MANAGEMENT PLAN FOR THE OCONEE RIVER ROBUST REDHORSE POPULATION

Photo courtesy of J. Evans, Georgia Department of Natural Resources

Oconee River Technical Working Group
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Executive Summary

Since 1995, the Robust Redhorse Conservation Committee (RRCC) has been working to restore and conserve robust redhorse populations in their native Atlantic slope drainages in Georgia, North Carolina, and South Carolina. The RRCC was formed under a Memorandum of Understanding in 1995 and was actively renewed in 2000 and 2005. The RRCC developed a Conservation Strategy for the Robust Redhorse (Strategy), a set of Policies, a Habitat Management Plan, and other documents to promote voluntary conservation initiatives and stakeholder partnerships for conserving the species. While all RRCC members (see www.robustredhorse.com) have committed to enhancement and restoration measures for this species within its historic range, a subset have particular interest in the management of the population residing in the Oconee River, Georgia. The active members of the Oconee River Technical Working Group (ORTWG) that developed this management plan were: the U.S. Fish and Wildlife Service (USFWS); Georgia Department of Natural Resources (GADNR); Georgia Power Company (GPC); and the U. S. Geological Survey (USGS).

The ORTWG developed this plan to guide the restoration effort on the Oconee River. The plan contains a series of tasks under the broad objectives of improving knowledge of biological requirements, monitoring the status of the Oconee River population and comparing with other populations, conserving and enhancing the Oconee River population, maintaining refugial populations, and creating a schedule for revisiting this Oconee River Management Plan. The plan also describes criteria that will help the ORTWG measure success of species conservation in the Oconee River. Four goal attainment criteria will have to be met before the restoration effort can be deemed successful.

Background

The robust redhorse was briefly described by Cope (1870) from a single specimen collected in the Yadkin River, North Carolina in 1869. The historic range of the species is believed to be Atlantic Slope drainages from the Pee Dee River, North and South Carolina to the Altamaha River Basin in Georgia. The following bullets, except the last two, are taken from "A fisheries survey of the Oconee River between Sinclair Dam and Dublin, Georgia" (Evans 1994).

- The "rediscovery" of the robust redhorse in the Oconee River and subsequent recovery activities were closely linked to the Federal Energy Regulatory Commission (FERC) relicensing of GPC's Sinclair Hydroelectric Project (FERC No. 1951) during the period 1991 – 1996. GADNR personnel conducted an investigation of fish community characteristics of the Oconee River between Sinclair Dam and Dublin in 1991 and 1992 to gather information for formulating relicensing issues. Five large, unidentified catostomids were collected during electrofishing sampling conducted on August 8, 1991, near the mouth of Commissioner Creek.
- Meristic characteristics of these specimens did not correspond precisely to any known species and average length exceeded that of all catostomid species known to occur in the Altamaha River drainage. Preserved specimens were sent to Dr. Henry Bart, then curator of the Auburn University fish collection. He indicated that the fish might belong to what

was then believed to be an undescribed species known to ichthyologists by only two existing specimens - one collected from the Savannah River, Georgia/South Carolina in 1980 and a second from the Pee Dee River, North Carolina in 1985. Informal names applied at the time to the species represented by the two Savannah/Pee Dee specimens were the bighead redhorse and the Savannah River redhorse. During the period 1981-1990, fisheries professionals in Georgia and the Carolinas had been consulted and portions of the Savannah River were sampled in an effort to obtain more specimens. None were found until the five specimens were collected in the Oconee River in 1991. Prior to this discovery, the taxonomic status of this species had been investigated by Dr. Robert Jenkins of Roanoke College in Salem, Virginia, by Dr. Noel Burkhead of the National Fisheries Research Center in Gainesville, Florida, and by Dr. Byron Freeman, Director of the Georgia Museum of Natural History. All investigators subsequently concluded that the Oconee, Savannah, and Pee Dee specimens represented a single species.

- Initially, the Oconee, Pee Dee, and Savannah specimens were believed to represent a new species, probably an Atlantic slope form of the river redhorse, *Moxostoma carinatum*. The species is now believed to have been described by master naturalist Edward Cope in 1870 from specimens collected from the Yadkin River, North Carolina and given the scientific name *Ptychostomus robustus* (*Ptychostomus* is synonymous with the present genus designation *Moxostoma*). The specimens collected from the Oconee, Pee Dee, and Savannah rivers during 1980 – 1991 represent the "rediscovery" of a species that had been lost to science for over 120 years.
- Cope's original type specimens were lost and later workers erroneously labeled specimens of other species as type specimens of robust redhorse. The scientific name *P. robustus*, which Cope had intended to be applied to the robust species represented by the Oconee, Pee Dee, and Savannah specimens, was instead misapplied by later revisionists of the Catostomidae to a smaller species. This smaller species, sympatric with the larger more robust form, has been incorrectly known in scientific literature since 1956 as *Moxostoma robustum* - the smallfin redhorse. As a result of these investigations, the scientific name *Ptychostomus* (*Moxostoma*) *robustus* will be transferred as *Moxostoma robustum* (Cope) (robust redhorse) to the species known from the Oconee, Pee Dee, and Savannah specimens. The species formerly known as the smallfin redhorse will be placed in the jumprock genus (*Scartomyzon*) and given the common name brassy jumprock (Jenkins and Freeman, in preparation; Jenkins, in preparation).
- Archaeological remains of an additional specimen from the Savannah River were discovered at the University of Georgia in the early 1990's. However, conclusive evidence of the existence of other remnant populations was not found until 1997 when Georgia Power Company personnel collected a single specimen from the upper coastal plain reach of the Savannah River about 50 river miles downstream of Augusta, Georgia.
- A remnant population of robust redhorse has since been discovered in the Ocmulgee River, Georgia and populations were found in the Savannah River, Georgia/South Carolina and the Pee Dee River, North Carolina/South Carolina.
- The species was named as a Category 2 candidate for Federal listing under the Endangered Species Act. The Category 2 designation was eliminated in 1995 and some of the species formerly with this designation were classified as "species of management concern".

