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Robust Redhorse Conservation

Strategy Report (2003)

Robust Redhorse Conservation Strategy



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North Carolina Wildlife Commission

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Carolina Power and Light

South Carolina Aquarium

South Carolina Electric and Gas

Georgia Wildlife Federation

U. S. Fish and Wildlife Service

U. S. Geological Survey Biological Resources Division

U. S. Forest Service

U. S. Army Corps of Engineers

Georgia River Network

Conservation Strategy
For
Robust Redhorse (*Moxostoma robustum*)

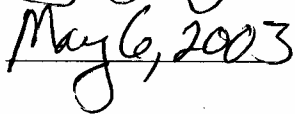
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Robust Redhorse Conservation Strategy

I. INTRODUCTION

The robust redhorse (*Moxostoma robustum*) was described by Edward Cope in 1870 from specimens collected in the Yadkin River, North Carolina. The species was essentially lost to science until 1991 when five specimens were collected by Georgia Department of Natural Resources, Wildlife Resource Division (WRD) biologists downstream of Sinclair Dam on the Oconee River near Tombsboro, Georgia. As of 2002, wild individuals are known to exist in the Oconee and Ocmulgee rivers in Georgia, the Savannah River of Georgia and South Carolina and the Pee Dee River of North and South Carolina. The species is considered to be very rare and is classified as endangered by the Georgia Department of Natural Resources (Freeman, 1999). Recovery efforts have been initiated by a diverse group of stakeholders that comprise the Robust Redhorse Conservation Committee (RRCC). The RRCC was established in 1995 through a Memorandum of Understanding (“MOU”) among stakeholders including state and federal agencies, conservation organizations, and the private sector. The MOU establishes a mechanism for conducting research on the robust redhorse, coordinating conservation actions, and sharing information on its status. The primary goals of the RRCC are to develop an understanding of the biology and status of this species, and to reestablish reproducing populations within its historic range. Current members of the RRCC include U. S. Fish and Wildlife Service, Georgia Department of Natural Resources, South Carolina Department of Natural Resources, U. S. Army Corps of Engineers, Georgia Power Company, Duke Power Company, CP&L—A Progress Energy Company, South Carolina Electric and Gas Company, U. S. Geological Survey Biological Resources Division, North Carolina Wildlife Resources Commission, U. S. Forest Service, Georgia Wildlife Federation, Georgia River Network, and the South Carolina Aquarium. The Parties to this Robust Redhorse Conservation Strategy (“the Strategy”) intend the Strategy will promote voluntary conservation initiatives and stakeholder partnerships for conserving the robust redhorse as a logical outgrowth of conservation efforts taken by the Parties since 1991. The Parties view the Strategy as a guide for decision making, allocation of resources, and a summary of research objectives. As such, this Strategy is intended to be consistent with, and in the spirit of, the Endangered Species Act. The Endangered Species Act contains provisions designed to encourage creative partnerships between public and private sectors and among government agencies to conserve imperiled species and their habitat (Endangered Species Act, 2(a)(5)). An example of this type of provision is the Candidate Conservation Agreement with Assurances (Conservation Agreement) as described in 64 Federal Register 32706 (1999).

Participation in the RRCC and decision making is described in policies developed by the RRCC. These policies were adopted by consensus during the RRCC annual meeting held October 16-18, 2002 (RRCC, 2002) and are the means for implementing the Strategy.

II. PURPOSE

The purpose of this Conservation Strategy is to assure the continued survival of the robust redhorse within its historic range. This document describes the status and distribution of the species, discusses problems facing the species, and presents conservation actions to be implemented.

III. STATUS AND DISTRIBUTION

A. Systematics and taxonomy

Five large catostomids were collected by Georgia Department Natural Resources biologists from the Oconee River, Georgia, near the mouth of Commissioner Creek on August 8, 1991. Meristic characteristics did not correspond precisely to any known species and average length exceeded all catostomid species known to occur in the Altamaha River drainage. Dr. Bud Freeman, curator of the Georgia Museum of Natural History Fish Collection, and Dr. Henry Bart, then curator of the Auburn University fish collections, independently indicated 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. Dr. Bob Jenkins, Professor of Biology at Roanoke College, determined that the specimens matched the description of a large North American sucker first described by Edward Cope in 1870.

