collections of insects from different streams and determine existence of some indicator species

•make inferences about the health of the streams from the diversity and types of insects found in each

•describe and graph seasonal differences in insect populations in one stream

Background

Insects, like fish, require certain environmental conditions to survive. Some insects are more sensitive to these conditions than others, and their presence or absence can be an indicator of water quality. Habitat conditions in two or more streams may be compared, in a general way, by looking at insects that live in them.

Several things can occur in a watershed that would disturb habitats in streams. Timber harvest, grazing and urban development can all lead to unstable watersheds that are prone to erosion. When fine sediment enters streams, it decreases the quality of habitat for many insects by filling in spaces between cobbles and gravel, thereby decreasing space and reducing water flow through the substrate. Influxes of sediments can also disturb the plants that grow in streams, which are the food base for many insects.

If riparian vegetation is removed or degraded, the water temperature often increases. Since warmer water holds less oxygen than cold water, those insects that require high levels of dissolved oxygen may not survive in streams with disturbed riparian zones.

Water pollution from urban or agricultural sources may also cause mortality of insects and other aquatic invertebrates, such as snails. Pollutants may only be in the stream at certain times, so they may be difficult to detect. Presence or absence of aquatic invertebrates can indicate that pollution is occuring.

Materials

Kick net, jars with tight fitting lids, labels, thermometer, camera (optional), magnifying glasses or two-way viewers, and a dissecting microscope, several trays or pans (white is best), fine tweezers, vials, alcohol, insect picture keys and dichotomous keys.

Sampling Procedure:

In an optimal situation, the students will collect samples from a stream near their school. If this is not possible, then the teacher may have to collect the samples. There are several factors to consider when choosing sampling sites. The streams you sample should be of similar size and gradients, and all samples should be taken from riffles. One set of samples should come from a healthy stream, and one set from a stream thought to be impaired.

Record some of the conditions of each stream, such as the character of the riparian zone, appearance of the substrate and water temperature. Also, take note of activities in the watershed, such as recent construction of roads or buildings. You could also take pictures of the streams, nearby watershed, and anything else you feel would be helpful in demonstrating stream conditions to students.

Collect samples using a kick net, and place them into a jar that has been labeled. If you will be able to look at the insects within the next 24 hours, you may place them into a cooler with ice. At school, they may be placed in a refrigerator overnight. It is important to keep samples cold and in a dark place. These conditions will make insects less active, and will decrease predations among them, which would greatly affect the sample.

You may also place the insects into jars filled with ethyl alcohol and water. If you plan to extend the activity over several days, or if you want to keep a reference sample for future comparisons, you should preserve the insects right away. This will also facilitate easy observations, since you can remove all the extra debris that will be in you sample, like plants and sand.

Classroom Procedure:

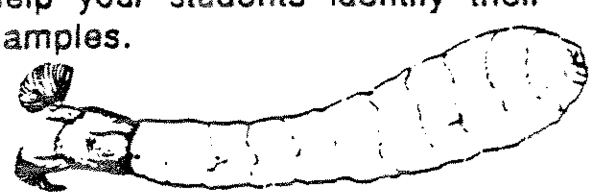
Students should be familiar with how to use the dichotomous keys. Several lessons on classification should have already been presented, and students should have had prior exposure to the keys they will be using, so they are not looking at them for the first time during this activity.

First day: Students should work in pairs or small groups. Give each group a portion of the sample from each stream. Place the samples in trays, and label the trays with the name of the stream or simply stream A, stream B. Students should use their magnifying glasses or viewers to determine what kind of insects are present in each sample. They should be careful to keep the samples separate. On the record sheets, they will make hatch marks as they identify the various insects. Once an insects has been identified, it should be placed into another container, so that it doesn't get counted again.

Second day: Students will analyze their findings, and determine which stream has the best habitat for insects. First, compile the data from all the student's groups, and make a list of the insects found in each stream and the estimated number of each. Ask students to compare the insects found in each stream. For instance, one streams might have many blackfly larvae, and few or no stoneflies, while the other may have many stoneflies and mayflies.

Determine if one of the streams has a greater diversity of insects. Then ask students to predict which stream has the best habitat. Describe the conditions you observed at each stream. Show them pictures, if you have any. Discuss possible reasons for differences in insect samples.

Note:
Additional drawings of various insects that have been collected in Klamath River Basin streams are included in the appendix. They will help your students identify their samples.

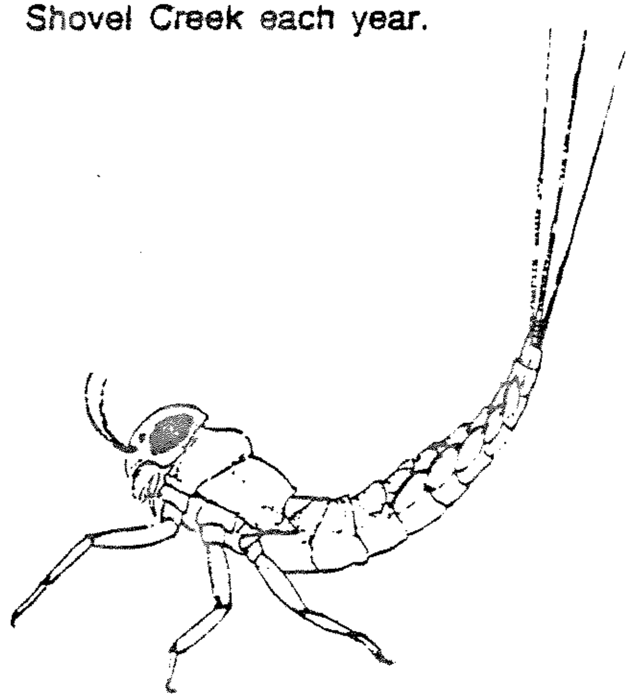


Begin a discussion about why there are differences in the types of insects found. Students should be relating watershed activities to stream conditions, and should be able to infer that insect populations can indicate habitat quality.

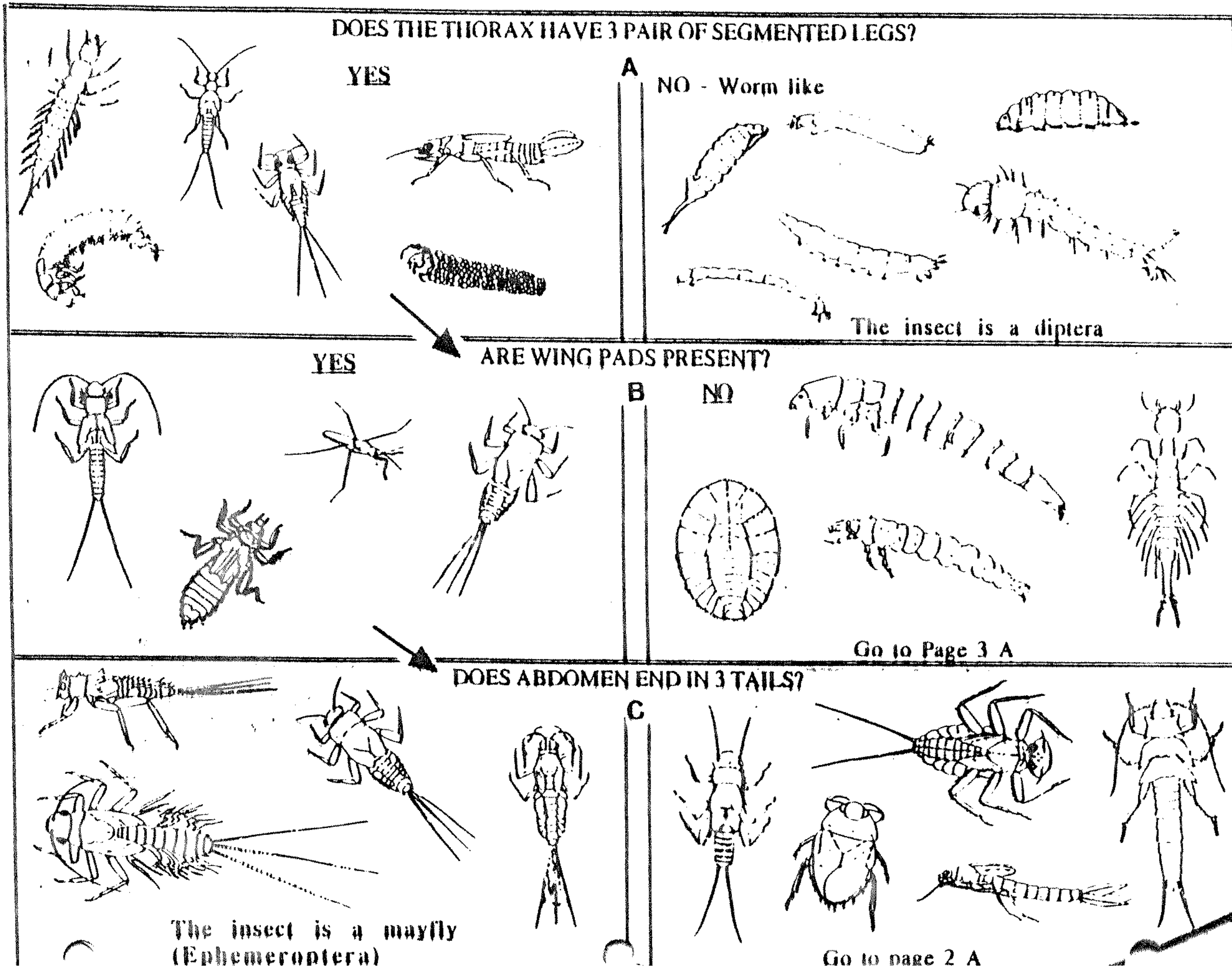
Seasonal Changes

You may also want to sample one stream several times during the school year. Try once in the early winter and once in late spring. Students should try to quantify the types of insects they find. Make graphs and pie charts showing the differences.

Samples of such graphs from Dorris Elementary School are included. It may be interesting to compare your stream with Shovel Creek. Perhaps your students could begin to communicate with Dave VanScoyoc's students, who will be studying Shovel Creek each year.



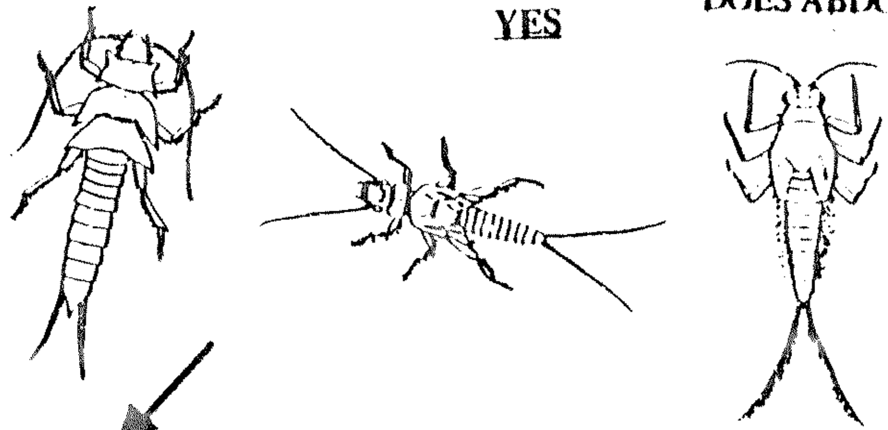
A KEY TO IMMATURE AQUATIC INSECTS PAGE 1



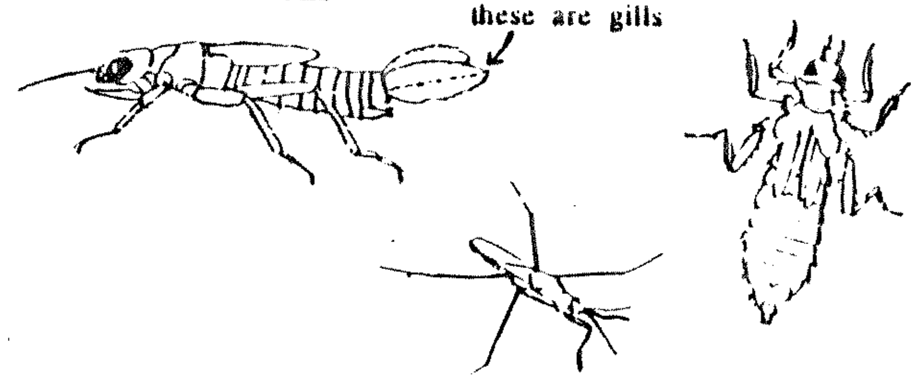
A KEY TO IMMATURE AQUATIC INSECTS

A — DOES ABDOMEN END IN 2 TAILS?

YES

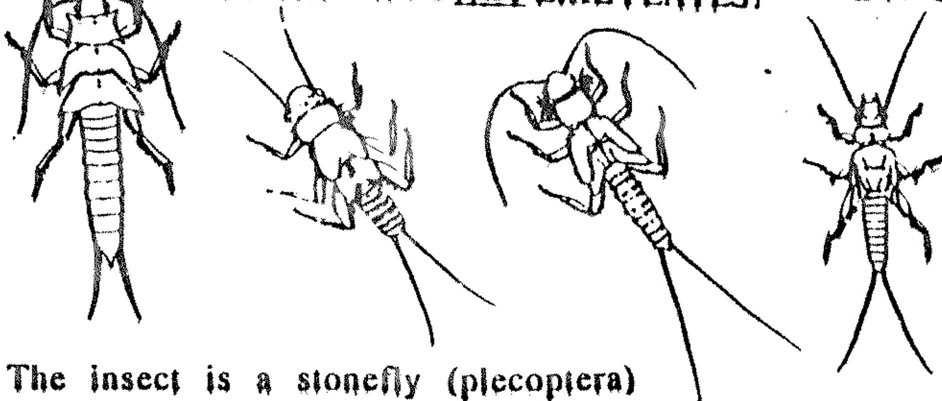


NO



Go to 2 C, below

B — ARE THERE TWO CLAWS AT END OF LEGS and ARE THE GILLS NOT LIKE PLATES?



The insect is a stonefly (plecoptera)

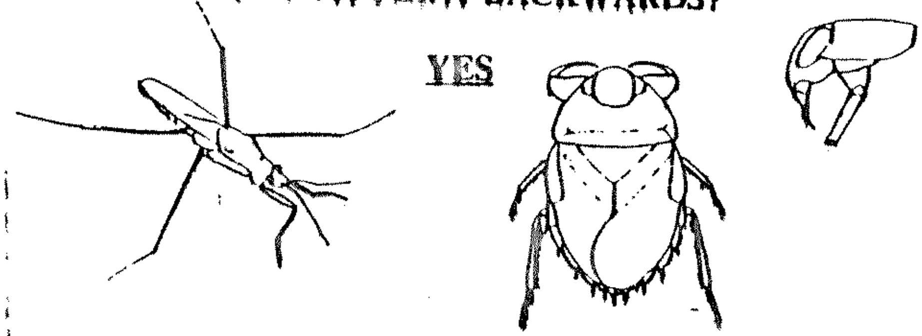
OR

IS THERE ONE CLAW AT THE END OF LEGS and ARE THERE PLATELIKE GILLS ON ABDOMEN?

