Bluehead Sucker (*Catostomus discobolus*): A Technical Conservation Assessment

Prepared for the USDA Forest Service,
Rocky Mountain Region,
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Authors' Biographies

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David E. Rees studied fishery biology, aquatic ecology, and ecotoxicology at Colorado State University where he received his B.S and finally his M.S. in 1994. His specific areas of specialization include aquatic insect identification and ecology, and native fish movement and habitat use. He has been involved with and supervised extensive projects involving electrofishing and population studies on the native and nonnative fish in tributaries of the Colorado River Basin, and other various locations. He has supervised habitat use studies using radio telemetry to monitor Colorado pikeminnow and other native and nonnative fish in the Yampa River, San Juan River and Colorado River. He has worked on projects in Colorado, Utah, New Mexico, Nevada, Arizona, Wyoming, Montana, and Puerto Rico. David is currently conducting research on the relationship between physical and ecological processes in the Colorado River, and the implications of these interactions on native fish species.

Dr. William J. Miller has over 23 years experience in fisheries, instream flow, and aquatic ecology studies. He has worked extensively throughout the western U.S. and is a recognized expert in the areas of Colorado River Basin endangered fish species, instream flow, water temperature modeling and habitat assessments. Dr. Miller's experience includes research and evaluations for several threatened, endangered, and candidate aquatic species in the Colorado River and Platte River basins. He has extensive experience in designing and conducting studies using the Instream Flow Incremental Methodology (IFIM), instream water temperature modeling and developing and implementing ecological models for aquatic systems. He has developed habitat suitability criteria for both anadromous and resident salmonids as well as warm-water game and forage species. Dr. Miller is a Certified Fisheries Scientist (No. 2008).

Cover Photo Credit

Bluehead Sucker (*Catostomus discobolus*).

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF THE BLUEHEAD SUCKER

Status

The bluehead sucker (*Catostomus discobolus*) is considered a sensitive species in Region 2 of the USDA Forest Service (USFS). It is native to the Colorado River Basin and ancient Lake Bonneville in Idaho, Utah, and Wyoming. Within Region 2, populations exist in western Colorado and south-central Wyoming. However, the only populations known to occur on lands managed by USFS Region 2 are located on the San Juan National Forest in southwestern Colorado.

Primary Threats

The primary threats to the bluehead sucker generally result from anthropogenic activities. Diversion of water results in changes in flow regime for mainstem rivers and tributary streams. Construction of passage barriers (e.g., diversion dams and reservoirs) within many rivers and streams causes habitat degradation and fragmentation. Introduction of non-native species increases predation on and competition with bluehead suckers. Other threats to this species include channelization of streams, land use that changes the landscape, and local development of riparian zones that reduces the natural function of the stream ecosystem. Detailed information concerning the distribution, life history, population trends, and community ecology of this species is relatively limited, and it typically comes from non-National Forest System lands. More specific information is needed at the local and regional levels prior to the development of management plans or actions for the bluehead sucker.

Primary Conservation Elements, Management Implications and Considerations

The general lack of information for this species suggests that management should begin with a detailed survey of drainages on National Forest System land that could hold populations of bluehead suckers. Like other species native to the Colorado River Basin, the bluehead sucker has not been well-studied until recent years. Fish studies currently underway in the Colorado River Basin are in conjunction with recovery efforts for species that are federally listed as Endangered. The information collected for bluehead sucker is only incidental to those prime studies but could be useful in developing management plans. The USFS should coordinate with other agencies (e.g., state game and fish departments, Bureau of Land Management, U.S. Fish and Wildlife Service) to obtain information from adjacent, downstream reaches that may be influenced by activities on the National Forest System lands. Given the known threats to this species, conservation measures should concentrate on maintaining habitat diversity and managing for natural temperature and flow regimes in stream reaches that contain bluehead sucker populations.

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the USDA Forest Service (USFS) Rocky Mountain Region (Region 2) (**Figure 1**). The bluehead sucker is the focus of an assessment because it is considered a sensitive species in Region 2. Within the National Forest System, a sensitive species is a plant or animal whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance and/or habitat capability that would reduce its distribution (FSM 2670.5 (19)). Due to concerns with population viability and abundance, a sensitive species requires special management. Consequently, knowledge of its biology and ecology is critical. This assessment addresses the biology, ecology, conservation, and management of the bluehead sucker throughout its range in Region 2. This introduction defines the goal of the assessment, outlines its scope, and describes the process used in its production.

Goal

The purpose of species conservation assessments produced as part of the Species Conservation Project is to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, conservation status, and management of certain species based on available scientific knowledge. The goals of this assessment limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. This assessment does not seek to develop specific management recommendations. Rather, it provides the ecological background upon which management must be based and focuses on the consequences of changes in the environment that result from management (i.e., management implications). Furthermore, it cites management recommendations proposed elsewhere and examines the success of those that have been implemented.

Scope

This assessment examines the biology, ecology, conservation, and management of the bluehead sucker with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. Although some of the literature originates from field investigations outside the region, this document places that literature in the ecological and social context of the central Rocky Mountains. Similarly, this assessment is concerned with the reproductive behavior, population dynamics, and other characteristics of bluehead sucker in the context of the current environment rather than under historical conditions. The evolutionary environment of the species is considered in conducting the synthesis, but placed in a current context.

In producing this assessment, we reviewed refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies. Not all publications on bluehead sucker are referenced in the assessment, nor are all published materials considered equally reliable. The assessment emphasizes refereed literature because this is the accepted standard in science. When information was unavailable elsewhere, we chose to use non-refereed publications and reports, but these were regarded with greater skepticism. Unpublished data (e.g., Natural Heritage Program records) were important in estimating the geographic distribution of the species. These data required special attention because of the diversity of persons and methods used in collection.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to this uncertainty is based on a progression of critical experiments to develop strong inference (Platt 1964). However, strong inference, as described by Platt, suggests that experiments will produce clean results (Hillborn and Mangel 1997), as may be observed in certain physical sciences. Ecological science, however, is more similar to geology than physics because of the difficulty in conducting critical experiments and the reliance on observation, inference, good thinking, and models to guide our understanding of the world (Hillborn and Mangel 1997). The geologist T. C. Chamberlain (1897) suggested an alternative approach to science where multiple competing hypotheses are confronted with observation and data. Sorting among alternatives may be accomplished using a variety of scientific tools (e.g., experiments, modeling, logical inference). A problem with using the approach outlined in both Chamberlain (1897) and Platt (1964) is that there is a tendency among scientists to resist change from a common paradigm. Treatment of uncertainty necessitates that a wide variety of hypotheses or experiments be undertaken to test both the true or false nature of the uncertainties at hand (Vadas 1994).

