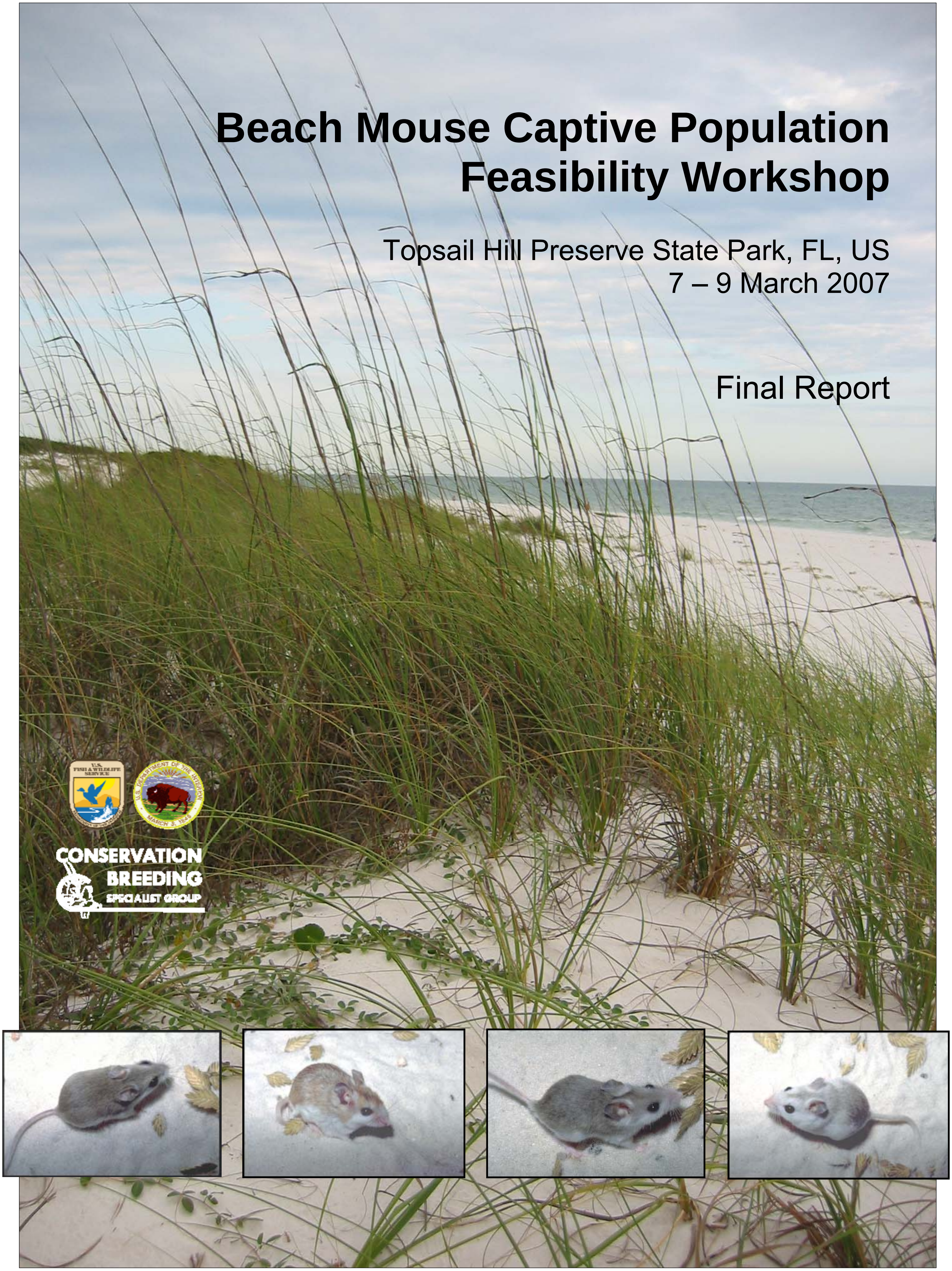
Beach Mouse Captive Population Feasibility Workshop

Topsail Hill Preserve State Park, FL, US
7 – 9 March 2007

Final Report



CONSERVATION BREEDING SPECIALIST GROUP

Beach Mouse Captive Population Feasibility Workshop

Topsail Hill Preserve State Park, FL, US
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Workshop organized by: US Fish and Wildlife Service (Service); IUCN/SSC Conservation Breeding Specialist Group (CBSG).

Workshop financial support provided by: US Fish and Wildlife Service

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A contribution of the IUCN/SSC Conservation Breeding Specialist Group.

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Traylor-Holzer, K. and R.C. Lacy (eds.). 2007. *Beach Mouse Captive Population Feasibility Workshop Final Report*. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, MN.

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April 2007

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SECTION 1

Executive Summary

Executive Summary

Introduction

Seven subspecies of oldfield mice known as beach mice (*Peromyscus polionotus* ssp.) inhabit the coastal landscape of the southeastern U.S. These nocturnal rodents live primarily along vegetated sand dunes, spending the day in burrows and emerging to feed at night. Five Gulf Coast subspecies are found on barrier islands, keys, or coastal mainland areas extending from Alabama's Fort Morgan Peninsula (Alabama beach mouse, *P.p. ammobates*) east to Perdido Key (Perdido Key beach mouse, *P.p. trissyllepsis*) and Santa Rosa Island (Santa Rosa beach mouse, *P.p. leucocephalus*), and along northwestern Florida's Gulf Coast (Choctawhatchee beach mouse, *P.p. allophrys*) to St. Joseph Peninsula (St. Andrews beach mouse, *P.p. peninsularis*). Two additional subspecies live along Florida's Atlantic Coast – the Anastasia Island beach mouse, *P.p. phasma*, and the Southeastern beach mouse, *P.p. niveiventris*. All subspecies except for the Santa Rosa beach mouse are federally listed as endangered or threatened. An eighth subspecies, the pallid beach mouse, *P.p. decoloratus*, disappeared from the Atlantic Coast about 50 years ago.

Beach mice live in some of the most beautiful and highly prized waterfront property along the coasts of Florida and Alabama, which is comprised of a mosaic of public and privately owned lands. This area is under increasing pressure for commercial and residential development, which has the potential to negatively impact beach mice populations through habitat loss and fragmentation, increased human-related mortality, and increased vulnerability to the impacts of hurricanes. The loss of high elevation habitat to development may reduce refugia for mice during hurricanes, driving populations smaller and increasing their vulnerability to other threats such as domestic cats. Local extinctions have been observed throughout the range of all beach mouse subspecies; several extirpated populations on public lands have been reestablished through translocation efforts.

Captive Management Feasibility Workshop

The Fish and Wildlife Service employs a variety of management actions for beach mice, from habitat conservation and restoration to translocation and reintroduction into unoccupied habitat. Given the projected high risk of extinction of at least some subspecies under current conditions, the Service approached the Conservation Breeding Specialist Group (CBSG) of the Species Survival Commission of the IUCN – World Conservation Union to design and facilitate a workshop to explore the feasibility of and options for developing a captive management program for beach mice subspecies. In preparation for this discussion, workshop participants were provided with an extensive volume of briefing material (about 1100 pages), which was distributed electronically to participants two weeks prior to the workshop. All literature cited in this workshop report is available from the FWS Panama City Field Office upon request.

The three-day workshop was held 7 – 9 March 2007 at Topsail Hill Preserve State Park and was attended by 18 participants, including FWS staff from several state and regional offices as well as external experts from other government agencies, universities, research facilities, and zoos. After welcoming remarks and introductions, the first morning was spent in plenary presentations providing an overview of the status of beach mouse populations, observed impacts of hurricanes on mice and their habitat, summaries of previous population viability analyses (PVAs), and an overview of previous translocation efforts. In the afternoon CBSG led the group through a discussion of the status, threats and population goals for each beach mouse subspecies, followed by an exploration of how various captive management options might be able to reduce these threats. This led to the following list of potential roles that captive populations might play in beach mouse conservation:

1. Provide an insurance policy against subspecies extinction.
2. Provide a source population for reintroduction into new habitat or habitat from which beach mouse populations have been extirpated.
3. Provide a source for demographic supplementation of small populations.
4. Provide a source for genetic supplementation of small (inbred) populations.
5. Preserve a genetic reservoir to guard against sudden population bottlenecks.
6. Preserve unique genetic lines to guard against loss of local genetically distinct populations.
7. Serve as ambassadors through education outreach to reduce threats associated with human activities.
8. Provide research opportunities to gain knowledge of the species and to improve the effectiveness of management actions.

Recognizing the potential benefits of captive management, participants began further exploration of this topic on Day 2 with several plenary presentations outlining captive management issues, including potential inbreeding effects and adaptation to captivity. The Key Largo wood rat breeding and reintroduction program was also reviewed for lessons learned that might be applicable. A plenary discussion enabled participants to brainstorm and categorize different options regarding captive management. These were grouped into short-term versus long-term strategies and were further addressed by two working groups. Working groups spent the afternoon defining captive management strategies and outlining the following for each: 1) roles and benefits of each strategy; 2) risks; 3) challenges/obstacles; 4) knowledge/data gaps; and 5) resources needed. At the end of the day each group made a brief report in plenary to describe the strategies addressed by the group (resulting in three short-term strategies and six long-term strategies).

Plenary presentations on Day 3 allowed the two working groups to describe their analyses in detail, which included general discussion, clarification and revision. The benefits, risks, and feasibility of using cryopreservation and assisted reproduction techniques for beach mice was also discussed, as well as a similar analysis for managing beach mice in the absence of any captive component. The working groups reconvened to outline general pros and cons of their strategies, prioritized these strategies (including the No Captive Component option), and made subspecies-specific recommendations regarding captive strategies. These analyses and recommendations were reported and discussed in plenary before conclusion of the workshop and are summarized below.

Working Group Summaries

The *Short-Term Management Strategies Working Group* explored all of the various short-term (temporary) captive management options for beach mice, resulting in the description of three different management approaches (in order of potential conservation benefit):

1. <u>Seasonal Holding</u>: Holding program in which mice are captured on *an annual basis* in anticipation of possible catastrophes (e.g., hurricanes or extremely low summer numbers).

Mice would not be bred and would be released if no catastrophe occurred. If a catastrophe occurs, these mice would be used to initiate a long-term breeding program.

2. Rescue/Emergency: Capture and holding of mice *immediately before* an anticipated catastrophe or when population numbers are low or face high risk of extinction. Similar to seasonal holding, mice would not be bred and would be released if feasible. If catastrophe events prevent release, this would evolve into a long-term breeding program.

3. Short-Term Colony: Planned, structured approach in which mice would be captured, held and bred *in anticipation of an upcoming reintroduction opportunity*. This approach would entail an established end date and might be used to offset some of the impacts from large developments and beach nourishment projects.

After discussing the benefits, risks, challenges, data gaps, and resources needed for all three strategies, and comparing the relative pros and cons for each as well as the option of no captive program, the working group recommended the same short-term strategy for all beach mouse subspecies: to evaluate the need for a rescue response and develop rescue plans as appropriate for implementation in the event of impending hurricanes and other foreseeable catastrophes expected to significantly impact or decimate beach mouse populations. Other short-term strategies were thought to be too costly or risky compared to their anticipated benefits and were not recommended for implementation (see Section 3 for details). For these reasons, the group preferred *in situ* (in the wild) management over development of a seasonal holding (1# above) or short-term colony (#3 above) strategy.

After brainstorming and discussing management ideas, the *Long-Term Management Strategies Working Group* categorized long-term captive programs into six different approaches (in order of potential conservation benefit to beach mice):

1. Supplementation Colony: Breeding population maintained in a semi-natural setting, likely managed with periodic transfers to and from the wild population. Used to *supplement declining wild populations* and possibly for outreach.

2. Traditional Colony: Large breeding population of mice in a controlled laboratory environment. Would be intensively *managed to retain genetic diversity*, either as a closed colony (no exchange with the wild) or open colony (periodic exchange with the wild or other captive populations).

3. Semi-Natural Enclosure: Breeding population in a semi-natural enclosure in an attempt to mimic the natural environment as close as possible to *minimize adaptation to captivity*. May be managed fairly rigorously, or with a more hands-off approach, and carefully monitored.

4. Experimental Population: Breeding population placed in unoccupied habitat outside the current range. Would provide *invaluable research opportunities* and potentially could be used for reintroduction. More likely used for less threatened subspecies, as the removal of mice is less likely to negatively affect the donor population.

5. Long-Term Holding: Population established as a *protective measure* in the face of an impending natural disaster (e.g., hurricane) or human-related threat (e.g., extensive development) that may destroy known habitat. Mice could be held up to 2 years, and would be released when suitable habitat is again available. May be used for outreach.

6. Education / Exhibit: Ambassador mice to be used in *public outreach programs*, particularly in zoological institutions. Comprised of mice of non-endangered subspecies or surplus animals from other programs. Facilities could also be used as an emergency resource for holding rescued mice prior to and following a catastrophic event.

The working group spent considerable time discussing the benefits, risks, challenges, data gaps, and resources needed for each strategy. Pros and cons for each approach were compared, both to each other and to the option of having no captive program.

The working group recommended differing long-term captive strategies for each subspecies of beach mouse; these progressed along a continuum depending upon the status of the wild population. For the most endangered subspecies – the Perdido Key, Choctawhatchee and Alabama beach mice – the establishment of a supplemental or semi-natural colony may be desirable but only if the wild population can withstand the removal of individuals to establish a captive population. Such removals might need to be opportunistic (e.g., rescued mice that cannot be returned to the wild). For less threatened subspecies, supplemental colonies, traditional laboratory colonies, and/or semi-natural colonies were recommended in varying degrees and combinations to provide backup secure populations and maximize research opportunities (see Section 4 for details).

Feasibility Analysis

The purpose of this workshop was to explore the potential usefulness and feasibility of utilizing captive management as an additional management tool to promote viable wild populations of beach mice and to minimize the risk of subspecies extinction. While captive management options have the potential to contribute to beach mouse preservation, this approach is not without risks or costs. The task of the workshop participants was to explore the relative pros and cons of various captive management strategies to aid in determining the feasibility and cost-effectiveness of this approach.

Although we did not attempt to reach a consensus regarding the use of captive management strategies for beach mice, the workshop participants were able to provide a detailed analysis of captive options. Management feasibility recommendations were made within the two working groups, which can be used by FWS and others to further explore these options. Workshop participants were also invited to provide individual perspectives and recommendations anonymously, which are included in Appendix II of this report.

