Rio Grande Sucker (*Catostomus plebeius*): A Technical Conservation Assessment

Prepared for the USDA Forest Service,
Rocky Mountain Region,
Species Conservation Project

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Rio Grande sucker (*Catostomus plebeius*). © Joseph Tomelleri.

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF THE RIO GRANDE SUCKER

Status

The Rio Grande sucker (*Catostomus plebeius*) is endemic to the Rio Grande Basin of northern New Mexico and southern Colorado. Consequently, the species has always had a limited distribution within the USDA Forest Service (USFS), Rocky Mountain Region (Region 2). Within the last 100 years, this species had been extirpated from most of its historic range, and by 1994 the existing population in Colorado was restricted to a 6 km (3.7 miles) reach of Hot Creek, immediately downstream of the Rio Grande National Forest. Since that time the Rio Grande sucker has been re-introduced into several streams in the Rio Grande Basin and the San Luis Valley. The Rio Grande sucker is considered a sensitive species in Region 2.

Primary Threats

Primary threats to this species generally result from anthropogenic activities that alter the physical or biological characteristics of the Rio Grande sucker's habitat. Most of the historic physical changes to the aquatic environment and the majority of future threats are related to water management and flow modifications. These include the construction of migration barriers, which can result in habitat fragmentation and dewatering, and land use practices or landscape scale changes that result in degraded aquatic conditions. Specific threats to the Rio Grande sucker include the modification of stream channels (including channelization, diversions, rerouting and straightening). The primary human-induced biological threat to Rio Grande suckers is the introduction of non-native predators and competitors. Detailed information concerning the historic distribution, life history, population trends, and community ecology of this species is relatively limited. Management implications must be based on recent information obtained from relatively small existing populations.

Primary Conservation Elements, Management Implications and Considerations

Efforts should be made to protect the existing populations in Region 2 by protecting habitat and avoiding the introduction of non-native fish species. The needs of the Rio Grande sucker are specific to the conditions in which they evolved, and the overall objective should be to manage fluvial systems, to the extent possible, in order to emulate historic conditions. These conditions include a natural hydrograph with ample magnitude to maintain suitable habitat and rearing conditions and a native fish assemblage. When Rio Grande suckers co-exist with other native fish, they occupy the ecological role of an algivore, maintain stable populations, and have limited negative interactions with other native species.

Monitoring populations that have been reintroduced into isolated locations can provide an opportunity to fill data gaps regarding the ecology of this species. Monitoring the size and health of these populations may also provide insight into cause-effect relationships with the primary threats to this species. This additional information will be helpful for the future development of specific conservation strategies.

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Introduction

This assessment of the Rio Grande sucker (*Catostomus plebeius*) is one of many being produced to support the Species Conservation Project for USDA Forest Service (USFS) Rocky Mountain Region (Region 2). The Rio Grande sucker 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 in habitat quality that would reduce its distribution (FSM 2670.5 (19)). Due to population viability and abundance, a sensitive species requires special management, so knowledge of its biology and ecology is critical. This assessment addresses the biology, ecology, conservation, and management of the Rio Grande sucker throughout its range in Region 2. The broad nature of the assessment leads to some constraints on the specificity of information for particular locales.

Goal

The purpose of this species conservation assessment is to provide forest managers, research biologists, and the public with a thorough discussion of the current understanding of the biology, ecology, conservation status, and management of the Rio Grande sucker. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The 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 potentially result from management (i.e., management implications). Furthermore, it cites management recommendations proposed elsewhere and examines the success of those recommendations that have been implemented.

Scope

The Rio Grande sucker assessment examines the biology, ecology, conservation status, and management of this species with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. Although some of the literature on the species 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 reproductive behavior, population dynamics, and other characteristics of Rio Grande 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 the assessment, we reviewed refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies. Not all publications on Rio Grande sucker are referenced in the assessment, nor were all published materials considered equally reliable. The assessment emphasizes refereed literature because these publications have been more rigorously reviewed. Non-refereed publications or reports were utilized when they were the best available information. Unpublished data (e.g., Natural Heritage Program records) were important in estimating the geographic distribution of this species, but these data required special attention because of the diversity of persons and methods used in their collection.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against biotic observations. However, because our descriptions of the environment and its web of interrelated interactions are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science 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. 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). Ecological science is, in some ways, more similar to geology than physical science because of the difficulty in conducting critical experiments and the reliance on observation, inference, good thinking, and models to guide understanding of the world (Hillborn and Mangel 1997). 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 by undertaken to test both the true or false nature of the uncertainties at hand (Vadas 1994).

Confronting uncertainty, then, is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted and alternative explanations described when appropriate. 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 are used in synthesis for this assessment.

Like many non-game native fish, the Rio Grande sucker has not been extensively studied. The limited amount of information on key characteristics for the species and the lack of understanding concerning critical species requirements create a great deal of uncertainty pertaining to the assessment for conservation of the Rio Grande sucker. This species assessment has synthesized a wide range of available data throughout the Rio Grande Basin including historical and current distributions, conservation strategies, habitat needs, and management requirements. The lack of precise information regarding this species' historic distribution on National Forest System land or near forest boundaries limits the actual data that can be used for this assessment. We have inferred from available data, using a sound scientific approach, 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 the Rio Grande sucker. 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 strategies 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 and general management relevance of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

The Rio Grande sucker is not a federally listed species (threatened or endangered) (U.S. Fish and Wildlife Service; http://endangered.fs.gov/). However, it is rare in Region 2, where it is considered a sensitive species. Colorado is the only state in Region 2 that historically contained populations of Rio Grande sucker.

This species has a Natural Heritage Program global rank of G3G4 (globally vulnerable but apparently secure), but a state rank of S1 (critically imperiled) in Colorado (http://natureserve.org/explorer). The Colorado Division of Wildlife (CDOW) considers the Rio Grande sucker a state endangered species (http: www.cnhp.colostate.edu/tracking/fish.html.). While the species was nearly extirpated from Colorado, it still maintains viable populations in New Mexico and Mexico. At this time the Rio Grande sucker has no state designation or rank in New Mexico.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

In November 1993, the Colorado Wildlife Commission passed regulations that designated the Rio Grande sucker as an endangered fish in Colorado. This designation is accompanied by regulation (Chapter 10, Article II, #1002) that states: "Any endangered fish taken by any means shall be returned unharmed to the water immediately." Several additional regulations are intended to protect native fish species and thus aid in the conservation of the Rio Grande sucker. Specific restrictions are in place in the Rio Grande Basin in Colorado that prohibit the live release of non-native fish species into rivers and lakes within this drainage. Another regulation indirectly assisting the conservation of Rio Grande sucker is a statewide statute that prohibits the seining, netting, trapping or dipping of fish in natural streams. Enforcement of regulations should concentrate on restricting release of non-native fish.

National Forest streams that support Rio Grande sucker habitat have not been impacted by past diversion structures. Future impacts to habitat will be prevented by the Forest Service in-stream flow claim provided in Colorado, Water Division No. 3 Case No. 81CW183 (Dobson personal communication 2005). Unfortunately, much of the native habitat (and thus potential habitat) for Rio Grande sucker is downstream of national forest boundaries and consequently subject to dewatering from other sources.

The rapid decline of Rio Grande sucker in Colorado led to the development of the "Rio Grande Sucker Recovery Plan" (Langlois et al. 1994). This plan provides a summary of available biological information and objectives designed to protect and maintain Rio Grande sucker populations in Colorado. The goal of this plan is to "protect genetic purity and preserve the genetic variability" and "ensure the long term survival of the Rio Grande sucker as part of the aquatic wildlife community in waters of the San Luis Valley". The Rio Grande Sucker Recovery Plan describes information needs and strategies for the conservation of this species. Information needs include specific habitat requirements, additional biological and ecological studies, and genetic testing of this species in populations throughout its range. Strategies related to conservation of this species include restoration and protection of habitat, protection of existing populations, and the re-establishment of populations in suitable habitats within the historic range.

