RED WOLF
(*Canis rufus*)

Population and Habitat Viability Assessment

Virginia Beach, Virginia
13 - 16 April, 1999

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(Canis rufus)

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WORKSHOP REPORT

A Collaborative Workshop:

United States Fish & Wildlife Service
The Conservation Breeding Specialist Group (SSC/IUCN)

A contribution of the IUCN/SSC Conservation Breeding Specialist Group in collaboration with the United States Fish & Wildlife Service.

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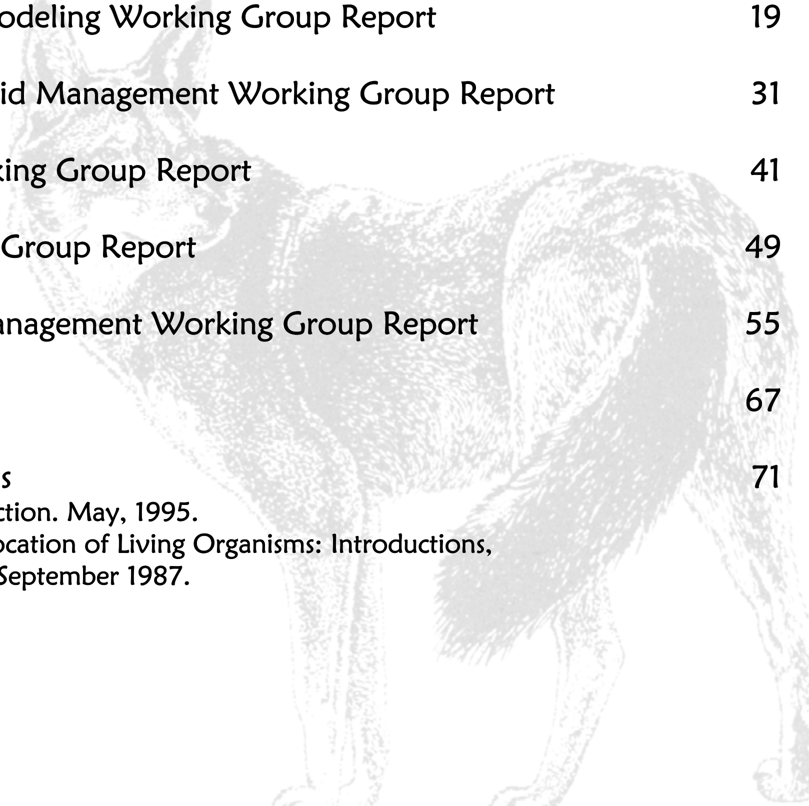

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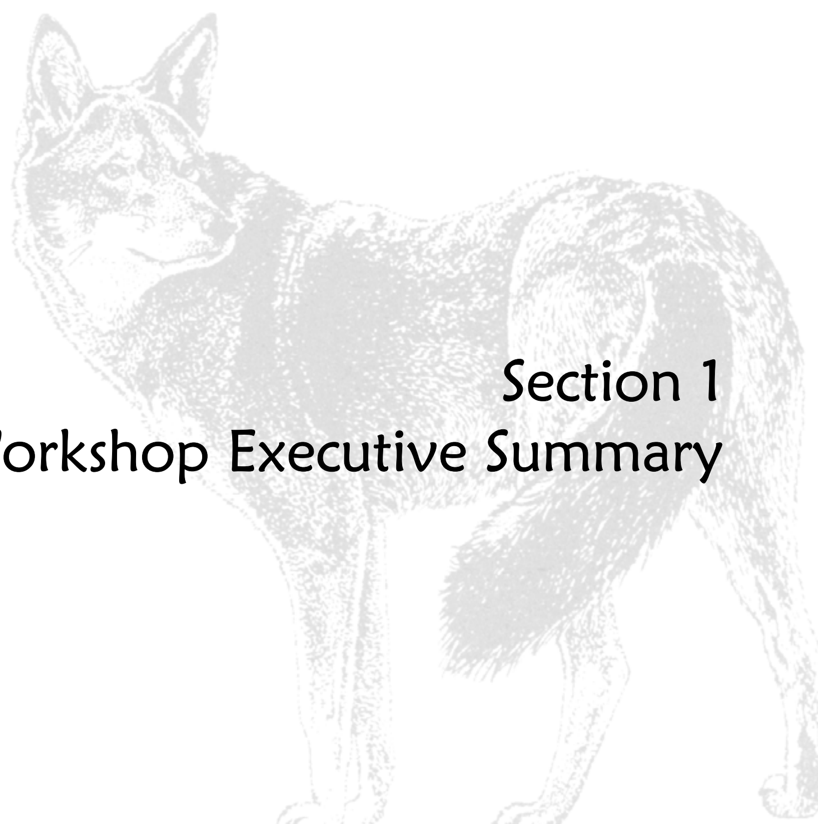

Section 1
Workshop Executive Summary

Population and Habitat Viability Assessment (PHVA) for the Red Wolf *(Canis rufus)*: Workshop Executive Summary

Introduction

The red wolf (*Canis rufus*) is one of the most endangered animals in the world. It is a shy species that once roamed throughout the southeast United States as a top predator. Aggressive predator control programs and clearing of forested habitat combined to cause impacts that brought the red wolf to the brink of extinction. By 1970, the entire population of red wolves was believed to be less than 100 animals confined to a small area of coastal Texas and Louisiana. Moreover, genetic swamping through hybridization with coyotes was recognized in the early 1960s by Carley (1975) as a major threat to the survival of this and other remnant red wolf populations. To save the species from extinction, the U.S. Fish and Wildlife Service (Service, USFWS) captured as many as possible of the few remaining animals from 1974 through 1980. Only 14 captured animals met the criteria established to define the species and stood between its existence and extinction. These animals formed the nucleus of a captive breeding program at the Point Defiance Zoo and Aquarium in Tacoma, WA with the final goal of reestablishing the species in portions of its original range. Thirty one zoos and nature centers in 19 states and the District of Columbia now cooperate in a national breeding program and are valuable partners in efforts to restore red wolves to their natural habitat. The red wolf is now back in the wild, hunting, rearing young, and communicating by its characteristic howl, in several locations in its original southeastern habitats, including one mainland reintroduction site, and three island propagation sites. The red wolf was one of the first endangered species to attract recovery attentions from the Service after the passage of the Endangered Species Act on December 28, 1973. An interim recovery team was appointed on August 4, 1974, and in January 1975, it received official sanction by the Service.

The Red Wolf Recovery Program has had significant successes over its history, including but not limited to perpetuation of the red wolf genome in captivity, third generation wild pups, and a population distributed over one million acres. It is vital to perpetuate this success. However, several critical issues challenge the expansion of the program to meet its recovery goals. Primary among these issues are: (1) selection of additional restoration sites, (2) assessing and managing the threat hybridization represents to recovery, (3) the need for an effective and feasible monitoring program, and (4) an assessment of the role of the captive breeding program to facilitate recovery in the wild. Because of the complexity of these issues, external expertise and review from the scientific community was required for the development of effective conservation action strategies. The inclusion of such expertise is consistent with the requirement of the Service's Strategic Plan to base decisions on sound scientific judgement. The Conservation Breeding Specialist Group (CBSG) of the IUCN / World Conservation Union has recognized expertise in facilitated intensive, scientifically rigorous workshops that are designed to generate creative and substantive management recommendations from participants with potentially different viewpoints on the relevant conservation issues. After researching the utility of the CBSG process, the Service decided to host such a workshop, known as a Population and

Habitat Viability Assessment or PHVA, and invite CBSG to facilitate to begin developing solutions focused on the technical issues facing the recovery of the red wolf.

A red wolf PHVA workshop was conducted April 13-16, 1999 in Virginia Beach, Virginia at the Holiday Inn Executive Center. Forty scientific and management experts in the fields of wolf and coyote biology, wildlife biology and management, genetics, captive breeding and population modeling attended this workshop. After brief opening statements by Red Wolf Recovery Program lead biologist Brian Kelly and CBSG Chairman Ulysses Seal, the participants engaged in a process of species conservation issue identification and description. A group of five primary issues were distinguished and selected for further analysis in small groups. These groups were: 1) coyote hybridization/genetic consequences, 2) wild population monitoring, 3) new population site selection 4) captive population management, and 5) risk assessment modeling. The hybridization/genetics group quickly realized that the immediacy and significance of the hybridization threat superceded all other issues. Consequently, this group divided the hybridization concerns into five distinct problems and ranked these problems according to priority. By noon on the second day of the workshop, it was clear that each of the working groups began to focus on hybridization as the primary issue driving discussions on red wolf conservation in the Alligator River region in particular and the southeastern United States more generally. As a result, the other four working groups decided to reorganize and/or restructure their directions for greater emphasis on the issues related to coyote hybridization and its threat to red wolf population viability.

The hybridization/genetics work group was disbanded with former members dispersing into the remaining four groups. The problems articulated by the former hybridization/genetics group were forwarded to the appropriate remaining work groups as the overriding issues for their own consideration. The working group originally discussing new population site selection was renamed the “biological control group” and eventually, through additional synthesis and reformulation, became the “wild canid management” working group. The recommendations arising from each of these working groups are presented below, with more detail to be found in the appropriate working group reports found elsewhere in this Report.

Summary of Working Group Recommendations

Canid Hybridization

While this group met for only one day, the issues they discussed were rapidly seen as paramount to any discussions centered on maintaining the genetic and demographic integrity of the red wolf as we know it today. This realization is reflected in the group’s general statement:

> Hybridization that affects the genetic and phenotypic integrity of the red wolf is the primary issue facing its recovery. How we proceed with red wolf recovery is dependent upon how we assess, and if possible, manage hybridization.

Following considerable discussion, the group developed five primary issues into the following statements that helped to guide the deliberation process in the remaining working groups:

- We need to determine the degree of hybridization that can occur without threatening the phenotypic (behavioral, morphological, etc.) or genetic integrity of the red wolf.
- We need to determine how to measure, monitor, and actively manage (e.g. coyote and hybrid control) hybridization levels as determined in the statement above.
- We need to determine the evolutionary context of the red wolf and the role that hybridization played in its evolution.
- We need to determine ways of contending with the political (i.e. degradation of state and local support), social (mutt effect), legal and administrative (lack of hybrid policy within the USFWS) problems.
- We need more experimental data on hybridization. For example the program should include breeding interactions, fitness of hybrids, etc.

Population Viability Modeling

The initial task for this group was the development of demographic models to assess the risk of red wolf population decline and extinction in and around the Alligator River National Wildlife Refuge site. This was to be accomplished using the *VORTEX* stochastic simulation modeling package used frequently by CBSG in PHVA workshops. However, given the participants' refocused emphasis on the threat of hybridization, the group felt that *VORTEX* was inadequate to address the genetic consequences of this process. As a result, attention shifted to the development of a simple genetic model to address the consequences of hybridization from the standpoint of measuring the rate of loss of red wolf "ancestry" – the proportion of the total population genome that can be traced back to the original red wolf stock – as a function of the frequency of hybridization (defined here as the proportion of total litters that are the product of hybrid matings). Preliminary analysis indicates that estimates of the current rate of hybridization – with as many as 20% of recent litters resulting from hybrid matings – are much higher than those allowed under reasonable limits of acceptable loss of ancestry over the next few red wolf generations.

The group recognized the immediate need for additional work on this model to refine it in terms of a number of general characteristics including the need for it to be spatially explicit, and for special emphasis to be placed on the density-dependent nature of red wolf – coyote hybridization.

Biological Control / Canid Management

The primary question facing the newly formed Biological Control/Canid Management Working Group was: how do we manage hybridization to benefit red wolves? The group identified six issues related to this question and then developed recommendations and actions to address them. In addition, this working group put forward a set of specific, innovative management actions and related recommendations for consideration.

- Revise recovery plan according to recommendations from this workshop
- Postpone selection of new reintroduction site and focus effort on Alligator River National Wildlife Refuge (ARNWR) site.
- Consider set of criteria derived from Site Selection Working Group when selecting this new site

- Focus necessary resources on development of a rapid technique for canid identification and develop relationships with a lab(s) willing to do this work
- Implement biological control until we can better understand hybridization management and/or the balance is shifted from coyotes to red wolves.
- Implement the management actions listed above to prevent coyote gene flow from entering the red wolf genome.
- While implementing management actions, collect data needed to test the hypotheses (answer the questions) listed above and ensure that all management actions include methods for evaluation of their success and effectiveness.

Field Monitoring

The charge of the Field Monitoring group was to recommend methods and direction for monitoring free-ranging red wolves. The group considered the relative merits of various manipulations and experimental approaches. The participants felt that the problem of coyote gene introgression into red wolves is so great that it is unwise to utilize any of the NENC (North East North Carolina) recovery area for hypothesis testing. Such hypothesis testing removes some packs from being managed for the primary goal of protecting and promoting the growth of the self-sustaining, non-hybridizing population of red wolves in NENC. Resolution of the data needed to address various null hypotheses is difficult to obtain because of limitations of field work. Conclusions from hypothesis testing will be difficult to draw from small samples, especially considering variability in canid behavior.

- Maximize number of releases to suitable sites to maximize red wolf population growth
- Kill coyotes and non-wolf canids in Dare, Hyde, Tyrrell, Washington, and Beaufort Counties (in that order of priority) with reviewed standard procedures.
- Processing and collaring/recollaring any red wolves captured and then released
- Ongoing assessment to estimate abundance of coyotes
- Lethal control for 6 years (two generations of three years per generation).
- Goal for internal ability to genetically identify canids (blood and scat)
- Assess potential development of hybridization in North Carolina by evaluating past and present status in southeast Texas

General Workshop Statement on the Hybridization Issue

Because of the serious nature of the hybridization issues related to red wolf conservation, and the differences in approach to coyote management taken by the Biological Control and Field Monitoring working groups, an ad-hoc group was formed to draft a joint statement on the hybridization issue and the need for its management:

> The Red Wolf Recovery Program has had significant successes over its history, including but not limited to perpetuation of the red wolf genome in captivity, third generation wild pups, and a population distributed over one million acres. It is vital to perpetuate this success. However, hybridization in the free-ranging population has been recognized as a serious threat to the continued success of this landmark program. Because of this threat, our primary recovery focus must be protecting and promoting the growth of a self-sustaining, non-hybridizing population of red wolves in the wild and sustaining an active captive component. Actions to be taken will use an adaptive management approach that will not compromise the ability to achieve this goal.

New Population Site Selection

This working group first addressed the question of whether or not this is the right time to select a new site. It was determined that development of criteria and rationale for those criteria would be beneficial even if the decision to choose a new site is postponed. Ultimately, the group concluded that this is not the best time to devote resources to new population site selection and re-formed with new responsibilities targeted at addressing the worsening threat of coyote hybridization. However, before disbanding, the group outlined the following broad recommendations:

- Current resources should be focused on acquiring information on conditions that will assure red wolf genetic stability.
- Determine if wolves can maintain themselves in presence of coyotes.
- Revise recovery plan based on current knowledge about the apparent threat of hybridization. Specifically consider the following: 1) the 170,000-acre requirement is unrealistic; 2) intensive management of various sorts will be required; 3) red wolves may need to be put outside historic range.
- Form Recovery Plan revision team and reassess Recovery Plan within the next year.

Captive Population Management

One fact became clear early in this PHVA workshop – that the role of the captive population in the recovery of red wolves had not diminished, but was becoming even more important than ever before. The hybridization of free-ranging red wolves with coyotes means that the captive population is the only repository of the original genetic composition of the species. Therefore, it was recognized that continued infusions of captive-bred wolves into the wild would be necessary to maintain hybrid-free populations of red wolves in the wild. As a result of the PHVA process, increased breeding of the captive populations and expansion of spaces for red wolves in zoos and other captive facilities has emerged as a critical need.

The Captive Population Management working group developed the following set of recommendations:

1. Maintenance of an independent captive population

- Recruit additional cooperators targeting the historic range (emphasize the multiple roles of the captive population; further promote re-introduction program)
- Increase number of spaces at current facilities (new holding areas or restructure current holdings) – quality of space/exhibits may differ depending on the long term need of specific animals
- Maintain current facilities by surveying cooperators and targeting their program focus (e.g. breeding, research, outreach and education)
- Increase number of breeding recommendations per year; reproductive evaluations of individuals in unproductive pairs or those with low reproductive success (including fecal hormone analysis of males and females and semen analysis); examine husbandry, nutritional and environmental factors that could affect reproduction; increase space to accommodate increased production, consider culling as an option to increase space for stabilizing the population; be sure reproductive organs are included in necropsy protocol;

look at past records to see if past hormone implant contraception may be contributing to lowered fertility.

- When males have similar mean kinship values, recommend the older animal for breeding; recommend separating sexes rather than MGA for contraception, so institutions should have facilities for separating sexes; continue to investigate the development of safe, effective and reversible contraceptives.
- Continue on-going research on semen freezing and timing ovulation;
- Develop a Genome Resource Bank (GRB) action plan that would also include serum, tissue samples and cell lines from the wild and captive population;
- Determine how much sperm from which individuals is banked, including data on post-thaw motility, bring this information to the Masterplan meeting and use it in population genetic modeling with *GENES* to evaluate effects on genetic diversity;
- Identify a central location to house samples; funding is in place for the reproductive research portion of this initiative.
- Maximize increase of gene diversity when picking breeding pairs

2. To supply wolves needed for release to augment wild population where and when appropriate.

- When wolves are requested for re-introduction: chose wolves for re-introduction that are under-represented in the wild; include this need when making breeding recommendations in the Species Survival Plan (SSP) master plan when possible; continue as a priority for the islands or mainland to set up pairs of under-represented animals to produce offspring for release; monitor survival and reproduction of re-introduced animals to track any contributions to increasing gene diversity.
- Produce sufficient numbers of wolves in captive or island facilities for release (transferred animals responsibility of USFWS)
- Give wolves experiences such as: opportunities to hunt, live in a social group, introduce at a young age so they have less time in captivity, minimal contact with humans, experience with raising young or having reproduced themselves, and reared in larger, diverse enclosures; monitor after release to assess survival.

3. Research to investigate hybrid problems and questions.

- Examination of archival information
- Identify individual researchers/group technical/scientific expertise
- At least one facility to carry out the research and find funding, and identify sufficient space,
- Design and conduct crosses, estimating a minimum of 32 animals needed with 104 produced, use F1 hybrid progeny at Sandy Ridge as part of the study. (Excess may be used in other studies).
- Ownership of animals will be retained by USFWS. Develop proactive position on usefulness of hybrid research.
- Use wolves produced to look at semen characteristics, estrous cycles, viability (juvenile mortality), litter size, sex ratio.

Literature Cited

Carley, C.J. 1975. Activities and findings of the Red Wolf Field Recovery Program for late 1973 to July 1, 1975. U.S. Fish and Wildlife Service Report. Pp. I-v + 1-215.