The catostomid in question is now believed to have been described by Edward Cope in 1870 based entirely on a large stout specimen collected in 1869 from the Yadkin River (Pee Dee drainage), North Carolina and given the scientific name *Ptychostomus robustus* (*Ptychostomus* is synonymous with the present genus *Moxostoma*). Cope's original type specimen was lost long ago and later workers erroneously labeled much smaller specimens of another species as types. Hence the scientific name *P. robustus* was misapplied by later revisers of the Catostomidae to a smaller species. This smaller species, sympatric with the larger more robust form, has since 1956 been known in the scientific literature, incorrectly, 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 River specimens (Jenkins and Freeman, and Evans in preparation; Jenkins, in preparation).

The robust redhorse is a long-lived, large, heavy-bodied sucker that attains total lengths greater than 700 mm and weights up to 8 kg. The oldest specimen that has been aged is believed to have been 27 years old. This species has large molariform pharyngeal teeth specialized for crushing hard-bodied prey such as mussels, and is the only species within its range with this character. The robust redhorse is bronze on the back and sides becoming pale or white ventrally. Adults are faintly striped along lower sides. Juveniles will have intense red in the caudal fin and anal fins, which becomes less distinct in adults.

Adult males develop large tubercles on the snout and head during the spawning season. The robust redhorse is distinguished from other Atlantic Slope suckers by coloration, large head, large adult size, and the straight margin of the lower lip often with the medial plicae extending more posterior than marginal plicae (i.e., a pronounced “flap” on the lower lip in adults). Members of the genus *Moxostoma* differ from the genus *Scartomyzon* by having 12-13 caudal peduncle scale rows rather than 15 or 16 .

B. Status, distribution, and habitat requirements

1. Existing Conditions

The robust redhorse is presently found in piedmont and upper coastal plain sections of the Oconee and Ocmulgee rivers, Georgia, the Savannah River, Georgia / South Carolina, and the Pee Dee River, South Carolina/North Carolina. The RRCC considers the extant populations to be Evolutionary Significant Units (ESUs) based on current genetic information. The RRCC will continue to manage identified ESUs as distinct populations in order to maintain the genetic diversity of the species across its historic range (See RRCC, 2002}.

Introductions have occurred in the Broad River and a population is now believed to exist in this river and the downstream reservoir, Clarks Hill Reservoir, Georgia. Introductions are also occurring in the Ogeechee River, and in a segment of the Ocmulgee River, Georgia.

The recent discovery of robust redhorse in the Savannah, the lower Ocmulgee, and Pee Dee rivers, which have been extensively sampled for other species, suggests that this species can be difficult to collect, or may have been overlooked or improperly identified in the past.

2. Distribution

The historic range of the robust redhorse is believed to include Atlantic Slope drainages from the Pee Dee River in North Carolina to the Altamaha River in Georgia. Individuals have been recorded from natural populations in the Pee Dee River, North Carolina, the Savannah River, Georgia / South Carolina, and the Oconee and Ocmulgee rivers, Georgia since 1991

A population of unknown size exists in the Pee Dee River, North Carolina/South Carolina, in the lower segment of the Yadkin-Pee Dee River system which this species historically occupied. Three specimens from the Pee Dee River have been collected in a 28-mile reach of the river in the piedmont/coastal plain regions of North Carolina/South Carolina below Blewett Falls Dam during 2000-2001.

Six native fish were captured from the Savannah River between October 1997 and October 1998. One was captured downstream from the New Savannah Bluff Lock and Dam in October 1997. Four fish were captured from the Augusta Shoals area in June

1998 and an additional fish was captured near the US 301 bridge in October 1998. Subsequently, twenty-three adults in spawning condition were collected in May 1999 from the Savannah River in the Augusta shoals area and four from below the New Savannah Bluff Lock and Dam. The size of the Savannah River population is uncertain at this time and is being investigated.

The Oconee River population is known from a 70 mile reach between Milledgeville and Dublin, Georgia (Evans, 1994). The population estimate was re-evaluated during 1999 and is believed to consist of 600 adult fish in the reach between Dublin, Georgia, and Big Black Creek (Jennings et al., 2000). An unknown but probably smaller number exist between Big Black Creek and Milledgeville.

