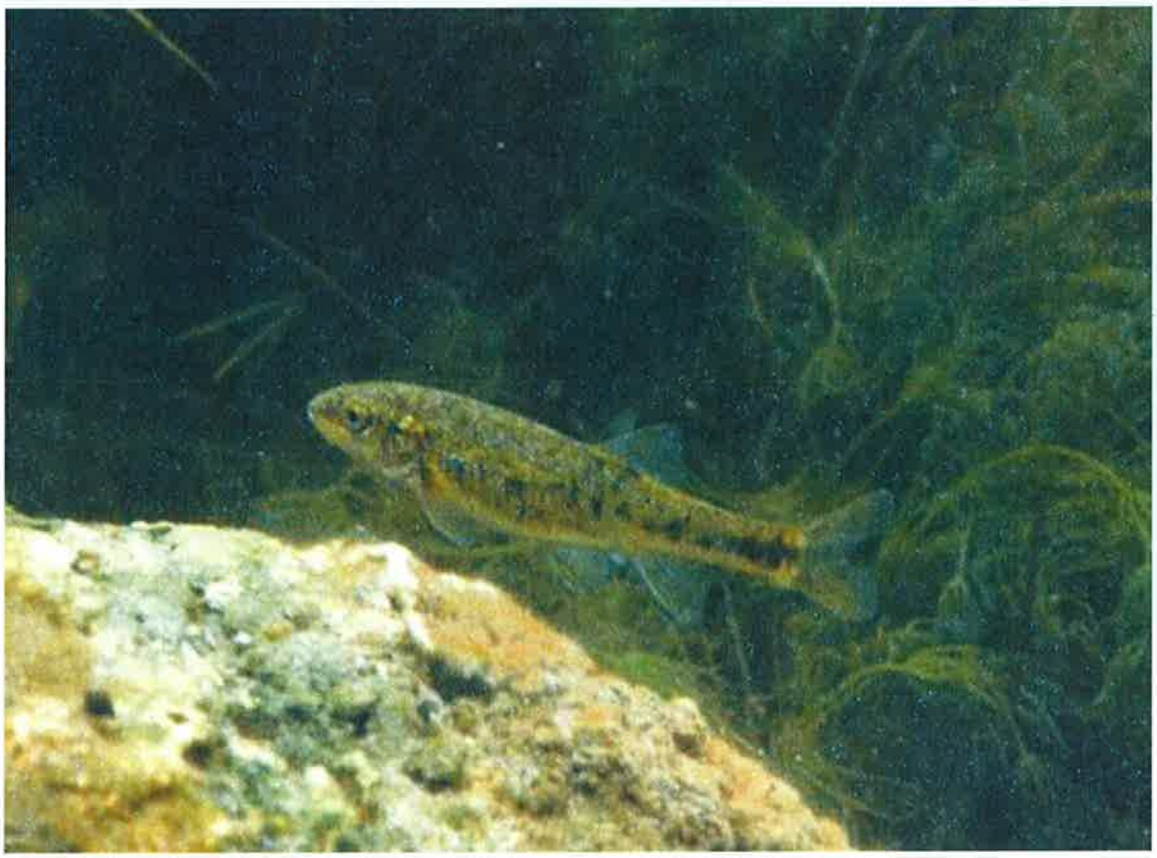
U.S. Fish & Wildlife Service

Kendall Warm Springs Dace

(*Rhinichthys osculus thermalis*)

Draft Revised Recovery Plan

Original Approved July 12, 1982



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U.S. Fish and Wildlife Service
Denver, Colorado

December 2012

Kendall Warm Springs Dace
(*Rhinichthys osculus thermalis*)

DRAFT REVISED RECOVERY PLAN
Original Recovery Plan Completed in 1982

Mountain-Prairie Region
U.S. Fish and Wildlife Service
Denver, Colorado

Approved: Noreen E. Walsh
Regional Director, U.S. Fish and Wildlife Service

Date: 12/5/2002

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EXECUTIVE SUMMARY

Current Species Status: The Kendall Warm Springs (KWS) dace (*Rhinichthys osculus thermalis*) was federally listed as endangered in 1970 under the Endangered Species Preservation Act of 1966. The species has a Recovery Priority Number of 12C indicating that it is a subspecies with a moderate degree of threat and low recovery potential and may be in conflict with development projects. It is endemic to one stream (984 feet in length) that originates from a series of thermal springs/seeps. The stream ends in a waterfall and empties into the Green River in Sublette County, Wyoming. The dace's entire habitat occurs on property administered by the U.S. Forest Service (USFS), Bridger-Teton National Forest. The number of fish present in the population has never been accurately estimated; however, population trend data indicate a decline over the last decade.

Habitat Requirements and Limiting Factors: The KWS dace is found in only one small thermal spring-fed stream of fast-flowing waters over cobble and gravel substrate associated with emergent aquatic vegetation. Primary threats at the time of listing were a limited distribution, habitat manipulation, and small population size. Currently, primary threats are potential catastrophic habitat loss due to manipulation or pollution of the aquifer that supplies the springs, degradation in habitat quality from potential oil and gas development, and potential nonnative species introductions.

Recovery Strategy: The recovery strategy is to maintain a viable population at KWS at its one known location in the wild and to establish at least two refugia populations. Recovery actions are designed to protect the species' habitat and increase the knowledge of the species' genetics, life history, population dynamics, the relationship of the dace to its environment, and its responses to identified threats.

Recovery Goal: Downlisting with eventual delisting.

Recovery Objective: The recovery objectives for the KWS dace are to reduce and/or remove threats to the species and its habitat, to ensure a population persists at KWS, to establish at least two captive refugia populations, and to obtain an increased understanding of the relationship of the KWS dace to its physical, chemical, and ecological environment. The accomplishment of these objectives is intended to provide reasonable assurance for the continued survival of the species even if Endangered Species Act protections are removed.

Recovery Criteria: The KWS dace will be considered ready for reclassification from Endangered to Threatened when all of the below criteria are realized:

(1) The population of KWS dace and its habitat are shown to be protected by the effective implementation of a no drilling zone (e.g., buffers, administratively unavailable areas, withdrawals, etc.) that significantly reduces the threats associated with the *introduction of toxins (petroleum products or fracking fluids)* to its habitat by oil and gas extraction activity that could intercept the spring recharge zone that supplies water to its habitat.

(2) The population of KWS dace and its habitat are shown to be protected by the effective implementation of a no drilling zone (e.g., buffers, administratively unavailable areas, withdrawals, etc.) that significantly reduces the threats associated with *manipulation of the spring's flow (and associated hydrologic regime) or thermal regime* by interception of the water table from oil and gas exploration activities in the spring's recharge zone.

(3) The naturally-occurring KWS dace population is not experiencing a downward trend in abundance.

The KWS dace (*Rhinichythys osculus thermalis*) will be considered recovered and ready for removal from the list of endangered and threatened wildlife (delisted) when all of the additional criteria listed below are realized:

(1) The population of KWS dace and its habitat are shown to be protected from present and foreseeable threats to the point where listing is no longer required through implementation of activities including stewardship, protection of groundwater in the spring recharge zone, and ensuring adequate regulatory enforcement.

(2) A viable population -- as evidenced by a Population Viability Analysis based on data collected on the population -- occurs within its historically-occupied habitat for at least 5 consecutive years. Benchmark criteria for viability, including time horizon, quasi-extinction threshold, and exact probability of persistence, will be developed by the Recovery Team using the abundance-based Population Viability Analysis (Dennis et al. 1991; Morris et al. 1999; Morris and Doak 2002) approach.

(3) Necessary administrative measures are implemented to ensure flows are maintained. Suitable flows and water quality in the KWS stream are determined through recovery tasks and assured through land management plans.

(4) Captive KWS dace populations are established and successfully propagated and maintained in two locations, including complete documentation of propagation methods and hatchery requirements. Populations will consist of the number of individuals and pairs that will ensure the maintenance of long-term genetic diversity and integrity necessary for long-term species viability as documented in the best available scientific information.

(5) Invasive species, if present, are controlled within the Kendall Warm Spring ecosystem and are not causing population declines of the KWS dace population there.

Types of Actions Needed: (1) Habitat protection, (2) Habitat enhancement, (3) Catastrophe planning, (4) Exotic species control, (5) Genetics studies, (6) Captive population establishment, (7) Reporting, (8) Post-delisting monitoring, (9) Adaptive management, (10) Life history studies, and (11) Cooperation with multiple agencies.

Total Estimated Cost of Recovery (in $thousands)

YEAR	ACTION											TOTAL
	1	2	3	4	5	6	7	8	9	10	11	
Y01	22	3	2	3.01	30	810	2	4	1	15	3	895.01
Y02	22	3	2	3.01	30	182	2	4	1	15	3	267.01
Y03	22	3	2	3.01	30	182	2	4	1	15	3	267.01
Y04	20	-	-	3.01	20	177	2	-	1	9	3	235.01
Y05	20	-	-	3.01	20	177	2	-	1	6	3	232.01
Total	**106**	**9**	**6**	**15.05**	**130**	**1528**	**10**	**12**	**5**	**60**	**15**	**1896.05**

Estimated Date of Recovery

If the recovery actions are accomplished on schedule, full recovery of the KWS dace can be achieved by the year 2018. However, it should be recognized that the recovery program may change over time or the timeframe to achieve the recovery actions may take longer than expected.

GLOSSARY

The consistent use of terminology is important when discussing the KWS dace. The following definitions will be used in this Recovery Plan:

Captive Population: populations established outside of or within historic range in aquaria, pools, ponds, streams, or springs at a dedicated rearing facility.

Historic range: a geographic area where the best scientific information indicates a species historically occurred

Native: a species within its historic range

Nonnative (exotic): a species outside its historic range

Population: all individuals occurring in a specified area, having a common ancestry or are potentially able to interbreed (Pianka 1978)

Refugia population: populations established for the primary purpose of preventing extinction of the species from the United States. They must be in a facility that can maintain them for the long-term, can maintain genetic characteristics of the source population, and is secure.

Stable population: a population where fertility and mortality are constant. This type of population will show an unvarying age distribution and will grow at a constant rate. Where fertility and mortality are equal, the stable population is stationary.

Viable population: a population containing an adequate representation of all age classes and cohorts, and having evidence of reliable annual recruitment.

Wild population: a population established within the historic range in a natural habitat at a location that is not a dedicated rearing facility.

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1.0 BACKGROUND

1.1 Brief Overview

October 13, 1970 (35 FR 16047) – listed as endangered under the Endangered Species Preservation Act of 1966 (80 Stat. 926; 16 U.S.C. 668aa(c)) prior to the Endangered Species Act of 1972 (ESA).

Entity listed: *Rhinichthys osculus thermalis*
Classification: Endangered
January 4, 1974 (39 FR 1171) – "grandfathered" the KWS dace into the ESA.

1.2 Description and Taxonomy

The KWS dace adults (Figure 1) range in size from 0.9 to 2.1 inches (23 to 54 millimeters). Breeding males have been characterized as having a bright purple color while females are dull olive green (Hubbs and Kuhne 1937). However, Gryska (Gryska, 2006 pers. comm.) only observed the olive-green coloration during his research efforts although he handled many (several thousand) spawning males with nuptial tubercles. It is unknown why there has been an inconsistency in observations of the fish's breeding coloration.

The KWS dace was originally described as a subspecies of the western dace (*Apocope osculus*) (Hubbs and Kuhne 1937). Later work on the fishes of Wyoming designated the KWS dace as *Rhinichthys osculus thermalis* (Baxter and Stone 1995). The taxonomic certainty of the KWS dace as a distinct subspecies has been discussed by many investigators (Binns 1978; Gould and Kaya 1991; Hubbs and Kuhne 1937; Kaya et al. 1989, 1992; USFWS 1982). Gould and Kaya (1991) and Kaya et al. (1988, 1989, 1992) concluded that the KWS dace is a distinct subspecies.

According to Kaya et al. (1989), the most important morphological difference between the KWS dace and the speckled dace is pharyngeal teeth. They found that KWS dace lack pharyngeal teeth in at least one minor row in 85% of the cases, whereas speckled dace lack this characteristic in less than 1% of the cases. Electrophoretic examination of 26 loci for both the KWS dace and speckled dace showed the two subspecies are genetically identical for the loci investigated in this study (Kaya et al. 1989). However, 5 of 12 restriction enzymes revealed polymorphic mitochondrial DNA (mtDNA) in speckled dace, whereas only 1 enzyme showed polymorphic mtDNA in KWS dace. One of the alternative mtDNA in KWS dace was not found in the speckled dace. For two other enzymes, the KWS dace was monomorphic for banding patterns not found in the speckled dace. The differences in mtDNA and pharyngeal teeth indicate both genetic and morphological differentiation between the KWS dace and the adjacent Green River speckled dace. Overall the differences are enough to warrant subspecies classification.

FIGURE 1. Kendall Warm Springs Dace

Photo taken by LuRay Parker, Wyoming Game & Fish Department

1.3 Distribution and Habitat Use

The KWS dace is confined to one stream approximately 328 yards (300 meters) in length that originates at a series of thermal springs near the base of a bluff. The KWS area is located on the east bank of the Green River in the northwestern Wind River Range, approximately 30 air miles (48.5 kilometers) north of Pinedale, Wyoming (Figures 2, 3, 4, 5, 6). The habitat ends with a waterfall approximately three meters in height that plunges downward to the non-thermal Green River below. The KWS dace are believed to occupy their entire historic range (Kaya et al. 1992; Hubbs and Kuhne 1937). The warm springs themselves remain a constant 85°F (29.4°C) year-round. The stream, fed solely by the warm springs, is 984 feet (300 meters) in length and supports the world's only population of the KWS dace. The stream temperature is more variable than the warm springs and has been recorded as low as 78°F (25.6°C) in the winter at the point where it cascades over a waterfall into the Green River. The peripheral areas of the stream have been recorded as low as 52°F (11.1°C) in the winter. The warm nature of KWS indicates discharge from a deeply circulating flow system (Mattson 1998). Water emerging from the KWS may be circulating as deep as 2,953 feet (900 meters) indicating that it may be part of a deep regional ground water flow system. Typically, water associated with these systems has long flowpaths and moves slowly with residence times in the aquifer of centuries to millennia (Mattson 1998). Assuming that the springs discharge from a regional flow system, recharge may occur at some distance away from the springs' sources. This consideration is important when assessing potential impacts of projects on the population and its habitat.

Most adult dace live in or along the main current of the stream, while dace fry are commonly found away from the primary flow. Small shallow pools located in beds of aquatic vegetation are well used by fry. Many small shallow pools are created by the hooves of elk and moose. The creation of the pools appears to be beneficial. Tiny, apparently newly hatched dace are common from the second pool downstream to the outfall in all seasons (Binns 1978).

Adult KWS dace inhabit fairly shallow pools and stream runs not more than 1 foot (0.31 meter) in depth. Plant growth within the water is necessary for escape cover and protection from the main current. Fry also use the vegetation as nursery areas (USFWS 1982).

The KWS dace numbers along the creek seem to correlate with dissolved oxygen and carbon dioxide levels with fewer fish upstream and none at all at the spring source. Plant growth provides their primary escape cover. A skittering flight to the nearest clump of plants is the typical predator avoidance reaction, although some also flee to the deeper, turbulent areas of the main current (Binns 1978).

In 1997, KWS dace were found to regularly drift over the waterfall and into the Green River during all months sampled (Gryska and Hubert 1997). Of those, 75% were larval fish and 25% were either juveniles or adults. Although the authors postulated that their estimates may have been low, they estimated that at least 75 larval fish per day drifted from the creek (a total of about 9,200 fish during the months of May through August). This was attributed to the relatively poor swimming ability of the larvae once they entered the swifter current. An estimated 24,000 larval fish were present in the stream in June (Gryska and Hubert 1997). Drift of juvenile and adult KWS dace from the stream was estimated to be 25 fish per day during the months of May through August (about 3,000 fish) (Gryska and Hubert 1997).

Habitat is limited, and only one population of the KWS dace exists. The habitat remains in relatively good condition; however, habitat alterations by recreational users have occurred in the form of construction of a series of dams/pools near the springs and also by contamination of the springs and stream by soaps, shampoos, and detergents. Bathing, wading, and washing clothes in the KWS area is currently prohibited, but some illegal activities have continued to occur, documented by issued citations. At the time of its listing, its habitat was fragmented into two sections by a road built across the stream prior to 1934. The road culvert bisected the stream at a point approximately two-thirds of the way downstream from the stream's origin. The road culvert has since been removed and replaced with a bridge that spans the stream (USFS 1997) allowing reconnection of the habitat.

