Robust Redhorse Conservation Committee

Policies

Adopted October 18, 2002

Table of Contents

Executive Summary

Rationale

The Robust Redhorse Conservation Committee (RRCC) was created in 1995 through a memorandum of understanding to conserve robust redhorse. A Conservation Strategy (Strategy) describing the status of the robust redhorse and presenting short and long term goals was finalized in 1998. The Strategy provides an overview of the history and direction of the RRCC's efforts. The RRCC has developed sufficient information on the robust redhorse and activities have expanded to the point that unifying policies were needed to implement the long and short term goals established in the Strategy. The following policies describe the current understanding and processes for conserving this unique species.

Goals Policies

Measurement of Success: RRCC members and collaborators agree to abide by and support its short- and long-terms goals and to use RRCC definitions of specific terms related to measuring the success of the restoration effort.

Species and Population-level Management: The RRCC will continue to mange the extant populations of the species as Evolutionary Significant Units (ESUs); newly discovered populations will be evaluated genetically and will be managed in accordance with its ESU status (i.e., new or existing ESU).

Conservation Policies

Criteria for Conducting Surveys for Robust Redhorse: Surveys should be conducted to detect the presence of robust redhorse in suitable rivers and habitats prior to the initiation of reintroduction or augmentation efforts. Further, these surveys should be scheduled and organized as described herein.

Propagation and Breeding: When management actions call for the use of cultured off-spring, such use should prevent the loss of genetic variability of an ESU and the species as a whole.

Goals and Objectives of the Refugial Population Program: The RRCC supports the continued establishment and maintenance of refugial populations of robust redhorse to safeguard the species against catastrophic losses of ESU in the wild.

Reintroduction Programs and Monitoring: Reintroductions of robust redhorse into a river system from which the species has been extirpated will be conducted according to a well-developed reintroduction plan that includes the assembly and synthesis of relevant information about the river to be stocked, the identification of potential factors that may limit the success of the reintroduction, and reasonable goals and monitoring schedules. The long-term goal of the reintroduction should be the establishment of a self-sustaining population.

Habitat Restoration: The RRCC will promote habitat restoration and protection.

Administrative Policies

Decision Making: The RRCC will use a combination of consensus- and vote-based decision approaches to develop and document 'recommendations' and 'decisions' of the RRCC as a whole or of subsets of members to guide implementation of the robust redhorse recovery and management effort and the structure and function of the RRCC.

Executive Committee and Technical Working Groups: The RRCC will elevate the original Technical Advisory Group (TAG) to the level of an Executive Committee (Excom). The RRCC empowers the Excom with the day-to-day issues associated with the regional recovery effort and to address regional issues. In addition, the RRCC will form Technical Working Groups (TWGs) and empower them to address local or special interest issues.

Membership to the Robust Redhorse Conservation Committee: Requests to participate in the RRCC shall be made in writing and addressed to the Chair of the RRCC. The letter should include the party's willingness and ability to bring resources to the conservation effort.

Stakeholder Notification of RRCC Recovery Actions: The RRCC supports notifying potentially affected local governments, large landowners, and other major stakeholders prior to undertaking major conservation or management actions and agreements that involve the RRCC as a whole, a subset of members of the RRCC, or individual RRCC members and will provide meaningful opportunities to these groups to give input on the proposed action

Evaluating and Communicating Threats to RRCC Recovery Efforts: The RRCC will inform all MOU signatories regarding potential actions that threaten recovery efforts so that each signatory can respond appropriately to agents posing threats or to regulatory agencies as needed during comment periods or in a timely manner.

Annual Meetings: The RRCC will dedicate ample time to research and management updates, presentations from guests who share knowledge of similar endeavors, discussions of information provided, and decisions.

Research: The RRCC will take an active role in determining research topics and prioritizing research needs in support of the robust redhorse recovery, without compromising the investigators' ability to fulfill requirements of the funding agent(s) or to pursue independent publication of research findings. In order to base decisions on sound information, the RRCC will require complete, timely, well-written research results that will serve as the scientific basis for its decisions.

Communications within the RRCC: The RRCC Executive Committee and TWGs should communicate activities and action items of the robust redhorse recovery effort to participants, as appropriate.

Preface

Policy: an informed position designed to guide independent, future actions or conduct (Clark and Kellart 1988; Carver 1990 in Fraidenburg 2001)

Organizational theorists note that over time organizations progress through a series of phases in a fairly predictable life cycle. In the early phase of an organization's life cycle, one finds a dream or vision that generates a great deal of excitement. This phase typically is informal and supports creativity because boxes 'to think outside of' do not yet exist.

Organizations that survive this 'start-up' phase grow, add personnel, and assume more responsibility. This growth inevitability creates the need for greater formality such as establishing policies and procedures, and clarifying the chain of command. In addition, people, the environment, and the political climate shift over time, and necessitate organizations to adjust if they are to remain viable.

These growth curves occur in all organizations, but the outcome is not guaranteed. At any time, organizations can reach a plateau, fail, and vanish. Organizations avoid a flattening of the growth curve by reorganizing and re-energizing.

The Robust Redhorse Conservation Committee (RRCC) was formed in 1995 under a Memorandum of Understanding (MOU). Although one cannot say with certainty where the RRCC is on its growth curve, it clearly has grown, matured, and been successful. It has successfully laid the foundation and framework to develop and coordinate the implementation of a conservation program for the robust redhorse and in doing so has moved toward accomplishing the initial 'vision' of species recovery. To remain successful, the RRCC should examine its life phase and shift controls as necessary or risk a flattening of its growth.

Measurement of Success - Restoration

Policy

RRCC members and collaborators agree to abide by and support its short- and long-terms goals and to use RRCC-accepted definitions of specific terms related to measuring the success of the restoration effort.

Commentary

The goal to the RRCC is the restoration of the species throughout its historic range (Memorandum of Understanding, 1995 and 2000). This goal will be accomplished when six self-sustaining populations of the species exists within its historic range (Conservation Strategy, 1998). Other goals include the development of an understanding of the biology and status of this species and to reestablish reproducing populations within its historic range (Conservation Strategy, 1999). To accomplish the goal of restoration, the RRCC has adopted a subset of Conservation Strategy objectives and strategies to accomplish its mission.

> Short-term goals: establish refugial populations; locate other wild populations; determine population characteristics; and implement management and regulatory actions to maintain the existing known populations.
>
> Long-term goals: establish or maintain at least six self-sustaining populations distributed within a significant portion of its historic range.

Definitions

During discussions related to the effort to prevent the extinction of and to effect the recovery and restoration of the robust redhorse, many words or terms are used that warrant defining. In the effort to save the species, participants often use a word or term that may have different meanings to different individuals. To reduce the likelihood of misunderstandings among individuals, the following definitions will be recognized by the RRCC as they relate to its efforts at restoration of the robust redhorse throughout its historic range.

<u>Recovery</u>: Rebuilding or reestablishing the robust redhorse as a species, population by population, to a self-sustaining level that requires only periodic monitoring and continued protection. Recovery actions can take many forms, including but not limited to: improving habitats to enhance spawning and nursery areas and adult holding habitat; reducing or eliminating siltation; monitoring population levels for survival and growth; spawning wild broodfish and rearing off-spring for reestablishing extirpated populations; spawning wild broodfish and rearing off-spring to bolster an existing population that is too small to remain genetically diverse; or establishing refugial populations to prevent the loss of the species or an evolutionary significant unit.

Self-sustaining: According to Webster's 3rd New International Dictionary (1966), self-sustaining is "maintaining or capable of maintaining oneself or itself by one's or its independent efforts." For robust redhorse, this infers that a population or all known populations are at a level where the natural recruitment rate is equal to or greater than its mortality rate (i.e., without supplementation by hatchery off-spring). To meet the requirement of self-sustainability, the population must have a "recruitment rate ... equal to or greater than its mortality rate" through some minimum time period. One suggested period could be the potential reproductive period of an individual robust redhorse. Currently, most robust redhorse males are believed to become sexually active at 4-5 years of age, whereas females become sexually mature at about 5-6 years of age. The oldest know specimen of robust redhorse is 27 years old (Jenkins, Roanoke College, pers. comm.). So, the potential reproductive period could be considered from age 5 to 27 or a 22-year period. Therefore, at a minimum, 22 years would be required to determine if a population of robust redhorse has sufficient recruitment from multiple year classes to maintain its numbers or be self-sustaining. A caveat to the 22-year monitoring period would be if the population estimate falls below a predetermined level. An example could be similar to the recommended level stated in the Species and Population-level Management policy on genetics, which requires a minimum of 100 pairs of broodfish to prevent loss of genetic variability. At this point, a management decision would need to be made on actions to be taken, such as the desirability of introducing hatchery reared animals to the population.

Recruitment: The addition of naturally produced individuals (off-spring) to a preexisting population (Jenkins and Burkhead 1993). Recruitment for robust redhorse recovery and self-sustainability will infer that a naturally produced (as opposed to hatchery reared) individual has entered the population as a reproducing adult. If the number of recruits per unit of time is equal to or greater than the mortality rate of adults in the population, the population is said to be self-sustaining (see above) and in the context of the RRCC has been recovered. If the number of recruits per unit of time is greater than the mortality rate, the population would be self-sustaining but would also be increasing in numbers. If the population was depressed previously, for whatever reason(s), it could now be considered to be in a restoration mode whereby the population would be increasing to some previously unknown level.

In addition to recruitment of naturally produced animals to a population as in the determination for self-sustainability, recruitment of hatchery produced and stocked animals can also occur. Two examples would be: in the case of a population or ESU that is below the 100 pairs of broodfish recommended in the genetics policy or in the case of reintroducing the species into a river or river basin from which it has be extirpated. In these cases, animals that were stocked, have survived, and are being collected during monitoring would be considered recruits, and the fish would be considered to be recruiting to the population.

Restoration: Actions taken to return a population or ESU of robust redhorse to historic levels throughout its entire range. If delineating historic levels for the species or a population is impossible, then the target population level should be a level that allows for consumptive use of the animals without affecting the survival of the species. Many of the actions taken for restoration are the same or similar to the actions taken for recovery, but the survival of the species is no longer at stake. Restoration will allow the species or a population to be used by humans for sport, commercial, or other purposes (e.g., education) in addition to its esoteric value.