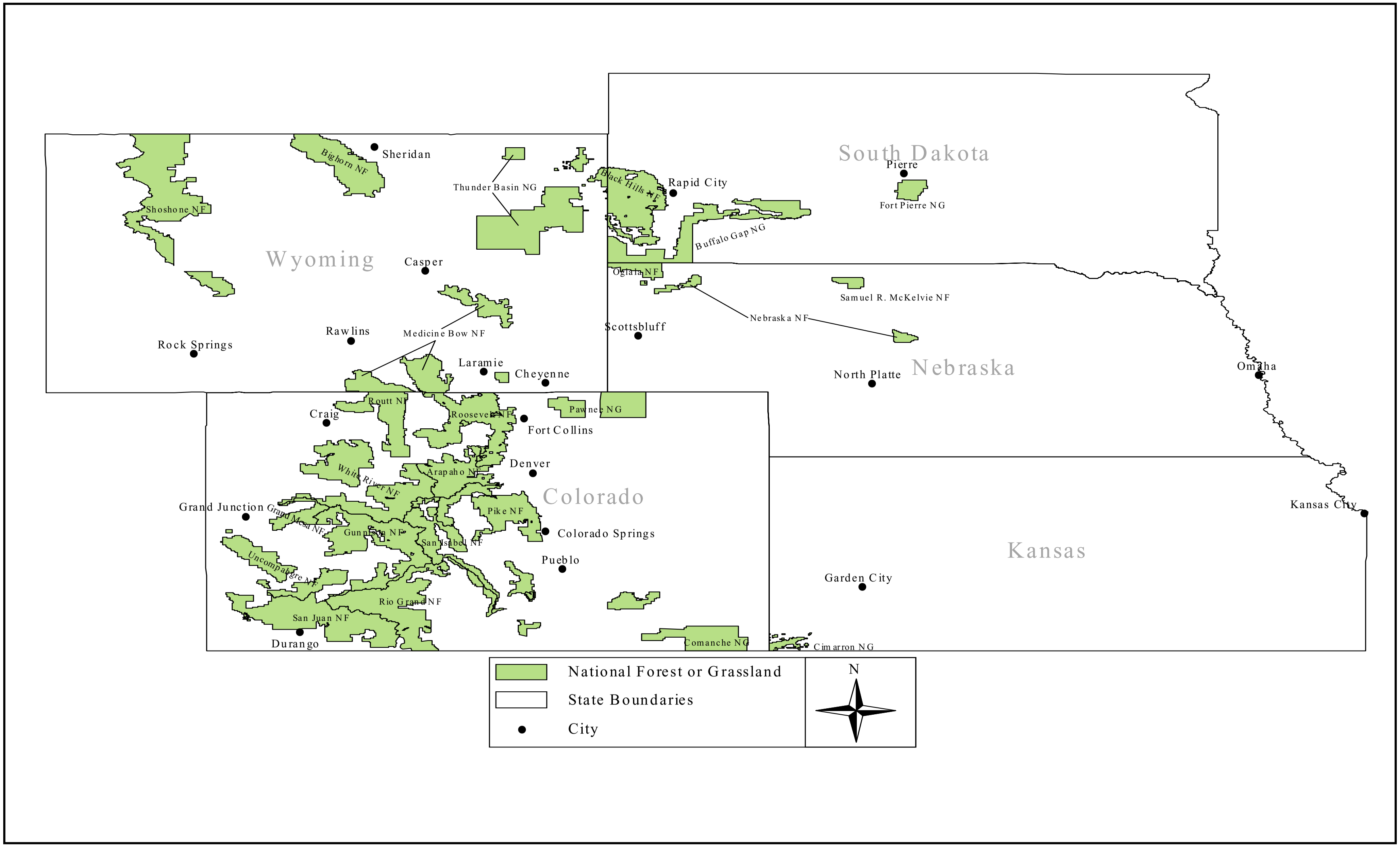

Figure 1. USDA Forest Service Region 2 national forests and grasslands.

Confronting uncertainty, then, is not prescriptive. While well-executed experiments represent a strong approach to developing knowledge, alternative approaches such as modeling, critical assessment of observations, and inference are accepted as sound approaches to understanding and used in synthesis for this assessment. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate.

The synthesis of material for the bluehead sucker included the use of the limited data sets that are available regarding the distribution, abundance, movements, habitat requirements, and life history of the species. Like many non-game, native fish, this species has not been extensively studied within Region 2, nor has it been extensively studied for all the parameters needed for the species assessment. The limited amount of information on key characteristics for the species and our lack of understanding concerning its needs create a great deal of uncertainty pertaining to the assessment for conservation of bluehead sucker. This species assessment has synthesized a wide range of available data throughout the Colorado River Basin, including historical and current distribution, conservation strategies, habitat needs, and management requirements. The general lack of precise information regarding species distribution on or near National Forest System land limits the actual data that can be used for this assessment. Using a sound scientific approach, we have inferred from available data to present an understanding of the current needs of the species for the purpose of this assessment.

Application and Interpretation Limits of This Assessment

Information used in this assessment was collected from studies that occurred throughout the geographical range of this species. The greatest emphasis for information regarding life histories and ecology was placed on studies and reports that were specific to Region 2. Although most information should apply broadly throughout the range of the species, it is likely that certain life history parameters (e.g., growth rate, longevity, spawning time) will differ along environmental gradients. Information regarding conservation status of the species pertains specifically to Region 2 and does not apply to other portions of the species' range.

Publication of Assessment on the World Wide Web

To facilitate the use of species assessments in the Species Conservation Project, they are being published on the Region 2 World Wide Web site (www.fs.fed.us/r2/projects/scp/assessments/index.shtml). Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, it facilitates their revision, which will be accomplished based on guidelines established by Region 2.

Peer Review

Assessments developed for the Species Conservation Project have been peer reviewed prior to their release on the Web. This report was reviewed through a process administered by the American Fisheries Society, which chose two recognized experts (on this or related taxa) to provide critical input on the manuscript. Peer review was designed to improve the quality of communication and to increase the rigor of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

The U.S. Fish and Wildlife Service does not list the bluehead sucker as federally threatened or endangered species, but other agencies have given it special status. The bluehead sucker currently has a Natural Heritage Program rank of G3G4 (globally vulnerable but apparently secure) and a state rank of S2 (imperiled) in Wyoming. The Bureau of Land Management (BLM) in Wyoming considers the bluehead sucker a sensitive species. Wyoming Game and Fish Department (WGFD) has assigned this species a state rank of NSS1, suggesting that its presence is extremely isolated and its habitats are declining or vulnerable. The Colorado Division of Wildlife (CDOW) has not given the bluehead sucker a special status, but the BLM in Colorado considers it a sensitive species. Bluehead suckers do not occur in Kansas, Nebraska, or South Dakota, but they do occur in several states outside of Region 2. The State of Utah considers the bluehead sucker to be a sensitive species, due to declining populations. In New Mexico, the species itself has no special status, but a subspecies, the

Zuni bluehead sucker (*Catostomus discobolus yarrowi*), is listed as endangered by the state and sensitive by the BLM in New Mexico. Idaho has not afforded the bluehead sucker special status.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

At this time there are no existing management strategies specific to the bluehead sucker. However, several states, including Colorado and Wyoming, have developed a "range-wide conservation agreement and strategy" to direct management for this species. By 2005, the CDOW intends to develop a "conservation/management plan" for bluehead sucker that will provide direction to research and management goals.

The CDOW has no regulations specifically designed to protect bluehead sucker, but several regulations are intended to protect native fish species and thus indirectly aid in the conservation of bluehead sucker. For example, live release of non-native fish species is prohibited in the Upper Colorado River Basin in Colorado. Another regulation that indirectly assists the conservation of bluehead sucker is a statewide statute that prohibits the seining, netting, trapping, or dipping of fish for bait in natural streams. Few, if any anglers specifically target bluehead suckers, but incidental take probably occurs as fisherman attempt to catch game fish species.

The WGFD has regulations regarding bluehead sucker habitat loss. The WGFD's objective is to permit projects in a manner that avoids altering or degrading the function of bluehead sucker habitat (Weitzel 2002). In addition, WGFD has regulations regarding baitfish that should assist in protecting bluehead suckers.

Ongoing recovery programs for federally-listed fish (e.g., Colorado pikeminnow [*Ptychocheilus lucius*], razorback sucker [*Xyrauchen texanus*]) in the Upper Colorado River Basin and San Juan River drainage should provide benefits for all native fish species. Recovery actions include recommendations to mimic a natural hydrograph (in-stream flow) and restrictions on non-native fish stocking within the basins.

Biology and Ecology

Systematics and general species description

The bluehead sucker belongs to the family Catostomidae, members of which are characterized by soft rays and a fleshy, subterminal, protractile mouth. This family is comprised of 12 genera and 60 species in the United States and Canada (Robins et al. 1991). Bluehead suckers are members of the genus *Catostomus* and subgenus *Pantosteus*. *Catostomus discobolus* has two recognized subspecies, *C. d. discobolus* and *C. d. yarrowi*. *Catostomus discobolus yarrowi* (Zuni bluehead sucker) occurs in small tributary streams in New Mexico and Arizona. *Catostomus discobolus discobolus* occurs throughout the remainder of the range of bluehead suckers. The focus of this document is on *C. d. discobolus*, and further reference will be made as *C. discobolus*.

The bluehead sucker can be differentiated from other Catostomids occurring sympatrically by several morphological characteristics. It possesses a cartilaginous scraping disc on the lip interior; this feature is lacking in both the white sucker (*Catostomus commersoni*) and the flannelmouth sucker (*C. latipinnis*). Bluehead suckers and mountain suckers (*C. platyrhynchus*) may occur sympatrically on the periphery of their distributions in smaller tributary streams. Both species possess a scraping disc, but the mountain sucker has an axillary process in the axil of the pelvic fin, which is lacking on the bluehead sucker. The reader should refer to Eddy and Underhill (1978) for identification and differentiation of bluehead suckers from other members of the genus *Catostomus*.