FIGURE 2. Location of Kendall Warm Springs Dace Population

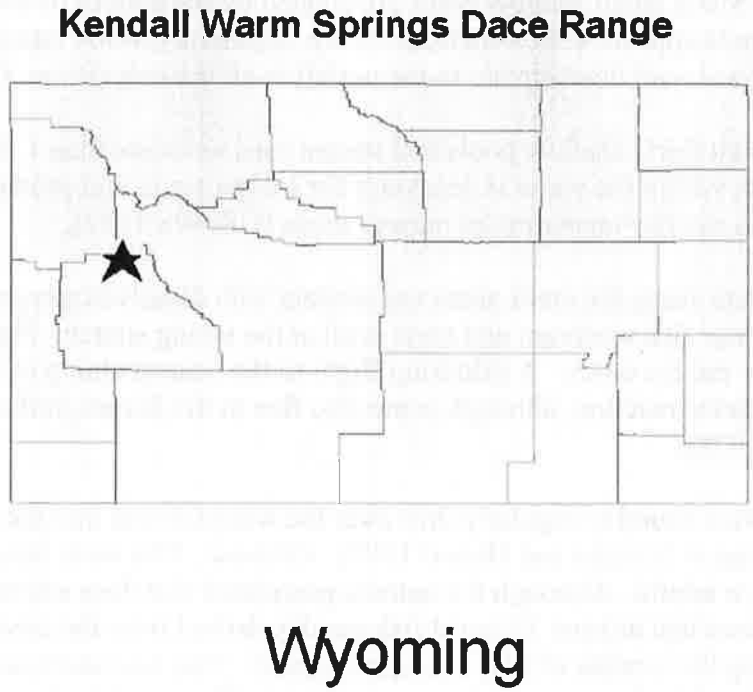


FIGURE 3. Diagram of Kendall Warm Springs Area

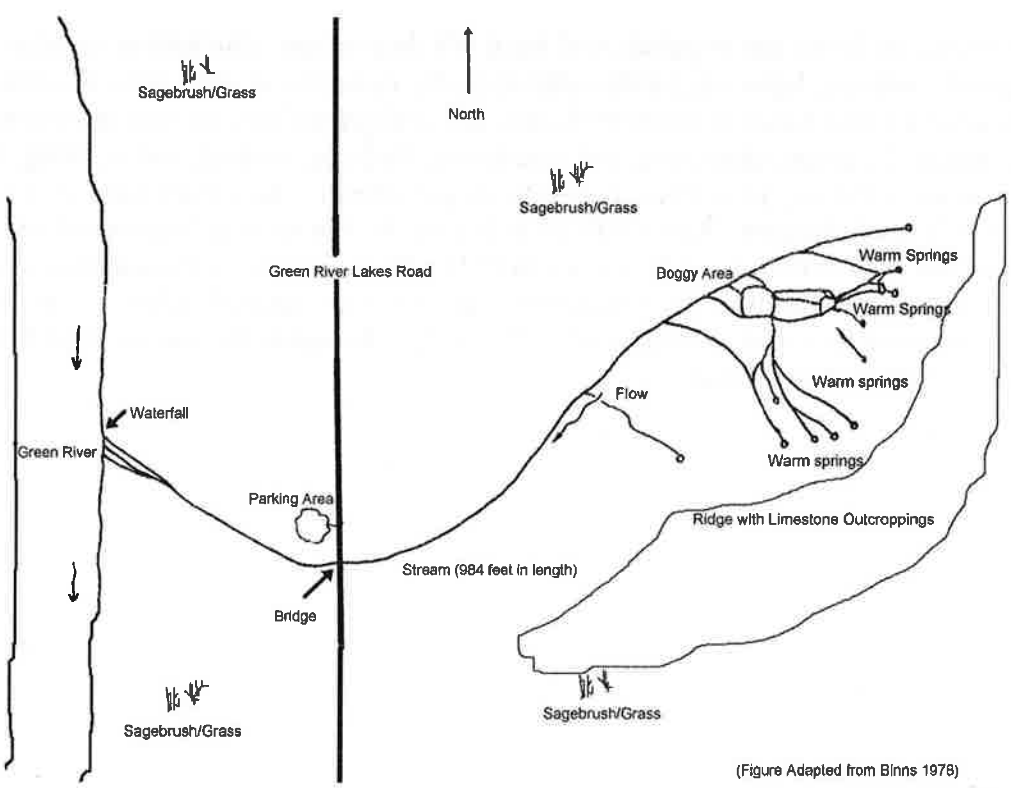


FIGURE 4. Historic Aerial View of Kendall Warm Springs Looking West

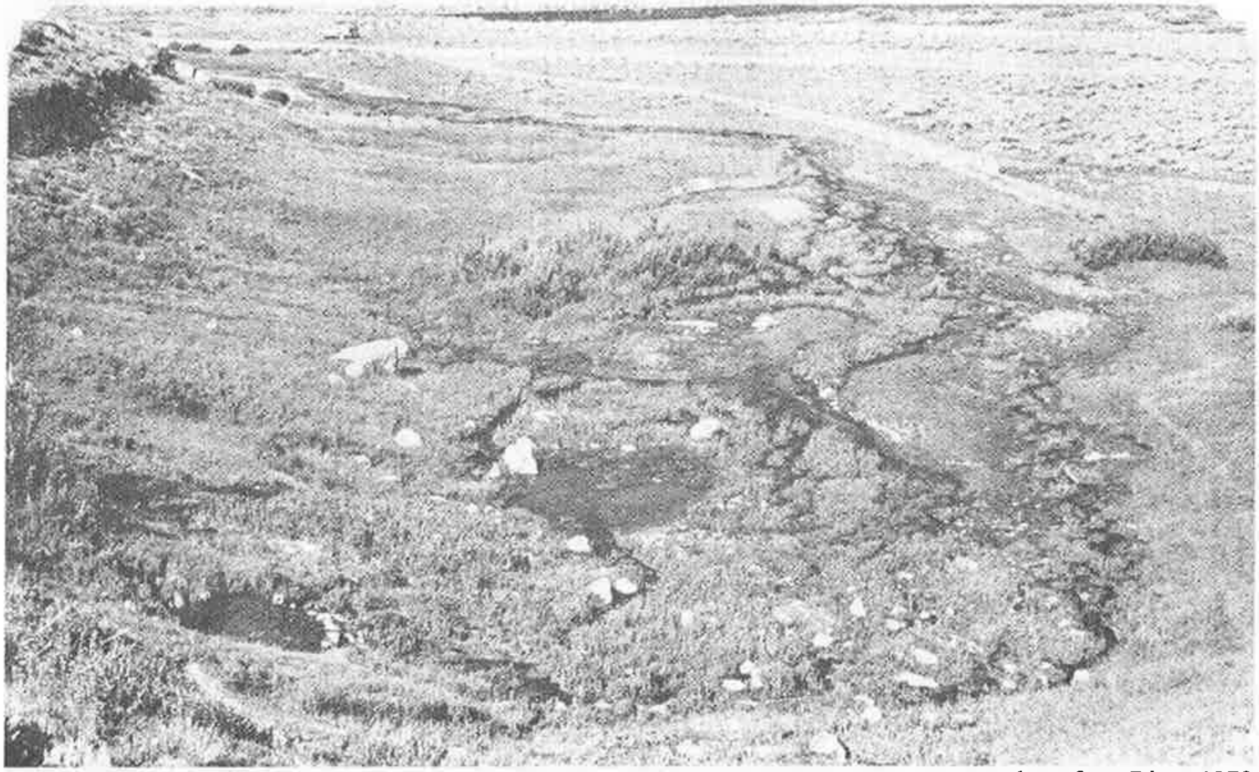


Photo from Binns 1978

FIGURE 5. Waterfall Showing 3-meter Drop from Kendall Warm Springs Stream to Green River Below

Photo from Binns 1978

FIGURE 6. Recent View of Kendall Warm Springs Stream Looking to the North from Atop Limestone Bluff

Photo provided by U.S. Forest Service

1.4 Life History

The KWS dace spawns year-round, although reproduction decreases in the winter (Gryska and Hubert 1997). During winter, very few larval fish are found along the shoreline, and the number of drifting larvae is substantially less in January than in May through August. Additionally, Gryska (1996) captured significantly fewer juvenile and adult fish in traps during winter than during summer. Mean length of fish captured in January was significantly greater than in summer (Gryska and Hubert 1997). The authors proposed two potential reasons for the seasonal changes they witnessed: (1) an overall reduction in primary productivity due to shorter winter days and reduced intensity of sunlight, and (2) cooler winter water temperatures in the shallow, near-shore larval fish habitat. It appears that photoperiod and/or water temperature may have an influence on reproductive rates (Gryska and Hubert 1997).

KWS dace feed on benthic invertebrates and epiphytic organisms (Gryska and Hubert 1997). They suck and scrape invertebrates from the substrate by using a subterminal mouth specialized for benthic foraging. Benthic invertebrates occurring in the KWS stream include: Odonata

(*Argia*, *Erythemis*), Trichoptera (*Cheumatopsyche, Hydroptila*), Coleoptera (Elmidae, Hydrophilidae), Diptera (Heleidae, Stratiomyiidae, Tendipedidae, Tipulidae), Amphipoda (*Hyalella azteca*), Hydracarina, and Gastropoda (*Lymnaea*, Planorbidae) (Binns 1978).

The KWS dace often form small aggregations. No information is currently available describing whether these fish have defined home ranges or if they display territoriality. In 1995, males were not observed to be purple when in breeding condition. The KWS dace do breed during the winter, as ripe adults and larval fish are present during that season (Gryska and Hubert 1995). Some larval habitat with cooler temperatures along the peripheral areas of the stream in winter were still occupied by larval fish, indicating that the fish have a wide thermal tolerance. Reproductive output decreases during the winter (Gryska and Hubert 1997).

1.5 Abundance Trends

KWS dace have declined in the stream from 1997 through 2011 (Figures 7 and 8). There is a slight (but statistically insignificant) uptick from 2010 to 2011. If this increase in abundance represents an increasing trend, the evidence is expected to come in future years. For survey methods, see Gryska (1995) and Gryska and Hubert (1995, 1997).

FIGURE 7. Mean Catch-Per-Unit-Effort (catch/trap-hour, n=approximately 3,000 trap-hours/year) (by site) by year. Site numbers go from the downstream end of KWS up to close to the spring (e.g., Site #10 represents the most upstream trap).

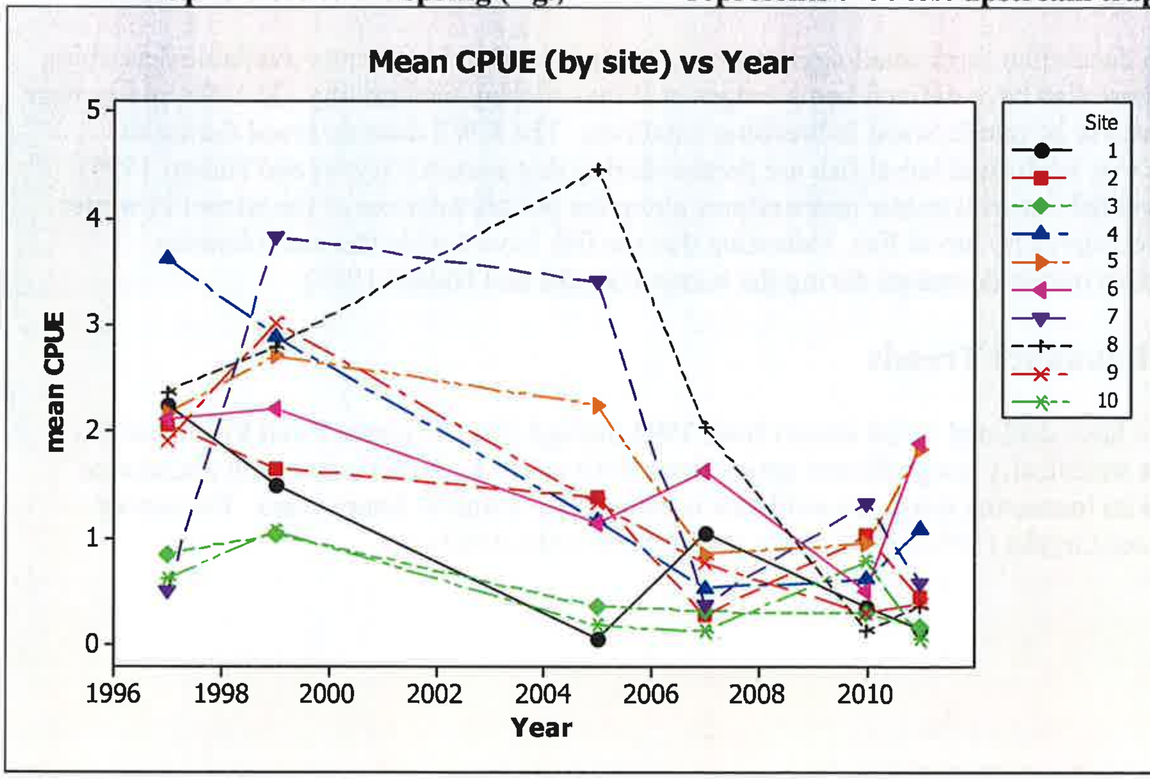
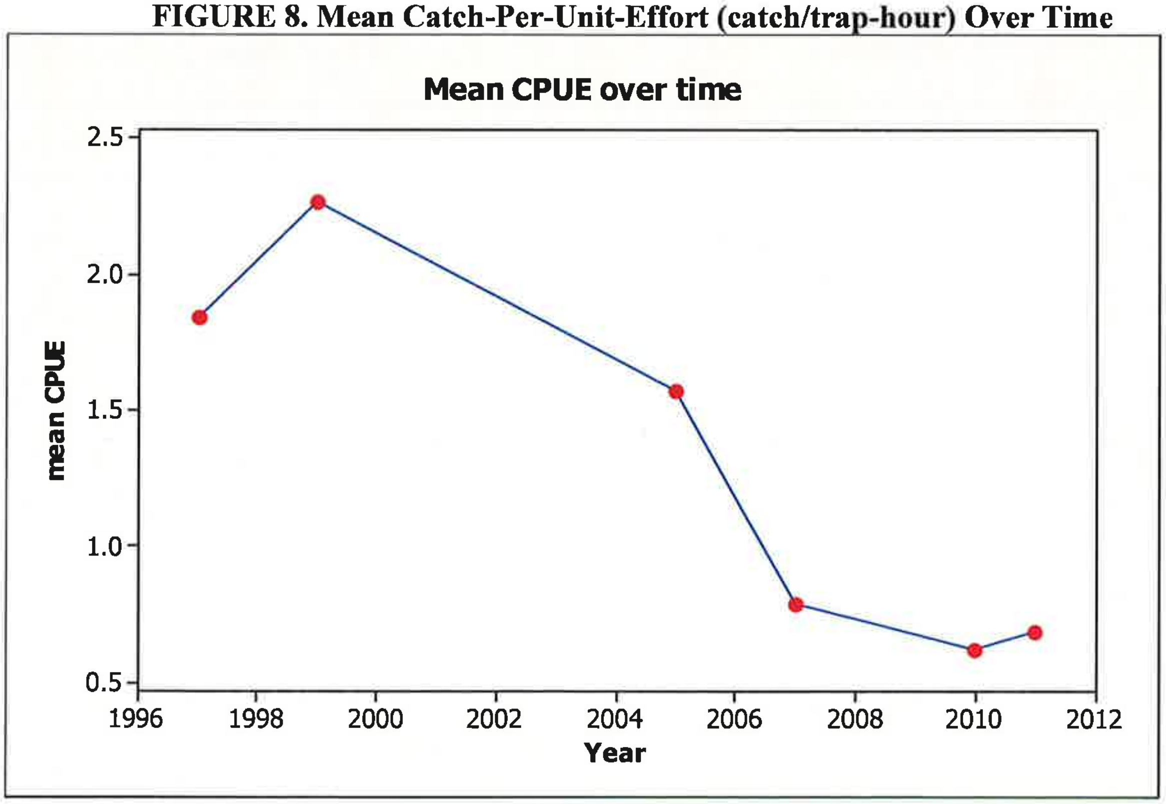


FIGURE 8. Mean Catch-Per-Unit-Effort (catch/trap-hour) Over Time



1.6 Threats

The set of listing factors set forth in Section 4(a)(1) of the ESA include: (A) the present or threatened destruction, modification, or curtailment of habitat or range; (B) overutilization for commercial, recreational, scientific, or education purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting the species' continued existence. The discussion under each listing factor, below, addresses the threats to the species at the time of the original listing and newly identified or predicted threats that are likely to occur in the foreseeable future.