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Species- and Population-Level Management

Policy

The RRCC will continue to mange the extant populations of the species as Evolutionary Significant Units (ESUs); newly discovered populations will be evaluated genetically and will be managed in accordance with its ESU status (i.e., new or existing ESU).

Commentary

Currently, robust redhorse are being managed as separate populations (representing Evolutionary Significant Units or ESUs) in the Altamaha, Savannah, and Pee Dee systems. Although Oconee River fish were stocked into the Broad River of Georgia (Savannah River drainage) with the intent of founding a new population, this stocking was initiated prior to knowledge of a genetically distinct natural Savannah River population and has since been ceased. The apparently small population size of robust redhorse comprising these three ESUs has been a point of concern. In the past, many in the RRCC believed that the species was in jeopardy of being extirpated by catastrophic events or that the natural populations were declining. Accordingly, the following questions were formulated for consideration.

1) Should the RRCC manage the robust redhorse at the ESU or species level?

2) Is stocking a natural population with progeny from a different ESU ever acceptable?

Genetic analyses (Wirgin et al. 2001; Ike Wirgin personal communications) have indicated that the robust redhorse population structure is divided into three ESUs, defining unique populations in the Altamaha, Savannah, and Pee Dee systems (see Appendix 1 for additional discussion). While restoring the robust redhorse as a species, retaining the natural distinction of each ESU that forms important components to the evolutionary legacy of the species, as a whole is highly desirable. Waples (1991) states, “the evolutionary legacy of a species is the genetic variability that is a product of past evolutionary events and which represents the reservoir upon which future evolutionary potential depends. Conservation of these genetic resources helps to ensure that the dynamic process of evolution will not be unduly constrained in the future.”

The extinction of one ESU would represent a significant loss to the composition of the species as a whole. However, attempts to “recover” a rapidly declining population by stocking with a different ESU would replace its genetic and ecological uniqueness. Each population may have evolved genetic, morphological, and physiological adaptations to unique environments, providing them with specific life history traits, habitat characteristics, disease and parasite resistance not found in other ESUs. Once an ESU is lost or genetically mixed with another, we can never recover the lost unique gene pool that was shaped for generations via natural selection.

In addition to the loss of genetic diversity, mixing ESUs theoretically can result in out-breeding depression and cause extirpation or severe population declines in the remnant natural population. Potentially, this phenomenon can disrupt the breeding cycle, reduce fitness in the F1 and subsequent generations of hybrids, and break up co-adapted gene complexes. Mixing of ESUs (via stockings) may also promote the transfer of parasites or disease to a native population and cause catastrophic declines in natural isolated populations being stocked. Given these factors, the RRCC recommends continued management of the robust redhorse at the ESU level in an attempt to preserve the natural partition of genetic and ecological variation currently present in the species.

Guidelines for Managing Robust Redhorse ESUs

The following are guidelines to adhere to the current ESU management goals.

- Candidate streams for founding new populations with stocked fish should be sampled extensively (Criteria for Conducting Surveys for Robust Redhorse Policy) to determine the presence or absence of natural populations of robust redhorse. If a natural population is not present, and the candidate stream has good critical habitat, it can be used to found a new population (reintroduction) with progeny from a geographically proximal ESU where available. Streams deemed to lack critical habitat can be removed from the candidate list for reintroduction, since all stocking of rivers should have the objective of establishing self-sustaining populations (Habitat Restoration Policy), which is not probable without critical habitat.

- If a natural population is discovered by survey (Criteria for Conducting Surveys for Robust Redhorse Policy), determining the population size, recruitment rate, and mortality rate is necessary to determine if the newly discovered population is self-sustaining or in need of recovery. Genetic studies also should be performed on newly discovered populations to identify their genetic affiliations to other known ESUs.

- If a newly discovered population is a member of a known ESU and is in need of recovery, tools such as habitat restoration (Habitat Restoration Policy), predator removal, and stocking (Propagation and Breeding Policy) with progeny from the same ESU are all appropriate options. If the newly discovered population represents a unique ESU and is in need of recovery, determining the cause of the natural population's decline is necessary to direct further recovery efforts.

All efforts to preserve the genetic and ecological uniqueness of a given ESU should be attempted. Stocking with an alternate ESU should be viewed as an option under only two specialized circumstances.

1) If the cause of population decline can be demonstrated clearly to result from severe inbreeding depression (see Appendix 2 for additional discussion) or the population will likely become extirpated within the next two generations or if tests of artificial outcrosses between ESUs in a hatchery or experimental population produce reproductively viable offspring with alleviated inbreeding depression, then the unique population would benefit from out-crossing and could be stocked with an alternate ESU (Land & Lacy 2000). Before out-crossing, the remnant population should be

"vouchered" by preserving genetic samples, cryopreserving sperm, and potentially maintaining a captive aquarium population for future research.

2) If the cause of population decline is because of habitat degradation, predation, or is unknown, and all attempts to recover the unique ESU are not effective, two final questions must be considered before attempting to replace the unique ESU by stocking with an alternate one. A) Is the unique ESU likely to become extirpated within the next two generations? B) Does the unique ESU inhabit critical habitat that is essential to restore the minimal number needed to found populations to safeguard against catastrophic loss of another ESU? If the answer to both these questions is clearly yes, mixing or replacing the unique natural population with the alternate ESU (see Figure 1) may be in the best interest of the species. The remnant natural population should be "vouchered" as above.

Literature

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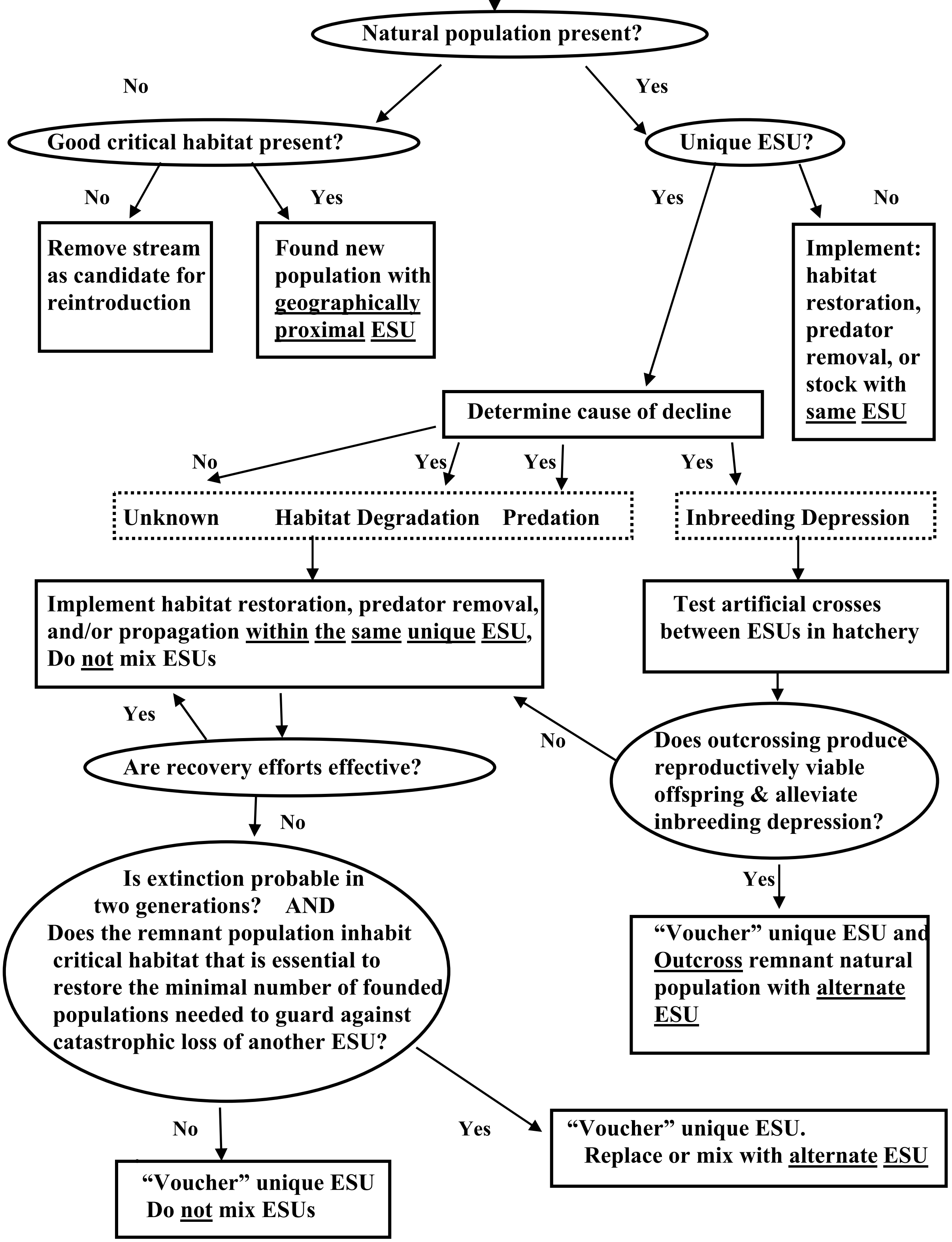
Figure 1. Maintaining Unique ESU Decision Tree (see Criteria for Surveys Policy)



Criteria for Conducting Surveys for Robust Redhorse

Policy

Surveys should be conducted to detect the presence of robust redhorse in suitable rivers and habitats prior to the initiation of reintroduction or augmentation efforts. Further, these surveys should be scheduled and organized as described herein.

Commentary

Surveys for unknown populations are a necessary and critical component of the conservation effort directed at the robust redhorse. The primary purpose of a survey is to detect the presence of robust redhorse. These surveys require substantial planning and coordination to accumulate the necessary sampling effort. The survey should supply the RRCC and applicable management agencies with enough information to direct future activities, which could include assessing the size and status of a newly discovered population or planning for a successful reintroduction effort.