Participants recognized that *in situ* (in the wild) conservation efforts are critical to endangered species such as the beach mouse, including minimizing habitat loss and fragmentation, reducing threats and their impacts on mouse populations and habitat, and using management strategies such as habitat restoration and translocation when appropriate. These *in situ* management actions were not addressed by this meeting, which focused solely on captive options. This does not imply that they are not considered important to beach mouse management or should not be implemented. Furthermore, any recommendations for captive management do not imply that these strategies should replace *in situ* conservation efforts, but rather should be viewed as an additional potential management tool.

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SECTION 2

Population Status, Goals and the Role of Captive Management

Plenary Discussion of Population Goals and Captive Management

Plenary Discussion: All workshop participants (facilitated by CBSG).

Captive management is one tool available to wildlife managers to improve population viability and lower the risk of extinction for threatened taxa. Before engaging in a thorough analysis of options for and feasibility of a captive management program for beach mice, it was important to identify the potential role(s) that captive management can play in conservation of this species. This in turn required a discussion of population goals as well as a review of the status of each subspecies and the threats that they face that impede the realization of those goals. The plenary discussion of these issues laid the framework in which the potential role of captive management could then be considered.

Overview of Population Goals

Recovery plans for beach mice only exist for a few subspecies, and most are in need of revision. The discussion of recovery goals for beach mice is ongoing. Workshop participants discussed past and new draft recovery goals under consideration as well as perspectives on what should be considered as recovery goals. Although there are some subspecific differences, several general themes were identified as common to the recovery of beach mice populations.

Viable Metapopulation

Many participants agreed that recovery goals should include multiple, viable populations spread across the geographic range (for each subspecies), with some level of connectivity among populations (if possible). Multiple populations across multiple locations provide security against the loss of a single population and promote retention of genetic variation. Further refinement and quantification of recovery goals will be necessary – for example, defining a *viable* population, possibly in terms of a minimum population size over a minimum habitat area. Measuring viability in terms of numbers is problematic for beach mice, given the widely fluctuating population size for this species. Participants suggested that a viable population is one that is self-sustaining, genetically diverse, of sufficient size to minimize risk due to stochastic processes, has an age structure with a variety of age classes that allows potential for growth, has access to refugia habitat, and has a low risk of extinction.

If recovery goals recommend multiple populations within a metapopulation framework, the term *population* likewise needs to be clarified. What constitutes a single population? At what point are two populations with a low level of connectivity considered to be a single population? If a minimum number of populations are recommended for recovery, what are the implications in terms of meeting recovery goals if two populations are connected to form one larger population?

There was some discussion regarding the number of target populations for each subspecies. Will recovery goals be driven by the current situation, by what is deemed achievable, or by what is needed to secure the viability of the subspecies? A guiding premise may be to at least preserve the current situation and allow no further substantial loss of mice or habitat. In some cases, some connectivity among populations is possible, in other cases it is not. Connectivity would allow for the natural recolonization of extirpated areas without management through translocation or reintroduction. The ultimate goal would be to have self-sustaining populations in the wild.

In addition to discussing common goals across beach mice subspecies, participants summarized current discussions surrounding population recovery goals for each subspecies, as listed below and in Table 1.

Alabama Beach Mouse (ABM)
- Multiple (2-3) viable populations spread throughout range (with some connectivity)
- Include time period (one for downlisting, another for delisting)
- No recommendations at this time for minimum area of habitat
- Dilemma of reconnecting currently isolated subpopulations to form one large metapopulation, therefore resulting in fewer total distinct populations

Perdido Key Beach Mouse (PKBM)
- Same as for the ABM
- At least 3 populations
- Maintaining connectivity is a goal
- Not sure if there are achievable goals that are acceptable in terms of risk

Santa Rosa Beach Mouse (SRBM)
- No existing recovery goals (not federally listed)

Choctawhatchee Beach Mouse (CHBM)
- Multiple (5) populations
- Connectivity unlikely
- Reduce risk to populations

St. Andrews Beach Mouse (SABM)
- Multiple (3-4) populations, stable or increasing for 10 years
- Partial connectivity (maintain existing connectivity)

Anastasia Island Key Beach Mouse (AIBM)
- Multiple (3) viable populations on protected land
- Use translocation to repopulate in case of local extinction

Southeastern Beach Mouse (SEBM)
- Maintain in historic range (beyond current range)
- Habitat restoration
- Reduce threats to population

This discussion of population goals provided a basis from which to examine the current status of each beach mouse subspecies and the general and specific threats that may reduce population viability and increase the risk of extinction. Table 1 summarizes the primary points of this discussion for each subspecies.

Table 1. Status of wild beach mouse populations by subspecies (ordered from west to east).

Common name	Rank (at risk)	Status[a]	Est. # mice[b]	Est. # pops	Habitat	Genetic uniqueness	Population trends	Primary threats	Population goals
Alabama beach mouse *P.p. ammobates*	2-3	E	Few thousands	2	1000ac occupied 2450ac total	More closely related to SRBM	Decline due to habitat loss (development)	Hurricanes, cats, high predator density, habitat loss (development), recreational use on public lands (habitat degradation), mosaic of land management designations and authorities (lack of cooperation)	Multiple (3) viable populations throughout range (self-sustaining metapopulation)
Perdido Key beach mouse *P.p. trissyllepsis*	1	E	Few hundreds	2	1300ac	Most gene flow from inland oldfield mice	Decline due to habitat loss (development)	Hurricanes (especially vulnerable), cats, high predator density, habitat loss (development), inbreeding, recreational use on public lands (habitat degradation), bad PR, mosaic of land mgmt designations and authorities (lack of cooperation)	Multiple (minimum of 3) viable populations throughout range, no loss of current populations; maintain connectivity (self-sustaining metapopulation)
Santa Rosa beach mouse *P.p. leucocephalus*	7	Not listed	Thousands	4	More	More closely related to ABM	Recent decline due to habitat loss (hurricanes)	Hurricanes, cats, high predator density, habitat loss (development), recreational use on public lands (habitat degradation), proposed transportation and nourishment projects (habitat loss and degradation)	Reduction of threats; maintain 4 core population units (no current recovery goals, not listed), (self-sustaining metapopulation)
Choctawhatchee beach mouse *P.p. allophrys*	2-3	E	Hundreds	4	2400ac	Topsail unique within subspecies (mtDNA)	Was stable, but recent declines (uncertain future)	Hurricanes, cats, high predator density, habitat loss (development), inbreeding (site-specific – Topsail and Grayton), recreational use on public lands (habitat degradation)	5 populations Reduction of threats, (self-sustaining metapopulation)
St. Andrews beach mouse *P.p. peninsularis*	5	E	Few thousands	2	2500ac		Decline due to habitat loss (development)	Hurricanes, cats, high predator density, habitat loss, recreational use on public lands (habitat degradation), mosaic of land mgmt designations and authorities (lack of cooperation)	3-4 populations, maintain existing connectivity; no cats; reduce threats, (self-sustaining metapopulation)
Anastasia Island beach mouse *P.p. phasma*	4	E	Few thousands	3	??		Stable	Hurricanes, cats, high predator density, habitat loss (development), recreational use on public lands (habitat degradation)	3 viable populations (self-sustaining metapopulation)
Southeastern beach mouse *P.p. niveiventris*	6	T	Thousands	6[c]	Even more		Stable	Hurricanes (some areas not highly vulnerable), cats (varies by site), high predator density, habitat loss (succession due to lack of management), recreational use on public lands (habitat degradation); mosaic of land mgmt designations and authorities (lack of cooperation)	Maintain throughout historic range; reduce threats (self-sustaining metapopulation)

[a] *E = endangered, T = threatened;* [b] *general estimates for comparative purposes only;* [c] *partial connectivity*

Status and Threats to Beach Mice

Population and Habitat Estimates

Overview presentations followed by plenary discussions reviewed and compared the relative status and threats of beach mice subspecies. Estimating beach mouse numbers is problematic, not only due to censusing difficulties but also due to highly fluctuating population size, both seasonally and in response to events such as hurricanes. Table 1 gives some general "off the cuff" population estimates intended only as an overall factor in comparing relative risk; these numbers are not meant to reflect accurate estimates of subspecies population size. Likewise, other attributes such as number of populations, amount of habitat, and population trends are general statements based upon the collective expertise of the workshop participants.

Threats

Threats to beach mouse populations are similar across subspecies, although some subspecies are more vulnerable to hurricanes or under heavier development pressure. Primary threats identified by workshop participants include hurricanes, domestic cats (and other predators at unusually high densities), habitat loss (primarily due to development), habitat degradation (primarily due to recreational use on public lands), and difficulties arising from a mosaic of land management designations and authorities (mixture of private and public lands).

Hurricanes have the potential to quickly and severely impact beach mouse populations and habitat. All populations are susceptible to hurricane effects, but Perdido Key populations are especially vulnerable. Historical records suggest that hurricanes are likely to hit all beach mouse habitat areas, both on the Gulf and the Atlantic coasts, with about the same frequency. The impact of such storms varies based on storm characteristics (e.g., direction of approach, point of landfall) as well as habitat features, such as the width of habitat and availability of high elevation habitat. Humans cannot control the occurrence of hurricanes, but management actions are possible that would reduce impacts and also promote restoration of beach mouse populations and habitat. Current management includes contingency plans for dealing with the impacts of hurricanes on beach mice and their habitat (e.g., dune restoration, translocation), as well as to reduce threats that are under more direct management control (e.g., restricted dune access).

Often threats may interact to affect beach mice. For example, development may reduce high elevation areas available to beach mice, exacerbating the effects of hurricanes by reducing storm refugia. Development might also displace natural predators, resulting in high predator densities in the remaining adjacent habitat and increasing pressure on mouse populations. While beach mouse populations may normally be able to withstand substantial predation rates, small populations that have been reduced due to hurricanes, habitat loss or habitat degradation are more vulnerable to stochastic processes and may not be able to withstand substantial and continued loss of mice.

The primary threats identified by workshop participants negatively impact beach mouse populations through one of three mechanisms – either by reducing the number of mice directly, or by reducing mouse habitat (quantity) or the carrying capacity (quality) of that habitat. These mechanisms reduce population size, promote the loss of genetic variation, and can increase the risk of extinction of single populations, thereby threatening the persistence of a self-sustaining, viable metapopulation (Figure 1).

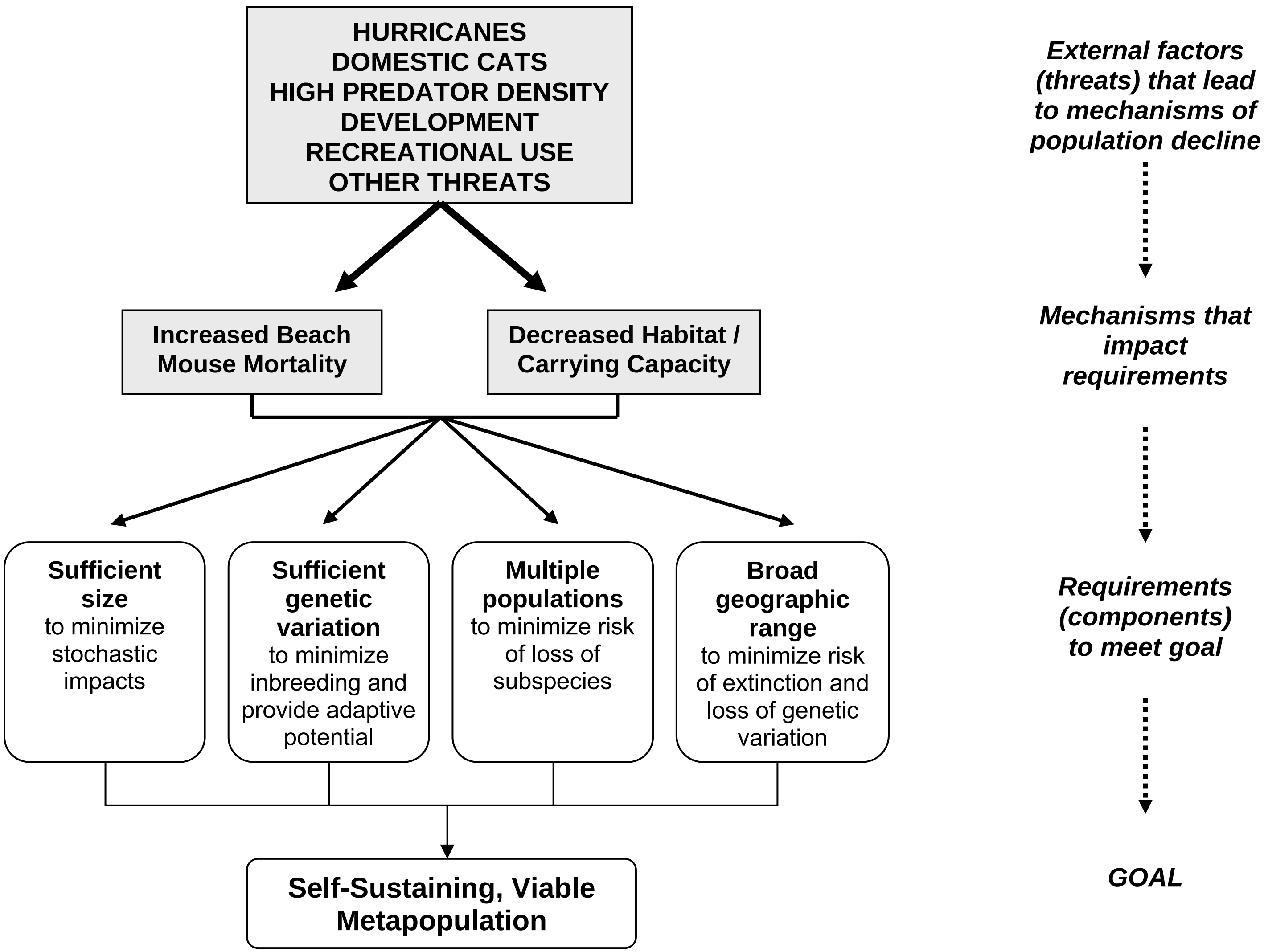

Figure 1. Flow diagram detailing factors that affect the goal of maintaining a self-sustaining, viable metapopulation of beach mice.