Biology and Ecology

Systematics and general species description

The Rio Grande sucker is a member of the Family Catostomidae, which is characterized by soft fin 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). Rio Grande suckers belong to the genus *Catostomus*. The Rio Grande sucker (*C. plebeius*) was described by Baird and Girard in 1854 from specimens obtained from the Mimbres River, New Mexico. It was eventually placed in the genus *Pantosteus*, and later moved to the genus *Catostomus* when *Pantosteus* was reduced to a subgenus (Smith 1966, Smith and Koehn 1971). Rio Grande suckers, like other members of the subgenus *Pantosteus*, have jaws with well-developed, cartilaginous scraping edges.

This species is a small-size member of the Catostomid family. Smith (1966) reports that males mature at a length of 60 to 80 mm (2.3 to 3.1 inches) Standard Length (SL) while females mature at a length of 70 to 90 mm (2.8 to 3.5 inches) SL. Adults are usually less than 170 mm (6.7 inches) SL. Raush (1963) conducted extensive research on age and growth on a population of Rio Grande suckers in Jemez Creek, New Mexico. Age and growth of more than 700 individuals were examined. After one year of growth, the average SL of juveniles was 33 mm (1.3 inches). The oldest males that were captured were age six (average SL was 134 mm [5.3 inches]), and the oldest females were age seven (average SL was 169 mm [6.7 inches]). It has been suggested that Rio Grande sucker growth rates in Hot Creek, Colorado are slightly faster than what has been reported in Jemez Creek, New Mexico (Swift-Miller et al. 1999b).

Some genetic variation has been reported from different drainages in Mexico (Ferris et al. 1982), but there is little evidence of geographic variation in the state of New Mexico (Crabtree and Buth 1987).

The Rio Grande sucker is distinguished from other members of the genus *Catostomus* using the following characteristics described by Sublette et al. (1990):

> *"Coloration: Back and sides brownish-green to dusky brown overlain with darker blotches; abdomen paler with mottling often present on the sides; peritoneum silvery/dusky with scattered melanophores. Caudal rays pigmented, interradial membranes lacking pigment.*
>
> *Head: Mouth ventral; snout broad. Lips uniformly papillose including external surface of upper lip; lower lip thick, fleshy; a deep median cleft with two or three rows of papillae between the base and lower jaw; well developed notches at the junction of upper and lower jaws. Cartilaginous ridge of mandible slightly convex; SL/width of mandibular ridge = 20.8*

(19.2-23.8)[1]; SL/Isthmus width = 6-9. Gill rakers papillose; rakers on outer row usually less than 25 (20-27), inner row usually less than 35 (26-37) in specimens longer than 70 mm standard length (Smith 1966; Smith et al. 1983). Pharyngeal teeth in a single row, 22-23, weakly bifurcate; diminishing in size towards the dorsal apex, becoming straplike and ultimately spinose. Fontanelle nearly closed in young specimens; nearly always closed in adults.

<u>Body</u>: Terete, moderately depressed dorsoventrally. Maximum standard length 260 mm. Caudal peduncle deeper than in other members of the subgenus Pantosteus; SL/Caudal peduncle depth = 10.5 (9.5-11.9). Predorsal scales usually less than 50 (40-55). Scales in lateral line usually 79-92 (74-99). Scales above the lateral line 14-15. Vertebrae 38-46 (Snyder 1979).

<u>Fins</u>: Dorsal triangular, short, Pectorals bluntly pointed; axillary process absent. Pelvics oval; inguinal process absent. Anal elongate, extending posteriorly to base of caudal fin. Caudal deeply forked, lobes bluntly pointed. Rays: Dorsal 9 (8-10); pectorals 14-15; pelvics 9 (8-10); anal 7.

<u>Sexual differences</u>: Breeding males black on dorsum with a crimson red lateral stripe, sometimes with a yellow golden band above; tuberculate on the anal and caudal fins and caudal peduncle; the dorsal side of the pectoral and pelvic fins occasionally with smaller tubercles. During spawning season, females with large tubercles on the ventral part of the caudal peduncle and rarely on the anal fin (Smith 1966)."

Distribution and abundance

The Rio Grande sucker is one of several fish species that are endemic to the Rio Grande Basin (Zuckerman and Langlois 1990). Historically, it was common throughout the Rio Grande and associated tributaries. The current distribution of this species includes two states (New Mexico and Colorado) (Sublette et al. 1990, Calamusso 1996) and several locations in Mexico (Hendrickson et al. 1980). The Rio Grande Basin includes a relatively small portion of Colorado and a much larger portion of the state of New Mexico. While specific historical distribution and population information is not available, it is likely that Rio Grande suckers have always been confined to a relatively small portion of Colorado (i.e., Rio Grande Basin). Within this basin, Rio Grande sucker distribution was likely further controlled by spatial (e.g., temperature, gradient) restrictions. Distribution information from the Carson and Santa Fe national forests (New Mexico) suggested that this species was rarely collected at an elevation above 2,743 m (9,000 ft.) (Calamusso and Rinne 1996). In Colorado, a synthesis of available information would suggest that historic Rio Grande sucker populations were mostly concentrated in low gradient streams of the San Luis Valley, with some limited distribution in mountain streams. This equates to a very localized distribution in Region 2 that is associated with only the Rio Grande National Forest (**<u>Figure 1</u>**). The current distribution of this species in Region 2, including natural and introduced populations, is restricted to several Hydrologic Unit Boundary (HUB) units in the southern portion of Colorado (**<u>Figure 2</u>**).

The distribution and abundance of Rio Grande suckers have been substantially reduced from historic levels in Colorado. Cope and Yarrow (1875) reported the results of a fish survey conducted in 1874 and stated that the Rio Grande sucker was "very abundant in the tributaries of the Rio Grande as far as we explored it, i.e., from Fort Garland, Colo., to Santa Fe". Jordan (1891) described this fish as "very abundant" in the Rio Grande and associated tributaries in Colorado. Ellis (1914) made reference to the San Luis Valley of Colorado and stated that Rio Grande sucker was "quite abundant throughout its range". These historical records suggest that this species' distribution included small tributaries and large rivers.

Sampling efforts from 1982 to 1985 indicated that the distribution of this species had been severely reduced and that populations existed in only two Colorado locations (Hot Creek and McIntyre Springs), both in Conejos County (Zuckerman and Langlois 1990). Results of extensive sampling in 1994 indicated that the McIntyre Springs population had become extirpated, leaving the Hot Creek population as the last known population of Rio Grande suckers in Colorado (Swift 1996). This population was estimated at approximately 1,500 individuals and was concentrated

[1]Counts are presented with the most common or average number outside the brackets and the range of values found in the literature inside the brackets.