1.0 Management Goals

The primary goal of this plan is to enhance and ensure a genetically diverse, self-sustaining population of robust redhorse in the Oconee River. Maintaining the sustainability of the Oconee River population would ensure that this population remains one of the six self-sustaining populations necessary to satisfy the long-terms goals of the RRCC (RRCC 2002).

2.0 Goal Attainment Criteria

The primary goal of this management plan will be realized when the following criteria are met for a self-sustaining robust redhorse population in the Oconee River:

- *Occurrence of natural recruitment to the adult population at a rate equal to or greater than the mortality rate*
- *Multiple age/size classes from natural reproduction and recruitment are present in the population*
- *Individuals can be collected in sufficient numbers to model long-term demographic trends and effective population size*
- *Augmentation with hatchery-reared individuals is not required to maintain the population of at least 400-600 adults.*
- *The long-term declining trend in population estimates and associated catch rates is reversed.*

3.0 Biology and Historic Status of Robust Redhorse in the Oconee River

Biology:

- Largest member of its genus, so far as known, as well as the largest native sucker species on the Atlantic Slope; fish attains a maximum length of approximately 31 inches and a maximum weight of almost 19 pounds (Ryan Heise, North Carolina Wildlife Resources Commission, personal communication).
- Adults have modified gill arches, which form molariform teeth. In addition to being a key diagnostic character for the species, the teeth are used to crush small mollusks (Jenkins and Freeman, in preparation). Throughout their range, their primary food source seems to be the introduced Asiatic clam (*Corbicula* sp.) (Evans 2004). Food preferences of juveniles are unknown.
- Limited age and growth studies (N = 38) conducted on fish collected from 1991-1997 revealed that the Oconee River fish that could be aged accurately ranged from 10 to 25 years of age (Jenkins et al. 1998, Roanoke College, unpublished age and growth study). Most of these fish were produced in the 1970s and early 1980s. Recruitment since the early 1990's has been low.
- Robust redhorse spawn in the spring, generally when water temperatures reach 21 - 23 degrees C (Nichols 2003). Spawning has been observed over gravel bars with moderate to swift current at depths ranging from six inches to three feet (Freeman and Freeman 2001). Females produce an average of 30,000 (range 1,700 to 86,000) eggs per season (Jaci Zelko, USFWS, personal observation).
- Spawning behavior is similar to other redhorses, wherein one female is typically flanked by two males, and the three form a spawning triad over loose gravel substrate (Freeman and Freeman 2001). The act of depositing the eggs cleanses the egg pocket of fine sediments, which has been shown to affect larval survival to emergence success. Based

on laboratory observations, fertilized eggs incubate for 3-4 days within the interstitial spaces between gravel particles (Lasier et al. 2001). Larvae remain in the gravel for an additional 7-10 days until the yolk sac is absorbed and swimup occurs (Haile McCurdy, USFWS, personal communication).

- The existing Oconee River population appears to be genetically heterogeneous and distinct from the Savannah and Pee Dee populations (Ike Wirgin, New York University, personal communication).
- Recruitment of wild individuals to the adult population appears limited. Robust redhorse reach sexual maturity at about 400 mm TL. Wild spawned juveniles (less than 400 mm TL) have not been collected in intensive sampling to date. Few (< 50) larval robust redhorse were collected in 1995 and 1996 prior to implementation of the new flow agreement (resulting from the relicensing of Sinclair Dam); larval collection has been variable (10 – 2100) after implementation (Peterson et al. 2008).
- Known harmful pathogens have not been observed from wild caught specimens. Heil (1997) examined external lesions and isolated bacteria that were opportunistic secondary invaders. Externally, there were no signs of gill, skin, or fin parasites.
- Juveniles and adults are moderately tolerant of a broad range of environmental physicochemical conditions (e.g., pH, dissolved oxygen, temperature), but in some instances a combination of factors affecting physiological and ecological requirements may act synergistically in limiting reproductive success (Walsh et al. 1998; Jaci Zelko, USFWS, personal observation).

Habitat Use and Behavior:

- In rivers with meanders, non-spawning adults are often associated with woody debris in relatively moderate to swift currents, typically in meander sections. In rivers without meanders, non-spawning adults seem to prefer deep holes, typically in association with woody debris (Jimmy Evans, GADNR, personal observation).
- Adult robust redhorse form spawning aggregates during spring, in some cases migrating long distances to spawning grounds, and then return to preferred habitat for the remainder of the year (Grabowski and Isely 2006; Ryan Heise, NCWRC, personal communication; Cecil Jennings, USGS, personal observation).
- Spawning activity in the Oconee River has been documented in only 2 – 3 small areas, generally associated with exposed gravel deposits; the first is a mid-channel gravel bar opposite the Avant Kaolin Mine (RM 120) between Toomsboro and Milledgeville; the second is a gravel bar extending from near shore to mid-channel at the lower end of a short meander section below Hwy 57 (RM 96). A third area, inferred only from the number of adults in spawning condition collected, is located near several meander bends just below the mouth of Commissioner Creek (RM 100 – 102). Specific gravel deposits associated with this aggregation have not been located. Spawning activity was also observed from 1993 to 1996 approximately 1.5 miles below the Central of Georgia railroad trestle. Spawning activity has declined gradually over a period of several years and presently the only known, active spawning site is located at the Avant Kaolin Mine. Undiscovered spawning sites may exist (Peterson et al. 2008; Jimmy Evans, GADNR, personal observation).
- In past observations, spawning aggregations have generally consisted of 30-50 adults, but more recently the number of individuals seems to have decreased. The cause for the reduction in number and/or possible shift in location of spawning aggregations over a 5 – 10 year period is unclear (Jimmy Evans, GADNR, personal observation).