Status of Beach Mouse Subspecies

Five of the existing beach mouse subspecies are federally listed as endangered. The SEBM is listed as threatened, and while the SRBM is currently not federally listed, recent population decline has been observed due to habitat loss resulting from hurricanes. Each of the two working groups considered all of the population, habitat and threat information tabulated for the seven beach mouse subspecies presented in Table 1, and ranked the subspecies according to level of risk of extinction. Group rankings agreed except for slight differences in the ranking of ABM and CHBM as 2 or 3. There was agreement that the PKBM is most at risk, while the SEBM and SRBM populations are least vulnerable.

Comparison of relative risk levels among the subspecies was useful to the participants in considering potential management options. Subspecies most at risk may be targeted for management strategies to reduce risk, while at the same time may be most vulnerable to management strategies that hold inherent risks in their implementation. These factors were considered by the working groups when evaluating captive management options for beach mouse subspecies.

Role of Captive Management

Figure 1 demonstrates how external factors such as hurricanes or development can lead to the direct loss of mice or their habitat, ultimately affecting population and thus metapopulation viability. In order to achieve and maintain the goal of a self-sustaining, viable metapopulation, there are a number of intervention points at which management action can be taken. Threats themselves can be reduced (e.g., the removal of domestic cats from beach mouse habitat). Another option is to address the mechanism through which threats impact population viability – for example, supplemental feeding and habitat restoration following storms to improve beach mouse survival and regain carrying capacity. A third approach is to promote the required components of metapopulation viability. To some extent, this approach is more reactive rather than proactive, in an attempt to reverse the impacts of threats rather than remove or ameliorate them. Current beach mouse management includes a suite of strategies that encompass all three approaches, as appropriate to the nature of each threat and its impacts.

Workshop participants were asked to consider these aspects of beach mouse population viability and to suggest how captive beach mouse populations may be able to contribute to subspecies persistence and metapopulation viability. This was a necessary step to determine whether or not captive management has a potential role in beach mouse conservation.

Participants suggested that captive populations have the potential to:

1. ***Provide an insurance policy against subspecies extinction.***
   Preservation of individuals in captivity helps insure against the loss of subspecies due to catastrophic events.

2. ***Provide a source population for reintroduction into new habitat or habitat from which beach mouse populations have been extirpated.***
   All populations of beach mice are highly fragmented. Captive animals may be used to reintroduce beach mice to areas in the event that local populations are extirpated, or new habitat becomes available.

3. ***Provide a source for demographic supplementation of small populations.***
   Captive animals could be used to supplement existing populations that are in decline.

4. ***Provide a source for genetic supplementation of small (inbred) populations.***
   Production of animals in a captive colony could be used to augment the genetic diversity of a population. Animals that possess genetic material not present in a wild population could be introduced to the population.

5. ***Preserve a genetic reservoir to guard against sudden population bottlenecks.***
   Genetic bottlenecks due to stochastic events can be corrected by introducing animals of diverse genetic lineages to restore the genetic variation that is lost during bottlenecks.

6. ***Preserve unique genetic lines to guard against loss of local genetically distinct populations.***
   The loss of unique genetic lines may occur through a catastrophic event such as a hurricane. The preservation of these lines in a captive colony would insure their persistence and provide a genetic bank for future reintroduction.

7. ***Serve as ambassadors through education outreach.***
   Captive animals in zoos or other public displays may garner support for their conservation.

8. ***Provide research opportunities to gain knowledge of the species and to improve the effectiveness of management actions.***
   There are several gaps in knowledge regarding basic beach mouse biology. Some of these gaps could best be addressed in a captive setting.

In general, these roles provide backup options to address population viability directly (e.g., by restoring mouse numbers or genetic variation) when particularly vulnerable rather than act to reduce threats to beach mice. Education outreach (#7) does address human behaviors that threaten mouse populations and has substantially different captive mouse requirements than the other roles to be effective. Research (#8) also differs from other roles, in that it has the potential to improve the effectiveness of Roles 1-6 (e.g., evaluating success of reintroduction of captive-born mice) as well as other management strategies not involving captive management (e.g., developing effective capture, translocation and release protocols).

This analysis of status, threats and potential captive management roles suggests that: 1) beach mouse populations are at risk due to a variety of interrelating factors and mechanisms; and 2) captive beach mouse populations have the potential to improve beach mouse population viability and lower risk of extinction. Captive management, however, is not without its own risks, directly or indirectly, to beach mouse populations. These options are also not without costs in funds, manpower and other resources, and in some instances may compete against other management strategies for limited resources. Finally, although captive populations have the potential to support wild beach mouse populations, it is uncertain how effectively this potential can be realized. For these reasons, it is necessary to further analyze the impacts of captive management beyond the identification of potential roles of this strategy. The next step in the process, therefore, was to explore more specifically the nature of captive management programs, the potential benefits and risks of each, and the logistical and financial feasibility of these options.

Captive Management Options

Beach mouse management involves a myriad of concurrent approaches and actions to address the variety of threats to metapopulation viability. These include habitat management, control of invasive species, and regulatory issues as well as population management. This workshop dealt only with the use of captive management (*ex situ* populations) as a population management tool. In this context, captive management does not imply the reduction of conservation efforts in other areas of beach mouse management, nor that other management strategies are less valuable. Rather, this discussion explored the feasibility to developing captive management programs in addition to other conservation efforts for these subspecies.

Short- and Long-Term Strategies

A plenary discussion was held to brainstorm and categorize types and attributes of captive management programs, including issues such as the captive environment, location, breeding strategy, length of time in captivity, and other factors. These options were loosely grouped into short-term and long-term management strategies, with short-term strategies involving temporary captive mice populations, usually maintained for less than one year. Workshop participants divided into two working groups to continue the benefit-cost analysis of management options within smaller discussion groups. Each group gave reports back to all participants in plenary for comment, discussion and revision. The analyses and recommendations of the two working groups are presented in Sections 3 and 4.

In Situ Management Only

Participants recognized that an additional option is to continue beach mouse management without any additional captive population component (i.e., managing mice exclusively in the wild, or *in situ*). This may be a viable option, particularly if captive management options carry substantial risks and/or are too costly with respect to the benefits that they may provide. In this instance, population management could still be addressed through translocation efforts that use wild mice from one population to augment another or provide animals for reintroduction into unoccupied habitat. A plenary discussion resulted in the following list of benefits and risks associated with this option.

<u>Benefits of having no captive program</u>

- Existing programs are less vulnerable to being cut from the budget. Conservation focus will remain on habitat versus a potential shift of funds to captive programs. This is true not just for beach mice but for the entire conservation budget that includes other species at risk.
- There is no threat of adaptation to captivity, either behaviorally or physiologically.
- There are fewer unknowns, so efforts are potentially less likely to fail.
- This approach offers administrative/bureaucratic simplicity.
- Valuable funds are not spent in anticipation of catastrophic events that do not materialize.

<u>Risks of having no captive program</u>

- Limits options to prevent subspecies extinction. Although captive management does not guarantee subspecies persistence, it reduces extinction risk by providing a “safety net” against extinction in the wild.

- Limits options to counteract significant loss of gene diversity or population bottlenecks (translocation provides some opportunities if secure wild populations remain).
- More vulnerable to challenges by the public or others for not pursuing all necessary options to ensure subspecies persistence.
- Risk of disease transmission during translocation efforts (both intraspecific and zoonotic), proportional to the level of animal movement
- Limits options for public relations, outreach, and research (e.g., does not take advantage of functionally "dead" animals that will be lost due to planned habitat loss or degradation)

Working groups were asked to include the "No Captive Program" option in their analysis of pros and cons, strategy prioritization, and recommendations within their target strategies.

General Conclusions

A significant part of this feasibility analysis is to estimate the costs and potential risks of pursing captive beach mouse population management and to weigh those factors against the potential benefits to beach mouse population viability and persistence. As part of this process working group participants made best guess estimates of program costs, presented in Table 2 and also detailed in the working group reports in Sections 3 and 4. These estimates were useful within the workshop context; however, they should not be taken as accurate estimates. More thorough investigation is needed before costs can be accurately estimated for further planning.

Each working group compared their targeted management options and made general recommendations within those options for each subspecies (see Sections 3 and 4). The *Short-Term Management Strategies Working Group* recommended the same short-term strategy for all beach mouse subspecies: to develop and execute emergency rescue plans in the event of impeding hurricanes and other foreseeable catastrophes expected to significantly impact or exterminate beach mouse populations. Other short-term strategies were thought to be too costly or risky compared to their anticipated benefits and were not recommended for implementation.

The *Long-Term Management Strategies Working Group* recommended differing long-term captive strategies for beach mice; these progressed along a continuum depending upon the status of the wild population. For the most endangered subspecies – the Perdido Key, Choctawhatchee and Alabama beach mice – the establishment of a supplemental or semi-natural colony may be desirable but only if the wild population can withstand the removal of individuals to establish a captive population. Such removals might need to be opportunistic (e.g., rescued mice that cannot be returned to the wild). For less threatened subspecies, supplemental colonies, traditional laboratory colonies, and/or semi-natural colonies are recommended in varying degrees and combinations to provide backup secure populations and maximize research opportunities.

No general conclusions or recommendations were made by the workshop participants as a whole. However, participants were invited to provide their individual perspectives anonymously regarding the feasibility and appropriateness of captive management for beach mouse subspecies. These viewpoints are provided in Appendix II.

Table 2. Rough estimates of relative costs of various captive management strategies (for comparable purposes only).

Strategy	Set Up	Equipment/ Materials	Facility	Operating Costs / Yr	Monitoring/ Research	Genetic Screening	Field	Comments
Seasonal Holding		$20,000	$21,000		Yes; $100,000 to $300,000/yr			
Rescue/Emergency		$20,000			Yes; $100,000 to $300,000/yr			Facility costs may be donated
Short-Term Colony								Potentially funded by permittee
Supplementation Colony	Investor	Investor		$20,000		$15,000	$30,000	Investment by others, field component, genetics
Traditional Colony	$25,000		Yes	$41,000		$5,000		
Semi-Natural Enclosure	$20,000 (incl. labor)	< $10,000		$30,000	Yes			
Experimental Population				$20,000	Yes			Depends on Project Habitat management
Long-Term Holding	$12,000		Yes	$41,000		$5,000		
Exhibit/Educational	$10,000							Interpretative materials

Beach Mouse Captive Population Feasibility Workshop

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Final Report

SECTION 3

Short-Term Management Strategies Working Group Report

Short-Term Management Strategies Working Group Report

Members: Jim Austin, Carl Couret, Annie Dziergowski, Bill Lynn, Sandra Sneckenberger, Rob Tawes, Aaron Valenta, Jeff Van Zant.

Tasks assumed by this working group included: identification of potential short-term captive program strategies; development of full descriptions of these strategies; discussion of each strategy's associated risks, costs, and challenges; analysis of whether each strategy would address the eight purposes of a captive program identified in the plenary session; and ranking of the strategies for each beach mouse subspecies.

Short-Term Strategy Definitions

The group considered the following short-term strategies discussed in plenary sessions: 1) targeted translocation; 2) rescue/emergency holding; 3) seasonal holding/breeding; and 4) head start program. A fifth option (short-term colony) was added during the break-out session. Targeted translocation (removal, holding and breeding of mice in anticipation of translocation) was considered a part of short-term colony and rescue/emergency strategies and was removed, resulting in the following four strategies:

- Headstart strategy: This is a breeding program designed to increase juvenile survival rates. Mice would be raised until they are juveniles or subadults and then released. This is similar to approaches employed with Massasauga rattlesnakes, freshwater mussels, and sea turtles.

- Seasonal holding strategy: This is primarily a holding program in which mice are captured on an annual basis in anticipation of possible catastrophes (e.g., hurricanes or extremely low summer population numbers). Mice would not be bred and would be released following hurricane season (or in the fall) if no catastrophe occurred. If a catastrophe occurs, seasonally-held mice would be used to initiate a long-term breeding strategy. Considerable planning prior to and during implementation of this strategy would allow for careful forethought on demographic and genetic diversity requirements in case a long-term colony would need to be established from these mice.

- Rescue/emergency program: This involves the capture and holding of mice immediately before an anticipated catastrophe or when monitoring efforts demonstrate that their situation is dire. Similar to the seasonal holding strategy, this approach does not involve breeding, but would rapidly turn into a long-term breeding strategy if the catastrophe occurs. However, unlike the seasonal holding strategy, as this program is initiated immediately before a catastrophe or when populations are low (or otherwise facing an immediate high risk), careful planning and systematic selection of individuals with desired genetic or demographic characteristics may not be possible.

- Short-term colony: This strategy involves a planned, structured approach in which mice would be captured from the wild, and both held and bred in anticipation of an upcoming reintroduction opportunity. This strategy differs from long-term strategies because each colony would have an established ending date. Such short-term colonies could be useful in increasing mouse numbers for discrete introduction opportunities or planned reintroductions.

The strategies were prioritized in terms of contribution to beach mouse viability as follows (using the paired-ranking method), due to the reasoning provided:

1. Seasonal holding strategy:
   This strategy was considered especially important as hurricane "insurance" or to attenuate summertime population reductions.

2. Rescue/emergency:
   This strategy was considered particularly applicable; potentially used prior to large threatening hurricanes, but also used for other threats, such as newly established feral cat colonies.

3. Short-term colony:
   This strategy may be used to offset some of the impacts to beach mice resulting from large developments and beach nourishment projects, and could possibly be financed by project applicants or development interests.

4. Headstart strategy:
   This strategy was later eliminated, as it is typically employed with species that have numerous offspring, very high rates of juvenile mortality, and little or no parental investment. It is uncertain whether juvenile beach mice are at a disproportionate risk, and "collection" of pups may prove logistically difficult or destructive.

Preliminary Analysis of Short-Term Strategies

The risks, costs, challenges, and logistical details of each short-term strategy were discussed. An analysis of each strategy with respect to the purposes of captive management identified in the plenary session was also conducted (Table 3). An additional purpose – to maintain population levels over the summer – was added by this working group.

Seasonal Holding Strategy

Purposes

The extent to which the Seasonal Holding Strategy addresses the identified purposes of a captive program is summarized in Table 3. The group believed that research is an important component of any holding/breeding strategy. Also, this strategy (and others) would not fully address outreach/ education purposes since any display situation best suited for viewing by the public would likely be stressful to the mice and may negatively impact reproduction. However, we could inform the public about the program, and perhaps let the public view the mice through the use of video and photographs. Press releases to inform the public would be possible with any strategy.

Risks

- Unique genotypes/ rare alleles may be missed when animals are collected for program, though measures would be taken to lessen this risk.
- The natural population is impacted as individuals are removed.
- Individuals collected may not survive being released back into the wild population.
- Diseases may be introduced or transferred into the population by the seasonally held mice.