A prioritized list of rivers believed suitable for robust redhorse is an important prerequisite of surveys. The RRCC, with assistance from each participating state agency, will generate this list. This list should be prioritized according to each individual river's potential to: A) harbor an extant population of robust redhorse, and B) support a self-sustaining population of robust redhorse that could be initiated through a reintroduction plan. If a list of rivers is prioritized separately according to criteria developed for scenarios A) and B), the resultant ranking from each effort may or may not be the same. The top priority rivers for survey would be rivers that received combined high marks from both rankings.

Surveys used by the RRCC should be intensive enough to determine presence or absence of robust redhorse as well as provide valuable information regarding the size or status of a newly discovered population. Survey results could be placed in 1 of 3 categories: Category 1 is characterized as a population containing numerous individuals; Category 2 is characterized by the failure to capture a single individual, which indicates a very low probability of an extant population; Category 3 is characterized by an intermediate situation in which there are only a few individuals captured despite substantial effort. Management options based on survey results are presented below.

<u>Category 1</u>: This situation is a positive conservation product and extensive study of this newly discovered population is warranted. The progression of further study and potential management should be consistent with the Robust Redhorse Conservation Strategy. A TWG or local RRCC members, as established and directed by the RRCC (Executive Committee and Technical Working Group Policy), would determine specific details regarding goals, methods, and time frames for conservation efforts.

<u>Category 2</u>: An opportunity might exist to create an additional population through stocking, which supports one of the original and primary goals of the RRCC. The establishment of this

population, if attempted, also should be consistent with the Conservation Strategy, which will include the Policy (or policy statements) on reintroduction programs and monitoring (Reintroduction Programs and Monitoring Policy). A TWG or local RRCC members, as established and directed by the RRCC, would determine specific goals, time frames, and appropriate methods for conservation efforts.

Category 3: Options are much less clear because of varying genetic philosophies and geographical and jurisdictional boundaries. Based on the current (October 2002) level of knowledge of the robust redhorse in the Pee Dee River, NC/SC, this river has a Category 3 population. The Conservation Strategy should ultimately serve as a guide for managing this population, because it will contain Policies (or policy statements) on genetics and management of individual populations (Species- and Population-Level Management Policy).

Having discussed the purpose and potential results for surveys and implications for the RRCC, the question facing the RRCC is what elements should a survey contain to detect the presence of robust redhorse and obtain the necessary quantity and quality of data to place a specific river into Categories 1, 2, or 3.

Robust redhorse are difficult to capture in their native habitats. So much so that existing fishery data, collected for purposes other than discovering robust redhorse, may be of little use except for prioritizing rivers for surveys. One aspect of river sampling for robust redhorse in light of limited resources is clear, a single agency or company probably would not be able to supply all the necessary personnel and equipment for a thorough and effective survey on any given river. Just as the RRCC is a cooperative body, surveys must be a cooperative effort.

Survey Organization

Ideally, the survey should be for one primary purpose – documenting the presence or absence of robust redhorse. To this end, the RRCC will draft a short protocol for surveys to be used in combination with this policy and which would include additional detail for consideration by the survey organizer. This protocol should include the following items at minimum:

- A single person or "organizer" should be in charge of planning, organizing, and leading the survey. The planning of such surveys should be done in coordination with the RRCC Excom and any appropriate TWG. The RRCC Excom should ensure that adequate sampling effort is expended in the appropriate types of available habitat. The organizer should recruit an appropriate number of participants and electrofishing boats[1] for the habitat to be sampled.

[1] Traditionally, surveys for robust redhorse have been conducted almost exclusively with electrofishing gear. This policy is directed at providing guidance on the appropriate amount of electrofishing effort necessary for RRCC purposes, but in no way intends to exclude other collection gears. Georgia's Wildlife Resources Division (GWRD), for example, has reservations about the use of gill nets for sampling robust redhorse, therefore other gear should be used as applicable and in cooperation with the appropriate state agency.

- On regulated rivers, the organizer must also coordinate with power companies and other river authorities to ensure that appropriate flow conditions are available for sampling.

- On unregulated rivers, the organizer must also pick seasonal windows that have a high probability of catching fish and for providing appropriate flows for effective sampling.

- The organizer should learn as much as possible about the habitats contained within a prospective sampling reach. This can be done through topographic maps, photography, and on-site habitat assessments

- The survey organizer should strongly consider conducting the survey during spring when water temperatures are between 18-24º C, as adults may be more vulnerable to sampling during spawning activities near shoals and gravel bars. However, the RRCC recognizes that the fall months, with lower seasonal flows, may also offer desirable sampling conditions on some rivers.

- The organizer must consider size of river and whether it is in the Piedmont or Coastal Plain to effectively distribute sampling crews and effort.

- The organizer should recruit participants that have previous experience collecting and identifying robust redhorse, if possible.

- Prior to the survey, the organizer should conduct a safety meeting with all participants and provide vital information including known hazards, water safety, and emergency phone numbers.

Presence / Absence Survey Components

The primary consideration of any survey is the accumulation of enough sampling effort (effective electrofishing time) in appropriate habitats at an appropriate time of year or flow condition to reasonably expect to discover robust redhorse. In a relatively narrow river such as the Oconee or Ocmulgee in Georgia, a reasonable assumption is that one electrofishing boat could sample 10 river miles in one day, primarily fishing appropriate habitat types and accumulating three to four hours of electrofishing pedal time. If a river is wide and relatively shallow such as the Pee Dee near the Blewett and Tillery hydropower plants or the Savannah River near Interstate 20, more effort from more boats will be necessary per river mile of habitat.

A single survey should not be considered sufficient effort for detecting robust redhorse because of high variability associated with fishery sampling. Ideally, an adequate effort for a given river or river reach should consist of multiple surveys, each accumulating at least 0.3 hours pedal time per river mile. This could be accomplished by conducting spring surveys in consecutive years or spring and fall surveys in the same year.[2] Surveys conducted during the spring spawning season (April – May; water temps vary) may be more productive than other times of the year.

[2] Jimmy Evans (GWRD) and John Crutchfield (Carolina Power and Light) were consulted on the appropriate amount of sampling effort, which will vary according to habitat available and type of river. It

The North Carolina Wildlife Resource Commission's (NCWRC) policy on augmentation and reintroduction recommends that a reintroduction may be considered when the species has not been detected during the last ten years (NCWRC 2000). The policy requires documentation of sampling protocol and effort, but does not address any minimum sampling effort required to detect presence of the species.

Green and Young (1993) used the Poisson distribution to estimate sampling efforts necessary to detect rare mussel species. Bayley and Peterson (2001) estimated the probability of missing a species when it was present by developing species-specific detection probabilities. These references may be useful to the RRCC to help develop a firm and scientifically defensible requirement for sampling effort to detect robust redhorse. However, much of the information in these two papers may be better applied after some sampling has already been done. Bayley and Austen (2002) developed models of catchability for many warm water lacustrine species, and this work may also be a useful reference to the RRCC and should be required reading for survey organizers.

As a General Rule of Thumb

- A minimum sampling effort target per survey should be at least 0.3 hours of pedal time per river mile

- A minimum of three to five surveys meeting the above target effort should be conducted during the previous ten years to detect robust redhorse in a given reach of river.

- Depending on the results of these surveys additional effort may be necessary to place the river into Category 1, 2, or 3.

Literature

Bayley, P. B. and D. J. Austen. 2002. Capture efficiency of a boat electrofisher. Transactions of the American Fisheries Society 131:435-451.

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is suggested that providing general guidance on a target of sampling effort and letting the organizer and local factors determine specific details is better than aiming for a fixed amount of pedal time.

Propagation and Breeding

Policy

When management actions call for the use of cultured off-spring, such use should prevent the loss of genetic variability of an ESU and the species as a whole.

Commentary

Before the RRCC was formed in 1995, spawning wild broodfish and rearing the resultant off-spring had been used as a management tool to meet the goal of restoration of the robust redhorse. Early on, the establishment of refugial populations established in both lotic and lentic habitats at sites within the known range was deemed necessary to protect the species. The objective of this effort was to safeguard the species, then known only from the Oconee River, GA, by placing its genetic compliment in several, unconnected locations. These populations would serve as the source of broodfish from which to reconstitute the species in the event of a catastrophic loss in the river or population decline from lack of recruitment. To further safeguard the Oconee River population, none of the individuals were removed or relocated elsewhere. Instead, a small number of these individuals were spawned manually and their offspring became the source for refugial populations elsewhere. Once the RRCC was established, propagation became a management tool to meet its goals. The philosophy of using propagation to meet the needs for establishment of any populations and to reestablish self-sustaining populations within the known range has continued from the early stages of the restoration effort up until the present. The use of propagation for restoration and recovery is a sound biological tool supported by many success stories with other species.

At the onset of the restoration program, the RRCC realized that establishing refugial populations either in riverine habitat or in managed ponds required the greatest effort possible to maximize genetic diversity either within an existing (founding) population or any refugial populations (Cross and King, 1983; Gharrett and Shirley, 1985; Kapuscinski and Jacobson, 1987). Loss of genetic diversity generally leads to inbreeding, loss of vigor and adaptability of the species, and should be avoided at all costs (Krueger, et al., 1981; Ryman and Laikre, 1991; Verspoors, 1988).

Propagation and Breeding Objectives

- Supply genetically diverse animals for reintroduction into suitable habitats from which the robust redhorse has been extirpated.
- Supply genetically diverse animals for establishment of refugial populations to prevent loss of the species or ESU because of a catastrophic loss in the wild or population or decline from lack of recruitment.
- Supply genetically diverse animals for reintroduction to restore an existing population (Measurement of Success - Restoration Policy).

- Supply genetically suitable animals for research directed at ensuring the survival of the species.

Genetics Conservation Goals

- Prevent in-breeding depression.

- Ensure maximum genetic diversity when establishing founding populations in habitats from which the robust redhorse has been extirpated.

- Ensure genetic diversity when establishing various refugial populations.

- Ensure genetic diversity when introducing animals into an existing population in an attempt to prevent in-breeding from occurring.

Robust Redhorse Genetics Management Plan

Schram (1999) and Kincaid (1993) have recommended at least a 20-year program for establishment of populations of long-lived species for recovery purposes. This is the time required to ensure that the greatest degree of genetic diversity is captured in the introduced animals. One of the goals of the Robust Redhorse Genetic Management Plan may require the introduction of at least 20 year classes into any reestablished population to capture the greatest amount of genetic diversity as possible (Measurement of Success - Restoration Policy) and establish a bell shaped age distribution curve.