The RRCC reintroduced the robust redhorse into the Broad River (located in the Savannah River drainage) and the Ogeechee River in Georgia. Approximately 32,000 age 0 and age 1 fingerlings from multiple year classes have been introduced into the upper Broad River, Georgia, between 1995 and 1998. Forty-five of these fish, ranging in length from 30 to 40 cm, have been recovered 60 miles downstream in Clark Hill Reservoir (C. Jennings, personal communication).

Reintroductions are also occurring in the Ogeechee River, and a segment of the Ocmulgee River, Georgia.

3. Life history

Most of the information available concerning the life history of this species has been generated from research conducted on the Oconee River. The robust redhorse spawns during April, May, and June when water temperatures reach 21 to 23 degrees Centigrade, although spawning may occur over the range from 18 to 25 degrees Centigrade. Spawning is typical of *Moxostoma* and involves spawning triads with two males fertilizing the eggs of a single female, which are deposited in gravel substrate. Shallow water conditions in the Oconee River occasionally allow visual observation of spawning fish, but there are indications of spawning activity at greater depths as well (Freeman et al., 1998). Adult fish are large (modal total length 66 cm, range from 42 cm to 72 cm). Juveniles less than 40 cm in length have not been collected from the Oconee River.

The requirements for successful recruitment of robust redhorse are not fully understood. The requirements for successful emergence of yolk-sac larvae from gravel beds include absence of fine sediment (Dilts, 1998). The subsequent food requirements and preferred habitats of juvenile robust redhorse are poorly understood. The recruitment rates in the Oconee River appear to be low, but need to be examined in the context of the population size and the long life span of the robust redhorse. Recruitment and population dynamics in the Ocmulgee, Savannah, and Yadkin-Pee Dee populations are not presently well documented. Possible migration of juveniles and adults are also not well understood. These are priority subjects of current research.

Diet studies of adults are limited. The few specimens examined from the Oconee River

suggest that adult fish feed primarily on bivalves, including the Asiatic clam (*Corbicula* sp.). The life span of robust redhorse is believed to be 25 to 30 years and the major known population is believed to be composed of numerous year classes (Jenkins, unpublished data).

4. Habitat requirements

The robust redhorse inhabits Piedmont Plateau and upper Coastal Plain sections of South Atlantic slope rivers. Piedmont reaches are characterized by rock shoals, outcrops, and pools, particularly along the Fall Line. The upper Coastal Plain reaches typically have sandy banks and beds interspersed with shoals and gravel bars. The upper Coastal Plain reaches also have extensive networks of swamps, oxbows, and floodplains. Woody debris and fallen trees seem to provide preferred habitat for adult robust redhorse in the Oconee River. Clean gravel bars are necessary for spawning and development of larval fish.

5. Site specific habitat and biological information

Site specific information should be evaluated when reintroduction is planned (See RRCC, 2002) Site characteristics recommended for consideration include:

Habitat

- Suitable flow
- Spawning areas consisting of suitable gravel substrate
- Adequate food supply
- Accessibility for sampling and monitoring
- Available river miles for sustaining a refugial or reproducing population
- Presence of woody debris providing cover for adults

Fishery issues

- Predatory fish presence and densities
- Genetic composition of stocked fish and isolation from other populations
- Impacts on native species (other endangered species)
- Impacts on commercial and sport fisheries
- Presence of historic fishery data, including surveys for robust redhorse
- Biomass or abundance of non-native species

Watershed criteria

- Presence of hydropower operations and low-head dams
- Significant water withdrawals
- Current water quality issues summarized in 305(B) reports
- Historic water quality data
- Non-point source management plans and practices
- NPDES permitted discharges which may influence water quality
- Active river or watershed protection group capable of monitoring and influencing land use
- Land use patterns (urban, forested, agriculture, feed lots)

- Presence/absence of sand and gravel operations

C. Research status and needs

1. Initial studies

Research regarding the status and re-establishment of robust redhorse populations has been underway since 1992. The Robust Redhorse Conservation Committee has coordinated research and management of the robust redhorse since 1995. Early research focused primarily on the Oconee River population, with emphasis on the following areas:

- flow requirements for young of year fish;
- larval fish densities;
- recruitment rates for the existing population;
- gravel substrate requirements for successful spawning;
- the process for collecting adult brood fish, collecting and fertilizing eggs, and rearing juvenile fish for reintroduction; and
- surveys for additional populations within the historic range.