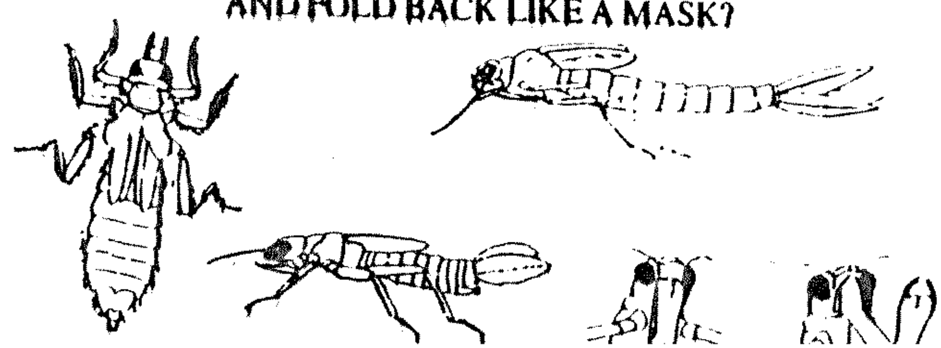
The insect is a mayfly (Ephemeroptera)

C — IS THE MOUTH SHAPED LIKE A BEAK AND DOES IT POINT BACKWARDS?

YES



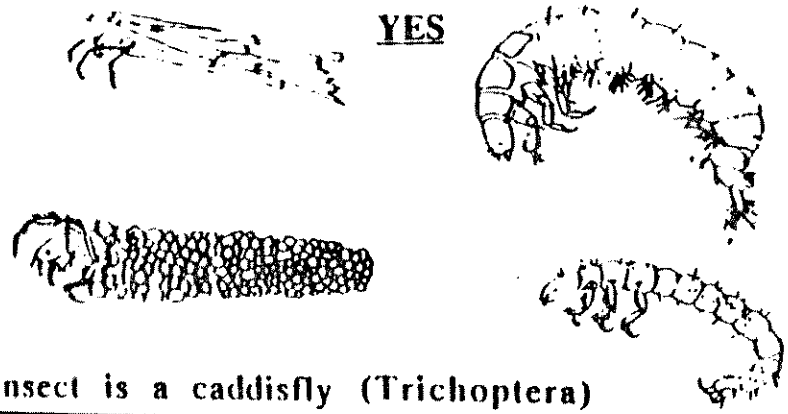
DOES THE MOUTH EXTEND OUT LIKE A SHOVEL AND FOLD BACK LIKE A MASK?



DOES ABDOMEN END IN PAIR OF CLAWS or IS INSECT INSIDE A CASE?

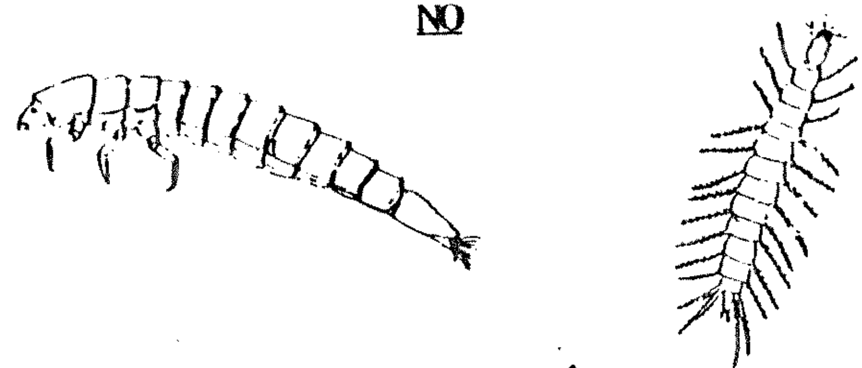
A

YES



The insect is a caddisfly (Trichoptera)

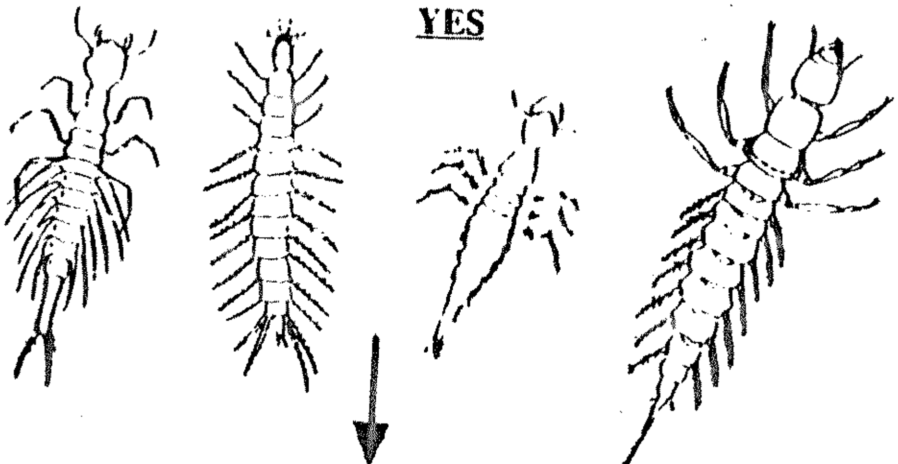
NO



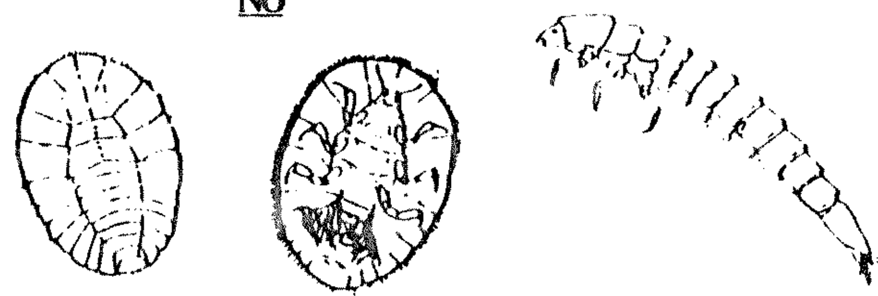
ARE THERE MANY FILAMENTS ON THE SIDES OF THE ABDOMEN?

B

YES



NO



water penny

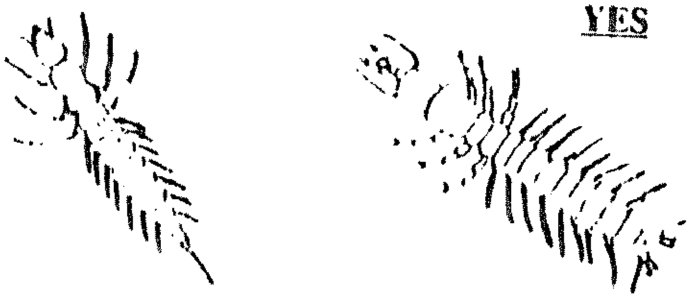
underside

The insect is a Coleoptera

DOES ABDOMEN END IN ONE LONG, SLENDER TAIL or IN A PAIR OF PROLEGS, EACH WITH A PAIR OF HOOKS?

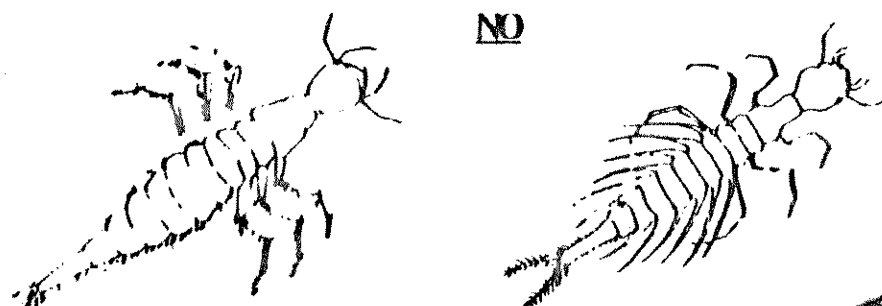
C

YES



The insect is a megaloptera

NO



The insect is a coleoptera

KEY TO FUNCTIONAL GROUPS
(for use in western Oregon by T.C. Dewberry)

1. Does animal have a shell or house?

Yes:

1. Snail (SCRAPER) 

2. Caddisflies 

A. If caddisfly has a stone or pebble case (SCRAPER)

B. If caddisfly has a leaf or twig case (SHREDDER)

C. If caddisfly spins a net-retreat (FILTER-GATHERER)

NO:

Go to #2

2. Does the animal have legs?

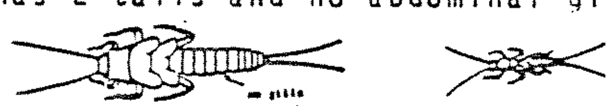
NO:

1) If it looks like this  it is a(SHREDDER).

2) If it looks like this  it is a(COLLECTOR-GATHERER).

3) If it looks like this  it is a (FILTERING-COLLECTOR)

Yes:

If the animal has 2 tails and no abdominal gills, it is a stonefly. 

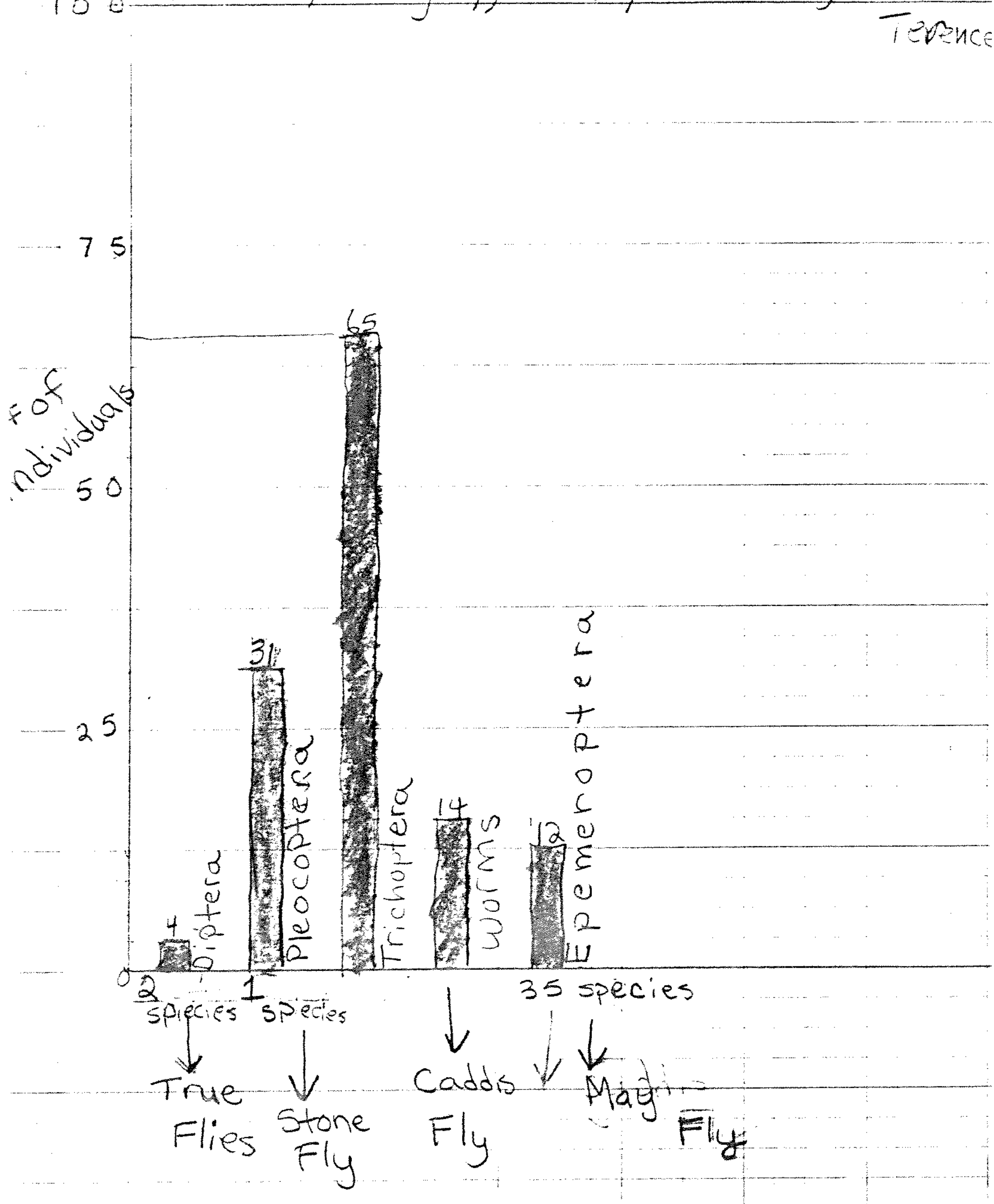
1) If the stonefly is brightly colored (especially has some yellow) and very active, it is a(PREDATOR).

2) If the stonefly is dull brown or black and sluggish, it is a(SHREDDER).