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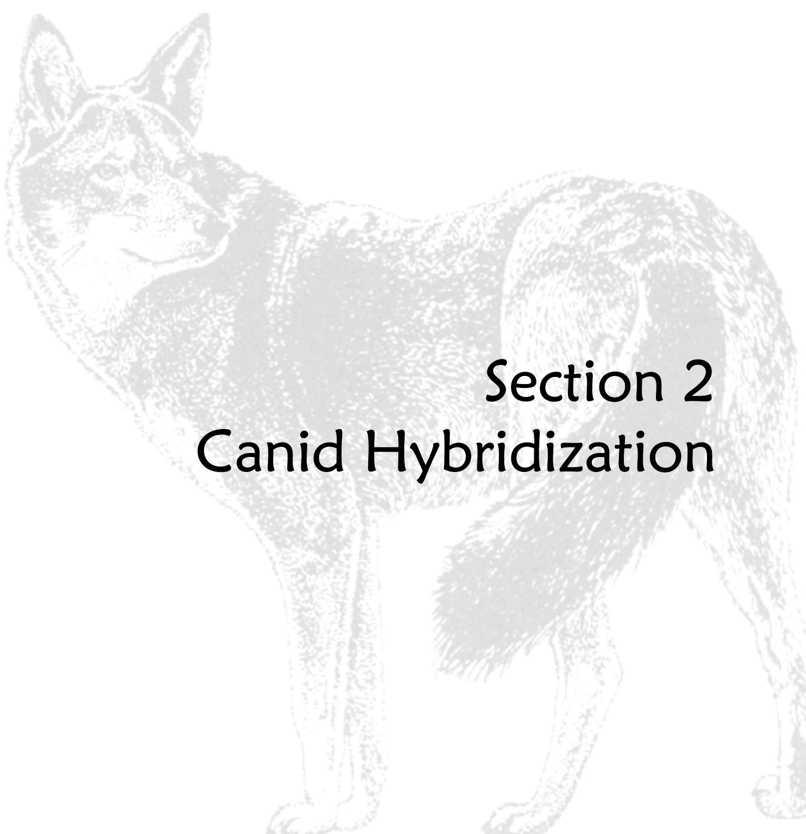

Section 2
Canid Hybridization

Canid Hybridization Working Group Report

Working Group Members:
George Amato, Wildlife Conservation Society
Ed Bangs, U.S. Fish & Wildlife Service
Dave Flemming, U.S. Fish & Wildlife Service
Gary Henry, U.S. Fish & Wildlife Service
Brian Kelly, U.S. Fish & Wildlife Service
Dave Mech, U.S. Geological Survey
Ron Nowak, Falls Church, VA
Mike Phillips, Turner Endangered Species Fund
Mary Theberge, Universityof Waterloo
Robert Wayne, University of California, Los Angeles
Paul Wilson, Trent University
Mary Hagedorn, National Zoological Park (Facilitator)

The Hybridization group met for less than one day. During that time they decided that hybridization was an overarching issue that was essential for further consideration of red wolf recovery. The following set of notes reflect some of the problems outlined by the group and the discussion that was generated by consideration of these processes.

Some discussion took place concerning the likelihood of reaching a resolution concerning the evolutionary origins of red wolves. Bob Wayne argued for avoiding discussion of the question of red wolf origins out of deference for restoring red wolves, because elucidation of origins is intractable.

George Amato argued that perhaps Wayne's approach was not the proper paradigm to follow because the evolutionary history/context of any species is central to recovery of that species.

Mike Phillips argued from the practical aspects of restoration that perhaps we should not follow the paradigm because the resolution of the question of origins might figure prominently in restoration design.

Dave Mech pointed out that given the existence of a conservation management program, it is best to focus on promotion of that red wolf recovery program. Additionally, it is important to recognize that anthropogenic forces facilitate hybridization so that conservation actions must proceed full-steam ahead.

Our initial discussion centered on a variety of issues related to hybridization. These are:

- How much hybridization can occur without threatening phenotypic (behavior, morphology etc.) or genetic integrity of the red wolf?
- Widespread hybridization
- How much hybridization can be tolerated w/o loss of species' phenotypic integrity?
- How is hybridization prevented?
- How do you recognize hybridization in the field and how quickly can decisions be made and implemented. How do we manage hybrids?

- Placing the process in an evolutionary context - what are we managing for, distribution of alleles and allelic patterns that may have occurred 200 years in the past.
- Should we preserve what we have in captivity?
- Complete discussion of what it means when these animals hybridize
- Societal versus more scientific value, societal and political perceptions and responses to the problem: hybridization is not seen as a good thing, legal issues because of the Endangered Species Act (hybrid policy, etc.)
- Administrative response by the USFWS
- Lack of data on the issue in the wild and captivity (fitness of hybrids, mating success and viability, predisposing factors)
- Is hybrid issue of such magnitude that all other issues are superseded by it?
- Are we to assume that this hybridization is a natural process? Is the hybrid red wolf better adapted to local and current conditions? Have we interfered with an important natural process?

Following identification of these issues, the group condensed the list to six major problems for prioritization using paired ranking. These are:

1. How much hybridization can occur without threatening phenotypic (behavior, morphology etc.) or genetic integrity of the red wolf?
2. How do you manage hybridization, i.e., difficulty of recognizing hybrids and to actively manage to prevent their production?
3. How do you place the red wolf in an evolutionary context, should we preserve it in captivity, is the red wolf a species or sub-species, is hybridization a natural process, are hybrids red wolf more adapted to current conditions (i.e., have we interfered with a natural evolutionary process that may not be constructive?).
4. Societal and legal repercussions (Endangered Species Act (ESA) considerations, administrative considerations, considerations and reaction of general public, etc.): the “mutt” response
5. There is a lack of data on hybridization
6. Is hybridization a problem of such magnitude that it supersedes all other programmatic problems (i.e. selection of new reintroduction sites, management of captive population, etc.)?

We discussed the criteria for determining the paired ranking. We did not use paired ranking to set the weighting factors of these criteria, but reverted simply to a consensus based on the discussions. Criteria for ranking problems:

- Biological significance of problem - does problem have the potential to prevent recovery (weighting factor 0.5)
- Feasibility of addressing problem (weighting factor 0.3)
- Scientific benefits from addressing problem (weighting factor 0.2)

The results of the group’s ranking procedure are tabulated below, with higher scores indicating overall higher priority placed on that issue for a given criterion by the working group as a whole.

Issue	Criteria		
	Potential for hindering recovery (biological or ecological significance)	Feasibility of addressing problems	Scientific merit of addressing problem
1. How much hybridization can be tolerated	47	31	41
2. How do you manage hybridization	37	38	35
3. What is a red wolf, what is a species, what are we managing for	35	19	32
4. Societal and legal repercussions	18	22	7
5. Lack of data on hybridization	24	24	23
6. If hybridization is a problem of such magnitude that it supersedes all other problems	25	19	23

During the plenary session, Dave Mech noted that Issue # 6 had very uneven scores. Some participants rated this issue quite highly while others assigned it very low priority, yet he felt that everyone in the group felt similarly about the importance of the issue. He raised the question that perhaps there had been a misunderstanding of the group when they voted for this issue. We decided to meet again after the plenary session and we defined our concepts further.

Initially, the group wanted to devise a general statement of the problem and ignore the process of paired ranking because a concern was voiced over results of ranking not representing what the collective group felt was important. Consequently, the group revised the definitions of the six issues and reapplied the prioritization process.

In addition, Issue #6 evolved into a general statement reflecting the collective feelings of the group:

Hybridization that affects the genetic and phenotypic integrity of the red wolf is the primary issue facing its recovery. How we proceed with red wolf recovery is dependent upon how we assess, and if possible, manage hybridization.

Following considerable additional discussion, the group revised the remaining five issues into the following statements:

1. Determine the degree of hybridization that can occur without threatening the phenotypic (behavioral, morphological, etc.) or genetic integrity of the red wolf.
2. Determine how to measure, monitor, and actively manage (e.g. coyote and hybrid control) hybridization levels as determined in the statement above.
3. Determine the evolutionary context of the red wolf and the role that hybridization played in its evolution.
4. Determine ways of contending with the political (i.e. degradation of state and local support), social (mutt effect), legal and administrative (lack of hybrid policy within the FWS) problems.
5. Collect more experimental data on hybridization. For example the program should include breeding interactions, fitness of hybrids, etc.

The criteria upon which these newly-revised issues were to be prioritized were also redefined:
- Potential to affect recovery (weighting factor 0.6)
- Feasibility: logistical, physical, and technical (weighting factor 0.3)
- Broader significance to conservation (weighting factor 0.1)

Based upon these well-defined issues and criteria, the paired ranking procedure was repeated with the results shown below (the weighted totals are in parentheses).

Issue Number	Potential to affect recovery	Feasibility: logistical, physical, and technical	Broader significance to conservation
1	35 (21)	33 (9.9)	31 (3.1)
2	38 (22.8)	36 (10.8)	27 (2.7)
3	15 (9)	9 (2.7)	31 (3.1)
4	14 (8.4)	20 (6)	15 (1.5)
5	18 (10.8)	22 (6.6)	16 (1.6)

Problems 1 and 2 are the highest priorities, however, there was a suggestion to refocus the entire meeting around hybridization questions, and to use the Alligator River population in a manner to test hybridization control. We need to experiment with this situation before we engage in any other activities. We decided to table refocus of the meeting until the morning plenary session.

During the latter portion of the group's time together, a great deal of information was shared and the question was asked, "Can the red wolf be recovered even under the best of conditions?" It appears from recent data that current hybridization levels are already unsustainable in terms of maintaining the current red wolf genotype. If all hybrids were caught and removed, the program could perhaps be maintained. Certainly, some hybrids have been missed, so considerable effort must be directed towards improving this aspect of the program.

It was noted that hybridization is not observed throughout the range of the species – but is not confined just to the edge. Nowak discussed the issue of reticulate patterns as being natural. It may be difficult to save something (i.e., the red wolf) that might not be considered natural. He described the movement of coyotes across the country and argued that we no longer had true red wolves or true coyotes --- they are part coyote/wolves and red wolf/coyotes. Regardless, he thought we should save the current population in a wildlife area as a national monument.

Could this particular perspective be difficult to sell to administrative and political leaders? Flemming thought that it might not, since there were already a host of policies concerning hybridization with the Florida panther, listed fish etc.

Henry suggested that the North Carolina population should be divided into:

1) Dare county population that would be the "pure" recovered red wolf. This could be maintained through extensive trapping, fences etc.
2) Western population that would be an experimental population that would look at hybridization issues. These data could be used for recovering wolves in areas with coyotes in other areas of the country.

One proposal: Fence the Alligator River area. Remove or sterilize coyotes – and add more red wolves to help establish pack structures – etc. Fifty animals is probably the upper limit in that area. Perhaps fire management would help; perhaps, line traps could be used instead of a fence.

Bob Wayne expressed his sentiment that we should treat the hybridization issue experimentally - test the system. There are concerns about public attitudes for coyote control, expense for a system unlikely to be replicated or even succeed.

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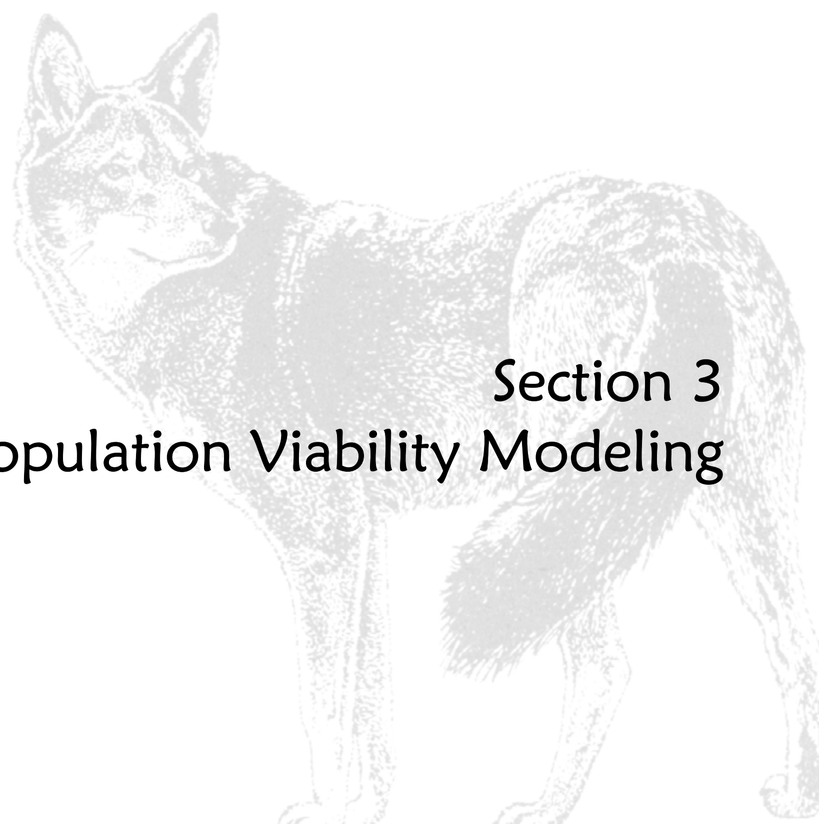

Section 3
Population Viability Modeling

Population Viability Modeling Working Group Report

Working Group Members:
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Brian Kelly, ARNWR / USFWS
Dennis Murray, Idaho State University
John Theberge, University of Waterloo
Bob Wayne, University of California Los Angeles
Phil Miller, CBSG (Facilitator)

Introduction

The need for and consequences of alternative management strategies can be modeled to suggest which practices may be the most effective in conserving the red wolf in the southeastern United States. Genetic and demographic modeling tools such as *VORTEX* (Miller and Lacy 1999) or other approaches have been used here to study the interaction of a number of life history and population parameters treated stochastically, and to explore which demographic parameters may be the most sensitive to alternative management strategies.

Population viability models are not intended to give absolute answers, since they project stochastically the interactions of the many parameters which enter into the models, and because of the random processes involved in nature. Interpretation of the output depends upon our knowledge of the biology of red wolves, the conditions affecting the populations, and possible changes to these conditions that may occur in the future. For a more detailed discussion of population viability analysis and the use of models, see Miller and Lacy (1999).

General Working Group Issues

As a first step, the group members identified the following issues pertinent to the red wolf population viability modeling process:

- How to model hybridization and its effects on red wolf demographics
- Overall model parameterization – including both means and variances
- Recognize and incorporate the differences between wild-born and captive-born animals with respect to demographic rates
- Use sensitivity analysis to identify research and management priorities
- How to deal with removal separate from mortality
- How to describe the erosion of social structure in red wolf populations impacted by humans – even when the total population numbers are not changing
- How to put metapopulation structures into the modeling process
- Put modeling effort into a broader management context

Using generalized ranking procedures, the group ranked these issues according to priority in the context of generating a more useful population viability model to assist in red wolf recovery. Clearly, the need to better understand the mechanisms underlying hybridization between red wolves and coyotes—and its influence on the future viability of the red wolf in northeastern North Carolina—is a top priority.

Input Parameters for *VORTEX* Demographic Simulations

Mating System: Red wolf breeding system was assumed to be monogamous because biparental care is an important (and well-documented) attribute of the genus Canis.

Age of First Reproduction: It was assumed that the minimum breeding age for females was 2 years; in most canids the onset of estrus in free-ranging females occurs in the second year even though physiologically they may become reproductive sooner.

Males were assumed to become reproductively active physiologically at age 2 even though in this and most canid species actual reproductive activity of most males is probably delayed considerably.

Age of Reproductive Senescence: Maximum breeding age was assumed to be 8, based on information from other canid species (including Algonquin wolves, J. Theberge, pers. comm.). However, studbook information indicates that this may be an overestimate and may need further refinement in subsequent models.

Offspring Production: We assumed that the average proportion of females producing a litter each year was 0.5; this assumption was largely arbitrary and should be adjusted following analysis of existing red wolf data.

Annual variation in female reproduction is modeled in *VORTEX* by entering a standard deviation (SD) for the proportion of adult females that produce a litter in a given year. *VORTEX* then determines this proportion by sampling from binomial distribution with a specified mean (50%) and standard deviation (in this case, 10%).

The maximum litter size was assumed to be 6 individuals based on the average litter size for other canid species. While this may seem to be rather high, we can assign a low probability to such a large litter according to the following distribution:

Litter Size	Frequency (%)
1	0
2	10
3	20
4	40
5	20
6	10

The choice of the above distribution was based largely on intuition but it may be possible to use existing red wolf data to refine these estimates.

Finally, the sex ratio at birth was assumed to be at parity because there exists no information to suggest otherwise.

Male Breeding Pool: It was assumed that, because of wolf territorial behavior, only 50% of males are available for breeding in a given year.

Survival Rates: Red wolf survival rates are similar among sexes but differ among age classes; in addition, survival rates have been shown to be significantly higher among wild- than captive-born animals—presumably resulting from different general conditions between the two environments (Murray et al. unpubl.). We initially utilized survival rates obtained from the current ARNWR population, in which all but one individual is wild-born. Further scenarios can assess the impact of a captive-born component infused into the original largely wild-born population.

Age	Captive-born	Wild-born
0-1	0.37	0.78
1-2	0.45	0.83
Adult	0.60	0.87

We assumed arbitrarily that the SD in annual survival rates for all age/source population cohorts was ± 0.10.

In addition, environmental variation in reproduction was chosen to be correlated to sources of variation in survival because red wolves occupy fixed territories year-round and thus are exposed to similar environmental conditions during the reproductive and non-reproductive seasons. Also, there is no *a priori* reason to anticipate survival and reproduction to be differentially affected by given environmental forces.

Inbreeding depression: Inbreeding depression has not been included in these initial models as, currently, no measurable evidence of inbreeding depression exists in the captive red wolf population (Kalinowski et al., in press).

Catastrophes: Catastrophes are singular environmental events that are outside the bounds of normal environmental variation affecting reproduction and/or survival. For some species, hurricanes, floods, volcanoes, etc. could wipe out a large part of a population in one year. These events are modeled in *VORTEX* by assigning a probability of occurrence and a severity factor ranging from 0.0 (maximum or absolute effect) to 1.0 (no effect).

We assumed that two types of catastrophes, such as a major disease epidemic and a hurricane, are capable of impacting the red wolf population independently. Each type of event was given a frequency of occurrence of 1% annually (i.e., one event every 100 years on average). When each event occurs, both fecundity and survival are reduced by 50% during that particular year and return to their normal values immediately after the event.

Initial Population Size: The current red wolf population was estimated to consist of 80 individuals (B. Kelly pers. comm.). Initial models assumed that these 80 individuals were distributed among age-sex classes according to the stable age distribution calculated from the life table.