Before reintroductions are undertaken, certain information needs to be at hand or parameters set. For example, information is needed on the expected carrying capacity (numbers of adults and younger year classes) of the reintroduction area when the genetic goal of 20 year classes is met.

A. Since we do not have historic information on this species to guide the program, models may need to be developed or models of other long-lived species (i.e., sturgeon, razorback suckers, river redhorse) need to be modified to supply a reasonable estimate of carrying capacity.

B. Estimate expected annual mortality rate for each year class to determine the number of off-spring to reintroduce (stock) each year to meet the carrying capacity goal and the goal of a self-sustaining population. Mortality may be highest during the first and possibly second year after the introduction. Mortality rates in subsequent years usually are much lower (e g., ?10-20%). Monitoring of the introduced fish will allow fishery managers to use actual survival rates to refine models.

Effective Breeding Population (Ne)

Whenever a population is being established in a river system in which the species either has been documented to have occurred or which reasonably should have occurred, this new population should be considered a founding population. All future natural recruitment within the population will originate from this initial founding population. This founding population should be established with a minimum parental population of 100-200 fish (Allendorf and Phelps 1980; Hynes et al. 1981; Krueger et al. 1981; Kincaid 1983). To err on the conservative side, a minimum of 200 broodfish (100 males and 100 females) should be used to establish the founding population. Because of the estimated age at maturity (females at 6 years; males at 4-5 years) and potential difficulties acquiring gametes from existing populations, the population should be established with a minimum of 20-year classes (Schram et al. 1999 and Kincaid 1993). Therefore, an average of 10 broodfish (total males and females) should be used each year. The actual number of broodfish available each year may be more or less than 10 but should total 100 males and 100 females over the 20-year period. See Appendix 2 for additional discussion.

None of the individuals in the parental population should be used more than once (St. Pierre 1996). This goal can be accomplished by tagging each broodfish with a passive integrated transponder tag (PIT) and an external tag. All available information (e.g., length, weight) on each broodfish at the time of capture should be recorded in a database. Additional data related to the spawning and resultant hatch also should be recorded. In addition, tissue samples (e.g., fin clip, blood) from each broodfish should be obtained. One sample should be kept as a backup to meet future genetic information needs, and a sample(s) should be made available for disease diagnosis.

Effective population (Ne) can be maximized by stocking equal numbers of progeny from each family (Allendorf 1993; Ryman and Laikre 1991). In fact, this approach will allow Ne to be calculated accurately since the number of males and females spawned each year as well as the number of fry stocked in rearing ponds from each family will be known. In the event that equal numbers of progeny from each family cannot be stocked each year, a reliable Ne can still be calculated with the known numbers of male and female broodfish and the number of progeny stocked from each family.

Annual Breeding and Captive Culture Plan

With the cooperation of the members of the RRCC, the spawning effort can acquire robust redhorse gametes from more than one system, such as the Oconee and Savannah rivers. Every effort should be made to acquire genetic material from as many individuals within an ESU as possible, which will generate the greatest genetic diversity within a founding population. Having said this and in accordance with the current philosophy in genetics, the source of broodfish should be from a site closest to the reintroduction site and of a similar environment to that where stocking will occur (Krueger et al. 1981; Ryman and Laikre 1991). This approach assumes equivocally that robust redhorse and the biologist studying them perceive habitat characters similarly. An alternative approach for rivers where robust redhorse currently are not found was suggested by Krueger et al. 1981. They advise making collections from all possible wild populations that represent the entire genetic diversity of the species, performing all possible crosses with and between the different sources, and then stocking the progeny. This strategy maximizes genetic variability, and after stocking relies on the wild environment for selection of the most fit. This approach should maximize the genetic diversity within the planted fish, provided that an adequate sample of the genetic variability within the species has been made. This strategy should not be used where the potential exists for interbreeding between stocked fish and indigenous populations. Such hybridization would break up previously existing and potentially adaptive gene combinations that occur in the wild populations (Krueger et al., 1981 and Species- and Population-level Management Policy).

There are two options where an existing population of robust redhorse is in need of supplemental stocking with hatchery produced fish to bolster the population: 1) If genetic analysis and population estimates determine that there are sufficient numbers of genetically variable adults available to support a spawning effort, these adults should be used as the source for supplemental stocking into that river (Krueger et al., 1981 and Species- and Population-level Management Policy). 2) In a case where genetic analysis and population estimates determines that there are insufficient numbers of genetically diverse adults available to support use, the population can be bolstered with hatchery produced progeny according to the guidelines in the previous paragraph and Species- and Population-level Management Policy.

Mating Design Options

Single pair and half-sib family mating are two basic mating designs in use with conservation aquaculture (Anders, 1998; Kincaid, 1993; Fiumera et al., in preparation). Modifications of these two designs include equal parental contribution and unequal parental contribution.

- In single-pair, full-sib matings, a single male is mated to a single female, and these broodfish are not mated with any other fish again for inclusion in the establishment of the founding population. Thus, each fish contributes genetic material at a single mating to create a family. Usually this method also incorporates the use of equal numbers of offspring (with equal parental contribution) from each family contributing to the population. Mating designs that equalize parental contributions consistently maintain the largest mean effective population sizes, but on average produce only about one-half as many offspring as designs that do not equalized parental contributions (Fiumera. et al., in preparation).

- Full-sib designs with unequal parental contributions normally maximize off-spring production, but produce the smallest mean effective population sizes (Fiumera et al., in preparation).

- Half-sib matings are most useful when small numbers of broodfish are available or when uneven numbers of males and females are captured. This option does not maximize Ne, but does allow for the greatest Ne possible when using small numbers of individuals from a parental population. This option also allows for the production of a greater number of off-spring than full-sib matings with equalized parental contribution. Generally, half-sib designs that did not equalize parental contributions come closest to the goal of jointly maximizing off-spring production while maintaining relatively large effective population sizes (Fiumera et al., in preparation).

- In half-sib family matings, the eggs from a single female are divided into two or more equal aliquots. Each aliquot of eggs is fertilized with sperm from a single, different male; that male not used again (Table 1). For example, the eggs from female "B1" could be divided into five aliquots, and each aliquot fertilized with the sperm from a single male (i.e., males A1-A5). The result would be five families related maternally but not paternally. This process would be repeated for each subsequent female such that the eggs from female "B2" would be divided and fertilized with sperm from males A6-A10. This process would create an additional five families that are related maternally but not paternally and are unrelated to the first five families.

- Another scenario for the production of half-sib families is the use of a matrix (Table 2) whereby the eggs from two or more females are divided equally, and each aliquot of eggs from each female is fertilized individually with the sperm from one of the available males. For example, if four females and five males are available, the eggs from each of the four females would be divided into five equal aliquots (20 total aliquots). Aliquot 1 from each female would be fertilized with the sperm from male A1, and Aliquot 2 from each female would be fertilized with the sperm from male A2. This scenario would produce 20 half-sib families (Table 3) and probably would be the easiest to use (especially with limited numbers of both sexes).

Table 1. Example of a partial half-sib family mating with 10 males and two females that produces 10 families.

Female	Male									
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
B1	X	X	X	X	X					
B2						X	X	X	X	X

Table 2. Example of a half-sib family mating with 10 males and two females to produce 20 families.

Female	Male									
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
B1	X	X	X	X	X	X	X	X	X	X
B2	X	X	X	X	X	X	X	X	X	X

Table 3. Spawning matrix with five males and four females to produce 20 half-sib families.

Female	Male				
	A1	A2	A3	A4	A5
Female B1	X	X	X	X	X
Female B2	X	X	X	X	X
Female B3	X	X	X	X	X
Female B4	X	X	X	X	X

Glossary

Refugial population - a population of fish established as a gene bank to supply genetically diverse off-spring in the event of the loss of a native, wild population or for use in reestablishing self-sustaining populations

Wild population - a population of fish or a particular individual within the population that has spent its whole life in its natal stream; as opposed to a population or individual fish that originates from a hatchery.

Founding population - 1) The adults (either wild or hatchery-reared) used to produce off-spring that are used to establish a population. For example, all of the Oconee River adults that were spawned and produced off-spring (F1 generation) that established the Broad River, GA, robust redhorse population would be considered the founding population. 2) The group of animals that are the base from which a population grows. An example is the F1 off-spring that is forming the adult population of the Broad River, GA and from which future generations of robust redhorse will be formed.

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Goals and Objectives of the Refugial Population Program

Policy

The RRCC supports the continued establishment and maintenance of refugial populations of robust redhorse to safeguard the species against catastrophic losses of ESU in the wild.

Commentary

Refugial populations are defined as non-reproducing populations established through stocking of hatchery-reared fingerlings for the purpose of safeguarding gene pools of individual Evolutionary Significant Units (ESUs) in the event of extinction of wild, riverine populations. Refugial populations should be composed of multiple year classes and may be established in:

- Managed ponds
- Select river reaches not suitable for establishing sustainable populations

The refugial population program was implemented when the only known robust redhorse population was found in the Oconee River (Altamaha drainage, Georgia) and was intended as a safeguard against the possible disappearance of that population and therefore the entire species. This program seemed especially crucial since the size distribution indicated low recruitment rates, and predation pressures may have increased with the appearance of flathead catfish in the early 1980s. In the mid-1990s, pond-reared refugial populations were established from Oconee River broodstock at Piedmont National Wildlife Refuge near Macon, Central Georgia Branch Station near Eatonton, and in several ponds on Georgia state fish hatcheries. A total of about 19,000 fingerings composed of five-year classes had been stocked in over 30 acres of ponds by 2002.

Robust redhorse were discovered in the Ocmulgee (Altamaha drainage), Savannah, and Pee Dee rivers during 1997-2000. The Altamaha (Oconee and Ocmulgee), Savannah, and Pee Dee populations were determined to be genetically distinct and were designated subsequently as distinct ESUs (Species- and Population-level Management Policy. Current emphasis has been given to the management of these populations as distinct ESUs; therefore, the long-term sustainability of individual stocks has become a concern. To address this concern, a refugial population composed of Savannah River stock was established in a single pond on the Fort Gordon Military Installation in Georgia in 1999. A total of 4,340 fingerlings from a single year class were stocked in this pond in 1999-2000.