- Since wild-spawned juvenile robust redhorse have never been collected from the Oconee River, preferred habitat is unknown. However, experimental studies with hatchery-reared individuals indicate that this life stage prefers areas with low to moderate current velocities (Mosley and Jennings 2007).
- Hatchery-reared juveniles released in the Ocmulgee River preferred woody debris where available; otherwise, they used boulder/cobble cover or other current refugia (e.g., bridge abutments) (Jennings and Shepard 2003, Grabowski and Jennings 2009).

Distribution:

- The historic range of the species is believed to be Atlantic Slope drainages from the Pee Dee River, North and South Carolina to the Altamaha River Basin in Georgia.
- Currently, wild populations are known to exist in the Oconee River, Georgia, Savannah River, Georgia/South Carolina, and the Pee Dee River system, South Carolina/North Carolina. Although two wild-spawned adults were collected in the Ocmulgee River in 1999, the status of the wild population there remains unclear.
- Currently, stocked populations exist in the Broad and Ogeechee rivers, Georgia, and the Broad and Wateree rivers, South Carolina (Nichols 2003; Forrest Sessions, SCDNR, personal communication). In addition, stocked individuals have been used to augment wild populations in the Oconee and Ocmulgee rivers, Georgia (Nichols 2003).

Status within Oconee River Basin:

- The Oconee River population was discovered by Jimmy Evans and Wayne Clark, GADNR, in August 1991 (Evans 1994). The species is considered to be very rare and is classified as endangered by the GADNR (GADNR 1999).
- Current range in the Oconee River is believed to be a 70-mile reach between Sinclair Dam and Dublin, Georgia. Although robust redhorse have never been collected from the immediate Sinclair Dam tailrace area or below Dublin, a telemetry study indicates that individuals are found at least intermittently below Dublin. The majority of the population appears to exist in the Fall Line Hills transition zone that extends roughly from just below the Fall Line to the beginning of the Upper Coastal Plain, or about 25 RM below Sinclair Dam to 10 RM above Dublin, a distance of about 45 RM (Jimmy Evans, GADNR, unpublished sampling data; Patrick Ely, USGS, unpublished telemetry data).
- Successful robust redhorse reproduction and recruitment is occurring in the Oconee River, but monitoring studies and results of annual broodfish sampling suggest that recruitment is relatively low (Nichols 2003).
- Annual population estimates show a population of approximately 100 adult robust redhorse in the Oconee River in 2004 (Jimmy Evans and Brent Hess, GADNR, unpublished modeling data), a decrease of approximately 75% since 1994. Long-term trends in electrofishing catch rates (Figure 1) and population estimates (Figure 2) indicate an apparent decline in the number of adult robust redhorse in the Oconee River from 1994 through 2009 (Jimmy Evans and Brent Hess, GADNR and Joey Slaughter, GPC; unpublished sampling data). The mechanism for the decline appears to have been a combination of mortality of the older age classes combined with low recruitment. Precise causes of the low recruitment are unclear. The reaches used in Figure 1 are within the broodfish sampling area (Figure 4), which is defined as the area from the mouth of Black Creek to the end of the last bend in the long meander section between Beaverdam WMA and Dublin:
    - Reach 1 is defined as the mouth of Black Creek to Central of Georgia railroad trestle;

- Reach 2 from the railroad trestle to Balls Ferry;
- Reach 3 from Balls Ferry to the Beaverdam WMA ramp;
- Reach 4 from Beaverdam Ramp to midpoint of long straight section just below Beaverdam ramp; and
- Reach 5 from the midpoint of the long straight section below Beaverdam to the end of long meander section between Beaverdam and Dublin.

- Whether the recruitment rate that has prevailed for the past decade is sufficient to sustain the population is unclear. Recent modeling results indicate that the population could be sustainable at between 30 and 400 individuals for at least several generations if current environmental conditions remain constant and population levels remain above the threshold for genetic viability (Figure 2) (Jimmy Evans and Brent Hess, GADNR, unpublished modeling data).