The following description of bluehead suckers is taken from Bezzerides and Bestgen (2002):

> "*Bluehead suckers have a short, broad head with a wide snout that overhangs a large mouth. Lips are large and the upper forms a fleshy hood over the mouth. The lower lip is shallowly notched at the midline. Small papillae are evenly scattered over the lower lip and oral face of the upper lip, but are absent from anterior face of upper lip. Both jaws have well-developed, cartilaginous scraping edges. The body is elongate and tapers to a caudal peduncle that varies in thickness. Fins are moderately sized, but the dorsal (rays 10-12[8-12]) may be enlarged and strongly falcate, or smaller and less concave (rays 9-10). Other fin ray counts are: pectorals 15-16[14-17]; pelvics 8-10[7-11], anal 7[7-8], and caudal 18.*
>
> *Other characteristics of bluehead suckers include: moderate- to small-sized scales, 90-110[78-122] in the lateral line series; predorsal scales usually more than 50-65[44-76]; gill rakers, 28 to 44 (usually more than 30) on the external*

row, with spines in two rows; the frontoparietal fontanelle is usually closed in adults, and reduced in immature specimens; and, a long intestine with 6 to 14 loops anterior to the liver.

In clear water, C. discobolus is typically dark olive to nearly black on the back and sides and yellowish on the belly, and in turbid water, silvery tan or lighter green above and dirty white below. The head is often bluish, thus the common name. Young fish are dusky above and white below."

Vanicek (1967) reports that young-of-the-year bluehead suckers in the Green River attain a total length of about 50 mm (2 inches) after one year. Juvenile bluehead suckers in the Green River reach a total length of about 90 mm (3.5 inches) after two years (Vanicek 1967). Age determination using scale analysis indicated that this species could achieve an age of at least 20 years in the Green River and other portions of the Colorado River Basin (Scoppettone 1988, Minckley 1991).

Distribution and abundance

Historically, bluehead suckers occurred in streams and rivers in the Colorado River Basin (Joseph et al. 1977, Bezzerides and Bestgen 2002) as well as in the drainages of the upper Snake, Weber, and Bear rivers (Sigler and Miller 1963, Sublette et al. 1990). However, only those populations found in the Colorado River Basin are within Region 2, and therefore, only those populations are discussed in this report. Within the Colorado River Basin, bluehead suckers are found in the Colorado, Dolores, Duchesne, Escalante, Fremont, Green, Gunnison, Price, San Juan, San Rafael, White, and Yampa rivers and numerous smaller tributaries (**Figure 2**; Vanicek et al. 1970, Bezzerides and Bestgen 2002). The bluehead sucker also occurs in the Little Colorado River drainage of the Lower Colorado River Basin (Minckley 1985). The range of the bluehead sucker often overlaps with that of other native suckers.

In the Colorado portion of Region 2, the bluehead sucker occupies most major tributaries associated with the Upper Colorado River Basin. Holden and Stalnaker (1975) found the bluehead sucker to be "common" to "abundant" at sample locations in the Yampa, Gunnison, middle to upper Green and Colorado rivers. Carlson et al. (1979) reported that the percent of bluehead suckers in fish collections ranged between 7.8 and 28.0 at six sites on the Yampa River between Dinosaur National Monument and the town of Hayden, Colorado. Miller and Rees (2000) indicated that the bluehead sucker was among the most common fish species collected in tributaries of the San Juan River. Most of these tributaries originate in the San Juan National Forest; however, the study area did not generally extend onto national forest property. Available data provided by Miller and Rees (2000) suggested that the range of bluehead suckers in the Piedra and San Juan rivers (and possibly other tributaries) included lower reaches in the San Juan National Forest.

In Wyoming, the range of bluehead suckers is smaller than historical reports indicate (Bezzerides and Bestgen 2002). It is known to occur in the Little Snake River and three tributaries, Savery Creek, Muddy Creek, and Littlefield Creek (Weitzel 2002). In a fish survey of 131 streams compiled by the Wyoming Game and Fish Department in 1987, bluehead suckers were collected in the Little Snake River beginning at the downstream most Stateline crossing, and extending upstream to the bridge on Highway 70 at Dixon, Wyoming (Oberholtzer 1987). They were also occasionally reported in collections upstream of Dixon and in Muddy Creek. Historical records indicate that bluehead suckers were widely distributed in Savery Creek in the mid-1950s. A follow-up study to assess the current distribution found a decline in most native species of fish, including the bluehead sucker (Wheeler 1997, Wyoming Game and Fish Department 1998).

Bluehead sucker populations exist in several tributary streams immediately downstream of lands managed by the Routt and San Juan national forests. These tributary streams include Divide Creek, Elkhead Creek, Florida River, La Plata River, Los Pinos River, and Rifle Creek. However, comprehensive annual and seasonal distribution information is lacking for these and other streams within Region 2.

Population trend

Recent work suggests that bluehead sucker populations are declining throughout their historic range (Wheeler 1997, Bezzerides and Bestgen 2002, Weitzel 2002). Currently, they are found in only 45 percent of their historic range in the Upper Colorado River Basin (Bezzerides and Bestgen 2002). The reasons for this decline are most likely due to the alteration of thermal and hydrologic regimes, degradation of habitat, and interactions with non-native species.

During the 1960s, two massive reductions in large river bluehead sucker populations occurred. In 1961, a non-game fish eradication program (using rotenone) was completed on a 112 km (69.6 miles) reach of the San Juan River (Olson 1962). In 1962,

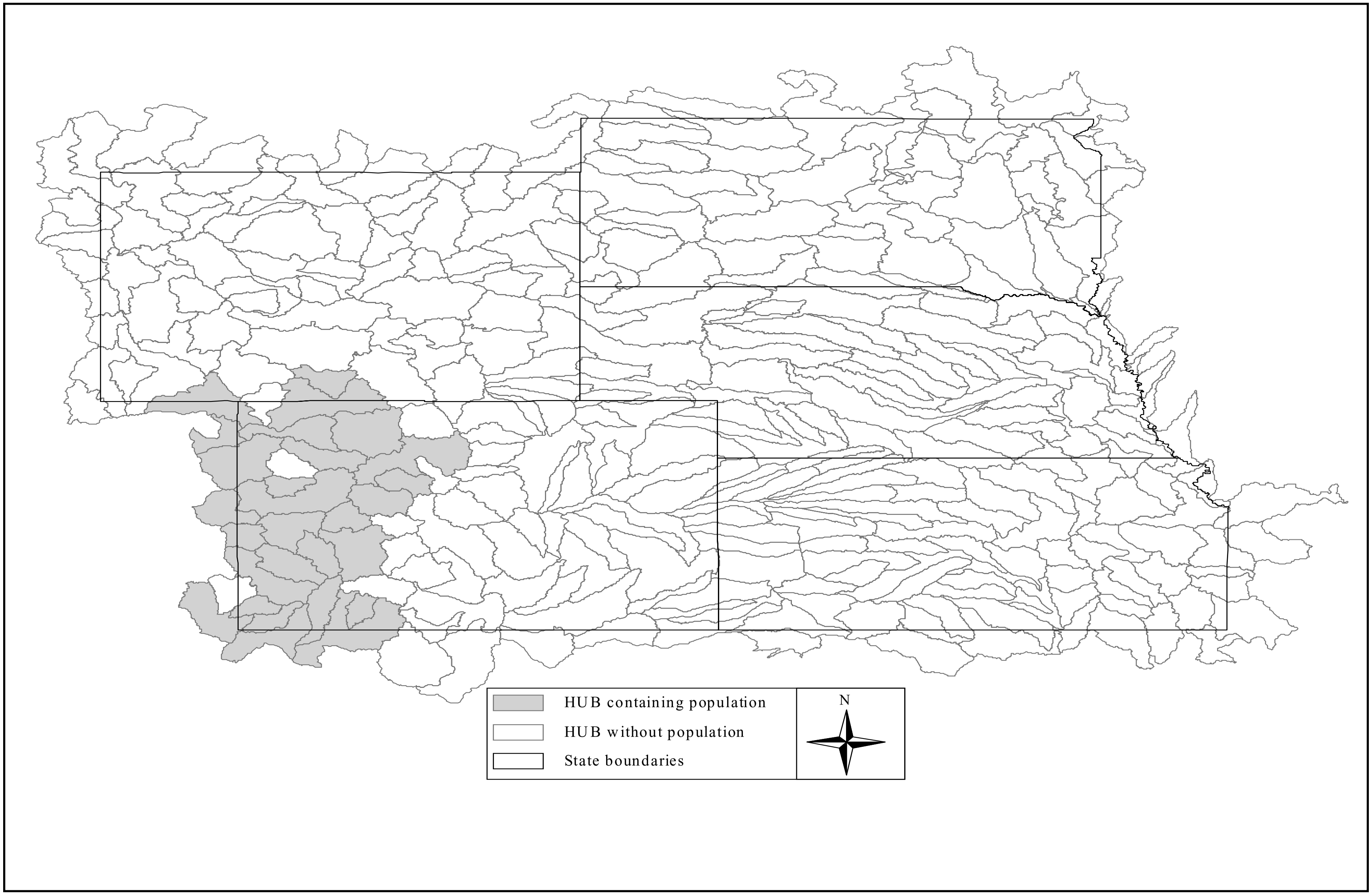

Figure 2. USDA Forest Service Region 2 hydrological unit boundaries (HUB) containing bluehead sucker populations.

a similar program was completed on 116 km (72.1 miles) of the Green River and many of its tributaries from the Colorado-Utah state line in an attempt to eliminate "coarse" fish prior to construction of Flaming Gorge and Fontenell dams (Binns 1967). Pre-treatment surveys indicated that bluehead suckers were abundant in the treatment area while post-treatment surveys showed that populations were completely eliminated. Bluehead suckers recolonized both rivers within a short time, but it is unknown what population-level impact each of these events had on this species.