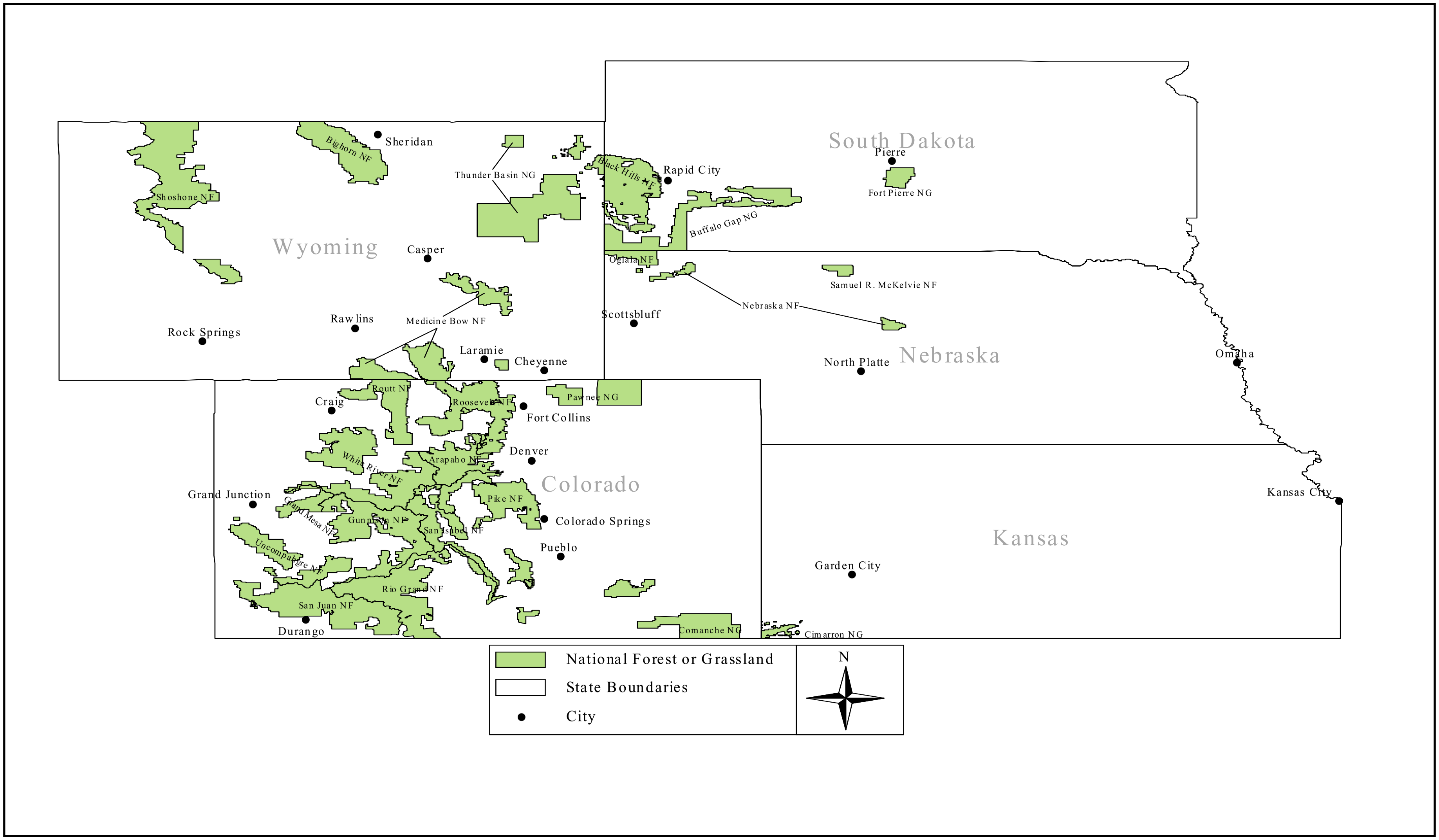

Figure 1. USDA Forest Service Region 2 designated national forest and national grassland ownership.

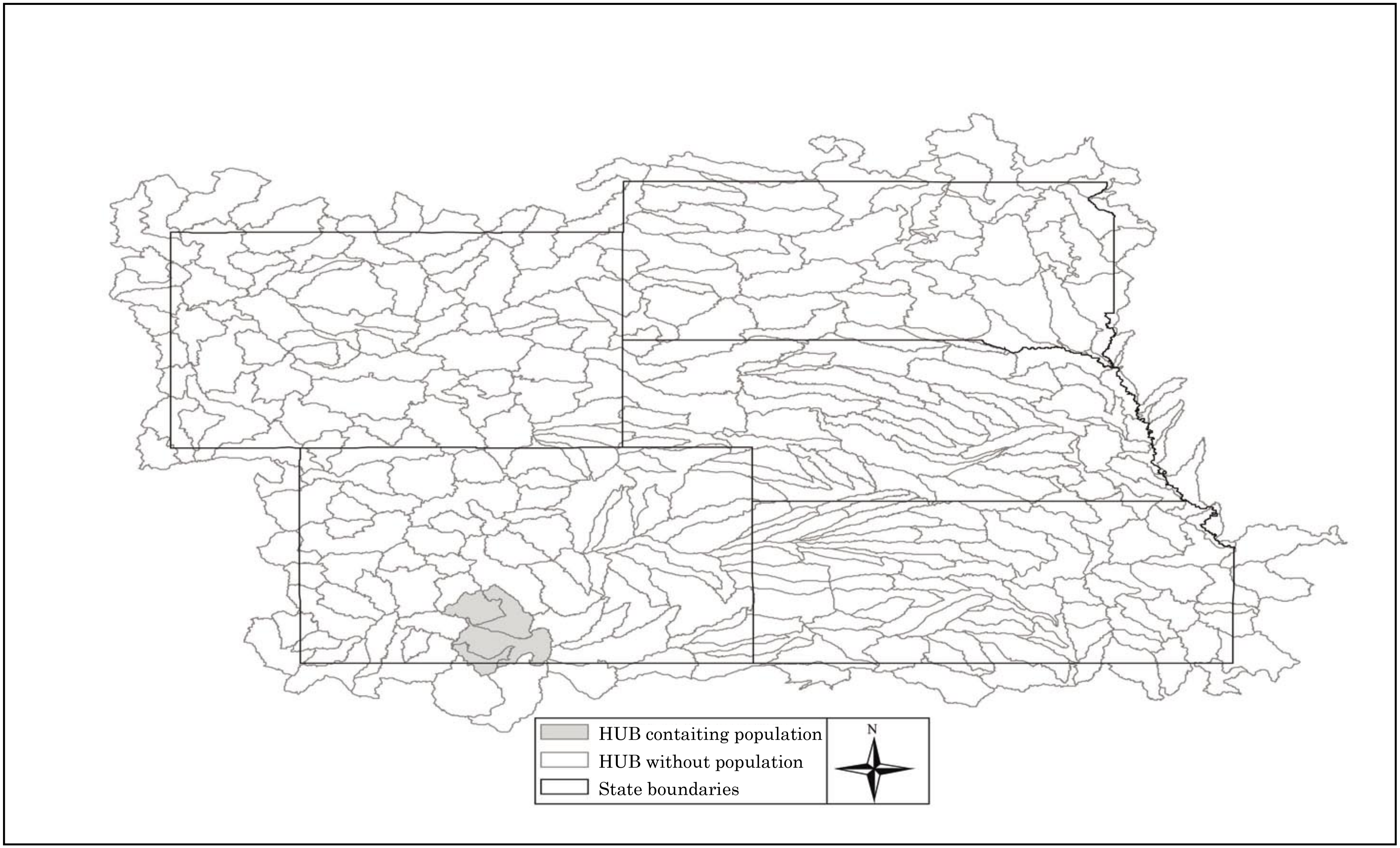

Figure 2. USDA Forest Service Region 2 hydrological unit boundaries (HUB) containing Rio Grande sucker populations.

in a 6 km (3.7 miles) reach in the Hot Creek State Wildlife Area, immediately downstream from the Rio Grande National Forest boundary (Swift 1996, Swift-Miller et al. 1999b).