A thoughtful, systematic examination of what is known about the KWS dace life history, in the context of the five listing factors in the ESA was used to help identify threats (See Appendix A). In order to better understand how any given threat actually affects the species, each identified threat was partitioned into a *stressor(s)* which actually impacts or has potential to impact individuals of the species. This helps to assess the magnitude of the impact, and the *source(s)* of the stressor which often provides insight into how to alleviate a threat. We used the threats assessment to evaluate each stressor for its *scope*, *immediacy*, and *intensity*, as a way of identifying the true magnitude of the potential threat to the target species. Using the threats assessment, we also characterized both the *exposure* of the target species to the stressors and the *response* of the species to the threat.

An overall threat level of low, moderate, high, or severe was ultimately determined by the recovery team for each threat for the KWS dace. Low level threats are those that do not require action at this time. For moderate level threats, action is needed. For high level threats, immediate action is necessary. Severe threats are those that require immediate action to ensure the survival of the species. At this time, no severe threats were identified by the recovery team for the KWS dace (See Appendix A). A 5-year review for this species was completed in 2007 (USFWS 2007). The threats analysis presented in this draft recovery plan does not differ markedly from that in the 2007 5-year review.

1.6.1 FACTOR A. The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

The following threats could result or have resulted in the destruction, modification, or curtailment of the habitat or range of the KWS dace (USFWS 2007). Because there is only one population of KWS dace in one geographic area, any detrimental impacts which are negatively affecting the population are affecting the entire KWS dace population.

Bathing and the Use of Soaps, Detergents, Sunscreen, and Bleaches in the Species' Habitat
Historically, recreational mountain travelers would bathe in the warm springs. It is reported that individuals also would wash clothes in the warm water of the springs (Binns 1978). Swimming and bathing degraded water quality and modified the quantity of vegetation present. This threat occurred rangewide. At one time, this threat may have been of moderate to high intensity resulting in mortality or inhibiting the basic needs of the species. The use of soaps, detergents, sunscreens, or bleaches in the KWS has been prohibited by the USFS since 1975 (Binns 1978) and signs posted onsite notify visitors of these prohibitions. As a result, the dace currently face

insignificant exposure to this threat; therefore, we conclude that the overall threat level for this threat is **low** at this time (See Appendix).

Deleterious Effects of Research Efforts

Research activities could stress the KWS dace population through reduction of habitat quantity and/or reduction in habitat quality. Researchers in their efforts to better understand the dace's habitat could enter the stream to analyze habitat and disturb the vegetation, the substrate and/or the invertebrates upon which the dace feed. The deleterious effects of research efforts are rangewide historic/future threats. The current exposure level for this threat is small. There are no current research efforts approved that could involve disruption or degradation of habitat. Permits are required by the Service, the USFS, and the Wyoming Game and Fish Department (WGFD) to perform research activities relating to the KWS dace. The overall threat level for this threat is **low**. In the future, the potential deleterious effects (likely transitory and ephemeral) to the dace population from properly designed research efforts should be weighed against the benefits potentially derived leading to better informed recovery and management actions.

Oil and Gas Development

Oil and gas development has not been known to affect the KWS dace population in the past. Future oil and gas development could potentially stress the dace population through changing the spring water quantity (e.g., drying up the spring or decreasing flow) or water quality (e.g., altering temperature regime). Although Mattson (1998) estimated the potential recharge area of the spring to be an area 21,270 acres (8,593 hectares) in size, the exact recharge area of the spring is not known with certainty and could extend across multiple watersheds. Oil and gas development within the recharge area is a potential future threat. If this threat does materialize, the exposure level could be very significant as 100% of the population could potentially be exposed. Surface disturbance associated with drilling (construction of drill pads, roads, and use of drilling fluids) could introduce sediment and contaminants to the spring. Subsurface disturbance could occur if drilling intercepts the fault zone that supports the spring. Introduction of drilling fluids or intercepting water may affect the temperature of the spring water. Any of these changes could have adverse impacts on the Kendall Warm Springs dace (USFS 2000). Significant mortality and possible extinction of the species could be realized within a very short time.

The USFS could authorize the Bureau of Land Management (BLM) to lease oil and gas development opportunities in the KWS area in the future. If leasing does occur, this could result in construction and operation of new well locations, upgrading of existing and building new roads, new pipelines, compressor stations, gas processing facilities, and evaporative ponds. Such development in the upper Green River watershed may impact crucial areas of KWS dace habitat and potential spring recharge areas. However, such activity would be subject to section7 consultation under the ESA and impacts potentially resulting from this activity could be minimized as a result.

The Mineral Leasing Act of 1920 directs that all public lands are open to oil and gas leasing unless a specific order has been issued to close an area. At present, with no protection measures or decisions in place, the Federal land management agencies involved could authorize the development of oil and gas exploration and development activities within the potential recharge zone of the KWS. The withdrawal of 160 acres (64.75 hectares) around KWS from mineral entry (27 FR 8830, August 28, 1962) only applies to "locatable" minerals such as gold, silver, and precious metals and not to "leasable" minerals (oil and gas) or "salable" minerals (gravel, cobblestone, sand, etc.).

Interest in oil and gas exploration and development on the Bridger-Teton National Forest has prompted evaluations of all potential impacts of USFS activities to the habitat of the KWS dace. In response to an increased interest in oil and gas drilling, Mattson (1998) conducted a hydrogeologic evaluation of the area surrounding the KWS. Mattson (1998) recommended that in order to protect the KWS dace from oil and gas development, a number of conservation measures and potential drilling restrictions should be implemented in the potential recharge area of the KWS.

The geologic environment surrounding KWS is complex and includes faulted and folded sedimentary rocks. The Wind River Mountains lie immediately east of KWS and were uplifted along the Wind River thrust fault. The mountain block shows evidence of shear zones in the interior of the mountain uplift. The younger strata on the west edge of the uplift are folded into a series of synclines and anticlines. A system of small high-angle reverse faults has further displaced and fractured the strata. The river corridor immediately surrounding KWS consists of a well-developed alluvial plain with unconsolidated glacial stream deposits. The complex geologic environment surrounding KWS gives rise to an equally complex hydrogeologic environment. The spring is apparently associated with a fault that delivers heated waters to the surface. Little detailed geologic investigation is available for the area, so it is difficult to precisely assess where recharge to the spring occurs (Mattson 1998).

The 1990 Bridger-Teton National Forest Land and Resource Management Plan (BT Plan) identified these areas as being administratively available for oil and gas leasing (USFS 1990). The USFS 2000 draft Environmental Impact Statement (draft EIS) describes a proposal to authorize leasing activities within the vicinity of KWS (USFS 2000). However, the BT Plan did not make site-specific decisions concerning the leasing of these available lands. The Forest Supervisor of the Bridger-Teton National Forest did decide to not pursue oil and gas leasing in the areas analyzed in the draft EIS (USFS 2000) due to overwhelming opposition from the public (USFS 2003). No final EIS or Record of Decision has been developed or completed over the draft proposal.

The draft EIS published by the USFS (2000) estimated that, over the approximately 369,900 acres (149,698 hectares) evaluated for potential oil and gas leasing activities, 30 to 128 wells could be expected to be drilled in the upper Green River area adjacent to where KWS is located (with associated facilities such as roads, pipelines, and power lines), if leasing were allowed. This scenario was developed using historical oil and gas development information from the U.S. Geological Survey (USGS), other known geologic information, and interpretation of information by the BLM and USFS geologists, as well as input from the oil and gas industry.

Alternatives and stipulations for development evaluated in the draft EIS included: (1) a no development alternative, (2) allowing leasing within all areas analyzed, (3) using No Surface Occupancy (NSO) stipulations in all USFS roadless areas and areas where sensitive soils exists,

(4) making unavailable the 21,270 acres (8,593 hectares) of potential recharge area of the KWS dace as evaluated by Mattson (1998), and (5) limiting the number of well pads to 1 per 160 acres (1 per 64.75 hectares).

Currently the Kendall Warm Springs recharge zone remains available for construction and operation of drill sites. If these activities are permitted, this could result in the potential contamination, depletion, or change in water quality of the aquifer which supplies the KWS. Such an irretrievable commitment of that water supply and recharge zone for KWS could cause the extinction of the KWS dace.

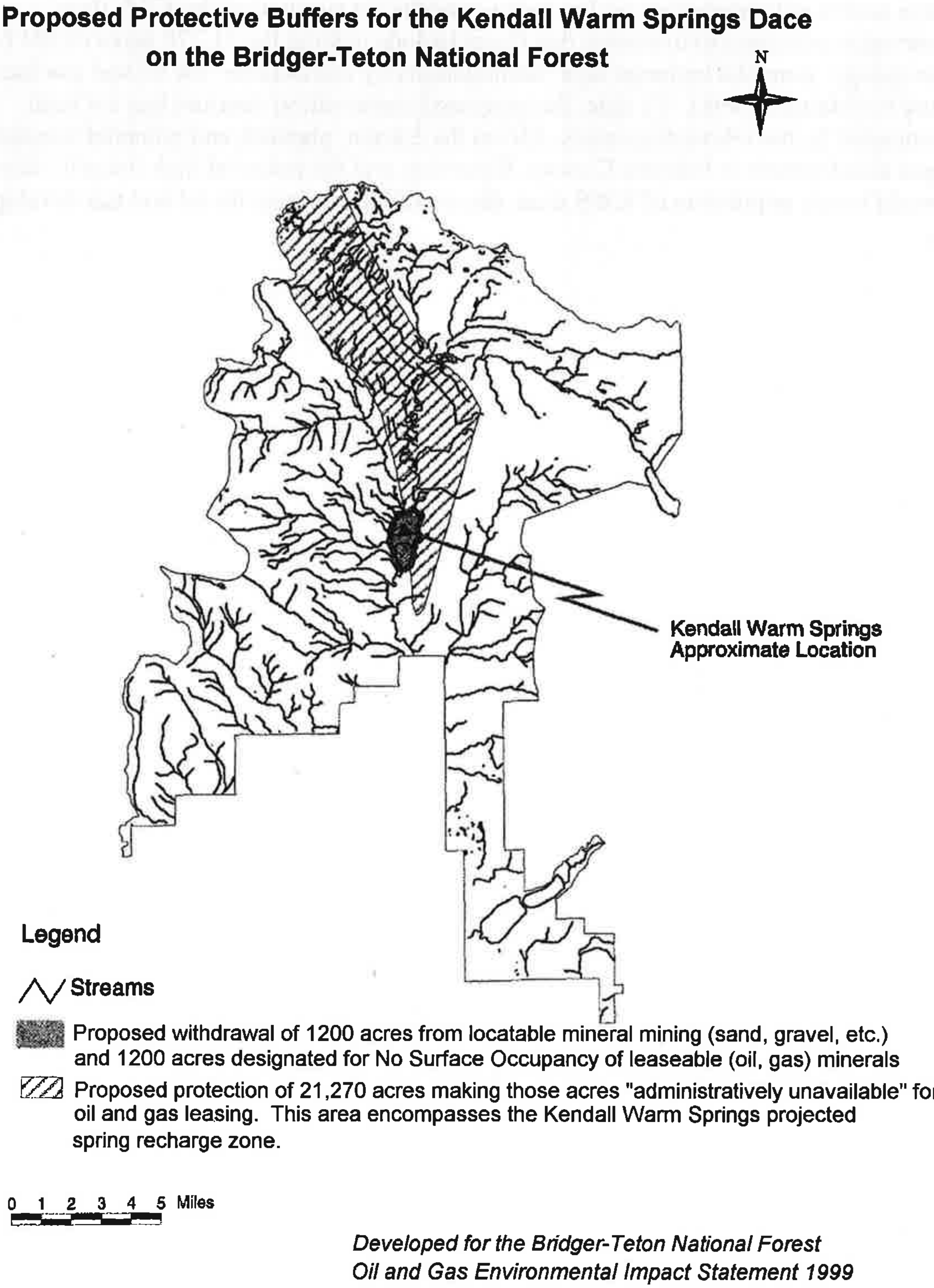
Since interest in oil and gas development remains high, these activities could eventually be approved and undertaken. If undertaken according to the draft EIS of the USFS (2000), the following project aspects would be expected to occur. All roads built or upgraded to access leases or facilitate field developments would be open to public traffic, except where administrative closures are in place. With field development, access roads would be plowed in the winter where and when possible, or would be utilized by over-the-snow vehicles. A total of 1,200 acres (485.6 hectares) around KWS would be recommended for withdrawal from locatable mineral entry as well as would carry a NSO Stipulation for leasable minerals. Acres of disturbance were estimated to be 3 acres for each well pad, and 1 mile of road and 1 mile of pipeline for each well, both located in the same corridor which would be 60 feet (18.3 meters) wide. During development (drilling), we assume that the area would receive high occupancy with high traffic use for approximately 90 days. However, this activity could occur for as much as 180 days. During production, we assume that one visit per well by pick-up truck would occur per day. Most emissions from oil and gas activities would be concentrated during the time period in which each well is being drilled and completed. This could extend from 3 to 6 months (USFS 2000).

During the production phase (which could last 15 years or longer), dust from roads and pads would be substantially less than during the exploration and development phase, given the same amounts of road construction. Pad sizes are typically smaller for production facilities, and vehicular use rates are much less. A producing field containing tank facilities, gas separation facilities, gas powered combustion compressor engines, diesel pumps, and other related equipment would produce odors due to the venting of gasses and other emissions. In the production phase, air pollutants such as carbon monoxide, hydrocarbons, nitrous oxides, sulfur dioxide, and hydrogen sulfide can be produced. The U.S. Environmental Protection Agency (EPA) states that a single well can produce in the vicinity of 250 tons (227 metric tons) of pollutants per year. These pollutants can be injected in the environment during disposal of liquid waste and unwanted gases by burning of waste products, and by fugitive loss of gases from storage tanks and other facilities. Accidental explosions, fires, blowouts, oil spills, and leaks cause potentially serious pollution problems as well (USFS 2000).

The management area that contains the KWS dace and the springs' potential recharge area is predicted to have one of the highest potentials for projected oil and gas development as analyzed by the draft EIS (USFS 2000). Despite the current lack of interest on the part of USFS, having such a high potential for oil and gas development increases the likelihood of renewed interest in oil and gas drilling in the area. Fracturing of the substrata supporting the hydrologic conditions of the KWS could occur, unless proper conservation measures or lease stipulations are implemented.

If plans for drilling in the area are pursued, the overall threat level for this threat could quickly become severe with immediate action being essential for survival of the KWS dace. Conservation measures to minimize this threat include making the 21,270 acres (8,593 hectares) of the springs' potential recharge area "administratively unavailable" for oil and gas leasing (Figure 9) (Mattson 1998). To date, this proposed conservation measure has not been implemented by the relevant agencies. Given the current, planned, and potential increase in oil and gas development in Sublette County, Wyoming, and the potential high intensity impacts to the world's only population of KWS dace, the overall threat level for oil and gas development is **high**.

FIGURE 9. Buffers for Kendall Warm Springs as proposed by USFS (2000)



Presence of Livestock in the Habitat

If allowed to enter KWS, livestock could affect the dace population through siltation of habitat and toxification of habitat. Livestock wading in the stream could cause some disturbance of the gravel and rock substrate of the stream bottom and allow some sediments to become suspended in the water or deposited in interstitial spaces that are critical for invertebrate production. Since the stream is relatively short (984 feet [300 meters] long) with a fairly rapid discharge of 6 to 8 cubic-feet-per-second (0.17 to 0.23 cubic-meters-per-second), it would not be expected that much effect would be observed from the disruption of the stream bottom caused by only a few head of livestock present over a short time period. It would be expected that most suspended sediment would be flushed from the stream, over the falls, and into the Green River within a relatively short time. Livestock use of the stream is known to increase the quantity of toxic chemical (e.g., nitrates, ammonia) levels from manure and urination of the large grazing animals in the stream. The extent of deleterious effects from this threat would depend on the number of livestock present and the duration of their stay. A fence regularly maintained by USFS excludes livestock from 160 acres (64.75 hectares) immediately adjacent to the stream. Since this is a historic threat that has been minimized by excluding the livestock from the KWS dace habitat, we rank the overall threat level for this threat as **low**.