The process for propagating fish has been established, although difficulty continues to be experienced with survival rates from the post yolk sac larval stage to harvestable juveniles after one or two years. This may be related to nutritional or habitat requirements during this stage. The rate of survival of year 1 fingerlings from eggs of artificially spawned robust redhorse has increased from 11 per cent in 1995 to 67 percent in 1997. The production of year 2 fingerlings from ponds, however, has been variable. The low production rate in 1996 (7.7% from fry to year 2 harvest) has resulted in an emphasis on using year 1 fingerlings for introductions. There is speculation that the survival of larval fish past the yolk sack stage in the hatchery environment is affected by nutritional requirements and food availability (Shelton, 1998). The propagation of robust redhorse is described in RRCC policies (See RRCC, 2002)

Larval fish (13 to 20 mm in length) are capable of swimming speeds in the range from 7 to 12 cm per second and exhibited avoidance behavior of high flow rates in laboratory systems (Ruetz and Jennings, 1997). The flow velocities in the Oconee River from hydroelectric and natural events are not believed to significantly restrict young of year habitat because habitable areas exist with flow velocities less than 7 cm per second even during varying flow conditions (Ruetz and Jennings, 1997). Beginning in 1997, the operation of Sinclair Dam on the Oconee River, Georgia, provides run of river flows from May 1 through June 10, removing potential negative effects of hydro-peaking during the spawning and early rearing period. The Flow Advisory Team, a subcommittee of the RRCC, is responsible for evaluating the effect of the flow regime on robust redhorse. Research indicates that emergence (swim-up) success is reduced in gravel substrate with significant percentages of fine sediments. Fifteen percent fine sediment to gravel ratio resulted in fifty percent survival measured as the emergence rate of fry. It is projected

from laboratory data that successful larval emergence rate in the Oconee River is approximately eight percent (Dilts 1998).

Larval fish densities have been assessed since 1995 as part of an on-going task to estimate the reproductive and recruitment success of robust redhorse in the Oconee River (Jennings et al, 1996). Multiple gear types including push-nets, D-ring nets, light traps, and seines have been used to sample larval and post-larval fish. Estimated densities at specific sampling locations are based on low sample numbers of robust redhorse and are variable. Prior to implementing the license flow agreement for Sinclair Dam in 1997, densities ranged from 0 to 13.4 larvae per 1000 cubic meters during May 1995 and 0 to 3.4 larvae per 1000 cubic meters during May and early June, 1996. Subsequent to implementing run-of-river flows in the spring, densities ranged from ? to 33 larvae per 1000 cubic meters during May 1997, and from ? to 10 larvae per 100 cubic meters during May 1998. (Do not have numbers for 1999). The low number of individuals collected and the variation in the natural hydrology of the Oconee River have made interpretation of results difficult, but the collection of greater numbers of other larval and post-larval catostomids suggests that the recruitment rates are unusually low.

The population number in the Oconee River was re-evaluated in 1999-2000 in order to assess its current status (Jennings et al, 2000). This study evaluated the capture data collected from 1994 through 1999 and implemented a capture-recapture study to provide parameters for use in the Jolly-Seber population model. The population is estimated to consist of 607 (standard error = 138) robust redhorse greater than 417 mm total length in the Oconee River between Dublin and a point one river mile above Black Creek. This assessment indicated that new individuals were recruited to the population annually (ranging from 5 to 57% of the estimated population in each of four years evaluated). Survival of robust redhorse from year to year was high (average of 0.68) but variable.