- There is the risk of genetic swamping upon re-release (more of an issue for breeding populations).

Challenges/Obstacles/Knowledge Gaps

- Funding: This strategy would likely be financed by state and federal resource agencies and their partners.
- Access to trapping sites (for collection); land managers do not wish to place their population at risk and access to private lands is tenuous.
- Establishing partners
- Availability of release sites: What if we do not have a place to put the captive mice (i.e., unwilling public and private land managers/owners, habitat already occupied) at the end of the holding period?
- Concern that public/media/regulators will see this as a panacea (i.e., feel that loss of native habitat is permissible because we can protect beach mice from hurricanes through this strategy).
- Can we successfully release back into wild? (see Van Zant and Wooten 2003)
- Species status: We need to know more about the status of each subspecies, the genetic diversity within and among populations, and their habitat before considering any strategy.
- Knowing how to release the mice properly (e.g., hard release, soft release, semi-soft release?)
- Determining the best method to mark/identify mice (pit tags, ear notching, and toe-clipping)
- Knowledge gap: Do mouse populations decrease over summer or are mice just less active (estivate)?
- We have some evidence, but do the majority of mice flee storms or do certain individuals more or less survive by chance?
- Unknown risks of this strategy to donor populations. Individuals collected for holding would not be a part of the natural population for many months. To what extent would this impact the remaining mice? Does the donor population fill back in? What implications would this have for genetic diversity and population levels?
- Habitat suitability assessment should be conducted prior to reintroduction.
- This strategy requires long-term commitment and, although conducted for a shorter time period, it is conducted annually, and therefore would likely be more expensive over the long term.

Details

- If mice are collected and held annually, during many years (those without hurricanes), the effort and cost for the program will show little or no benefit. The public may view these unnecessary trapping cycles as a waste of taxpayer dollars, and by using these funds for this annual effort they would not be available for other equally important tasks/species.
- When should we collect mice? April may be the best time to collect animals because population levels are high, and then decline from that point through the summer. If we collected in preparation for the most active part of the hurricane season, we would hold mice from about August 1 through November 1. Trapping of Alabama beach mice, however, have occasionally shown population peaks in summer. Also see knowledge gap concerning summer trapping.

- When do we release the mice? Can the habitat support the held mice in November? Would it be better to wait until early spring?
- How many do we collect? For maximum genetic diversity, between 20-50 individuals were suggested. Since some may not breed, 50-60 animals might be better in case the storm really does hit. Captures could be spread out along several weeks to minimize impact to the subspecies. Knowledge of genetic variation and current population estimates would assist in this determination.
- If there is little population variation, then fewer individuals would need to be collected. If there is great variation or we do not know, we may need to have representation from all subpopulations.
- As with any approach, we would need to develop a solid, science-based plan before we begin.
- The seasonal approach could become an annual reintroduction experiment that produces a lot of information. Because this is primarily a holding program, research opportunities would focus more on reintroduction success and possibly some genetic work.
- The seasonal short-term strategy could quickly become a long-term strategy if a hurricane made landfall and resulted in catastrophic loss of habitat. Any seasonal plan would have to account for this contingency (i.e., a long-term strategy would also have to be in place).

<u>Costs</u>
$5,000 for traps and manpower
$5,000 for containers and water bottles (during holding phase)
$10,000 for ATV
$21,000 for captive facility

The costs and scope of research was discussed extensively. Would this involve USGS, graduate students or consultants? Possible research topics could include how and where to release, monitoring following release (transmitters and tags), data synthesis, genetics, etc. It was decided that genetic research should be conducted before and after capture of mice.

We estimate that the Seasonal Holding Strategy would cost from $192,000 - $292,000, including research, and this would be an annually recurring cost. Many of items (e.g., traps and ATV) might already be available from partners. In order to minimize the cost of disease testing, we would treat all wild mice as though they were diseased.

Rescue/Emergency Strategy

<u>Purposes</u>
The extent to which the Rescue/Emergency Strategy addresses the identified purposes of a captive program is summarized in Table 3. This strategy would only conditionally meet listed purposes since this strategy is initiated by an event, and mice held would ultimately be integrated into a long-term strategy if the event initiating the rescue actually occurred. For example, captive mice would serve as a source of genetic supplementation, a genetic reservoir, or provide distinct genetic lineages only if the variation within animals collected was representative of the entire population, and if the event initiating the rescue actually happened. Outreach/education goals could possibly be met, depending on the length of time the animals were in captivity and other issues listed in the preceding seasonal approach.

Risks

- Unique genotypes/ rare alleles may be missed when animals are collected for program (presents a higher risk here than for the Seasonal Holding Strategy, as collection will likely be more haphazard or constrained by access and time).
- The natural population is impacted as individuals are removed.
- Individuals collected may not survive if the anticipated event does not occur if they are unable to re-assimilate into the wild population.
- Diseases may be introduced or transferred into the population by the captured and held mice.
- There is the risk of genetic swamping upon re-release (more of an issue for breeding/long-term populations).

Challenges/Obstacles/Knowledge Gaps

Refer to the Seasonal Holding Strategy, as the same issues also apply to the Rescue/Emergency Strategy. In addition:

- Mice may be better off left in the wild to contribute to the population after the event.
- Lack of release sites may be less of a problem since mice will be held for a short time period. If the event occurs, however, and mice are held long-term, release sites may be an issue.
- Higher risk of missing genotypes (through frantic collections prior to emergency).
- Inherent risks to trappers
- Timing: If the storm is 3 days out, for example, it could hit a number of locations. The subspecies that is most at risk may not be known until the storm is closer, and then it might be too late to initiate a comprehensive trapping effort.
- Where will the mice be held and how do we get them there? We would have to have a solid plan in place, with all details and approvals worked out beforehand, as this plan may be implemented during a hectic time.
- Knowledge gap regarding details on beach mouse response to a hurricane. Do mice flee from the dunes into the scrub when a hurricane approaches, or is it that only those mice already inhabiting the scrub are the ones that survive the storm?

Details

This strategy would be used only in the direst of situations with “the big one” on the horizon. A detailed plan and collection/holding protocol needs to be in place before initiating this strategy. This strategy in entirety could be logistically difficult because beach access might be blocked, and in the event of a large hurricane, mandatory evacuations may be issued (all lanes directed away from the coast). Balancing the competing priorities of human and beach mouse needs during an evacuation may also be problematic, and it may be difficult to obtain authorization to carry out such a task. Group members discussed the fact that while the strategy may never be implemented, having such a contingency plan is crucial, especially for the most vulnerable subspecies. This strategy could be used for non-hurricane emergencies, such as a feral cat population explosion. There is less risk of surplus mice (than in seasonal strategy) because mice are not held as long (unless the storm does hit).

The circumstances under which such a plan would be implemented should be discussed in great detail. Ideally, the plan should be based on the vulnerability of the subspecies, the availability of high-elevation habitat, predicted storm category, and similar factors. It may be helpful to set factors and look back at how many times we would have collected mice in previous years.

Costs
Costs are very similar to the Seasonal Holding Strategy, but slightly less because mice would typically be held for less time and a holding site could possibly be donated from a partner.

$5,000 for traps and manpower
$5,000 for containers and water bottles (during holding phase)
$10,000 for ATV (could be used for other activities, or provided by another agency)
$1,000 for development of management plan
Captive facility (donated?)

Costs would be much less ($21,000 estimated) than the Seasonal Holding Strategy. Similarly, if a storm really does hit this would transition into a long-term strategy.

Short-Term Colony Strategy

Purposes
The extent to which the Short-Term Colony Strategy addresses the identified purposes of a captive program is summarized in Table 3. This strategy would meet nearly all listed purposes of a captive program, and would meet all purposes if the colony were held over the summer.

Risks
The risks are similar to the previous two approaches and also include:
- Impacts to wild populations
- Missing rare alleles or unique genetic lines during capture for the captive population.
- Mice may have to be kept longer than expected (e.g., it takes longer than expected to remove threats from a reintroduction site). In other words, any short-term strategy could quickly become a long-term strategy.
- Limited resources for listed species conservation would be used unnecessarily – these could be used for coastal conservation, land acquisition, and conservation of other rare species.

Challenges/Obstacles/Knowledge Gaps
Many of the concerns, challenges, and data gaps addressed in the previous strategies are applicable to the Short-Term Colony Strategy as well. There are fewer capture and release site concerns since such projects would involve considerable planning and releases would occur into previously identified unoccupied habitat. This strategy would have many of the same challenges, obstacles, and knowledge gaps as a long-term strategy (i.e., behavioral changes in mice, carrying capacity of habitat). As with all strategies, there is concern that short-term colonies could be viewed as a cure-all by the public, regulators, or politicians and take attention away from the importance of habitat conservation. Securing funding for this strategy is an obstacle unless it is tied into a mitigation measure.

Details
This strategy is similar to the previous two strategies but also incorporates breeding in its initial stages. A short-term colony might also arise from seasonal holding and rescue/emergency populations, if a natural disaster or other threat really does occur. However, it would mainly be used for anticipated discrete events. This may be a useful option if a threat cannot be immediately fixed (i.e., a feral cat colony). This could also be used in the case of a beach

nourishment project that would impact the vegetated dunes. In this case the project could be funded as part of mitigation. A detailed plan (including genetic management) would need to be developed prior to implementation because individuals will be in captivity longer and bred under this system. Because of its planned, discrete nature, funding for this strategy is more effective than the other strategies.

Costs

Costs are estimated to be $112,000-292,000. All costs listed for the Seasonal Holding Strategy also apply to this approach. In addition, the captive facility would be needed for a longer period of time and would have the added costs associated with breeding and genetics management. A management plan would need to be developed and would have to be more thorough and include more opportunities for laboratory research (e.g., studies on the loss of natural tendencies). For these reasons, this strategy would be more expensive than one year of the seasonal holding strategy, perhaps closer to the maximum of the given cost range.

Evaluation and Ranking of Short-term Strategies

The working group reconvened to summarize the primary pros and cons of each of the three short-term management strategies, which are listed below. Group members then used all available information and the paired ranking method to rank the various alternatives, including a "No Captive Management" alternative, since it is possible that no captive program would be the preferred alternative.

Rescue/Emergency Strategy – Ranked #1

The Rescue/Emergency Strategy was considered a "must-do" management option. This plan costs less than most and can be implemented only when needed.

Pros
- Least complicated
- Can be implemented only when needed
- No permanent facility needed
- Most economical
- Fewer surplus mice
- Fewer release issues (because fewer releases)

Cons
- Many logistic obstacles
- Requires a plan and funding in case event occurs and mice must be transitioned into a long-term strategy
- Safety of personnel
- Possible higher risk of loss of genetic variation
- Could separate breeding pairs/families
- Pre-plan for populations that are "at risk"

No Captive Management Program – Ranked #2

The No Captive Program alternative still allows other management actions to address the majority of the issues faced in the conservation and recovery of beach mice and can be done at no additional cost.

Pros
- Saves money, time, resources
- Existing conservation programs less affected or unaffected

Cons
- No additional "safety net"
- Potentially more advocacy group challenges
- Limits options

Table 3. Analysis of each short-term captive program strategy with respect to the purposes of captive management identified in the plenary session.

Purpose	Seasonal Holding Strategy	Rescue/ Emergency Strategy	Short-Term Colony Strategy
1: Insurance against subspecies extinction	Yes, primary focus of strategy	Yes	Perhaps indirectly, but not against extinction from an "event"
2: Source for reintroduction for extirpated populations/ new habitat	No, mice would be released at capture site or used to initiate a long-term strategy	No, mice would be released at capture site or used to initiate a long-term strategy	Yes, primary focus of strategy
3: Source for demographic supplementation	Yes	Yes	Yes
4: Source for genetic supplementation	Yes	Only if variation within mice collected are representative of population, and catastrophe occurs	Yes
5: Genetic reservoir in case of sudden population bottleneck or loss of genetic diversity	Yes	Only if variation within mice collected are representative of population, and catastrophe occurs	Yes
6: Preserve unique genetic lines within subspecies	Yes	Only if variation within mice collected are representative of population, and catastrophe occurs	Yes
7: Ambassadors to lessen threats through education/ outreach	Would not expose held mice to public viewing, but could use press releases, videos as outreach	Would not expose held mice to public viewing, but could use press releases, videos as outreach	May be possible to have some mice for educational display, if population is stable. Could also use press releases, videos as outreach.
8: Research opportunities to gain knowledge of subspecies biology	Yes, monitor and evaluate effectiveness of program	Yes, gain knowledge of captive care of beach mice	Yes, research is an important part of ***all*** strategies
9: Maintain population levels of the summer	Yes, primary focus of strategy	Potentially, if mice are collected prior to summer low	Only if colony is held over summer months

Short-Term Colony – Ranked #3

The Short-Term Colony Strategy presents many data gaps, but could be linked with other strategies, and provide research opportunities.

<u>Pros</u>
- Can be carefully planned and implemented
- Potentially funded as mitigation
- Fewer release location problems (if site is unoccupied)
- Research opportunities
- Fewer genetic issues
- Costs less than seasonal, long-term
- Discrete project (fewer long-term issues)

<u>Cons</u>
- Viewed as panacea, taking focus off not impacting habitat in first place
- Many applications would not have secured funding
- May increase risks to wild population
- Costs more than emergency/rescue

Seasonal Holding Strategy – Ranked #4

The Seasonal Holding Strategy was generally considered costly, difficult, and presented too many data gaps to ensure that it would not risk the wild population.

<u>Pros</u>
- Systematic plan
- May reduce risks to population
- Less complicated than permanent colony
- Retains more genetic variation from wild than emergency rescue

<u>Cons</u>
- Cost and effort per benefit is low
- May increase risks to wild population
- May redirect funds from other efforts/species
- Panacea effect/ takes focus off habitat
- Many data gaps
- Fate of surplus mice
- Potential lack of release sites

Suggested Strategies by Subspecies

The working group discussed their recommended captive management strategies for each beach mouse subspecies and concluded that the recommendations were the same across subspecies – namely, to prepare an Rescue/Emergency Strategy in the event of an approaching hurricane or other foreseeable catastrophe but not to instigate any other short-term management strategy (i.e., seasonal holding or a short-term colony) at this time (Table 4).

Table 4. Recommendations for short-term management strategies by subspecies.