Since 1995, Rio Grande suckers have been re-introduced in several Colorado streams in the Rio Grande Basin and San Luis Closed Basin (Swift-Miller personal communication 2003). The following aquatic systems have received transplanted fish: Cascade, Osier, North Carnero, Middle Carnero, Medano, and San Francisco creeks, and the Closed Basin Canal. Cascade, Osier, North Carnero, Middle Carnero, and San Francisco creeks have Rio Grande sucker populations that exist within the Rio Grande National Forest boundary. Successful reproduction has only been confirmed in the North Canero Creek, Middle Canero Creek, and Medano Creek populations (Swift-Miller personal communication 2003, Wiley personal communication 2005). In 2004 recent sampling in San Francisco Creek on National Forest and private land yielded no Rio Grande sucker individuals, while additional stocking efforts occurred in Big Springs and San Francisco creeks (Wiley personal communication 2005). Established populations have also not been confirmed within the Closed Basin Canal.

Population trend

In the case of the Rio Grande sucker, information on population trends must be based on historic surveys that lack specific detail and were not repeated or verified over large expanses of time (i.e., several decades). Early fish surveys are all in agreement that Rio Grande suckers were abundant in the Rio Grande and associated tributaries in Colorado (Cope and Yarrow 1875, Jordan 1891, Ellis 1914). During the following decades, specific information regarding population trends in Colorado is virtually nonexistent. The results of a survey from 1982 to 1985 indicated that the distribution of Rio Grande sucker had been severely reduced from probable historic levels (Zuckerman and Langlois 1990). The species also appears to be declining across its northern range in New Mexico (Calamusso 1996, Calamusso and Rinne 1996, Calamusso et al. 2002).

Studies that have identified reductions in Rio Grande sucker populations and distribution have mostly been conducted during the last two decades (since 1982). Unfortunately, most of the population decline in Colorado occurred prior to this time and was not recorded or studied. Specific mechanisms relating to habitat requirements and non-native species interactions are still poorly understood, but recent research has identified general cause and effect relationships that are contributing to the decline of this species.

Rio Grande sucker populations have likely been reduced due to depleted flows that result in increased temperatures, dewatering, etc.; habitat alteration from siltation, channelization, etc.; habitat destruction, including pollution, transbasin diversions, etc.; and interactions with non-native fish (Zuckerman and Langlois 1990).

In many systems, interactions with non-native fish species have been cited as the primary cause for decline in range and density of Rio Grande suckers (Calamusso et al. 2002). Negative interactions between Rio Grande sucker and the non-native white sucker (*Catostomus commersoni*) have been suggested as a major contributing factor to the decline of this species throughout much of its historic range (Zuckerman and Langlois 1990, Calamusso 1996, Calamusso and Rinne 1996, Swift-Miller et al. 1999a). It is hypothesized that competition for limited resources (e.g., food, spawning habitat, rearing areas) between these species has negatively impacted the Rio Grande sucker. The earliest record of the white sucker reported from the San Luis Valley was in 1945 (Zuckerman and Langlois 1990). Swift-Miller et al. (1999a) sampled one Rio Grande sucker population in Colorado and 12 in New Mexico and found that the abundance of Rio Grande suckers was significantly lower in streams with white sucker populations. White suckers are present in every stream where Rio Grande sucker populations have declined or been extirpated in the State of New Mexico (Calamusso et al. 2002).

Activity pattern

There has been no research specifically conducted to describe the activity patterns of Rio Grande suckers. During a survey of streams in Mexico, Hendrickson et al. (1980) noted that Rio Grande suckers occupied pool habitat during the day and moved into riffle habitat for feeding at night and during the early morning. Other movement or dispersal patterns (e.g., larval drift) have been described for other species of catostomids (Carter et al. 1986), but it is unknown whether the Rio Grande sucker displays similar behavioral strategies.

Habitat

Little information is available regarding the habitat requirements of the Rio Grande sucker prior to its recent decline in distribution and abundance (Swift 1996). While some habitat associations have been reported, there is currently a need to study specific seasonal and life stage habitat requirements of this species.

The Rio Grande sucker is an obligate riverine species (Calamusso et al. 2002). Specific life history events, diel movement, or seasonal changes probably influence habitat associations, but this information is generally lacking. White (1972) found young-of-the-year (YOY) Rio Grande suckers using relatively low velocity (specific velocity not provided) stream margins. These fish were 11 to 22 mm (0.4 to 0.9 inches) long and schooled in groups of 20 or 30, often in shaded areas.

With the exception of White (1972), most of the habitat data that is available is based on adult Rio Grande suckers. In a survey of several New Mexico streams, Calamusso (1996) found that this species preferred pool and glide habitat, but suggested that riffles may be ecologically important at certain times. Swift-Miller et al. (1999b) captured Rio Grande sucker in all major habitat types (i.e., pools, riffles, glides) in Hot Creek, Colorado. In reaches of Hot Creek where Rio Grande suckers were present, they were found in 80 percent of the riffle habitat that was sampled. Surveys in New Mexico determined that this species avoided stream reaches with a gradient greater than 3.2 percent (Calamusso et al. 2002). In fact, the data indicate an inverse relationship between abundance and gradient (down to at least 0.8 percent). Calamusso (1996) found that adult Rio Grande suckers within the Carson and Santa Fe national forests of New Mexico preferred low gradient habitats with cobble and small boulder substrate (64 to 500 mm [2.5 to 19.7 inches]). Velocity was usually less than 20 cm per second (0.7 ft. per second) but could be as high as 113 cm per second [3.7 ft. per second]). Preferred depth ranged from 10 to 40 cm (3.9 to 15.7 inches).

The deposition of fine sediments has been found to negatively impact the abundance and condition of Rio Grande suckers (Swift-Miller et al. 1999a). The amount of sand/silt substrate was inversely related to fish density in each habitat unit in Hot Creek (Swift-Miller et al. 1999b). Similarly, Rio Grande sucker condition was negatively related to the proportion of fine sediment in streams that were surveyed in Colorado and New Mexico (Swift-Miller et al. 1999a). The Rio Grande sucker may have an affinity for larger substrate because the stability associated with coarse substrate provides a greater opportunity for algal growth and macroinvertebrate production (Calamusso 1996), which comprise the dominant proportions of the Rio Grande sucker's diet (Zuckerman and Langlois 1990).

Food habits

The mouth of the Rio Grande sucker has a well-developed cartilaginous ridge that is specifically adapted for scraping algae from rocks (Koster 1957, Smith 1966, White 1972, Zuckerman and Langlois 1990). Diet consists of periphyton (algae) and benthic macroinvertebrates that are scraped from rocks, gravel, or boulders (Sublette et al. 1990, Zuckerman and Langlois 1990). Swift-Miller et al. (1999a) reported that periphyton was the dominant food item in gut contents obtained from one location in Colorado and 12 locations in New Mexico. No difference in diet between size classes was observed. White (1972) studied the diet of the Rio Grande sucker in a New Mexico stream with a high sediment load and found that the dominant prey item in gut samples from adult Rio Grande suckers shifted between benthic macroinvertebrates and periphyton, depending on sampling time and location. Gut samples of 145 Rio Grande suckers in Jemez Creek, New Mexico contained algae, aquatic invertebrates, larval fish, organic detritus, and sand and silt (White 1972). There is no historic information on the diet of this species in Colorado prior to its reduction in distribution, but it is likely that feeding habits would be similar throughout its range.

White (1972) observed YOY facing upstream in low velocity habitats along stream margins. These fish were making frequent darting movements that were presumed to be feeding behavior. Gut contents of YOY Rio Grande suckers in Jemez Creek consisted of 59 percent animal matter and 41 percent algae. The animal matter was primarily Cladocera, and the algae consisted mostly of diatoms (White 1972). As these fish grow into a juvenile life stage and the mouth shifts to a completely ventral position, the feeding behavior was reported as being similar to that of adults. The diet of juveniles in Jemez Creek consisted primarily of algae (periphyton) (White 1972).