Carrying Capacity: The carrying capacity, *K*, for a given habitat patch defines an upper limit for the population size, above which additional mortality is imposed across all age classes in order to return the population to the value set for K. The carrying capacity of wolves in northeast North Carolina was assumed to be 150, based largely on best guess estimates.

Demographic Impact of Coyote Hybridization: We attempted to develop some simple preliminary models that would address the issue of demographic consequences of hybridization between red wolves and coyotes. Our initial hypothesis is that, as the frequency of coyotes increases relative to red wolves, fewer female red wolves will successfully breed in a given year. In other words, the proportion of adult female red wolves that breed annually ("successful breeding" meaning a red wolf female breeding with a red wolf male and not a coyote) will decline. Specifically, preliminary models included a 75% reduction in the proportion of adult females breeding annually over a period of 50 years. We took a conservative approach and assumed that, through some sort of management intervention after 50 years, this rate of decline would stabilize so that, after 50 years, the proportion of adult females successfully breeding annually would have been reduced from 50% to 12.5%.

Results of Preliminary Demographic Models

The tables that follow present the numerical results from the risk assessment models developed during this workshop. The results are described in terms of the following:

r_s	Mean stochastic population growth r_s in the stochastic simulations, calculated prior to any carrying capacity truncation, and averaged across years. The population growth rate in the simulations will be depressed relative to the calculated deterministic projection because of a variety of stochastic processes, such as random fluctuations in breeding, survival, and sex ratio, and possibly inbreeding depression.
SD(r_s)	Standard deviation in the stochastic growth rate across simulated populations and across years. Larger SD(stoch r) indicates a less stable population, with more variation in size from year to year. In about 68% of the years, the value of r will fall within 1 SD of the mean.
N_{100} - Ext.	Mean size of the simulated populations extant at year 100.
SD(N_{100})	Standard deviation in the population size at year 100 across simulated populations. SD(N) is a measure of the predictability of the final population size. Larger SD(N) relative to N indicates that the final population size of any given simulated (or real) population may deviate considerably from the mean simulation result.
H_{100}	The mean expected heterozygosity (gene diversity) remaining in the simulated population after 100 years, relative to the level of original genetic variation in the population at the beginning of the simulation.

The Baseline Model

We developed a simulation model incorporating our best estimates of red wolf demography and habitat characteristics. We have called this simulation our *baseline model*. Using this set of input data, our simulated red wolf population is projected to increase at a rate approaching 20% per year (Table 1). This vigorous rate of population growth is due in large part to the low mortality estimates for wild-born individuals compared to their counterparts born in a captive environment and subsequently released into wild habitat. As a result of this rapid rate of growth, there is no immediate risk of extinction under these circumstances, and the simulated population is able to increase in size until carrying capacity is reached in just ten years (Figure 1). However, the extent of original population heterozygosity that is retained is relatively low – below the 90% threshold commonly cited as an important benchmark for maintaining population viability in the short term (i.e., 5 – 10 generations). This is due to the relatively small population size that must be managed within the Alligator River NWR boundaries.

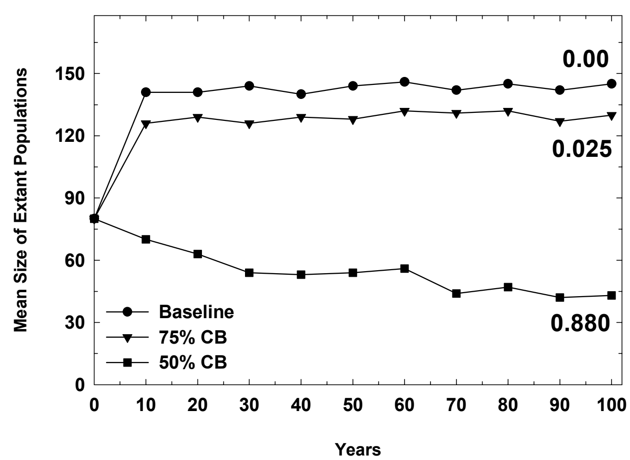
In summary, our baseline model demonstrates some measurable degree of demographic security (in the absence of major catastrophic events that may not be included in our model) but the relatively small population size characteristic of the NENC region may lead to a rate of loss of genetic variation that could lead to longer-term problems with respect to population fitness.

It is important to remember that this baseline model does not include any hybridization events and their associated impacts on native red wolf demographic and genetic structure. An initial attempt to study this phenomenon is provided later in this section.

Table 1. Red wolf population risk analysis: Demographic impact of increasing the proportion of captive-born animals comprising the total simulated population. See text for definitions of column titles.

Conditions	r_s (SD)	P(E)	T(E)	N_{100}–Ext. (SD)	H_{100}
Baseline (98% CB)	0.195 (0.224)	0.000	—	145 (13)	0.809
75% CB	0.101 (0.238)	0.025	—	130 (31)	0.768
50% CB	-0.043 (0.287)	0.880	47	43 (40)	0.576

Figure 1. Population size projections for a simulated red wolf population composed of nearly 100% wild-born individuals (baseline model), and for alternative populations in which the percentage of captive-born (CB) wolves comprising the total population is either 75% or 50%. Numbers accompanying each trajectory indicate the population extinction risk over the 100-year timeframe of the simulation. See text for additional information on model parameterization.



Impact of Releasing Captive-Born Wolves into the NENC Population

Based on the survival analyses of Dennis Murray and his colleagues, the survival rates of captive-born individuals released into the Alligator River population are considerably lower than those of their wild-born counterparts. In an attempt to simulate the demographic impact of this phenomenon, a pair of models were developed in which the total Refuge population was composed of either 75% or 50% wild-born animals, thereby reflecting a major increase in the percentage of captive-born animals relative to the baseline model previously presented. This increased contribution from the captive population is reflected in an increased mortality rate among all age-sex classes that is directly proportional to the relative contributions of each source to the total population.

As shown in Table 1, the population growth rate is reduced by nearly 50% compared to the baseline model when the simulated population is composed of 25% captive-born animals. However, the stochastic growth rate of 10% remains high enough that the simulated population is able to approach the carrying capacity of 150 wolves and the extinction risk remains low (but, significantly, non-zero). If we assume that the population is composed of 50% captive-born individuals (Table 1, Figure 1), the growth rate becomes significantly negative, the simulated population shows a marked decline in size over time, and the risk of population extinction jumps dramatically to 88% over the 100-year simulation timeframe.

While this small set of simulations is quite simple in its parameterization, the negative impact of higher mortality among captive-born wolves following release is clearly evident. These detrimental consequences may possibly be alleviated by either minimizing the proportion of captive-born animals in the NENC population, or by implementing some set of management actions that would rapidly increase the survival of those animals recently released from a captive environment.

Subsequent demographic modeling efforts – using *VORTEX* or other population viability tools – could perhaps refine this scenario by defining the mortality of captive-born animals as a function of time so that their survival may increase following release and subsequent acclimatization to their new wild surroundings. In addition, a type of modified metapopulation approach – in which the total population is effectively modeled as a pair of "subpopulations" with some degree of interchange among them – could be developed to potentially provide greater realism.

Demographic Impacts of Hybridization with Coyotes

We made an attempt at simulating the demographic impacts of increasing the rate of hybridization among red wolves and coyotes within the Alligator River NWR and surrounding areas. To do this, we had to derive a mechanism by which hybridization could be defined in terms of red wolf demographic rates. Our assumption was that, as the density of coyotes in and around red wolf habitat increases, the frequency of matings between red wolf females and coyote males would likewise increase. This would effectively remove an increasing proportion of red wolf females from the annual total population of breeding red wolves over time – from the perspective of looking at the red wolf population as a demographic entity separate from the sympatric coyote population. Consequently, we simulated this increasing hybridization rate by gradually decreasing the proportion of red wolf adult females that successfully breed in a given year. Again, it is important to remember that "successful breeding" is defined here as a mating between a pair of red wolves, and not between a red wolf female and a coyote male. As such, we are therefore projecting the viability of a "pure" red wolf population that interacts with coyotes within and immediately adjacent to NENC.

In the two hybridization models we developed, the proportion of adult red wolf females that successfully breed each year declines at a linear rate over the first 50 years of the simulation and is ultimately reduced to either 50% or 75% of the baseline value at that time. Beginning in year 51 of the simulation, this value remains constant at the lower breeding rate. Therefore, the final proportion of adult red wolf females that successfully breed is reduced to 25% or 12.5% compared to the original value of 50%.

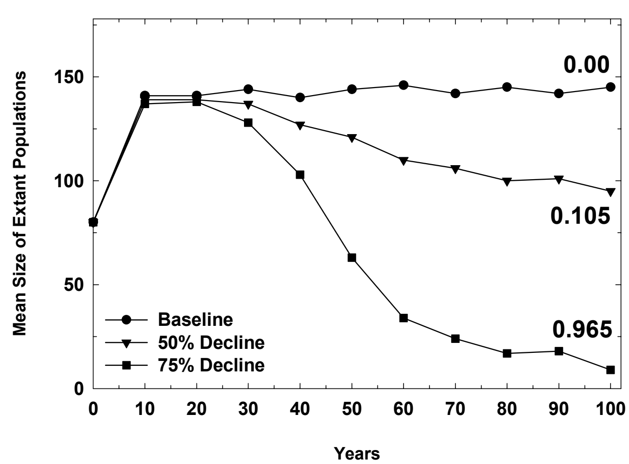
The results of these models are presented in Table 2 and Figure 2. If the proportion of adult females declines by 50% over the first 50 years of the simulation, the population begins to decline after an initial rapid growth phase through the first twenty years of the simulation (Figure 2). This population decline results from the decrease in the proportion of successful female breeders to a level below the original 50% level that is demographically unsustainable. Beyond year 30, the simulated population gradually declines from a maximum population size of about 140 individuals to just under 100 animals at the end of the simulation. Additionally, despite this relatively gradual decline, the simulated population is at a measurable risk of extinction: approximately 10% over the 100-year timeframe of the simulation.

If the rate of hybridization increases to a 75% decline in the proportion of adult females successfully in a given year, the population shows a significantly greater rate of decline following the initial growth phase. Moreover, the risk of extinction is extremely high over a 100-year simulation timeframe as the mean population size drops to about ten animals in 100 years.

Table 2. Red wolf population risk analysis: Demographic impact of increasing the rate of hybridization between red wolves and coyotes. As "hybridization" is defined here as a mating between a red wolf female and a coyote male, this event effectively removes the female from the red wolf breeding pool. This event is therefore simulated in Vortex as a gradual decrease in the annual percentage of successful female red wolf breeders, i.e., those that breed with a male red wolf. See text for additional details.

Conditions	r_s (SD)	P(E)	T(E)	N_{100}–Ext. (SD)	H_{100}
Baseline (50% EE)	0.195 (0.224)	0.000	—	145 (13)	0.809
50% Decline (25% EE)	0.089 (0.265)	0.105	—	95 (49)	0.730
75% Decline (12.5% EE)	0.025 (0.308)	0.965	68	9 (9)	0.486

Figure 2. Population size projections for a simulated red wolf population with no threat of hybridization with coyotes (baseline), and with increasing hybridization threat manifest by a gradual decline in the percentage of successful female red wolf breeders. Numbers accompanying each trajectory indicate the population extinction risk over the 100-year timeframe of the simulation. See text for additional information on model parameterization.



It appears clear that, from the perspective of the simple demographic model presented here, that hybridization between red wolves and coyotes is not sustainable from a simple demographic point of view. As increasingly more coyotes encroach upon red wolf habitat, the increasing frequency of matings between the two species will decrease the reproductive output of "true" red wolves to the point that the rate of red wolf replacement is not of sufficient magnitude to offset natural (and human-mediated) mortality.

This demographic model of a significant hybridization threat is, of course, highly simplified. We are not considering the detrimental impacts of this hybridization event on the genetic structure of the red wolf population. How much hybridization can a population of red wolves tolerate and still be called "red wolves"? Unfortunately, the implementation of *VORTEX* discussed here can not easily help us deal with this question quantitatively. We need to develop a more specific genetic model to investigate the nature and consequences of hybridization between red wolves and coyotes. This is addressed in greater detail in the next portion of this working group report.

If deemed appropriate, additional *VORTEX* models could be developed to investigate the impact of:

- Gradual reduction in available habitat carrying capacity at the annual rate of 0.1%.
- Because of the need to periodically remove wolves causing problems in the wild (i.e., depredations, wide ranging movements, frequenting community, etc.) and that this rate is estimated to be 0.19/year in the NENC population, we might assume the same removal rate for our modeled population. However, it should be noted that this estimate is derived largely from the higher removal rate in captive- than wild-born animals and should be reduced in future modeling efforts where the modeled population consists largely/exclusively of wild-born animals.
- We could assume that the gradual loss of red wolf genetic material in the wild (due to hybridization with coyotes and genetic drift) will necessitate periodic supplementation with captive-born stock. For the sake of simplicity, we might assume that animals would be added on a yearly basis for 20 years and the rate of addition was equal to 0.5 individuals for each age/sex cohort (total of 3 individuals/year).

A Genetic Model of Red Wolf – Coyote Hybridization

A population of red wolves introgressed by coyotes will experience a change in its genetic constitution relative to its original state as coyote genes are introduced into the red wolf population genome. Using standard population genetics theory, one can calculate the proportional loss of red wolf ancestry ("ancestry" is defined here as the proportional change in the original frequency of a given allele present in the initial unhybridized population) as a function of the proportion of hybrid litters produced per generation:

$$G = \frac{q_{RW(t)}}{q_{RW(t=0)}}\left(1 - \frac{m}{4}\right)^{t},$$

where

- G = proportion of red wolf ancestry retained in the hybridized population;
- $q_{RW(t)}$ = Frequency of a given red wolf allele at time t;
- m = frequency of hybrid litters produced per generation;
- t = number of red wolf generations (generation length assumed here to be 4 years).

The rate of loss of ancestry is slowed by the fact that hybrids themselves have 50% ancestry to red wolves and are therefore a source of red wolf genes to be backcrossed into the original wolf population. Consequently, this rate is not simply a direct function of m – hence the denominator of "4" in the above expression. In addition, this method assumes that (*i*) 50% of the hybrids will remain in the red wolf population and therefore potentially breed with red wolves, and (*ii*) only one of the two possible hybrid × red wolf crosses – F1 female × RW male – is realized.

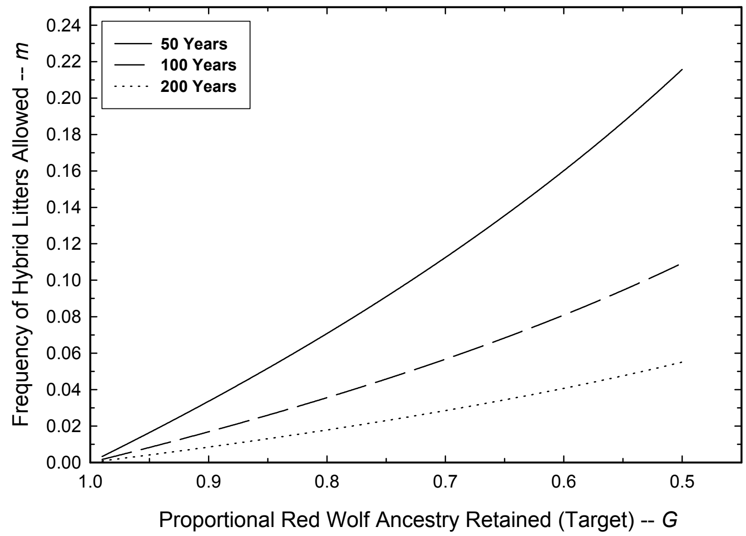
We could identify a particular genetic goal for a given level of retention of red wolf ancestry over a specified time frame—for example, 90% retention for 100 years. Using the expression above, we can calculate the maximum frequency of hybrid litters that can be produced while still satisfying a specific genetic goal:

$$m = 4\left(1 - G^{(1/t)}\right).$$

Figure 3 shows a graphical representation of this relationship. The curves indicate that the proportion of hybrid litters that can be tolerated increases as the target ancestry retention decreases; in other words, a more relaxed genetic goal allows a greater degree of tolerable hybridization. Moreover, a more conservative (longer) genetic management timeframe means that fewer hybrid litters can be tolerated. For example, if the genetic management goal is **90%** retention of red wolf ancestry over **100** years, the maximum tolerable frequency of hybrid litter production is **1.7%** (i.e., 1 out of every 59 litters). However, if this goal is relaxed to 80% over the same time period, the frequency increases to 3.55% (i.e., 1 out of 28 litters). Additionally, if **200** years is the management time horizon, the original frequency is reduced to **0.85%** (i.e., 1 out of every 118 litters).

Current estimates of hybrid litter production are on the order of 15 – 20% over the last 3-4 years, roughly equivalent to one red wolf generation. The genetic model presented here suggests that this rate is far too high to achieve any reasonable genetic goal. Indeed, an ancestry retention of 50% characterizes a population composed entirely of red wolf – coyote hybrids.

Figure 3. Maximum tolerable levels of red wolf – coyote hybridization as a function of genetic management goal (defined as the target level of proportional red wolf ancestry retained in the managed population) and program time horizon. Rate of hybridization is expressed here in terms of the proportion of total litters produced annually that result from a hybrid mating.



We addressed a number of scenarios (with varying degrees of realism and acceptability) under which red wolf genetic ancestry could be retained. It was felt that 50% red wolf ancestry was unacceptable because it is characteristic of wolf-coyote hybrids. One question that was posed was whether/not hybrids are capable of producing offspring in the wild; the general consensus was that hybrids likely were fertile, although data allegedly are not available to confirm this suspicion with this taxon in this area.

It was also suggested that newer models developed to evaluate the impacts of hybridization be spatially-explicit and evaluate the rate of hybridization given several scenarios (i.e, hybridization restricted to the periphery of the core population, hybridization along the periphery with limited core penetration, random spatial distribution and equal mating probability for each animal). In addition, an evaluation of hybridization probability to density of species (i.e., whether hybridization probability is uncorrelated, positively correlated, or negatively correlated). In all likelihood there will be a negative correlation between coyote and red wolf density, whereby high wolf densities will beget low coyote densities.

In addition, it was noted that the topic of mate selection and offspring viability of wolves, coyotes, and hybrids should be assessed in captive and wild animals because the outcome of such studies will importantly affect the parameterization of the model.