Subspecies (risk priority)	***Seasonal Holding Strategy***	***Rescue/ Emergency Strategy***	***Short-Term Colony***	***No Captive Program***
Perdido Key beach mouse (1)		●		●
Alabama beach mouse (2)		●		●
Choctawhatchee beach mouse (3)		●		●
Anastasia Island beach mouse (4 or 5)		●		●
St. Andrew beach mouse (4 or 5)		●		●
Southeastern beach mouse (6)		●		●
Santa Rosa beach mouse (7)		●		●

Potential Next Steps

Future actions discussed focused on: 1) developing emergency/rescue plans for each subspecies, with priority given to most vulnerable subspecies; 2) ramping up other beach mouse conservation efforts that do not involve captive management (e.g., translocations, land acquisition); and 3) informing the public through outreach.

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SECTION 4

Long-Term Management Strategies Working Group Report

Long-Term Management Strategies Working Group Report

Members: Tylan Dean, Julie Glenn, Tim King, Robert Lacy, Darren LeBlanc, Ron Loggins, Anna Ogburn, Michael Wooten.

Description of Long-Term Strategies

This working group convened to explore various long-term management options involving the captive management of beach mouse subspecies. Members examined suggestions and considerations made during the plenary discussion, brainstormed further ideas, and then categorized these options into six primary long-term management strategies as described below.

1. Semi-Natural Enclosure

The purpose of the semi-natural enclosure strategy is to try to mimic the natural environment of the beach mouse as close as possible within a captive setting. Semi-natural enclosures would be comprised of tracks of land approximately ¼- ½ acre in size with appropriate boundaries constructed to both keep the mice within the enclosure and prevent predators from entering the enclosure. Previously constructed semi-natural enclosures have included boundaries comprised of a concrete-filled three-foot deep trench encircling the enclosure and fine meshwork covering the top of the enclosure, mainly as a deterrent for avian predators. A predetermined number of mice would be released into the enclosure pending enclosure size with up to 20 animals per ½ acre. Animals housed in a semi-natural enclosure could be carefully monitored through the use of underground cameras placed within burrows. The mouse population could be managed fairly rigorously with careful genetic monitoring, or the population could be managed with a more hands-off approach and allow natural breeding to take place.

2. Traditional Laboratory-style Mouse Colony

The traditional laboratory-style strategy would support a larger population of mice, approximately 50-100 breeding pairs, in a controlled laboratory environment. Animals would be housed in cages within the constructs of a research laboratory or other similar facility. Several variables would be consistent, such as diet, light cycles, ambient temperature and humidity, and caging substrate. The population would be intensely managed as either a closed colony (i.e., no wild-caught mice introduced to an existing laboratory colony) or as a flow-through colony (i.e., mice from the wild or from other captive populations allowed to move in and out of the laboratory colony depending upon management needs).

3. Supplementation Colony

As the name suggests, a supplementation colony has characteristics of both the semi-natural and traditional laboratory colonies. Such a colony would support a population of mice in which animals would be housed in a semi-natural type enclosure or in a more formal zoological park-type setting. Animals housed in a zoo setting may be housed on or off exhibit in variably-sized enclosures. This colony could be used to help supplement an existing wild population in which there had been a dramatic decrease in population size. The colony would most likely be managed as an open colony where there are periodic transfers between the wild and captive population in order to maintain genetic diversity. Colony size may vary considerably and consist of just a few animals or up to 50-100 breeding pairs. Some mice may be housed in semi-natural enclosures while others may be housed in a traditional colony. This strategy will maximize the likelihood of finding an environment in which mice of critical genetic lineages will breed the best. The semi-natural areas will further provide a transitional environment for laboratory-bred mice which will not only help maintain wild characteristics but will also provide an opportunity to learn survival skills prior to release in the wild. Management of the colony could include provision of nesting materials, natural substrates, access to natural food items, and exposure to the environment in a limited captive outdoor area. Depending on the location of this population, there may be opportunities for public outreach and education, particularly if housed at a zoological institution.

4. Long-Term Holding
The long-term holding strategy could be used as a protective measure in the face of an impending natural disaster (e.g., hurricane, flooding, fire) or when there is a man-made threat to the habitat, such as extensive development that would destroy known habitat of a population. Prior to an impending threat, as many of the animals in a population as possible would be trapped and placed in a holding facility. A target of at least 30 mice is suggested, although the minimum is one male and one female, and the suggested maximum is in the 100s of mice. The animals would then be released when the habitat had sufficient time to recover if destroyed by the natural disaster, or if the habitat was spared, the animals could also simply be released. The population could be held for as long as 1-2 years. During this holding period, the animals would be cared for with the intent of eventual repatriation. This type of strategy is not meant to be a part of a reproduction program. Similar to the supplementation colony strategy, a long-term holding population may also be used in public outreach programs.

5. Experimental Population
The experimental population strategy would be comprised of a population of mice placed in a habitat outside of the current range of a particular subspecies but in a habitat that could naturally support a new population of mice. This population would be the subject of intense research projects designed to better understand the beach mouse and its habitat. An experimental population would provide a multitude of research opportunities and could be managed with respect to food, habitat, or artificial burrow supplementation or not managed at all. An experimental population could be used for possible reintroduction programs for the various subspecies if the population is successful and deemed appropriate for reintroduction. An experimental population of mice would most likely be comprised of one of the subspecies that is not currently endangered; thus removing those animals from the existing population for this project would not adversely affect the wild population. The results of such research are anticipated to be invaluable to the management of more critically threatened or endangered subspecies.

6. Educational/Exhibit
The educational/exhibit strategy would use ambassador mice in public outreach programs, particularly in zoological institutions. These outreach programs would be designed to educate the public about the beach mouse and the beach dune ecosystem. A few ambassador mice would be placed on exhibit in an effort to allow people to make that personal connection with this elusive nocturnal species we are asking them to preserve. These mice would be comprised of animals from a currently non-endangered subspecies or surplus animals from other programs. These animals may be used within the education departments of zoos in such outreach programs that include day and week-long camps, home-schooling programs, teacher lesson plans for public and private schools from pre-school through college, keeper shadowing programs, and docent and

volunteer programs. These facilities could also be used as an emergency resource for holding rescued mice prior to and after a natural disaster.

Captive Management Goals

Based on the plenary discussion of purposes that captive populations may serve, the working group acknowledged the following eight captive program goals for beach mice (see Section 2):

1. Insurance against subspecies extinction
2. Source for reintroduction for extirpated populations / new habitat
3. Source for demographic supplementation
4. Source for genetic supplementation
5. Genetic reservoir in case of sudden bottleneck / loss of genetic diversity
6. Preserve unique genetic lines within subspecies
7. Education Ambassadors to increase awareness and decrease threats
8. Research opportunities to gain knowledge of species' biology

These goals were discussed in relation to each of the long-term management strategies to determine the purpose and goals that each strategy could serve. The results of this discussion are presented in Table 5.

Risks Associated with Captive Strategies

There are several potential risks associated with implementing a beach mouse captive management program. These risks are rooted in perception, implementation, and success of the proposed action. Described below are 13 un-ranked risks identified by the working group.

1. ***Regulatory and public perception may increase impacts to habitat***
   With animals being held in a colony there may be increased exploitation of beach mouse habitat. The increased pressure may result from both regulatory and public perception that since beach mice are being preserved in captivity, destruction of habitat would not pose a significant risk to the species and therefore may be more likely to occur.

2. ***Limited resources***
   If a large proportion of resources (financial and personnel) were redirected from conservation in the wild to conservation in captivity, the wild populations may not be as well managed and may be lost. This applies to all species, not just beach mice.

3. ***Decline in maintenance of wild populations***
   A management shift away from protection of wild populations may threaten their persistence in the wild. This risk is a manifestation of the two previous risks – the perception that beach mice are protected in captivity and that limited resources may result in loss of habitat and decrease in animal abundance and distribution.

4. ***Adaptation to captivity***
   There are significant concerns regarding captive beach mice becoming adapted to captivity and losing the ability to recognize predators, forage for foods, and perform other behaviors critical to survival in the wild upon repatriation/reintroduction.

5. ***Knowledge gaps***
   Gaps in knowledge regarding captive propagation and reintroduction may lead to failure of these programs. Significant gaps in knowledge exist in understanding how laboratory conditions influence mate selection, reproductive success, and behavior. Further, there may be issues related to reintroduction, as mice raised in captivity may no longer be adapted to survive in the wild. Furthermore, the conditions optimal to the survival of reintroduced mice have yet to be determined.

6. ***Negative impact on wild donor populations***
   The effects associated with the removal of individuals from an existing population and placing them in captivity are not well understood. Several questions regarding the impact on the donor population have been raised and need further investigation, such as the minimum size of the donor population that can withstand removal of individuals.

7. ***Effect of supplemental animals to existing population***
   The effect of introducing captive animals to existing populations is unknown and could be potentially hazardous to the wild population through the introduction of disease, novel behaviors, and genetic swamping.

8. ***Failure of captive breeding programs***
   The chosen captive breeding program may not be successful. Success would be determined by the ability of the captive program to meet established goals, such as successful reintroduction or preservation of unique genetic lineages.

9. ***Disease risk***
   Colony densities may influence disease spread and expression, which may lead to catastrophic loss of the colony. Captive colonies may face novel diseases introduced by workers or new animals.

10. ***Catastrophic loss***
    The colony could face catastrophic loss due to disease, equipment failure or other threats.

11. ***Lack of public support (apathy)***
    Captive programs may lack public support based on a perception of government waste or apathy toward program goals. An effective education program could address these issues.

12. ***Zoonotic disease***
    Colony workers may be exposed to zoonotic diseases such as hantavirus, plague, West Nile virus, etc. Risks to workers could be reduced by screening animals as they enter the colony. Proper safety in housing, handling, and ventilation would reduce these risks.

13. ***Sustained funding (long-term)***
    Sustainable funding would be required for captive breeding projects. Typically these projects would last for 10-15 years and would need a dedicated funding source throughout the project.

These risks were then discussed with respect to each of the long-term management strategies to identify those risks associated with each strategy. Discussion results are presented in Table 6.

Table 5. Potential of each long-term captive management strategy to meet each of the captive management goals.

Strategy / Goal	Semi-Natural Enclosure	Traditional Colony	Supplementation Colony	Long-Term Holding	Experimental Population	Exhibit / Educational
Insurance against extinction	Potential	Good if breeding well	Good – primary purpose	Good – primary purpose	Depends on subspecies, location and threat	Last resort
Source for reintroduction	Good	Good	Good – primary purpose	Good – primary purpose	Depends on subspecies and reason for extirpation	Poor
Source for demographic supplementation	Good	Good	Very good	N/A	Potential	N/A
Source for genetic supplementation	Depends on how it is managed; potential if monitored	Fair (if adequate scale; dependent on founders)	Very good	N/A	Potential	N/A
Genetic reservoir in case of loss of gene diversity	Not great – population too small	Very good	Potential – not primary purpose	Potential	Not great	Last resort
Preservation of unique genetic lines	Not great	Fair (unique lineages may not breed)	Good potential	Not great – need to be lucky	Some potential	N/A
Education Ambassadors	Possible, depending on location	Surplus may serve purpose but not the lab animals	Potential	Not great – offshoot	Poor	Excellent
Research opportunities	Very good	Good for certain types of research – good to measure effects of certain evolutionary processes	Good for certain types of research – good to measure effects of certain evolutionary processes	Potential – limited	Great	Potential

Table 6. Potential risks associated with each of the long-term captive management strategies.

Strategy / Risk	Semi-Natural Enclosure	Traditional Colony	Supplementation Colony	Long-Term Holding	Experimental Population	Exhibit / Educational
Regulatory and public perception leading to increased exploitation	Low	High	Very low	Low	High	Low
Limited resources	High, then low	High – costly	High – costly	Moderate	Low	Low
Decline in maintenance in wild	Moderate to high	High – related to public perception	Low	Primary goal	Low	N/A
Adaptation to captivity	Low	High	Low	Low	Low	N/A
Knowledge gaps	Some	Yes e.g., reintroduction	Designed to address	Yes	Some – unsure if habitat can support	Yes
Negative impact on wild donor pops	Low	Population specific	Low	N/A	Low	N/A
Effect of supplementation to existing population	Low?	High	Low	Moderate	Moderate	N/A
Failure of captive breeding programs	Low	Subspecies specific	Moderate	N/A	N/A	Potential
Disease risk	Potential low	Low but costly	Moderate to high	Low – density dependent	Same	Low – density dependent
Catastrophic loss	High	Low	Shared among facilities	High	High	Low to moderate
Lack of public support	Low	Low	Low	Low	High	Low – the primary goal of this strategy is to reduce this risk
Zoonotic disease	Low	Moderate	Moderate	High	Low	Low
Lack of sustained funding (long term)	Low	High	High	Low	Low – depends on scenario	Facility will assume most if not all costs
Specific Risks / Challenges	Knowledge gaps on system, monitoring, space, less control, low capacity	Uncertain breeding success, possibility of behavioral change, genetic drift, disease risks, uncontrolled adaptation to captivity	Shared risk, high degree of cooperation, partners lead to innovation	Recovery plan, obtaining individuals	Knowledge gaps, regulatory risks, identifying sites, escape	Regulatory, animal availability

Logistical Concerns and Resources Required

The working group discussed various aspects of captive management of beach mice, including transport, disease screening, husbandry, and breeding protocol. The following information was compiled by Julie Glenn based on experience and procedures adhered to by the *Peromyscus* Genetic Stock Center, University of South Carolina (products used and costs as of Spring 2007). Specific details are outlined in the workshop supplemental briefing materials (Glenn 2007).

Logistics of Transportation after Capture

Once wild beach mice have been captured they will need to be transported to a holding facility, ensuring that all capture and transportation permits accompany the mice. During this time humans handling the mice should be protected from exposure to dust and excretory material due to the potential of contracting hanta virus. Thus, mice should be transported in cages with micro filter tops (such as those sold by Ancare, www.ancare.com) or in shipping containers covered with filter paper. Handlers should wear a face mask with an N95 OSHA rating.

Mice should be transported in cages with a density no higher than $12 in^2$/mouse (see *Guide for the Care and Use of Laboratory Animals*, http://books.nap.edu/readingroom/books/labrats/), and at lower density if mice appear to be fighting and injuring one another. Food should be provided in the form of rodent chow (e.g., Harlan Teklad Rodent Diet 8604, minimum 1 biscuit/mouse/day, http://www.teklad.com/standardrodentdiet/r8604.asp), and water should be provided in the form of fresh potatoes. Three to four potatoes cut in half should provide enough moisture for 2 days. Most bedding types will do (e.g., aspen, any kind of soft wood which does NOT have oil, shredded paper products), but cedar should be avoided. Cotton will help reduce fighting during transportation.