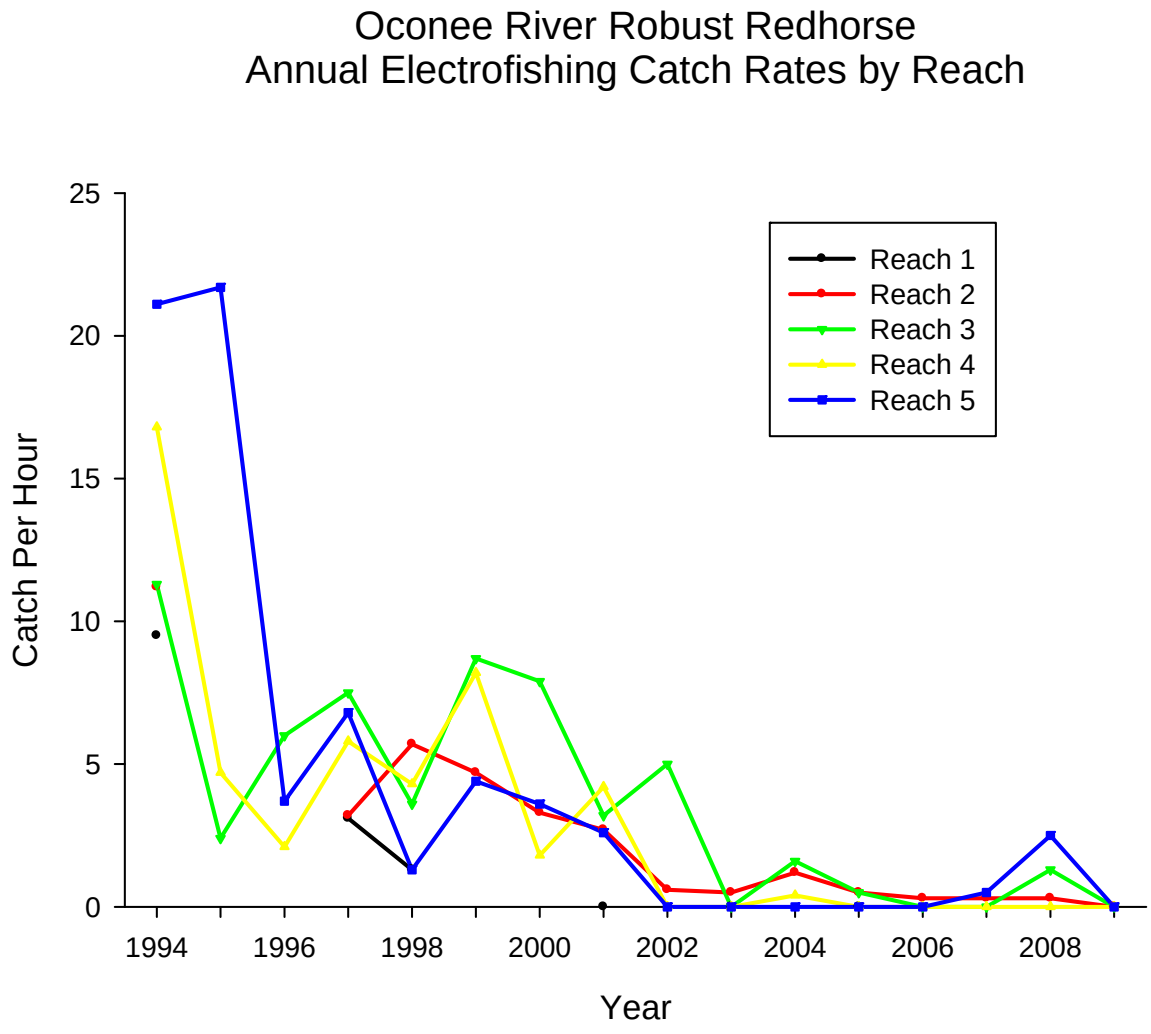

Figure 1. Electrofishing catch rates by year for robust redhorse in the Oconee River between the mouth of Black Creek and Dublin, Georgia since 1994.

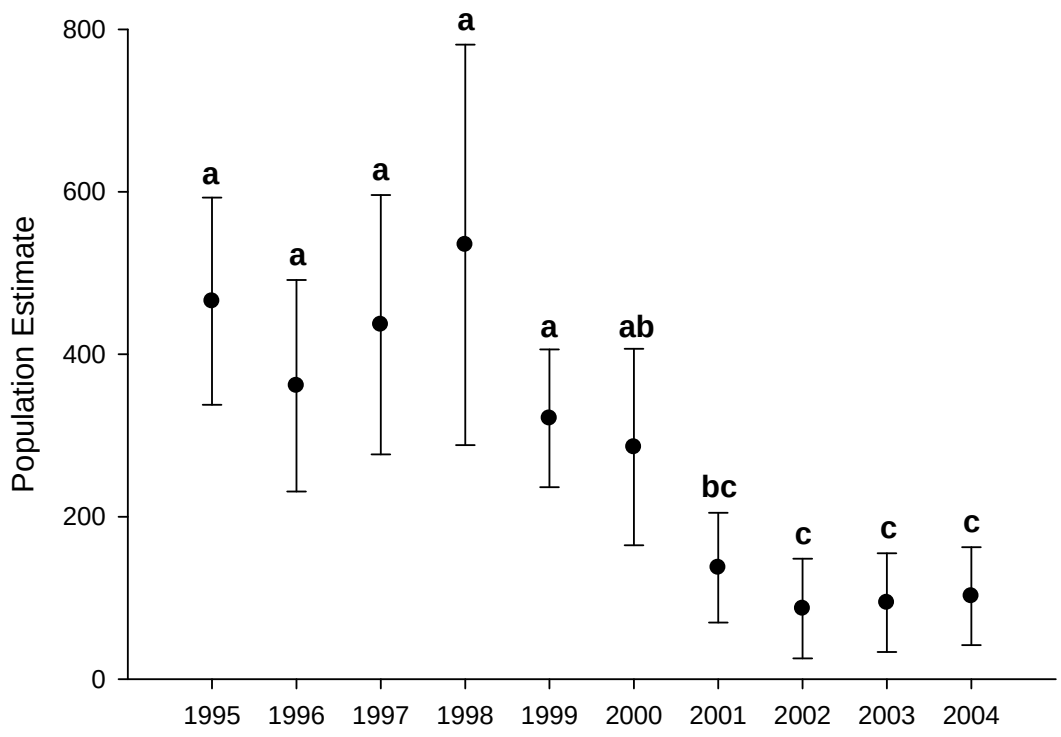

Figure 2. Mark-recapture population estimates for robust redhorse in the Oconee River between the mouth of Black Creek and Dublin, Georgia. Error bars indicate 95% confidence intervals.

Genetics:

- A target population size needs to maintain sufficient genetic variation for adaptation to environmental changes. It should be based upon the life history and genetic diversity of the organism, as well as the carrying capacity of the system (Greg Moyer, USFWS, personal communication).
- Soule (1980) and Franklin (1980) indicate a conservative effective population size of 50-500 individuals to maintain sufficient genetic variation for adaptation to environmental changes.
- Effective population size does not equal census population size. Palstra and Ruzzante (2008) found the effective population size to census size ratio to be 0.14 for a variety of organisms.
- Based on the range of initial population estimates in the Oconee River of approximately 350-600 adults, the target effective population size would be approximately 84 individuals; however, an effective population size of 50 individuals, with an appropriate sex ratio, would meet the minimum criteria for a genetically viable population.