(Continue next page)

MacroInvertebrates In [illegible]
Creek, May 4, 1994

by Erica Terence



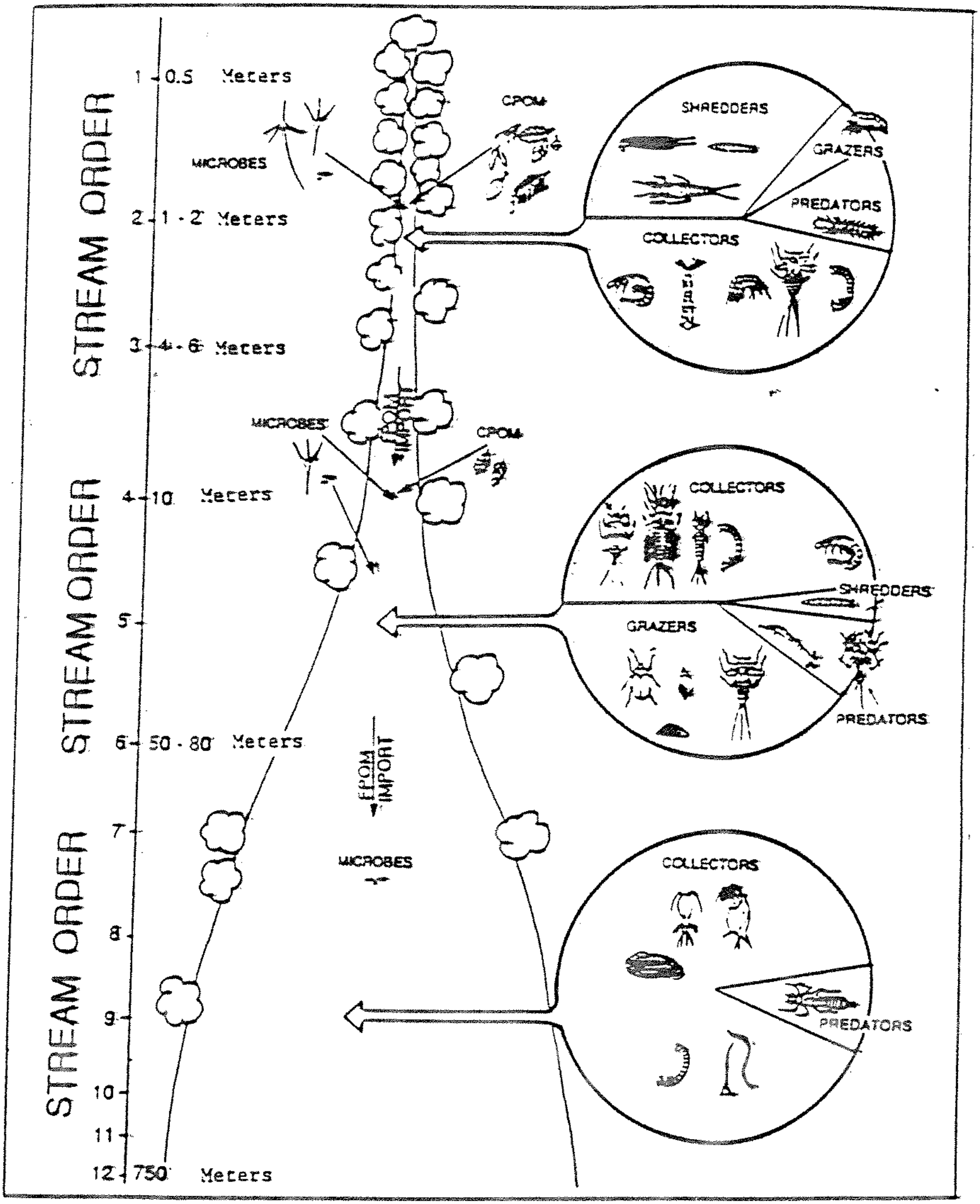
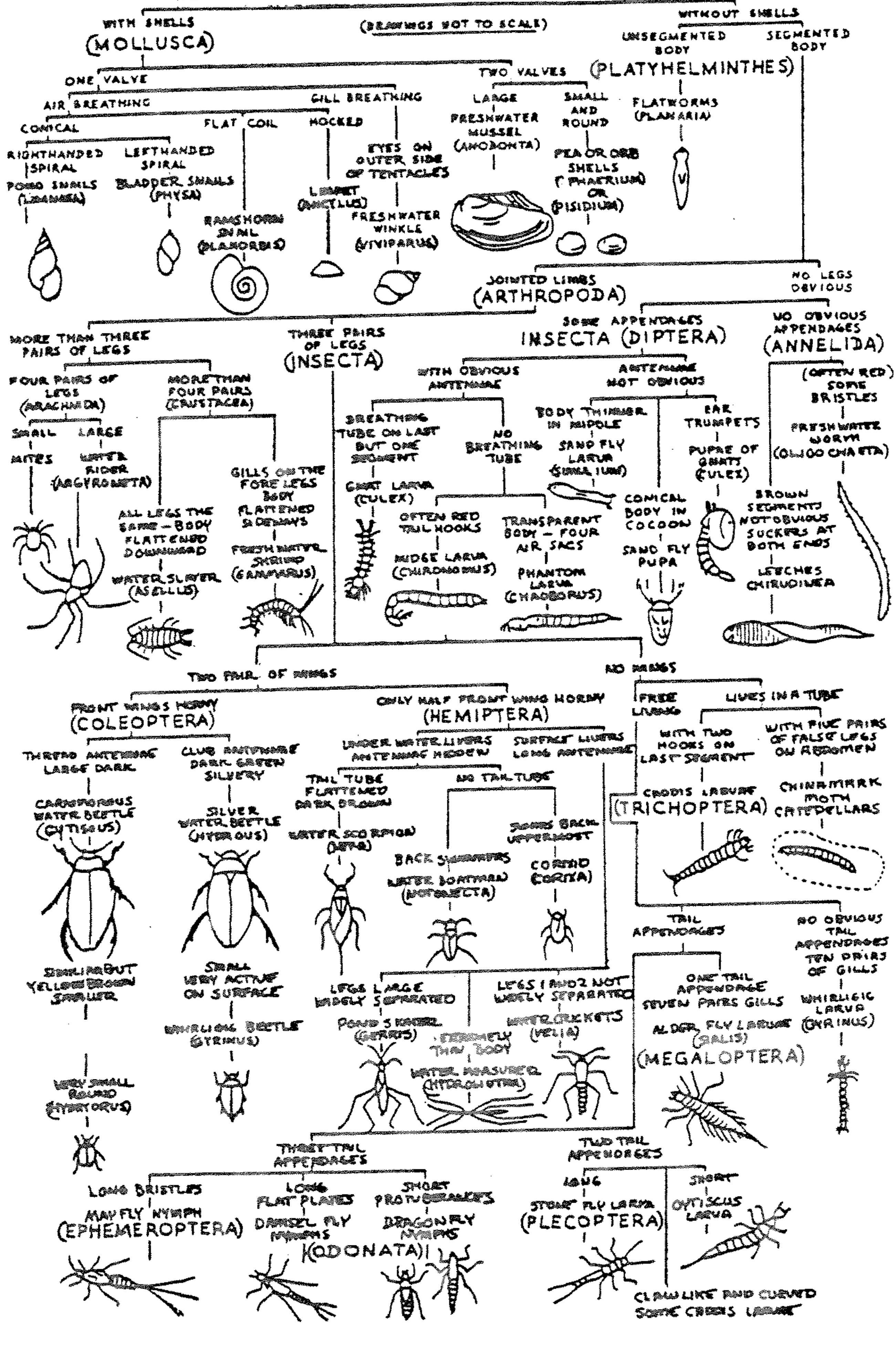


Figure 13. The River Continuum. (from Cummins, 1977, p. 306)

KEY TO THE COMMONER AQUATIC ANIMALS



Grant Ck. 10/18/94

Ephemeroptera
- Leptophlebiidae
  - Paraleptophlebia 29
- Baetidae
  - Baetis 1
- Siphlonuridae
  - Ameletus 2
- Heptageniidae
  - Ironodes 1
  - Cinygma 4
- Ephemerellidae
  - Ephemerella inermis 1

Plecoptera
- Chloroperlidae
  - Sweltsa 6
  - Kathroperla perdita 1
- Nemouridae
  - Zapada oregonensis gp. 1
- Leuctridae
  - Despaxia augusta 4
  - Moselia infuscata 3

Trichoptera
- Rhyacophilidae
  - Rhyacophila 5
- Polycentropodidae
  - Polycentropus 6
- Philopotamidae
  - Dolophilodes 1
- Calamoceratidae
  - Heteroplectron californicum 13

Coleoptera
- Elmidae
  - Lara 1
- Psephenidae
  - Eubrianax edwardsi 2
- Ptilodactylidae
  - Anchycteis velutina 1

Diptera
- Chironomidae
  - Orthocladiinae
  - Tanypodinae 7
  - Tanytarsini 3
- Ceratopogonidae 1
- Simuliidae
  - Simulium 2
- Dixidae
  - Dixa 4

Odonata
- Gomphidae
  - Octogomphus 2

Crustacea
- Isopoda
  - Asellidae 5

- Brillia 2
- Parametriocnemus 11
- Orthocladius/Cricotopus 11
- Tvetenia 1
- Corynoneura 4
- Thienemanniella 1
- Eukiefferiella 2

Sones Creek 10/18/94

Ephemeroptera

Baetidae

Baetis 28

Siphlonuridae

Ameletus 1

Heptageniidae

Ironodes 4

Rhithrogena 1

Ephemerellidae

Caudatella hystrix 2

Plecoptera

Perlidae

Hesperoperla pacifica 3

Perlodidae

Isoperla 1

Pteronarcyidae

Pteronarcys 1

Nemouridae

Malenka 1

Zapada columbiana 2

Z. oregonensis sp. 1

Peltoperlidae

Yoraperla 8

Capniidae

Paracapnia (?) 1

Trichoptera

Rhyacophilidae

Himalopsyche phryganea 1

Rhyacophila 8

Hydropsychidae

Arctopsyche 1

Philopotamidae

Dolophilodes 3

Wormaldia 1

Hydroptilidae

Hydroptila 4

Lepidostomatidae

Lepidostoma 4

Brachycentridae

Micrasema 2

Coleoptera

Elmidae

Ampumixis dispar 11

Heterlimnius 3

Psephenidae

Eubrianax edwardsi 1

Diptera

Chironomidae

Orthocladiinae

Tanytarsini 50

Simuliidae

Simulium 14

Dixidae

Dixa 1

Empididae

Chelifera 1

Tipulidae

Limonia 1

Odonata

Gomphidae

Octogomphus 1

	5	
Orthocladiinae		
Eukiefferiella	58	
		35
Tvetenia	17	
Orthocladiinae/Orthocladius	36	
		1
Brillia	5	
	5	
Parametriocnemus		
		4
Corynoneura	10	
		1
	3	
		1
		1
		1
		2
		1
		3
		1
		1
		1

Butter Creek X-18-94

Ephemeroptera
- Leptophlebiidae
  - Paraleptophlebia 4
- Baetidae
  - Baetis 11
- Siphlonuridae
  - Ameletus 4
- Heptageniidae
  - Ironodes 26
  - Rhithrogena 19
- Ephemerellidae
  - Ephemerella inermis 4
  - Drunella doddsi 1
  - Drunella spinifera 3

Plecoptera
- Perlidae
  - Calineuria californica 19
  - Hesperoperla pacifica 6
  - Doroneuria baumanni 2
- Chloroperlidae Sweltsa 2
  - Kathroperla perdita 2
- Pteronarcyidae
  - Pteronarcys 2
- Peltoperlidae
  - Soliperla 1
  - Sierraperla cora 1
  - Yoraperla 3
- Nemouridae
  - Malenka 9
- Perlodidae Chernokrilus 1
  - Isoperla 3
- Leuctridae
  - Moselia infuscata 2
- Capniidae 3

Trichoptera
- Rhyacophilidae
  - Rhyacophila 18
- Hydropsychidae
  - Parapsyche 5
  - Hydropsyche 9
- Glossosomatidae
  - Glossosoma 1
- Philopotamidae
  - Dolophilodes 1
- Lepidostomatidae
  - Lepidostoma 4
- Calamoceratidae
  - Heteroplectron californicum 1
- Brachycentridae
  - Micrasema 24

Coleoptera
- Elmidae
  - Ampumixis dispar 3
  - Narpus 2
  - Ordobrevia nubifera 8

Megaloptera
- Corydalidae
  - Orohermes crepusculus 2

Diptera
- Tipulidae
  - Dicranota 1
  - Hexatoma 1

Pelecorhynchidae

Glutops 1

Empididae

Chelifera 3

Dixidae

Dixa 2

Simuliidae

Simulium 12

Chironomidae Note: (*) Chironomid genera may be incorrect. This should not affect metrics.

Orthocladiinae

Brillia 24

Corynoneura 6

Thienemanniella 12

Symposiocladius lignicola 3

* Eukiefferiella 5

* Tvetenia 1

* Parametriocnemus 13

* Orthocladius/Cricotopus 17

Diamesinae 1

Tanypodinae 1

Tanytarsini 1

Sample Site (10/18/99)

Metrics

	Grant Ck. (138 total)	Somes Ck. (300 total)	Butler Ck. (300 total)
Species Richness	32	37	51
Modified Hilsenhoff Index	1.17	2.15	1.43
# scrapers / # filtering collectors	.89	.68	1.96
EPT / Chironomidae	1.86	.42	2.15
% Dominant taxa	21%	16.7%	8.7%
EPT index	78	80	181
# shredders / # individuals	.4	.08	.27
Simpson Diversity Index	.9258	.9029	.9589

Species indicative of "healthy" systems (top indicators):

Grant Ck. : <u>Anchycteis velotina</u>

Somes Ck. : <u>Himalopsyche phryganea</u>

<u>Ampumixis dispar</u>

Butler Ck : <u>Doroneuria baumanni</u>

<u>Isoperla</u>

<u>Sierraperla cora</u>

<u>Chernokrilus</u>

<u>Parapsyche</u>

<u>Ampumixis dispar</u>

CHIEF SEATTLE'S
STATEMENT ON ECOLOGY

[Editor's note: In 1854, President Franklin Pierce made an offer for a large area of Indian land and promised a "reservation" for the Indian People. This is Chief Seattle's reply, published here in full.]

How can you buy or sell the sky, the warmth of the land? The idea is strange to us.

If we do not own the freshness of the air, and the sparkle of the water, how can you buy them?

Every part of this earth is sacred to my people. Every shining pine needle, every sandy shore, every mist in the dark woods, every clearing and humming insect is holy in the memory and experience of my people. The sap which courses through the tree carries the memory of the red man.

The white man's dead forget the country of their birth when they go walk among the stars. Our dead never forget this beautiful earth, for it is the mother of the red man. We are part of the earth and it is part of us. The perfumed flowers are our sisters, the deed, the horse, the great eagle, these are our brothers. The rocky crests, the juices in the meadows, the body heat of the pony, and man all belong to the same family.

So when the great chief in Washington sends word that he wishes to buy our land, he asks much of us. The great chief sends word he will reserve us a place so we can live comfortably to ourselves. He will be our father and we will be his children. So we will consider your offer to buy our land. But it will not be easy. For this land is sacred to us.

This shining water that moves in the streams and rivers is not just water but the blood of our ancestors. If we sell you land, you must remember it is sacred, and you must teach your children that it is sacred and that each ghostly reflection in the clear water of the lakes tells of events and memories in the life of my people. The water's murmur is the voice of my father's father.

The rivers are our brothers, they quench our thirst. The rivers carry our canoes and feed our children. If we sell you our land, you must remember to teach your children that the rivers are our brothers, and yours, and you must henceforth give the rivers the kindness you would give any brother.