Breeding biology

Growth rate and age of maturity likely depend on the thermal regime and food resources of a given stream. Smith (1966) reported that in Mexico streams, most Rio Grande suckers were sexually mature by age 2. However, studies in Jemez Creek, New Mexico indicated that males and females did not become sexually mature until they were 3 years old (Raush 1963).

Tuberculation and changes in coloration have been reported in both sexes during the spawning period (Rinne 1995). These features are generally more pronounced in males, and tuberculation is usually restricted to the head and gular region (Rinne 1995).

Runoff patterns, thermal regime, and season can all influence the time of spawning for western catostomids (Rinne 1995). Zuckerman and Langlois (1990) report that spawning of Rio Grande sucker in Colorado (Hot Creek and McIntyre Springs) occurs when water temperatures are between 11 and 16 °C (51.8 and 60.8 °F). Spawning can begin as early as February in the southern range (Mexico) of this species and progressively moves to the northern range based on climate (Smith 1966). Spawning in Jemez Creek, New Mexico occurs in May (Raush 1963). Rinne (1995) reported that spawning occurs in June and July in the Rio de las Vacas in northern New Mexico. Rio Grande sucker in Colorado have been observed in spawning condition from late March through late May (Zuckerman and Langlois 1990).

Rio Grande suckers in Hot Creek, Colorado have also been observed in spawning condition and coloration in the fall (November) (Zuckerman and Langlois 1990, Swift 1996). The altered thermal regime that results from the influence of springs in Hot Creek may result in the observed reproductive condition of fish in November (Swift-Miller et al. 1999b).

Much information is still needed regarding spawning activities, reproductive success, and habitat associations. Koster (1957) indicated that spawning occurs over areas of clean gravel substrate. Rinne (1995) reported that female Rio Grande suckers >100 mm (3.9 inches) total length (TL) could produce an average of 2,035 mature ova. Many details surrounding the spawning process have not yet been studied.

Demography

The current intermittent nature of most tributary streams with reintroduced or natural populations of Rio Grande suckers effectively eliminates gene flow between these populations. The potential loss of genetic heterogeneity and diversity is unknown at this time. It is logical that the isolated populations are more vulnerable to impacts from catastrophic events.

Hybridization between the Rio Grande sucker and the white sucker has been reported in Hot Creek (Zuckerman and Langlois 1990, Swift-Miller et al. 1999b), and hybridization with white suckers was reported in the McIntyre Springs population several years prior to the extirpation of Rio Grande suckers at that location (Zuckerman and Langlois 1990). Hybrids between white sucker and Rio Grande sucker are thought to be infertile. No evidence of introgression has been detected (Swift-Miller et al. 1999b).

The development of a meaningful life cycle diagram for the Rio Grande sucker requires life stage-specific data regarding survival rates, fecundity, and sex ratio. Existing data on Rio Grande sucker survival rates and other components necessary to construct a valid life cycle diagram are sparse, especially data specific to Rio Grande sucker populations occurring in Colorado. The information that is available is highly variable and typically restricted to single site locations in New Mexico. The following life cycle description is presented as a tool to recognize existing data and to identify data needed to refine the model (**Figure 3**).

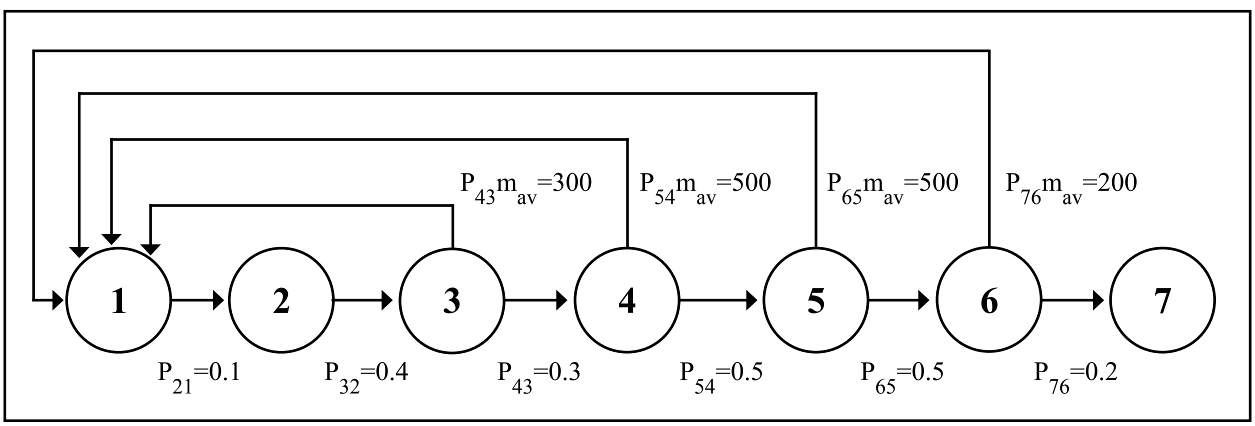

Figure 3. Life cycle graph for the Rio Grande sucker. The number of circles (nodes) represent the 7 age-classes. The arrows connecting the nodes represent survival rates. Fertility is represented by the arrows that point back to the first node. Fertilities involve offspring production, m_i, number of female eggs per female as well as survival of the female spawners. Note that reproduction begins in the 3rd year.

Input data needed for a population projection matrix model consist of sex ratios, age-specific survival and fecundity rates. Bezzerides and Bestgen (2002) have determined that these characteristics often depend on location (e.g., stream size, habitat) and can be highly variable for other species of catostomids in their native range. Data specific to Rio Grande sucker are incomplete and restricted to a few site-specific studies. Fecundity values used in the model were based on Rinne (1995), who reported an average fecundity of 2,035 ova produced by females >100 mm TL (n=21; range = 695 to 4,701). This study did not report a relationship between fecundity and age. Raush (1963) provided information on sex ratios, growth, age structure, and age of sexual maturity for Rio Grande sucker populations in Jemez Creek, New Mexico. This study determined that females and males become sexually mature at age 3, but 3-year-old females had an average length of 89 mm (3.5 inches). Based on size and growth information provided by Raush (1963) and fecundity data provided by Rinne (1995), the life cycle diagram was constructed using an average fecundity of 2,000 ova (with sexual maturity beginning at age 3) for all adult ages (**Table 1**, **Figure 3**). Typical of many fish species, the Rio Grande sucker likely has a high mortality rate from egg through age 1, and a high mortality rate following the first year of spawning. Other life-stages have lower mortality rates. Age-specific survival rates for the life cycle diagram were estimated from population age structure data provided by Raush (1963). Estimates were used for portions of the population age structure that were inconclusive or incomplete. Comparison of sex ratios reported by Raush (1963) and Rinne (1995) were inconsistent, so a ratio of 1:1 was used in the life cycle diagram (**Figure 3**). Spawning and recruitment likely take place each year but with a high rate of variability. Overall success depends on location and fluctuating environmental conditions.

Community ecology

The Rio Grande sucker is primarily algivorous (Zuckerman and Langlois 1990, Swift-Miller et al. 1999a). It co-evolved with the Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*) and the Rio Grande chub (*Gila pandora*), which filled the trophic levels of piscivore and insectivore, respectively (Zuckerman and Langlois 1990). Feeding habits of the Rio Grande sucker imply that it would prefer streams with low turbidity and minimal sediment deposition (Swift-Miller et al. 1999a). The Rio Grande sucker probably evolved with adequate food resources and limited interspecific competition. Human-induced changes in the ecology of the Rio Grande drainage may be responsible for the decline of this species throughout most of its range.