Maintenance at Holding Facility: Disease Screening

Upon arrival, wild mice should be placed in quarantine. Two sentinel mice of the same species (not necessarily beach mouse) should be placed in a cage on the same rack as the wild mice. Small bits of soiled bedding from each beach mouse cage should be placed in the cage holding the sentinel mice. After a minimum period of 4 weeks, the sentinel mice should be sacrificed and sent to a laboratory for disease screening. For best results, the lab should use *Peromyscus* anti-serum (e.g., Bioreliance, http://www.bioreliance.com/). Note that little is known about the diseases *Peromyscus* may carry and what diseases they are susceptible to. Also note that the diseases screened are diseases common to *Mus musculus*; thus there may be a high rate of false positives and false negatives. The sentinel mice should also be screened for presence of parasites such as mites and worms. Because *Peromyscus* are variably susceptible to parasites and many do not show up on a fecal flotation, the digestive tract will have to opened and screened carefully. Check to see if the evaluating laboratory performs this service. Many laboratories only want blood from the sentinel animals, thus a local veterinarian/ parasitologist may have to perform the parasite screen. Alternatively, or in addition to screening, all mice could be treated with Ivermectin for external parasites such as mites, and given Fenbendazole-treated food as a general de-wormer.

No one knows for certain if beach mice are prone to carrying any of the hanta virus strains. The strains known to occur in the southeastern US are listed in Table 7. The holding facility, along with the attending veterinarian, should discuss their concerns about hanta virus and a decision made about how intensely they wish to screen the wild mice. Screening may involve testing only the sentinel mice, a sub-sample of the wild-caught mice, or all the wild-caught mice. Testing requires at least 20µl of blood, which can be drawn from a retro-orbital bleed or whatever method the attending veterinarian is most comfortable with. Samples should be sent to Dr. Brian Hjelle at the University of New Mexico for screening as he is one of the world's experts on hanta virus and one of the few people who can accurately test for the various strains.

The fate of beach mice testing positive for any disease, including hanta virus, should be discussed among the holding facility personnel and the regulatory agencies involved. Alternatives may include sacrificing the mouse (probably only necessarily if testing positive for a dangerous strain of hanta virus), keeping the mouse in quarantine until proven healthy, returning the mouse to the wild, or doing nothing. Until mice are shown to be free of hanta virus, workers should consider wearing N95 OSHA rated face masks. Once mice are believed to be disease-free they may be integrated into an existing colony, or housed in the same room as another subspecies. Until then, mice in quarantine should be handled only after all healthy mice have been handled for the day, and workers should never re-enter a room with healthy mice after being in the same room as quarantined mice.

Table 7. Strains of hanta virus known to occur in the southeastern United States, the rodent reservoir known to carry the virus, and the risk of Hanta Virus Pulmonary Syndrome.

Virus	Reservoir[1]	Location	Human Disease?
Black Creek Canal	*Sigmodon hispidus*	SE U.S.	Yes[2]
Tamiami	*Sigmodon hispidus*	SE U.S. / Everglades	No
Bayou	*Oryzomys palustris*	Southern U.S.	Yes[2]

[1]Does not mean the virus cannot be carried by *Peromyscus*.
[2]Causes a variant of Hanta Virus Pulmonary Syndrome that is characterized by a greater degree of renal failure than associated with Sin Nombre Virus.

Maintenance at Holding Facility: Husbandry

The manner in which beach mice are housed will depend upon the type of captive program implemented. If mice will be held in cages similar to a traditional breeding colony, then see recommendations in the supplementary material for specific suggestions. If mice will be housed in semi-natural environments, the density should be much less than the $12in^2$/mouse recommended for mice in traditional mouse colony cages, though the density will likely be higher than occurs naturally in the wild.

Choice of diet will depend upon the goals of the captive program. A balanced diet may be obtained with the use of rodent chow, and supplementary feeding should probably be avoided to ensure mice do not prefer one food to the exclusion of others, which could lead to nutritional deficiencies. However, if one of the goals is to release mice back to their native habitat, then the benefits and extra efforts involved in feeding more natural foods may outweigh the concern for a balanced diet. Mice should have unlimited access to fresh water and adequate bedding or burrowing substrate. Wild-caught mice do especially well when they are given or allowed to create a place of refuge, such as a burrow in the case of semi-natural captive situations or a breeding hut if in a more traditional colony. This will help reduce stress, fighting, and injuries.

Beach mice, especially those trapped in the wild, tend to be nervous and prone to stress (although less so than other *Peromyscus* or wild *Mus* species), so handling should be kept to a minimum.

Maintenance at Holding Facility: Breeding

The presence of burrows or breeding huts will also improve breeding success if breeding is a goal of the captive management strategy. If in a semi-natural enclosure, light cycles will not be regulated and beach mice will likely breed during the winter months. If housed in a controlled environment, beach mice may breed year-round depending upon the light cycle. The experience of the *Peromyscus* Genetic Stock Center has been that members of the genus *Peromyscus*, including Santa Rosa (*P. polionotus leucocephalus*) and Perdido Key (*P.p. trissyllepsis*) beach mice, typically do not breed with fewer than 16 hours of light/day. Other facilities have obtained breeding success with beach mice on shorter light cycles (i.e., 12:12 or 10:14 light:dark cycle).

Because beach mice are monogamous, and because females go through a post-partum estrus and are frequently bred within 12 hours of delivery, breeding males should not be removed from the cage/enclosure. When considering how many mice to house in a cage/enclosure, allowances should be made for the density in the cage/enclosure if a set of parents has a litter near weaning age. Thus, cages containing mated pairs typically do not include more than one male and one female.

Large enclosures with semi-natural environments housing many mice will likely not have a problem with density. Furthermore, this plan will give mice a choice of mates, which may improve breeding success. *Peromyscus* do not withstand even moderate amounts of inbreeding; thus if breeding fails to occur, the potential mates may be too closely related and the mice should be given additional mate choices. Potential mates should be given approximately 4 months to produce their first litter before they are split. An alternative strategy would be to give mice a choice of mates in a Y-maze, letting the female choose her preferred partner. Another possibility is to pair mice that differ in their genotypes at the major histocompatibility complex.

Although *Peromyscus* are typically considered sexually mature at 55 days, breeding may occur earlier. Thus, young may be weaned from their parents around 25-30 days of age. If housed in a large semi-natural enclosure with many mice, the decision to remove these sub-adults will depend upon the goals of the study. For example, subadults may be left in the enclosure if there is no active breeding management and therefore no concern over any particular animal's parentage or degree of inbreeding.

Because beach mice brought into a captive program are likely to be listed as threatened or endangered, and because one of the goals of a captive program is to ensure the maintenance of genetic diversity, the parentage of all mice born in captivity is likely important. This may be accomplished by restricting mate choice so parentage is known, or by allowing free mate choice and genotyping all animals. Both methods should have some method of identifying individuals, whether the identification is via ear notching, ear tags, or pit tags. Note that ear tags and pit tags are sometimes lost or actively removed by mice. Ear notching can fail as well if the mouse experiences extreme aggression and loses part of its ears. Of all methods, however, ear notching may be the easiest and most fail-proof. Beach mouse ears are difficult to notch cleanly, but scissor-type notchers similar to those produced by Roboz (www.roboz.com) seem to work the best.

Estimated Costs

The working group discussed and developed the following estimates for costs associated with each of the long-term management strategies. These are “off the cuff” estimates for comparative purposes during the workshop and are in need of further research and refinement before being considered for implementation. Note that in most cases the costs associated with research have not been estimated.

Semi-Natural Enclosure
$20,000 including labor per enclosure
Under $10,000 in materials per unit (part of set-up)
First-year operating expenses: minimum $30,000 plus research per unit
Following years: $30,000/yr

Traditional Laboratory-style Mouse Colony
Set-up: $25,000
Maintenance: $40,000/yr for personnel
Food: $1000/yr
Genetic screening: $5,000/yr
Animal facility needed
Additional subspecies do not affect costs significantly

Supplemental Colony
Needs financial commitments from partners
Field component: $30,000/yr for a half-time field tech
Genetic analysis: $12-15,000 (includes captivity and wild populations)
Less than $20,000/yr per facility

Long-Term Holding
Similar to Traditional Colony, but set-up costs would be about half ($12,000) because no flux of offspring; adding additional subspecies does not affect costs

Experimental Population
Set-up: Generally lower than others, but significant if habitat clearing is needed
Operating costs: $20,000/yr plus research

Zoological Exhibit / Educational Program
$10,000 - $50,000 exhibit set-up
Personnel, time, permits

Comparisons of Management Strategies

Based on the discussions surrounding the purposes, risks, knowledge gaps, logistics, and estimated costs, the working group summarized the primary advantages (Pros) and disadvantages (Cons) of each long-term management strategy, resulting in an overview comparison of all options. For comparison, Pros and Cons were also listed for a No Captive Action strategy, in which beach mouse management would not include any captive component. The results of this comparison are presented in Table 8.

Group members then ranked these potential strategies, using the paired ranking method, in terms of its recommended use for beach mice in general. The Supplementation Colony approach received the highest rating (29). Traditional Colony (20), Semi-Natural Enclosure (18), and Experimental Population (17) were moderately ranked, while Long-Term Holding (10) and Exhibit/Educational (9) were ranked lower. Management without any captive component (No Caption Action) ranked very low (2) and was not recommended.

Table 8. Primary "pros" and "cons" of each of the long-term captive management strategies.

	Primary PROS	Primary CONS
Semi-Natural Enclosure	Semi-natural Relatively inexpensive Many research opportunities	Many knowledge gaps Vulnerable to catastrophe Limited capacity Viewed as panacea
Traditional Colony	Large capacity Reasonable implementation knowledge Unique research capabilities	Long-term financial commitment Possibility of domestication Uncertainty of return to wild Viewed as panacea
Supplementation Colony	Shared risks Scalable / flexible Opportunity for genetic management Mix of benefits of semi-natural and traditional colonies	Low capacity for restoration to wild Requires long-term funding commitment Requires collaborations Disease transmission risk among mice Viewed as panacea
Long-term Holding	Security against extinction Logistically simple	Disease transmission risk among mice Uncertain outcome Uncertain outcome and end strategy Viewed as panacea
Experimental Population	Natural setting Novel research opportunities Low cost Creates an additional population for security against extinction	Catastrophic loss No certainty of success Regulation and PR issues Viewed as panacea
Exhibit / Educational	Great public relations opportunities Last resort population Does not take animals from populations or programs	Uncertain funding Few research opportunities Few reintroduction opportunities (mice not intended for release)
No Captive Action	Simple Does not divert funds from other needed actions Does not allow panacea excuse	Vulnerable to catastrophic loss / declines All options to preserve subspecies not explored Losing research opportunities Could be losing genetic diversity

Management Priorities by Subspecies

The highest priority for any beach mouse management plan is to make captive populations unnecessary. We recognize, however, that long-term captive options may be required for some subspecies, at least temporarily, in order to achieve that goal. The following is a list of beach mouse subspecies, ordered by decreasing risk of extinction, and the long-term captive strategy for that subspecies that minimizes the risk of extinction.

Perdido Key Beach Mouse (P.p. trissyllepsis)

Considered to be the subspecies most at risk of extinction, the recommended strategy would be establishment of a supplemental colony (Strategy 3). Because this is the most endangered of all beach mice, however, the current wild population may not be able to withstand the removal of mice for the establishment of a captive supplemental colony. Therefore, the best option may be to remove several individuals for a long-term holding strategy (Strategy 4) in the face of impending danger. Impending danger may include, but is not limited to, severe hurricane threats, planned development in which certain mice may be killed or habitat otherwise rendered uninhabitable, and beach restoration activities that might temporarily destroy or limit habitat but which ultimately will lead to more habitat for reintroduction attempts.

Recognizing that there are many instances in which mice captured on a long-term holding strategy may not be returned to their natural habitat within a few months to a year, such mice should be considered as founders of a supplemental colony. The few mice that breed in a supplemental colony may be retained as breeders and the ones that do not breed would be good candidates for repatriation attempts when habitat is restored. This combination strategy has the potential to limit the numbers of captive mice to those most likely to breed, while providing opportunities for research into captive management, success of repatriation of wild-caught mice, and success of introduction of captive-bred mice. At the same time, mice are not removed from an already struggling population unless the risk is high that population numbers will decline further. Short of such an event occurring, however, the best immediate strategy may be to do nothing so as not to diminish the numbers or genetic diversity of the population currently living on Perdido Key.

Choctawhatchee Beach Mouse (P.p. allophrys)

Choctawhatchee beach mice are the second most endangered subspecies, so concerns and strategies are similar to those discussed for Perdido Key beach mice. The primary concern is that there are many subpopulations that may not be able to withstand the removal of mice as captive colony founders. Should that not be the case, then, as with the Perdido Key beach mouse, the best long-term captive option is the implementation of a supplemental colony (Strategy 3). If subpopulations are found that could withstand removal of individuals, then those subpopulations may provide founders for a semi-natural enclosure (Strategy 1) or an experimental population outside of the current range (Strategy 5). Both options keep the mice in as natural a setting as possible, thereby limiting adaptation to captivity. A semi-natural enclosure would allow more direct human control over many factors, including an increased ability to trap and genetically monitor the captive populations, as well as to conduct basic research difficult or impossible to do in the wild. Numerous semi-natural enclosures could also be placed in a variety of locations to limit the possibility of catastrophic loss.

These advantages are not as likely if mice are placed in an experimental population outside of the current range. However, an experimental population offers research opportunities different from those of a semi-natural enclosure, among them the ability to assess correlates of reintroduction success. This plan also has a relatively low cost and low maintenance. Because these mice would remain in a natural wild environment, such a population has the greatest likelihood of producing mice that will be successful upon reintroduction to their current range.

Alabama Beach Mouse (P.p. ammobates)

As the third most endangered subspecies, Alabama beach mice are candidates for a supplemental colony (Strategy 3), as their populations are likely high enough to sustain removal of mice as founders. An alternative would be to implement a captive colony in a semi-natural enclosure (Strategy 1). Advantages of these strategies are outlined above for the Perdido Key beach mouse and the Choctawhatchee beach mouse.