2. Current research

Current research is focused on robust redhorse culture, genetics, and biological requirements. Research projects include:

- Locating and characterizing spawning sites;
- Evaluating collection methods for juvenile fish, and locating preferred habitat(s);
- Evaluating the genetic variability of existing populations; and
- Assessing abundance, mortality rate, and recruitment rate for the known populations.
- Study of movement of wild adults and cultured juveniles
- Evaluating population status in river systems in the historic range; and
- Evaluation of mass marking of fry and fingerlings

IV. PROBLEMS FACING THE SPECIES

Species warrant listing under the Endangered Species Act if the species is endangered or threatened throughout all or a significant portion of its range due to any one of the following five listing criteria:

- present or threatened destruction, modification, or curtailment of its habitat or range;
- overutilization for commercial, recreational, scientific, or educational purposes;
- disease or predation;
- inadequacy of existing regulatory mechanisms; or
- other natural or manmade factors affecting its continued existence.

A. Habitat

Current research indicates that habitat modification is one of the primary factors affecting the decline of robust redhorse. Historic land use practices including intensive farming and deforestation led to excessive erosion and subsequent sedimentation, and caused dramatic changes in riverine habitats. Reproduction by this species appears to be sensitive to sedimentation (Dilts, 1998). Mollusks, presumed to be a major food source for the robust redhorse, would also have been severely impacted by sedimentation (Stansbery, 1971) (although Asiatic clams, a food source, have proliferated). Although direct cause and effect relationships have not been determined, water quality degradation from point and non-point sources may also have contributed to historic declines.

The members of the RRCC are pursuing habitat restoration opportunities within the affected watersheds, including habitat restoration, restoration of degraded stream channels, and the development of conservation agreements. Specific activities include development of a policy on habitat restoration addressing potential funding, partnerships, and activities (See RRCC, 2002). Water quality concerns are addressed primarily through the federal and state permitting process.

It is possible fisheries workers have missed the robust redhorse in collections and the current range of the species may be underestimated as a result. Because of the robust redhorse's benthic habitat and the depth of rivers, additional populations may exist within the historic range but remain undetected.

B. Over-utilization

Other factors affecting the decline of robust redhorse may include historic over-harvesting in the late 1800s during the spawning season when the fish are vulnerable. There appears to be no current over-utilization for commercial, recreational, or educational purposes.

C. Disease or predation

Robust redhorse from the Oconee River and Savannah River have been examined for the presence of parasites and infectious diseases by the US Fish and Wildlife Service's Warm

Springs Fish Health Center. No evidence of infectious disease has been identified in fluid or tissue samples collected from wild fish (Heil, 1997, 1998).

The introduction of non-native species such as the flathead catfish has influenced the abundance of native fish species (Evans, 1991), and may impact robust redhorse populations through predation on juveniles. Flathead predation on young robust redhorse is suspected to be a significant factor in limiting recruitment into the Oconee River or other river populations, however, the extent of any predation is unknown. Flathead catfish have been introduced in nearly all of the large southeastern rivers within the historic range of the robust redhorse. Effective control of the flathead catfish may not be possible, and it is unclear whether removal efforts would have a significant long-term impact on flathead catfish or robust redhorse populations. The flathead catfish is a potential concern for the RRCC conservation efforts. The effect of predation by flathead catfish on robust redhorse has not been evaluated due to practical limitations in conducting such studies. Additionally, the impact and interactions of other large, non-native fishes, such as smallmouth buffalo, blue catfish, and common carp with the various life stages of robust redhorse are also presently not well understood or defined in the river systems where these species coincide.

D. Inadequacy of existing regulatory mechanisms

Many of the environmental factors believed to have reduced populations of robust redhorse to the current levels are historic in nature, including sedimentation from poor land use practices, and chronic, (and severe) water quality degradation. The implementation of the Clean Water Act, the Resource Conservation and Recovery Act, the National Environmental Policy Act, agriculture and soil conservation programs, reforestation, and many other regulatory programs, have improved riverine conditions significantly.

Development of hydropower facilities affects robust redhorse populations by limiting access to probable historic spawning sites and reducing the amount of historic riverine habitat. Site specific flow regimes may be limiting factors below hydropower facilities but can be addressed through the FERC relicensing process for non-federal projects and by NEPA for actions involving federal projects. In many cases, dams also help with sedimentation loading in immediate downstream riverine areas by acting as sediment traps and thus locally improving water quality in tailwater reaches.