Water development, overgrazing, and other land use practices (i.e., channelization for agriculture, timber harvest practices, road management, mining) have resulted in increased sediment loads in many western streams. Judy et al. (1984) described sedimentation as the most important factor that is limiting fish habitat in the United States. The presence of suspended sediment has been found to impact periphyton communities by increasing turbidity (resulting in a decrease in light penetration), and it can cause the removal of periphyton by a frictional scouring process (Newcombe and MacDonald 1991, Allan 1995). The deposition of fine sediments on periphyton communities is suspected to have a smothering effect (Waters 1995) and to decrease the nutritional value of periphyton by increasing the inorganic content (Graham 1990).

Much of the historic range of the Rio Grande sucker currently receives high sediment loads. The impact of sediments on some aquatic systems probably

Table 1. Parameter values for the component terms (P_i and m_i) that make up the vital rates in the projection matrix for Rio Grande sucker. Survival rates were estimated from age structure data provided by Raush (1963). Rinne (1995) provided data from which fecundity was estimated. The model assumes a 1:1 sex ratio so the egg number used is equal to half the total fecundity.

Parameter	Numeric value	Interpretation
P_{21}	0.1	First year survival rate
P_{32}	0.40	Survival from 2nd to 3rd year
P_{43}	0.30	Survival from 3rd to 4th year
P_{54},P_{65}	0.50	Fourth and fifth year survival rate
P_{76}	0.2	Survival rate for oldest adults
m_{av}	1000	Average fecundity for mature females

results in altered foraging behavior and depreciated nutritional benefits (White 1972, Swift-Miller et al. 1999b). White (1972) studied the diet of the Rio Grande sucker in Jemez Creek, New Mexico, a system where land use practices have resulted in "massive erosion" and consequently heavy deposits of inorganic fine sediment in the aquatic system. Fine sediment that was deposited on algal communities was often ingested during the feeding process. Inorganic fine sediment accounted for up to 91 percent of the material examined in gut samples (White 1972). Swift-Miller et al. (1999b) suggested that high turbidity and sediment deposition deplete and degrade the food supply for Rio Grande suckers in Hot Creek, Colorado.

The Rio Grande sucker is the only catostomid that evolved in the Rio Grande drainage. Therefore, it is likely that the Rio Grande sucker did not evolve with the biological and behavioral mechanisms necessary to successfully compete with other catostomids (Calamusso 1996). Evidence of negative interactions between Rio Grande suckers and non-native white suckers have been presented (Swift-Miller et al. 1999a). A high degree of diet overlap was observed between these two species. Swift-Miller et al. (1999a) described significant ($P < 0.05$) changes in the diet of Rio Grande suckers when they coexist with white suckers. Competition for food between these two species is suspected at times when food resources are limited. Studies in Hot Creek, Colorado suggest that the Rio Grande sucker and the white sucker have considerable overlap in habitat as well as diet and may compete for preferred habitat (Swift-Miller et al. 1999b). The smaller size of the Rio Grande sucker, relative to the white sucker, may create a competitive disadvantage for the Rio Grande sucker when competing for limited habitat (Swift-Miller et al. 1999b). Calamusso (1996) found that Rio Grande sucker populations persisted in streams with some degree of habitat degradation, providing that white sucker populations were not present. However, he points out that non-native species (specifically white sucker), if introduced to these streams, might be better adapted to cope with habitat degradation and disturbances. Within approximately 40 years since its introduction, the white sucker replaced the Rio Grande sucker in most of its Colorado range (Zuckerman and Langlois 1990).

Swift-Miller et al. (1999a) found that Rio Grande suckers responded negatively to increases in sediment deposition and the presence of white suckers. Calamusso (1996) and Swift-Miller et al. (1999a) suggested that sediment deposition and the presence of white suckers may work synergistically or separately to impact Rio Grande sucker condition and population size. The specific ecological processes are still poorly understood. Swift-Miller et al. (1999a) provided evidence that suggested that abiotic conditions such as season, elevation, and location may contribute to the influence and relative importance of these impacts on Rio Grande sucker populations. For example, periphyton growth can vary with temperature, which is a function of both season and elevation, and sedimentation and periphyton growth are both influenced by the hydraulics of a specific reach.

The white sucker has been associated with poor condition and also a high incidence of disease in Rio Grande suckers in Hot Creek, Colorado. Zuckerman and Langlois (1990) suggested that the high incidence of "blackspot disease" (a metacercaria of various trematodes) and the poor condition of Rio Grande sucker may be directly related to the presence of white sucker.

Some of the non-native fish that have been introduced into the Rio Grande drainage prey Rio Grande suckers. In some areas, the introduction of northern pike (*Esox lucius*) may be responsible for the extirpation of Rio Grande sucker (Langlois et al. 1994). Introduced brown trout (*Salmo trutta*) may prey on Rio Grande sucker in Hot Creek (Swift-Miller et al. 1999b).

An envirogram for Rio Grande sucker was developed to help elucidate the relationships between land use practices/management and Rio Grande sucker characteristics (**Figure 4**). In general the usefulness of an envirogram is the visual representation of linkages between Rio Grande sucker life history parameters and environmental and biological factors affecting them. Those elements that directly affect the Rio Grande sucker are depicted in the envirogram by the centrum, which is further separated into resources, predators, and malentities. Resources elicit a positive response in Rio Grande sucker populations 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 of all envirogram components. The relative importance of the linkages is poorly understood and warrants further study to validate.