Threats:

- Limited geographic range, low number of wild individuals, and low recruitment rates are considered the most serious threats to continued survival of the species (Bryant et al. 1996, Nichols 2003).
- Habitat alterations (e.g., sedimentation, contaminants, flow and temperature modification, barriers) that degrade or eliminate spawning or rearing habitat may limit the ability of the population to sustain itself (Nichols 2003, Lawrence et al. 2007).
- Predation and/or competition with nonnative species affect various life stages of the species. The relatively recent appearance of flathead catfish (*Pylodictus olivarus*) (Mike Geihsler, GADNR, personal communication) and blue catfish (*Ictalurus furcatus*) (Steve Schleiger, GADNR, personal communication) in the Altamaha River system pose direct predation threats or indirect threats through the alteration of predator/prey relationships**.** For example, increases in the abundance of bannerfin shiners (*Cyprinella leedsi*), known to feed heavily on robust redhorse eggs (Bud Freeman, University of Georgia, personal communication), may reflect a reduction in native predators such as redbreast sunfish (*Lepomis auritus*) caused by the appearance of flathead catfish in the Oconee River in the early 1980s.

4.0 Management Unit

The current management unit covered by this plan encompasses the Oconee River (Altamaha Basin) downstream of the Sinclair Dam in Georgia (Figure 3). If the distribution of the population is expanded beyond the current management unit boundaries, plans for those management units will be developed. The Oconee River flows through two major physiographic provinces, the Piedmont and Coastal Plain, separated by the Fall Line Hills transition zone. Robust redhorse have been stocked and recaptured in the Ocmulgee and Oconee rivers. In addition, a single individual stocked in the Oconee River was recaptured in the upper reaches of the Altamaha River. Genetic analyses indicate that the Oconee and Ocmulgee populations share numerous alleles (Wirgin et al. 2001). Currently, there are no known barriers to block movement of fish among the Altamaha, Ocmulgee below Juliette Dam, and the Oconee River below Sinclair Dam.

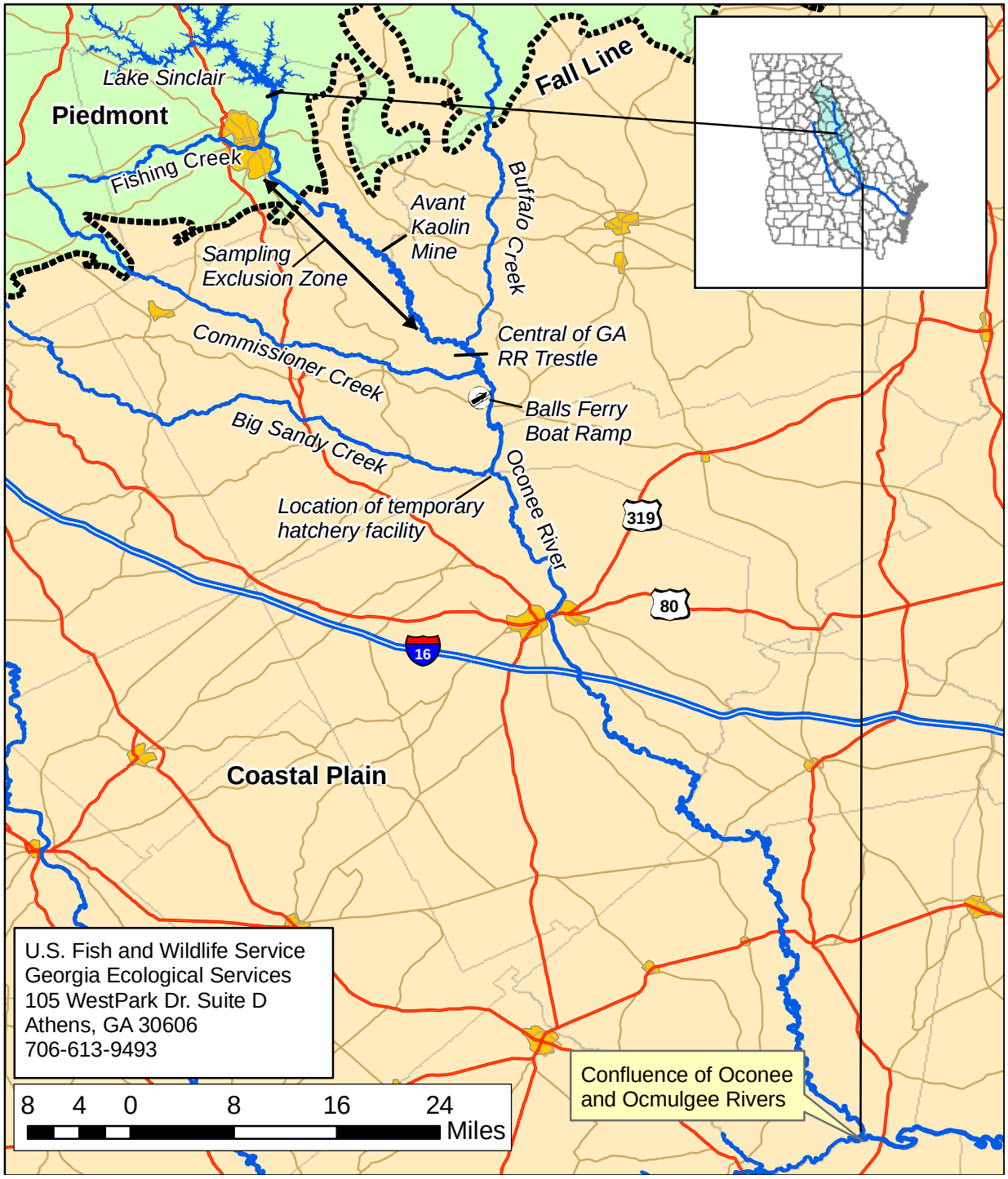

Figure 3. The portion of the Oconee River Basin covered by this Management Plan.