While the RRCC has no authority to manage non-point source pollution impacts, participants including the U. S. Fish and Wildlife Service and the state natural resource agencies are pursuing riparian enhancements, watershed protection plans, and similar habitat protection activities through the federal and state regulatory processes. The U. S. Fish and Wildlife Service and state agencies participating in the conservation effort conduct extensive reviews of proposed projects that may impact habitat for robust redhorse. These environmental reviews are major considerations in the issuance of state and federal permits.

E. Other natural or manmade factors affecting its continued existence

The limited geographic range and the presumed low number of wild individuals are considered the most serious threat facing the continued survival of the robust redhorse. The recent discovery of wild populations in the Ocmulgee, Savannah, Pee Dee rivers suggest further exploration of other rivers within the historic range or adjacent rivers close to the historic range (e.g. Cape Fear River) may be productive.

The existing Oconee River population appears to be genetically heterogeneous and actively spawns in the spring (RRCC, 1997). An age and growth investigation indicated over 90% of the population is between 15 and 26 years of age although a few fish as young as 5-6 years have been collected. The absence of juvenile fish from surveys in the Broad River following introduction of 32,000 fingerlings between 1995 and 1998 is consistent with this pattern. The collection of over 40 tagged fish from this introduction in Clarks Hill Reservoir during 1998 through 2002 is also consistent with the observation that collected fish typically have minimum lengths of 40 cm and that a sampling bias may occur.

Lasier et al. (2001) evaluated sediment associated contaminants in the lower Oconee River to determine their sources and evaluate potential for reducing survival and growth of early life stages of robust redhorse. Manganese and zinc were found to be present in potentially deleterious concentrations in sediment pore water, but only zinc was found to inhibit growth in the selected surrogate, a freshwater amphipod, *Hyalomma azteca*. Significant reductions in sediment-metal concentrations occurred between the fall of 1998, when amphipods were tested, and the spring of 1999 when robust redhorse egg and larval stages were evaluated. While manganese concentrations for sediments collected in the spring of 1999 were lower than concentrations in sediments from the fall of 1998, pore water collected downstream of specific creeks discharging into the Oconee River did exhibit toxicity to early robust redhorse life stages. Toxicity is believed to be related to the concentration of manganese and reduction to the Mn^{2+} species.

V. CONSERVATION ACTIONS TO BE IMPLEMENTED

A. Conservation Goals

The following short and long-term goals have been adopted and are implemented through consensus policies approved by the RRCC in October, 2002 (See RRCC, 2002).

1. Short-term goals (2003 – 2008)
 - a) Establish refugial populations to reduce the impact of potential catastrophic events on known populations and core ESUs.
 - b) Locate wild populations within the historic range
 - c) Determine characteristics of populations, including population size, age structure, genetic variability, recruitment rate, and mortality rate.
 - d) Implement necessary actions to maintain populations.
 - e) Identify and implement habitat restoration and/or protection measures to benefit the species.
2. Long term goals

Establish or maintain at least six self-sustaining populations distributed throughout the historic range.

B. Conservation Actions

The conservation actions necessary to achieve long and short term goals are included in specific policies adopted by the RRCC. Specific conservation actions are adopted in management plans for each river system or distinct ESU. These actions address the following:

1. Implement habitat restoration and watershed management practices to protect suitable spawning sites, nursery, and adult holding sites.
2. Assess possible existence of additional spawning sites.
3. Manage artificial propagation from adult broodfish collected from specific ESUs with an identified need for reintroduction of robust redhorse into selected river systems and refugial ponds.
4. Establish a list of candidate sites and a process for prioritization,
5. Determine habitat and life history requirements.
6. Establish river basin management plans or agreements to implement conservation actions for specific sites, including monitoring survival and growth.

The conservation actions necessary to achieve short and long term goals are described in specific policies adopted by the RRCC. These policies provide the operating principles for this conservation effort including: goals; restoration, biology, and conservation; and administration (RRCC, 2002).