Increased Recreational Use of the Area

The increase in recreational use of the area could lead to an increase in incidents of trespass and wading/bathing in KWS. Dace habitat could be modified by bathers seeking to increase the depth of the stream by excavating areas and constructing rock dams. People wading in the stream also could alter vegetation and stream beds. This is a potential rangewide threat that would be expected to have a low intensity. There have been a few citations issued over the past decades by Forest Service law enforcement officers. However, recent habitat modifications or trespass into KWS by bathers has not been recently documented. For these reasons, we rank the overall threat level for this threat as **low**.

Reservoir Construction/Water Impoundments in the Upper Green River Watershed

An impoundment in the watershed which supplies the recharge water for the KWS could potentially change both the quantity and quality of the water in KWS. Although unlikely at this time, a major water impoundment could completely inundate the KWS as has occurred to other thermal springs in Wyoming (e.g., Alcova Hot Springs currently inundated by Alcova Reservoir). If water quality or quantity of the KWS is changed, the dace would likely suffer significant mortality and potential extinction.

Three potential reservoir sites on the upper Green River (Kendall, Wells, and Gannett) were mentioned in potential reservoir impoundment plans by a Wyoming Water Resources Research Institute study done in the late 1960s (Binns 1972 and N. A. Binns, pers. comm., June 15, 2007). Plans developed at that time indicated that a dam at the Kendall site could impound as much as 1 million acre-feet (1,233 million cubic meters), which would most certainly inundate KWS and the 984 feet (300 meters) of stream habitat occupied by the KWS dace. On May 17, 1968, an application was filed to the Wyoming State Engineer for a 608,600 acre-feet (750,403,800 cubic meters) capacity Kendall Reservoir (Binns 2007 pers. comm.). Public hearings on the proposed Kendall Dam were held in Pinedale and Green River City, where the proposal encountered considerable public resistance and the proposal was later shelved (Binns 2007 pers. comm.).

Recently, there has been renewed interest in developing water storage facilities in the Upper Green River basin (P. Ogle, Wyoming Water Commission, pers. comm., April 3, 2011). This interest was focused on an area many miles downstream from the KWS area. Furthermore, the request for funding was denied for that proposal due to numerous conflicting resource issues. There are currently no approved plans to impound waters in areas that may affect the KWS area. Therefore, we believe the KWS dace have a negligible, insignificant exposure to this threat at this time and we rank the overall threat level as **low**. If plans are developed for reservoir construction or water impoundments in the area, then the overall threat level could quickly change to one with severe effects.

Catastrophic Wildfire

The threat of catastrophic wildfire could represent a rangewide threat to the KWS dace. This is a future threat that could be of high intensity. Catastrophic wildfire in the forested area which recharges the KWS could cause hydrologic or thermal changes to the spring. This effect was seen lower in the watershed in the Surprise Lake area in Sublette County. There, a wildfire burned areas of the drainage and changed the temperature regime of the major spawning tributary of golden trout in the lake. The tributary was no longer suitable for golden trout spawning and the natural recruitment of that population declined (S. Roth, USFWS, pers. comm., February 15, 2007).

Depending on the severity and intensity of a wildfire, burning of the forest could cause: (1) increased runoff rates from the surrounding mountainsides, (2) decreased infiltration of precipitation into the KWS recharge zone, and (3) siltation of the spring water of KWS. The KWS dace habitat is located in a sagebrush/grass vegetation type. Forested areas occur in the upper slopes of the recharge area for the KWS. Currently, the forest surrounding the KWS is predominantly lodgepole pine that is dying out due to pine bark beetle infestations. Fuel loading is typical for that region (5 to 20 tons/acre (11.2 to 44.8 metric tons/hectare)). The potential recharge area for the KWS is large (21,270 acres (8,593 hectares)) and the potential for a wildfire to occur there is moderate. Given the high public use of that area, suppression of any wildfires occurring there would be attempted at the earliest stages (P. Hutta, USFS, pers. comm., January 22, 2007). As catastrophic wildfires occurring in that area are expected to be controlled by suppression efforts before they could potentially have deleterious effects to the KWS ecosystem, the overall threat level for this threat is **low**. Furthermore, wildfire is a natural event in the ecosystem surrounding the KWS. It is likely that large fires have historically burned through the area on a periodic basis. Fire suppression efforts are not likely to occur in the area given the Forest Service conservation measures currently in place.

Acid Rain

An increase of pollutants in the air could lead to a change in the pH of the rain water/snowmelt which recharges the KWS. A change in pH caused by acid rain could be a threat of regional scope affecting multiple states. It is unknown if effects from this threat are currently affecting the KWS dace population. Given the increase in industrialization of Sublette County, Wyoming, and the concomitant concern with decreasing air quality, it is conceivable that acid rain could alter the water chemistry of KWS. Prevailing winds may transport pollutants for industrialized regions located to the west. It is anticipated that the acid rain, if it occurred in the KWS dace area, would be of low intensity. Also, the spring water is alkaline and emits from a limestone formation supplying calcium anions to the spring water (Binns 1978). Therefore, the spring may be fairly insulated from any threat from acid rain. Presently, no evidence of acid rain affecting the spring is known so the overall threat level from this threat is currently **low**.

Herbicide/Pesticide Use

The use of herbicides for weed control could affect the KWS dace habitat in the near future. Some invasive weed species are present in the immediate vicinity of KWS. Treatment of these with herbicides, if not appropriately conducted, could lead to localized contamination of the dace's habitat, a decrease in aquatic vegetation of the habitat, and a reduction in invertebrate numbers leading to decreased habitat suitability for the dace. Even a brief exposure to a weak solution could prove lethal to the dace. A weak solution in the stream also could damage or destroy algae and phytoplankton, thus altering the basic productivity of the stream and degrading the food chain upon which the dace depend. Similarly, pesticide use, if not conducted properly, could be lethal to the dace or damage or destroy aquatic benthic invertebrates, as well as zooplankton, upon which the dace feed.

Because potential applications of herbicides or other pesticides near the dace's habitat are under the control of USFS and Section 7 consultation requirements apply to this activity, we have ranked the overall threat level of this threat as **low**. The ESA, requires USFS to consult with the Service prior to activities which they determine "may affect" a listed species. It is assumed that a well-planned protocol to minimize or eliminate adverse effects to the dace would be developed during section 7 consultation between USFS and the Service prior to the use of either herbicides or pesticides near the dace's habitat.

Climate change

Scientific evidence currently indicates that the increase in greenhouse gases in the Earth's atmosphere caused by the burning of fossil fuels such as coal, oil, and natural gas are having a worldwide effect on the Earth's climate. Worldwide temperatures have risen over the past century and that trend is expected to continue. With worldwide warming, the polar ice caps and montane glaciers are melting at accelerated rates and below normal precipitation is occurring in many areas (Barry and Seimon 2000; Hall and Fagre 2003; Thomas et. al. 2009).

The magnitude of warming in the northern Rocky Mountains has been particularly great, as indicated by an 8-day advance in the appearance of spring phenological indicators since the 1930s (Cayan et al. 2001). The hydrologic regime in the northern Rockies also has changed with global climate change and is projected to change further (Bartlein et al. 1997; Cayan et al. 2001; Stewart et al. 2004). Under global climate change scenarios, the mountainous areas of northwest Wyoming may eventually experience milder, wetter winters and warmer, drier summers (Bartlein et al. 1997). Additionally, the pattern of snowmelt runoff also may change, with a reduction in spring snowmelt (Cayan et al. 2001) and an earlier peak runoff (Stewart et al. 2004), so that a lower proportion of the annual discharge will occur during spring and summer.

Our analyses under the Endangered Species Act include consideration of ongoing and projected changes in climate. The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). "Climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19). In our analyses, we use our expert judgment to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

Future climate change will be the product of natural variability acting over multiple spatial and temporal scales superimposed on anthropogenic trends (Gray et al. 2003, 2004; Jackson et al. 2009). Predicting ecological and biogeographic responses to climate change constitutes an immense challenge for ecologists (Jackson et al. 2009; Romme and Turner 1991). The effect that climate change could have on the KWS dace is unknown at this time. The KWS dace currently inhabits water which is geothermally warmed to a temperature of around 29.4°C (85°F). A drastic increase in the temperature of the spring water could lead to thermal or hydrologic changes to the springs that could be out of tolerance limits to the dace population. Lower precipitation levels potentially caused by global climate change could lead to reduced flows of the KWS and a reduction of available habitat for the dace.

Climate change is a potentially imminent and future threat. However, there is a large degree of uncertainty regarding what the localized effects of climate change will be and how localized effects may potentially impact the dace and its habitat. For these reasons, we rank the overall threat level for this threat as currently **low**. Further studies should be conducted to determine if there is a need for strategies to monitor and minimize the effects of this potential threat.

1.6.2 FACTOR B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The following are threats caused by the overutilization of the KWS dace for commercial, recreational, scientific, or educational purposes:

Illegal Taking of the Dace

Illegal taking of the dace for home aquaria or for other commercial trade purposes could cause reduction of KWS dace numbers. To date, this has not been an issue since no illegal taking of the dace has been documented. If illegal take has occurred, it appears that the population has not been impacted. However, in other parts of the world, other rare and endangered species have been exploited for food, medicinal, or ornamental properties. Some are sold locally or internationally to rare species collectors pushing those species closer to extinction. Potential exists for similar activity to occur to the KWS dace. Any illegal collections of the dace would be presumed to be of low intensity with a small portion of the population exposed to such efforts. For these reasons, we rank the overall threat level for this threat as **low**.

Deleterious Effects of Research Efforts

By visual observations from the stream-side, the population appears robust. The habitat appears to be completely occupied and the fish breed year-round. Because there are some unknown aspects of the dace's biology, there is a high probability that some KWS dace or their invertebrate prey will be utilized for scientific purposes in the future. Some research efforts may include attempts at captive rearing or population monitoring. Successful captive rearing or establishment of refugia populations will depend on learning the breeding requirements of this species in captivity. If this is undertaken, it will require field capture of individuals and acclimatization to a laboratory setting. It is likely that some individuals will die from trapping mortality or disease. It is unlikely that individuals removed from the KWS dace population for captive rearing studies would be returned to KWS because doing so would risk the introduction of disease contracted in the laboratory to the KWS population.

Studies to determine accurate estimates of the population size of the KWS dace or its prey base have not been attempted. To date, only CPUE studies for the dace have been employed indicating only trends in abundance over time. Mark-recapture experiments, if they were to be undertaken, could be used to estimate the dace's population size. However, mark-recapture studies could stress fish causing mortality to some dace. Currently, because of the dace's listed status, a recovery permit would be required under Section 10 of the ESA and the effects to the species would have to be evaluated prior to issuance of a permit to conduct research. Because any research efforts to study the dace would not be approved unless they were of low threat intensity and/or constituted insignificant exposure to the population as a whole, we rank the overall threat level for this threat as **low**.

Use of Kendall Warm Springs Dace as Bait Fish
The KWS dace were historically used as bait fish; although it is uncertain to what extent this activity occurred in the past. The WGFD prohibited the use of KWS dace as bait beginning in the 1960s.

This was a rangewide historical threat with an unknown past exposure level. Depending on the extent of its capture by anglers, anywhere from a small part of the population to a very significant part of the population may have been impacted. Death would be assumed to be the response of KWS dace used as bait fish; and if they were released alive, it would be unlikely that they would be returned to KWS.

As there currently are prohibitions against using KWS dace as bait and no exposure of the population to this threat is anticipated in the future, we rank the overall threat level for this threat as currently **low**.

1.6.3 FACTOR C. Disease or Predation

Disease Stemming from Research Efforts
Deleterious effects from disease could be realized as a result of research efforts. Equipment or waders used in habitat during dace population assessment could serve as pathways for the introduction of disease into the population. This is a rangewide threat that could occur under current management procedures. Precautions are now taken to minimize the risks of disease being introduced into the KWS dace population. Current research protocol calls for all

equipment and waders used for research efforts in the habitat of the KWS dace be disinfected with a 10% bleach solution before entering the habitat.

If disease were to be introduced into the population, potentially 100% of the KWS dace population could be affected. Depending on the type of disease introduced, the response from individuals could range from behavioral to significant mortality or extinction. At this time, the overall threat level from this activity is **low** because action is taken by researchers to avoid the introduction of disease into the population.

Disease or Predation of Dace From Introduction of Exotics

Historically, disease or predation has not been an issue as no introduced species or diseases have been documented in the habitat of the KWS dace. Potential exists for illegal introduction of warmwater or tropical fishes into the habitat of this species. Introduced fish diseases or predators to the KWS could have devastating effects on the KWS dace population potentially affecting 100% of the population. Introduced predatory fishes could easily decimate the dace population and lead to extinction of the species. The overall level for this threat is high. Refugia populations are needed to ensure survival of the KWS dace should disease or predation by exotic species decimate the only dace populations currently in existence. Many examples exist of other fish restricted to one location that have been decimated or gone extinct at least partially caused by exotic species introductions. For further detail regarding the potential effects of introduced species on the KWS ecosystem, see discussion below under Factor E.

The Wyoming Game and Fish Commission currently prohibits the introduction of nonnative fishes to KWS or any waters of the State; but illegal introductions of nonnative fish species still do occur (Rahel 2000; WGFD 2012a, b). Aquatic invasive species legislation (Enrolled Act 62, see WGFD 2010) was passed by the Wyoming legislature in 2010, substantially increasing the potential penalties for introducing exotic aquatic species into waters of the State. A program to prevent the expansion of aquatic invasive species also was started as a result of the recently passed legislation. It is uncertain how successful this legislation will be at preventing illegal introductions of exotic aquatic species to the waters of Wyoming. Because illegal introductions do still occur despite laws aimed at stopping them, we conclude this is a high intensity threat with potential for very significant exposure of the species and potentially causing significant mortality or extinction of the species. Therefore, we rank the overall threat level for this threat as **high** (see discussion under Factor E. below).

1.6.4 FACTOR D. The Inadequacy of Existing Regulatory Mechanisms

Although many regulatory mechanisms are currently in place independent of the ESA and have been fairly effective at controlling some of the deleterious threats that historically affected the dace, additional regulatory mechanisms could be improved for further protection of the dace. For instance, a regulatory mechanism in the BT Plan to protect the recharge zone for KWS from potential oil and gas development by making the area "administratively unavailable" is not currently in place, but has been discussed (USFS 2000). The high-level threat of oil and gas development in the spring's recharge zone is discussed under Factor A above. The following is a general synopsis of all existing regulatory mechanisms (independent of the ESA) currently employed and their inadequacies, if applicable.

Prohibitions currently exist against: 1) wading, bathing, or the use of soaps or detergents for washing clothes in the KWS and associated stream habitat; 2) livestock use of the stream for watering purposes; 3) introductions of exotic species into the habitat of the dace; 4) mining or staking locatable mineral claims in a 160-acre (64.75-hectare) area surrounding the KWS habitat; 5) the use of KWS dace as baitfish (WGFD 2012a); and 6) fishing in the KWS area (WGFD 2012c). These existing regulatory mechanisms are important and help protect the species.

The enforcement portion of some regulatory mechanisms may be a key issue in some cases. The difficulty of complete and adequate enforcement of regulations in a remote setting like KWS may put the dace at risk. Although prohibited since 1975, some wading and bathing in the spring has still occurred. The USFS conducted a population survey of the KWS dace in 2005. During that survey, four of the traps used to capture the dace were tampered with. One trap disappeared completely during a day set (was the most visible from the road), two traps were partially stepped on (presumably by a small, hoofed animal), and one was removed from the stream and placed atop an algae mat. Five dace were found dead in that trap (USFS 2006). These instances demonstrate the difficulty of ensuring that KWS dace are protected from illegal activities. However, to our knowledge such events have been relatively rare.

The 1990 Bridger-Teton National Forest Land and Resource Management Plan includes a goal to protect populations of, and provide suitable and adequate amounts of habitat for the KWS dace (USFS 1990). The plan also states that the existing populations and habitat of the KWS dace will be maintained and enhanced (USFS 1990). Included in the activities that are likely to take place during implementation of the plan are a KWS dace exclosure fence and fence reconstruction activities (USFS 1990). Livestock are currently prohibited from entering KWS and an exclusion fence is regularly maintained by the USFS. These measures have been fairly effective at excluding livestock from KWS. However, livestock have occasionally gained access to the springs for watering. Those situations involved: 1) downed portions of the exclusion fence, 2) low water levels in the Green River due to drought conditions allowing livestock to swim across the Green River, or 3) low water levels in the Green River allowing cattle to walk or wade around the portion of the fence which extends to the edge of the Green River. Therefore, regular monitoring of fences and livestock use are necessary to ensure the protections enacted remain effective.