Anastasia Island (P.p. phasma) and St. Andrews Beach Mouse (P.p. peninsularis)

Anastasia Island and St. Andrews beach mice are the next most endangered subspecies but have populations that are likely large enough and genetically diverse enough to withstand removal of individuals as founder animals for captive management. Because *Peromyscus* species typically fail to breed with close relatives, the likelihood of increased genetic diversity in these subspecies also increases the chance that they will breed in captivity and lead to a successful captive program. Again, the preference is to keep captive mice in as natural an environment as possible in order to reduce the risk of adaptation to captivity, while still being able to trace family, and hence, genetic lineages. Thus, the supplemental colony (Strategy 3) is still preferred. However, a supplemental colony may be limited in its ability to produce large numbers of offspring similar to what a traditional breeding colony may produce (Strategy 2). In addition, a traditional colony offers many research opportunities not possible with other captive management strategies (e.g., hormone and breeding cycles, effects of inbreeding, mate choice, growth).

The best option, then, may be a hybrid of these two strategies. Some wild-caught mice could be maintained in a supplemental colony where conditions are more natural, and some could be maintained in a traditional colony. Offspring could be moved between the two captive populations depending upon particular management goals. For example, if a mated pair typically produces more litters in a traditional colony, then mice in the supplemental colony with rare but important genetic lines may be moved to the traditional colony for a period of time to increase the representation of those genes in the captive population as a whole. Conversely, mice in traditional colonies may be moved to the more naturalistic setting of the supplemental colony in order to maintain wild behavior in wild-caught mice or to let young born in a traditional colony learn wild-type skills, either with or without a wild-caught individual as instructor.

Southeastern Beach Mouse (P.p. niveiventris)

Southeastern beach mice populations are doing fairly well compared to the other beach mice. Thus, they present one of the best opportunities for research that may aid in the recovery of other subspecies. Their populations likely can withstand the removal of mice as founder animals for multiple long-term captive colonies. In particular, having Southeastern beach mice housed simultaneously in a traditional colony (Strategy 2), a semi-natural enclosure (Strategy 1), and a supplemental population (Strategy 3) would allow for maximum research opportunities. Mice could be moved among the various types of enclosures depending upon management goals as outlined in part for Anastasia Island and St. Andrews beach mice. In addition to limiting adaptation to captivity, such a combination strategy would provide enough offspring for reintroduction efforts and allow a more accurate assessment of the factors influencing repatriation success. Such information would prove invaluable in guiding management strategies for those subspecies in more immediate danger of extinction. Their status as "threatened" is a potential advantage because implementing some of these strategies is more likely to gain support from federal funding agencies, but is a potential disadvantage because permits to remove mice from the wild may not be easily forthcoming.

Santa Rosa Beach Mice (P.p. leucocephalus)

Santa Rosa beach mice are not currently listed as either threatened or endangered; thus they provide the same research opportunities as outlined for Southeastern beach mice. Again, the best strategy would be to establish a traditional colony (Strategy 2), a colony in a semi-natural enclosure (Strategy 1), and a supplemental population (Strategy 3) in order to collect data that will prove useful in preserving more endangered subspecies. The advantage of using Santa Rosa beach mice for research is that, because they are not federally listed as either "threatened" or "endangered", receiving permits for their capture may be expeditious. The disadvantage, however, is that federal funding agencies may be less likely to support research on a non-listed subspecies.

General Considerations

For all long-term captive strategies, especially those involving breeding, animals should be taken from across the geographic range of the subspecies to ensure genetic diversity, assuming the population or subpopulations can withstand the removal of those individuals. In addition, the preference for supplemental populations (Strategy 3) reflects an attempt to balance the need for captive breeding while limiting adaptation to captivity and maximizing the likelihood of future reintroduction success. Consideration of such a captive management strategy should be given highest priority to subspecies at the greatest risk of extinction first, as these subspecies are the most in need of aid. Finally, although the options discussed above are the most desirable, other lower priority strategies not mentioned would frequently be compatible in concert with the strategies mentioned, and should be pursued when possible. For example, mice from a particularly prolific captive breeding pair may be deemed genetically surplus and unimportant for future breeding efforts and therefore would provide opportunities for research in a variety of captive management settings. In addition, such surplus mice would make excellent zoo or educational animals. This option in particular should be pursued rigorously, as the success of any endangered species management program relies heavily on public support.

Assisted Reproductive Technology Options

Cryopreservation of genetic material and the application of assisted reproductive technologies (ART), such as artificial insemination and *in vitro* fertilization, were raised as potential alternative options to the maintenance of a captive population of beach mice. In response, the following information was compiled by Julie Glenn, *Peromyscus* Genetic Stock Center, regarding the current status and potential of these technologies for beach mice.

Currently, the *Peromyscus* Genetic Stock Center is funded from federal grants to develop assisted reproductive technologies for members of the genus *Peromyscus*. Although the logistics of gamete and embryo cryopreservation and embryo transplant techniques have been worked out for the morphologically similar *Mus musculus*, the same procedures frequently do not work in *Peromyscus*, a genus that is separated from *Mus musculus* by approximately 10 million years. The process, therefore, is still in its infancy and many difficulties have yet to be overcome.

At this time, gametes (sperm or ova) can only be extracted by killing the donor animal. Once gametes or embryos are harvested, the proper buffer and freeze/thaw conditions will need to be determined in order to ensure maximum viability. Experiments have progressed the furthest with cryopreservation of sperm. Upon thaw, however, many sperm show characteristics that may not be conducive to a high fertilization success rate.

The logistics of artificial insemination are also being pursued. The first problem is the need for timed matings. *Peromyscus* do not produce copulatory plugs; thus, it is not possible to assess the readiness of a female to mate by placing her with a vasectomized male and checking for a plug. Hormone priming females and/or superovulating them has also met with little success. Recently, Dr. Gabor Szalai, Associate Director of the *Peromyscus* Genetic Stock Center, has managed to obtain what appear to be viable embryos from females with timed matings. This process involved putting an intact male in a cage with a female believed to be receptive, allowing mating to occur, and the next day artificially inseminating the female with fresh sperm, whether mating occurred or not. In this experiment, the success of artificial insemination was not the goal, but merely the ability to accurately assess when a female is receptive. Although this is the first success in this arena, currently embryos are obtained from only 1 out of 6 females.

The following is a partial list of the milestones involved in perfecting all aspects of assisted reproductive technologies in *Peromyscus*. Note that not all of the steps need to be perfected before some form of assisted reproduction may be applicable to beach mice.

1. Extraction of gametes without killing the donor
2. Extraction of embryos (may always require killing the female)
3. Freezing and thawing of sperm, eggs, and/or embryos
4. Timed matings of females
5. Successful artificial insemination of females using fresh sperm, then using frozen sperm
6. Successful fertilization of eggs *in vitro* using fresh sperm, then using frozen sperm
7. Embryo transfer from donor female to host female and production of viable offspring, first from naturally derived embryos, then from artificially derived embryos

At best, perfection of the technology is many years away; thus it is not yet a viable option for beach mouse conservation. Depending on continued funding, the technology may never be realized. Even if the technology does become applicable to beach mice, there is always the risk that at least some people will view the preservation of beach mouse genetic material in this way as a panacea and therefore will feel free to destroy the remaining habitat. This viewpoint is one that pervades all options for captive management in any form, and thus is not unique to assisted reproduction.

Should the technology progress to a state where it could be considered as a conservation option for beach mice, there are several advantages:

1. Federal grants are already funding the development of this technology through the *Peromyscus* Genetic Stock Center; thus additional state funds are not likely necessary.
2. Many beach mice will never breed in captivity. The current estimate is that about 1/3 of the mice brought into captivity will eventually produce litters. Assisted reproduction eliminates these difficulties and allows for the production of offspring between mice that otherwise refuse to breed.
3. Assisted reproduction offers one more option for the preservation of unique genes. This is especially important given that many unique genes may be lost when wild mice fail to breed in captivity.
4. Embryos of an endangered beach mouse subspecies may be implanted into a host female of another, less threatened beach mouse subspecies.
5. Once the technology is developed, assisted reproduction is relatively cheap. Gametes and embryos are small and easily stored in liquid nitrogen.
6. The storage of gametes and/or embryos acts as an insurance policy in case of a sudden lack of funding. Keeping live mice is usually best, but costly. With this technology, an entire live colony could be euthanized, their gametes and/or embryos stored, and another colony re-derived many years later if necessary. This is potentially one of the most important advantages of this technology.

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APPENDIX I

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APPENDIX II

Individual Statements/Recommendations

Individual Statements / Recommendations

While I think it is important to consider the long-term genetic viability of the beach mouse species and agree some type of captive breeding program would help maintain that genetic viability, I believe the Service's first responsibility is to maintain and work towards recovery of the species in the wild. Available funds should first be put forward to habitat purchase and enhancement. There are also biological research needs that I believe are more immediate than a captive breeding program. We must find out if captive mice can be conditioned to be released back into the wild. If that cannot be successfully worked out, there is no need to pursue a large captive breeding program.

I believe the Service should work on an emergency rescue program and have a plan for long-term holding, and possibly breeding, in case a hurricane destroys large portions of any of the beach mouse's habitats. I think priorities should be given to PKBM, ABM, and CBM since they have the lowest populations and their habitats have been reduced by recent storms. I also believe that we should do as much educational exhibiting as we can with available facilities and beach mice.

Of course the problem with anything is finding adequate funding to implement the plans. Funding sources for any of the long-term strategies should be examined while developing the conceptual plans. Short-term strategies may be easier to implement, especially in the wake of a hurricane, but the Service must have contingencies if emergency funding does not come through. My recommendations, in order of preference and why, are as follows:

1. *No Captive Action, with Emergency (Snatch and Grab)* in case the big one is coming. This can be done with current funding, requires the Service to fulfill its obligations under the ESA, and has a contingency against disaster.

2. *Semi-Natural or Supplementation (depending on funding), with Educational*. Funding is less, impact to the native population is less, and includes actions to maintain wild instincts. Probably easier to get through regulatory hurdles.

3. *Experimental Population*. Can be less expensive than other options, but lots of unknowns and possible regulatory/public perception hurdles.

4. *Traditional Colony*. Expensive and must have long-term funding source. Can animals be returned to the wild successfully or are we growing fox food?

5. *Seasonal, Short-Term, or Long-Term Holding*. Not recommended. Too many problems, too little benefit.

There are many available options and all of them have associated pros and cons. Many of them are useful in different situations. If I had to vote, I would opt for the rescue/emergency holding strategy. This would need to have a solid, well-designed plan, with contingencies in case a hurricane or other emergency did indeed hit. If this happened the program could quickly jump to a long-term strategy with a breeding component. My decision is based on my knowledge of limited funding for endangered species conservation, and our lack of knowledge regarding the success of beach mouse captive propagation and re-assimilation into the wild. If monies were available and we determine captive propagation to be feasible, there could be also be uses (in certain situations) for short-term colonies, semi-natural enclosures, and long-term supplementation.

The role of captive breeding (CB) in conservation has played an important role for many species. However, one thing that has been learned is that it can, in some if not the majority of cases, detract from what might be more critical aspects of ensuring species persistence in the wild.

My knowledge of beach mice biology and conservation limit me from specific comments regarding their management; therefore my thoughts are more general (philosophical?!). One aspect of the meeting that really stood out to me was that the idea of CB was being considered before what might be more critical aspects were understood. I understand that this exercise was meant as a brainstorming session on CB, but why was there not a brainstorming session on how best to identify and secure additional protected habitat (for example)? Are there not other listed (or “near-listed”) species (e.g. plants) in these habitats that could benefit from a habitat approach?

A trend that I see is that when species are perceived as being up against a wall, the first thing considered is CB. Given that these mice have evolved with hurricanes, it seems that the ultimate threat is range contraction due to habitat loss, rather than the perceived threat of storms. In this sense CB is a stopgap, rather than a solution. Where should the conservation resources go? Another concern is with the possibility of the ‘tail wagging the dog’, both with respect to some of the “vested interests” (zoos and CBSG) at the meeting - all good intentioned obviously, but it precluded the detailed examination of other options by the FWS. Again, this probably was the point for the workshop – to examine the feasibility of CB, not habitat management or even translocations. This is even more of a concern for me when the public perception is considered – many perceive CB as “doing something”, whereas habitat protection is not a visible (nor sexy) management strategy.

My general thoughts on the workshop were that many, by the end, felt that CB in its various forms would be very expensive and very complicated (in many scenarios). Is CB feasible? Probably, but it should not be considered in the absence of other approaches. Of all the CB scenarios considered, the longer term colony approach seemed the most ‘realistic’ in terms of actually being implemented, and perhaps the most useful for some of the more at risk populations, although the unknowns really scare me (would mice adapted to captivity be worth anything insurance-wise?). The short-term ideas like rescues and seasonal collections were, in the end, a bit over the top and unlikely to be effectively implemented.

Following an intense three days of presentations and discussions on the viability of a captive management program for the beach mouse, I believe we should invest some of our resources in a comprehensive public outreach program through zoological institutions, particularly in the southeast. There are multiple zoological institutions within the southeast that could be vital partners in the conservation efforts to preserve this species and the beach dune ecosystem. Preservation of endangered species is most often contingent upon a well-educated and well-informed public who understands the needs of the species and values the species as a vital part of the environment. The vast majority of people have not even seen the nocturnal beach mouse, unlike the more charismatic sea turtle that shares the beach dune ecosystem; thus it is very difficult to gain support for conservation efforts without providing people the opportunity to make that personal connection with the species they are asked to preserve.

Zoological institutions are in the unique position to reach a large number of people across a variety of age groups and ethnicities within a short time frame. The education departments of many zoos have well-developed outreach programs that include day and week-long camps, home-schooling programs, teacher lesson plans for public and private schools from pre-school through college, keeper shadowing programs, and docent and volunteer programs. Furthermore, zoological institutions could also be an emergency resource for holding rescued mice prior to and after the hurricane season or in the event of any other natural disaster. Zoological institutions could also be used as a potential resource for fund-raising efforts towards the preservation of the species, habitat restoration, and habitat acquisition. Some institutions are also in the position to support a larger captive breeding program and other research opportunities if any of those options become desired as a management tool for the species. And finally, zoological institutions are in the business of educating people about the importance of preserving ecosystems around them, through personal, up-close, and intense experiences with plants and animals that vary in diversity and size from the small invertebrates to the charismatic megavertebrates. Through exhibits and programs that educate the public about the beach mouse, we will also help ensure the preservation of all the organisms that are the framework of the beach dune ecosystem.