During 1995-2002, the Broad, Ogeechee, and Ocmulgee rivers in Georgia were stocked with about 65,000 fingerlings produced from Oconee River broodfish; these stockings were an effort to create self-sustaining populations. In combination with the pond-reared refugial populations, the establishment of these stocked populations substantially reduced the risk of extinction of the Oconee River ESU. Fingerlings produced from Savannah or Pee Dee River broodfish have not been stocked in any other rivers.

The initial goal of the refugial population program was simply to reduce the possibility of extinction of the species until more could be learned of its status and conservation measures taken to assure its survival. Since the discovery of the Oconee River population in 1991, three other populations have been discovered, three rivers have been stocked with fingerlings from Oconee River broodstock, and much has been learned about the status of the species throughout its historic range. The following policy direction for the refugial population program reflects current understanding of the status of the species.

Goals and Objectives of Refugial Populations

The goal of the RRCC's refugial population program is to reduce the threat of extinction of individual robust redhorse ESUs; refugial populations should be maintained at levels consistent with perceived threats to the survival of ESUs. Presently, these ESUs are found in the Altamaha (Oconee and Ocmulgee), Savannah, and Pee Dee drainages. Others may be discovered in the future. Status of ESUs is determined primarily from a synthesis of available information on abundance and distribution, reproduction and recruitment success, predation pressures, and an evaluation of trends in electrofishing catch rates. These parameters provide a very general assessment of the risk of extinction of individual ESUs over a 10-20 year period (Table 4). The number of refugial ponds recommended is a function of both risk assessment and pond availability in 2002. Refugial pond requirements for each risk level can be adjusted periodically based on pond availability, improvements in culture methods, and changes in agency as well as Committee goals and priorities.

Table 4. Planning level assessment of relationships between risk of extinction of individual robust redhorse ESUs over a 10 – 20 year period and refugial pond requirements.

Factor	Risk			
	High	Moderate	Low	None
Population size[a]	< 300	300 – 500	500 – 1000	> 1000
Electrofishing catch rates (no/hr)[b]	< 3	3 – 6	6 – 10	> 10
Recruitment rate	Low or unknown	Low to moderate	Moderate to high	High
Longitudinal distribution (RM)[c]	< 50	>50	> 50	> 50
Flathead catfish abundance[d]	High	Low or none	Low or none	None
Number of refugial ponds needed	> 3	2 – 3	1 – 2	None

a Relates to population size needed to prevent inbreeding depression (Propagation and Breeding Policy).
b To date (Fall 2002), a general correlation between population size and electrofishing catch rates has not been established to be statistically significant in the Oconee River, GA.
c Populations confined to relatively shorter river reaches are more vulnerable to significant mortalities from catastrophic natural or manmade events (e.g., chemical spills, prolonged droughts).
d Recognizes established relationship between presence of flathead catfish, declines in abundance of catostomids (Evans 1991), and shifts in fish community composition (Ashley and Buff 1986).

Note: Each stocked riverine population, with evidence of significant growth and survival, reduces the risk of ESU extinction by one level. Each stocked population that shows evidence of significant survival and recruitment reduces the risk of ESU extinction by two levels. All stocked populations are assumed to be composed of multiple year classes.

The RRCC recognizes that some ESUs may not fit precisely into one of these categories, risk status will change over time, and that data may not be available to assign risk categories to all ESUs. In these instances, a risk category will be assigned based on the best available information and professional judgment. In the absence of data needed to assign risk, managers should assume a worse case scenario when assessing refugial pond requirements for individual ESUs.

The following objectives apply to the goal of establishing refugial populations.

A. Since refugial ponds are difficult to locate and costly to stock and maintain, the total number of refugial ponds should be minimized while still meeting the primary goal of reducing the risk of extinction of ESUs.

B. River reaches that contain minimal suitable spawning habitat may be useful for establishing refugial populations and are of great use if populations are easily accessible for monitoring and broodfish collection.

C. Refugial populations of individual ESUs should be composed of multiple year classes where possible, but there is also potential value in maintaining populations composed of single year classes.

D. Refugial populations of individual ESUs should never be established outside of native drainages.

E. The objectives of the refugial population program should be expanded to include a secondary goal of providing a source of juveniles and adults for research purposes (e.g., age and growth, nutrition, meristics, telemetry investigations).

F. Rivers typically are stocked with the objective of establishing self-sustaining populations. However, if full sustainability is never realized, these populations should be viewed as refugial and stocking should continue to maintain abundance and genetic diversity. Whether self-sustaining or refugial, stocked riverine populations significantly reduce the risk of extinction of ESUs and should be factored into assessments of refugial pond requirements (Table 4).

The suitability of individual rearing ponds will be evaluated according to the Rearing Protocols, and only ponds with required characteristics will be stocked as refugial ponds. Unsuitable ponds that have been stocked in the past should not be considered refugial ponds and should not be systematically stocked in the future. These ponds do retain some value since they may contain very small numbers of relatively large juveniles and could be stocked with limited numbers of fingerlings (< 20/ ac), if there is a surplus.

Finally, although the goals and objectives of this policy could be considered long-term, implementation will vary substantially as knowledge increases about the status of individual ESUs. The refugial population program should be reviewed every three years and modified as needed to reflect the most current understanding of relationships between the risk to individual ESUs and the allocation of refugial ponds.

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Reintroduction Programs and Monitoring

Policy

Reintroductions of robust redhorse into a river system from which the species has been extirpated will be conducted according to a well-developed reintroduction plan that includes the assembly and synthesis of relevant information about the river to be stocked, the identification of potential factors that may limit the success of the reintroduction, and reasonable goals and monitoring schedules. The long-term goal of the reintroduction should be the establishment of a self-sustaining population.

Commentary

The MOU that established the RRCC described the general intent, function, and responsibilities of the RRCC and charged it with implementing a conservation program for robust redhorse. The conservation program was to include "conservation measures that will focus on protection and management of the remaining population of the robust redhorse, establishment of captive-breeding populations, and reestablishment of the species within a significant portion of its historic range in Georgia, North Carolina, and South Carolina."

Reestablishment of the species is an integral part of the ongoing conservation effort, and each opportunity for reintroduction should be approached systematically to help fulfill the responsibilities of the RRCC. Each decision to initiate a reintroduction action for a specific river or river reach should be considered a long-term commitment, with the primary goal of establishing a self-sustaining population of robust redhorse. RRCC's investment of time and effort to collect site-specific habitat and biological information on the target river or river reach is wise. Collecting and assembling this information prior to initiating a reintroduction action helps ensure that the RRCC is investing its time and resources in rivers that appear to offer the greatest chance for success.

However, the RRCC should recognize that every river or river reach may not support a self-sustaining population of robust redhorse, at least not within reasonable time and funding constraints. The RRCC also should recognize that there are benefits to be realized by establishing wild populations that could be considered "refuge" or "research" populations that may never become self-sustaining. In either case, a little extra time spent investigating and evaluating the target river or river reach is necessary to develop realistic goals and expectations for any reintroduction action.

Site-specific information should be evaluated when reintroductions are planned. Section III.B.5. of the Robust Redhorse Conservation Strategy is a good place to start to determine the types of site-specific habitat and biological information necessary to develop reintroduction plans. Site characteristics recommended for consideration include:

Habitat

- Suitable spawning substrate consisting of gravel substrate
- Adequate food supply
- Accessibility for sampling and monitoring
- Available river miles for sustaining a refugial or reproducing population
- Suitable water flows
- Presence of woody debris to provide cover for adults

Fishery Issues

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

Watershed

- 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

This list certainly is not all-inclusive, but it is a good start for a long-term commitment to establishing a population of robust redhorse. Some of the bulleted items are under consideration as individual policy decision items, which will necessarily be important components for implementing a reintroduction action. The following steps should be considered as the basis for a reintroduction action guide to be developed and included in the Conservation Strategy for Robust Redhorse:

1) Develop a 'Reintroduction Plan' for Any River Under Review, which would:

    - Identify the target river or reach for reintroduction through surveys for robust redhorse (per Criteria for Conducting Surveys for Robust Redhorse Policy);

    - Identify the appropriate source and availability of broodfish (per Species- and Population-level Management Policy);

- Collect, summarize, and evaluate existing information for the target reintroduction site;

- Identify any real and potential limitations to success of the reintroduction action as well as positives and potential partners. Recognize any individual state reintroduction policies, or other directives, that may affect the project;

- Present short (5-10 years), intermediate (10-20 years), and long-term (20-25) goals as applicable, bearing in mind that the ultimate long-term goal should be the establishment of a self-sustaining population (per definitions attachment and appropriate policies);

- Present stocking recommendations (i.e., numbers, sizes, schedule);

- Present reasonable schedule for monitoring progress toward goals and reporting requirements; and

- Identify parties responsible for the implementation of the Reintroduction Plan.

2) Submit Plan to RRCC for approval.

3) When approved, RRCC makes appropriate notifications regarding the conservation effort and the reintroduction plan (per policy on Stakeholder Notification of RRCC Recovery Actions).

4) Implement the Reintroduction Plan

These steps formalize *ad hoc* policies currently used by the RRCC. The North Carolina Wildlife Resources Commission policy on reintroduction and augmentation includes several additional points that may be valuable for a reintroduction plan. The RRCC should recognize and respect existing state policies regarding reintroduction and augmentation, if applicable, to conservation of robust redhorse.

Habitat Restoration

Policy

The RRCC will promote habitat restoration and protection.

Commentary

The Committee realizes that habitat degradation resulting from poor land-use practices is a threat to the robust redhorse. Species such as the robust redhorse that depend upon clean gravel substrates for spawning and early development are especially sensitive to siltation. Because habitat degradation has been identified as a major cause of decline, the RRCC needs to address its position regarding habitat restoration.