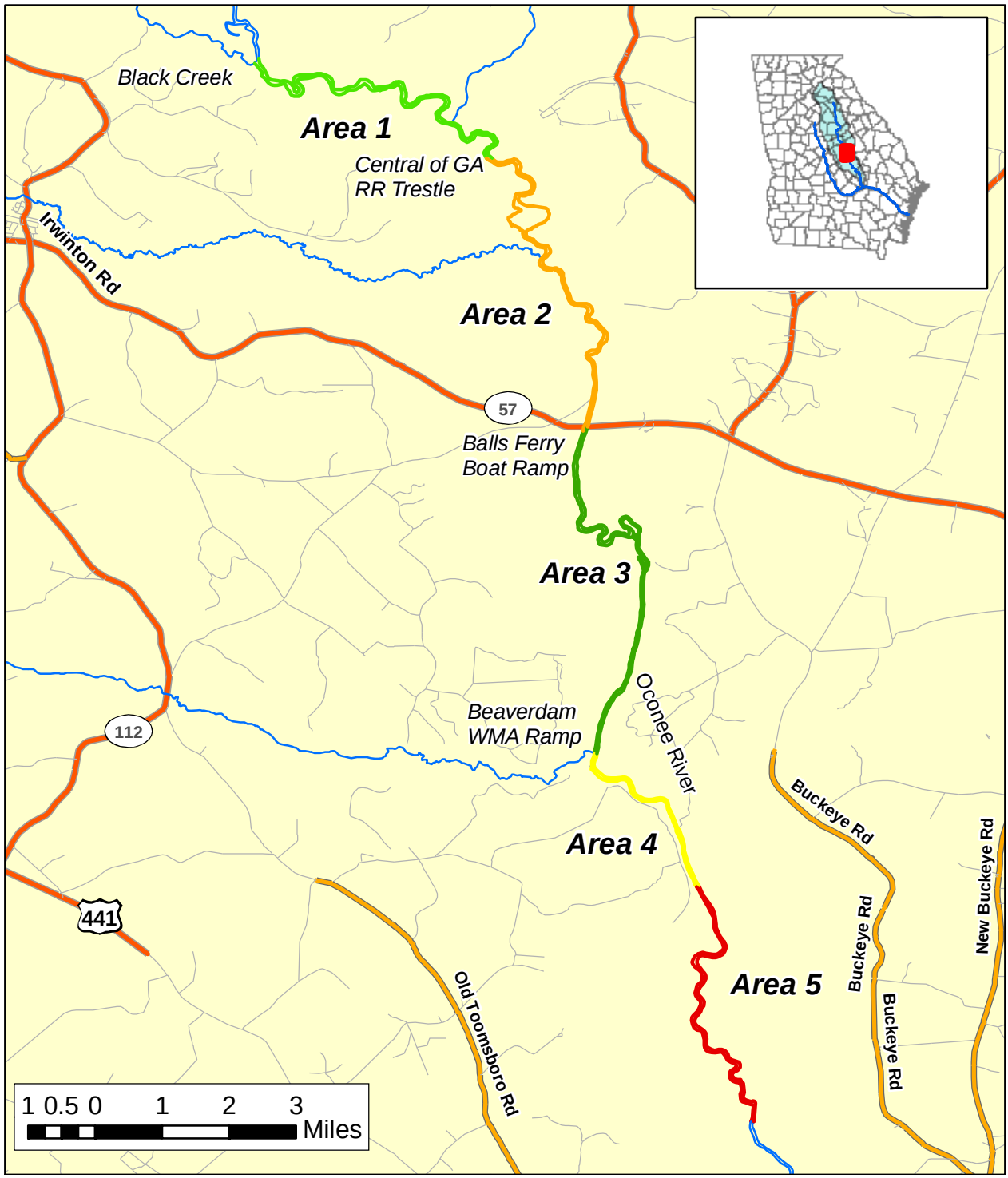

Figure 4. Delineation of sampling reaches within the broodfish sampling area.

5.0 Management History

The primary goals of the RRCC are to develop an understanding of the biology and status of this species, protect and enhance existing populations, and reestablish additional reproducing populations within its historic range. More specifically, the RRCC works to identify and prioritize data needs, evaluate project proposals for addressing those needs, coordinate conservation actions, and share information on species status.

Identification of the species and its historical range were largely completed by February 1992. Biological assessments conducted in 1992 and 1993 suggested the species has limited distribution and low abundance throughout its historical range (Jenkins and Burkhead 1993; Jenkins and Freeman, in preparation). An Oconee River population composed primarily of older individuals with extremely low recruitment rates, as evidenced by the skewed length distribution towards larger size classes, was another cause for concern (Bryant et al. 1996). Absence of individuals below about 400 mm TL may also be related to gear bias towards larger individuals. Recovery strategies were discussed at interagency meetings in September and December 1993 and the robust redhorse was classified as a Category 2 candidate for Federal listing under the ESA. Based on this information, the resource agencies agreed that flow requirements for the robust redhorse should be a major focus of the Sinclair Hydroelectric Project relicensing studies, as well as future operations affecting the downstream flow regime. Agencies also agreed that large-scale management intervention would be necessary to secure and enhance the species' status.

The 1995 Oconee River Flow Agreement for the Robust Redhorse (Agreement) was developed as part of the FERC relicensing of GPC's Sinclair Dam. Sinclair Dam modifies the flows in the section of river occupied by the Oconee River robust redhorse population. For the duration of the FERC license, the Agreement sets forth seasonally variable flow requirements that are adaptively managed for the conservation of the species (Table 1).

Table 1. Negotiated flow agreement for the Sinclair Hydroelectric Project.