We know that the white man does not understand our ways. One portion of the land is the same to him as the next, for he is a stranger who comes in the night and takes from the land whatever he needs. The earth is not his brother, but his enemy, and when he has conquered it, he moves on. He leaves his fathers' graves behind, and he does not care. His fathers' graves and his children's birthright are forgotten. He treats his mother, the earth, and his brother, the sky, as things to be bought, plundered, sold, like sheep or bright beads. His appetite will devour the earth and leave behind only desert.

There is no quiet place in the white man's cities. No place to hear the unfurling of leaves in the spring, or the rustle of an insect's wings. But perhaps it is because I am a savage and do not understand. The clatter only seems to insult the ears. And what is there to like if man cannot hear the lonely cry of the whippoorwill or the arguments of the frogs around a pond at night? I am a red man and do not understand. The Indian prefers the soft sound of wind darting over the face of the pond, and the smell of the wind itself cleansed by a midday rain, or scented with pinyon pine.

The air is precious to the red man, for all things share the same breath - the beast, the man, they all share the same breath. The white man does not seem to notice the air he breathes. Like a man dying for many days, he is numb to the stench. But if we sell you our land, you must remember that the air is precious to us, that the air shares its spirit with all life it supports. The wind that gave our grandfather his first breath also receives his last sigh. And if we sell you our land, you must keep it apart and sacred as a place where even the white man can go to taste the wind that is sweetened by the meadow's flowers.

So we consider your offer to buy our land. If we decide to accept, I will make one condition: the white man must treat the beasts ofythis land as his brothers.

I am a savage and do not understand any other way. I have seen a thousand rotting buffalos on the prairie, left by the white man who shot them from a passing train. I am a savage and do not understand how the smoking iron horse can be more important than the buffalo that we kill only to stay alive.

What is man without the beasts? If all the beasts are gone, man would die from a great loneliness of spirit. For whatever happens to the beasts, soon happens to man. All things are connected.

You must teach your children that the ground beneath their feet is the ashes of our grandfathers. So that they will respect the land, tell your children that the earth is rich with the lives of our kin. Teach your children what we have taught our children - that the earth is our mother. Whatever befalls the earth soon befalls the sons of the earth. If men spit on the ground, they spit on themselves.

Whatever befalls the earth befalls the sons of the earth. Man did not weave the web of life; he is merely a strand of it. Whatever he does to the web, he does to himself.

Even the white man, whose God walks and talks with him as friend to friend, cannot be exempt from common destiny. We may be brothers after all. We shall see. One thing we know, which the white man may someday discover, our God is the same God. You may think that you own Him, as you wish to own our land, but you cannot. He is the God of man, and his compassion is equal for the red man and the white. This earth is precious to him, and to harm the earth is to heap contempt on its Creator. The whites, too shall pass, perhaps sooner than all other tribes. Contaminate your own bed and you will on night suffocate in your own waste.

But in perishing, you will shine brightly, fired by the strength of God, who brought you to this land and for some special purpose gave you dominion over this land and over the red man. That destiny is a mystery to us, for we do not understand when the buffalo are all slaughtered, the wild horses are tamed, the sacred corners of the forest heavy with the scent of many men, and the view of the hills blotted by talking wires. Where is the thicket? Gone. Where is the eagle? Gone. The end of living and the beginning of survival.

SALMONIDS

1. What kind of water do salmonids require?

2. Name the five species of Pacific salmon.

3. Describe the mating process for salmon.

4. What must the eggs have in order to survive in their redds?

5. How long is it before the eggs hatch?

6. Where does the salmon live during the alevin stage? Why?

7. What do the fry eat? Why do they eat at night?

8. What is natural selection? (p. 16)

9. Make a chart that shows the spawning time, time in fresh water before going to the sea, and time of return to fresh water for the spring-run Chinook, fall-run Chinook, coho, steelhead, and summer steelhead.

10. Why can hatchery fry be hazardous to the wild juveniles?

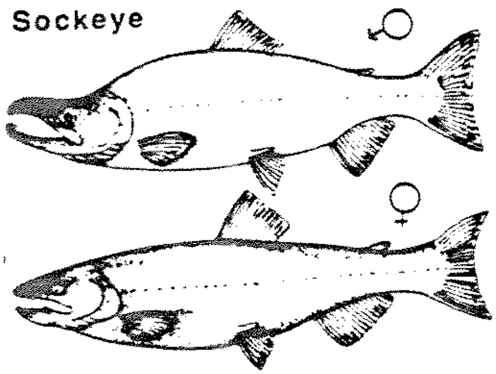
From: Adopting a Stream
Steve Yates

Fishes

Salmonids

Within the cold, clear streams whose headwaters arise among the glaciers and snow fields of western mountains and in smaller coastal streams, the dominant fishes belong to the salmonid family—comprised of salmon, trouts, chars, graylings, and whitefish.

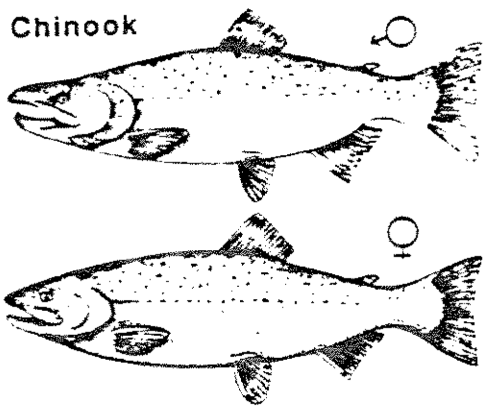
Sockeye



Throughout the Great Basin and the high inland valleys between the Cascades and the Rockies, the largest instream predators are adult rainbow and cutthroat trouts and Dolly Varden chars. Though these colorful resident fishes also inhabit Pacific coastal streams and the lower reaches of the Columbia River drainage (and are the only salmonids in coastal streams blocked by waterfalls or dams), their presence is overshadowed by their magnificent anadromous relatives—Pacific salmon and sea-run races of trouts and char.

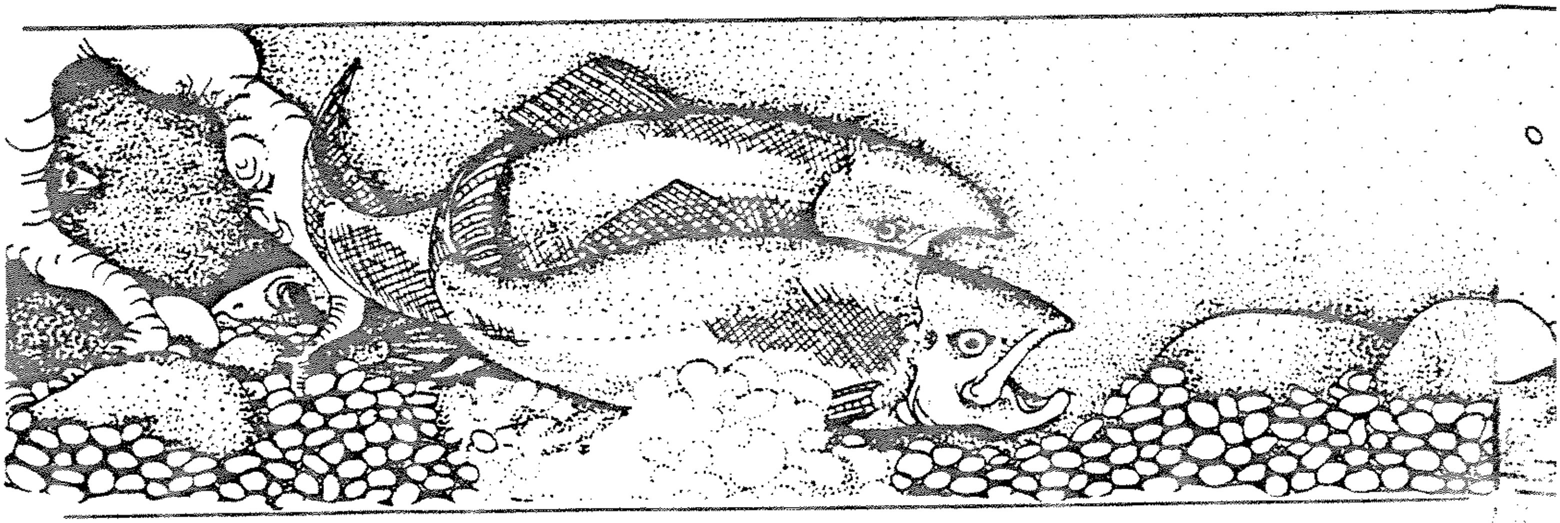
Salmonids are not only the dominant fishes, they are also sensitive indicators of stream health. They require cool, uncontaminated water that is high in dissolved oxygen and low in suspended sediments. Robust salmonid populations in our creeks are sure signs that we are living in harmony with our aquatic environment.

Chinook



Eight species of anadromous, or sea-run, salmonids spawn and rear in rivers and streams of the Pacific Northwest. Five are Pacific salmon, two are trout, and one is a char. The salmon (all in the genus *Oncorhynchus*) include chinook (kings; blackmouths); coho (silvers); sockeye (reds); chum (dogs); and pink (humpies). The two trout species with sea-run populations are rainbow (steelhead) and cutthroat--both in the genus *Salmo*. The char, Dolly Varden, is a close relative of the eastern brook trout (both are genus *Salvelinus*).

The hefty salmonid adults running up shallow rivers to spawn in tiny streams seem oversized and out of place, like human adults in a kindergarten playground. And, truly, they are out of place. They return from the huge and fertile sea with great fanfare, reproduce in our rivers and streams, and soon die (except for a small percentage of the trouts and char, which may spawn two or more years in succession). Most salmonids do not even feed once they enter fresh water. But during the crucial early stages of their



lives—as eggs and alevins (hatchlings) of all species, juveniles of some—they are dependent on rivers and streams.

When spawning, a female salmon or trout turns on her side and lashes her tail to lift streambed gravels into the current, thus creating a broad, shallow depression (redd). Within the redd she digs a deeper nest in which to deposit hundreds of round, pink eggs.

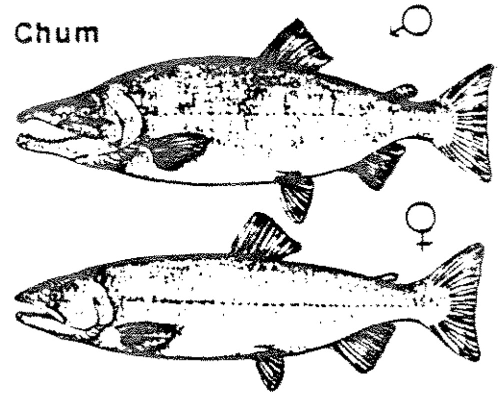
As the female lays her eggs, a successful male suitor swims over the nest alongside her. Vibrating furiously, he releases his cloudy, sperm-filled milt. Within seconds, a wriggling sperm penetrates the tiny hole (micropyle) in each of the eggs. The fertilized eggs are covered by the female as she moves slowly upstream, excavating the next in a series of nests within the redd. There the spawning process is repeated.

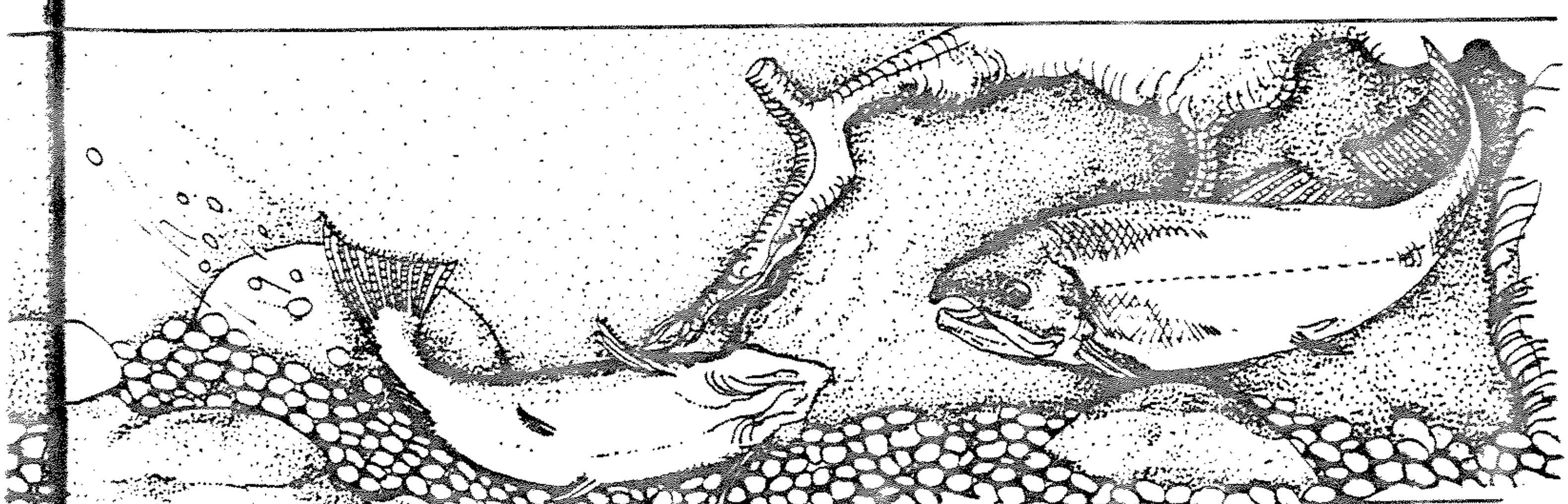
The spawning scene is often chaotic. While the pair are mating, other males may attempt to join in, and are driven off by the dominant male. Jacks—younger and much smaller, sexually precocious males—sometimes slide into the redd to add their milt. Some of the eggs are swept away by the current before they can be covered; these are snapped up by sculpin, resident trout, or the Dolly Varden char, which sometimes follows the salmon runs for this very reason. In heavily used spawning beds, later runs of spawners may uncover eggs laid by earlier runs.

The gravel-covered eggs develop as they overwinter in the streambed for one to four months (depending on species and water temperature). During this time they are dependent on intergravel currents to bring fresh oxygen and remove the waste products of metabolism. If sediments settle on the gravels and block the intergravel spaces, these currrents will cease, and the eggs will die.