Role of the Committee

Restoration of robust redhorse habitat should be facilitated by the RRCC. The RRCC can help recruitment by introduction or reintroduction of cultured animals. This effort can be enhanced by restoring degraded habitat and preventing habitat degradation in the future. The RRCC will first select a Habitat Technical Working Group (TWG) to oversee restoration activities. The Habitat TWG will: 1) identify critical habitat needs, 2) establish guidelines for evaluating habitat, and 3) establish guidelines for evaluating restoration activities. With the assistance of this Habitat TWG, the respective basin TWGs will be able to select sites, prepare proposals, secure funding, and remain an active member in actual restoration activities. These responsibilities may be accomplished by facilitating partnerships with other agencies and organizations.

Decision Making

Policy

The RRCC will use a combination of consensus- and vote-based decision approaches to develop and document 'recommendations' and 'decisions' of the RRCC as a whole or of subsets of members to guide implementation of the robust redhorse recovery and management effort and the structure and function of the RRCC.

Commentary

The RRCC is faced regularly with reaching concurrence on research results and implications, agreeing on the evaluation of the pros and cons of management options, and seeking consensus on goals, management decisions, administrative procedures, and other matters. The RRCC and the robust redhorse recovery effort have matured to a point where evaluating RRCC processes and developing policies that guide how the RRCC makes decisions are beneficial. In particular, a clarification of perceptions of authority, especially in the realm of dictating the implementation of RRCC decisions, may be prudent.

The intent of the RRCC's decision-making policy approach includes: (1) exploring all aspects of issues by involving everyone with a stake or substantial interest in the species, (2) keeping discussions and decisions focused on science (known vs. unknown), (3) developing management decisions and policy positions of the RRCC, and (4) documenting the positions of present signatories, cooperators, stakeholders, or others with substantial interest in the species.

Procedure for Decision Making

The first step in consensus building and voting is agreement on the language of the question or issue (Figure 2). This language is an important determinate of the final decision that is made. A consensus may be reached either through alack of vocal dissension or through a polling technique such as sticking dots. If consensus is not reached, then the vote process will be employed.

The usual method of taking a vote is by voice; yeas indicate affirmative answers and nays represent negative responses. Other voting methods that may be employed: a show of hands, by standing, by roll call or ballot. The responsibility of announcing the vote, declaring the voting method, and representing the voting result rests upon the RRCC Chair or Vice-Chair (if the Chair is not present).

All votes will proceed and be recorded in the following order: (1) stakeholders and interested others, (2) cooperators, and (3) signatory representative with voting authority. The tallies of the first two categories of voters will be documented as positions of all interested parties and by cooperators that are present at the time of the vote. Votes of signatory members of the MOU will involve one vote for each 'signatory'. Each signatory must appoint one primary representative with the authority to vote and assure that they are present at meetings at the time of votes. Each signatory should appoint one proxy representative with the authority to vote for the primary representative, if he or she is not present at the time of the vote.

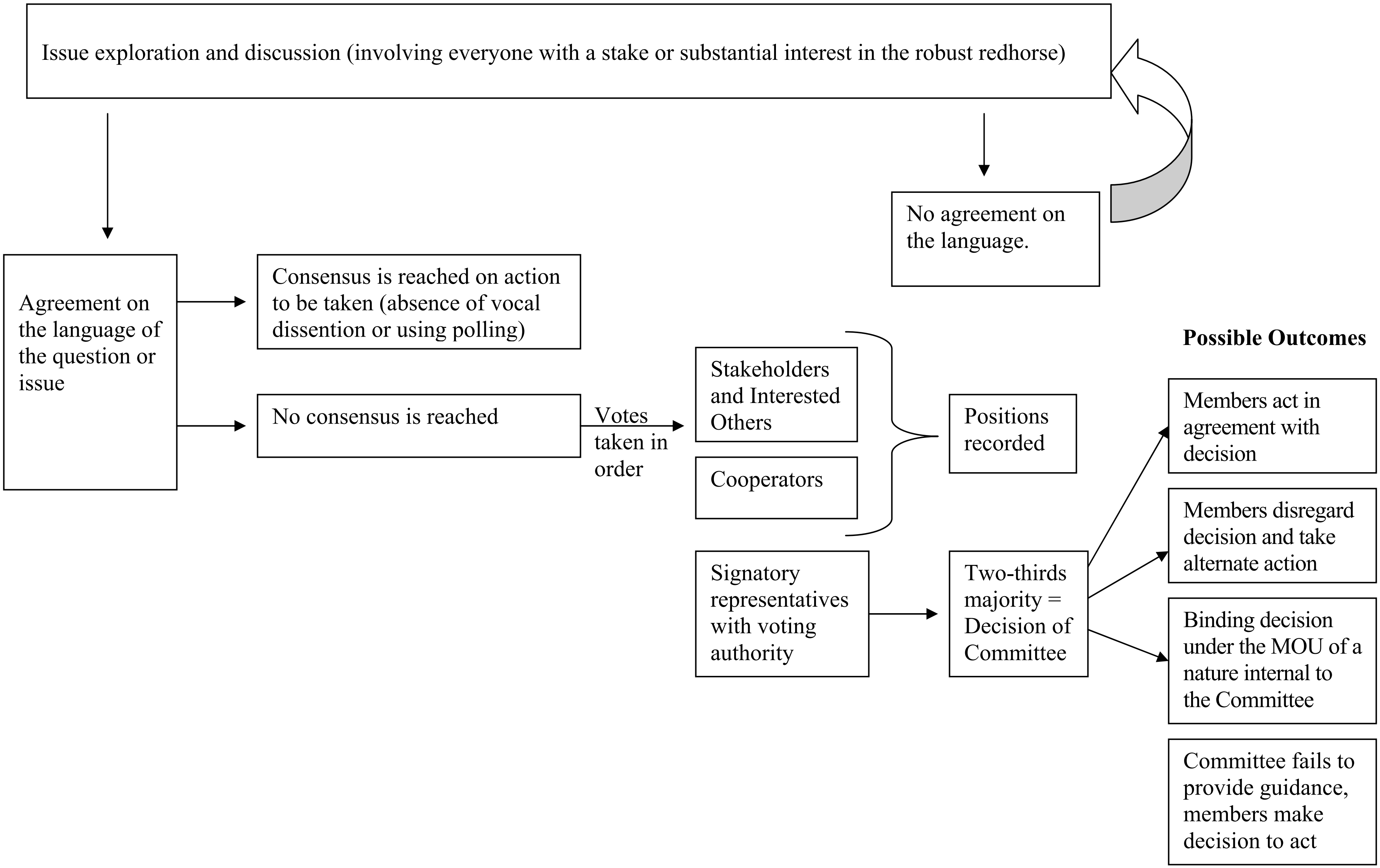
A 2/3rds majority of the signatory representatives (or their proxies with voting authority) present at the meeting at the time of the vote will constitute a documented decision of the RRCC even if all signatories are not present. Dissenting signatory representatives or their proxies with voting authority can submit comments on their position within two weeks of the votes; these comments will be filed as part of the permanent record (meeting minutes and annual report).

The signatory representative vote can be delayed for 2 weeks to allow signatory members the chance to confer with their respective organization to determine an acceptable position on highly polarized or sensitive issues, especially when new information is presented near the time of the vote. Votes of stakeholders, cooperators, and interested others cannot be delayed and will occur in the usual method for those groups. As a result, the signatory members will have the benefit of other perspectives in as they conduct internal discussions. The responsibility of announcing a delayed vote rests upon the RRCC Chair or Vice-Chair. If undertaken, the wording of the vote and an appropriate email address must be agreed upon at the meeting. The signatory representative with voting authority will have up to the close of business, 14 calendar days after the decision to delay a vote, to submit their vote via email to the RRCC Chair or Vice-Chair.

A 2/3rds majority of the signatory representatives or their proxies with voting authority that respond within the designated timeframe will constitute a documented decision of the RRCC. Dissenting signatory representatives or the proxies with voting authority can submit comments on their position within two weeks of the close of the vote. These comments will be filed as a part of the permanent record (meeting minutes and annual report).

The RRCC's decisions, reached through consensus or voting, are either (1) recommendations for the coordination and implementation of the recovery of the robust redhorse in public waters, or (2) of a nature internal to the RRCC. The decision to accept and institute the RRCC's recommendations (the first type of decision) lies wholly on the federal or state agency that has primary statutory authority for that particular action. Therefore, all signatory members have three choices in responding to recommendations of the RRCC: (1) the agency can act in accordance with the RRCC's recommendation; (2) the agency can choose to undertake an action of its own determination if the RRCC fails to provide clear guidance on the issue; or (3) the agency can determine that it has an internal conflict with the RRCC's decision and choose to take an alternate course of action of its own determination. If an agency has an internal conflict, the agency will submit a written statement to the Excom with alternate courses of action. The second type of decision, those of a nature internal to the RRCC, will be binding decisions under the MOU for the structure and function of the RRCC.

Figure 2. Robust Redhorse Conservation Committee Decision-Making Policy – Decision Flow



Decision-Making Policy Background

The RRCC is different from many other organizations in key ways that affect the manner in which it makes decisions.

- The RRCC is established under a MOU that specifies a stated charge and provides the only structure for RRCC processes and function.
- The RRCC is purely voluntary in membership, which is comprised of federal and state agencies, private utility companies, and nonprofit environmental and educational organizations.
- The voluntary partnership exists as an alternative to a regulatory approach for the recovery and conservation of the robust redhorse.
- The MOU does not provide binding statutory or regulatory authority to the RRCC either as an entity or over signatory partners to accomplish its charge.
- The MOU stipulates the initiation of regulatory action if the RRCC fails in its charge.
- Authority to delay or refuse implementation of a regulatory mechanism remains at the local level and is a singularly powerful and common imperative of the public and private members.

Each of these key characteristics will be discussed in the following sections in exploration of how the RRCC has made decisions in the past and in the options for strengthening its decision-making process into the future.

Charge of the RRCC

The MOU states that the specific charge of the RRCC is to identify priority conservation needs for the robust redhorse and its habitat and coordinate implementation of programs for addressing those needs. Section IV grants the RRCC the responsibility to develop and coordinate implementation of conservation programs. Such programs consist of implementation of conservation measures that will focus on protection and management of the remaining population of the robust redhorse, establishment of captive-breeding populations, and reestablishment of the species within a significant portion of its historic range in Georgia, North Carolina, and South Carolina. In addition, the RRCC must evaluate program implementation and prepare an annual progress report.