Dam construction and the associated alterations of the thermal and hydrological regimes have reduced bluehead sucker populations in both the Lower and Upper Colorado River basins (Vanicek et al. 1970). Hypolimnetic releases below impoundments cause a change in the thermal regime in the river downstream, which is usually colder in the summer and warmer in the winter than historic conditions. Vanicek et al. (1970) found that the resulting change in temperature and flow regime created by Flaming Gorge Dam displaced bluehead suckers. Bluehead suckers were absent in the first 11 km (6.8 miles) downstream of Flaming Gorge Dam, but increased with distance downstream of the dam (Vanicek et al. 1970).

Activity pattern

Larvae of bluehead sucker are known to drift for various distances after emerging from the egg stage (Carter et al. 1986, Robinson et al. 1998). Information describing movement patterns of adult bluehead suckers is limited (Bezzerides and Bestgen 2002). Most studies have found this species to be relatively sedentary, moving only a few kilometers (Vanicek 1967, Holden and Crist 1981, Beyers et al. 2001, Rees and Miller 2001). However, Vanicek (1967) and Holden and Crist (1981) reported recapturing individuals more than 19 km (11.8 miles) from the original capture location, but these studies had relatively small sample sizes. Thus, bluehead sucker populations may exhibit both sedentary and mobile activity patterns; further study is warranted to define specific proclivities. Data on the timing and extent of spawning migrations of bluehead sucker are likewise limited. Weitzel (2002) reported bluehead suckers migrating into a creek to spawn in Wyoming.

Habitat

Although this species sometimes occupies areas of suitable habitat in larger, low elevation, mainstem streams, it is most commonly collected in small or mid-sized tributaries of the Upper Colorado River Basin. Most reaches of the basin receive heavy sediment loads, high annual peak flows, and low base flows. Little is known about the influence of these annual events, but healthy bluehead sucker populations have persisted in habitats with a wide range of annual flows, sediment transport and sediment deposition, providing that these physical events are associated with a natural flow regime.

Studies that determine specific habitat use related to diel or seasonal changes are rare; however, several researchers have made observations regarding habitat associations. Adult bluehead suckers exhibit a strong preference for specific habitat types (Holden and Stalnaker 1975). In-stream distribution is often related to the presence of rocky substrate which they prefer (Holden 1973). This species has been reported to typically be found in runs or riffles with rock or gravel substrate (Vanicek 1967, Holden and Stalnaker 1975, Carlson et al. 1979, Sublette et al. 1990). Juveniles have been collected from shallow riffles, backwaters, and eddies with silt or gravel substrate (Vanicek 1967).

Information concerning water quality requirements for bluehead suckers is lacking. Although the species generally inhabits streams with cool temperatures, bluehead suckers have been found inhabiting small creeks with water temperatures as high as 28 ^{o}C (82.4 ^{o}F) (Smith 1966). This species is found in a large variety of river systems ranging from large rivers with discharges of several hundred m^3 per sec to small creeks with less than a 0.05 m^3 per second (1.8 ft.^{3} per sec) (Smith 1966).

Food habits

Bluehead suckers are omnivorous, benthic foragers with uniquely adapted chisel-like ridges that occur inside the upper and lower lips (Sigler and Miller 1963, Joseph et al. 1977). The ridges allow this fish to scrape algae, benthic insects, and other organic and inorganic material from the surface of rocks (Vanicek 1967, Joseph et al. 1977, Carlson et al. 1979). Although the diet of bluehead sucker changes with age and location, their feeding strategy remains relatively consistent throughout their range. Bluehead sucker larvae (<25 mm [1 inch] total length) drift to backwaters or areas of low velocity where they are known to feed on diatoms, zooplankton, and dipteran larvae (Carter et al. 1986, Muth and Snyder 1995). Juveniles and adults reportedly consume a variety of inorganic material, organic material, and benthic macroinvertebrates (Childs et al. 1998, Osmundson 1999, Brooks et al. 2000). Vanicek (1967) found that gut samples from bluehead suckers from the Green River contained mud, filamentous algae, and Chironomidae larvae. Carlson et al. (1979) reported that gut samples collected from bluehead suckers during August and September in the Yampa River contained mostly periphyton (algae) and a few invertebrates.

It is unknown if bluehead suckers demonstrate an active shift in diet preference due to seasonal or hydrologic regime changes.

Breeding biology

McAda and Wydoski (1983) determined that the majority of male and female bluehead suckers in the Upper Colorado River Basin were sexually mature at total lengths greater than 380 mm (15 inches). In smaller streams, bluehead suckers mature at smaller sizes. McAda and Wydoski (1983) reported that the smallest mature female was 313 mm (12.3 inches) total length; however, Smith (1966) reported mature females as small as 79 mm (3.1 inches) from a small tributary stream in Arizona.

Bluehead suckers spawn in the spring and early summer. Holden (1973) and Andreasen and Barnes (1975) reported spawning activity occurring during June and July in the Upper Colorado River Basin. Vanicek (1967) reported ripe bluehead suckers present in the Green River during June or July, depending on water temperature. All ripe fish that were collected occurred in pools or slow runs associated with large cobble or boulders. Spawning of bluehead suckers was observed by Maddux and Kepner (1988) in Kanab Creek, Arizona on 2 May 1985. They reported that spawning occurred during daylight hours over a "cleaned depression" in gravel substrate with a mean particle diameter of 6.6 mm (0.26 inches). Spawning occurred as one or two males positioned themselves laterally with the female and created a depression by fanning and shuddering of the body and fins, with the female subsequently releasing eggs into the depression. Spawning occurred when water temperatures ranged from 18.2 to 24.6 ^{o}C (64.8 to 76.3 ^{o}F), and water velocities at spawning sites were always between 0.34 and 0.35 m per sec (1.11 and 1.12 ft. per sec) (Maddux and Kepner 1988).

Bluehead suckers are a long-lived species with maximum ages reported over 20 years in the Upper Colorado River Basin (Scoppettone 1988, Minckley 1991). Similar to other sucker species, males comprise a higher proportion of the spawning population than do females. Maddux and Kepner (1988) and Otis (1994) report male to female sex ratios of approximately 2:1.

There is significant variability in the number of eggs produced by the same length reproductive females between rivers (P = 0.001) as well as between years in the same river (P = 0.05) (McAda 1977). McAda (1977) established relationships between total length and fecundity for the Colorado, Gunnison, and Yampa rivers. His estimates for a 319 mm (12.6 inches) fish ranged from 5,050 eggs for a fish in the Yampa River to 7,761 eggs for a fish in the Colorado River. Comparatively, Smith (1966) estimated that a 319 mm total length female in the Green River contained 8,500 eggs.

Demography

Hybridization between bluehead suckers and other sucker species occurs throughout the range of this species. Bluehead suckers are known to hybridize with the native flannelmouth sucker and mountain sucker, as well as the non-native white sucker (Bezzerides and Bestgen 2002).

In natural or minimally altered systems, certain undefined mechanisms (e.g., depth and velocity requirements, habitat selection, spawning timing) likely isolate spawning individuals of bluehead sucker and flannelmouth sucker; however, hybrids of these two species do occur (Hubbs and Hubbs 1947, Hubbs and Miller 1953, Whiteman 2000, authors' unpublished data). The most common instance of hybridization, and perhaps the most detrimental, occurs with the non-native white sucker. These two species have no natural mechanisms to isolate reproductive individuals, which can lead to an increased occurrence of hybridization. Where sympatric populations of bluehead and white suckers occur, hybridization is likely to occur. However, the reproductive viability of hybrids is unknown, and the overall impact is unclear. Contradictory reports on abundance of hybrids within the same system increase the uncertainty. Holden and Stalnaker (1975) found bluehead and white sucker hybrids to be common in the Yampa River; however, in a later survey Holden and Crist (1981) did not find any of these hybrids within the Yampa River system.