C. Monitoring

Monitoring and reporting on the status of the robust redhorse is an important and necessary part of this Conservation Strategy (See RRCC, 2002). Interested organizations, as well as the public at large, are kept informed of the RRCC's efforts on behalf of the robust redhorse and the results of those efforts. In order to monitor the species properly, the RRCC has determined it necessary to take the following steps:

D. Organization and Resources

The continuing coordination issues of the overall effort are the responsibility of the RRCC Excom. The RRCC Excom review research needs, prioritizes projects for proposal and funding, and coordinate use of resources. The RRCC Excom includes representatives from research institutions, US Fish and Wildlife Services, state natural resource agencies, and other participants (See RRCC, 2002).

In addition, each river system is assigned a technical working group (TWG). TWGs represent the members of the RRCC who are actively engaged in research, protection, and restoration of robust redhorse in a specific geographic region. The Conservation Actions developed for the river basin / ESU management plan are coordinated by the TWG and implemented using facilities and resources provided by its members.

The following list examples of research funding and resources provided to this effort.

Georgia Power Company funds research regarding the habitat requirements and recruitment success of the Oconee River population.

The U. S. Fish and Wildlife Service and the Georgia Department of Natural Resources fund brood-fish collection, hatchery operation, reintroduction efforts, and status surveys.

The South Carolina Department of Natural Resources provides additional hatchery production, conducts surveys, and manages projects in South Carolina drainages.

The South Carolina Department of Natural Resources, the North Carolina Wildlife Resources Commission, the U.S. Fish & Wildlife Service, and CP&L conduct population status surveys on the Yadkin-Pee Dee River.

The Electric Power Research Institute funds population genetics research with financial support by Duke Power Company and CP&L.

Georgia Department of Natural Resources and Georgia Power Company fund research on improving culture techniques.

In addition to funding for conservation actions under this Conservation Strategy, specific actions may be agreed upon in Reintroduction Programs (see RRCC, 2002) or through specific Conservation Agreements. Funding for these activities is described in the respective management plans or agreements.

VI. CONSERVATION AGREEMENTS

The Endangered Species Act includes provisions for conservation agreements among private and non-Federal property owners, State and local managing agencies, and the US Fish and Wildlife Service to restore, enhance, or maintain habitats for proposed, candidate and other unlisted species. Conservation agreements may facilitate reintroduction of robust redhorse and related habitat protection through definition of certain goals and commitments by parties cooperating in this restoration effort. The following describes important aspects of these agreements.

A. Conservation Benefits

Implementation of Conservation Agreements for reintroduction of robust redhorse at a number of similar sites may be a necessary step to remove threats to the continued existence of this species as described in section III of this document. It is believed that clearly delineated responsibilities and actions will facilitate conservation of this species.

B. Non-Federal Landowner Assurances

Conservation Agreements may include assurances for property owners that if the robust redhorse is listed as a Federal Endangered Species at a future date, and the agreement has been implemented in good faith by the participating non-federal property owner, the US Fish and Wildlife Service will not require additional conservation measures nor impose additional land, water, or resource restrictions beyond those committed to under the terms of the original agreement. Assurances involving take will be authorized through the issuance of a section 10(a)(1)(A) Enhancement of Survival permit, which will allow the property owner to take individuals of the covered species consistent with those levels agreed upon and identified in the agreement.

C. Adaptive Management Provisions

Adaptive management provisions are necessary to ensure that unforeseen circumstances affecting the conservation of the robust redhorse can be adequately addressed through Conservation Agreements. Adaptive management provisions are especially necessary when, as here, significant biological information is lacking, including information on the life history of the species, possible existence of additional wild populations, and the effectiveness of proposed conservation measures described in specific Conservation Agreements.

If unforeseen circumstances arise through the development of new biological information or result from a catastrophic event that warrant additional conservation measures, such measures would, to the maximum extent possible, be consistent with the original terms of the Conservation Agreement.

D. Additional Provisions in Conservation Agreements

Conservation Agreements created to implement this Conservation Strategy should identify:

- Existing wild populations of the robust redhorse or existing inhabitable river reaches suitable for reintroduction;
- Habitat available for all life stages and habitat protection and enhancement measures that may be necessary to protect wild or introduced robust redhorse;
- Conservation measures participating non-Federal property owners are willing to undertake to conserve the robust redhorse;
- A description of the benefits expected to result from the conservation measures;
- Monitoring provisions including measuring and reporting progress and changes in habitat conditions; and
- Notification provisions to provide state natural resource agencies and the US Fish and Wildlife Service reasonable opportunity to rescue individual robust redhorse before any authorized take occurs.