Literature Cited

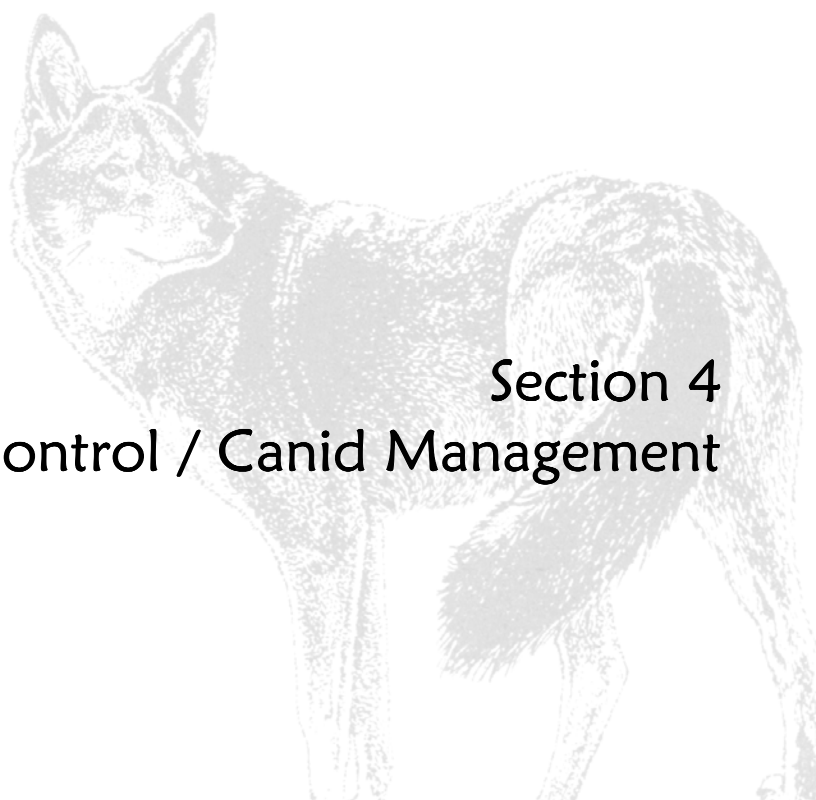
Miller, P.S., and R.C. Lacy. 1999. Vortex: A Stochastic Simulation of the Extinction Process. Version 8 User's Manual. Apple Valley, MN: Conservation Breeding Specialist Group (SSC/IUCN).

Red Wolf

(Canis rufus)

Population and Habitat Viability Assessment (PHVA)

Virginia Beach, Virginia
13 - 16 April, 1999



Section 4
Biological Control / Canid Management

Biological Control/Canid Management Working Group Report

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After recognition by all participants in the plenary session that the problem of hybridization was of over riding concern, the working groups were reformed to address specific hybridization-related issues. The primary question facing the newly formed Biological Control/Canid Management Working Group was: how do we manage hybridization to benefit red wolves? The group identified 6 issues related to this question and then developed recommendations and actions to address them. In addition, this working group put forward a set of specific, innovative management actions and related recommendations for consideration.

Issues

1. Need to identify hybrid genotype

   There is an urgent need to know what we've got in the population and to do this a reliable, rapid method to detect hybrids must be developed.

   Recommendation:
   Fund research into markers for identification of hybrids and rapid turnaround of samples and, if possible develop a field test.

   Actions:
   1. Consider multiple approaches simultaneously.
      - Gene marker insertion with field readable expression – NASA Bioscience Center-Tulane
      - Forensic Elisa – North Carolina State Bureau of Investigation (NCSBI)
      - Other

2. Bid process to find lab to analyze samples from wild canids to identify hybrids.
    - Ashland Forensics Lab
    - Bob Wayne?
    - 1000 genetic labs in US

3. Captive program should supply captive stock blood and scat to DNA lab for baseline data set.

2. Can we switch the balance of population survival between red wolves and coyotes?

The maximum survival of the red wolf may not be related simply to an increase in their density relative to coyotes. However, assuming hybridization is a function of species density, altering the following parameters to favor red wolves may be beneficial:

- prey available to red wolves, not coyotes
- habitat favorable to red wolves, not coyotes
- trapping / removing coyotes
- sterilizing of coyotes
- augmentation of red wolf pups
- chemical repellants

Recommendation:
Implement biological control until we can better understand hybridization management and/or the balance is shifted from coyotes to red wolves.

3. Where to focus effort?

Several options were discussed in detail.

- Focus all effort on the current Alligator River National Wildlife Refuge (ARNWR) site only
- Manage current site (using gradient approach described below) while continuing to work on criteria for site selection.
- Focus on finding an alternative site
- Postpone, but not abandon, looking for alternative site

Recommendation:
Issues are important and complex and there is still so much uncertainty that effort should be focused on ARNWR.

Once this decision was made, the discussion turned to whether or not to manage the ARNWR consistently throughout the site or to separate portions for application of different management actions (see gradient implementation concept below). There was spirited discussion about the various means for isolating portions of the site and where management effort would be applied. Some of the concerns that surfaced regarding the splitting of the current site included:

- Other species
- Feasibility of the plan
- Adequate size of minimum number of groups that make up a population
- Expendability of red wolves at ARNWR

- The need to learn by our actions
- Political/social risks
- Risk of closure of red wolf program

4. Need to optimize recovery on the site by whatever means available.

Recognizing that hybridization is the primary problem, all available techniques must be used to minimize it throughout the site.

Recommendation:

All management actions and studies must first and foremost prevent coyote genome from entering red wolf population.

Actions:

Optimize recovery on site by the use of multiple techniques and shift the basic unit of management from the entire site to specifically defined territories.

Possible techniques:

- Fence off peninsula
- Sterilize coyotes on peninsula
- Lethal control of anything not marked
- Leave population alone to see if it can survive
- Insert marker gene
- Manage NENC intensively to minimize hybridization

5. Methods to evaluate success of studies/management actions

Recommendation:

All studies/management actions must include methods for evaluation of their success and effectiveness.

Actions:

- Stabilization / expansion of coyote / hybrid free zone as described by current trapping results
- Western movement of hybrid front
- Decrease in portion of hybrid litters (model may give us this info) relative to wolf litters
- Decrease number of hybrids based on fecal analysis identification, trapping results, etc
- Answers to study questions provide information

6. Is biological control possible in the long term?

Recommendation:

Implement biological control until we can better understand hybridization management and/or the balance is shifted from coyotes to red wolves.

Note: Must define what is meant by long term in a management context and determine level of effort necessary for long term biological control.

Management Actions

Throughout the course of developing these six issues, three themes emerged which required considerable debate. The discussion surrounding these themes of study vs. control, the gradient implementation concept and sterilization vs. euthanasia resulted in the development of an adaptive management strategy for the Alligator River site.

Study vs. control

We are in a crisis situation so we have to ask ourselves whether we have time to study the effects of hybridization and biological controls or if we should simply apply the strictest control available across the board. Although we are in a crisis, it is dynamic with changes requiring constant decision-making. The working group agreed, after intense discussion, that the best response is to control AND study simultaneously to avoid continued decision-making without needed knowledge. The primary objective in this combined approach should maintain preventing the coyote genome from entering the red wolf genome as a primary tenet.

Valuable knowledge can be gained from asking the right questions while implementing management actions.

For example:

- Do sterilized coyotes take up red wolf breeding spaces?
- Will neutered hybrids hold territories against intact coyotes?
- Do territories overlap?
- Does hybridization occur evenly across territory?
- Can coyotes and red wolves be kept apart?
- Is there a management technique that will limit the hybridization of coyotes and red wolves?

Gradient implementation concept

The gradient implementation concept refers to the desire to answer questions using different techniques in different areas. This was a crucial concept in the development of the management strategy. It was decided that adoption of the gradient concept would increase the opportunity to learn from the results of various management actions, increase the probability of success and ensure appropriate allocation of resources.

Note: Wolf crew will decide, on the ground, where to apply which studies/management actions, focusing on the area with the most probability to be coyote-free zone. The experimental design of any study will include criteria to determine where to implement, for how long, when to stop.

Sterilization vs. Euthanasia (removal)

Sterilization:

- Avoids creation of vacuum
- Allows choice of time to remove from population
- Allows study of interaction –can efficiently remove collared animals later
- Helps define area where you have info
- Extends time before crew has to go back in
- Occupies space longer

Euthanasia:

- Avoids the issue of competition for breeding spaces
- Reduces competition for food
- Cheaper
- Faster
- Only method for litters / newborn

We propose to implement biological control and study control methods simultaneously. We will use multiple control methods to determine the best long-term method of control for recovery of the species. The primary objective in all cases is the prevention of coyote gene flow from entering the red wolf genome. Management actions will be chosen with this as primary directive.

Hypotheses to test:

1. Red wolf and coyote home ranges are of equal size.
2. Red wolf and coyote territories overlap.
3. Red wolves do not directly cause coyote mortality.
4. Hybridization will occur uniformly across wolf populations.
5. Hormonally intact sterilized coyotes will hold territory from invading intact coyotes.
6. Hormonally intact sterilized hybrids will hold territory from invading intact coyotes.
7. Inserted wolves can reclaim territories from extracted hybrid/wolf or coyote/wolf pairs.

Recommendation:
Establish a technique for reliable on-site field determination of hybrid status and establish a relationship with a genetics lab(s) for rapid results.

Experimental designs will use territories as the sample units. Decisions on hybridization design will be situational using inclusion/exclusion criteria. For example, use of sterilized hybrids will be in situations where replacement wolves are not in the territory or available from captive stock. We consider the identified hypotheses to be inter dependent and equally critical to successful management of the coyote hybridization problem. We envision them being tested in one integrated study using territories as the experimental unit with different territories being assigned to cohorts based on inclusion and exclusion criteria. This should occur to achieve population size N determined by a suitable power study of the design and all experimental data collection can be implemented through a cogent management plan.

Gradient Implementation Management Strategy

1. Coyote-Free Territories (CFT)

- Confirm red wolf territories
- Determine number of coyotes present – baseline
- Identify any gaps in territories – what's in there
- Euthanize ALL coyotes / hybrids
- Monitoring (pre-breeding season) to be sure area maintains as coyote-free (telemetry and fecal analysis and trapping)
- Collect blood from all individuals and have analyzed as soon as possible

- After CFT established, if monitoring and find coyote, sterilize, collar and release

2. Isolation Zone

- Remove all coyote / hybrid litters
- Sterilize coyote / hybrid adults; collar and release
- Collect blood from all individuals and have analyzed as soon as possible
- Insert appropriate red wolves at appropriate time (when captive program can supply, relative to age and sex, relative to season)
- Focus on 2 beachheads (at risk sites)
- Remove individual coyotes paired with red wolves and replace with red wolves from islands/ captive program (use release techniques and individuals to increase probability that red wolves will stay in area).
- Insert a red wolf when a known red wolf loses mate OR when a single red wolf can be identified
- Leave sterilized coyotes in areas where unable to establish red wolves
- Continually review results and revise management plan accordingly

3. Dispersal Zone (DZ)

- Manage public opinion
- Agree on how to message this new management plan to all stakeholders
- Collect blood from all individuals and have analyzed as soon as possible
- Respond / capture problem wolves
- Respond to coyotes / hybrids opportunistically.
  Euthanasia as determined by crew and landowner
  Sterilize and collar
  Leave them alone
- Investigate increased access to private land and tools for encouraging habitat management and conservation on private lands. Additionally, investigate current resource conservation initiatives to determine how red wolf recovery initiatives should be incorporated. Use current and additional data to determine habitat use and land management practices that: maximize red wolf population growth and favor red wolf range over coyote.
- Use this zone to collect any additional data to answer study hypotheses.

Notes:

- The management goal of this gradient implementation strategy is to progressively expand the boundaries of the Coyote-Free Zone as expertise and confidence in establishing this zone is developed.
- It was suggested that we consider the competitive control points concept and employ a strategy in the dispersal zone of introducing large numbers of sterile coyotes to preemptively "fill" territories until we move the isolation zone out to these areas.

Resource needs:

With the exception of the recommendation to find a field identification test, all recommendations can be implemented with the existing financial and personnel resources.

Measurable outcomes:
- Stabilization or expansion of coyote / hybrid-free zone based on number of territories.
- Decrease in proportion of hybrid litters to wolf litters in NENC
- Successfully test stated hypotheses
- A reduction on the number of hybrids in the area based on trapping data exploring newer technologies such as seat analysis

Timeline:
- 1 year to create Coyote Free Territory (CFT).
- Annual evaluations of measurement of success for minimum of 6 years.

Summary of Recommendations

1. Revise recovery plan according to recommendations from this workshop
2. Postpone selection of new reintroduction site and focus effort on Alligator River National Refuge site.
3. Consider set of criteria derived from Site Selection Working Group when selecting this new site
4. Focus necessary resources on development of a rapid technique for canid identification and develop relationships with a lab(s) willing to do this work
5. Implement biological control until we can better understand hybridization management and/or the balance is shifted from coyotes to red wolves.
6. Implement the management actions listed above to prevent coyote gene flow from entering the red wolf genome.
7. While implementing management actions, collect data needed to test the hypotheses (answer the questions) listed above and ensure that all management actions include methods for evaluation of their success and effectiveness.

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Appendix I

Criteria for insertion animals

Recommendations:

1. Island facilities breed pair this season so offspring will be ready for insertion
2. If one needed prior to availability of animals, translocate animal from DZ to CFT
3. In all cases, individual(s) chosen must be optimum candidate for relocation (age, sex, group size, original territory, etc)

Appendix II

While the Biological Control Working group was developing the management strategy outlined above, the Monitoring Working Group was designing a similar strategy. When the two groups reviewed the specifics of the strategies, one major difference was found. The monitoring group was advocating removal of coyotes while the Biological Control group suggested sterilization. A plenary discussion of two plans resulted in the following set of comparisons:

	Sterilization	Removal
Stop Gene Flow	from territory	from animal
Duration of Effect	2-4 years	< 6 months
Identify area involved	yes	no
Capture effectiveness of effort/animals	2X capture	X
Removal time identifiable	yes	partial
Short-term efficiency	no	yes
Permit wolf colonization from existing RW pop	no	yes
Contribute to "studies"	yes	no

In addition, the following general workshop statement was drafted by members of each of the two groups:

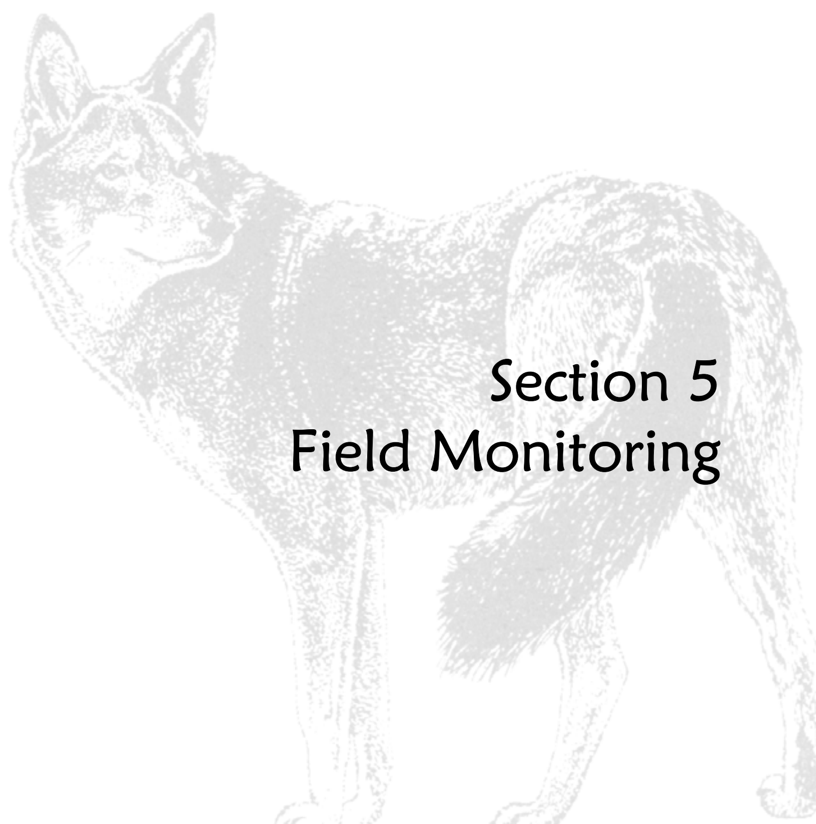
> The Red Wolf Recovery Program has had significant successes over its history, including but not limited to perpetuation of the red wolf genome in captivity, third generation wild pups, and a population distributed over one million acres. It is vital to perpetuate this success. However, hybridization in the free-ranging population has been recognized as a serious threat to the continued success of this landmark program. Because of this threat, our primary recovery focus must be protecting and promoting the growth of a self-sustaining, non-hybridizing population of red wolves in the wild and sustaining an active captive component. Actions to be taken will use an adaptive management approach that will not compromise the ability to achieve this goal.

Red Wolf

(Canis rufus)

Population and Habitat Viability Assessment (PHVA)

Virginia Beach, Virginia
13 - 16 April, 1999



Section 5
Field Monitoring

Field Monitoring Working Group Report

Working Group Members:
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Gloria Bell, U.S. Fish & Wildlife Service
Mike Chamberlain, Mississippi State University
Todd Fuller, University of Massachusetts
Eric Gese, U.S. Department of Agriculture
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Scott McLellan, U.S. Fish & Wildlife Service
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Mike Phillips, Turner Endangered Species Fund
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John Theberge, University of Waterloo
Mary Theberge, University of Waterloo
Bob Wayne, University of California, Los Angeles
Paul Wilson, Trent University
Jack Grisham, Oklahoma City Zoo (Facilitator)

Introduction

The charge of the field monitoring group was to recommend methods and direction for monitoring free-ranging red wolves. After an initial brainstorming session designed to elicit a set of issues of relevance to this group, fifteen items were listed and prioritized using a paired-ranking system according to the following three criteria.

Priority rankings - criteria for evaluating topics	Score
1. Is it directly related to meeting recovery goals	18
2. Logistic and economic feasibility	1
3. Data needs/gaps/urgency	8

Issue	Score
Estimate population w/ eye towards recovery goals -- assumes that you can identify individuals as to species	91
Interspecific interactions among carnivores and with prey/livestock	89
Experimental design/hypothesis testing	87
Prey abundance	80
Effectiveness/accuracy/precision of monitoring schemes	77
Sociopolitical monitoring	75
Research prioritization / model parameterization	68
Documentation of individuals animals -- documentation of what is there, all canids (Canis)	65
Monitor viability of population (monitoring - individuals, population)	62
Expanded collaboration	57
Survival rate of pups	46
Centralized data bank (standardized methods)	39
Training sociopolitical issues	32
How do you get the most bang for your buck	31
Increase use of Geographic Information System (GIS) technology	31

After the first workshop plenary session and the questions posed by the whole group during that session, the initial list was revisited on day two. The original list of fifteen issues was refined down to seven priorities using just one new criterion. After prioritizing, again using paired ranking, the following priorities surfaced:

Criterion: Related to recovery of the red wolf

Issue	Score
Hybridization incidence and effect over time	42
Population dynamics/demographics Document individual animals; monitor population viability (disease, survival, etc.)	40
Population monitoring - "how many?"	36
Prey relationships	20
Sociopolitical attitude/training	12
Livestock relationships	10
Interactions w/ other carnivores	8

The Field Monitoring Group dynamics changed on day two throughout the meeting with the consolidation of Hybridization Group and flow of original members to other groups. Currently 50 red wolves and two coyotes are being monitored in NENC. Now is the best time for initiating the projects in ARNWR with the recent relocation of red wolf personnel and resources from the Smokies. The group recognized the hybridization problem and the need to do something about it. It is important to note that the group felt strongly some type of ad hoc/advisory/recovery team, consisting of 6 - 10 individuals, be maintained to periodically review and assist the red wolf personnel. The ad hoc/advisory/recovery team needs to meet on a regular schedule to review the progress of this work (six months, a year, etc.). Also, specialized groups/teams need to be developed to address specific problems: hybrid index, skull radiographs, genetic testing and morphology. Suggestion of correlating measurements and weights from free-ranging red wolves will be analyzed to develop parameters for evaluation of red wolves, red wolf/canid hybrids in the field. There is also a need to have the captive population used as a reservoir for the free-ranging population for re-introductions and sampling is paramount.