Voluntary Membership

Section VII of the MOU seems to emphasize the voluntary, non-binding nature of the partnership. In the formative stages, the voluntary members depended on the RRCC to establish the recovery framework and initiate the recovery process. Signatory members were expected to implement RRCC decisions in good faith. It is detrimental to the RRCC's function and member relationships to expect signatory members to take a strong role in implementing RRCC decisions that may be beyond individual agency perspectives or contrary to single agency judgments.

However, Section VII specifically does not restrict members from engaging in "similar activities", which can be interpreted to allow signatory members the flexibility to undertake robust redhorse activities outside of the conservation program developed through and coordinated by the RRCC.

Non-Binding Authority

Section I establishes statutory authority for the parties to enter the MOU under the Endangered Species Act of 1973 (16 U.S.C. 1531-1548), the Fish and Wildlife Coordination Act (16 U.S.C. 661), the Fish and Wildlife Conservation Act of 1980 (16 U.S.C. 2912), and the Fish and Wildlife Act of 1956 (16 U.S.C., 742f (a) (4)). Although federal and state agencies having statutory authority voluntarily entered into the RRCC partnership, their participation does not establish or grant statutory authority to the MOU or shift statutory authority from the parties to the RRCC.

The MOU does not supercede statutory authority, but rather seeks to guide use of member's existing authority for the benefit of the robust redhorse. The MOU cannot be construed as legally defensible in asking federal or state agencies to surrender authority if they choose to do otherwise. The non-binding verbiage in the second paragraph of Section VII indicates that signatories are not bound as to be obliged to act or expend funds. This non-binding language could be interpreted to extend to other management decisions unless statutes authorize agencies to be bound in this way.

Regulatory Alternatives

The last paragraph in Section VII of the MOU outlines alternative regulatory actions if the RRCC does not accomplish the task of protecting or preserving the survival of the fish. Specifically, the MOU recognizes that the U.S. Fish and Wildlife Service (the Service) has the authority to and will initiate actions to list the robust redhorse under Section 4 provisions of the Endangered Species Act. Such actions will be taken if and when the Service deems that threats to the survival of species survival cannot be resolved through the MOU or another agreement.

The Service may be disinclined to list the robust redhorse as there is little federal money that can be dedicated to implementation of recovery actions, there is little congressional support for additional listings, and the agency is focused on responding to current lawsuits. However, if the information from the robust redhorse recovery effort indicates that the species is in trouble, the agency is prepared to propose the species for Candidate status.

Local Control

Although there appears to be little support for listing the robust redhorse, political climates shift very quickly; and occasionally, the shifts are in direct opposition to previous views. The RRCC's successes to date have improved the status of the species significantly since the MOU was initially signed in 1995. If the RRCC cannot effectively cooperate to make decisions, it will become less viable as a vehicle for implementing recovery. Some may view reduced effectiveness of the RRCC as evidence for the need to list the species and manage its recovery under the auspices of one federal agency.

Alternately, if a member agency acts contrary to a decision of the RRCC (e.g., chooses not to wait for more data or disagrees with the RRCC's position), then the responsibility for undertaking those management actions falls to the specific state agency. Any consequences of sole actions taken by an individual member will be the responsibility of that member.

Executive Committee and Technical Working Groups

Policy

The RRCC will elevate the original Technical Advisory Group (TAG) to the level of an Executive Committee (Excom). The RRCC empowers the Excom with the day-to-day issues associated with the regional recovery effort and to address regional issues. In addition, the RRCC will form Technical Working Groups (TWGs) and empower them to address local or special interest issues.

Commentary

The Memorandum of Understanding (MOU) that formed the RRCC provides for the RRCC to establish its own protocols for conducting business (MOU, Section III C). One such mechanism is the TAG. In 1997 the RRCC formed a group referred to as the TAG to address a series of work items during 1997 and 1998. The TAG was to report to the RRCC its accomplishments and the status of work items assigned in 1997. The TAG has continued to function since its original establishment and has evolved at its own pace to address its own needs. The TAG has performed an essential function for the RRCC by handling the myriad of issues that occur in the day-to-day processes of the recovery effort. The TAG has evolved to address an increasing need for the RRCC to handle day-to-day functions of the RRCC.

As interest in the robust redhorse has increased, the demand for RRCC input into the recovery process also has increased. Essentially, the TAG has been filing this role; and in doing so, has taken on a role for which it was not originally intended. With increased interest in the status of the robust redhorse in the Yadkin/Pee Dee drainage NC/SC the RRCC agreed to establish a Technical Working Group (TWG) in this area of the historic range of the fish. Because of the resultant increases in the complexity of the recovery effort, the RRCC needs to better define the status and structure of the original TAG and subsequent TWGs.

Overall changes to the structure and function of the Excom and TAG are as follows. The Excom should be a permanent body with a defined structure. The members of the Excom should be confirmed or reconfirmed by the RRCC at each annual meeting. The body should be made up as follows:

RRCC Chair
RRCC Vice Chair (or the immediate past Chair when no Vice Chair exists)
GADNR (1)
SCDNR (1)
NCWRC (1)
USFWS (1)
USGS (1)
Utility Company Representative (2)
Academician Representative (1)

Each group represented on the Excom will provide to the RRCC their designee to be that agency's or group's representative. The RRCC will have the right to ask each group or Agency for a substitute designee if the RRCC feels the original designee is unacceptable. However each member organization of the Excom has the responsibility to appoint their representative.

All Excom and TWG meetings will be open meetings such that anyone wishing to attend may do so. The Excom will be empowered with the option of consulting with at-large experts on technical matters, including inviting these experts to attend and participate in the discussions during their meetings. All voting during Excom and TWG meetings will follow the Decision Making Policy.

The RRCC Chair or Vice Chair (or immediate Past Chair if the Vice Chair position is vacant) will schedule and preside over the Excom meetings. The Excom is empowered by the RRCC to deal with the day-to-day issues associated with the regional recovery effort. However, the Chair should have the authority to delay implementation of an Excom decision to allow the full RRCC to address the question. If the Chair feels compelled to delay implementation of an Excom decision, then the Chair will immediately poll the entire RRCC or call a special meeting of the RRCC to address the issue. Only the RRCC has the authority to decide matters of policy or to approve new policy.

The use of TWGs to address local or special interest issues will continue. TWGs will be formed, as necessary, to determine needs such as conservation actions, research, information exchange, public education or outreach. When appropriate, TWGs may work to plan, coordinate, implement and facilitate implementation of conservation actions agreed to by the RRCC and report progress periodically to the RRCC within existing constraints of authority, policy review, and budgets. TWGs may be formed and disbanded, as needed, at the discretion of the RRCC (MOU, Section V).

The Excom will be involved with all TWGs, with an Excom member assigned to participate with each TWG. The Excom is empowered to establish TWGs between annual meetings as needed; the RRCC would re-authorize the existence of the TWG at their next meeting. The RRCC (or Excom during intervening periods) will establish the specific purpose and charge of a TWG and will appoint a Coordinator for the TWG who is charged with the administration of the TWG and directing the TWG in its prescribed mission. The RRCC should review the status, standing, and accomplishments of each TWG annually. The status of each TWG will be reaffirmed by the RRCC on an annual basis.

Membership to the RRCC

Policy

Requests to have formal membership should be made in writing to the Chair of the RRCC.

Commentary

Section II of the MOU outlines the establishment of the RRCC and conservation needs for the robust redhorse. Section III considers RRCC membership, structure, and operations. The MOU states: "Membership on the Committee is open at any time to any agency or non-governmental organization or individual interested in taking an active role in the conservation of the robust redhorse. Membership becomes official at such time as the Memorandum of Understanding is signed by the head of the agency/organization or a designee."

Section IV of the MOU lists committee responsibility to: "(d)evelop and coordinate the implementation of a conservation program fro the robust redhorse…, (e)stablish technical working groups…, (c)oordinate program implementation …, and (e)valuate program implementation…".

Consideration Process

Parties or individuals expressing an interest, willingness, and ability to take an active role in the recovery of the species will be encouraged to sign the MOU. Otherwise, the interested party will be encouraged to become a cooperator. In either case, a recommendation is made by the Excom and forwarded to the RRCC for confirmation at the next annual RRCC meeting. The candidate will be allowed to participate in all recovery activities until confirmed by the RRCC. Signatories to the MOU and active Cooperators are not subjected to term limits. However, any membership can be terminated at the member's written request or after five years of inactivity.

Committee members will be expected to:

- Be a signatory to the Memorandum of Understanding.
- Designate representatives (2) to the Committee.
- Exercise their voting authority (per Decision Making Policy) on decision-making.
- Have their membership remain in effect until the MOU expires or until the member no longer wishes to participate in the recovery effort.

Cooperators will be expected to:

- Actively participant in the conservation activities directed at the recovery of the robust redhorse.
- Participate in the RRCC annual meeting in consensus building and polling of the group.
- Have their membership remain in effect until the MOU expires or until the member no longer wishes to participate in the recovery effort.

Stakeholder Notification of RRCC Recovery Actions

Policy

The RRCC supports notifying potentially affected local governments, large landowners, and other significant stakeholders prior to undertaking major conservation or management actions and agreements that involve the RRCC as a whole, a subset of members of the RRCC, or individual RRCC members and will provide meaningful opportunities to these groups to give input on the proposed action.

Commentary

Biologically sound conservation and management actions are recognized as important options in active recovery of species, including the robust redhorse. Yet, before these options are undertaken, the concerns of potentially affected stakeholders must be considered.

Evaluating and Communicating Threats to RRCC Recovery Efforts

Policy

The RRCC will inform all MOU signatories of potential actions that threaten recovery efforts so that each signatory can respond appropriately to agents posing threats or to regulatory agencies as needed during comment period or in a timely manner.

Commentary

Section 2 of the Endangered Species Act encourages interested parties to develop and maintain cooperative conservation programs for safeguarding the Nation's heritage in fish, wildlife, and plants. A proposed policy for evaluation of conservation efforts when making listing decisions was published by FWS in September 2001 and this generally outlines criteria that must be met to preclude listing (http://endangered.fws.gov/POLICY/pece.pdf). These broadly include certainty that the conservation effort will be implemented and effective. These criteria provide a good starting point to develop a policy on evaluation of effects, alterations, and other actions undertaken.