To date, no exotic species are known to have been introduced into KWS. However, numerous thermal springs throughout North America have received unauthorized introductions of nonnative species causing disastrous consequences for the native dace species there (see Table 1 below), making precautions at KWS appropriate. Possible factors contributing to KWS not yet having received unauthorized nonnative species introductions are: (1) the low publicity level of the KWS area; (2) the inaccessibility of the area to the general public during much of the year due to winter road closures; (3) Wyoming regulations against the use of live baitfish along the Upper Green River; and (4) prohibitions against the introduction of nonnative species in the State (WGFD 2012b). Also, coldwater fish species in the adjacent Green River may not survive the warmer water temperatures found in KWS. In 2010, the Wyoming Legislature established an Aquatic Invasive Species Program to combat the threat of illegal aquatic introductions in Wyoming. This effort is aimed at zebra mussels (*Dreissena polymorpha*) and quagga mussels

(*Dreissena rostriformis*) that have continued to spread throughout North America, despite intense efforts to stop their range expansion, causing major changes to aquatic ecosystems where these species have been introduced. Vigilant enforcement of restrictions on illegal exotic aquatic species introductions is necessary, but the complete elimination of the threat from exotic species introductions (e.g., tropical aquarium fish, etc.) may be highly difficult because this crime may not be discovered until long after it is committed.

Although the area surrounding KWS has been withdrawn from locatable mineral entry (27 FR 8830, August 28, 1962), the possibility still remains that fluid mineral mining (oil and gas development) or salable mineral mining (e.g., pea gravel, gravel, cobblestone) could be still be authorized in the KWS recharge zone which has been estimated to be 21,270 acres in size (Mattson 1998). A prohibition, if put in place, against fluid or salable mineral development in the spring's recharge zone would provide needed administrative protections from these threats to the dace's habitat.

A Kendall Warm Springs Biological Unit Management Plan was approved by USFS in 1978. The management objectives of that plan were to: (1) maintain or improve the quality and quantity of the presently occupied habitat, and (2) to perpetuate a viable population level of dace. The area designated by this plan encompasses 160 acres (64.75 hectares). This same acreage was withdrawn from locatable mineral entry under EO-10355 in 1962, fenced to provide habitat protections in 1969, and identified as "essential habitat" for the dace in 1977. Boundaries include most of the small watershed and adjacent terrestrial communities which surround and directly affect the spring and stream section (USFS 1978). The 1978 plan provides a good description of the taxonomy and ecology of the dace. Several threats are addressed in the plan and recommendations were made in the plan to address those threats. Several follow-up actions since 1978 have been employed. However, more recent threats to the dace's continued existence should be addressed before efforts to downlist and delist the dace are initiated.

The U.S. Forest Service Bridger-Teton National Forest Land and Resource Management Plan, approved in 1990, covers the known population of dace (USFS 1990). The BT Plan contains general standards and guidelines for the maintenance and enhancement of the KWS dace habitat. More specific conservation measures such as making the recharge area of KWS "administratively unavailable" for oil and gas development (USFS 2000) would serve to alleviate this threat though the Bridger-Teton National Forest began the revision process for its Land and Resource Management Plan in 2005, that revision process has been put on hold pending ongoing litigation over forest-planning rules.

The current inadequacy of some existing regulatory mechanisms is a rangewide threat with a moderate intensity as opportunities to more effectively regulate activities affecting the species may be missed. We rank the intensity level of this threat as moderate and the exposure level as moderate/significant. Therefore, we assign the overall level of threat as **moderate** at this time.

1.6.5 FACTOR E. Other Natural or Manmade Factors Affecting the Species' Continued Existence

The following are other threats to the dace which are not fully analyzed in the preceding sections:

Other Effects Stemming From Introduction of Exotics

The introduction of nonnative fish or other aquatic species to the spring could upset the ecological balance currently present in the spring ecosystem thereby potentially impacting the KWS dace or potential hybridization could destroy the genetic integrity of this unique subspecies (Dowling and Childs 1992; Echelle and Conner 1989). Predation, competition for food, shelter, breeding sites, or competition for other resources could occur as a result of the introduction of nonnative species.

Small populations of other dace species occurring in thermal springs in other areas of North America have been severely impacted, been partially extirpated, or become extinct, because of the introduction of nonnative species (see TABLE 1) which were able to survive in the warm waters that those dace historically inhabited (Deacon et al. 1964; Lanteigne 1987; McAllister 1969; Nico 2006; Nico and Fuller 2006; Renaud and McAllister 1988; USFWS 2006).

TABLE 1. Species of dace, their status, location, and exotic species introduced into their habitat

NATIVE SPECIES	STATUS	LOCATION	EXOTIC SPECIES INTRODUCED INTO ITS HABITAT
Moapa dace (*Moapa coriacea*)	Federally Endangered	Moapa River and associated thermal springs in Clark County, Nevada	Common carp (*Cyprinus carpio*)
			Shortfin molly (*Poecilia mexicana*)
			Channel catfish (*Ictalurus punctatus*)
			Largemouth bass (*Micropterus salmoides*)
			Fathead minnow (*Pimephales promelas*)
			Black bullhead (*Ameiurus melas*)
			Tilapia (*Oreochromis aurea*)
			Mosquitofish (*Gambusia affinis*)
			Fish tapeworm (*Bothriocephalus acheilognathi*)
			Fish nematode (*Contracaecum* spp.)
			Anchor worm copepods (*Lernaea* spp.)
Speckled dace (*Rhinichthys osculus*)	Common	Kelly Warm Springs, Wyoming	Bullfrog (*Rana catesbeiana*)
			Convict cichlid (*Cichlasoma nigrofasciatum*)
			Green swordtail (*Xiphophorus helleri*)
			Guppy (*Poecilia reticulata*)
			Koi (*Cyprinus carpio*)
			Red rim snail (*Melanoides tuberculatus*)
			Tadpole madtom (*Noturus gyrinus*)
	Extirpated	Near Lake Mead, Nevada	Convict cichlid (*Cichlasoma nigrofasciatum*)
Kendall Warm Springs dace (*Rhinichthys osculus thermalis*)	Federally Endangered	Kendall Warm Springs, Wyoming	None
Banff longnose dace (*Rhinichthys cataractae smithi*)	Extinct	Thermal spring in Banff National Park, Alberta, Canada	Mosquitofish (*Gambusia affinis*)
			Green swordtail (*Xiphophorus helleri*)
			Convict cichlid (*Cichlasoma nigrofasciatum*)
			Sailfin molly (*Poecilia latipinna*)
			Jewelfish (*Hemichromis bimaculatus*)
			Angelfish (*Pterophyllum scalare*)
			Blue gourami (*Trichogaster trichopterus*)
			Siamese fighting fish (*Betta splendens*)
			Brook charr (*Salvelinus fontinalis*)
Desert dace (*Eremichthys acros*)	Federally Threatened	Thermal springs in Humboldt County, Nevada	Lahonton redside (*Richardsonius egregious*)
			Largemouth bass (*Micropterus salmoides*)
			Channel catfish (*Ictalurus punctatus*)
			Goldfish (*Carassius auratus*)
			Anchor worm copepods (*Lernaea* spp.)
Ash Meadows speckled dace (*Rhinichthys osculus nevadensis*)	Federally Endangered	Thermal springs in Ash Meadows, Nevada	Mosquitofish (*Gambusia affinis*)
			Sailfin molly (*Poecilia latipinna*)
			Largemouth bass (*Micropterus salmoides*)
			Crayfish (*Procambarus* spp.)
			Bullfrog (*Rana catesbeiana*)
			Arawana (*Osteoglossum bicirchosum*)
			Black bullhead (*Ameiurus melas*)

The nearest thermal spring to KWS where there are documented cases of introduced nonnative species is Kelly Warm Springs located to the northwest in Teton County, Wyoming. Kelly Warm Springs, which is inhabited by the more common speckled dace (*Rhinichthys osculus*), currently contains introduced populations of guppies (*Poecilia reticulata*), convict cichlids (*Cichlasoma nigrofasciatum*), green swordtails (*Xiphophorus helleri*), bullfrogs (*Rana catesbeiana*), red rim snails (*Melanoides tuberculatus*), and tadpole madtoms (*Noturus gyrinus*) (Grand Teton National Park 2009; Nico 2006; Nico and Fuller 2006). Convict cichlids pose a threat to small native fish because of their predatory nature. Guppies pose a threat to native fish because not only are they a hardy, prolific competitor, but they also can carry exotic trematode parasites (Nico 2006). They also are effective predators of larval fish (e.g., potentially KWS dace fry). According to Deacon et al. (1964), convict cichlids, in combination with other nonnative fishes, apparently caused the decline and extermination of a population of speckled dace (*R. osculus*) near Lake Mead, Nevada.

The speckled dace (*Rhinichthys osculus*) occurs in the Green River adjacent to KWS. In other environments, speckled dace have hybridized with other cyprinid minnows (e.g., least chubs (*Iotichthys phlegethontis* (Miller and Behnke 1985), redside shiners (*Richardsonius balteatus*) (Baxter and Stone 1995), and longnose dace (*Rhinichthys cataractae*) (Smith 1973)). If speckled dace were able to persist in the thermal environment of the KWS stream, then an introduction of the speckled dace, either deliberate or without malicious intent, could have significant implications for the genetic integrity of the KWS dace population through intraspecific hybridization. Similar effects have occurred to the Pecos pupfish (*Cyprinodon pecosensis*) (Echelle and Connor 1989), the Apache trout (*Oncorhynchus apache*), and the Gila trout (*O. gilae*) (Dowling and Childs 1992) through the introduction of allopatric conspecifics. We know of no studies involving KWS dace undertaken to identify whether or not incidents of intraspecific hybridization have occurred in the past. Though we rank the exposure level of this threat as currently small, the intensity level could be high given the potentially significant implications for the preservation of genetic integrity of this unique subspecies and because the ability to detect genetic contamination by speckled dace is very low given the size of the occupied habitat and lack of genetic monitoring currently employed.

The potential upset of the ecological balance of the KWS ecosystem by the introduction of one or more nonnative species or the potential loss of the genetic integrity of the KWS dace through introduction of other *Rhinichthys* species if it occurred would be a rangewide threat. Any introduction of nonnative species could presumably affect 100% of the KWS dace population since the dace is only found in one locality. The KWS dace population could suffer significant mortality or other deleterious effects. Enforcement of regulations and laws associated with illegal exotic species introductions and apprehension of perpetrators after the fact also are decidedly difficult. Because this threat could materialize relatively easily, with high intensity, inhibiting the basic needs of the species over the species' entire range, this threat has an overall threat level rank of **high.** Action should be undertaken to lessen the potential impacts associated with this threat. After a thorough evaluation of potential effects to the KWS dace population, attempts at controlling any introduced exotic species could potentially be employed by implementing one or more removal strategies.

Activities of Vandalism

Potential exists for deliberate poisoning of the KWS dace or the purposeful introduction of deleterious nonnative species into its habitat. Poisoning could occur through the application of piscicide or other contaminant(s). Because it is only found in one location, the entire population of the KWS dace could be eliminated by such an action. To date, there is no indication that anyone or any group would attempt to vandalize the KWS dace population. This is a rangewide threat which has the potential to affect 100% of the population and since only one population of the KWS dace exists, this could lead to its extinction. We rank the intensity of this threat as high, but with only a small exposure to the population at this time. However, because of the dace population's current vulnerability to acts of vandalism and because the dace could be perceived as an obstacle to some projects, we give this threat an overall threat level of **moderate.** Action is needed to reduce the degree of the dace's vulnerability to this potential threat possibly by establishing refugia populations that would not be exposed to such a threat.

Threats Associated with Small Population Size and Restricted Geographic Range

Stochastic, or random, changes in a wild population's demography or genetics, can threaten its persistence (Brussard and Gilpin 1989; Lacy 1997). A stochastic demographic change such as a skewed age or sex ratio (for example, a sudden loss of adult females) could negatively affect reproduction, especially in a small population. Disruption in gene flow due to reduction and isolation of populations may create unpredictable genetic effects that could impact the KWS dace's existence.

Species with small population size and restricted distribution are vulnerable to extinction by natural processes and human disturbance (Levin et al. 1996). Random events causing population fluctuations or population extirpations become a serious concern when the number of individuals or the geographic distribution of the species is very limited. A single human-caused or natural environmental disturbance could destroy the entire population of KWS dace.
When a population's genetic variability falls to low levels, its long-term persistence may be jeopardized because its ability to respond to changing environmental conditions is reduced. In addition, the potential for inbreeding depression increases, which means that fertility rates and survival rates of offspring may decrease. Although environmental and demographic factors usually supersede genetic factors in threatening species viability, inbreeding depression and low genetic diversity may enhance the probability of extinction of rare species (Levin et al. 1996).

Because there is only one population of KWS dace in one geographic area, any detrimental impacts which are negatively affecting the population are affecting the entire KWS dace population. The lack of more than one KWS dace population may increase the likelihood of its extinction. The overall threat level for this threat is **moderate** and action is needed. Establishing refugia populations has been discussed; to date, no refugia populations (captive or wild) have been established. The KWS dace have never been documented to reproduce in captivity. Their captive rearing would be very important to the establishment of refugia populations.

Toxins

Toxins may enter the KWS ecosystem in a number of ways. Potential sources of toxins include: (1) the use of soaps, detergents, sunscreens, or bleaches in the KWS, (2) vehicle use on the bridge which crosses the KWS ecosystem, (3) road construction/maintenance activities, (4) fire suppression activities, or (5) oil and gas development. Effects to dace could include: (1) direct poisoning, (2) impaired reproduction of the species, or (3) poisoning of the dace's food supply. As this dace occurs in only one location, this threat is considered a rangewide threat.

At one time, the use of soaps, detergents, and bleaches may have been of moderate/high intensity. The use of such materials has been prohibited since 1975. The dace currently are not exposed to this threat.

The use of vehicles on the bridge over the dace's stream habitat could affect the dace population if: 1) a toxic spill occurs, 2) garbage is dumped, or 3) road salt or sediment is washed from the road into the stream. There have been no instances recorded of this activity historically occurring. Because: 1) the road which crosses the bridge over the dace's stream habitat is the only access road to the heavily used Green River Lakes recreational area and campground and because 2) recreational use of the area is likely to increase in the future, this threat could have more potential to affect the dace in the future. Depending on the extent of any inputs into the stream this could be a low/moderate threat. It is expected that up to 30% of the population would be affected, since only the lower one-third of the dace's habitat is downstream from the bridge crossing. Some habitat could be modified or dace mortality could occur as a result of poisoning.

If a wildfire occurred in the recharge zone for the KWS, the fire suppression activities associated with that wildfire could have deleterious effects to the KWS dace population. Fire suppression activities could include increased vehicle traffic around the springs and the use of fire retardants. Fire retardants are often composed of either ammonia nitrate or surfactants. Ammonia nitrate is toxic to fish and could enter the spring water and poison the dace, or reduce or eliminate the aquatic plants or invertebrates present in the KWS. Fire retardant use is banned within the 160-acre fenced exclosure around KWS as per the Fire Management Plan for the Bridger-Teton National Forest (J. Neal, USFS, pers. comm. 2008, 2011). The USFS also has recently agreed to implement a 0.5-mile mandatory fire retardant application buffer around KWS to further reduce the possibility that a misapplication could occur near the springs -(USFS 2011).

Toxins from oil and gas development have not been known to have stressed the KWS dace population in the past. However, toxins associated with this activity could stress the dace population in the future through impacts to the underground aquifer. The scope of the threat of oil and gas development is rangewide. The exact recharge area of the spring is not known with certainty and could extend across multiple watersheds. Currently no deleterious effects from oil and gas development are realized by the population as this is a potential threat. If this threat does materialize, the exposure level would be very significant as 100% of the population would be exposed. Significant mortality and possible extinction of the species could be realized within a very short time. If drilling in the area is pursued, the overall threat level for this threat could quickly become severe with immediate action being essential for survival of the KWS dace. Conservation measures to minimize this threat have not yet been committed to by the relevant agencies. Proposed conservation measures include making the 21,270 acres (8,593 hectares) of the springs' potential recharge area "administratively unavailable" for oil and gas leasing (Mattson 1998). Given the push for increased oil and gas development in Sublette County, Wyoming, the overall threat level associated with toxins is **high**.