From these discussions and feedback in the Plenary sessions, the following Action steps were developed.

Action Plans:

The use of good science is important in the development of all projects. These should include, but not be limited to the following items: experimental design/quality control; effectiveness/accuracy/precision on monitoring schemes; the use of GIS; a centralized data bank and collaboration with other agencies, universities and researchers.

<u>1. Hybridization - incidence/effect over time</u>

- Number of breeding pairs that are wolf/wolf, wolf/coyote, wolf/dog.
- We need guidelines in determination of a red wolf.
- Distribution and abundance of coyotes and free-ranging dogs in relation to red wolves prior to, during, and after reintroduction.

2. Population dynamics/demographics

- Reproduction, survival, dispersal, age at first reproduction, movements, distribution, density, sex ratio and age structure, morbidity, mortality, growth rate.
- Continue current handling of pups to monitor and assess; add transponders, consider taking blood samples for analysis.

3. Population monitoring - how many?

- Modify techniques as the population grows and expands and you can't track every individual.
- How do we address population enumeration (i.e., estimate rather than count (confidence intervals))?
- Further use of GIS system to facilititate numeration, population data, analysis.
- Collection of scats for analysis

4. Prey relationship

- Distribution, abundance, and composition of prey species (e.g., raccoons, deer)
- Gain enough knowledge that wolf has enough to eat and to address public issues.
- Collection of scats for analysis

5. Sociopolitical attitude/training

- Documenting the sociopolitical attitudes of stakeholders.
- Provide training (e.g., negotiation techniques, conflict resolutions, involving stakeholders, team building, etc.) to red wolf personnel.
- Broad brush education to all stakeholders.
- Create a periodic monitoring system to check our effectiveness.

6. Livestock relationship

- Monitor how often livestock depredation occurs.
- Ensure rapid response when depredations occur (communication between FWS and stakeholders).

7. Interactions with other carnivores

- Everything but coyotes. Bobcats, foxes, bears, free-ranging dogs.
- Temporal and spatial use of landscape. Dietary overlap. Interference competition.
- Scat collection for analysis

Recommendations:

Revise recovery plan (recovery criteria)

Priority Action Plan

Rationale Statement

Our group considered the relative merits of various manipulations and experimental approaches. We feel that the problem of coyote gene introgression into red wolves is so great that it is unwise to utilize any of the NENC recovery area for hypothesis testing. Such hypothesis testing removes some packs from being managed for the primary goal of protecting and promoting the growth of the self-sustaining, non-hybridizing population of red wolves in NENC. Resolution of the data needed to address various null hypotheses is difficult to obtain because of limitations of field work. Conclusions from hypothesis testing will be difficult to draw from small samples, especially considering variability in canid behavior.

Issue 1: Hybridization - incidence/effect over time
Problem: Red wolves interbreed with non-wolf canids
Goal: Protect and promote the growth of a self-sustaining, non-hybridizing population of red wolves in NENC

Actions:

1. Maximize number of releases to suitable sites to maximize red wolf population growth
   A. Pre-release surveys
   B. Landowner and other logistics
   C. Hard and soft releases
   D. Possible release sites in order of priority:
      1. Mainland Dare County (Durant Island, ARNWR, and other sites)
      2. South of Lake Mattamuskeet
      3. Northern Tyrrell County (north of US 64)
      4. Pocosin Lakes National Wildlife Refuge
      5. Farther west as opportunities present
   E. Recommend to captive group that they begin maximizing the number of release candidates (up to 6 pairs for 1999-2000).
      1. Put pairs together as soon as possible and move to Sandy Ridge or islands.
      2. Goal to release between November 1999 and mid-March 2000.
      3. Provide other wolves as needed to pair with wild, solitary wolves.
      4. Ideal wolves for release are 2-4 years of age with reproductive experience.
      5. Maximize the involvement of island-reared wolves in the release campaign.
      6. Point of introductions is to promote growth of population, not genetic stabilization
      7. Disposition of recently released animals will be decided on a case by case basis
   F. Sandy Ridge (ARNWR captive facility) should be maintained for pre-release candidates

TIME LINE: 1999-2000 and beyond as needed
OUTCOME: See final outcome summary

2. Lethal control of coyotes and non-wolf canids.
   A. Kill coyotes and non-wolf canids in Dare, Hyde, Tyrrell, Washington, and Beaufort Counties (in that order of priority) with reviewed SOPs.
      1. "Banking" of biological samples including blood, skulls, (periodic analysis of skulls by trained/knowledgeable personnel) etc. Occasional collection of entire skeleton and skins. Consider banking semen if collection can occur during breeding season.
      2. Necropsies should be standard (including collection of reproductive tracts.)
   B. Ability to differentiate hybrids (NEEDS TO BE APPLIED QUICKLY):
      1. Morphology from captures/releases in NENC and info from Algonquin
      2. Hybrid index
      3. Skull radiographs
      4. Genetics test conducted at ARNWR
      5. Possible outcomes

a. Radio-collar and release any animal that passes test(s)
b. Any animal that fails morphological test:
1. Any coyote captured is euthanized
2. Questionable animals should be maintained in captivity to await results of genetic tests

TIME LINE: 1999-2004
OUTCOME: See final outcome summary

3. Assessment study (Is lethal control necessary?/get out of coyote killing mode)
   A. Assessment during control period
      1. Processing and collaring/recollaring any red wolves captured and then released
         a. Monitor for vital life statistics, for example:
            1. Distribution (territory characteristics with spatial and temporal distributions/GIS application) and density
            2. Reproduction
            3. Mortality
      2. Ongoing assessment to estimate abundance of coyotes
         a. Rate of capture (non-wolf hybrids/trap night)
         b. Collection of scats (identify as wolf or non-wolf)
         c. Howling surveys
         d. Reports of crew and non-crew members of coyote sightings
         e. Documentation of wolf population
   B. Assessment of program after lethal control finishes
      1. Lethal control for 6 years (two generations of three years per generation).
      2. Assessment program continues for three years after termination of lethal control
         a. Field work continues except for lethal control aspect
         b. Coyotes still entering area?
         c. Ability to "short-circuit" if necessary

TIME LINE: 1999-2007
OUTCOME: See final outcome summary

4. Advisory Committees
   A. Diagnostics/identification
      1. Goal for internal ability to genetically identify canids (blood and scat)
   B. Advisory Team
      1. Consists of 8 to 10 participants from this meeting
      2. First meeting in 6 to 12 months
      3. Action-oriented team

TIME LINE: 1999-2007
OUTCOME: See final outcome summary

5. Other related activities/collaboration
   A. Assess potential development of hybridization in North Carolina by evaluating past and present status in southeast Texas
   B. Analysis of morphological data from NENC captures

TIME LINE: 1999-2007

OUTCOME: See final outcome summary

Although items 2 - 7 (see pages 48-49) were not developed into Action Plans, they are still important and relevant to all studies/projects currently underway or to be developed in the future.

Final Outcome Statement:

Final determination if the goals were met or not met and attendant determination by USFWS on the fate of red wolf recovery program (development of a new site, preservation of mainland Dare County and captive population, development of fencing around ARNWR or termination of program)

Summary

On day four of the meeting a small group of two individuals from the Monitoring Working Group, two from Wild Canid Working Group and one from the Captive Working Group met to find common ground and reach an agreement to move forward on the red wolf program. The goal was to develop a statement that would achieve a doable action plan that can work towards the goal of a self-sustaining free-ranging red wolf population. This general workshop statement is shown below.

> The Red Wolf Recovery Program has had significant successes over its history, including but not limited to perpetuation of the red wolf genome in captivity, third generation wild pups, and a population distributed over one million acres. It is vital to perpetuate this success. However, hybridization in the free-ranging population has been recognized as a serious threat to the continued success of this landmark program. Because of this threat, our primary recovery focus must be protecting and promoting the growth of a self-sustaining, non-hybridizing population of red wolves in the wild and sustaining an active captive component. Actions to be taken will use an adaptive management approach that will not compromise the ability to achieve this goal.

Red Wolf

(Canis rufus)

Population and Habitat Viability Assessment (PHVA)

Virginia Beach, Virginia
13 - 16 April, 1999

Section 6
New Population Site Selection

New Population Site Selection Working Group Report

Working Group Members:
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Michael Morse, U.S. Fish & Wildlife Service
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Kathy Whidbee, U.S. Fish & Wildlife Service
Aubrey White, Red Wolf Coalition
Onnie Byers, CBSG (Facilitator)

Goals

1. Develop list of criteria for choosing site
2. Provide rationale for each criteria
3. Prioritize list of criteria
4. Outline site selection process describing how Service is to use criteria for decision making. Include aspects of outreach/education and legal protection.

The working group first addressed the question of whether or not this is the right time to select a new site. It was determined that development of criteria and rationale for those criteria would be beneficial even if it is the decision to choose a new site is postponed.

Criteria for Site Selection

Biological
Socio-economic
Socio-political
Logistical

Biological Criteria for Population Survival

- #1. Reproductive isolation from coyotes
- Adequate prey base
- Minimum space requirement for 3 or more family groups (intensive genetic management required)
- Human settlement (density & distribution)
- Shape of site, circular, reduce edge, or peninsula
- Minimal competition w/ other large predators (ex. Florida panther)
- Low road density relative to type
- Low prevalence of infectious & non-infectious (i.e.: low habitat health risk) disease (low canid density diminishes concern)
- Minimal conflict w/ other managed species (ex. sea turtles
- Minimal conflict with livestock

Socio-Political Criteria for Population Survival

- Distance from human population centers
- Landownership/landuse amenable to long-term recovery particularly private vs. public land
- Tolerant landowners
- Supportive agencies/institutions (State Fish & Game, Farm Bureau)
- Tolerant / vocal support
- Lack of conflict w/ other human activities, e.g. hunting (some types of hunters might welcome red wolf populations)
- Road density/type (potential for conflicts often indicated by road density; increase in road density increases access for hunters as well as other human access)
- Shape of site (minimize edge)
- Minimal conflict with livestock (compensation program)

Socio-Economic Criteria for Population Survival

- Tourism dollars going to local community leading to public support
- Low risk to other economic interests
- Cost of program implementation (including outreach programs)

Logistical criteria

- Physical access to recovery site
- Radio signal problems – topography
- Climate (for flying, etc)
- Elevation

Highest priority must be given to biological requirements. Socio-political, socio-economic and some logistical criteria can be influenced or compensated for (i.e., spend more money to overcome unfavorable logistics) but, if the site doesn't meet biological criteria, public support and perfect logistics won't improve it as a site for red wolves.

Notes: Before implementation of a new reintroduction site, information on conditions that will assure red wolf genetic stability must be obtained.

Outline of site selection process

1. Site selection should proceed in a step-wise fashion, first winnowing down, based on best available data, the current list of potential site to a list of the best 6 sites for further investigation. Then select the top 2 sites for release and conduct a prospective habitat health risk assessment.

2. Include best and worst case scenarios regarding hybridization when making decisions regarding site selection.

3. Include historic knowledge in site selection decision-making process. By reviewing the choice of the Smokies site, we can learn whether the problems were biological, socio-political, economic or logistical.

- Didn't have detailed list of criteria for picking site at time Smokies site was chosen
- It was a political decision
- All Federal land
- Wolves went on private land – socio-political problem
- Possibly inadequate prey available
- Extremely low pup survival – disease, disturbance/stress
- The door was open
- High elevation – related to poor access; inability to monitor

4. Coyote issues must be of primary concern when choosing future sites.

   A. High food availability leads to high coyote density
      a). Consider island populations. Small island area requires constant intervention (genetically)
      b). Consider pre-release removal of coyotes; need "critical mass" of core population
      c). Sterilize coyotes

   B. Need to know coyote demographics and population surrounding chosen site

   C. Conditions potentially limiting hybridization: ratios of number of wolves to coyotes, density of coyotes in area surrounding site, and need "critical mass" of red wolves out there

   D. Need to know if the peninsula NENC is saturated with red wolves.

Note: Some observational data suggest that red wolves may be able to maintain dominance over coyotes in habitat similar to that from which last red wolves came: dense, evergreen understory, swamp. These preliminary observations must be pursued with additional information.

5. Site Size Issues
The minimum area requirement of 170,000 acres (680km^2) in the current Recovery Plan excludes islands. There is a need to discern how this figure was chosen and to consider revision of this number during a reassessment of the Recovery Plan.

Based on the above discussions the following recommendations were made:

1. Current resources should be focused on acquiring information on conditions that will assure red wolf genetic stability.

2. Determine if wolves can maintain themselves in presence of coyotes.
   Ensure red wolf genetic stability until we better understand the factors affecting coyote hybridization rates. Until this can be ensured, any release site must be an "island" population. An "island" can be an actual island, a fenced site or a site isolated by some other secure geographic barrier. If data show that genetic stability can be ensured in the presence of coyotes, other non-"island" sites can be considered

3. Revise Recovery Plan based on current knowledge about the apparent threat of hybridization. Specifically consider the following: 1) the 170,000-acre minimum area requirement is

unrealistic; 2) intensive management of various sorts will be required; 3) red wolves may need to be put outside historic range.

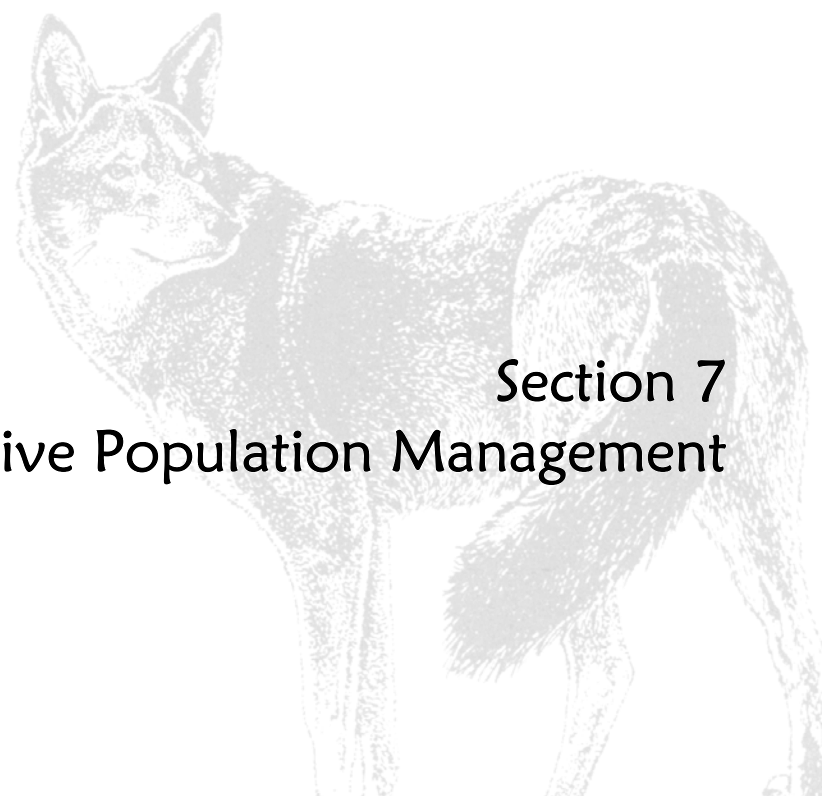
4. Form Recovery Plan revision team and reassess recovery plan within the next year.

Red Wolf

(Canis rufus)

Population and Habitat Viability Assessment (PHVA)

Virginia Beach, Virginia
13 - 16 April, 1999



Section 7
Captive Population Management

Captive Population Management Working Group Report

Working Group Members:
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Karen Goodrowe, Toronto Zoo
Sue Lindsey, Wild Canid Survival and Research Center
Will Waddell, Point Defiance Zoo
Kathy Traylor-Holzer, Minnesota Zoo (Facilitator)

Introduction

The role of the captive population in the recovery of the red wolf has changed over the last few years, as fewer wolves were needed for release. The focus of the American Zoo Association (AZA) Red Wolf Species Survival Plan (SSP) has shifted from breeding wolves for release to managing a stable captive population. This role also includes promoting the successes of the red wolf recovery program, the role of zoos in conservation, and the threats to wild canids and other top predators in North America. All of these are important and valid reasons for maintaining a captive population of red wolves in zoos, but the emphasis on these types of educational programs is a change from the original impetus to establish a captive breeding program for red wolves.

One fact became clear early in the workshop – that the role of the captive population in the recovery of red wolves had not diminished, but was becoming even more important than ever before. The hybridization of free-ranging red wolves with coyotes means that the captive population is the only repository of the original genetic composition of the species. Therefore, it was recognized that continued infusions of captive-bred wolves into the wild would be necessary to maintain hybrid-free populations of red wolves in the wild. As a result of the PHVA process, increased breeding of the captive populations and expansion of spaces for red wolves in zoos and other captive facilities has emerged as a critical need.

The processes that led to the recommendations in this report reflect the realization that the captive population has multiple roles to play in the recovery of the species. The working group was also very aware of the importance of careful application of scientific management of the captive population to ensure its survival, and the immediate need to produce captive-bred wolves that would be good candidates for release into the wild.

The group outlined nine major issues for the captive population:

1. Serve as a genetic and demographic reservoir
2. Ability to provide wolves for reintroduction
3. Use captive population for research to support wild population
4. Education/outreach
5. Need for captive population independent of recovery
6. Evaluate relative roles of captive population and changes over time
7. Space limitations
8. Captive management issues
9. Husbandry techniques to produce good release candidates (changes needed?)

Pairwise priority based on two separate criteria:

A. The captive population will be used to provide wolves for reintroduction;
B. The captive population will not be used for reintroduction.