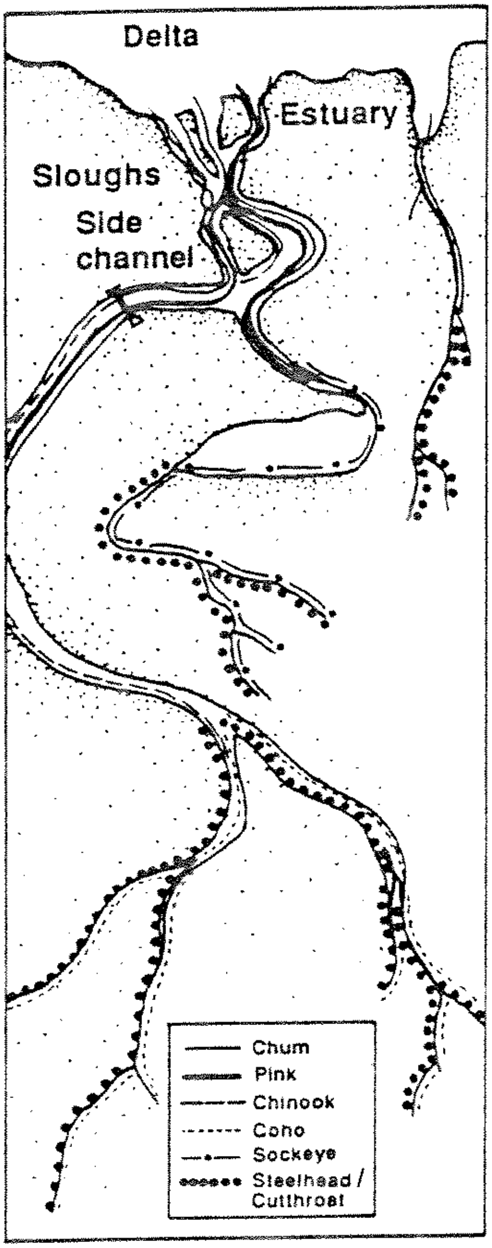
Long after the large embryonic eyes have become visible through the clear outer membrane of the soft egg, the tiny hatchling, called an alevin, pops out. Though it is no longer egg-bound, much of the egg's nutrients remain in the form of a yolk sac bulging from the alevin's abdomen. For a few more weeks or months it remains in the gravel, still feeding off the yolk sac and receiving much of its oxygen through the large veins that pulse in the sac membrane. Finally it emerges as a "fry" from the gravel and joins the active life of the stream.

Most of the food for the independent fry (and throughout its life in freshwater) comes from "drift," primarily in the form of aquatic insects. Even resident adult fishes which feed on smaller fish will obtain most of

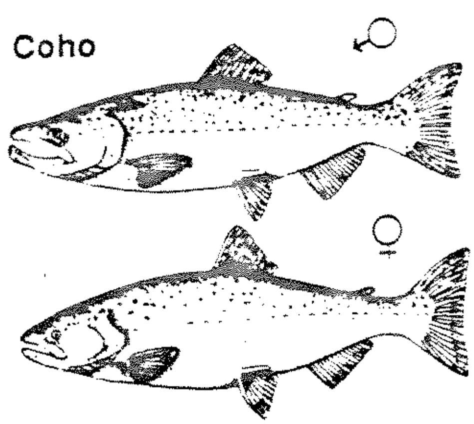




Spawning locations



Coho



their nutrients from insects. To avoid visual predators, such as sculpins and salmonids, aquatic insect larvae spend most of the daylight hours hidden under rocks or among the gravel. At night, however, they must come out to feed. Exposed to the current, they may be carried downstream as drift. Others will drift voluntarily to find better spots when insect populations outstrip the local food supply or if the stream section dries up in summer. All aquatic insects must move to the surface when they transform into flying adults. In the process, they become particularly vulnerable as they drift on or just under the surface.

Most insect species also remain within the stream corridor as adults. Some fall into the creek from overhanging streamside trees; others are caught by surface tension as they lay their eggs, and most fall into the stream as they die. And so, a good portion of the countless tiny insects eventually end up as fish food.

At each stage of their lives large numbers of fish are competing for limited spawning beds, shelter, and food. Such competition between members of the same species is a necessary driving force for the natural selection that adapts each run to the physical characteristics of its natal stream system. Wild steelhead that enter one river may have to leap many waterfalls; in another river, low autumn flows may favor a smaller, late-season spawner; in a third, minimal rearing habitat, or competition with coho salmon, may demand an especially aggressive fry.

Behavioral adaptations, however, have allowed salmonids to maximize their populations. They "partition" limited resources in the same way that different kinds of athletic teams share a gymnasium by using different facilities or by scheduling competing uses at different times (see Appendix A).

Partitioning in streams actually starts when the adult fishes first leave the sea to enter fresh water. Each population, or "run," of each species spawns at a somewhat different time, often in a different size or type of stream. Each species prefers a different size spawning gravel and a different velocity of water over the gravels.

Chinook, the largest salmon (averaging 15-25 pounds), tends to spawn in the main stems of rivers or larger tributaries. Leaping seemingly impassable barriers, kings often migrate hundreds of miles up major river systems. Spring-run populations with long migrations may enter freshwater as early as March-April in order to reach distant spawning grounds by September. Fall-run populations remain in the sea until September or October, spawning just a month or so later in mainstems of coastal rivers. Chinook prefer to spawn on large gravels in high-velocity water. The females lay about 5,000 eggs apiece in large, deep redds.

Coho salmon, the most adaptable of all the salmonids, are found in almost all stream systems. But they tend to spawn in smaller streams than do Chinook, or they choose the side channels and tributaries of larger rivers. Coho often spawn in small tributaries that flow only in winter months, underscoring the importance of even the most "insignificant" creeks. The red-sided, green-backed coho adults generally enter fresh water from September to November before spawning from mid-October to mid-December (some as late as February). They prefer medium-size spawning gravels and medium velocities.

Chum and pink salmon both spawn in coastal streams. Chum, the least energetic stream migrants, generally stay within a few miles of the sea. They frequently choose coastal sloughs and blind channels with very low flows; in these cases they find spots where upwelling groundwater will bring oxygen to the eggs. Pinks are willing to travel farther upstream and prefer slightly greater water velocities above their spawning beds than do chum.

Sockeye salmon, whose juveniles rear in lakes, spawn in streams that are inlets or outlets for lakes; some prefer the gravelly shores of the lake itself.

Steelhead trout spread their spawning migrations over a long period, entering streams in all months of the year. Summer steelhead runs, most of which travel far up the Columbia River system, spawn in spring or summer. These spawn from late winter almost into summer. Steelhead prefer the same size streams and similar spawning beds as coho salmon and Dolly Varden char. Winter runs are now dominant in coastal streams since logging of many coastal watersheds has reduced summer flows and raised stream temperatures.

Sea-run cutthroat trout rarely stray far from the estuaries at the mouths of their spawning streams. They tend to move upstream a little in advance of steelhead and spawn in streams that are smaller and of lower gradient than those preferred by the steelhead.

Newly-hatched salmonid alevins are independent of the stream food web while their yolk sacs are being absorbed. But as they emerge from the gravels, usually during spring, the fry begin to feed on their own. Now they (and their later "parr," or "fingerling," stages) must share a limited food supply. Here, an even more profound partitioning occurs.

Chum and pink salmon fry immediately migrate down stream, usually at night, to rear in coastal estuaries. Sockeye fry also leave the natal streams soon after hatching. They move into nearby lakes to feed on tiny creatures in the plankton for one to three years before migrating to the sea.

Fall-run Chinook hatch in mid-winter; the fry emerge from the gravel by March or April and remain in the river for two to four months, usually migrating out by June. Spring-run Chinook, however, spend an entire year or more in the rivers, migrating out May to July of the following year. Chinook spend crucial weeks or months in rivermouth estuaries while they adapt to salt water and grow rapidly on the rich diet provided within the productive marshes and seagrass meadows in the estuaries.

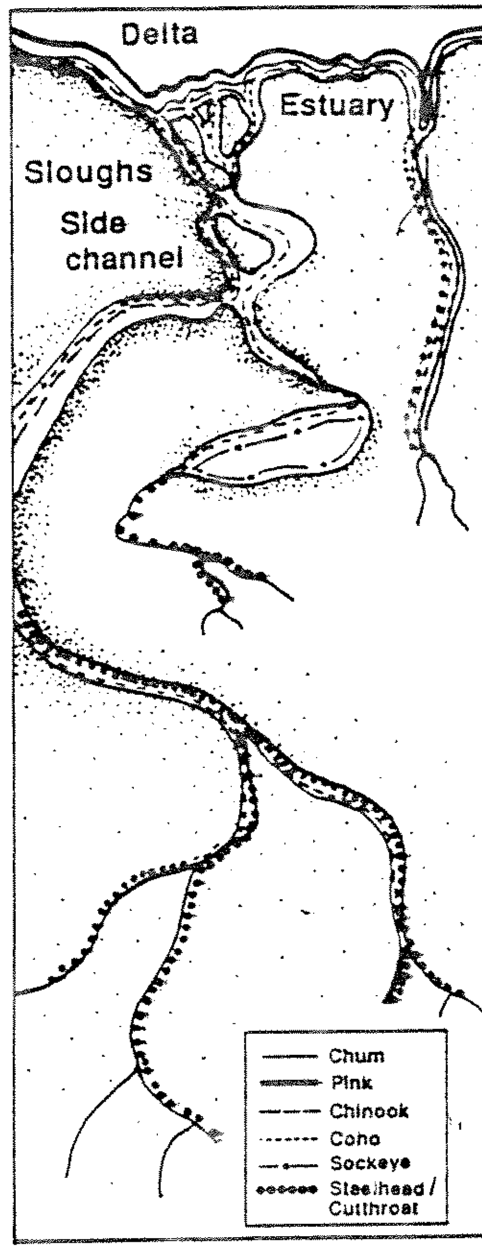
Coho fry emergence peaks in April and May, a month or so after the Chinook. They remain in fresh water as boldly-striped parrs for a full year or more before heading to the sea. (Salmonid out-migrants are called "smolts; the process of adapting to salt water is "smoltification").

Steelhead do not emerge until late spring or summer. Steelhead fingerlings remain in freshwater even longer than do coho or spring-run Chinook. They migrate out in late spring after two, or even three, years.

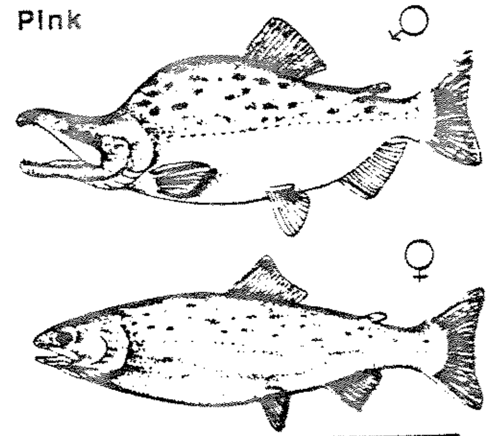
Sea-run cutthroat trout rear in small streams for about a year before heading down into larger streams for another two or more years, often utilizing side sloughs in the lower reaches. Dolly Vardens are found in pools or cool lakes throughout the stream system.

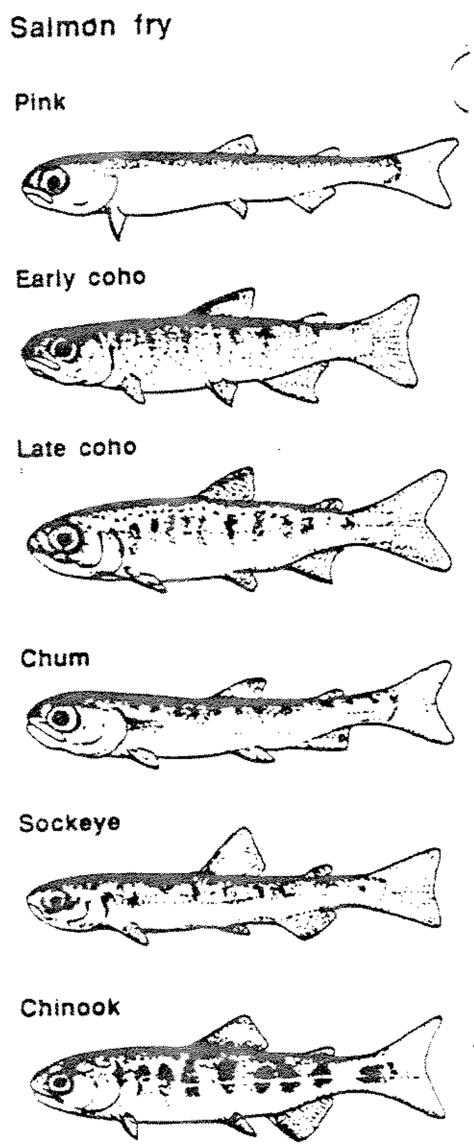
Even where there is competition between juveniles of those species that rear in the stream, a certain amount of partitioning takes place. Juvenile coho and steelhead juveniles rearing in the same small streams tend to use different areas of the creek. During spring and

Rearing locations



Pink





summer, when populations of both species are high and the fingerlings are actively feeding, juvenile coho are mostly found in back eddies or pools of moderate velocity. First-summer steelhead parr occupy the shallow riffles or the tail ends of pools. The larger, second-summer steelhead gravitate to the heads of pools, runs, and riffles, often with surface turbulence or white water above them for cover.

During winter both species avoid the near-freezing upland headwater streams by gravitating downstream to deeper, slower pools or the quiet water of side channels off the main stem. There, the coho form tight schools nearer the surface, while steelhead parr are most often found scattered near the bottom. Both are relatively inactive and spend much of their time near cover; but one study found that coho utilize overhanging brush and cut banks, while steelhead do not.