VII. MEASUREMENT OF SUCCESS

The goal of the RRCC is the restoration of the *Moxostoma robustum* throughout its known range (See RRCC, 2002). In order to implement this effort effectively, the RRCC has adopted short- and long-term goals expressed in this Conservation Strategy and implemented policies to guide future actions (RRCC, 2002).

VIII. FIGURE

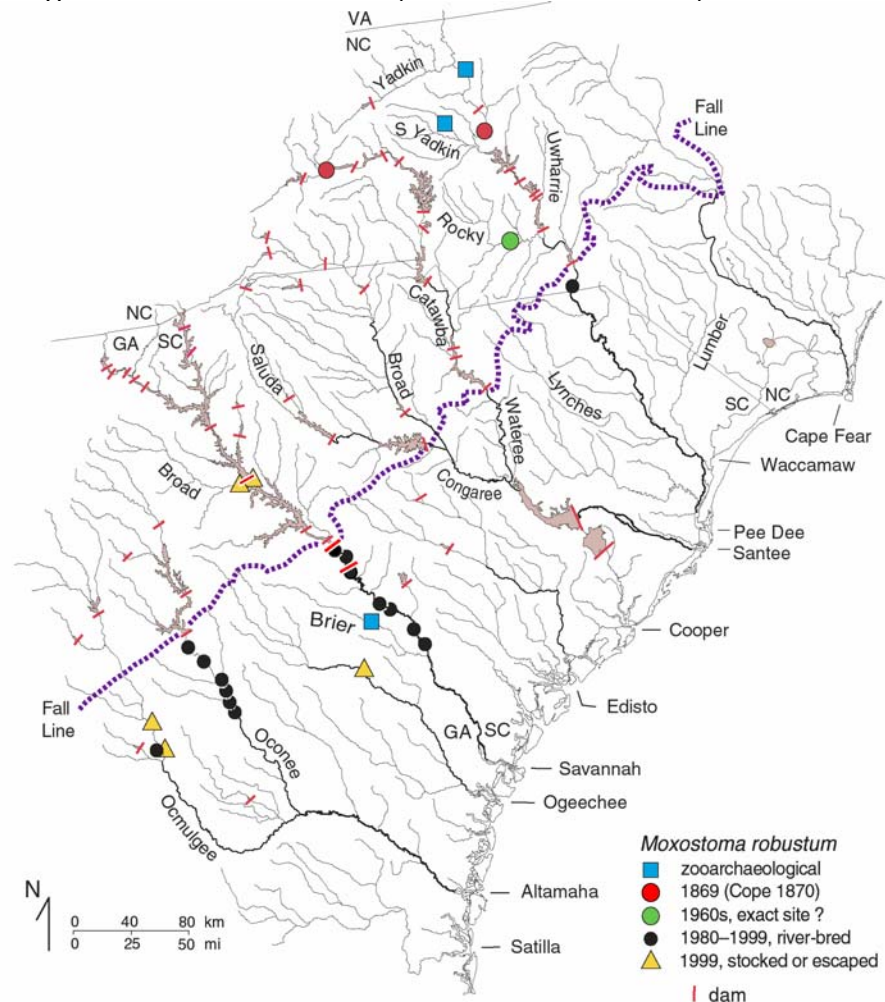
A. Historic range of the robust redhorse (*Moxostoma robustum*).

Fig. 1. Records of *Moxostoma robustum*. Number of specimens by drainage or system: Pee Dee 5; Santee 1; Savannah 42 (sites of the 4 record symbols crossed by dam symbols are below the dams); Ogeechee 1; Oconee 870 (detail in Fig. 1); Ocmulgee 3. Triangles represent artificially bred fish captured after stocking or escape from rearing ponds. Fall Line drawn from Anonymous (1963a-c) and Harris and Zullo (1991). Dams shown mainly for larger streams (south of Cape Fear drainage).

Map by R. E. Jenkins, B. J. Freeman, and J. W. Evans (October 1999)

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