Listing of issues according to priority:

A. <u>Reintroduction</u>	B. <u>Captive population independent of wild</u>
Release	Space limitations
Space limitations	Captive management
Reservoir	Captive population independent of wild
Captive management	Education
Husbandry techniques	Evaluation of roles
Evaluation of roles	Research
Research	Reservoir
Education	Husbandry techniques
Independent population	Release

Following discussion of these various roles for the captive population, the nine issues discussed above were reorganized into three major issue areas. Four roles for the captive population were identified to aid in the conservation of the red wolf. These are:

1) To maintain a genetic and demographically healthy captive population;
2) To supply wolves needed for release into the wild where appropriate; and
3) To conduct research to help investigate hybrid problems and questions.
4) To serve as a national voice for the recovery of red wolves independent of biological programs using educational outreach programs.

The Issues

The issues were further developed by producing a problem statement and definition, identifying needs for further information, establishing goals, determining actions and outlining outcomes that will constitute success for recovery of the red wolf.

<u>1. Maintenance of an independent captive population</u>

Overview statement: The captive population is the primary hedge against extinction of the red wolf. Because the wild population is being severely threatened by hybridization with coyotes, the captive population takes on an extraordinarily important role because it is the only repository of the original genetic representation of red wolves.

Definition - Management of a genetically and demographically healthy captive population. (Goal: retention of 83% gene diversity (expected heterozygosity) for 100 years)

The genetic goal for the population was determined by modeling the captive population using the captive population management software <u>Drift</u> (reference?). Various combinations of the parameters in the table below were assessed. Retaining 83% gene diversity (GD, also called expected heterozygosity) over 100 years came out as the best possible scenario and was taken as a reasonable goal for the captive population. The factors that produced 83% GD included increasing generation time (T), increasing under-represented founder lines through use of assisted reproductive techniques, and increasing the current GD of the captive population. One clarification is in order: for the purposes of this exercise, new founders were taken as infusion of genetic material from underrepresented animals from semen banks and not as new animals from the wild.

Current Pop	Curr GD	Fdr lambda	T	lambda	Max Size	Min Size	# New Fnd	Ne/N	Length Prg	GD
166	.905	0	5.1	1.1	250	150	0	.3	100	79.7
166	.905	0	5.1	1.1	250	150	0	.3	200	69.7
166	.905	0	5.1	1.1	300	150	0	.3	100	81.4
166	.905	0	5.1	1.2	300	150	0	.3	100	81.4
166	.905	0	6.0	1.2	300	150	0	.3	100	82.8 *
166	.905	1.2	6.0	1.2	300	150	0	.3	100	83.3 *
166	.905	1.2	6.0	1.2	250	150	0	.3	100	81.8
166	.920	1.2	6.0	1.2	250	150	0	.3	100	83.0 *

Problem: Population size insufficient to achieve long-term management goals
Need: Increase AZA and non-AZA spaces
Goal: 250-300 spaces
Actions:

- Recruit additional cooperators targeting the historic range (emphasize the multiple roles of the captive population; further promote re-introduction program)
- Increase number of spaces at current facilities (new holding areas or restructure current holdings) – quality of space/exhibits may differ depending on the long term need of specific animals
- Maintain current facilities by surveying cooperators and targeting their program focus (e.g. breeding, research, outreach and education)

Outcomes:

Responsibility of SSP coordinator and management group

Timeline:

Intensify efforts immediately. (Timeline begins now (model included lambda of 1.2 or 20% growth per year which is around 40 new spaces per year and get to 300 population size in 5 years, if increase at 20 spaces per year (10%) take 6 years to 250 and 8 years to 300; if 10 spaces per year take 8 years to reach 250.)

Discussion:

Are all of these spaces to be in zoos? Is there a difference in breeding vs. exhibit space? A common practice is to have new facilities start with non-breeding group for a couple of years before moving to a breeding group. Non-AZA spaces will likely be needed because of the large number of spaces needed. Max that can be added per year is 20.

Problem: Unstable age structure due to lack of space to breed and uneven breeding success
Need: Increase breeding to stabilize age structure
Goal: Increase pup production to a lambda that will produce a stable age structure

Actions:

- Increase number of breeding recommendations per year; reproductive evaluations of individuals in unproductive pairs or those with low reproductive success (including fecal hormone analysis of males and females and semen analysis); examine husbandry, nutritional and environmental factors that could affect reproduction; increase space to accommodate increased production, consider culling as an option to increase space for stabilizing the population; be sure reproductive organs are included in necropsy protocol; look at past records to see if past hormone implant contraception may be contributing to lowered fertility.

Outcomes:

SSP management group and coordinator responsibility; discussions on culling would include input from the USFWS.

Problem: current generation time is contributing to an overly rapid loss of GD.
Need: slow rate of loss of genetic diversity in the captive population
Goal: increase generation time (T) from 5.1 to 6 years
Action:

- When males have similar mean kinship (MK), recommend the older animal for breeding; recommend separating sexes rather than MGA for contraception, so institutions should have facilities for separating sexes; continue to investigate the development of safe, effective and reversible contraceptives.

Outcomes:

SSP management group and coordinator responsibility in consort with the AZA Contraception SAG, timeline is now and ongoing; contraception study now being conducted and will continue, should have a good assessment of current tests within five years.

Problem: Genes from behavioral and physical non-breeders or dead animals that have rare genes are being lost from the captive population.
Need: increase genetic contribution of under-represented founder lines
Goal: develop reliable assisted reproduction techniques
Action:

- continue on-going research on semen freezing and timing ovulation;
- develop a Genome Resource Bank (GRB) action plan that would also include serum, tissue samples and cell lines from the wild and captive population;
- determine how much sperm from which individuals is banked, including data on post-thaw motility, bring this information to the Masterplan meeting and use it in modeling with *GENES* to evaluate effects on genetic diversity;
- identify a central location to house samples; funding is in place for the reproductive research portion of this initiative.

Outcomes:

SSP management group and coordinator responsibility. Will Waddell to bring information on banked semen to the Masterplan meeting, June 1999.

Problem: Current GD is lower than potential
Need: Increase GD of captive population
Goal: Move GD from current 90.5% to as close to potential of 94%

Action:

- Maximize increase of GD when picking breeding pairs

Outcome:

SSP management group and coordinator responsibility; timeline to use at next master plan meeting in June 99

<u>2. To supply wolves needed for release to augment wild population where and when appropriate.</u>

The captive population needs to provide periodic infusion of individuals into the wild population to support genetic integrity of the species in the wild at current or future release sites. These infusions can also be used to increase wild population sizes as a hedge against stochastic demographic events. A large number of individuals from the captive population may be needed for release into the wild as a way to address density dependent hybridization threats.

Discussion:
The suite of morphological features used to originally define the red wolf have not been figured for the current captive population. If they are going to be used to identify hybrids it could help to characterize the current captive population. One way to do this is to develop a phenotypic ID standard procedure to be used in the field as part of the experiment to correlate genetic and phenotypic markers. Data would be collected opportunistically. In order to be a valid procedure, a large number of wolves, coyotes and hybrids will need to be measured. It may be wise to bring someone from Alligator River to assess wolves at Graham to control for inter-observer differences that might negate measurement. In addition, central collection of photographs would be a valuable addition to the general red wolf information database; however, the problem is using phenotype to tell the difference between wolves and hybrids, especially F2,3 and so on. Since we are producing the hybrids already for genetic analysis, we may as well use them to see if there are conserved coyote physical traits that could be used as a marker for hybrids.

Overview statement: The captive population is the primary hedge against extinction of the red wolf. Because the wild population is being severely threatened by hybridization with coyotes, the captive population takes on an extraordinarily important role because it is the only repository of the original genetic representation of red wolves.

The captive population needs to provide periodic infusion of individuals into the wild population to support genetic integrity of the species in the wild at current or future release sites. These infusions can also be used to increase wild population sizes as a hedge against stocastic demographic events. A large number of individuals from the captive population may be needed for release into the wild as a way to address density dependent hybridization threats.

Problem: The gene diversity of the wild population is depauperate; the gene diversity of free ranging population is lower than potential and also lower than the captive population so there may be situations where animals are moved from the captive to wild population that can be used to augment the gene diversity of the wild population.
Need: To increase gene diversity of the wild population
Goal: Improve genetic diversity of the free ranging population without endangering the integrity of the captive population

Action:

- when wolves are requested for re-introduction: choose wolves for re-introduction that are under-represented in the wild; include this need when making breeding recommendations in the SSP master plan when possible; continue as a priority for the islands or mainland to set up pairs of underrepresented animals to produce offspring for release; monitor survival and reproduction of re-introduced animals to track any contributions to increasing GD

Outcome:

SSP coordinator and management group responsibility with Service determining the need for wolves for reintroduction; successful reproduction in the wild of release animals.

Demographic augmentation:

Releasing captive-born animals to increase the size of wild populations, increase density of wolves compared to coyotes, increase number of breeding age animals, fill in territories to exclude coyotes. This would be done regardless of the individual's representation in the captive population.

Problem: insufficient numbers of red wolves to prevent interbreeding with coyotes
Need: increase number of red wolves in NENC
Goal: Higher density of wolves
Action:

- Produce sufficient numbers of wolves in captive or island facilities for release (transferred animals responsibility of USFWS)

Problem: provide good release candidates
Need: released wolves need to survive to reproduction
Goals: maximize probability of survival and reproduction and minimize behavior that would result in the animal being removed from the wild (such as tolerance of people, depredation,)
Action:

- Give wolves experiences such as: opportunities to hunt, live in social group, introduce at a young age so they have less time in captivity, minimal contact with humans, experience with raising young or having reproduced themselves, and reared in larger, diverse enclosures; monitor after release to assess survival.

Outcome:

Improved survival and fewer removals from captive born released animals.

A): investigate mate choice as a technique for evaluating potential release candidates not only for the separate species, but for FI and backcross situations. **Action**: Move this to another category, i.e., changes in husbandry techniques to support release.

B): mate selection: look at red wolf's choice between wolf or coyote given equal opportunity. Does familiarity with coyotes influence choice of mate? Or, if one has testicles, one mates anything? Is age a factor? Produce aversion of wolves to mating with coyotes through conditioning? What about choice of wolves that have bred in captivity in choosing coyotes for mates? Do wolves choose coyotes on their first litter or later litters, when they lose a mate, when they lose a litter or fail to mate? Aversion training to odors that may affect mate choice?

Discussion of research role for captive population
From hybrid group: research needed to identify genetic markers to identify wolves, hybrids, and coyotes. Suggestion is that F1 hybrids are intermediate and can be separated from wolves and coyotes. Because species share genes it is a suite of genes, an F1 backcross may or may not be clearly one or the other, thus the research is needed.

Kinds of research and numbers of animals needed. Two issues at the same time: may have to raise a relatively large number of wolves for release while at the same time need space to do hybrid research. For first, zoos may be the spaces, other spaces from other institutions (not zoos) may be needed for research because zoos are not likely to be able to produce hybrids needed for research.

Do we know if hybrids are viable? Don't know. Red Wolf x Dog works, and red wolves and coyotes are closer. Have original hybrids now removed from the studbook. Need to look at fertility of hybrids. Wild may be better method because of numbers needed to answer the question. General feeling is that hybrids can breed, but we need to do the controlled study.

If question of space for wolves, Sandy Ridge could be used as an experimental station. Don't want to take a chance on any hybrids produced at sandy ridge contaminating alligator river population.

Space needs are common to all of the roles for the captive population (maintain, breed for release, and research). Need 33-40 spaces next year to grow at lambda 1.20.

Maintain -> zoos
Breed for release -> islands
Research -> sites other than zoos

<u>3. Research to investigate hybrid problems and questions.</u>

Problem: To identify wolves, coyotes and hybrids in the wild.
Need: A technique for identifying different species and hybrids in the wild
Goal: To be able to identify hybrid individuals and red wolves in wild population based on genetic and phenotypic markers (such as voice patterns, behavior, food habits, and morphology). Identification by inserting biomarkers is a possibility that should be explored.

Discussion:
To develop a way to identify wild canids by setting up known red wolf/coyote crosses to establish a genetic baseline for monitoring hybridization in the wild, including parental generation, F1s, backcrosses, F2s, other backcrosses. Minimum of three generations, 8 animals in each group. RWm x CF, Cm x RWf, 2x2. Take same numbers from litters to make up backcross, etc. Take 32 animals to do the study. Another question is time, may take two years before red wolves could reproduce. Will produce many more than are needed because litter size is larger than is needed just for the study. Could use animals produced for fertility/viability studies for genetic studies as well, but will still need to adress culling surplus animals. To look at fitness would take a large number of animals and may not be feasable or useful to use the captive population. May take too long to be useful in face of immediate challenge to the pop.

Investigations of dog x coyotes have been done. Research has been done in academic colonies, may be that this research will be most likely done in an academic setting. Ethical issues of producing animals that will be euthanized as part of research must be considered. Excess could also be used for behavioral research rather than be euthanized. It would be difficult for the zoo community to meet the needs for producing and housing hybrids because of limitations on space needed for maintaining the captive population and ethical issues of producing animals that would be surplus to cooperative breeding programs.

Action:

- examination of archival information
- identify individual researchers/group technical/scientific expertise
- at least one facility to carry out the research and find funding, and identify sufficient space,
- design and conduct crosses, estimating a minimum of 32 animals needed with 104 produced, use F1 hybrid progeny at Sandy Ridge as part of the study. (excess may be used in other studies).
- Ownership of animals will be retained by USFWS. Develop proactive position on usefulness of hybrid research.

> **Outcomes**: initiate first breedings for next breeding season (Jan 2000) with animals put together by Nov 1999. First round of genetic results needed by Oct 2000. Responsibility for initiating the process is with USFWS. USFWS develop a position statement prior to initiating breeding. Ethical issues -> conflicts with AZA guidelines (deliberate production of hybrids).

Problem: Mate selection: see mate selection above in section II

Problem: Hybrid fitness: difficult to test with captive population because of large numbers of animals needed to address the issues. Seman characteristics from captive males or captive females' cycles may indicate fitness.

Action:

- Use wolves produced to look at semen characteristics, estrous cycles, viability (juvenile mortality), litter size, sex ratio.

Problem: Crosses with grey wolf to look at evolutionary scenarios.

Comment:

Red x grey or grey x coyote crosses may be useful for evolutionary study: space is a issue for supplying wolves for maintaining the captive population, for release and for research projects directly aimed at recovery of the red wolf in the U.S., therefore using space for this type of study is not a priority use of that limited space. However, the captive population should continue to provide samples and support this research in ways it can.

List of Actions (prioritized based upon value to the conservation of the red wolf)

1. Provide additional spaces for captive red wolves by maintaining facilities, new facilities
2. Breed underrepresented animals
3. Produce additional wolves for release for demographic augmentation of the wild
4. Compile existing data from captive and captured wild animals
5. Deliberate production of hybrids to establish genetic and phenotypic baselines for fitness assessment
6. Monitor released animals for survival and reproduction
7. Produce additional wolves for release for genetic augmentation of wild
8. Provide minimal human contact, including choose young animals
9. Increase number of breeding recommendations
10. Provide hunting experience
11. Develop assisted reproduction techniques
12. Reproductive evaluation of under-represeented and low reproductive success animals
13. Develop GRB action plan and bank
14. Develop effective reversible contraception
15. Provide adequate enclosures for release conditions
16. Provide reproductive experience
17. Delay age of breeding
18. Evaluate mate preference of release candidates

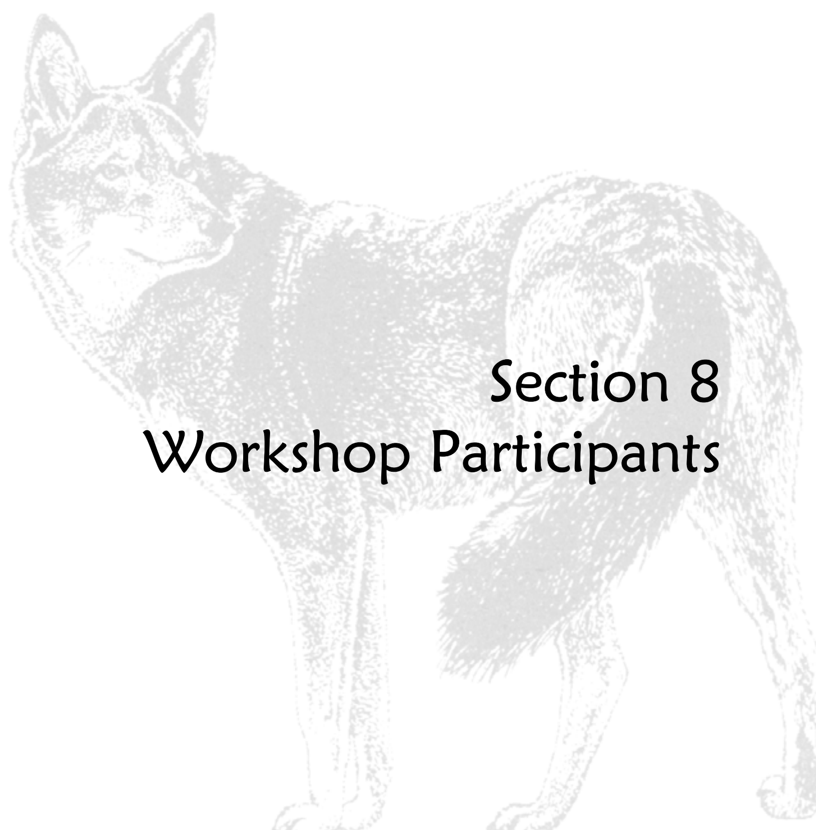
	Total	**Ranking**
Additional space	70	1
Breed under-represented wolves	63	2
Demographic supplementation	62	3.5
Compile database	62	3.5
Hybrid research study	59	5
Monitor released wolves	55	6
Genetic supplementation	53	7
Minimize human contact	51	8
Increase # of breedings	49	9
Hunting experience	41	10
AI techniques	34	11
Reproductive evaluation	33	12.5
GRB action plan	33	12.5
Contraception	30	14
Enclosure size and quality	27	15
Reproductive experience	26	16
Delay age of breeding	17	17
Evaluate mate preference	8	18

Red Wolf

(Canis rufus)

Population and Habitat Viability Assessment (PHVA)

Virginia Beach, Virginia
13 - 16 April, 1999



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Population and Habitat Viability Assessment (PHVA) for the Red Wolf *(Canis rufus)*: List of Workshop Participants

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Red Wolf

(Canis rufus)

Population and Habitat Viability Assessment (PHVA)

Virginia Beach, Virginia
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Section 9
IUCN Policy Statements

IUCN/SSC Guidelines For Re-Introductions

Prepared by the SSC Re-introduction Specialist Group *
Approved by the 41st Meeting of the IUCN Council, Gland Switzerland, May 1995

INTRODUCTION

These policy guidelines have been drafted by the Re-introduction Specialist Group of the IUCN's Species Survival Commission (1), in response to the increasing occurrence of re-introduction projects worldwide, and consequently, to the growing need for specific policy guidelines to help ensure that the re-introductions achieve their intended conservation benefit, and do not cause adverse side-effects of greater impact. Although IUCN developed a Position Statement on the Translocation of Living Organisms in 1987, more detailed guidelines were felt to be essential in providing more comprehensive coverage of the various factors involved in re-introduction exercises.