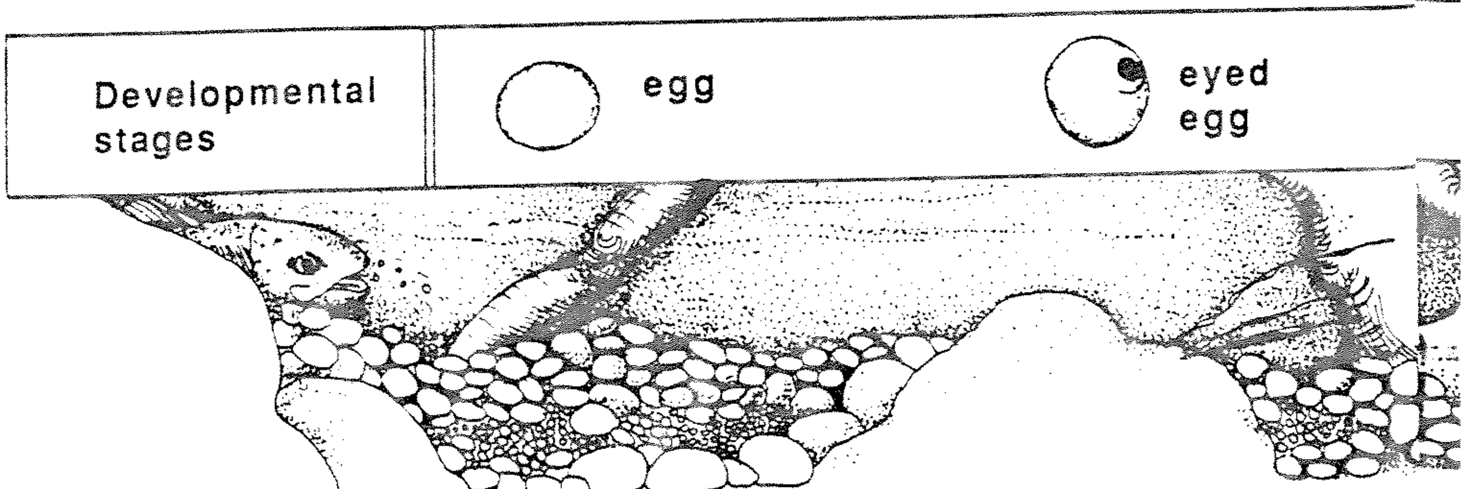
The habits of juvenile cutthroats and Dolly Varden are generally the same as steelhead, but cutthroats are usually found in streams of lower gradient. Chinook juveniles are similar to coho, but prefer larger streams or mainstem rivers. As they grow, Chinook fry move from the shelter of cut-banks and logs to areas of higher velocity, especially bouldery runs away from the banks.

Rainbow and cutthroat trout and Dolly Varden char have both resident and sea-run population, allowing these species to fully utilize the stream system, while at the same time a large portion of their members leave to feed in the ocean instead of competing for limited stream resources. All salmonids tend to move downstream to larger reaches or streams as they grow, further lessening the competition for food and shelter in the smaller creeks.

For many salmonid populations, availability of rearing habitat is the limiting factor. Any salmon or trout that remains in streams for more than a few days had better be able to find and defend a spot offering shelter from strong current and larger predators—or its life will be brief.

This fact may limit the success of hatchery plantings, unless the released juveniles are large enough to immediately emigrate to the sea. Hatchery fry tend to stay in tight, aggressive feeding schools. If they "residualize" (stay in the stream), they can displace wild juveniles from their rearing territories. They may then overwhelm the available food supply, causing both themselves and the wild juveniles to perish.

Introducing more eggs or fry into a creek, or even increasing spawning habitat (except for chum or pinks), may be of no use if critical



rearing habitat for the juveniles remains limited. Successful restoration or enhancement of fish populations usually means restoring or enhancing the availablility and complexity of the stream's rearing habitat.

Other Fishes

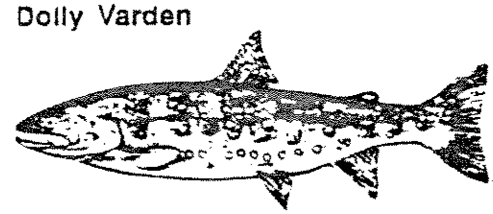
If we were to don face mask and snorkle to peer into a medium sized stream in summer, we might see schools of tiny rainbow trout in the riffles. In the still water behind a boulder rests a large adult resident cut-throat trout who has perhaps lived in this backwater its entire life. It feeds mainly on insects but is not above snapping up an unwary trout fry or even a frog. Rainbow juveniles snap at hapless insects drifting on the churning water above. A large Dolly Varden lurks in a deep pool nearby, feeding on bottom-dwelling insects and on any hapless small fish that wanders into its territory.

We will also find other types of fishes among the rocks. A number of species of sculpins may live in the stream. The small, three to six inch, slow-moving sculpins or "bullheads" are usually seen resting on the bottom, supported by their large fan-shaped pectoral fins. They are extremely variable in shape and color and species are often difficult to tell apart. All have rather large heads that taper toward the tail; most are drab yellowish or greenish brown, and mottled. Sculpin juveniles school in pools and lakes, joining the sockeye salmon to feed on plankton. The adults feed mainly on aquatic insects but also on salmonid eggs and fry. Their young are taken in turn by cutthroat and rainbow trout, coho salmon, and Dolly Varden.

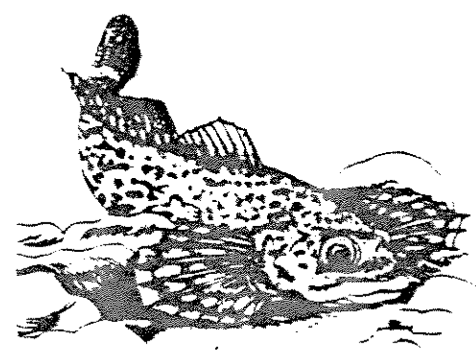
Though their habits and diets are fairly similar, sculpins differ in their preference for current speeds and their tolerance of high summer temperatures. Shorthead and torrent sculpins prefer fast riffles of coastal streams throughout the Northwest; the riffle sculpin prefers slower riffles. The coastrange sculpin is found mostly west of the Cascade Mountains, in larger streams, as is the prickly sculpin, which prefers pools. The reticulate sculpin, closely related to the riffle sculpin, can penetrate a foot or so down into bottom gravels to hide, to avoid drought, and perhaps to feast on salmon eggs.

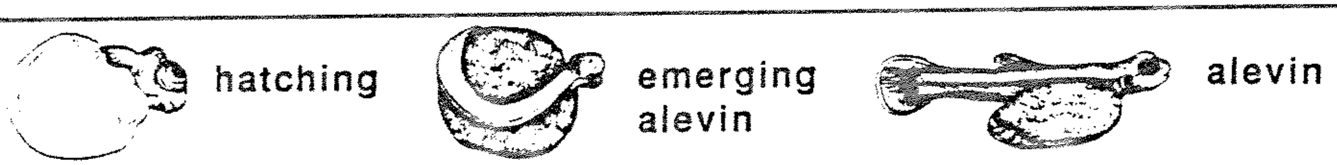
The Paiute sculpin tolerates high temperatures and prefers low-gradient riffles in eastern Washington and Oregon. The mottled sculpin, called the "miller's thumb" in the eastern U.S., is a wide-ranging species found mainly east of the Cascades. The Pacific staghorn sculpin,

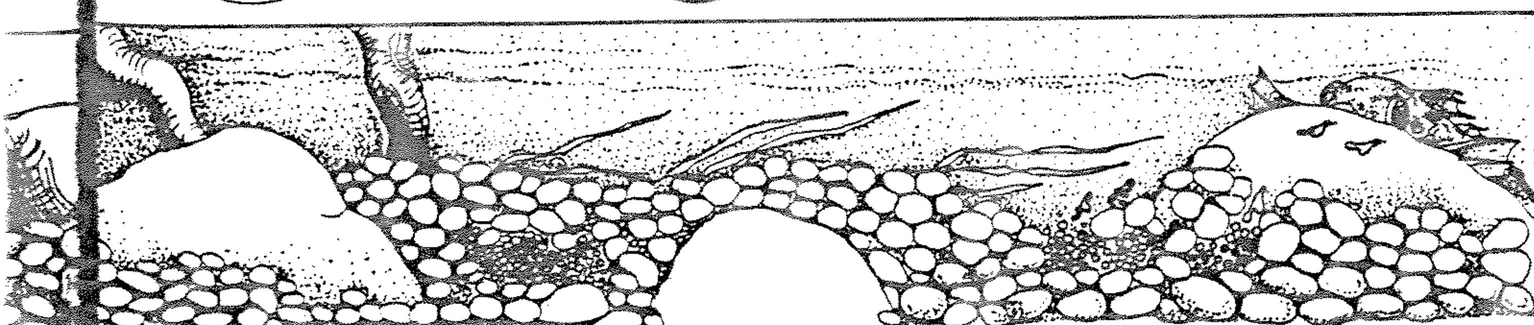
Dolly Varden



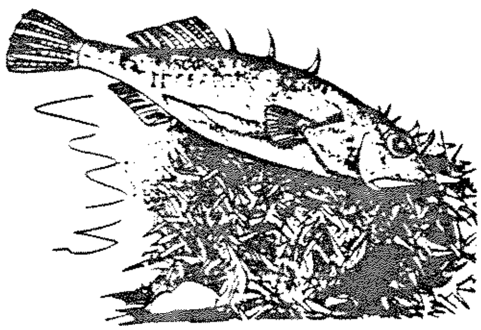
Torrent sculpin



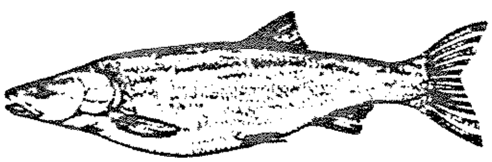




Threespine stickleback



Northern squawfish

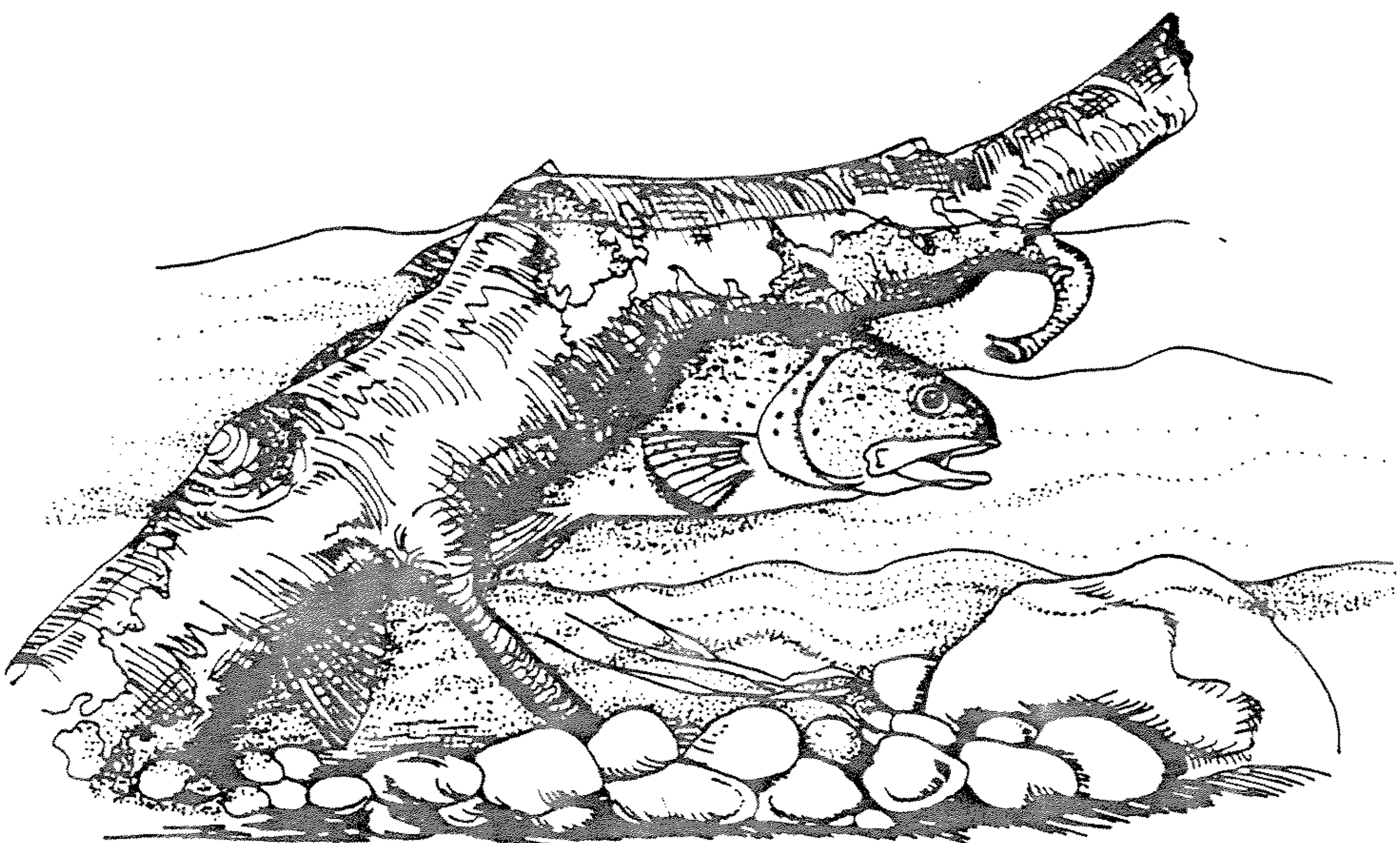


primarily a saltwater species, is also seen in brackish sloughs and far up the mouths of coastal streams. Just about wherever you look, there will be a sculpin of some sort.

Another widespread small fish—the threespine stickleback—is rare in fast-moving streams but can be found almost anywhere else, freshwater or salt, especially among aquatic vegetation—it may in fact be the world's most widely distributed fish species. The stickleback can be easily recognized by the dorsal fin, which has been reduced to two stout, well-separated spines and a third, smaller one just before the soft-rayed dorsal fin. Sticklebacks usually school, but males are highly territorial during breeding season—elaborate nest-building, courtship, and brooding behaviors make them a favorite subject for animal behaviorists.

The northern squawfish is a large minnow which can reach a length of two feet. Juveniles feed on aquatic insects; the long-lived adults prey on sculpins, juvenile salmon, and many other lake fishes. The squawfish inhabits lakes, but is also found in slow-moving coastal streams and Columbia River tributaries.

Three smaller species of minnow are also common to Pacific Northwest streams. The longnose dace (to five inches) can be told by its long, overhanging snout, slender body and rounded, forked tail. It is found in riffles among bottom stones in summer but moves to deeper pools in winter. Male speckled dace develop deep orange or red around the mouth and bases of fins as they court females in the riffles. The plumper redside shiner, told by the bright red splotch above the base of its pectoral fins, prefers lakes but can also be found in streams and irrigation ditches. All three small minnow species may compete with juvenile salmonids for food.

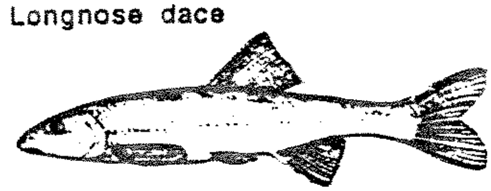


but they and their juveniles also serve as food for trouts.

Lampreys are strange-looking fish that superficially resemble eels; but they lack jaws and are actually a much more primitive type. Juvenile lampreys (called "ammocoetes") filter algae and detritus through vacuum-cleanerlike mouths. Ammocoetes of three species can be found burrowing in the silt along the edges or backwaters of the stream.