Section 4(a)(1) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1533(a)(1)) states that listing agencies must determine whether a species is threatened or endangered because of any of the following five factors: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) over-utilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting its continued existence.

The five factors used by FWS to determine whether a species is threatened or endangered need to be considered and re-evaluated periodically. Successful conservation efforts will preclude the need to list, and more importantly, help insure that the robust redhorse large river ecosystems that support them remain healthy and intact.

Communication of an evaluation of activities proposed and undertaken by RRCC and other State, Federal and private entities as well as specific characteristics affecting the evaluation of each of the three native Evolutionary Significant Units (ESU) in light of the five-factor criteria used by USFWS is potentially important.

This policy may facilitate conservation by communicating to other entities, especially State and Federal regulatory and conservation agencies, results of our evaluations. Outreach to these other organizations is extremely important.

Annual Meetings

Policy

The RRCC will dedicate ample time to research and management updates, presentations from guests who share knowledge of similar endeavors, discussions of information provided, and decisions.

Commentary

Section III of the MOU requires the Committee to "meet a minimum of once per year…" with member representatives attending the scheduled meetings.

The most important tasks to accomplish at the annual meetings (not in priority order) are to (1) make important decisions on action items that guide short- (next year) and long-term (5 years) conservation and restoration efforts, (2) convey recent scientific information on the status of the species, (3) build support and enthusiasm for the recovery process, and (4) attend to business matters to facilitate the RRCC functioning.

Work at the Annual Meeting will be best accomplished by allotting a predetermined amount of time to discussing the four tasks identified in the policy statement. Time allotment can be modified as needed, but initially will be: research and management - 40%; invited expert opinion - 10%; discussion of all information provided - 20%; and decisions to guide RRCC actions - 30 %. The research and management updates or presentations must emphasize only important results that are given in simple, easily comprehended tables and figures. Methods should be reviewed very quickly, if at all. Implications and recommendations should be an important part of all presentations, and time must be allowed for the group to comment on interpretations and implications, engage in full discussion, and make decisions.

As of October 2002, the full RRCC has met only on an annual basis, as required by the MOU. Although members, individually and in subsets, communicate and work together on various endeavors throughout the year, the annual meetings take on special purpose for the function of the Committee. The once-a-year timing sometimes complicates committee decision-making. For example, wholly new information has been presented one day, and the RRCC acted upon it the next day. This scheduling leaves little time to integrate the new findings and develop positions let alone engage group discussions. Occasionally, this situation is exacerbated when research and management presentations at the annual meeting eclipse the time available to integrate the new findings, discuss their implications, and decide on a required course of action.

Research

Policy

The RRCC will take an active role in determining research topics and prioritizing research needs in support of the robust redhorse recovery, without compromising the investigators' ability to fulfill requirements of the funding agent(s) or to pursue independent publication of research findings. In order to base decisions on sound information, the RRCC will require complete, timely, well-written research results that will serve as the scientific basis for its decisions.

Commentary

The RRCC has taken an active role in determining and prioritizing research in support of the robust redhorse recovery. The RRCC often receives disparate, outdated summaries of preliminary and final research results, if at all and uses these data to assess further data needs. If decisions of the RRCC are to be guided by the best science available, then the RRCC must receive complete, timely, written research results.

In implementing the research policy, the RRCC will assign the general tasks of guiding research direction for the recovery efforts to the Excom. Historically, these duties were performed by the TAG (see Executive Committee and Technical Working Groups Policy) and included: (1) identifying research needs; (2) determining the direction of potential research; and (3) having meaningful input into research agendas, funding, principle investigators, and study methods. If necessary, the Excom can establish reporting requirements in addition to the requirements normally established by the funding entity to ensure that the RRCC is supplied with relevant written research reports and presentations that thoroughly explain the research findings and their implications.

Communications within the RRCC

Policy

The RRCC Executive Committee and TWGs should communicate activities and action items of the robust redhorse recovery effort to participants, as appropriate.

Commentary

To ensure effective and regular communication and information sharing; and in order to articulate policy decisions, biological information, and conservation initiatives within the range of the robust redhorse. The following types of information should be shared in a timely manner:

- The Excom and the TWGs will develop and distribute advance meeting agendas to provide the opportunity to attend a meeting or present concerns or views involving specific agenda topics; and

- Meeting summaries outlining meeting decisions, topics, and new biological information.

The RRCC participants will have the opportunity to provide input or concerns on meeting summaries for the administrative record.

Dissemination of information will be accomplished by posting to the web site (www.robustredhorse.org).

Appendix 1

Species- and Population-Level Management

Support for legitimate ESU status in the robust redhorse

Moritz (1994, 1995) promoted the utility of molecular phylogenies in defining and prioritizing management units for conservation issues. These management units, termed Evolutionary Significant Units (ESUs), are defined by significant (1%) mtDNA divergence between populations, monophyly within them, and significant nuclear divergence in allelic frequencies. Genetic structure of the robust redhorse samples from the Oconee, Ocmulgee, and Savannah rivers was investigated using sequence analysis from a portion of the mtDNA control region and microsatellite data (Wirgin et al. 2001).

Oconee and Ocmulgee samples shared two mtDNA haplotypes that showed fixed differences (1% sequence divergence) from the three haplotypes in the Savannah samples. Additionally, each of these populations was reciprocally monophyletic. Microsatellite analysis found fixation of alleles at one locus and significant allelic frequency differences at three other loci between the Altamaha and Savannah river populations (Wirgin et al. 2001). The latest results from the Wirgin lab indicate the Pee Dee samples also are fixed for unique mtDNA haplotypes (with 3% sequence divergence between Pee Dee samples and those from other drainages) and several fixations for alleles at microsatellite loci (I. Wirgin - New York University Medical Center, personal communication July 2002). These data indicate that the three populations have been evolving independently, probably since the Pleistocene, and continue to do so. Under the criteria of Moritz (1994, 1995), the Pee Dee, Savannah, and Altamaha river systems should be regarded as ESUs and managed separately. Further, many researchers (Cracraft, 1997; Wood and Mayden, 1992; Xu and Arnason, 1996; Riddle et al., 1998; Switzer and Wood, 2002) have interpreted similar data as an indication of the presence of cryptic biodiversity that warrants taxonomic recognition at the species level. Some conservative researchers (Waples 1991, Fraser and Bernatchez 2001) suggest looking at additional criteria such as morphological and ecological traits prior to designation of populations as ESUs. In this instance, morphological differences (body shape) have been noted between populations (Robert Jenkins, Roanoke College, pers. comm.) further supporting their designation as ESUs by forming important components to the evolutionary legacy of the species. In a comprehensive review on ESU concepts, Fraser and Bernatchez (2001) compare and contrast different criteria for ESU designation and use the case of the robust redhorse as a specific example supporting designation of ESUs.

Demonstration of Inbreeding Depression

Inbreeding depression can be defined as a decline in the mean reproductive fitness resulting from the chance fixation of deleterious alleles in an inbred population. As inbreeding increases in a closed population, heterozygosity decreases, and the frequency of deleterious alleles increases. Although measuring the frequency of deleterious alleles in a population is not feasible, the average heterozygosity can be estimated with genetic markers (microsatellites, VNTRs, or allozymes) and used as a relative measure of relatedness of individuals.

The inbreeding coefficient (F) of an individual is a measure of how closely related are its parents. Offspring from completely unrelated parents have an F=0. When inbreeding goes to completion, F=1. An F of 0.986 is expected after 20 generations of continuous brother-sister matings. Inevitably, average F will rise as mates become increasingly related in a small, isolated population and will increase at a rate of 1/(2/N) per generation in a randomly breeding population size of N. There is a linear relationship between the inbreeding depression of a population and its inbreeding coefficient. The genotype frequencies of a population (measured by genetic markers) can be used to estimate levels of inbreeding. One measure of F can be obtained by the frequency of heterozygotes compared to Hardy-Weinberg equilibrium expectations. A second estimate of average F can be obtained from the rate of loss of genetic diversity over time compared to expectations.

Some Signs of Inbreeding Depression

- Poor gamete quantity and quality: sperm abnormalities, reduced number of gametes.
- Significant reduction in juvenile survival in the wild
- Decreased rate of development: in larvae or sexual maturation
- Developmental abnormalities: spinal deformations
- Reduction in longevity of adults
- Low genetic diversity or heterozygosity in the population

None of these individual factors should be taken by themselves to suggest that the population is clearly suffering from inbreeding depression. For example, low heterozygosity measured by molecular markers does not by itself indicate that a population is suffering from inbreeding depression since bottlenecked populations can purge themselves of deleterious alleles and therefore minimize the effects of inbreeding depression. Clear documentation of inbreeding depression should include several factors.

Appendix 2

Propagation and Breeding

Attempts to maintain heterozygosity within founding populations will help meet our goals of maximizing genetic diversity. However, expected heterozygosity will inevitably be lost over time in small populations. While it is difficult to monitor the loss of expected heterozygosity in a founded population, effective population size can be calculated for each year's stock and the accumulative founding population.

Expected heterozygosity (Ht/Ho) is related to Ne by: $Ht/Ho = [1\text{-}1/2Ne]^t$, where t represents generation time, in years. If we want to retain at least 95% of the expected heterozygosity over 10 generations, we should maintain an Ne = 98 over 10 generations. In practice, our propagation plan will likely only last about 1-2 generations (20 years) and we therefore expect to loose more than 5% of the expected heterozygosity over 10 generations due to natural reproduction creating unequal offspring contributions in the wild population. We therefore want to be conservative for this minimal Ne and extend it to a goal of delivering an Ne = 200 over the duration of the propagation program. If an Ne of 200 was maintained over 10 generations, the expected heterozygosity would be 0.975 (we would maintain 97.5% of the expected heterozygosity 10 generations later). We therefore desire to found new populations with an Ne within a range of 100 to 200. This number is smaller than what is suggested by Soule' (1987), but represents a more realistic goal based on the propagation efforts to date (which is dictated by the number of ripe broodfish captured per year from the Oconee population.