General life history characteristics are reviewed in the Breeding biology section of this document and are not repeated here. The development of a meaningful life cycle diagram for bluehead sucker requires life stage-specific data regarding survival rates, fecundity, and sex ratio. Existing data on bluehead sucker survival rates and fecundity components necessary to construct a life cycle diagram are sparse, especially data specific to bluehead populations occurring in smaller tributary streams. We include the following life cycle description as illustration of the data needed to refine the model (**Figure 3**).

Input data needed for a population projection matrix model consist of age-specific survival and fecundity rates, and very little data of this type are available for the bluehead sucker. We used bluehead sucker data from McAda (1977) to provide average adult fecundity estimates. Length at age is highly variable for bluehead suckers, and therefore we chose to use an average fecundity for all adult ages. We are unaware of age-specific survival rate information for bluehead suckers. We constructed a simple life table to provide estimates for survival rates. Gender specific survival rates or fertility rates of bluehead sucker have not been reported. To provide some information on survival and population dynamics, we have used a general survival rate for both males and females. The value for eggs per mature female is an estimate for an approximately 400 mm (15.7 inches) total length female. This data was calculated from regression equations presented in McAda (1977). The annual survival rates (**Figure 3**, **Table 1**) provide longevity of the species to over age 20. Bluehead sucker populations likely have variable survival rates, depending on the flow regime and water quality characteristics at the time of spawning. Long-lived species such as bluehead suckers would not require high recruitment success of individuals each year. Typical of many long-lived fish species, the bluehead sucker likely has a high mortality rate from egg through age 1, followed by decreasing mortality rate and probably fairly constant mortality rates for adult fish. This life history trait would provide large cohorts with which to infuse the population in years when conditions were optimal for spawning. This pulse of young bluehead suckers would provide a strong cohort that would replenish or augment the adult population until the next period of favorable spawning conditions. Spawning and recruitment likely takes place each year but with a very high rate of variability and overall success dependent on fluctuating environmental conditions.

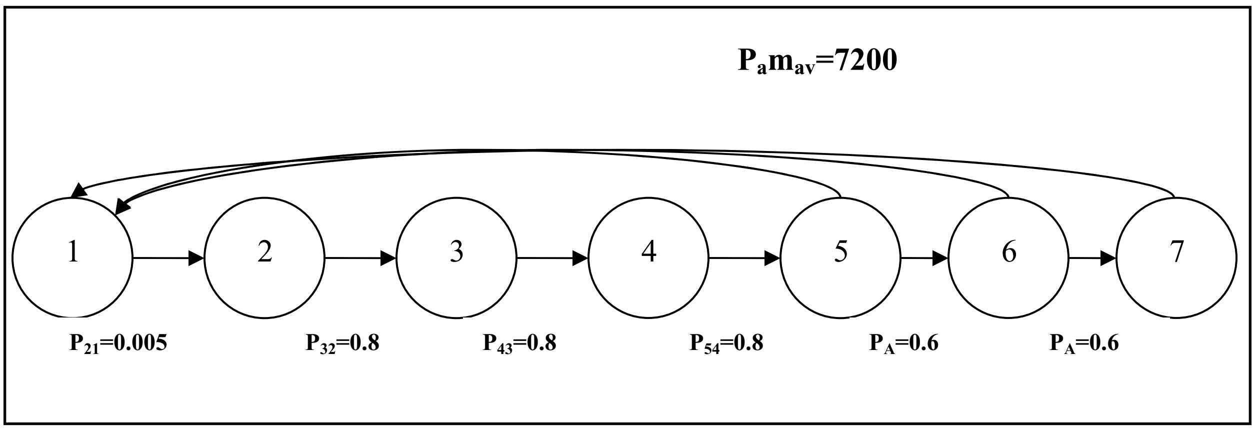

Figure 3. Life cycle graph for bluehead sucker showing both the symbolic and numeric values for the vital rates. The circles denote the 7+ age classes in the life cycle, first year through adult females. Arrows denote survival rates. Survival and fertility rates provide the transition between age classes. Fertilities involve offspring production, mi, number of female eggs per female as well as survival of the female spawners.

Table 1. Parameter values for the component terms (Pi and mi) that make up the vital rates in the projection matrix for bluehead sucker. Fecundity was estimated from data presented in McAda (1977).

Parameter	Numeric value	Interpretation
P_{21}	0.005	First year survival rate
P_{32}	0.80	Survival from 2^{nd} to 3^{rd} year
P_{43}	0.80	Survival from 3^{rd} to 4^{th} year
P_{54}	0.80	Survival from 4^{th} to 5^{th} year
P_a	0.60	Survival for adults
m_{av}	12000	Average fecundity for mature females

Community ecology

Historically, the bluehead, flannelmouth, and razorback suckers comprised the medium to large size Catostomid population in the Upper Colorado River Basin. Currently, distribution and abundance of bluehead suckers have diminished (Bezzerides and Bestgen 2002). Dams and diversions that isolate small populations in headwater reaches are the principal cause for reduction of the bluehead sucker's range. This species has been eliminated from areas inundated by reservoirs, and upstream migration has been blocked by dams. Fragmentation of populations may lead to a decrease in genetic diversity in isolated populations and a higher risk of extirpation of isolated populations due to catastrophic events. Reduction of bluehead sucker range and abundance has also been attributed in part to interactions with non-native species, changes in flow regime, increases in fine sediment loads, reductions in backwater and flooded habitats, and other types of habitat alteration (i.e., channelization).

The introduced white sucker and channel catfish (*Ictalurus punctatus*) have diets that partially overlap with bluehead sucker and are thus competitors for food resources. In addition to competing with bluehead suckers, several non-native and native fishes prey on bluehead suckers. Tyus and Beard (1990) and Nesler (1995) documented northern pike (*Esox lucius*) predation on bluehead sucker in the Yampa River, Colorado; however, the proportion of bluehead suckers in the diet of northern pike was relatively minor in both studies. It is also possible that bluehead suckers are taken as prey where they occur sympatrically with nonnative piscivors. These include brown trout (*Salmo trutta*), rainbow trout (*Oncorynchis mykiss*), red shiner (*Cyprinella lutrensis*), channel catfish, and smallmouth bass (*Micropterus dolomieu*). Predation on native suckers has been documented in the San Juan River, New Mexico and Yampa and Green rivers, Colorado (Brooks et al. 2000, Ruppert et al. 1993).

Young bluehead suckers are used as a forage fish by several native piscivorous species, including roundtail chub (*Gila robusta*) and Colorado pikeminnow. Populations of bluehead suckers often occur in smaller streams and at higher elevations than are inhabited by Colorado pikeminnow, which are restricted to larger river systems such as the Colorado, Green, Yampa, White, and Gunnison rivers. Consequently, in the small tributary streams, bluehead sucker populations are not a prey source for Colorado pikeminnow (Joseph et al. 1977); however, when these two species occur sympatrically, bluehead suckers are likely an important prey item.

Little is known about the impact of disease and parasites on bluehead sucker populations. Landye et al. (1999) surveyed the occurrence of parasites on bluehead suckers in the San Juan River from 1992 to 1999. Asian tapeworm (*Bothriocephalus acheilognathi*) and anchor worm (*Lernia*) were found in the system, but neither was found to infect bluehead suckers (Landye et al. 1999). Bluehead suckers were found to have a much lower rate of disease than flannelmouth suckers. The parasites, *Trichodina* and *Gyrodactylus*, were found to infect bluehead suckers in the San Juan River (Landye et al. 1999). Brienholt and Heckmann (1980) found that over 92 percent of the bluehead suckers from two Utah creeks were infected with parasites. Parasites and disease can adversely affect fish health; however, the extent of the impact and role in bluehead sucker mortality is unknown.

The bluehead sucker is an integral component of the aquatic ecosystem. Bluehead suckers provide an important link to the conversion of periphyton and algal communities into energy available to higher trophic levels. They possess a morphological adaptation (cartilaginous ridge) not found in other native and non-native sucker species within the majority of its range.