MONTH	FLOW	OPERATION
Dec - Feb	500 cfs minimum	normal peaking
Mar - Apr	1500 cfs minimum	modified peaking[a]
May	run-of-river	
Jun[b] - Nov	700 cfs minimum	normal peaking

[a] modified peaking refers to the number of units (1 or 2) utilized, depending on inflow into the reservoir
[b] from June 1-10, units are operated run-of-river unless electric system demands necessitate normal peaking operation. The agreement also provides for an increase in generation (from 5 to 7 days per week) to reduce extended low-flow periods that previously resulted from little weekend generation.

Both the Agreement and the required Flow Advisory Team became important components of the new FERC license for the Sinclair Project, which became effective in 1996. A key component of the new flow regime provided higher minimum flows and enhanced flow stability, including run-of-river flows during the robust redhorse spawning season from May 1 through June 10. The new flow regime was codified in the Agreement negotiated among GPC and State and Federal natural resource agencies. The Flow Advisory Team for the Oconee River was established under a second agreement and charged with the task of monitoring the effectiveness of the new flow

regime in enhancing recruitment success. Both the Agreement and the Flow Advisory Team are key elements in the current 40-year project license.

Most of our current understanding of the status of this species in the Oconee River is a direct result of relicensing studies, subsequent monitoring designed to determine the effectiveness of the negotiated flow regime in enhancing population status, and sampling conducted to collect broodfish for propagation efforts.

A robust redhorse stocking program utilizing broodfish collected from the Oconee River was conducted during 1993 - 2007. A sampling exclusion zone (Figure 3) was established above the mouth of Black Creek to avoid disturbing a known spawning site and reduce the possible harmful effects of broodfish collection on natural reproduction and recruitment.

A primary rationale for the hatchery program was the apparent low recruitment rates in the Oconee River and concerns that significant population declines were possible. Several refugial ponds were stocked and refugial populations established in the Broad, Ogeechee, and Ocmulgee rivers in Georgia. In addition, during 2000 – 2008 the wild parental population in the Oconee River was augmented with over 4,200 fingerling and juvenile robust redhorse from nine year classes. In order to avoid genetic swamping of the wild Oconee River population, relatively small numbers of larger fish produced from numerous hatchery crosses were stocked annually based on genetic evaluations. Prior to stocking, all fish received coded-wire tags and larger fish received PIT tags as well.

Management actions and research studies have been undertaken prior to the establishment of the current Oconee Management Plan. These studies were conducted in support of the broad management objectives listed below.

6.0 Historical Management Objectives:

6.1 Identify the species and its biological requirements.

6.2 Assess the status of the Oconee River population.

6.3 Identify new populations and conduct status surveys of existing populations.

6.4 Conserve and enhance the Oconee River population.

6.5 Establish refugial populations in ponds and rivers within the historic range.

6.6 Establish, maintain, and/or identify six self-sustaining populations across the historic range.

7.0 Future Management Objectives and Tasks:

Future management objectives and tasks will focus on evaluating causes of the apparent low recruitment rates and population declines that have been documented in the Oconee River over the 17-year period since the species was rediscovered. Where possible, we provide specific recommendations for improving the status of the species in the Oconee River.

7.1 Improve knowledge of biological requirements.

7.1.1 Continue to document spawning activity at known sites and identify any additional sites.

- Investigate and describe characteristics of any previously unknown spawning sites.
- Investigate any past, present and/or future sources of degradation at all sites.

7.1.2 Continue to estimate larval abundance and distribution.

- Establish trends in abundance and distribution.
- Establish relationships between observed abundance and levels required for long-term sustainability.

7.1.3 Develop non-lethal methodology for determining age of individuals.

- Investigate methodologies for scale collection, preparation, and reading, and interpretation of data collected.
- Explore feasibility of using fin-ray cross-sections as an additional method to help validate data collected from scales.
- Explore other aging methodologies.

7.1.4 Assign a year class to each collected individual.

- Age un-tagged fish by non-lethal methods (e.g., scales, rays).
- Age tagged fish by determining a coded-wire tag location or PIT tag number.

7.1.5 Determine an appropriate length frequency distribution for a self-sustaining robust redhorse population.

- Compare Oconee River histograms developed in recent years when sample sizes were relatively low to earlier years when sample sizes were larger.
- Assess contributions of stocked fish to histogram.
- Determine if recent histograms suggest sustainability without stock augmentation.
- Compare histograms collected from robust redhorse in the Oconee River with catostomids collected from other rivers.
- Compare histograms of robust redhorse collected from the Oconee River with histograms collected from other robust redhorse populations.

7.1.6 Continue to investigate seasonal movement/migration patterns and habitat preferences through radio-telemetry studies, as appropriate.

- Conduct targeted electrofishing sampling to verify the presence of wild-spawned fish in association with locations of radio-tagged fish.
- Characterize population demographics and habitat preferences of any previously undiscovered aggregations of wild-spawned fish.

- Factor these observations into assessments of species status in the Oconee River.

7.2 Monitor the status of the Oconee River population and compare with other populations.

7.2.1 Continue observations and assessment of spawning activity at known spawning sites.

- Standardize methods of observation and reporting requirements.

7.2.2 Continue and refine standardized electrofishing program.

- Standardize sampling variables to conditions that have been maintained during broodfish sampling conducted from 1994 to present.
- Continue to evaluate long-term trends in the status of the Oconee River population.
- Develop additional statistical methods as needed to analyze trend data.

7.2.3 Survey areas not specifically targeted in the past, sampled only sporadically, or outside the management unit. These areas include:

- Sinclair Dam tailrace area to Hwy 22 in Milledgeville;
- Dublin to the confluence with the Ocmulgee River;
- Lake Oconee to Barnett Shoals Dam; and
- Oconee River above Barnett Shoals and Middle and North Forks in the Athens area.

7.2.4 Monitor reproductive output by continuing larval and juvenile sampling.

- Focus on habitat types and seasons that have not been sampled extensively in the past, including using information gathered from surveys in other river systems.
- Develop consistent sampling strategies and technologies to collect larvae and juveniles.