These guidelines are intended to act as a guide for procedures useful to re-introduction programmes and do not represent an inflexible code of conduct. Many of the points are more relevant to re-introductions using captive-bred individuals than to translocations of wild species. Others are especially relevant to globally endangered species with limited numbers of founders. Each re-introduction proposal should be rigorously reviewed on its individual merits. It should be noted that re-introduction is always a very lengthy, complex and expensive process.

Re-introductions or translocations of species for short-term, sporting or commercial purposes - where there is no intention to establish a viable population - are a different issue and beyond the scope of these guidelines. These include fishing and hunting activities.

This document has been written to encompass the full range of plant and animal taxa and is therefore general. It will be regularly revised. Handbooks for re-introducing individual groups of animals and plants will be developed in future.

CONTEXT

The increasing number of re-introductions and translocations led to the establishment of the IUCN/SSC Species Survival Commission's Re-introduction Specialist Group. A priority of the Group has been to update IUCN's 1987 Position Statement on the Translocation of Living Organisms, in consultation with IUCN's other commissions.

It is important that the Guidelines are implemented in the context of IUCN's broader policies pertaining to biodiversity conservation and sustainable management of natural resources. The philosophy for environmental conservation and management of IUCN and other conservation bodies is stated in key documents such as "Caring for the Earth" and "Global Biodiversity Strategy" which cover the broad themes of the need for approaches with community involvement and participation in sustainable natural resource conservation, an overall enhanced quality of human life and the need to conserve and, where necessary, restore ecosystems. With regards to the latter, the re-introduction of a species is one specific instance of restoration where, in general, only this species is missing. Full restoration of an array of plant and animal species has rarely been tried to date.

Restoration of single species of plants and animals is becoming more frequent around the world. Some succeed, many fail. As this form of ecological management is increasingly common, it is a priority for the Species Survival Commission's Re-introduction Specialist Group to develop guidelines so that re-introductions are both justifiable and likely to succeed, and that the conservation world can learn from each initiative, whether successful or not. It is hoped that these Guidelines, based on extensive review of case - histories and wide consultation across a range of disciplines will introduce more rigour into the concepts, design, feasibility and implementation of re-introductions despite the wide diversity of species and conditions involved.

Thus the priority has been to develop guidelines that are of direct, practical assistance to those planning, approving or carrying out re-introductions. The primary audience of these guidelines is, therefore, the practitioners (usually managers or scientists), rather than decision makers in governments. Guidelines directed towards the latter group would inevitably have to go into greater depth on legal and policy issues.

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1. DEFINITION OF TERMS

"Re-introduction": an attempt to establish a species(2) in an area which was once part of its historical range, but from which it has been extirpated or become extinct (3) ("Re-establishment" is a synonym, but implies that the re-introduction has been successful).

"Translocation": deliberate and mediated movement of wild individuals or populations from one part of their range to another.

"Re-inforcement/Supplementation": addition of individuals to an existing population of conspecifics.

"Conservation/Benign Introductions": an attempt to establish a species, for the purpose of conservation, outside its recorded distribution but within an appropriate habitat and eco-geographical area. This is a feasible conservation tool only when there is no remaining area left within a species' historic range.

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2. AIMS AND OBJECTIVES OF RE-INTRODUCTION

a. Aims:
The principle aim of any re-introduction should be to establish a viable, free-ranging population in the wild, of a species, subspecies or race, which has become globally or locally extinct, or extirpated, in the wild. It should be re-introduced within the species' former natural habitat and range and should require minimal long-term management.

b. Objectives:
The objectives of a re-introduction may include: to enhance the long-term survival of a species; to re-establish a keystone species (in the ecological or cultural sense) in an ecosystem; to maintain and/or restore natural biodiversity; to provide long-term economic benefits to the local and/or national economy; to promote conservation awareness; or a combination of these.

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3. MULTIDISCIPLINARY APPROACH

A re-introduction requires a multidisciplinary approach involving a team of persons drawn from a variety of backgrounds. As well as government personnel, they may include persons from governmental natural resource management agencies; non-governmental organisations; funding bodies; universities; veterinary institutions; zoos (and private animal breeders) and/or botanic gardens, with a full range of suitable expertise. Team leaders should be responsible for coordination between the various bodies and provision should be made for publicity and public education about the project.

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4. PRE-PROJECT ACTIVITIES

4a. BIOLOGICAL

(i) Feasibility study and background research

- An assessment should be made of the taxonomic status of individuals to be re-introduced. They should preferably be of the same subspecies or race as those which were extirpated, unless adequate numbers are not available. An investigation of historical information about the loss and fate of individuals from the re-introduction area, as well as molecular genetic studies, should be undertaken in case of doubt as to individuals' taxonomic status. A study of genetic variation within and between populations of this and related taxa can also be helpful. Special care is needed when the population has long been extinct.
- Detailed studies should be made of the status and biology of wild populations(if they exist) to determine the species' critical needs. For animals, this would include descriptions of habitat preferences, intraspecific variation and adaptations to local ecological conditions, social behaviour, group composition, home range size, shelter and food requirements, foraging and feeding behaviour, predators and diseases. For migratory species, studies should include the potential migratory areas. For plants, it would include biotic and abiotic habitat requirements, dispersal mechanisms, reproductive biology, symbiotic relationships (e.g. with mycorrhizae, pollinators), insect pests and diseases. Overall, a firm knowledge of the natural history of the species in question is crucial to the entire re-introduction scheme.
- The species, if any, that has filled the void created by the loss of the species concerned, should be determined; an understanding of the effect the re-introduced species will have on the ecosystem is important for ascertaining the success of the re-introduced population.
- The build-up of the released population should be modelled under various sets of conditions, in order to specify the optimal number and composition of individuals to be released per year and the numbers of years necessary to promote establishment of a viable population.
- A Population and Habitat Viability Analysis will aid in identifying significant environmental and population variables and assessing their potential interactions, which would guide long-term population management.

(ii) Previous Re-introductions

- Thorough research into previous re-introductions of the same or similar species and wide-ranging contacts with persons having relevant expertise should be conducted prior to and while developing re-introduction protocol.

(iii) Choice of release site and type

- Site should be within the historic range of the species. For an initial re-inforcement there should be few remnant wild individuals. For a re-introduction, there should be no remnant population to prevent disease spread, social disruption and introduction of alien genes. In some circumstances, a re-introduction or re-inforcement may have to be made into an area which is fenced or otherwise delimited, but it should be within the species' former natural habitat and range.
- A conservation/ benign introduction should be undertaken only as a last resort when no opportunities for re-introduction into the original site or range exist and only when a significant contribution to the conservation of the species will result.
- The re-introduction area should have assured, long-term protection (whether formal or otherwise).

(iv) Evaluation of re-introduction site

- Availability of suitable habitat: re-introductions should only take place where the habitat and landscape requirements of the species are satisfied, and likely to be sustained for the for-seeable future. The possibility of natural habitat change since extirpation must be considered. Likewise, a change in the legal/ political or cultural environment since species extirpation needs to be ascertained and evaluated as a possible constraint. The area should have sufficient carrying capacity to sustain growth of the re-introduced population and support a viable (self-sustaining) population in the long run.
- Identification and elimination, or reduction to a sufficient level, of previous causes of decline: could include disease; over-hunting; over-collection; pollution; poisoning; competition with or predation by introduced species; habitat loss; adverse effects of earlier research or management programmes; competition with domestic livestock, which may be seasonal. Where the release site has undergone substantial degradation caused by human activity, a habitat restoration programme should be initiated before the re-introduction is carried out.

(v) Availability of suitable release stock

- It is desirable that source animals come from wild populations. If there is a choice of wild populations to supply founder stock for translocation, the source population should ideally be closely related genetically to the original native stock and show similar ecological characteristics (morphology, physiology, behaviour, habitat preference) to the original sub-population.
- Removal of individuals for re-introduction must not endanger the captive stock population or the wild source population. Stock must be guaranteed available on a regular and predictable basis, meeting specifications of the project protocol.
- Individuals should only be removed from a wild population after the effects of translocation on the donor population have been assessed, and after it is guaranteed that these effects will not be negative.
- If captive or artificially propagated stock is to be used, it must be from a population which has been soundly managed both demographically and genetically, according to the principles of contemporary conservation biology.
- Re-introductions should not be carried out merely because captive stocks exist, nor solely as a means of disposing of surplus stock.
- Prospective release stock, including stock that is a gift between governments, must be subjected to a thorough veterinary screening process before shipment from original source. Any animals found to be infected or which test positive for non-endemic or contagious pathogens with a potential impact on population levels, must be removed from the consignment, and the uninfected, negative remainder must be placed in strict quarantine for a suitable period before retest. If clear after retesting, the animals may be placed for shipment.
- Since infection with serious disease can be acquired during shipment, especially if this is intercontinental, great care must be taken to minimize this risk.
- Stock must meet all health regulations prescribed by the veterinary authorities of the recipient country and adequate provisions must be made for quarantine if necessary.

(vi) Release of captive stock

- Most species of mammal and birds rely heavily on individual experience and learning as juveniles for their survival; they should be given the opportunity to acquire the necessary information to enable survival in the wild, through training in their captive environment; a captive bred individual's probability of survival should approximate that of a wild counterpart.

- Care should be taken to ensure that potentially dangerous captive bred animals (such as large carnivores or primates) are not so confident in the presence of humans that they might be a danger to local inhabitants and/or their livestock.

4b. SOCIO-ECONOMIC AND LEGAL REQUIREMENTS

- Re-introductions are generally long-term projects that require the commitment of long-term financial and political support.
- Socio-economic studies should be made to assess impacts, costs and benefits of the re-introduction programme to local human populations.
- A thorough assessment of attitudes of local people to the proposed project is necessary to ensure long term protection of the re-introduced population, especially if the cause of species' decline was due to human factors (e.g. over-hunting, over-collection, loss or alteration of habitat). The programme should be fully understood, accepted and supported by local communities.
- Where the security of the re-introduced population is at risk from human activities, measures should be taken to minimise these in the re-introduction area. If these measures are inadequate, the re-introduction should be abandoned or alternative release areas sought.
- The policy of the country to re-introductions and to the species concerned should be assessed. This might include checking existing provincial, national and international legislation and regulations, and provision of new measures and required permits as necessary.
- Re-introduction must take place with the full permission and involvement of all relevant government agencies of the recipient or host country. This is particularly important in re-introductions in border areas, or involving more than one state or when a re-introduced population can expand into other states, provinces or territories.
- If the species poses potential risk to life or property, these risks should be minimised and adequate provision made for compensation where necessary; where all other solutions fail, removal or destruction of the released individual should be considered. In the case of migratory/mobile species, provisions should be made for crossing of international/state boundaries.

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5. PLANNING, PREPARATION AND RELEASE STAGES

- Approval of relevant government agencies and land owners, and coordination with national and international conservation organizations.
- Construction of a multidisciplinary team with access to expert technical advice for all phases of the programme.
- Identification of short- and long-term success indicators and prediction of programme duration, in context of agreed aims and objectives.
- Securing adequate funding for all programme phases.
- Design of pre- and post- release monitoring programme so that each re-introduction is a carefully designed experiment, with the capability to test methodology with scientifically collected data.

Monitoring the health of individuals, as well as the survival, is important; intervention may be necessary if the situation proves unforseeably favourable.

- Appropriate health and genetic screening of release stock, including stock that is a gift between governments. Health screening of closely related species in the re-introduction area.
- If release stock is wild-caught, care must be taken to ensure that: a) the stock is free from infectious or contagious pathogens and parasites before shipment and b) the stock will not be exposed to vectors of disease agents which may be present at the release site (and absent at the source site) and to which it may have no acquired immunity.
- If vaccination prior to release, against local endemic or epidemic diseases of wild stock or domestic livestock at the release site, is deemed appropriate, this must be carried out during the "Preparation Stage" so as to allow sufficient time for the development of the required immunity.
- Appropriate veterinary or horticultural measures as required to ensure health of released stock throughout the programme. This is to include adequate quarantine arrangements, especially where founder stock travels far or crosses international boundaries to the release site.
- Development of transport plans for delivery of stock to the country and site of re-introduction, with special emphasis on ways to minimize stress on the individuals during transport.
- Determination of release strategy (acclimatization of release stock to release area; behavioural training - including hunting and feeding; group composition, number, release patterns and techniques; timing).
- Establishment of policies on interventions (see below).
- Development of conservation education for long-term support; professional training of individuals involved in the long-term programme; public relations through the mass media and in local community; involvement where possible of local people in the programme.
- The welfare of animals for release is of paramount concern through all these stages.

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6. POST-RELEASE ACTIVITIES

- Post release monitoring is required of all (or sample of) individuals. This most vital aspect may be by direct (e.g. tagging, telemetry) or indirect (e.g. spoor, informants) methods as suitable.
- Demographic, ecological and behavioural studies of released stock must be undertaken.
- Study of processes of long-term adaptation by individuals and the population.
- Collection and investigation of mortalities.
- Interventions (e.g. supplemental feeding; veterinary aid; horticultural aid) when necessary.
- Decisions for revision, rescheduling, or discontinuation of programme where necessary.
- Habitat protection or restoration to continue where necessary.
- Continuing public relations activities, including education and mass media coverage.
- Evaluation of cost-effectiveness and success of re- introduction techniques.
- Regular publications in scientific and popular literature.

Footnotes:

1. Guidelines for determining procedures for disposal of species confiscated in trade are being developed separately by IUCN.
2. The taxonomic unit referred to throughout the document is species; it may be a lower taxonomic unit (e.g. subspecies or race) as long as it can be unambiguously defined.
3. A taxon is extinct when there is no reasonable doubt that the last individual has died

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The IUCN/SSC Re-introduction Specialist Group

The IUCN/SSC Re-introduction Specialist Group (RSG) is a disciplinary group (as opposed to most SSC Specialist Groups which deal with single taxonomic groups), covering a wide range of plant and animal species. The RSG has an extensive international network, a re-introduction projects database and re-introduction library. The RSG publishes a bi-annual newsletter RE-INTRODUCTION NEWS.

If you are a re-introduction practitioner or interested in re-introductions please contact:

IUCN/SSC Re-introduction Specialist Group (RSG),
c/o African Wildlife Foundation (AWF),
P.O. Box 48177,
Nairobi,
Kenya.
Tel:(+254-02) -710367, Fax: (+254-02) - 710372 or
E-Mail: awf.nrb@tt.gn.apc.org

IUCN Position Statement on Translocation of Living Organisms:

INTRODUCTIONS, REINTRODUCTIONS AND RE-STOCKING

Prepared by the Species Survival Commission in collaboration with the Commission on Ecology, and the Commission on Environmental Policy, Law and Administration

Approved by the 22nd Meeting of the IUCN Council, Gland, Switzerland, 4 September 1987

FOREWORD

This statement sets out IUCN's position on translocation of living organisms, covering introductions, re-introductions and re-stocking. The implications of these three sorts of translocation are very different so the paper is divided into four parts dealing with Introductions, Re-introductions, Re-stocking and Administrative Implications, respectively.

DEFINITIONS:

Translocation is the movement of living organisms from one area with free release in another. The three main classes of translocation distinguished in this document are defined as follows:

- **Introduction** of an organism is the intentional or accidental dispersal by human agency of a living organism outside its historically known native range.
- **Re-introduction** of an organism is the intentional movement of an organism into a part of its native range from which it has disappeared or become extirpated in historic times as a result of human activities or natural catastrophe.
- **Re-stocking** is the movement of numbers of plants or animals of a species with the intention of building up the number of individuals of that species in an original habitat.

Translocations are powerful tools for the management of the natural and man made environment which, properly used, can bring great benefits to natural biological systems and to man, but like other powerful tools they have the potential to cause enormous damage if misused. This IUCN statement describes the advantageous uses of translocations and the work and precautions needed to avoid the disastrous consequences of poorly planned translocations.

PART I

INTRODUCTIONS

BACKGROUND

Non-native (exotic) species have been introduced into areas where they did not formerly exist for a variety of reasons, such as economic development, improvement of hunting and fishing, ornamentation, or maintenance of the cultures of migrated human communities. The damage done by harmful introductions to natural systems far outweighs the benefit derived from them. The introduction and establishment of alien species in areas where they did not formerly occur, as an accidental or intended result of human activities, has often been directly harmful to the native plants and animals of many parts of the world and to the welfare of mankind.

The establishment of introduced alien species has broken down the genetic isolation of communities of co-evolving species of plants and animals. Such isolation has been essential for the evolution and maintenance of the diversity of plants and animals composing the biological wealth of our planet. Disturbance of this isolation by alien species has interfered with the dynamics of natural systems causing the premature extinction of species. Especially successful and aggressive invasive species of plants and animals increasingly dominate large areas having replaced diverse autochthonous communities. Islands, in the broad sense, including isolated biological systems such as lakes or isolated mountains, are especially vulnerable to introductions because their often simple ecosystems offer refuge for species that are not aggressive competitors. As a result of their isolation they are of special value because of high endemism (relatively large numbers of unique local forms) evolved under the particular conditions of these islands over a long period of time. These endemic species are often rare and highly specialised in their ecological requirements and may be remnants of extensive communities from bygone ages, as exemplified by the Pleistocene refugia of Africa and Amazonia.

The diversity of plants and animals in the natural world is becoming increasingly important to man as their demands on the natural world increase in both quantity and variety, notwithstanding their dependence on crops and domestic animals nurtured within an increasingly uniform artificial and consequently vulnerable agricultural environment.

Introductions, can be beneficial to man. Nevertheless the following sections define areas in which the introduction of alien organisms is not conducive to good management, and describe the sorts of decisions that should be made before introduction of an alien species is made.

To reduce the damaging impact of introductions on the balance of natural systems, governments should provide the legal authority and administrative support that will promote implementation of the following approach.

Intentional Introduction

General

1. Introduction of an alien species should only be considered if clear and well defined benefits to man or natural communities can be foreseen.
2. Introduction of an alien species should only be considered if no native species is considered suitable for the purpose for which the introduction is being made.

Introductions to Natural Habitats

3. No alien species should be deliberately introduced into any natural habitat, island, lake, sea, ocean or centre of endemism, whether within or beyond the limits of national jurisdiction. A natural habitat is defined as a habitat not perceptibly altered by man. Where it would be effective, such areas should be surrounded by a buffer zone sufficiently large to prevent unaided spread of alien species from nearby areas. No alien introduction should be made within the buffer zone if it is likely to spread into neighbouring natural areas.