An envirogram for bluehead suckers was developed to help elucidate the relationships between land use practices/management and bluehead sucker population characteristics (**Figure 4**). In general, the usefulness of an envirogram is the visual representation of linkages between bluehead sucker life history parameters and environmental and biological factors affecting them. Those elements that directly affect the bluehead sucker are depicted in the envirogram by the centrum, which is further separated into resources, predators, and malentities. Resources elicit positive responses in bluehead suckers whereas predators and malentities produce either negative or neutral responses. Web levels illustrate factors that modify elements within the centrum or within the next lower web level. Andrewartha and Birch (1984) provide further detail into the specific description of all envirogram components. The relative importance of the linkages is poorly understood and warrants further study.

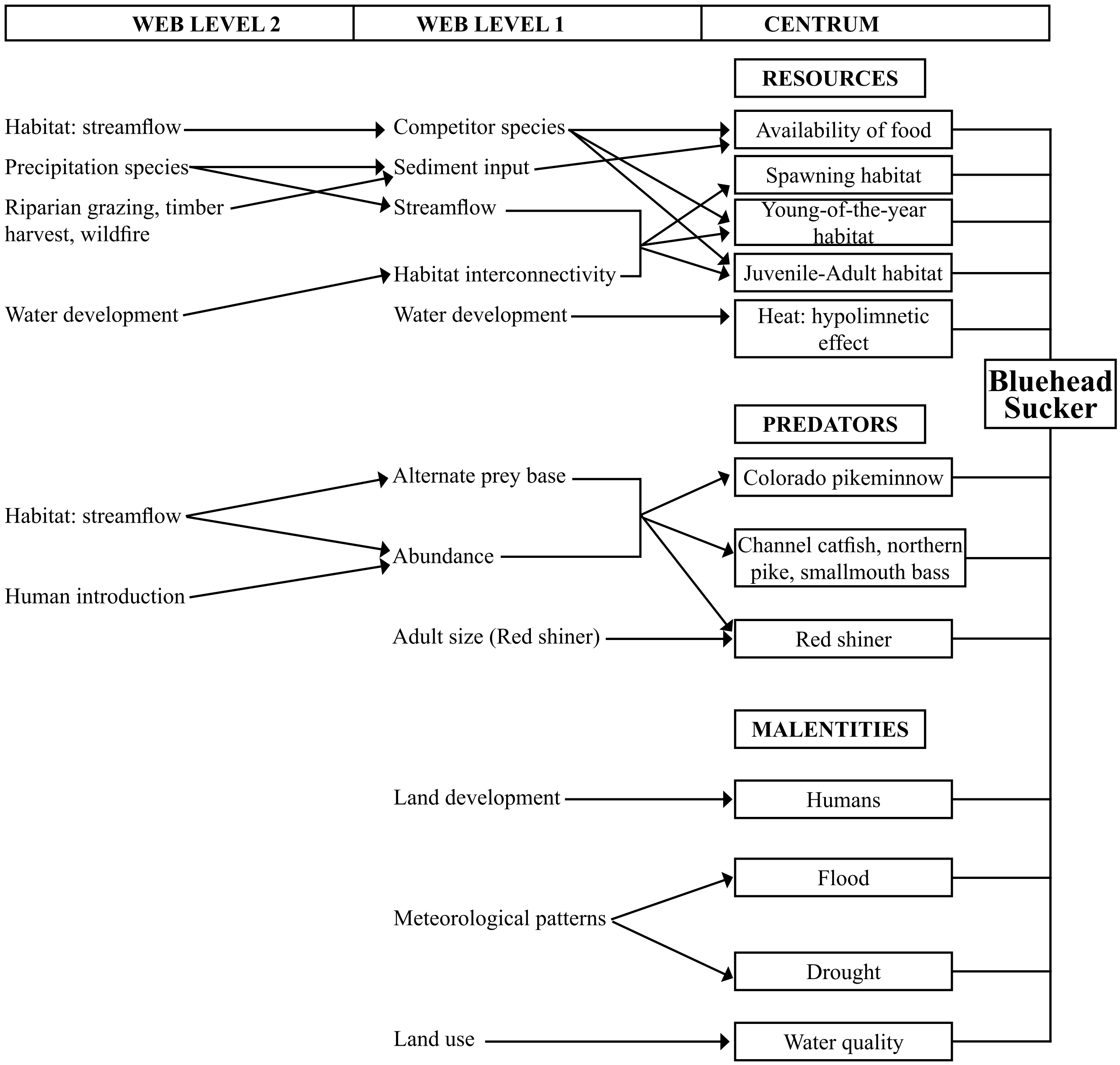

Figure 4. Envirogram for the bluehead sucker.

CONSERVATION

Threats

The native fish community that evolved in the warm-water reaches of the Upper Colorado River Basin has been greatly reduced as a result of human activities during the last century. Bluehead sucker populations have suffered reductions in abundance and distribution from the same mechanisms that have caused the extirpation and near extinction of other endemic fish species in this drainage. These mechanisms can be separated into two general categories that encompass the majority of the threats to the current and future survival of bluehead sucker: 1) habitat degradation through loss, modification, and/or fragmentation and 2) interactions with non-native species.

Both of these threats imperil the long-term persistence of the bluehead sucker. Each may work independently or in conjunction with the other to create an environment where populations may be reduced or eliminated. The relative importance of each threat and the specific cause-effect relationship usually depend on location. The complexity of each threat requires further explanation.

Effects of habitat degradation may not be limited to localized areas but may cascade through the system. Therefore, activities or events occurring on forest lands may possibly have detrimental impacts on populations of bluehead suckers existing in rivers many kilometers downstream of National Forest System lands.

Habitat loss typically occurs when streams are dewatered or when reservoir construction inundates suitable bluehead sucker stream habitat. Habitat modification occurs when the natural flow regime is altered, and when stream channels are modified due to channelization, scouring, or sedimentation from land use practices. Land use practices that can impact stream channels include construction of roads through highly erodible soils, improper timber harvest practices, and overgrazing of riparian areas. These can all lead to increased sediment load in the system and a subsequent change in stream channel geometry (e.g., widening, incision). These modifications alter width: depth ratios, pool:riffle ratios, and other aspects such as pool depth that affect the quality of habitat occupied by bluehead suckers.

The effect of wildfire has little direct impact on quality of habitat; however, post-fire conditions can affect downstream populations. Input of large quantities of sediment into streams frequently occurs during storm events at recently burned areas. The increased sediment load can diminish suitable spawning habitat, smother eggs and larvae, reduce fitness of juvenile and adults through reduction of the prey base, and cause direct mortality through suffocation of all life stages.

Habitat fragmentation is often a result of dewatering, but it also results from the creation of barriers to fish passage such as dams and diversions. Large and small-scale water development projects can profoundly impact the persistence of the bluehead sucker. Irrigation diversions and small capacity irrigation reservoirs reduce streamflow, alter the natural hydrograph, and provide barriers to migration and normal population exchange. Barriers that preclude fish passage can cause population fragmentation and completely prevent or significantly reduce genetic exchange between populations. The fragmented populations in some areas remain viable and maintain population levels at the same density as they were before fragmentation occurred. This typically occurs in the larger mainstem river sections. In smaller rivers and tributaries to the mainstem, habitat fragmentation can eventually lead to habitat loss and extirpation of populations. As habitat is fragmented and populations are isolated, the probability that "bottlenecks" will occur in the life history of the bluehead sucker become more pronounced, and single catastrophic events may extirpate populations from entire drainages.

Habitat modification contains aspects already discussed under fragmentation and degradation but also includes changes in temperature and flow regimes, as well as alterations to water chemistry related to pollution. Severely reduced streamflows may lead to increased water temperatures and reduced dissolved oxygen levels, especially in smaller tributaries, especially those with degraded riparian habitat. Although specific tolerances to water quality parameters (i.e., temperature, dissolved oxygen, toxicants) are undefined for this species, it is likely that as water quality is altered from the natural unimpacted range, bluehead sucker fitness also declines. During periods of elevated summer water temperatures and decreased baseflows, bluehead suckers were observed in stressed condition with evidence of increased adult mortality compared to periods of normal summer temperatures and baseflows (author's personal observation).

Water developments, road construction, timber harvest, and grazing of riparian areas are likely to continue to impact bluehead sucker habitat in the future. Modification of land use management techniques to decrease the impact to bluehead sucker habitat may lessen the anthropogenic threats to this species, however, it is unlikely that all impacts or threats could be minimized or halted. Modifications of land use management techniques include the specification of fish passage at new or existing low-head diversions to eliminate or reduce habitat loss and fragmentation, specification of minimum flow regimes to promote habitat connectivity, and maintenance of baseflow habitat during summer or irrigation seasons. Other practices include specifications for buffer zones for both road construction and timber harvest, and managing grazing practices in riparian areas to promote healthy vegetative development and to reduce sedimentation from upland areas.