The western brook lamprey grows to about six inches. It remains in coastal streams its entire life. As a juvenile, it forms dense aggregations within the mud along the stream's edge, later moving to the riffles to spawn. The river lamprey and Pacific lamprey, on the other hand, migrate to sea after about five years in the stream. There, both become parasitic, attaching to fishes and whales by means of a round mouth surrounded by many tiny, sharp teeth. The adults (the river lamprey to one foot long, the Pacific species more than twice that size) return in early summer to spawn in stream riffles.

Longnose dace



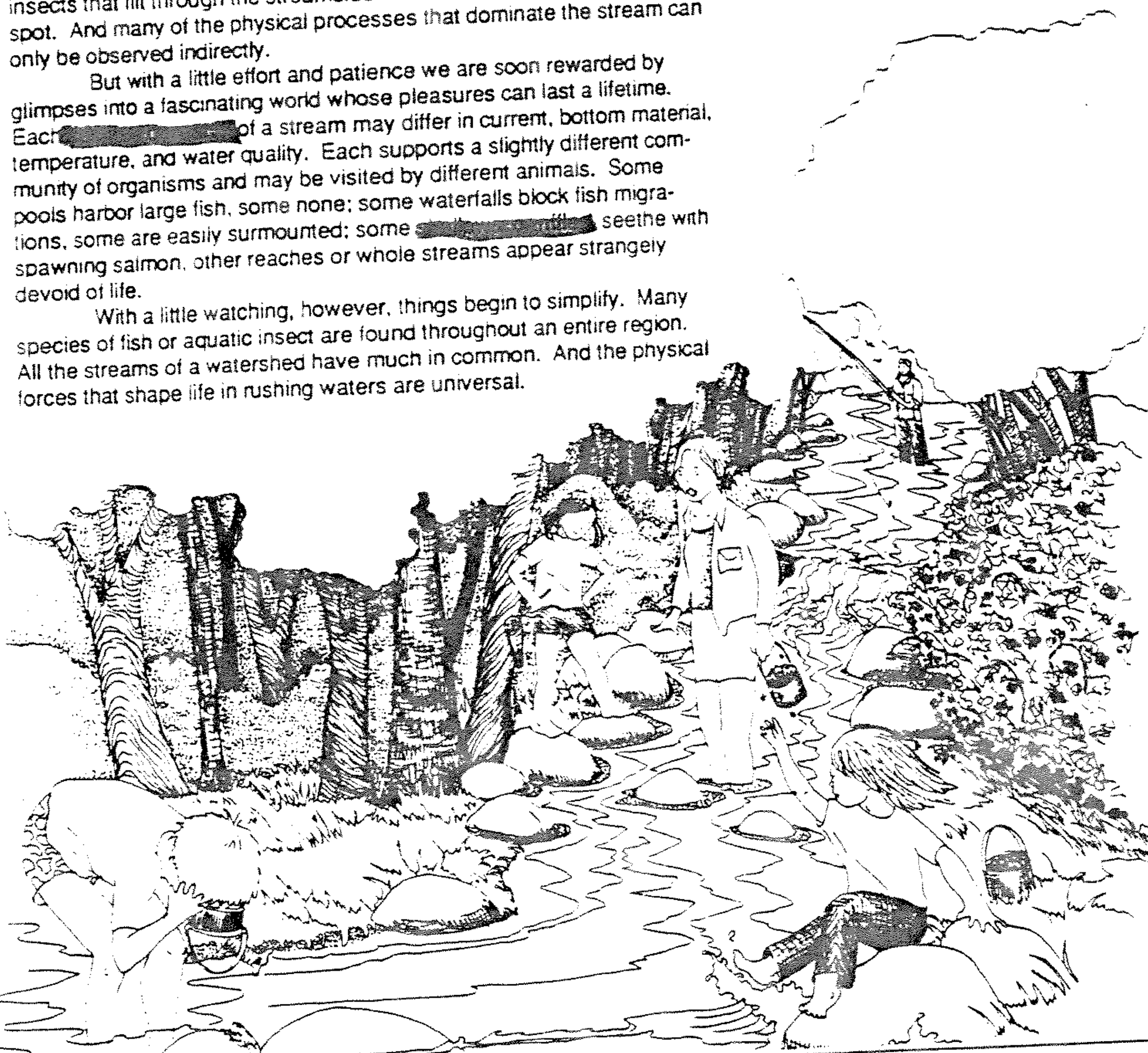
from Adopting a Stream: A Northwest Handbook
by Steve Yates

The Secret Life of A Stream

A stream and the vegetation bordering it form one of the richest and most fascinating of wildlife habitats. But much of what goes on in and around a stream is hidden from casual view. Fish stay out of sight under cutbanks or behind snags to hide from predators or prey; their eggs develop within the bottom gravels. Aquatic insects, so important as food for fish, are usually tiny and often live under rocks, away from the current and the hungry fishes. Mammals that come to the stream to drink or forage are secretive and often arrive at night. Most of the birds and insects that flit through the streamside trees and bushes are difficult to spot. And many of the physical processes that dominate the stream can only be observed indirectly.

But with a little effort and patience we are soon rewarded by glimpses into a fascinating world whose pleasures can last a lifetime. Each [redacted] of a stream may differ in current, bottom material, temperature, and water quality. Each supports a slightly different community of organisms and may be visited by different animals. Some pools harbor large fish, some none; some waterfalls block fish migrations, some are easily surmounted; some [redacted] seethe with spawning salmon, other reaches or whole streams appear strangely devoid of life.

With a little watching, however, things begin to simplify. Many species of fish or aquatic insect are found throughout an entire region. All the streams of a watershed have much in common. And the physical forces that shape life in rushing waters are universal.



The Physical Environment

[redacted]

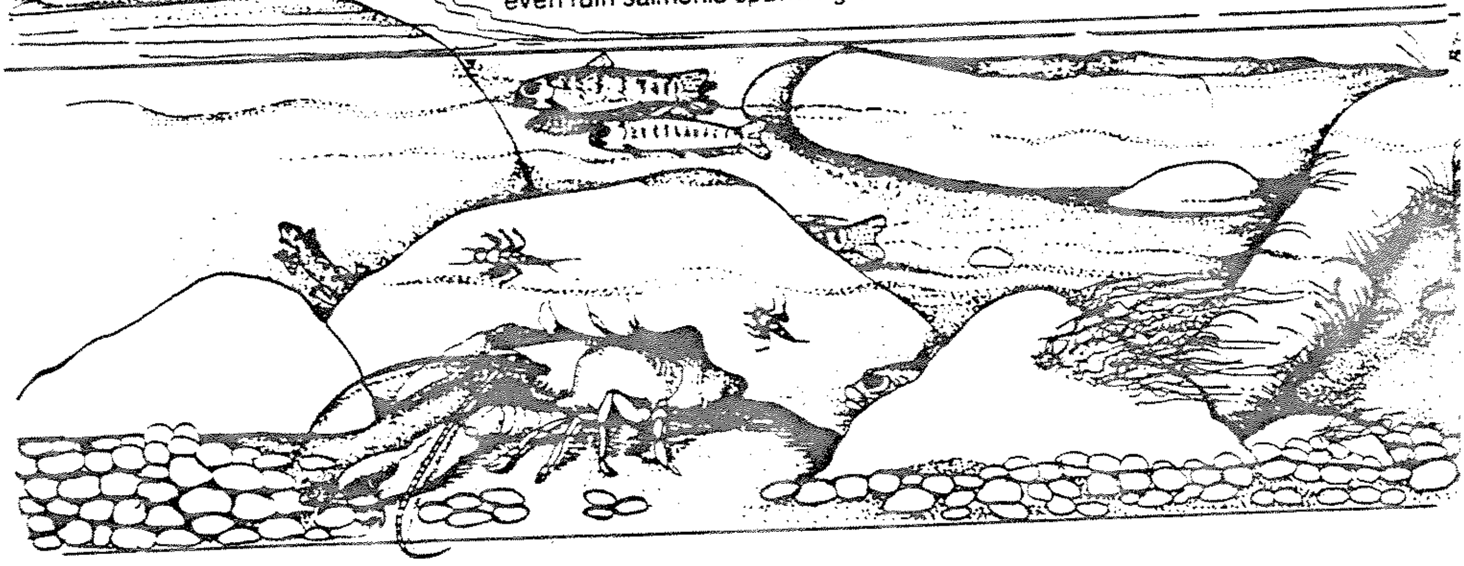
The first things we notice when approaching a creek are the clarity and color of the water. Most streams run perfectly clear; others run milky white, dirty brown, or rusty red.

The color of a stream's water gives clues to its origins. Rainwater, groundwater, or snowmelt run clear unless the stream's banks are eroding. Glacial meltwater, on the other hand, appears milky gray from "glacial flour," the tiny suspended particles of rock crushed by the grinding force of moving glaciers. Reddish waters may be stained by tannins in conifer needles (the same chemicals that give tea its color). Brown water might be a sign of a mudslide in the mountain headwaters, but it could also indicate local erosion. Greenish water may represent blooms of algae nourished by excess fertilizers from farms, lawns, or golf courses. "Suds" might point to detergents or to septic tank failures. An iridescent sheen on the water may have been released from rotting leaves; it might also point to waste oil or oil-based pesticides leaked or dumped upstream, or storm runoff from the oily layer that builds on roads, driveways, and parking lots .

Non-glacial creeks in the Pacific Northwest should run as clear as drinking water. In fact, surface streams still feed the reservoirs which serve, with minimal purification, as sources of drinking water for such large cities as Seattle and Portland.

Wa[redacted] Fishes need clear water for sighting prey; they must also defend and move around their territories by sight. Filamentous algae (which form one of the bases of the aquatic food web) and mosses (which form productive habitats for aquatic insects) both need sunlight for photosynthesis, and this light must first pass through the water.

Turbidity--cloudiness-- may be caused by algae or by organic acids, which stain the water a dark brown. But it usually indicates suspended sediments—fine soil particles, held in suspension by the turbulence of the current--which scatter light passing through the water. Excess sediments not only reduce water clarity, they can also harm the gills of fish and aquatic insects or even ruin salmonid spawning beds. The eggs of salmon and trout, buried in



streambed gravels, must remain for one to four months in silt-free water if they are to successfully hatch into alevins; and the tiny alevins need silt-free gravels for further weeks or months.

Temperature

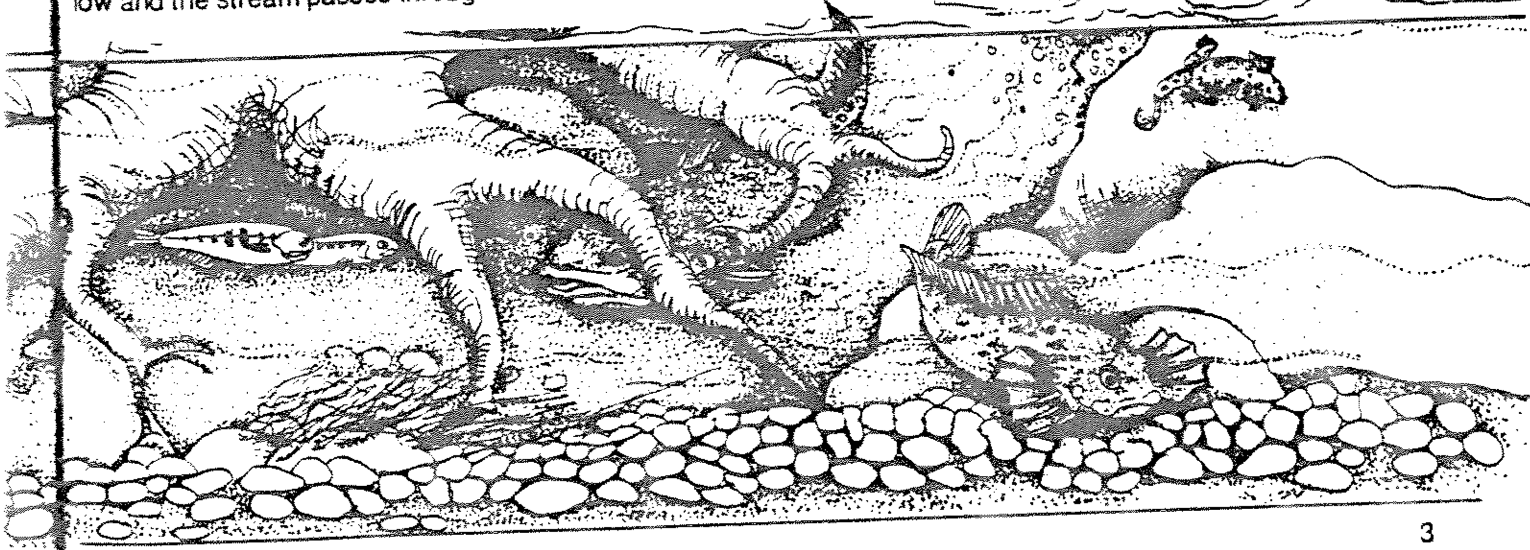
Wading into the creek, the next thing we are sure to notice is the temperature of the water, especially if it's a glacier-fed stream. Water temperature determines what organisms can live in that stream reach. It also gives important clues to the stream's origins.

Meltwater from glaciers or snowpack is at or near freezing point when it starts downstream; but if retained in shallow lakes or reservoirs, it may heat up to the temperature of bathwater. Water in shaded streams may be many degrees cooler than the air above it, yet heat up (10°F or more) when passing through exposed pasture or clearcut forest. The warmed water may be suddenly re-cooled downstream by colder tributaries, groundwater seeps, or springs.

Temperature in flowing water is deceptive. In still water, our body heat warms the layer of water next to our hand, but in a stream the warmed layer is immediately swept away and replaced by unwarmed water; and so the creek may seem cooler than still water of similar temperature.

Plants and animals that live in the creek are completely surrounded by water, and so their "climate" depends on water temperature rather than air temperature. In fact, since fish and aquatic insects are "cold-blooded," they *become* the temperature of the water. Their metabolism, growth rate, and all internal chemical reactions are regulated by the water temperature.