7.2.5 Develop a consistent population estimate methodology.

- Conduct population modeling using more recent sampling data.
- Evaluate applicability and conduct population modeling using a variety of appropriate models.
- Compare modeling results and interpretations.

7.2.6 Evaluate effectiveness of various sampling methodologies and gear types.

- Test gears and techniques used for catostomid sampling in other river systems.
- Evaluate these gears and techniques for sampling robust redhorse.
- Modify sampling protocols as needed to develop more efficient sampling regimes.

7.2.7 Review existing data on habitat quality and quantity to develop a more accurate estimate of available habitat.

- Repeat flow/habitat and low-velocity cell modeling using more recent information on habitat preferences of various life stages.
- Update the 1994 gravel survey conducted in the Oconee River with current data and develop a long-term monitoring strategy.
- Compare early aerial photos, maps, etc. with more recent images from Google Earth to assess changes in channel morphology.
- Relate any changes to possible large-scale habitat modifications that may affect robust redhorse habitat availability and quality.
- Determine if current flow regime provides optimal habitat for critical life stages. Provide appropriate flows as needed.
- Determine data needs and evaluate relationships between long-term changes in temperatures in the project area and declines in reproductive and recruitment success.
- Determine data needs and evaluate relationships between observed water quality and reduced reproduction and recruitment success.

7.2.8 Update information regarding habitat use based on results of periodic habitat surveys in the management unit.

- Evaluate preliminary observations of robust redhorse spawning over gravel deposits in deeper areas.
- Assess the quantity of suitable and available spawning, larval, and juvenile habitat.

7.2.9 Evaluate the contribution of stocked fish to the adult population.

- Incorporate the stocked component of the population into modeling exercises.
- Determine relative contribution of stocked fish under various levels of recruitment into the models.
- Evaluate the need for additional stocking to achieve population sustainability.
- Determine overall contribution of stocked fish to long-term genetic sustainability of the Oconee population.

7.3 Conserve and enhance the Oconee River population.

7.3.1 Quantify the effects of predation on robust redhorse survival.

- Determine the significance of flathead catfish or other predation pressures which may limit recruitment, such as through literature review, workshops, and/or field studies.
- Make decisions on predator abatement strategies, if needed.

7.3.2 Actively participate in the environmental review process, as appropriate.

- Evaluate potential effects of development projects on the Oconee River robust redhorse population.

- Focus on possible effects of flow quantity and quality, including sedimentation and temperature alterations that could affect all life stages of robust redhorse.

7.3.3 Continue evaluation of habitat augmentation and identify augmentation strategies to address habitat bottlenecks.

- Continue evaluation of gravel augmentation projects, to include the magnitude and characteristics of gravel transport from the project area, levels and rate of sedimentation, and seasonal utilization by robust redhorse.
- Modify future projects based on results of monitoring.
- Develop additional augmentation strategies, if needed (e.g., large woody debris, bank stabilization).
- Locate funding sources for additional projects if effectiveness is demonstrated.

7.3.4 Continue efforts to maximize genetic diversity.

- Determine genetic characteristics of stocked population and genetic diversity in the wild spawned component.
- Develop appropriate strategy to enhance genetic diversity if required.

7.3.5 Continue to refine artificial propagation and culture methods (e.g., pond rearing, cryopreservation).

- Develop protocols for appropriate use of cryopreserved sperm in artificial propagation.
- Evaluate intensive culture success of fry and fingerlings at various hatcheries.

7.3.6 Determine need and methodology for additional supplemental stocking(s) in the Oconee River.

- Determine characteristics of stocked population (age/year class distribution, genetic diversity).
- Conduct population monitoring under assumption of no recruitment from stocked fish as well as various levels of recruitment.
- Assess population sustainability/risk of extinction of Oconee population with no additional augmentation and at various levels of future augmentation.
- Factor genetic risks from inbreeding depression, outbreeding depression, and genetic swamping into assessments of the need for future stocking.
- Determine most appropriate sizes, ages, and sources of juveniles for future stocking, if needed.

7.3.7 Quantify the effects of angler harvest on robust redhorse survival.

- Conduct a targeted creel survey or develop an angler questionnaire.
- Incorporate harvest estimates into population models.

- Publicize harvest restrictions for robust redhorse to minimize potential harvest.

7.3.8 Expand public education and outreach efforts.

- Place signage at major access points that describes the recovery efforts, aids in species identification, lists possible threats, explains ways that the public can assist, and encourages the release of all robust redhorse that may be caught by anglers.
- Develop press releases and other educational materials in coordination with public relations offices of the GADNR, GPC, UGA, and FWS.
- Encourage ownership and participation in the recovery project by the public within the project area.
- Update the RRCC, FWS, and GADNR websites with new developments, information, press releases, etc.

7.4 Maintain refugial populations.

7.4.1 Monitor refugial populations and augment as needed.

- Conduct studies of stocked refugial populations in the Ocmulgee, Ogeechee, and Broad rivers to determine population size and demographics, movement patterns, habitat use, reproductive and recruitment success, and genetic composition.
- Determine if stocked populations are sustainable and if additional stock enhancement is needed.

7.4.2 Evaluate the need for establishing additional refugial populations.

- Evaluate habitat suitability throughout the Oconee River Basin, especially from Lake Oconee to Barnett Shoals and from Barnett Shoals to above Athens.
- Conduct targeted sampling to ensure robust redhorse do not exist in these areas.
- Determine the most appropriate strategy for introducing fish into the area if suitable habitat is available and robust redhorse are not detected.
- Monitor refugial population dynamics, predator-prey interactions, habitat use, and threats within refugial populations.

7.5 Create a schedule for revisiting this Oconee Management Plan.

7.5.1 Objectives and action items outlined in this report suggest a planning horizon of about 10 years.

- Annual progress updates will be prepared for the RRCC.
- Revisions to the management plan will take place every five years.
- Long-term objectives will be readdressed every ten years.

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