Interaction with non-native species is another threat to bluehead sucker population health and viability. Non-native species prey upon, compete with, and hybridize with bluehead suckers when found sympatrically. Many introduced species tend to be well-adapted to a variety of environmental conditions, allowing a competitive advantage. Without fish passage barriers, the introduction of non-native fish into stream reaches that do not contain bluehead suckers often results in the uncontrollable dispersal of these fishes into stream reaches containing bluehead suckers.

All life stages of the introduced white sucker, due to similar life history traits, have a competitive impact on bluehead sucker populations. However, perhaps the most serious threat imposed by the introduction of white suckers is perhaps hybridization. These two species appear to lack any significant mechanism to isolate reproductive individuals, and distribution and abundance of white suckers are increasing within the Upper Colorado River Basin. Further treatment of hybridization can be found in the Demography section.

The bluehead sucker is likely a desirable prey item for some non-native species. Large, non-native predators (e.g., northern pike, channel catfish, smallmouth bass) occur in many of the drainages that contain bluehead suckers. In addition, red shiners have been reported to feed on native larval fish within the Upper Colorado River Basin. Preferred habitat for red shiners is slack water shoreline or backwater areas, which are the same habitats utilized by larval bluehead suckers (Holden 1999).

The current distribution and the historical range-wide distribution of bluehead sucker indicate that few populations occurred on USFS lands. In fact, many sucker populations in the mainstem rivers likely occurred downstream of current Region 2 lands. The proximity to Region 2 lands and the effects of some of the threats such as increased sedimentation from grazing, timber practices, and road construction could impact the downstream populations. Fragmentation of populations or habitat loss may exist as barriers to migration occurring on occupied USFS land stream reaches (i.e., impassable water diversion or road crossing structures). Both of those threats could be eliminated by designing fish passage inclusive with construction of diversions and proper sizing of road crossings for culverts or bridges to allow natural passage conditions.

Conservation Status of the Bluehead Sucker in Region 2

At present, there is concern regarding the status of bluehead suckers in the Colorado River Basin. Although the specific mechanisms of most threats to this species are poorly understood, the species appears to be vulnerable throughout its range in the Upper Colorado River Basin due to the combined impacts of habitat loss, habitat degradation, habitat fragmentation, and interactions with non-native species. A decrease in bluehead sucker populations has been documented or suggested throughout most of the basin (Bezzerides and Bestgen 2002).

Healthy populations of bluehead sucker still exist in various locations in the Upper Colorado River Basin (e.g., Colorado, Green, Yampa, San Juan rivers). These locations are usually defined by suitable habitat (as specified in the Habitat section of this report), and natural temperature and flow regimes. They often maintain healthy populations of other native fish species as well.

The bluehead sucker evolved in a system with a high natural disturbance regime. This disturbance regime included a large contrast between annual peak flows and base flows, and considerable sediment transport. Life history attributes and population dynamics allowed this species to persist during (or recolonize after) a disturbance event; however, modifications to the physical (habitat loss, fragmentation, refugia) and biological environment (non-native species) have reduced the ability to recover after such an event. Habitat fragmentation through streamflow reduction, passage barriers, and habitat degradation disconnects populations of bluehead suckers. Competition, predation, and hybridization associated with non-native species can depress bluehead sucker populations to precarious levels.

Based on the impacts to bluehead sucker populations and distribution that have occurred in the last century, the potential for future declines in distribution and abundance is high. Unless alleviated, habitat loss, habitat degradation, habitat fragmentation, and non-native species interactions will likely intensify and jeopardize the existence of the bluehead sucker.

Potential Management of the Bluehead Sucker in Region 2

Implications and potential conservation elements

Management of the bluehead sucker is based on an understanding of specific threats to the species. Habitat loss, degradation, and fragmentation due to land and water use practices are prime threats to bluehead sucker persistence in the Upper Colorado River Basin. Reduction of streamflows and creation of barriers to fish passage can severely degrade habitat to the extent that bluehead sucker populations are extirpated from the area. The degree of influence that population fragmentation has on bluehead sucker populations is speculative, but it could potentially impact the long-term persistence of this species. Creating isolated populations disrupts the natural exchange of genetic material between populations. Isolated populations are subject to extinction due to catastrophic events because of the impediment to recolonization from other nearby populations. Loss of genetic diversity can also lead to depression of fecundity and survival rates. The genetic exchange along a metapopulation framework within bluehead sucker distribution can provide the required demographic variability and viability.

Other considerations for conservation elements should include protection of riparian areas, minimization of sediment input due to anthropogenic causes (e.g., road building, timber harvest), and management of non-native fish species. Construction associated with road improvements or development, timber harvesting, grazing, and fire activity can result in increased sediment loads to adjacent streams. It is likely that increased sediment loads or sediment deposition could have a negative impact on bluehead sucker populations; however, specific thresholds and mechanisms associated with this impact have not been studied well enough to make precise predictions.

Management of non-native fish species requires strict adherence to existing regulations regarding live release of fish. Interactions between bluehead sucker and non-native fish species threaten bluehead sucker populations. Specifically, competition between bluehead sucker and introduced sucker species and predation by large non-native predatory species represent the two most deleterious effects of non-native interaction. Implementation of management strategies should be designed to restrain further expansion of nonnative fish distribution on National Forest System lands. These strategies should include strict enforcement of existing prohibitions regarding the release of non-native fish. Programs for the eradication of non-native fish in streams and within the historical range of bluehead sucker may also be considered.

The preservation of stream flows that are adequate to maintain complex habitat, interconnectivity of habitats, and instream cover should be a focal point of management policy or strategy. Conservation elements should address the function of the entire aquatic and riparian ecosystem, with particular attention to downstream populations. Any future plans for the conservation of bluehead suckers should take into account the entire native fish assemblage in the Colorado River Basin. This assemblage of species evolved in a system with a high differential between peak spring runoff and fall base flows. Native fish species of the Colorado River all require similar management considerations related to channel maintenance and restoration of historical flow regimes.

Tools and practices

The following review describes specific tools and techniques employed in the collection of bluehead sucker data. We are unaware of any management approaches implemented specifically for bluehead suckers in Region 2. Because little information exists or is being currently collected regarding this species, this portion will deal with techniques intended to gather the missing or needed information from the next section, Information Needs.

The absence of distribution and abundance data for bluehead sucker in Region 2 (with emphasis toward National Forest System land) should be a concern to forest managers. Because the bluehead sucker is a benthic fish often found in riffle areas, the use of electrofishing as a means to determine distribution and abundance is warranted. The initial priority should be a complete survey of National Forest System streams that possibly contain bluehead suckers. The compilation of all available (agency, academia, private) distribution data into a comprehensive database would provide a foundation to which further surveys could update and identify unknown populations. Concurrently with distribution surveys, general stream reach habitat surveys should be collected to provide additional information regarding the habitat use of bluehead suckers. Winters and Gallagher (1997) developed a basin-wide habitat inventory protocol that would be a cost-effective tool to collect general habitat data.

Once basic distribution information has been gathered, intensive population estimates would provide baseline information with which the effectiveness of future management strategies could be evaluated. Focus should be on areas where future management strategies may include activities that could possibly impact bluehead sucker populations. However, the long-term monitoring goal should be population estimates and population trend data on all streams containing bluehead sucker populations on Region 2 lands. Consultation with agencies managing populations off USFS lands but which are affected by forest practices is imperative to allow forest managers to continually monitor the status of those populations. Electrofishing techniques that would provide population estimates include mark/recapture and multiple pass removal estimates. Each has its advantages; however, due to the smaller size of many streams on National Forest System lands, estimating populations using a depletion/removal technique should be a cost effective method to produce high quality data. Riley and Fausch (1992) recommend that a minimum of three passes be conducted when using the removal method. Use of a single pass method to develop a catch per unit of effort (CPUE) index is cost-effective on a time basis, but precision may be sacrificed and the introduction of bias more likely, especially over long-term monitoring with significant researcher/technician turnover. With removal estimates, researchers are able to calculate confidence intervals, allowing insight into sampling quality.