Other Natural Events

The potential for earthquakes, seismic activity, or great floods exists within the dace's habitat. The area is within an Intensity VII Earthquake Area (Case et al. 2002). The U.S. Geologic Survey (USGS) estimated that a 4.2 to 4.5 magnitude earthquake might occur somewhere in the Green River Basin every 62 years (BLM 1999, as cited in BLM 2004). The effects that an earthquake of this magnitude might have on Kendall Warm Springs remains unknown however. The Yellowstone National Park region, located about 60 miles to the northwest, is a hotspot for geothermal, seismic activity and some major volcanic eruptions have occurred there in the past. The intensity of this threat if it were to occur could potentially be very high with a very significant exposure level and 100% of the KWS dace population affected. Significant mortality could result. Currently, the population is not known to be experiencing any effects from this threat and the likelihood is low that deleterious effects would materialize from this threat. Furthermore, the dace has existed with natural events without causing its demise to date, further leading to our conclusion that the threat from this activity is currently **low** overall threat level.

TABLE 2. Summary of Threats and Overall Threat Level Ranking

THREATS		OVERALL THREAT LEVEL			
		Low	Moderate	High	Severe
Habitat					
	Bathing and the use of soaps in stream	X			
	Research efforts	X			
	Oil and gas development			X	
	Excluding livestock from habitat		X		
	Increase in recreational use	X			
	Reservoir construction	X			
	Catastrophic wildfire	X			
	Acid rain	X			
	Herbicide/pesticide use	X			
	Climate change	X			
Overutilization					
	Illegal Taking of the dace	X			
	Deleterious effects of research	X			
	Use of KWS dace as bait fish	X			
Disease or Predation					
	Disease stemming from research	X			
	Disease/predation from exotics			X	
Regulatory Mechanisms					
	Inadequacy of regulatory mechanisms		X		
Other					
	Other from exotics			X	
	Vandalism		X		
	Small populations size		X		
	Toxins			X	
	Catastrophic Natural Events	X			

2.0 RECOVERY STRATEGY

The general recovery strategy for the KWS dace is to reduce threats to the species, allow a viable, self-sustaining population to persist at KWS, and establish at least two refugia populations as insurance that a catastrophic event would not cause extinction. Many of the necessary actions for habitat protection are based on an increased understanding of the relationship of the KWS dace to its physical, chemical, and ecological environment. Several recovery actions are designed to collect information on the species and its habitat to provide for better future science-based management decisions and conservation actions. For example, an increased understanding of the species' genetics, life history, population dynamics, and responses to identified threats would be useful.

Implementation of the revised recovery plan will require adaptive management strategies to more effectively manage the KWS dace, both in the wild, as well as in captivity. Knowledge of genetic variation of the wild population will be needed to ensure that genetic variation is not lost in captivity through bottleneck or founder effects.

3.0 RECOVERY PROGRAM

3.1 Recovery Goal, Objectives, and Criteria

Goal

The ultimate goal of this revised recovery plan is to minimize the threats to the KWS dace to the point that protection under the ESA is no longer required and the KWS dace can be delisted.

Objectives

The KWS dace currently occupies all of its historic range and is presumed to be within the natural variability of historic population levels. The recovery objectives for the KWS dace are to reduce and/or remove threats to the species and its habitat, ensure a population persists at KWS, establish at least two refugia populations, and obtain an increased understanding of the relationship of the KWS dace to its physical, chemical, and ecological environment. The accomplishment of these objectives is intended to provide reasonable assurance for the continued survival of the species even if ESA protections are removed.

Criteria

The ESA requires recovery plans to include "objective, measurable criteria" which, when met, would result in the determination…that the species be removed from the list." Recovery criteria describe discrete targets with standards for measurement to determine that species have achieved recovery objectives and may be delisted. Developing precise measurable criteria for recovery of KWS dace is challenging because many of the largest potentially devastating threats to the species have not yet manifested and are currently not affecting the population. However, the threats could manifest at any time and could cause a drastic reduction in population levels or extinction of the dace in a short time period. Many of the recovery actions in this recovery plan will allow for future development of more specific criteria.

A. Reclassification to Threatened

The KWS dace will be considered ready for reclassification from Endangered to Threatened when all of the below criteria are realized:

(1) The population of KWS dace and its habitat are shown to be protected by the effective implementation of a no drilling zone (e.g., buffers, administratively unavailable areas, withdrawals, etc.) that significantly reduces the threats associated with the introduction of toxins (petroleum products or fracking fluids) to its habitat by oil and gas extraction activity that could intercept the spring recharge zone that supplies water to its habitat.

(2) The population of KWS dace and its habitat are shown to be protected by the effective implementation of a no drilling zone (e.g., buffers, administratively unavailable areas, withdrawals, etc.) that significantly reduces the threats associated with manipulation of the spring's flow (and associated hydrologic regime) or thermal regime by interception of the water table from oil and gas exploration activities in the spring's recharge zone.

(3) The naturally occurring KWS dace population is not experiencing a downward trend in abundance.

B. Delisting

The KWS dace (*Rhinichythys osculus thermalis*) will be considered recovered and ready for removal from the list of endangered and threatened wildlife (delisted) when all of the additional criteria listed below are realized:

(1) The population of KWS dace and its habitat are shown to be protected from present and foreseeable threats to the point where listing is no longer required through implementation of activities including stewardship, protection of groundwater in the spring recharge zone, and ensuring adequate regulatory enforcement.

(2) A viable population -- as evidenced by a Population Viability Analysis based on data collected on the population -- occurs within its historically-occupied habitat for at least 5 consecutive years. Benchmark criteria for viability, including time horizon, quasi-extinction threshold, and exact probability of persistence, will be developed by the Recovery Team using the abundance-based Population Viability Analysis (Dennis et al. 1991; Morris et al. 1999; Morris and Doak 2002) approach.

(3) Necessary administrative measures are implemented to ensure flows are maintained. Suitable flows and water quality in the KWS stream are determined through recovery tasks and assured, through land management plans.

(4) Captive KWS dace populations are established and successfully propagated and maintained in two locations, including complete documentation of propagation methods and hatchery requirements. Populations will consist of the number of individuals and pairs that will ensure the maintenance of long-term genetic diversity and integrity necessary for long-term species viability as documented in the best available scientific information.

(5) Invasive species, if present, are controlled within the KWS ecosystem and are not causing population declines of the KWS dace population there.

Changes to Recovery Criteria
Recovery plans are not regulatory documents, but are instead intended to provide guidance on methods of minimizing threats to listed species and on criteria that may be used to determine when recovery is achieved. There are many paths to accomplishing recovery of a species, and recovery may be achieved without all criteria being fully met. For example, one or more criteria may be exceeded while other criteria may not be accomplished. In that instance, we may judge that the threats are minimized sufficiently, and the species is robust enough to reclassify from endangered to threatened or to delist. In other cases, recovery opportunities may be recognized that were not known at the time the recovery plan was finalized. These opportunities may be used instead of methods identified in the recovery plan. Likewise, information on the species may be learned that was not known at the time the recovery plan was finalized. The new information may change the extent that criteria need to be met for recognizing recovery of the species. Recovery of a species is a dynamic process requiring adaptive management that may, or may not, fully follow the guidance provided in a recovery plan.

3.2 Recovery Actions

The recovery program for the KWS dace is divided into eight areas of action: 1) protection of habitat, 2) exotic species, 3) genetics, 4) captive populations/refugia, 5) monitoring, 6) adaptive management, 7) life history studies, and 8) cooperation with stakeholders/agencies. Overall, these sets of recovery actions are tied directly to achievement of the recovery criteria for the KWS dace (Appendix B).

Full descriptions of the recovery actions are provided in the Recovery Action Narrative. In the narrative, a priority number of 1 to 3 has been assigned to each action. These priorities are based on the following criteria:

Priority 1a: Actions that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 1b: Actions that by itself will not prevent extinction, but which is needed to carry out a Priority 1a action.

Priority 2: Actions that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

Recovery Action Narrative

HABITAT PROTECTION

1. Develop/revise and implement a **habitat protection plan**. A plan should comprehensively identify specific protection parameters and threats to the water quality/quantity and habitat of the KWS dace (Priority 1b).

1.1 Protect and **maintain the hydrology** for the estimated recharge zone for KWS to provide for continual uninterrupted flow of the springs, particularly from the threat of oil and gas development in the recharge zone. Work toward the inclusion of oil and gas development protection measures within the spring's recharge zone during the revision of the BT Plan (Priority 1a).

1.2 More thoroughly verify the source and **recharge zones** of the aquifer that supports stream flow in KWS. Perform comprehensive investigation, mapping, and modeling so that effective groundwater management and conservation is ensured (Priority 1b).

1.3 Monitor and maintain **stream flow, water quality, and channel morphology** in natural conditions to provide for ecosystem functions to support KWS dace. A USFS Land and Resource Management plan that serves to improve watershed health should be developed and implemented for the protection of the watershed supporting KWS dace (Priority 1a).

1.4 Identify and eliminate potential **pollution** sources to aquatic habitats of the KWS dace to the maximum extent practicable. Of special concern are potential inputs from oil and gas development (Priority 1b).

1.5 Through both field and laboratory investigations, determine flow velocities, temperatures, extent/amount of habitat needed, and water quality **tolerances and preferences** of different life history phases (including reproduction) of KWS dace. Information on factors that may influence these habitat requirements includes the impacts of vegetation in spring outflows, assessment of aquatic and riparian vegetation cover, and water flows and water levels. The information should be analyzed by season, age class, and stream section. Some information has already been gathered in this area. Qualitative assessments of habitat preferences have been made, suggesting the adults occupy areas with moderate depths and velocities, and gravel substrates near aquatic vegetation and the fry occupy shallower, backwater areas. Future investigations will be predicated on sufficient numbers in the wild to allow for experimentation without affecting the population (Priority 2).

1.6 Investigate the **effect of disturbance** in the system as it relates to the needs of the fish. Complete research to determine the effects of various land management methods (e.g., grazing practices) in the riparian area around KWS (Priority 3).

1.7 Enforcement of existing regulations to protect habitat should be continued (Priority 1a).

2. Develop a **habitat enhancement plan**. A habitat enhancement plan for KWS aimed at improving and maintaining physical habitat for KWS dace should be formulated and implemented. This may include the physical alteration of stream morphology. A number of anthropogenic habitat modifications occurred during the past century including: partially damming the stream after the construction of a road across the stream, placement of road culverts within the streambed and their subsequent removal, the construction of wading pools within the stream by the building of small rock dams, the watering of livestock within the spring and the subsequent construction and maintenance of a fence around the spring to exclude livestock (Priority 2).

3. Prepare a KWS dace **catastrophe plan**. The plan should be implemented if necessary to ensure the continued survival of this species if a catastrophe occurs (Priority 1a).

Exotic Species

4. Minimize potential introduction of nonnative species. Protective measures that minimize the possibility that nonnative competitors, predators, and/or carriers of parasites and/or diseases remain out of the ecosystem should be developed and employed. Potentially introduced species within the range of the KWS dace are a major potential threat and alleviating this threat will require ongoing enforcement of State regulations and keeping the habitat as little publicized, as possible. Potential problems could include not only nonnative fishes, but also other nonnative animals or plants that could introduce a parasite or disease or alter the natural habitat. Because of the dangers of predation, competition, diseases, parasites, and hybridization, introductions of all **exotic organisms** that could affect the aquatic environment, should be prevented within the range of the KWS dace. Methods for control should be developed and implemented for exotic species that could potentially be detrimental to the KWS dace population or its habitat. Declines, extirpations, and extinctions of several other dace species are attributable to negative impacts by introduced nonnative fishes (Priority 1a).

   4.1 Strict regulations on use and enforcement and movement of baitfish are currently in place and should be continued (Priority 1a).

   4.2 All equipment and waders used for research efforts in the habitat of the KWS dace should be disinfected with a 10% bleach solution, or best available decontamination method before entering the habitat (Priority 1b).

Genetics

5. Develop and implement a **genetics management plan**. A genetics management plan should be completed in accordance with the Service's Captive Propagation Policy. The purpose of the plan is to ensure that: 1) the genetic makeup of propagated individuals is, to the extent practicable, representative of the wild population; 2) propagated individuals are behaviorally and physiologically suitable for introduction; and, 3) this genetic makeup is maintained in captivity over generations. The genetics management plan should include adaptive management provisions to incorporate biological information gained during the research and early implementation of captive propagation (Priority 1b).

   5.1 Evaluate the species' **genetic structure**. The results should help in the management of the population(s). This information will be essential for establishment of captive populations and the maintenance of genetic diversity. Evaluate any changes in the variation in the KWS dace' genetic structure and/or morphology by comparing current specimens to the original type-specimens collected in the 1930s. It is possible that the dace in KWS has undergone bottleneck effects as a result of its use as baitfish from the 1930s to the 1960s prior to the prohibition of its use as bait (Priority 1b).

5.2 Preserve **genetic integrity**. There is only one population of KWS dace. For genetic diversity tracking purposes, the population of KWS dace in KWS will be considered one management unit. Any additional established populations will be considered separate management units (Priority 1b).

Captive Populations/Refugia

6. Maintain **refugia populations** of KWS dace in captivity to lessen the risk of extinction by a catastrophic event. These refugia populations should be in a facility that can maintain the population for the long term, can maintain the genetic characteristics of the source population, and is secure. Specific details on holding facilities should be developed and their establishment should be pursued by designated individuals. Refugia populations should be maintained in manmade habitats or aquaria, as necessary. Artificial refugia are an important component of the effort to preserve several endangered or nearly endangered fish species (Pister 1981; Johnson and Jensen 1991; Weedman 1998). These refugia should preserve a large fraction of the genetic variability originally present in their progenitors (Turner 1984). Captive populations may be established at facilities managed by a variety of groups (schools, museums, public education displays, zoos, National Fish Hatcheries, etc.). The level of genetic diversity in the population will, in part, determine the number of fish that need to be housed in captivity. Dexter National Fish Hatchery and Technology Center has played a major role in the recovery programs for other species. Other captive populations of threatened fish are held at zoos, museums, and universities (Bagley et al. 1991; Brown and Abarca 1992; Weedman 1998). Since these populations may have high fluctuations in size and structure, periodic genetic reviews of currently maintained captive populations also must be implemented (Priority 1b).

6.1 It is important to establish at least **2** additional stocks that contain the genetic diversity of the species. Identify and select two potential sites (Priority 1b).

6.2 Protocols should be developed for capture, transport, establishment, and management of the KWS dace refugia populations (Priority 1b).

6.3 An important aspect of the success of the genetic conservation management plan is the continued **monitoring of the refugia** populations. The KWS dace introduced into refugia need to be maintained and monitored for survivability, health, growth, and reproductive success. Additional KWS dace need to be periodically stocked in the refugia to maintain the genetic diversity of the stock (Priority 1b).

6.4 Prior to any captive population establishment efforts, a comprehensive **introduction plan** should be developed in accordance with the Service's Captive Propagation Policy (Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act, 65 FR 56916, September 20, 2000). This plan would include, but not be limited to, a consideration of population genetics, an assessment of reintroduction effects should reintroduction become necessary in Kendall Warm Springs, and a specific monitoring component to measure reintroduction results (Priority 2).

Monitoring

7. Maintain a population and habitat database and generate **regular reports**. The USFS is designated as the repository agency for habitat and population monitoring data. Regular reports should be generated and distributed to other interested parties involved in the management of the KWS dace. Data is stored at the Pinedale Ranger District Office of the Bridger-Teton National Forest and is available to cooperating partners. Standardized population and habitat monitoring protocols have been established and implementation of those protocols should continue. A consistent report format should be adopted to allow rapid analysis of comparable data from reports over time (Priority 3).

8. **Post-delisting monitoring**. Develop a post-delisting monitoring plan for the KWS dace. Section 4(g)(1) of the ESA requires that the Service monitor the status of all recovered species for at least 5 years following delisting. In keeping with this mandate, a post-delisting monitoring plan should be developed by the Service in cooperation with WGFD, USFS, other Federal agencies, academic institutions, and other appropriate entities. This plan should outline the indicators that will be used to assess the population status of the KWS dace, develop monitoring protocols for those indicators, and evaluate factors that may trigger consideration for relisting (Priority 3).