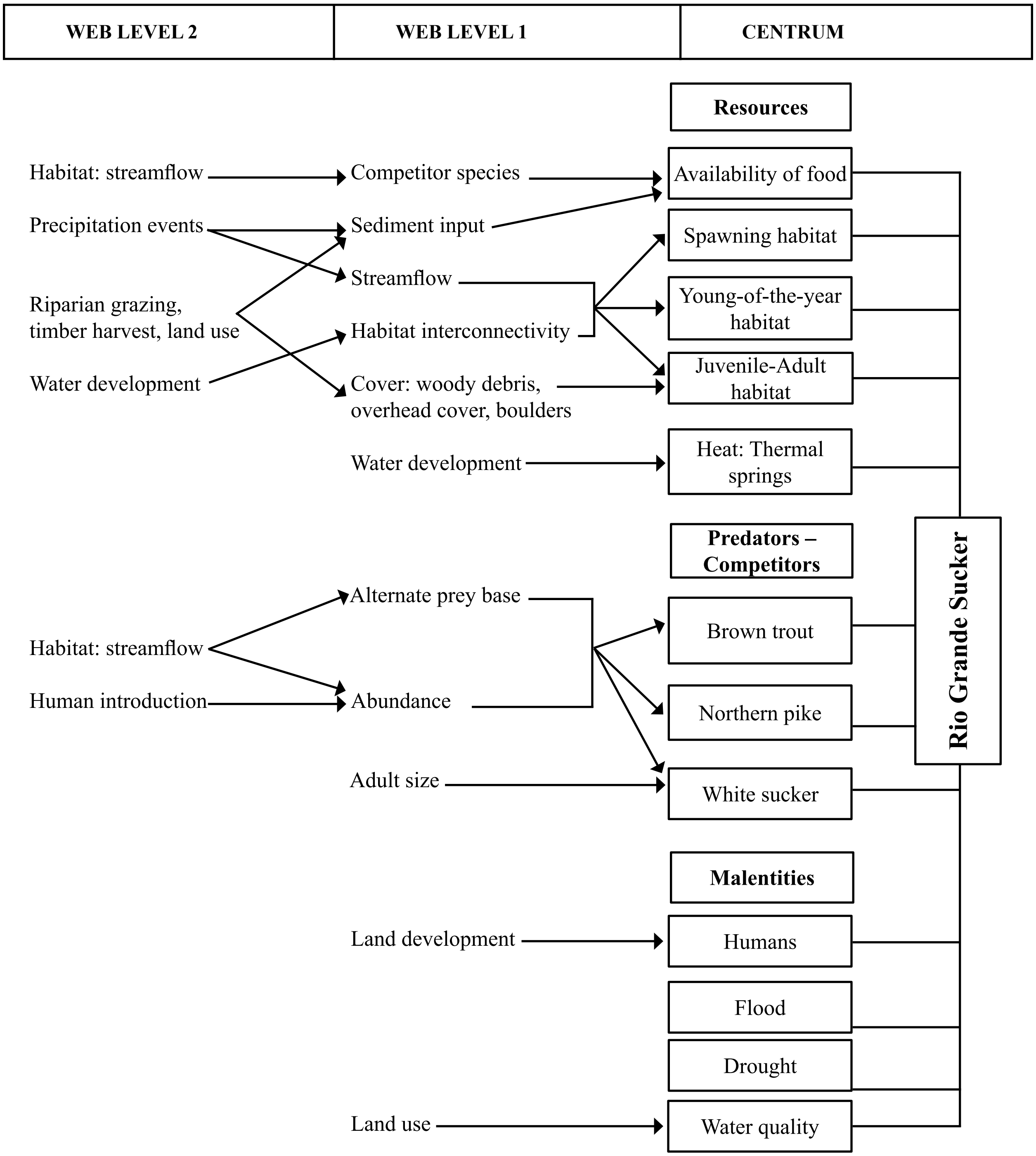

Figure 4. Envirogram for the Rio Grande sucker.

CONSERVATION

Threats

The native fish community that evolved in the Rio Grande Basin has been greatly reduced as a result of human activities during the last 100 years. Rio Grande sucker populations have suffered reductions in abundance and distribution from the same mechanisms that have caused the decline of other endemic fish species (e.g., Rio Grande cutthroat trout and Rio Grande chub) 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 Rio Grande 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 Rio Grande sucker. Each may work independently or in conjunction with the other to create an environment where Rio Grande sucker populations may be reduced or eliminated. The relative importance of each threat and the specific cause-effect relationship can depend on a number of biotic and abiotic factors. The complexity of specific threats requires further explanation.

Habitat degradation includes three extensive areas of concern: habitat loss, habitat fragmentation, and habitat modification. Habitat loss and fragmentation typically occur when streams are dewatered due to water use practices. Habitat fragmentation can also be caused by the creation of barriers to fish passage such as dams and diversions. Large and small scale water development projects can have profound impacts on the persistence of Rio Grande suckers. Even undersized (or improperly designed) culverts at road or trail crossings can act as barriers, especially at low flows. 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 currently occurs in tributaries to the Rio Grande that have become isolated from the mainstem river due to water diversions. In instances where habitat is fragmented and populations are isolated, the probability that genetic "bottlenecks" will occur becomes more pronounced, and single catastrophic events may extirpate populations from entire drainages.

Habitat modification includes not only aspects discussed under fragmentation and loss, but also includes modification of stream channels due to channelization, scouring, or sedimentation from land use practices; changes in temperature and flow regimes; and alterations to water chemistry related to pollution. Land use practices that can impact stream channels include construction of roads through highly erodible soils, improper timber harvest practices, irrigation, and overgrazing in 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 (e.g., pool depth) that affect the quality of habitat occupied by Rio Grande suckers.

Flow regime changes may alter historic timing of spawning as well as use of seasonally available floodplain habitat. Severely reduced stream flows may lead to increased water temperatures, changes in the algal community, and reduced dissolved oxygen levels especially in smaller tributary systems. 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 reduced, Rio Grande sucker fitness will also decline.

The effect of fire has little direct impact on the quality of Rio Grande sucker habitat, but post-fire conditions can effect downstream populations. During storm events on recently burned areas, large quantities of sediment are frequently loaded into streams. Once in the watershed, the increased sediment load can cover substrate, decrease pool depth, diminish suitable spawning habitat, and reduce fitness by decreasing the nutritional value of the food base.

Competition with and predation by non-native species are two more extensive threats to the health and viability of Rio Grande sucker populations. The lack of protecting spines makes the Rio Grande sucker a desirable prey item for predatory native and non-native species. Non-native predators include northern pike and brown trout. The introduced white sucker tends to be well-adapted to a variety of degraded environmental conditions, allowing it a competitive advantage on a spatial or temporal scale over the Rio Grande sucker. The larger white sucker competes with Rio Grande sucker for available food sources (periphyton and macroinvertebrates), and also has the ability to hybridize with Rio Grande sucker. Further treatment of hybridization can be found in the Demography section.

The effects of habitat degradation and non-native species introduction may not be limited to localized areas but may cascade through the system. The current distribution of Rio Grande suckers on or near National Forest System lands creates a unique situation where forest management strategies may cause substantial negative impacts on populations occurring many kilometers downstream of national forest boundaries. The introduction of non-native fish into stream reaches that do not contain Rio Grande sucker often results in the uncontrollable dispersal of these fish into other stream reaches. Water development, road construction, timber harvest and grazing of riparian areas are likely to continue to impact Rio Grande sucker habitat (or potential habitat) in the future. Landscape scale changes and land use practices have resulted in an increase in the erodability of soils in the Rio Grande Basin. Modification of land use management techniques to decrease the impact to Rio Grande sucker habitat may lessen the anthropogenic threats to this species; however, it is unlikely that all impacts or threats could be minimized or halted.

Modification of land use management techniques include the specification of minimum flow regimes and fish passage in drainages with populations of Rio Grande sucker. The specification of minimum flow regimes will promote habitat connectivity and maintain baseflow habitat during irrigation seasons. Specification of fish passage at new or existing low head diversions (including proper sizing and construction of culverts to allow natural passage conditions at road crossings or bridges) will reduce or eliminate fragmentation and loss of habitat. Other practices include 1) design specifications for buffer zones concerning both road construction and timber harvest and 2) management for expected riparian vegetation via adequate grazing systems to promote healthy growth and to reduce sedimentation from stream bank and upland areas.

Conservation Status of the Rio Grande Sucker in Region 2

At present, there is concern regarding the status of remaining populations of the Rio Grande sucker throughout its historic range. This species is endangered in Colorado due to the combined impacts of habitat loss, habitat degradation, habitat fragmentation, and interactions with non-native species. Although specific mechanisms of impacts to this species are poorly understood, it is likely that sediment loading in streams and interactions with the white sucker are the most important considerations for conservation of Rio Grande sucker in Region 2.

In a cooperative effort, the USFS and CDOW have started translocation projects, using streams with adequate habitat in southern Colorado. Reproducing populations have been identified in several of these streams. The success of these projects depends on the ability to maintain adequate habitat in an environment that is free of non-native fish species. The potential for future declines in distribution or abundance of these populations is high. Isolated populations are more susceptible to catastrophic events because of the impediment to recolonization from other nearby populations. Educated fish management strategies and land use practices could determine the fate of these remaining populations. Translocations should proceed with caution and use local seed populations, due to the potential genetic variability within the range of this species.

Potential Management of the Rio Grande Sucker in Region 2

Implications and potential conservation elements

Rio Grande sucker populations are threatened due to the combined impacts of habitat degradation and interactions with non-native fish species. A brief description of threats is provided in order to form a basis for the conservation elements; however, an in-depth discussion of threats to Rio Grande sucker can be found in the Threats section of this document.