A large data gap exists in the knowledge of bluehead sucker movement and stream use on National Forest System lands. The implementation of a survey methodology to determine bluehead sucker distribution and abundance can also provide insight into movement and growth through the use of passive integrated transponder (PIT) tags. PIT tags are unobtrusive, long lasting (indefinitely), uniquely coded tags that allow the efficient determination of movement with a minimum of disturbance. Other marking techniques (e.g., floy tags) lack the longevity of tag retention provided with a PIT tag. However, any marking technique used will require subsequent surveys to provide data. PIT tags are currently being used successfully in the San Juan River to determine growth and movement of native sucker species. Establishment of a long-term monitoring program would be required. The time required to develop a robust data set depends upon sample size, recapture rates, and survey frequency.

Habitat selection and preference can be determined through the use of a variety of techniques. The simplest technique involves correlating capture locations (during distribution surveys) to specific habitat types. Construction of habitat suitability curves is time intensive but could be used in conjunction with hydraulic modeling methodologies to estimate how habitat changes in relation to streamflow. This would allow land use managers to effectively compare the impacts of different altered flow regimes (due to water development projects) on bluehead sucker habitat. Data obtained could also be used to justify the acquisition of adequate instream flows for bluehead suckers and other native fishes.

Defining the relationship between habitat alteration and bluehead sucker population characteristics will be a difficult task. This process may require significant amounts of data, including:

- ❖ quantitative analysis of differences in prey base over time
- ❖ measurement of changes in habitat quality/function
- ❖ some form of abundance estimates.

In addition to collecting data specifically related to the distribution and life history of bluehead suckers, forest managers can implement techniques that will increase the quality of habitat and ensure that barriers do not fragment populations.

A healthy riparian corridor is important to overall aquatic ecosystem function. Forest managers can address minor riparian issues by altering the grazing rotation or by fencing riparian areas. In areas with severely degraded riparian growth, revegetation of the riparian area may also be prudent. Other tools and techniques to improve habitat condition and function could include physical habitat restoration. This technique can be costly and time-intensive and may only be practical when other options (i.e., preventing grazing, revegetation) fail or become infeasible.

In addition to proper future design of stream culverts that when improperly constructed can act as fish passage barriers, managers should inventory and assess the threat of all potential barriers currently in place. Barriers located within the bluehead sucker range (as defined by distributional surveys) on national forests should receive priority and, when possible, be removed.

The mechanical removal of non-native fish is currently being conducted in larger streams and rivers within the Upper Colorado River Basin, which contain bluehead sucker populations. The effectiveness of this technique to significantly reduce non-native populations is not clearly understood. Mechanical removal is likely most effectively utilized before non-native populations become well established.

In order to effectively gather data valuable to the conservation of this species, managers need to coordinate with federal and state agencies, academia, and private firms managing or studying portions of streams downstream of USFS lands to determine or verify the distribution and abundance of bluehead sucker populations existing elsewhere but that are still affected by USFS management policies and strategies.

Information Needs

Much of the information that has been collected regarding the bluehead sucker has been presented as a byproduct of studies that were designed to learn more about federally listed fish in the Colorado River Basin. In order to attain the level of understanding that is necessary to properly manage this species at a localized level, specific studies must be conducted by drainage. General information needs for bluehead sucker include a wide range of information:

- distribution
- habitat requirements and associations
- general attributes of life history and ecology
- movement patterns
- influence of non-native fish
- an understanding of human-induced habitat modification.

The current distribution of bluehead sucker on National Forest System lands in Region 2 is poorly understood. Specific knowledge of streams and watersheds containing bluehead sucker on USFS lands is essential prior to developing any regional management strategies designed to preserve this species. Basic knowledge regarding locations of specific bluehead sucker populations is inadequate or obsolete. A research priority should be to survey all streams with potential bluehead sucker habitat for the presence of this species. Initial focus should be on streams with suspected populations or known populations downstream of USFS lands. During these surveys, information regarding the physical and chemical characteristics of the habitat should be obtained. Data collected should include chemical (e.g., dissolved oxygen, pollutants, water temperature) and physical (e.g., elevation, discharge, depth, turbidity, substrate, habitat type) characteristics. This information will provide baseline data regarding habitat requirements and acceptable ranges for each physical parameter. Fish that are collected should be tagged with PIT tags to allow studies of movement, migration, and growth rates during continued monitoring.

In addition to general distribution and abundance information, additional data on seasonal distribution are required. Bluehead sucker may not establish resident populations in National Forest System streams, but these tributaries may in fact provide important spawning habitat. The available data on habitat use emphasizes large river systems, and few studies have been conducted on smaller tributary systems. It is unknown whether bluehead sucker life history traits are uniform between large river and small tributary systems. Temporal and spatial changes in abundance, distribution, and age structure should be documented prior to implementation of conservation strategies.

A data gap exists in basic life history information for the bluehead sucker. Habitat requirements and preferences are poorly understood for most life stages and life history events. Specific studies need to be designed to provide information on spawning behavior and habitat, larval biology, and the importance of larval drift. Habitat requirements and feeding habits at each life stage should also be addressed. Monitoring of tagged fish will also provide an estimate of survival rate that is a necessary component for the creation of a life cycle diagram. It may be important to collect data from several sub-basins because much of the specific life history information may vary by drainage.

In order to better understand the community ecology of the bluehead sucker, future studies should include inventory and monitoring of all fish (adult, juvenile, and larvae), macroinvertebrates, and periphyton taxa in the streams where the bluehead sucker occurs. Stomach content analysis at various life stages will allow for a better understanding of bluehead sucker feeding habits. Diet studies on sympatric fish populations need to be conducted to determine potential competition and to understand the impact of introduced and native predators on bluehead sucker populations.

Genetic testing during future studies on bluehead sucker populations is important. Tissue samples (e.g., plugs, fin clips) should be taken for analysis of genetic structure from fish from mainstem and isolated populations. Genetic characterization would allow long-term investigation of population connectivity, migration, population diversity, viability of isolated populations, and the extent and effects of hybridization with native or introduced sucker species.

In order to ensure the long-term conservation of this species, research must examine techniques to minimize the impact of impoundments on flow regimes, temperature regimes, and movement of native fish. This research should focus on the modification of existing impoundments, providing guidelines for construction of future impoundments, and exploring the use of off-channel impoundments. Specific scientific evidence relating the mechanisms in which habitat degradation links to bluehead sucker population attributes is missing. Investigating the impacts of land use management (e.g., grazing, road construction, culverts) on bluehead suckers is warranted. The development of a process-response model would further identify bluehead sucker life history components that are not adequately understood.

Essential to the long-term persistence of the bluehead sucker is the collection, analysis, and understanding of data relating to the distribution, life history, and impacts of threats to this species. Initially, determining the distribution and abundance of bluehead suckers on USFS lands is imperative to establishing baseline information from which future sampling can then be prioritized. Long-term monitoring of bluehead sucker abundance and distribution will establish a foundation of data to determine population and distributional trends. Short-term studies (e.g., diet analysis, habitat selection, movement) can be completed concurrently with long-term monitoring and will expand basic knowledge of bluehead sucker life history traits on USFS lands. Studies specifically designed to evaluate the impact of riparian grazing, road construction, passage barriers, and non-native species interactions are also imperative to preserving this species.

DEFINITIONS

Centrum – any component that directly affects the central organism.

Endemic – a species that is confined to a particular geographic region.

Habitat quality – the physical characteristics of the environment (e.g., soil characteristics for plans or channel morphology for fish) that influence the fitness of individuals. This is distinguished from habitat quantity which refers to spatial extent.

Hybridization – the production of offspring by crossing two individuals of unlike genetic constitution.

Malentities – all components other than predators that directly affect the central organism and cause a negative response.

Metapopulation – a fish population defined by its expansive presence in accessible habitat whereby its needs for sustainability are met through diversity of habitats, corridors for movement, and interconnection.

Process-response model – either a conceptual or mechanistic model used to portray the biological response of a species to physical factors.

Scale – the physical or temporal dimension of an object or process (e.g., size, duration, frequency). In this context, extent defines the overall area covered by a study or analysis and grain defines the size of individual units of observation (sample units).

Species viability – used in a most general way throughout the document and outlines. In general, the term refers to the probability of persistence for a species over some specified temporal scale. Throughout this document, the term 'population' could be substituted for 'species'. Because biologists can identify (as in name) and define 'species' more easily than populations, that term is used here. However, the dynamics of persistence take place at the level of the population (Wells and Richmond 1995), and the National Forest Management Act focuses on populations. Therefore, our process targets species populations and species.

Viability – a focus of the Species Conservation Project. Viability and persistence are used to represent the probability of continued existence rather than a binary variable (viable vs. not viable). We note this because of the difficulty in referring to 'probability of persistence' throughout the manuscript.

Web Level 1 – any component that affects the centrum.

Web Level 2 – any component that affects Web Level 1.

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