A creek's creatures have, over thousands of generations, adapted to its seasonal variations. But they may not be able to tolerate extreme or unexpected changes. If the water gets too cold, respiration and growth will slow down and reproduction may not be possible. If the water heats up too much—as it may in summer when water levels are low and the stream passes through unshaded areas—fish and insect



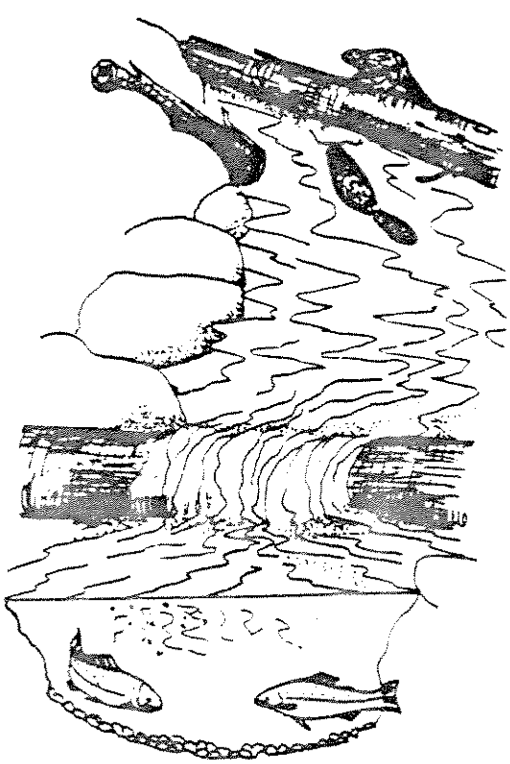
respiration will be speeded up (demanding more oxygen) at the same time that the dissolved oxygen is decreasing. Warm water holds much less oxygen than cold water. Algae may bloom in great quantity, further depleting the oxygen supply as they decay. Disease pathogens may also bloom in warm water, infecting the fishes. What may seem cold and inhospitable to us may be just right for a rainbow trout or mayfly nymph.

Current and Flow

The next obvious characteristic of the stream is its current—especially if it is swift. The force of the current makes it difficult to keep our balance in the stream, even if the water is fairly shallow. At depths above the knees, a strong current can make wading dangerous—not only because of the force against our legs (and the slippery algal scum covering the smooth rocks) but because the rocks or gravel under our feet may also be slipping and moving in the current.

Current is determined in part by the gradient, or slope, of the stream. Mountainous headwaters have swift currents because they drop quickly over a short reach. Streams of gentler gradient, when squeezed between narrow banks or when flowing over shallow riffles and runs, may move even more swiftly than in steeper streams. Large streams usually have relatively smoother beds than small, rocky headwater streams and so there is less friction to slow the current. Given equal gradient, the larger the stream, the stronger the current.

Current also varies with the flow, which is the amount of water carried by the stream channel at any given time. West of the Cascade Mountains, most creeks rise with winter rains and may flood with winter or spring snowmelts. Water levels fall during summer, and, especially if dry conditions extend into autumn, the creek may even dry up. Stream levels in interior regions, on the other hand, may fall during winter freeze-up, rise with spring snow-melt, and occasionally flood from summer thunderstorms.



Streams that are fed by rainfall in winter and glacial melt in summer have fairly even flows throughout the year. Other creeks will vary greatly between seasons. But all streams occasionally fill or overflow their banks, and some do so with regularity. Many streams that once were stable now flood more quickly and more often as their watersheds are logged or cleared for development. Paved surfaces replace natural areas, allowing all the rainwater to reach the creeks without delay.

Since high flows involve greater than normal volumes of water moving at greater than normal velocities, flood flows are many times more powerful than normal flows. The erosive impacts of a single flood event on the stream channel—and on any structure in the stream—often exceed the effects of months, or even years, of normal flows.

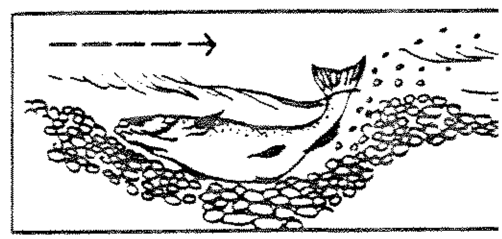
Since large stream channels are sculpted by the occasional high flow, the stream often appears too small for its bed for most of the year—until heavy rains or heavy snowmelt release more water than the watershed's soils and stream channels can handle. These flood events, or "freshets," can be as damaging to the instream animals as they are to man-made bridges and fish hatcheries—washing out fish fry and churning the streambed, killing fish eggs and stream insects. It may take months to recolonize the stream reach.

During normal flow regimes, currents are controlled by instream structures, both natural and man-made. Large boulders, fallen trees, and beaver dams are examples of natural current checks. On a larger scale, hydroelectric, irrigation, and flood-control dams also check the current. Bridges often squeeze the flow between pilings, slowing the water upstream but increasing the current in the vicinity of the bridge (and often eventually undermining the bridge pilings).

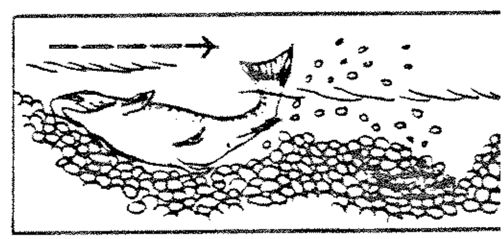
In a natural stream system, trees that fall from old age, beaver activity, or bank erosion are constantly "recruited" into the stream. Fallen trees are necessary and valuable additions to the stream system. They form natural check-dams that slow the current above, holding sediments and spawning gravels in place, and they create plunge pools below. They add stability to the streambed and, as they slowly decay, add nutrients to the stream. Too many trees from logging slash or slumping banks, however, can form logjams that may be barriers to fish migration. Logjams also can accelerate bank erosion, and can even change the course of the stream.

Current is a force with which stream creatures must always contend, either by fighting it, avoiding it, or using it to advantage. When salmon migrate upstream, they must fight the current, yet when the female excavates a nest (called a redd) she turns sideways and whips her tail—as she lifts her tail, negative pressure lifts gravels up into the current where they are swept away. After laying her eggs, she uses the same method to cover them with gravels.

Building the redd



Covering eggs



Juvenile salmon and adult resident trout avoid strong currents by resting behind large rocks and snags. They make use of the current by waiting for insects to drift downstream. They bury their eggs in the bottom gravels to avoid their being washed away by the main current; but the same eggs depend on intergravel micro-currents to bring fresh dissolved oxygen and to carry away waste products.

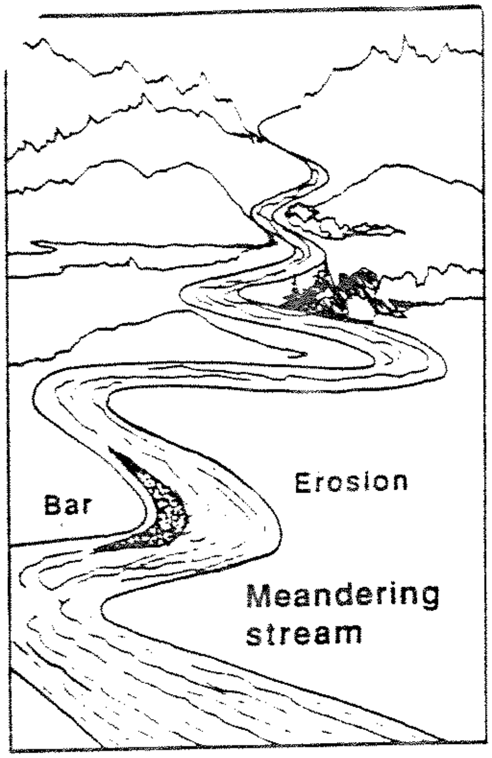
Inspect the streambed stones where the current is strong and you will find aquatic insects adapted to avoid the force of the water. Larval mayflies and stoneflies are often flattened in shape and usually live under rocks or in the thin layer of water near the rock surface, where friction slows the current to almost nothing. Some caddisfly larvae, which are not flattened, build slender tubes and pupal cases of pebbles to weight themselves down. Other caddisfly species and gnat, midge, and blackfly larvae attach themselves directly to the rocks with threads or hooked appendages.

Unlike fishes, which are much stronger, insects cannot fight heavy currents. To compensate for the inevitable downstream movement of the larvae caused by the current, the short-lived adults fly back upstream to deposit their eggs.

Stream Forms

An obvious characteristic of streams (bemoaned by roadbuilders and flood-control engineers) is that they are rarely straight. Bends may be caused by detours around hard, erosion-resistant rock, but the most sinuous streams are usually those on the flattest ground and in the most erodable floodplain soils, implying that this tendency to curve is a trait inherent to all flowing water.

The momentum of moving water and the erosive "work" it performs cause streams and rivers to assume characteristic shapes. Where restrained by hard, resistant rock, streams run relatively straight, using their erosive energy to cut downward into the rock. Streams



flowing through soil, however, tend to create S-shaped curves called meanders.

Centrifugal force throws the main current toward the outside of the meander curve. Gravel and sand cut from the bank at the outside of the curve are deposited downstream on the inside of a curve, where the current is weaker. The bar thus formed on the inside pushes the water farther to the outside of the curve, causing more erosion and deepening of the outside channel. Long, curved pools are created along the outer bends.

Gravel from the inner bar is gradually moved downstream and spread out to become a shallow riffle in the straighter sections between the bends. At higher streamflows, the riffles tend to become long, smooth, fast-moving runs.

Over time, the stream assumes a characteristic sinuous shape, with bends five to seven stream widths apart and with a stable "pool to riffle" ratio. When the bends become too sharp, flood flows cut them off, creating abandoned meanders called "oxbows."

Other streams and rivers—especially ones with greatly fluctuating flows that are cutting through floodplains—assume a "braided" form. A large river often becomes braided as it wanders over the flat lowlands near its mouth. A braided stream, however, usually remains within its oversized channel. The flow of a braided stream is much smaller than the size of the streambed would indicate—except when the stream is at flood stage. The stream meanders inside its wide channel, separating into many branches, which merge and part again. Between floods, vegetation stabilizes some of the interchannel islands. After flood events rework the unstable gravel bed, the stream assumes new patterns.

Two variations on this theme are important to fishes. Along many low-gradient river sections there are side channels—remnants of former channels or flood channels cut by high flows. During low stream flows, these side channels may be weed-choked or filled with stagnant water, or be fed by groundwater infiltration or leakage from the main channel. But during high winter and spring flows they fill with relatively slow-moving water, providing critical refuge for fry and fingerlings of stream-rearing salmon and trout. Gravelly side channels with moderate currents are also used by spawning chum and coho salmon.

As rivers meander through their deltas and associated wetlands, the lower reaches and abandoned channels form a network of slow-moving, vegetated sloughs. During high tides, salt water moves upstream through the sloughs, creating complex, low-energy, high-nutrient estuarine systems ideal for juvenile salmon and many other aquatic creatures. Here, salmon smolts can feed and adjust to salt water in an environment that is full of tiny crustaceans and relatively free from predators. Sloughs fed by upwelling groundwater are also used as spawning beds by chum salmon.

Unfortunately, the value of these sloughs and side channels, like other shallow estuarine wetlands, has been understood only recently. Since sloughs and side channels do not have the aesthetic appeal of tumbling streams, and since they often cut through valuable farmland or land being rapidly urbanized, it will take special effort to preserve these critical rearing and spawning areas. Sloughs and side channels make ideal sites for stream enhancement projects.

From: California Creeks
Junge

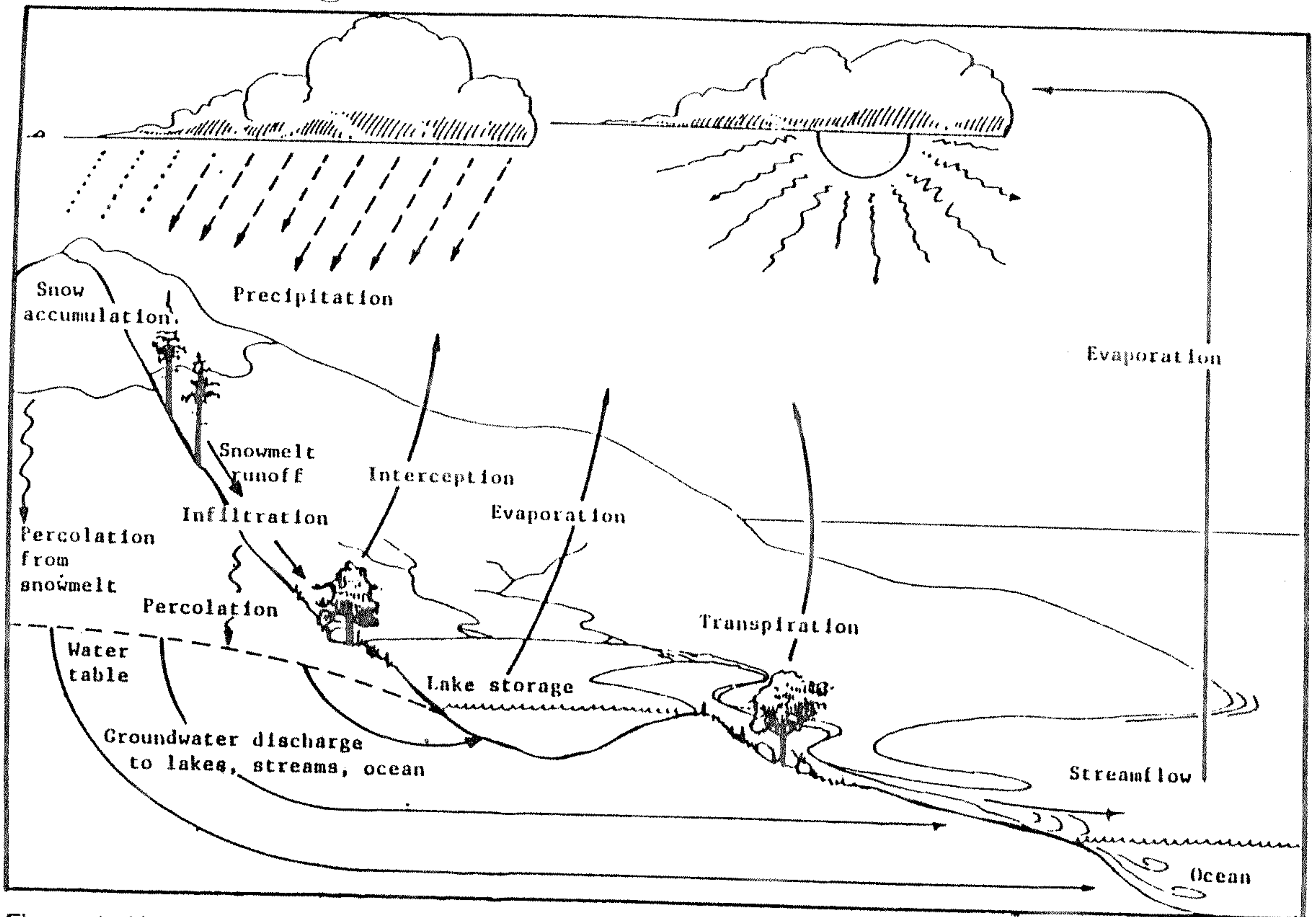


Figure 1. Hydrologic Cycle. (adapted from Dunne and Leopold, 1978, p. 5)