Adaptive Management

9. Apply **Adaptive Management**. The strategy of this recovery plan is based on the best available science; however, we recognize there are considerable knowledge gaps regarding the species and the ecosystem upon which it depends. As a result of this uncertainty, the process of KWS dace recovery will necessitate adaptive management. Throughout the implementation of recovery actions outlined below, new information and technologies will become available. New information should be evaluated and used to modify the strategy for recovery of KWS dace, as appropriate. With increasing knowledge, some recovery actions will likely become obsolete and other actions will be proposed that cannot be envisioned now. Likewise, the objectives and criteria of this recovery plan may be adjusted in the future as our understanding improves.

   Through a continual circular process of biological planning, conservation design, conservation delivery, outcome-based monitoring, assumption-based research, evaluation, and adjusting management, we will learn how to effectively conserve this species. The knowledge we gain from implementation of this recovery plan will be incorporated in the future recovery process. The Service periodically reviews approved recovery plans to determine the need for modifications. This recovery plan should be considered a living document that is flexible and consistent with the available, contemporary, scientific information. This may require periodic updates to the plan without full revisions being completed. This flexibility will maximize the usefulness of the recovery plan. The adaptive management concept ensures that all parties who choose to participate will have opportunities to contribute to the KWS dace recovery process. The work to accomplish the species' recovery should be coordinated with multiple agencies. Only by working together with different resources, knowledge, and expertise can recovery objectives and criteria be achieved (Priority 2).

10. Perform **Life history studies** (predicated on sufficient numbers of fish in the wild to allow for experimentation without affecting the population). Information on life history will be useful to ensure adequate husbandry needs for captive populations (Priority 1b).

10.1 Determine the **population structure** of the KWS dace. Determine population viability, optimum numbers and the spatial arrangement of the population, and population dynamics including fecundity, age and size class, sex ratio and longevity, through population estimations (Priority 1b).

10.2 Study interactions with **coexisting species**. Investigations of competition will require additional knowledge of reproduction, life history, habitat use, and food preference. The KWS dace is thought to eat invertebrates and algae; however, virtually nothing is known of specific food preferences (Priority 3).

10.3 Perform laboratory studies on **spawning** habitat, embryo development, and habitat preferences for yolk-sac larvae, feeding larvae, and juveniles of KWS dace. Perform further field observations on spawning adults and habitat preference of larvae, juveniles, and adults. Comprehensive studies in laboratory and field settings are needed to determine reproductive traits such as timing, duration, frequency, behavior, fecundity, and habitats (including water velocities, depths, and substrate). This information can be used to assist in developing captive breeding techniques for maintaining captive populations and assessing potential competition. This information also could be critical to management of the ecosystem to benefit reproduction of the species. Important factors could be discovered that are currently limiting the reproduction and early survival of KWS dace (Priority 1b).

10.4 Investigate **predation** by other species and incorporate information obtained into management of the population. Predation levels by all co-habitating species should be determined for KWS dace through field study (Priority 3).

10.5 Investigate **disease and parasites**. No data are available on the diseases and parasites of the KWS dace. Advancing knowledge of the diseases and parasites of the fish could help contain any potential future epidemic (Priority 3).

COOPERATION WITH STAKEHOLDERS/AGENCIES

11. Cooperate with **stakeholders/partner agencies** (Priority 1b).

11.1 Seek and maintain a team relationship with partners. Endorse and encourage the partnerships of agencies and stakeholders to continue protection of the KWS dace and its habitat. Approval and support of governmental agencies and grazing lessees are needed. These entities should be recognized for past land management actions that have allowed the species to persist (Priority 1b).

11.2 Thoroughly evaluate all proposed projects prior to beginning any study (Priority 1b).

4.0 IMPLEMENTATION SCHEDULE

The following Implementation Schedule outlines actions and estimated costs for the KWS dace recovery program over the next 5 years. It is a guide for meeting recovery objectives discussed in section 3 of this plan. This schedule indicates action priorities, action numbers, action descriptions, links to recovery criteria, duration of actions, and estimated costs. In addition, parties with authority, responsibility, or expressed interest to implement a specific recovery action are identified in the schedule. The listing of a party in the Implementation Schedule neither requires nor implies a requirement for the identified party to implement the action(s) or secure funding for implementing the action(s). However, parties willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and, therefore, is considered a necessary action for the overall coordinated effort to recover the KWS dace. Also, Section 7(a)(1) of the ESA, as amended, directs all federal agencies to use their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of threatened and endangered species. The schedule will be updated as recovery actions are initiated and completed.

Key to Implementation Schedule Priorities (column 1)

The ESA requires that recovery plans include actions that may be necessary to achieve recovery. The recovery actions (and their corresponding recovery action numbers) listed in this section (section 4) correspond to the recovery actions (and their corresponding numbered headings) described in section 3.2, respectively. Priorities also are assigned to each action in the implementation schedule (TABLE 3). In compliance with Endangered and Threatened Species Listing and Recovery Priority Guidelines (55 FR 24296) (Appendix S), all recovery actions will have assigned priorities based on the following:

Priority 1a: Actions that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 1b: Actions that by itself will not prevent extinction, but which is needed to carry out a Priority 1a action.

Priority 2: Actions that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

Key to Responsible Parties (column 6)

Team = Kendal Warm Springs Dace Recovery Team

USFWS = U.S. Fish and Wildlife Service

USFS = U.S. Forest Service

USGS = U.S. Geological Survey

WGFD = Wyoming Game and Fish Department

RIs = Research Institutions (e.g., University of Wyoming)

Other = Other, as of yet unidentified, constituencies

TABLE 3. Implementation Schedule: Kendall Warm Springs Dace Revised Recovery Plan

Priority#	Recovery Action#	Recovery Action Description	Recovery Criterion#	Action Duration (Years)	Responsible Parties	USFWS Lead?	Total Cost $1000s	Year 1 $1000s	Year 2 $1000s	Year 3 $1000s	Year 4 $1000s	Year 5 $1000s	Comments
1a	1.1	Protect groundwater in spring recharge zone	A(1), A(2), B(1), B(3)	5 years	USFS USGS WGFD RIs Other	N	5	1	1	1	1	1	-
1a	1.3	Maintain stream flow & quality	A(1), A(2), B(1), B(3)	Continuing	Team	N	15	3	3	3	3	3	Although future yearly costs may vary, action should be repeated indefinitely. Total cost is estimated for the next 5-year time period.
1a	1.7	Continue existing habitat protection enforcement	B(1)	Continuing	USFS USFWS WGFD	N	15	3	3	3	3	3	Although future yearly costs may vary, action should be repeated indefinitely. Total cost is estimated for the next 5-year time period.
1a	3	Prepare a catastrophe plan	A(1), A(2), B(3), B(4), B(5)	3	Team	Y	6	2	2	2	-	-	-
1a	4	Minimize potential introduction of exotics	A(3), B(1), B(2), B(3), B(4), B(5)	Continuing	Team	N	10	2	2	2	2	2	Although future yearly costs may vary, action should be repeated indefinitely. Total cost is estimated for the next 5-year time period.
1a	4.1	Continue existing enforcement of baitfish prohibition	A(3), B(1), B(2), B(4), B(5)	Continuing	WGFD	N	5	1	1	1	1	1	Although future yearly costs may vary, action should be repeated indefinitely. Total cost is estimated for the next 5-year time period.
1b	1	Develop/revise a habitat protection plan	A(1), A(2), A(3), B(1), B(2), B(3)	5 years	Team	Y	5	1	1	1	1	1	-
1b	1.2	Verify recharge zone	A(1), A(2), B(1), B(3)	5 years	USFS USFWS USGS	N	15	3	3	3	3	3	-

Priority#	Recovery Action#	Recovery Action Description	Recovery Criterion#	Action Duration (Years)	Responsible Parties	USFWS Lead?	Total Cost $1000s	Year 1 $1000s	Year 2 $1000s	Year 3 $1000s	Year 4 $1000s	Year 5 $1000s	Comments
1b	1.4	Identify & have a strategy in place to address pollution issues	A(1), B(3)	3 years	Team	Y	6	2	2	2	-	-	-
1b	4.2	Disinfect research equipment	A(3), B(1), B(2), B(5)	Continuing	USFS USFWS RIs	N	0.05	0.01	0.01	0.01	0.01	0.01	-
1b	5	Develop & implement a genetics management plan	B(2), B(4)	3 years	Team	Y	30	10	10	10	-	-	-
1b	5.1	Evaluate species' genetic structure	B(2), B(4)	5 years	Team	N	50	10	10	10	10	10	-
1b	5.2	Track genetic diversity	B(2), B(4)	Continuing	Team	N	50	10	10	10	10	10	-
1b	6	Maintain 2 refugia populations	A(1), A(2), B(1), B(4)	Continuing	Team	Y	1488	800	172	172	172	172	Although future yearly costs may vary, action should be repeated indefinitely. Total cost is estimated for the next 5-year time period.
1b	6.1	Identify & select at least 2 rearing facilities	B(4)	3	Team	Y	3	1	1	1	-	-	-
1b	6.2	Develop protocols to establish captive populations	B(4)	3	Team	Y	6	2	2	2	-	-	-

Priority#	Recovery Action#	Recovery Action Description	Recovery Criterion#	Action Duration (Years)	Responsible Parties	USFWS Lead?	Total Cost $1000s	Year 1 $1000s	Year 2 $1000s	Year 3 $1000s	Year 4 $1000s	Year 5 $1000s	Comments
1b	6.3	Monitor captive populations	B(4)	Continuing	Team	Y	25	5	5	5	5	5	Although future yearly costs may vary, action should be repeated indefinitely. Total cost is estimated for the next 5-year time period.
1b	10	Conduct life history studies	A(3)	5	Team	N	5	1	1	1	1	1	-
1b	10.1	Determine population structure	A(3), B(1), B(2)	4	Team	N	12	3	3	3	3	-	-
1b	10.3	Study spawning habits	B(4)	5	Team	N	25	5	5	5	5	5	-
1b	11	Cooperate with stakeholders/partner agencies	A(1), A(2), A(3), B(1), B(2), B(3), B(4), B(5)	Continuing	Team	Y	5	1	1	1	1	1	Although future yearly costs may vary, action should be repeated indefinitely. Total cost is estimated for the next 5-year time period.
1b	11.1	Seek & maintain a team relationship between partners	A(1), A(2), A(3), B(1), B(2), B(3), B(4), B(5)	Continuing	Team	Y	5	1	1	1	1	1	-
1b	11.2	Evaluate all proposed projects prior to beginning any study	A(3), B(2)	Continuing	USFWS USFS	Y	5	1	1	1	1	1	Although future yearly costs may vary, action should be repeated indefinitely. Total cost is estimated for the next 5-year time period.
2	1.5	Determine habitat needs	A(3), B(1), B(2), B(3), B(4)	5	Team	Y	25	5	5	5	5	5	-

Priority#	Recovery Action#	Recovery Action Description	Recovery Criterion#	Action Duration (Years)	Responsible Parties	USFWS Lead?	Total Cost $1000s	Year 1 $1000s	Year 2 $1000s	Year 3 $1000s	Year 4 $1000s	Year 5 $1000s	Comments
2	2	Develop a habitat enhancement plan	A(3), B(1)	3	Team	Y	9	3	3	3	-	-	-
2	6.4	Develop a reintroduction plan	B(2), B(4)	3	Team	Y	6	2	2	2	-	-	-
2	9	Apply adaptive management	A(3), B(1), B(2), B(3), B(4), B(5)	Continuing	Team	N	5	1	1	1	1	1	Although future yearly costs may vary, action should be repeated indefinitely. Total cost is estimated for the next 5-year time period.
3	1.6	Investigate effect of disturbance	A(3), B(1), B(2)	5	Team	N	20	4	4	4	4	4	-
3	7	Maintain database & generate regular reports	A(3), B(1), B(2), B(4)	Continuing	Team	N	10	2	2	2	2	2	Although future yearly costs may vary, action should be repeated indefinitely. Total cost is estimated for the next 5-year time period.
3	8	Develop a post-delisting monitoring plan	B(1), B(2)	3	Team	Y	12	4	4	4	-	-	-
3	10.2	Study interactions with coexisting species	A(3), B(1), B(2), B(5)	3	Team	N	6	2	2	2	-	-	-
3	10.4	Investigate predation levels	A(3), B(1), B(2), B(5)	3	Team	N	6	2	2	2	-	-	-
3	10.5	Investigate disease & parasites	A(3), B(1), B(2), B(4), B(5)	3	Team	N	6	2	2	2	-	-	-

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APPENDIX A
Threats Assessment Table

Kendall Warm Springs Dace Threats, Stressors, & Their Associated Scope, Immediacy, Intensity, Exposure, Response, & Overall Threat Level Ratings

Threat		Stressor Associated with Threat	Factor	Scope	Immediacy	Intensity	Exposure	Response	Overall Threat Level
1	Bathing & use of soaps, detergents, sunscreen, & bleaches in spring & creek	Poisoning of dace	A	rangewide	historic	low	insignificant	mortality	low
		Poisoning of macroinvertebrates	A	rangewide	historic	low	insignificant	basic needs inhibited	low
		Poisoning of plant community	A	rangewide	historic	low	insignificant	basic needs inhibited	low
		Modification of water quality	A	rangewide	historic	low	insignificant	basic needs inhibited	low
		Modification of habitat	A	rangewide	historic	low	insignificant	basic needs inhibited	low
2	Personal aquaria/commercial trade purposes	Reduction in dace numbers in population	B	rangewide	future	low	small	removal from population	low
3	Deleterious effects of research efforts	Reduction in dace numbers	B	rangewide	historic/ future	low	small	mortality	low
		Impaired reproduction/survival	B	rangewide	historic/ future	low	small	basic needs inhibited	low
		Introduction of disease	C	rangewide	future	moderate	moderate	mortality	low
		Reduction in prey abundance/diversity	B	rangewide	historic/ future	low	small	basic needs inhibited	low
		Reduction of habitat quantity	A	rangewide	historic/ future	moderate	small	basic needs inhibited	low
		Reduction of habitat quality	A	rangewide	historic/ future	moderate	small	basic needs inhibited	low

Threat		Stressor Associated with Threat	Factor	Scope	Immediacy	Intensity	Exposure	Response	Overall Threat Level
4	Oil & gas leasing, drilling, fracking, flushing with warmer or colder water, flushing with surfactants, other fluids, reinjection of water, removing groundwater	Modification of the aquifer by drilling activities	A	rangewide	future	high	significant	mortality (potential extinction)	high
		Changes in spring water quantity (drying up the spring)	A	rangewide	future	high	significant	mortality (potential extinction)	high
		Changes in spring water quality (e.g., introduction of toxins from drilling, changes in water chemistry)	A	rangewide	future	high	significant	mortality (potential extinction)	high
5	Introduction of tropical or warmwater fish species, other *Rhinichthys* species, or other exotic aquatic species (e.g., zebra mussels, exotic snails, exotic plants) to spring. Introduction of parasites	Introduction of disease, impaired reproduction/survival, physiological changes	C	rangewide	future	high	significant	mortality (potential extinction)	high
		Predation on dace	C	rangewide	future	high	significant	mortality (potential extinction)	high
		Competition for important resources (habitat, food)	E	rangewide	future	high	significant	basic needs inhibited	moderate
		Upset of ecological balance	E	rangewide	future	high	significant	basic needs inhibited	high
		Potential hybridization	E	rangewide	future	high	small	loss of genetic integrity	high
6	Activities of vandalism (e.g., deliberate poisoning of KWS dace)	Reduction or elimination of dace population through poisoning or other malicious activity	E	rangewide	future	high	small	mortality (potential extinction)	moderate
7	Climate change	Changes in hydrological conditions, habitat conditions	E	rangewide	imminent/ future	low	low	basic needs inhibited	low

Threat		Stressor Associated with Threat	Factor	Scope	Immediacy	Intensity	Exposure	Response	Overall Threat Level
8	Lack of (or inefficiency of) Existing Regulatory Mechanisms independent of ESA	Insufficient protective measures	D	rangewide	historic/ imminent/ future	moderate	moderate	various	moderate
9	Livestock grazing (livestock crossing the fence & watering in spring)	Siltation of habitat	A	rangewide	historic	high	small	basic needs inhibited	low
		Pollution of habitat	A	rangewide	historic	high	small	basic needs inhibited	low
10	Vehicle use on bridge over stream	Potential for toxic spill/garbage,	E	localized	historic/ future	low	small	behavioral (avoidance, startle, mortality)	low
11	Use of KWS dace as a bait fish	Reduction of numbers of dace	B	rangewide	historic	high	insignificant	mortality confirmed	low
12	Road construction/Improvement	Siltation of habitat	E	localized	historic/ future	low	small	behavioral (avoidance)/ basic needs inhibited	low
		Pollution of habitat	E	localized	future	low	small	behavioral (avoidance)/ basic needs inhibited	low