Introduction into Semi-natural Habitat

4. No alien species should be introduced into a semi-natural habitat unless there are exceptional reasons for doing so , and only when the operation has been comprehensively investigated and carefully planned in advance. A semi-natural habitat is one which has been detectably changed by man's actions or one which is managed by man, but still resembles a natural habitat in the diversity of its species and the complexity of their interrelationships. This excludes arable farm land, planted ley pasture and timber plantations.

Introductions into Man-made Habitat

5. An assessment should be made of the effects on surrounding natural and semi-natural habitats of the introduction of any species, sub-species, or variety of plant to artificial, arable, ley pasture or other predominantly monocultural forest systems. Appropriate action should be taken to minimise negative effects.

Planning a Beneficial introduction

6. Essential features of investigation and planning consist of:
    - an assessment phase culminating in a decision on the desirability of the introduction;

- an experimental, controlled trial;
- the extensive introduction phase with monitoring and follow-up.

THE ASSESSMENT PHASE

Investigation and planning should take the following factors into account:

a) No species should be considered for introduction to a new habitat until the factors which limit its distribution and abundance in its native range have been thoroughly studied and understood by competent ecologists and its probable dispersal pattern appraised.

Special attention should be paid to the following questions:

- What is the probability of the exotic species increasing in numbers so that it causes damage to the environment, especially to the biotic community into which it will be introduced?
- What is the probability that the exotic species will spread and invade habitats besides those into which the introduction is planned? Special attention should be paid to the exotic species' mode of dispersal.
- How will the introduction of the exotic proceed during all phases of the biological and climatic cycles of the area where the introduction is planned? It has been found that fire, drought and flood can greatly alter the rate of propagation and spread of plants.
- What is the capacity of the species to eradicate or reduce native species by interbreeding with them?
- Will an exotic plant interbreed with a native species to produce new species of aggressive polyploid invader? Polyploid plants often have the capacity to produce varied offspring some of which quickly adapt to and dominate, native floras and cultivars alike.
- Is the alien species the host to diseases or parasites communicable to other flora and fauna, man, their crops or domestic animals, in the area of introduction?
- What is the probability that the species to be introduced will threaten the continued existence or stability of populations of native species, whether as a predator, competitor for food, cover, breeding sites or in any other way? If the introduced species is a carnivore, parasite or specialised herbivore, it should not be introduced if its food includes rare native species that could be adversely affected.

b) There are special problems to be considered associated with the introduction of aquatic species. These species have a special potential for invasive spread.

- Many fish change trophic level or diet preference following introduction, making prediction of the results of the re-introduction difficult. Introduction of a fish or other species at one point on a river system or into the sea may lead to the spread of the species throughout the system or area with unpredictable consequences for native animals and plants. Flooding may transport introduced species from one river system to another.
- introduced fish and large aquatic invertebrates have shown a great capacity to disrupt natural systems as their larval, sub-adult and adult forms often use different parts of the same natural system.

c) No introduction should be made for which a control does not exist or is not possible. A risk-and-threat analysis should be undertaken including investigation of the availability of methods for the control of the introduction should it expand in a way not predicted or have unpredicted undesirable effects, and the methods of control should be socially acceptable, efficient, should not damage vegetation and fauna, man, his domestic animals or cultivars.

d) When the questions above have been answered and the problems carefully considered, it should be decided if the species can reasonably be expected to survive in its new habitat, and if so, if it can reasonably be expected to enhance the flora and fauna of the area, or the economic or aesthetic value of the area, and whether these benefits outweigh the possible disadvantages revealed by the investigations.

THE EXPERIMENTAL CONTROLLED TRIAL

Following a decision to introduce a species, a controlled experimental introduction should be made observing the following advice:

- Test plants and animals should be from the same stock as those intended to be extensively introduced.
- They should be free of diseases and parasites communicable to native species, man, his crops and domestic livestock.
- The introduced species' performance on parameters in 'the Assessment Phase' above should be compared with the pre-trial assessment, and the suitability of the species for introduction should be reviewed in light of the comparison.

THE EXTENSIVE INTRODUCTION

If the introduced species behaves as predicted under the experimental conditions, then extensive introductions may commence but should be closely monitored. Arrangements should be made to apply counter measures to restrict, control, or eradicate the species if necessary.

The results of all phases of the introduction operation should be made public and available to scientists and others interested in the problems of introductions.

The persons or organisation introducing the species, not the public, should bear the cost of control of introduced organisms and appropriate legislation should reflect this.

ACCIDENTAL INTRODUCTIONS

1. Accidental introductions of species are difficult to predict and monitor, nevertheless they "should be discouraged where possible. The following actions are particularly important:
    - On island reserves, including isolated habitats such as lakes, mountain tops and isolated forests, and in wilderness areas, special care should be taken to avoid accidental introductions of seeds of alien plants on shoes and clothing and the introduction of animals especially associated with man, such as cats, dogs, rats and mice.
    - Measures, including legal measures, should be taken to discourage the escape of farmed, including captive-bred, alien wild animals and newly-domesticated species which could breed with their wild ancestors if they escaped.
    - In the interest of both agriculture and wildlife, measures should be taken to control contamination of imported agricultural seed with seeds of weeds and invasive plants.
    - Where large civil engineering projects are envisaged, such as canals, which would link different biogeographical zones, the implications of the linkage for mixing the fauna and flora of the two regions should be carefully considered. An example of this is the mixing of species from the Pacific and Caribbean via the Panama Canal, and the mixing of Red Sea and Mediterranean aquatic organisms via the Suez Canal. Work needs to be done to consider what measures can be taken to restrict mixing of species from different zones through such large developments.

2. Where an accidentally introduced alien successfully and conspicuously propagates itself, the balance of its positive and negative economic and ecological effects should be investigated. If the overall effect is negative, measures should be taken to restrict its spread.

WHERE ALIEN SPECIES ARE ALREADY PRESENT

1. In general, introductions of no apparent benefit to man, but which are having a negative effect on the native flora and fauna into which they have been introduced, should be removed or eradicated. The present ubiquity of introduced species will put effective action against the majority of invasives beyond the means of many States but special efforts should be made to eradicate introductions on:
    - islands with a high percentage of endemics in the flora and fauna;
    - areas which are centres of endemism;
    - areas with a high degree of species diversity;
    - areas with a high degree of other ecological diversity;
    - areas in which a threatened endemic is jeopardised by the presence of the alien.
2. Special attention should be paid to feral animals. These can be some of the most aggressive and damaging alien species to the natural environment, but may have value as an economic or genetic resource in their own right, or be of scientific interest. Where a feral population is believed to have a value in its own right, but is associated with changes in the balance of native vegetation and fauna, the conservation of the native flora and fauna should always take precedence. Removal to captivity or domestication is a valid alternative for the conservation of valuable feral animals consistent with the phase of their evolution as domestic animals.

    Special attention should be paid to the eradication of mammalian feral predators from areas where there are populations of breeding birds or other important populations of wild fauna. Predatory mammals are especially difficult, and sometimes impossible to eradicate, for example, feral cats, dogs, mink, and ferrets.
3. In general, because of the complexity and size of the problem, but especially where feral mammals or several plant invaders are involved, expert advice should be sought on eradication.

BIOLOGICAL CONTROL

1. Biological control of introductions has shown itself to be an effective way of controlling and eradicating introduced species of plants and more rarely, of animals. As biological control involves introduction of alien species, the same care and procedures should be used as with other intentional introductions.

MICRO-ORGANISMS

1. There has recently been an increase of interest in the use of micro-organisms for a wide variety of purposes including those genetically altered by man.
    Where such uses involve the movement of micro-organisms to areas where they did not formerly exist, the same care and procedures should be used as set out above for other species.

PART II

THE RE-INTRODUCTION OF SPECIES*

Re-introduction is the release of a species of animal or plant into an area in which it was indigenous before extermination by human activities or natural catastrophe. Re-introduction is a particularly useful tool for restoring a species to an original habitat where it has become extinct due to human persecution, over-collecting, over-harvesting or habitat deterioration, but where these factors can now be controlled. Re-introductions should only take place where the original causes of extinction have been removed. Re-introductions should only take place where the habitat requirements of the species are satisfied. There should be no re-introduction if a species became extinct because of habitat change which remains unremedied, or where significant habitat deterioration has occurred since the extinction.

The species should only be re-introduced if measures have been taken to reconstitute the habitat to a state suitable for the species.

The basic programme for re-introduction should consist of:

- a feasibility study;
- a preparation phase;
- release or introduction phase; and a
- follow-up phase.

THE FEASIBILITY STUDY

An ecological study should assess the previous relationship of the species to the habitat into which the re-introduction is to take place, and the extent that the habitat has changed since the local extinction of the species. If individuals to be re-introduced have been captive-bred or cultivated, changes in the species should also be taken into account and allowances made for new features liable to affect the ability of the animal or plant to re-adapt to its traditional habitat.

The attitudes of local people must be taken into account especially if the reintroduction of a species that was persecuted, over-hunted or over collected , is proposed. If the attitude of local people is unfavorable an education and interpretive programme emphasizing the benefits to them of the re-introduction, or other inducement, should be used to improve their attitude before re-introduction takes place.

The animals or plants involved in the re-introduction must be of the closest available race or type to the original stock and preferably be the same race as that previously occurring in the area.

Before commencing a re-introduction project, sufficient funds must be available to ensure that the project can be completed, including the follow-up phase.

THE PREPARATION AND RELEASE OR INTRODUCTORY PHASES

The successful re-introduction of an animal or plant requires that the biological needs of the species be fulfilled in the area where the release is planned. This requires a detailed knowledge of both the needs of the animal or plant and the ecological dynamics of the area of re-introduction. For this reason the best available scientific advice should be taken at all stages of a species re-introduction.

This need for clear analysis of a number of factors can be clearly seen with reference to introductions of ungulates such as ibex, antelope and deer where re-introduction involves understanding and applying the significance of factors such as the ideal age for re-introducing individuals, ideal sex ratio, season, specifying capture techniques and mode of transport to re-introduction site, freedom of both the species and the area of introduction from disease and parasites, acclimatisation, helping animals to learn to forage in the wild, adjustment of the gut flora to deal with new forage, 'imprinting' on the home range, prevention of wandering of individuals from the site of re-introduction, and on-site breeding in enclosures before release to expand the released population and acclimatise the animals to the site. The re-introduction of other taxa of plants and animals can be expected to be similarly complex.

FOLLOW-UP PHASE

Monitoring of released animals must be an integral part of any re-introduction programme. Where possible there should be long-term research to determine the rate of adaptation and dispersal, the need for further releases and identification of the reasons for success or failure of the programme.

The species impact on the habitat should be monitored and any action needed to improve conditions identified and taken.

Efforts should be made to make available information on both successful and unsuccessful re-introduction programmed through publications, seminars and other communications.

PART III

RESTOCKING

1. Restocking is the release of a plant or animal species into an area in which it is already present. Restocking may be a useful tool where:
   - it is feared that a small reduced population is becoming dangerously inbred; or
   - where a population has dropped below critical levels and recovery by natural growth will be dangerously slow; or
   - where artificial exchange and artificially-high rates of immigration are required to maintain outbreeding between small isolated populations on biogeographical islands.
2. In such cases care should be taken to ensure that the apparent nonviability of the population, results from the genetic institution of the population and not from poor species management which has allowed deterioration in the habitat or over-utilisation of the population. With good management of a population the need for re-stocking should be avoidable but where re-stocking is contemplated the following points should be observed:

   a) Restocking with the aim of conserving a dangerously reduced population should only be attempted when the causes of the reduction have been largely removed and natural increase can be excluded.

   b) Before deciding if restocking is necessary, the capacity of the area it is proposed to restock should be investigated to assess if the level of the population desired is sustainable. If it is, then further work should be undertaken to discover the reasons for the existing low population levels. Action should then be taken to help the resident population expand to the desired level. Only if this fails should restocking be used.
3. Where there are compelling reasons for restocking the following points should be observed.

   a) Attention should be paid to the genetic constitution of stocks used for restocking.

   - In general, genetic manipulation of wild stocks should be kept to a minimum as it may adversely affect the ability of a species or population to survive. Such manipulations modify the effects of natural selection and ultimately the nature of the species and its ability to survive.

- Genetically impoverished or cloned stocks should not be used to re-stock populations as their ability to survive would be limited by their genetic homogeneity.

b) The animals or plants being used for re-stocking must be of the same race as those in the population into which they are released.

c) Where a species has an extensive natural range and restocking has the aim of conserving a dangerously reduced population at the climatic or ecological edge of its range, care should be taken that only individuals from a similar climatic or ecological zone are used since interbreeding with individuals from an area with a milder climate may interfere with resistant and hardy genotypes on the population's edge.

d) Introduction of stock from zoos may be appropriate, but the breeding history and origin of the animals should be known and follow as closely as possible Assessment Phase guidelines a, b, c and d (see pages 5-7). In addition the dangers of introducing new diseases into wild populations must be avoided: this is particularly important with primates that may carry human zoonoses.

e) Restocking as part of a sustainable use of a resource (e.g. release of a proportion of crocodiles hatched from eggs taken from farms) should follow guidelines a and b (above).

f) Where restocking is contemplated as a humanitarian effort to release or rehabilitate captive animals it is safer to make such releases as re-introductions where there is no danger of infecting wild populations of the same species with new diseases and where there are no problems of animals having to be socially accepted by wild individuals of the species.

PART IV

NATIONAL, INTERNATIONAL AND SCIENTIFIC IMPLICATIONS OF TRANSLOCATIONS

NATIONAL ADMINISTRATION

1. Pre-existing governmental administrative structures and frameworks already in use to protect agriculture, primary industries, wilderness and national parks should be used by governments to control both intentional and unintentional importation of organisms, especially through use of plant and animal quarantine regulations.
2. Governments should set up or utilise pre-existing scientific management authorities or experts in the fields of biology, ecology and natural resource management to advise them on policy matters concerning translocations and on individual cases where an introduction, re-introduction or restocking or farming of wild species is proposed.
3. Governments should formulate national policies on:
    - translocation of wild species;
    - capture and transport of wild animals;
    - artificial propagation of threatened species;
    - selection and propagation of wild species for domestication; and

- prevention and control of invasive alien species.

4. At the national level legislation is required to curtail introductions:

   Deliberate introductions should be subject to a permit system. The system should apply not only to species introduced from abroad but also to native species introduced to a new area in the same country. It should also apply to restocking.

   Accidental introductions

   - for all potentially harmful organisms there should be a prohibition to import them and to trade in them except under a permit and under very stringent conditions. This should apply in particular to the pet trade;
   - where a potentially harmful organism is captive bred for commercial purposes (e.g. mink) there should be established by legislation strict standards for the design and operation of the captive breeding facilities. In particular, procedures should be established for the disposal of the stock of animals in the event of a discontinuation of the captive breeding operation;
   - there should be strict controls on the use of live fish bait to avoid inadvertent introductions of species into water where they do not naturally occur.

   Penalties

5. Deliberate introductions without a permit as well as negligence resulting in the escape or introduction of species harmful to the environment should be considered criminal offences and punished accordingly. The author of a deliberate introduction without a permit or the person responsible for an introduction by negligence should be legally liable for the damage incurred and should in particular bear the costs of eradication measures and of habitat restoration where required.

INTERNATIONAL ADMINISTRATION

Movement of Introduced Species Across International Boundaries

1. Special care should be taken to prevent introduced species from crossing the borders of a neighboring state. When such an occurence is probable, the neighboring state should be promptly warned and consultations should be held in order to take adequate measures.

   The Stockholm Declaration

2. According to Principle 21 of the Stockholm Declaration on the Human Environment, states have the responsibility 'to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states'.

   International Codes of Practice, Treaties and Agreements

3. States should be aware of the following international agreements and documents relevant to translocation of species:
   - ICES, Revised Code of Practice to Reduce the Risks from introduction of Marine Species, 1982.
   - FAO, Report of the Expert Consultation on the Genetic Resources of Fish, Recommendations to Governments No L 1980.
   - EIFAC (European Inland Fisheries Advisory Commission), Report of the Working Party on Stock Enhancement, Hamburg, FRG 1983.

- The Bonn Convention MSC: Guidelines for Agreements under the Convention.
- The Berne Convention: the Convention on the Conservation of European wildlife and Natural Habitats.
- The ASEAN Agreement on the Conservation of Nature and Natural Resources.
- Law of the Sea Convention, article 196.
- Protocol on Protected Areas and Wild Fauna and Flora in Eastern African Region.

In addition to the international agreements and documents cited, States also should be aware of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). International shipments of endangered or threatened species listed in the Appendices to the Convention are subject to CITES regulation and permit requirements. Enquiries should be addressed to: CITES Secretariat**, Case Postale 456, CH-1219 Chatelaine, Genève, Switzerland; telephone: 41/22/979 9149, fax: 41/22/797 3417.

Regional Development Plans

4. International, regional or country development and conservation organisations, when considering international, regional or country conservation strategies or plans, should include in-depth studies of the impact and influence of introduced alien species and recommend appropriate action to ameliorate or bring to an end their negative effects.

Scientific Work Needed

5. A synthesis of current knowledge on introductions, re-introductions and re-stocking is needed.

6. Research is needed on effective, target specific, humane and socially acceptable methods of eradication and control of invasive alien species.

7. The implementation of effective action on introductions, re-introductions and re-stocking frequently requires judgements on the genetic similarity of different stocks of a species of plant or animal. More research is needed on ways of defining and classifying genetic types.

8. Research is needed on the way in which plants and animals are dispersed through the agency of man (dispersal vector analysis).

A review is needed of the scope, content and effectiveness of existing legislation relating to introductions.

IUCN Responsibilities

International organisations, such as UNEP, UNESCO and FAO, as well as states planning to introduce, re-introduce or restock taxa in their territories, should provide sufficient funds, so that IUCN as an international independent body, can do the work set out below and accept the accompanying responsibilities.

9. IUCN will encourage collection of information on all aspects of introductions, re-introductions and restocking, but especially on the case histories of re-introductions; on habitats especially vulnerable to invasion; and notable aggressive invasive species of plants and animals.

Such information would include information in the following categories:

- a bibliography of the invasive species;
- the taxonomy of the species;
- the synecology of the species; and
- methods of control of the species.

10. The work of the Threatened Plants Unit of IUCN defining areas of high plant endemism, diversity and ecological diversity should be encouraged so that guidance on implementing recommendations in this document may be available.
11. A list of expert advisors on control and eradication of alien species should be available through IUCN.

Note:
* The section on re-introduction of species has been enhanced by the Guidelines For Re-Introductions
** The address of the CITES Secretariat has been updated.