The information that must be used to make management decisions is based on recent studies of existing populations. Information regarding the biology and ecology of Rio Grande sucker prior to its recent decline in distribution and abundance is generally nonexistent (Swift 1996).

Management of the Rio Grande sucker is based on an understanding of specific threats to the species. Habitat loss and habitat degradation due to land and water use practices are prime threats to Rio Grande sucker populations. This species is particularly vulnerable to reduced stream flows and increased sediment loads. 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 negatively impact Rio Grande sucker populations; however, specific thresholds and mechanisms associated with this impact have not been studied well enough to make precise predictions.

Interactions between Rio Grande sucker and non-native fish species threaten Rio Grande sucker populations. Specifically, competition and hybridization between Rio Grande sucker and introduced sucker species, and predation by large non-native predatory species represent the most deleterious effects of non-native interaction. Implementation of management strategies should be designed to restrain further expansion of non-native 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 Rio Grande sucker may also be considered.

The preservation or restoration of stream flows that are adequate to maintain complex habitat, interconnectivity of habitats (longitudinally and laterally onto the floodplain) 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. It is important to remember that most of the Rio Grande sucker habitat that has been lost in the San Luis Valley is at low elevations in the Rio Grande National Forest or downstream of Forest boundaries. Any future plans for the conservation of Rio Grande sucker should take a watershed approach to restore historical riverine functions (e.g., flows and their timing) and, therefore, assist the entire native fish assemblage. This assemblage may also include the Rio Grande cutthroat trout and the Rio Grande chub. These fish would all benefit from management related to restoration of historical flow regimes and the associated channel maintenance.

Tools and practices

The absence of life history and habitat data for Rio Grande sucker in Region 2 (with emphasis toward National Forest System land) is a concern. This section describes specific tools and techniques that could be employed to gather the missing or needed information for the following Information Needs section.

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 stream flow. Winters and Gallagher (1997) developed a basinwide habitat inventory protocol that would be a cost-effective tool to collect general stream habitat data. This protocol includes characterizing and quantifying habitat type, channel type, substrates, and bank stability. All of these parameters assist in describing habitat quality.

Re-introduced populations should be monitored, and associated habitat should be evaluated to increase the general understanding of habitat needs and limitations for the Rio Grande sucker. Evaluation of re-introduced population viability and habitat limitations can be used to determine potential sites for additional re-introductions. Consultation with agencies managing populations that are affected by forest management practices, even though they are not on National Forest System lands, is imperative to allow managers to continually monitor the status of those populations.

The implementation of a survey methodology to determine Rio Grande sucker distribution and abundance can also provide insight into movement of the species through the use of passive integrated transponder (PIT) tags or radio telemetry. Both of these techniques would require surgically implanting a small device that would be less obtrusive in larger adult fish. PIT tags are long-lasting (indefinitely), uniquely coded tags that allow for the efficient determination of movement with a minimum of disturbance. They have been used in fish as small as 55 mm (2.2 inches) TL, but they would be less obtrusive if used only in adult (>90 mm [3.5 inches] TL) Rio Grande suckers. These tools may provide a useful means of monitoring re-introduced populations.

Population estimates would provide baseline information with which managers could evaluate the effectiveness of future management strategies. Focus should be on areas where future management strategies may include activities that impact Rio Grande sucker populations. However, the long-term monitoring goal should be population estimates and population trend data on all streams containing Rio Grande sucker populations that may be influenced by activities on National Forest System lands. Several electrofishing techniques exist that would provide population estimates. These 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 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 is 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. It should also be noted that caution should be taken to ensure that suckers are not negatively impacted by electrofishing. Populations are especially vulnerable under poor water quality conditions or during spawning.

Defining the relationship between habitat alteration and Rio Grande sucker population characteristics is a relatively difficult task. This process may require significant amounts of data including quantitative analysis of differences in food resources over time, changes in habitat quality/function, and some form of abundance estimates.

In addition to collecting data specifically related to the distribution and life history of the Rio Grande sucker, forest managers can implement techniques that will increase the quality of habitat for Rio Grande sucker and other native fish, while ensuring 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 warranted. 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 techniques (previously mentioned) are unsuccessful.

In addition to ensuring the proper future design of stream culverts (i.e., size and gradient to allow fish passage), managers should inventory and assess the threat of all potential barriers currently in place. Barriers located within the Rio Grande sucker's range (as defined by distributional surveys) on national forests should receive priority and when possible, be removed.

The mechanical removal of non-native fish should be conducted at sites scheduled for re-introduction. If the source for non-native fish cannot be controlled, then periodic mechanical removal can be conducted. The effectiveness of this technique in significantly reducing non-native populations is not clearly understood. Mechanical removal is likely to be most effective when utilized before non-native populations become well-established and prolific.

In order to effectively gather data valuable for the conservation of this species, managers need to coordinate with private land owners and agencies that manage portions of streams downstream of national forest boundaries. This would help to determine the potential effects of USFS management policies and strategies.

Information Needs

Basic knowledge regarding the life history of the Rio Grande sucker is inadequate or obsolete. In order to attain the level of understanding that is necessary to properly manage this species at a localized level, specific threats must be identified by drainage. General information needs for the Rio Grande sucker include a wide range of information consisting of potential distribution, habitat requirements and associations, general attributes of life history and ecology, movement patterns, influence of non-native fish, and effects of human-induced habitat modification.

Habitat requirements and preferences are poorly understood for most life stages and life history events. More information is needed that describes the mechanisms that link sedimentation and other habitat degradation to Rio Grande sucker population attributes (e.g., abundance, condition). The development of a process-response model would further identify Rio Grande sucker life history components that are not adequately understood. In addition to general distribution and abundance information, a temporal component should be added to data collection to provide seasonal information. Temporal and spatial changes in abundance, distribution, and age structure should be documented prior to the implementation of conservation strategies. Given the small number of isolated populations that represent this species' distribution in Region 2, future management practices should proceed cautiously but include frequent population monitoring.

During population surveys, information regarding the physical and chemical characteristics of the habitat should be obtained. Data collected should include elevation, water temperature, dissolved oxygen, dissolved solids (pollutants), discharge, depth, turbidity, substrate, and habitat type. This information will provide baseline data regarding habitat requirements and preferences for each physical parameter. Adult fish should be tagged with PIT tags to allow for studies of movement, migration, and growth rates during continued monitoring.

A data gap exists in the basic life history information for the Rio Grande sucker. Specific studies need to be designed to provide information on spawning behavior and habitat, and larval biology and 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. Sex ratio and fecundity data (based on age and size) should be collected to provide other components missing from the life cycle diagram. It may be important to collect data from several populations because much of the specific life history information may vary by drainage.

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

Genetic testing during future studies on Rio Grande sucker populations will be important to determine the genetic diversity necessary to maintain isolated populations. Tissue samples should be taken from fish for analysis of genetic structure between isolated populations. Genetic characterization would allow studies of population diversity, viability of isolated populations, and the extent and effects of hybridization with non-native sucker species.

Identification of impacts from land use management (e.g., grazing, road construction, culverts) is essential to the long-term persistence of Rio Grande sucker populations that are associated with USFS lands. Studies specifically designed to evaluate the impact of riparian grazing, road construction, passage barriers, and non-native species interactions will be important for the preservation of this species.

DEFINITIONS

Centrum – any component that directly affects the central organism.

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

Habitat quality – the physical characteristics of the environment (e.g., soil characteristics for plants 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 – one or more core populations that are fairly stable and several surrounding areas with fluctuating populations.

Process-response model – a conceptual or mechanistic model used to portray the biological response 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).

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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