Threat		Stressor Associated with Threat	Factor	Scope	Immediacy	Intensity	Exposure	Response	Overall Threat Level
13	Increased recreational use of area	Illegal take of dace	B	rangewide	future	moderate	small	removal from population	low
		Modification of habitat by bathers	A	rangewide	historic	low	small	behavioral (avoidance)/ basic needs inhibited	low
14	Reservoir construction (changes in hydrology, etc.)	Changes in spring flow, inundation of spring	A	rangewide	future	high	insignificant	mortality (potential extinction)	low
15	Catastrophic wildfire	Changes in hydrology	A	rangewide	future	moderate	small	basic needs inhibited	low
		Changes in siltation rates	A	rangewide	future	moderate	small	basic needs inhibited	low
16	Fire suppression activities	Increased vehicular traffic around spring	E	rangewide	future	low	small	basic needs inhibited	low
17	Fire retardants	Pollution of spring	E	rangewide	future	high	small	basic needs inhibited/ mortality	low
		Poisoning of dace	E	rangewide	future	high	small	mortality	low
		impaired reproduction/survival	E	rangewide	future	high	small	basic needs inhibited/ mortality	low
		Poisoning of macroinvertebrates	E	rangewide	future	high	small	basic needs inhibited	low
		Poisoning of plant community	E	rangewide	future	high	small	basic needs inhibited	low
		Modification of water quality	E	rangewide	future	high	small	basic needs inhibited/ mortality	low
18	Acid rain	Change in water chemistry	A	rangewide	future	low	small	unknown	low

Threat		Stressor Associated with Threat	Factor	Scope	Immediacy	Intensity	Exposure	Response	Overall Threat Level
19	Natural catastrophe (earthquake)	Change in hydrology	E	rangewide	future	low	small	unknown	low
20	Herbicide/pesticide use	Contamination of dace's habitat	A	localized	future	low	small	basic needs inhibited/ mortality	low
		Decrease in aquatic vegetation of habitat	A	localized	future	low	small	basic needs inhibited	low
		Reduction in invertebrate numbers	A	localized	future	low	small	basic needs inhibited	low

Factors
A = The present or threatened destruction, modification, or curtailment of its habitat or range
B = Overutilization for commercial, recreational, scientific, or educational purposes
C = Disease or predation
D = The inadequacy of existing regulatory mechanisms
E = Other

Scope = Geographic extent of threat factor occurrence
Immediacy = Time frame of stressor
Intensity = Strength of stressor
Exposure = Level of total known population exposed to threat source
Response = Level of physiological/behavioral response
Overall Threat Level = Integration of the scope, immediacy, intensity, exposure, and response at the species level

APPENDIX B

Kendall Warm Springs Dace Threats Tracking Table

Threat	Factor	Recovery Criteria	Recovery Action
Bathing & use of soaps, detergents, sunscreen, & bleaches in spring & creek	A	Threat reduced since listing, B(1), B(2), B(3)	Continued enforcement, Protection of habitat, Cooperation with partner agencies (Action 1, 1.7, 4, 11, 11.1)
Collection of dace for personal aquaria/commercial trade purposes	B	Threat reduced since listing, B(1), B(2)	Continued enforcement (Action 4)
Deleterious effects of research efforts	A, B, C	A(3), B(1), B(2)	Thorough review of all research projects; Use of bleach solution to wash equipment (Action 4.2, 9, 10.5, 11)
Oil & gas leasing, drilling, fracking, flushing with warmer or colder water, flushing with surfactants, other fluids, reinjection of water, removing groundwater	A	A(1), A(2), B(1), B(2), B(3), B(4)	Establishment of no drilling buffer, Protection of habitat, Cooperation with partner agencies (Action 1, 1.2, 1.3, 1.4, 1.5, 3, 6, 6.1, 6.2, 7, 11)
Introduction of tropical or warmwater fish species, other *Rhinichthys* species, or other exotic aquatic species (e.g., zebra mussels, exotic snails, exotic plants) to spring. Introduction of parasites	C, E	B(1), B(2), B(4), B(5)	Limiting publicity of area; Establishment of refugia populations; Attempted removal of exotics, if necessary; Continued enforcement (Action 4, 6, 6.1, 6.2, 7, 9, 10.1, 10.3, 10.4, 10.5, 11)
Activities of vandalism (e.g., deliberate poisoning of KWS dace)	E	A(3), B(1), B(2), B(3), B(4), B(5)	Continued monitoring; Protection of habitat, Cooperation with partner agencies, Establishment of refugia populations, Monitoring (Action 1, 3, 6, 6.1, 6.2, 7, 11)
Climate change	E	A(3), B(1), B(2), B(3), B(4)	Monitoring & modeling potential changes to ecosystem (Action 1, 1.3, 1.5, 2, 3, 6, 7, 8, 9, 11)
Lack of (or inefficiency of) existing Regulatory Mechanisms independent of ESA	D	Threat reduced since listing, A(1), A(2), A(3), B(1), B(2), B(3), B(4)	Continued implementation & enforcement of existing regulations; Development & implementation of buffer zone around springs to sufficiently protect groundwater & spring recharge zone from oil & gas drilling/contamination/water flow manipulation (Action 3, 4, 4.1, 6, 6.1, 6.2, 7, 9, 11)
Livestock grazing (livestock crossing fence & watering in spring)	A	Threat reduced since listing, B(1), B(2), B(3)	Protection of habitat, continued exclusion of livestock from spring area most of year; monitoring & maintenance of exclusion fence, Adaptive management, Cooperation with partner agencies (Action 1, 1.3, 1.4, 1.6, 1.7, 2, 7, 9, 11)

Threat	Factor	Recovery Criteria	Recovery Action
Vehicle use on bridge over stream/Road Construction/Accidental introduction of toxins/siltation	E	B(1), B(2), B(3)	Protection of habitat, Preparation of catastrophe plan, Establishment of refugia populations, Monitor spring for signs that introduction of toxins, siltation has occurred. (Action 1, 1.4, 3, 6, 6.1, 6.2, 7, 11)
Use of KWS dace as a bait fish	B	Threat reduced since listing, B(1), B(2)	Continued implementation/enforcement of prohibitions currently in place, Cooperation with partner agencies (Action 5.1, 11).
Increased recreational use of area	A, B	B(1), B(2)	Limiting publicity of the area; monitoring; reporting (Action 1, 4)
Reservoir construction (changes in hydrology, etc.)	A	B(1), B(2), B(3)	Habitat protection, Catastrophe plan, Establishment of refugia population, Continued coordination with Wyoming Water Development Commission to ensure that reservoir proposals are evaluated early (Action 1, 1.1, 1.2, 1.3, 1.7, 3, 6, 11, 11.1, 11.2)
Catastrophic wildfire/Fire suppression/Flame retardants	A	B(1), B(2), B(3), B(4)	Use of proper restriction buffers & fuel management/fire suppression techniques. (Action 1, 1.3, 1.4, 3, 7, 11, 11.1, 11.2)
Acid rain	A	B(1), B(2), B(3)	Monitoring pH of spring water & precipitation in area (Action 1, 1.3, 7)
Natural catastrophe (earthquake)	E	B(4)	Catastrophe plan, Establishment of refugia populations (Action 3, 6, 6.1, 6.2)
Herbicide/pesticide use	A	B(1), B(2), B(3)	Development & implementation of a herbicide/pesticide use plan for area (Action 1, 1.3, 1.4, 7, 9, 11, 11.1, 11.2)

APPENDIX C

Population Viability Analysis Explanation

Traditionally, most recovery plans have defined goals and benchmarks with hard numbers, usually of the number of separate populations or of total wild individuals. A frequently mentioned problem with this approach (Morris and Doak 2002) is that these firm numerical criteria are usually not tied to any clear measure of population viability – that is, safety from extinction. For many species and recovery plans, this disconnect between recovery criteria and estimated population safety occurs because at the time the recovery plan is drafted, insufficient data exist to rigorously make this tie. This is the case for the Kendall Warm Springs dace.

An alternative approach to the definition of recovery criteria is to set criteria in terms of population viability, and then stipulate that indicators of population health, that can be measured in the field and then used to estimate viability, must indicate that a population has reached a sufficient level of safety in order for down- or de-listing. This approach has recently been used in the recovery planning of the Island Fox (*Urocyon littoralis*), among other species (Bakker and Doak 2009; Bakker et al. 2009). While this method of setting recovery goals requires more analysis of ongoing data collected as part of monitoring and management activities, it has a clear advantage of not locking a plan to outdated information or even mere guesses as to what safe numbers or viable dynamics might be.

Below, we outline the steps to the approach for setting and then using this type of viability criteria:

1. First, the recovery team must decide on a level of population safety that is deemed acceptable. Since any population has some chance of extinction, this process must balance relative safety versus the realities of an uncertain world. At least five different numbers will govern the levels of safety that make up a recovery goal:

   a) The quasi-extinction threshold. This is the lower limit on acceptable population sizes, below which a population is assumed to be at drastically increased risk of complete extinction.

   b) The time horizon over which to evaluate future viability, which is the probability that a population will not fall below the quasi-extinction threshold. For example, a team could suggest that recovery requires that a population be large and stable enough that there is little chance of hitting the quasi-extinction threshold over the next 10 years or over the next 1,000 years. The longer the time horizon, the more stringent the recovery criteria.

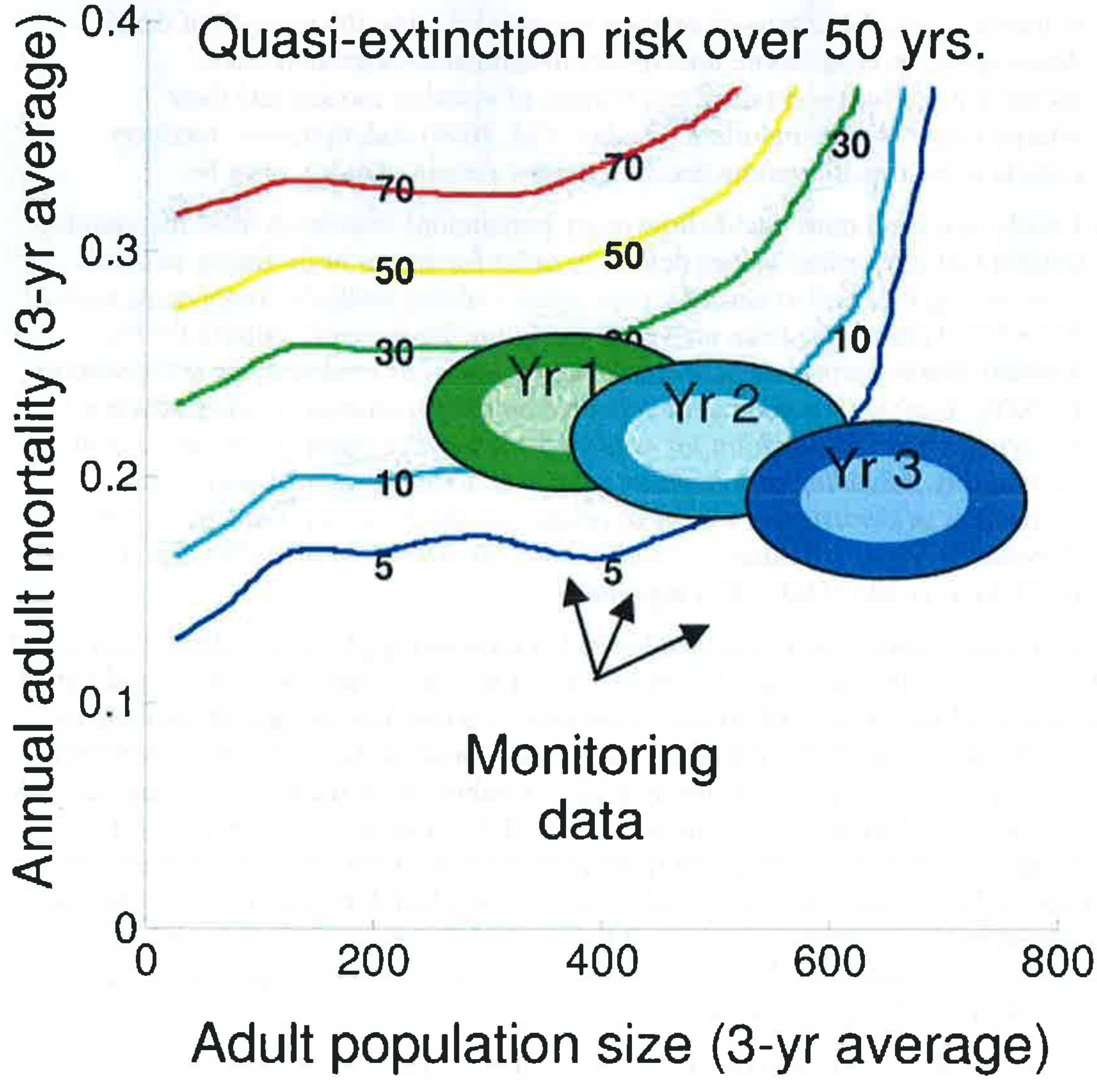
   c) Given the quasi-extinction threshold and the time horizon, the team must decide what risk of "quasi-extinction" is acceptable for recovery, with lower acceptable risks means more stringent criteria.

   d) The certainty of the estimated extinction risk that will be used to trigger recovery also must be decided. All estimations of future extinction risk are based on population models that are in turn parameterized with values that come from field data. Estimates from real data always have uncertainty and this in turn creates uncertainty in model outputs, including estimates of extinction risk. In addition, uncertainty about important aspects of population dynamics (e.g., the effects of weather on survival rates, the strength of density dependence, etc.) add more uncertainty to estimated extinction risks. Incorporating this uncertainty into outputs of viability models and their interpretation is thus important (Bakker et al. 2009) and, therefore, recovery criteria should include some decision of how certain viability must be.

e) Finally, the team must decide how many populations must each meet the viability criteria that these other values define, in order for down- or de-listing to occur. Considering the need to consider population viability analysis components such as those listed above, the team arrived at the following recovery criteria for the Kendall Warm Springs dace; *a viable population -- as evidenced by a Population Viability Analysis based on data collected on the population—occurs within its historically-occupied habitat for at least 5 consecutive years. Benchmark criteria for viability, including time horizon, quasi-extinction threshold, and exact probability of persistence, will be developed by the Recovery Team using the abundance-based Population Viability Analysis (Dennis et al. 1991; Morris et al. 1999; Morris and Doak 2002) approach.*

2. After viability criteria have been established, a monitoring plan that collects data useful in understanding the basic population biology of the target species must be established and continued over time. The information collected can then be used to estimate the basic information needed to establish whether a population has reached the recovery threshold, as embodied in the viability criteria established in the recovery plan. Common types of useful information from monitoring include: the mean and variance of stage-specific survival, growth, and reproductive rates; effects of weather events on survival and reproduction, disease and density-dependent dynamics and how they are influenced by environmental factors. It is expected that as a monitoring plan continues through time, estimates of all these key rates and effects will be improved, reducing uncertainty in viability estimates.

3. Pre-existing information and that from the monitoring plan will be used to develop and update a population model(s) for the species (see Morris and Doak 2002 for reviews of different viability models). At its most basic, this model can then be used to estimate future extinction risk: given parameter and model uncertainty, in practice, the model(s) will be used to estimate a mean risk of extinction given different starting conditions or other model assumptions. To make the model most useful for assessing extinction risk, these different scenarios should be tied to observable features of the population in the field: for example the current adult population size and survival rates from the most recent years of data. The estimated extinction risk (from model simulations) for a population with different current sizes and mortality rates can then be estimated into the future, allowing assessment of future viability from currently observed data. An example of this connection is shown below, taken from the island fox recovery plan and from Bakker and Doak (2009):



Here, the estimated mean future viabilities of populations with different initial adult population sizes and adult mortality rates are shown as isoclines of risk (e.g., the 10% isocline indicates a 10% risk of quasi-extinction over the next 50 years). The confidence limits of field-observed data on mortality and population size are for 3 years are shown, indicating movement of a population toward lower and lower risk. A series of isocline figures such as that shown above are the key connection between monitoring data and recovery criteria that were developed for the island fox.

This appendix gives only an outline of the general approach of using viability criteria to set and evaluate recovery. Only after several years of field data are examined will it be possible to better define the exact form of the model that will be used to estimate viability.

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