I recommend the following to the agencies charged with conservation of beach mice (in order of priority):

1. Reemphasize and focus on non-captive breeding efforts. Given that: 1) nearly all threats to beach mice can be eliminated or minimized through non-captive breeding efforts, such as land acquisition, public outreach, habitat restoration, translocations, and predator and feral cat control; 2) beach mice breed readily in the wild, and recover from low population densities if sufficient habitat is available; 3) breeding of beach mice in captivity is a relatively complex, costly venture that has been problematic in the past; and 4) success of captive bred beach mice returned to the wild is unknown and uncertain; I would recommend that future efforts to recover or conserve beach mice should focus on the non-captive breeding efforts mentioned above. This is not to say that current conservation efforts are sufficient. Greater emphasis and effort should be placed on these efforts prior to engaging in captive options. Many of these non-captive breeding efforts have never been adequately pursued, or have not been pursued in several years.

2. Develop emergency response plans for beach mouse subspecies. While hurricanes can severely reduce beach mouse population densities, impacts from these storms also maintain the open, early successional habitat that is suitable to beach mice. However, a catastrophic hurricane making landfall at the “right” place and time is a threat that may not be sufficiently minimized with non-captive breeding efforts alone. Therefore, concurrently with the increased non-captive breeding efforts, I recommend the development of emergency/hurricane response plans for each subspecies, with the focus on the most vulnerable subspecies first. More specifically, I believe that an emergency response should be activated by a suite of risk factors including forecasted hurricane track and predicted strength at landfall, status of the subspecies potentially in danger, current quality of habitat, availability of high elevation habitat, genetic issues, and the number of populations/geographic units/critical habitat units involved, aimed to trigger collecting beach mice when there is a moderate/high to high(?) risk that a subspecies will go extinct or locally extirpated from more than one area or several areas or certain key areas. (Since translocations can be used to some extent to reestablish extirpated areas.)

3. Solicit and fund research involving captive breeding, acclimation/release techniques for translocation of captive bred mice, and low population thresholds. Since the emergency response plan will need to defer to some level of captive management should a response be triggered and habitat severely impacted, research to determine standard protocols for long-term captive beach mice care and eventual release should be sought after and funded. Research addressing the identification of population thresholds at which beach mice should be brought into captivity to prevent extinction should also be encouraged. Inclusion of genetic components for all research suggested above is crucial.

4. Develop a comprehensive plan. Despite the best intentions, some *ad hoc* efforts in the past may have been more “feel-good” measures than scientifically sound strategies. Biologists/Managers need to be very conscious of decisions and choose management actions that will provide a benefit to the subspecies persistence in the wild. A plan should be developed that addresses and prioritizes management options ranging from non-captive breeding efforts to long-term captive breeding, and outlines tasks, research needs, policies, and future actions.

As beach mice are important and unique components of the dune systems along the Gulf of Mexico and southern Atlantic coasts, their continued decline is symbolic of the larger problem of habitat destruction. Therefore, efforts to preserve these mice in the wild will have far-reaching positive ecological effects including, but not limited to, preservation of many critical plant and animal species, and protection of man-made structures by the dunes themselves.

Every effort should be made, then, to preserve the habitats and the mice in those habitats in as natural a manner as possible. For many subspecies captive options offer benefits which will help meet that goal. Those options should be explored with preference given to those strategies that keep the mice in as natural a setting as possible while still ensuring the preservation of as many unique and diverse genetic lineages as possible. For many subspecies, the intermediate supplemental colony is likely to accomplish these goals best as it combines the benefits of both semi-natural and traditional colonies. Thus, the managers have a great deal of flexibility when choosing the captive environment that works best for a specific mouse or a specific subspecies.

Due to the high initial startup and maintenance cost and low likelihood of success for captive breeding of beach mice subspecies, it is my opinion that captive breeding has a very low, and possibly detrimental, conservation value for all listed beach mouse subspecies. As demonstrated by the past and current captive breeding population of Perdido Key beach mice, captive breeding has a low likelihood of success without extensive genetic loss. While translocations to remaining suitable habitat have effectively avoided extensive genetic bottleneck effects by the reintroduced population growing quickly, the same effects clearly cannot be avoided within a captive breeding colony. The data presented by the captive breeding researchers at the meeting demonstrate that a large segment of remaining populations will be needed to avoid a genetic bottleneck to successfully establish a captive breeding colony. With some subspecies' remaining populations at currently low levels (i.e., Perdido Key beach mouse), we believe this effort would exacerbate an already dire situation. If captive breeding eventually became successful, we believe the opportunities for successful reintroduction of captive individuals to suitable habitat would be complicated by risk of disease transmission to native populations and questionable survival of ecologically naive captive individuals. We believe the Service and State Conservation agencies could put this money to a higher and better conservation use by one or several the following suggestions:

- Purchasing of remaining available beach mouse habitat for remaining subspecies
- Funding of a permanent person for monitoring of beach mouse populations on public lands (Florida especially)
- Funding of a permanent person for control of feral animals on public and private lands
- Establishment of a habitat restoration trust fund triggered by storm events to restore habitat of protected coastal species, including beach mice
- Grants to local native nurseries to ensure re-vegetation supplies after a major storm
- Grants for rapid restoration of beach and dune habitat following storm events
- Grants to local owners to re-vegetate their lands with beach mouse friendly landscaping
- Grants to land owners for boardwalks
- Grants to land owners for beach mouse friendly lighting
- Grants to local communities for control of feral animals
- Grants to local communities for public education of coastal wildlife

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I recommend that we develop a rescue/emergency program with two ultimate outcomes. One outcome would be if "the big one" hits, the program would immediately transition into a long-term holding strategy. During the duration of the colony, individuals would hopefully be able to be held in semi-natural enclosures. If enough enclosures are not possible to maintain the needed numbers and genetic diversity, then this would be supplemented with a traditional laboratory style colony. If the "big one" doesn't hit, then the mice would be released as close as possible to their capture site at the end of the hurricane season.

The second outcome would be the development of a rescue/emergency program that would only be instituted if a Category 4 or 5 hurricane watch has been issued for a specific subspecies range. All details would have to be worked out beforehand to ensure that in a very short time, volunteers would be able collect the mice and evacuate the area to a pre-arranged holding site.

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APPENDIX III

Bibliography of Workshop Briefing Materials

Bibliography (Workshop Briefing Materials)

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Beach Mouse Captive Population Feasibility Workshop

Topsail Hill Preserve State Park, FL, US
7 – 9 March 2007

Final Report

APPENDIX IV

Introduction to CBSG Processes

CBSG Workshop and Training Processes

Information on capabilities of the Conservation Breeding Specialist Group (CBSG/SSC/IUCN)

Introduction

There is a lack of generally accepted tools to evaluate and integrate the interaction of biological, physical, and social factors on the population dynamics of threatened species and populations. There is an urgent need for tools and processes to characterize the risk of species and habitat extinction, on the possible impacts of future events, on the effects of management interventions, and on how to develop and sustain learning-based cross-institutional management programs.

The Conservation Breeding Specialist Group (CBSG) of IUCN's Species Survival Commission (SSC) has more than 15 years of experience in developing, testing and applying a series of scientifically-based tools and processes to assist risk characterization and species management decision making. These tools, based on small population and conservation biology (biological and physical factors), human demography, and the dynamics of social learning are used in intensive, problem-solving workshops to produce realistic and achievable recommendations for both *in situ* and *ex situ* population management.

Our workshop processes provide an objective environment, expert knowledge, and a neutral facilitation process that supports sharing of available information across institutions and stakeholder groups, reaching agreement on the issues and available information, and then making useful and practical management recommendations for the taxon and habitat system under consideration. The process has been remarkably successful in unearthing and integrating previously unpublished information for the decision making process. Their proven heuristic value and constant refinement and expansion have made CBSG workshop processes one of the most imaginative and productive organizing forces for species conservation today (Conway 1995; Byers and Seal 2003; Westley and Miller 2003).

Integration of Science, Management, and Stakeholders

The CBSG PHVA Workshop process is based upon biological and sociological science. Effective conservation action is best built upon a synthesis of available biological information, but is dependent on actions of humans living within the range of the threatened species as well as established national and international interests. There are characteristic patterns of human behavior that are cross-disciplinary and cross-cultural which affect the processes of communication, problem-solving, and collaboration: 1) in the acquisition, sharing, and analysis of information; 2) in the perception and characterization of risk; 3) in the development of trust among individuals; and 4) in 'territoriality' (personal, institutional, local, national). Each of these has strong emotional components that shape our interactions. Recognition of these patterns has been essential in the development of processes to assist people in working groups to reach agreement on needed conservation actions, collaboration needed, and to establish new working relationships.

Frequently, local management agencies, external consultants, and local experts have identified management actions. However, an isolated narrow professional approach which focuses primarily on the perceived biological problems seems to have little effect on the needed political and social changes (social learning) for collaboration, effective management and conservation of habitat fragments or protected areas and their species components. CBSG workshops are organized to bring together the full range of groups with a strong interest in conserving and managing the species in its habitat or the consequences of such management. One goal in all workshops is to reach a common understanding of the state of scientific knowledge available and its possible application to the decision-making process and to needed management actions. We have found that the decision-making driven workshop process with risk characterization tools, stochastic simulation modeling, scenario testing, and deliberation among stakeholders is a powerful tool for extracting, assembling, and exploring information. This process encourages developing a shared understanding across wide boundaries of training and expertise. These tools also support building of working agreements and instilling local ownership of the problems, the decisions required, and their management during the workshop process. As participants appreciate the complexity of the problems as a group, they take more ownership of the process as well as the ultimate recommendations made to achieve workable solutions. This is essential if the management recommendations generated by the workshops are to succeed.

Participants have learned a host of lessons in more than 120 CBSG workshop experiences in nearly 50 countries. Traditional approaches to endangered species problems have tended to emphasize our lack of information and the need for additional research. This has been coupled with a hesitancy to make explicit risk assessments of species status and a reluctance to make immediate or non-traditional management recommendations. The result has been long delays in preparing action plans, loss of momentum, and dependency on crisis-driven actions or broad recommendations that do not provide useful guidance to the managers.

CBSG's interactive and participatory workshop approach produces positive effects on management decision-making and in generating political and social support for conservation actions by local people. Modeling is an important tool as part of the process and provides a continuing test of assumptions, data consistency, and of scenarios. CBSG participants recognize that the present science is imperfect and that management policies and actions need to be designed as part of a biological and social learning process. The workshop process essentially provides a means for designing management decisions and programs on the basis of sound science while allowing new information and unexpected events to be used for learning and to adjust management practices.

Workshop Processes and Multiple Stakeholders

Experience: The Chairman and Program Staff of CBSG have conducted and facilitated more than 260 species and ecosystem workshops in 50 countries. Reports from these workshops are available from the CBSG Office or at *www.cbsg.org*. We have worked on a continuing basis with agencies on specific taxa (e.g., Florida panther, Atlantic Forest primates in Brazil, black-footed ferret) and have assisted in the development of national conservation strategies for other taxa (e.g., Sumatran elephant, Sumatran tiger, Mexican wolf).

Scientific Studies of Workshop Process: The effectiveness of these workshops as tools for eliciting information, assisting the development of sustained networking among stakeholders, impact on attitudes of participants, and in achieving consensus on needed management actions and research has been extensively debated. We initiated a scientific study of the process and its long-term aftermath four years ago in collaboration with an independent team of researchers (Westley and Vredenburg, 2003). A survey questionnaire is administered at the beginning and end of each workshop. They have also conducted extensive interviews with participants in workshops held in five countries. A book detailing our experiences with this expanded approach to Population and Habitat Viability Assessment workshops (Westley and Miller, 2003) will provide practical guidance to scientists and managers on quantitative approaches to threatened species conservation. The study also is undertaking follow up at one and two years after each workshop to assess longer-term effects. To the best of our knowledge there is no comparable systematic scientific study of conservation and management processes. *We would apply the same scientific study tools to the workshops in this program and provide an analysis of the results after the workshop.*

CBSG Workshop Toolkit

Our basic set of tools for workshops include: small group dynamic skills; explicit use in small groups of problem restatement; divergent thinking sessions; identification of the history and chronology of the problem; causal flow diagramming (elementary systems analysis); matrix methods for qualitative data and expert judgments; paired and weighted ranking for making comparisons between sites, criteria, and options; utility analysis; stochastic simulation modeling for single populations and metapopulations; and deterministic and stochastic modeling of local human populations. Several computer packages are used to assist collection and analysis of information with these tools. We provide training in several of these tools in each workshop as well as intensive special training workshops for people wishing to organize their own workshops.

Stochastic Simulation Modeling

Integration of Biological, Physical and Social Factors: The workshop process, as developed by CBSG, generates population and habitat viability assessments based upon in-depth analysis of information on the life history, population dynamics, ecology, and history of the populations. Information on demography, genetics, and environmental factors pertinent to assessing population status and risk of extinction under current management scenarios and perceived threats are assembled in preparation for and during the workshops. Modeling and simulations provide a neutral externalization focus for assembly of information, identifying assumptions, projecting possible outcomes (risks), and examining for internal consistency. Timely reports from the workshop are necessary to have impact on stakeholders and decision makers. Draft reports are distributed within 3-4 weeks of the workshop and final reports within about three months.

Human Dimension: We have collaborated with human demographers in several CBSG workshops on endangered species and habitats. They have utilized computer models incorporating human population characteristics and events at the local level in order to provide projections of the likely course of population growth and the utilization of local resources. This information was then incorporated into projections of the likely viability of the habitat of the threatened species and used as part of the population projections and risk assessments. We are preparing a series of papers on the human dimension of population and habitat viability assessment. It is our intention to further develop these tools and to utilize them as part of the scenario assessment process.

Risk Assessment and Scenario Evaluation: A stochastic population simulation model is a kind of model that attempts to incorporate the uncertainty, randomness or unpredictability of life history and environmental events into the modeling process. Events whose occurrence is uncertain, unpredictable, and random are called stochastic. Most events in an animal's life have some level of uncertainty. Similarly, environmental factors, and their effect on the population process, are stochastic - they are not completely random, but their effects are predictable within certain limits. Simulation solutions are usually needed for complex models including several stochastic parameters.

There are a host of reasons why simulation modeling is valuable for the workshop process and development of management tools. The primary advantage, of course, is to simulate scenarios and the impact of numerous variables on the population dynamics and potential for population extinction. Interestingly, not all advantages are related to generating useful management recommendations. The side-benefits are substantial.

- Population modeling supports consensus and instills ownership and pride during the workshop process. As groups begin to appreciate the complexity of the problems, they have a tendency to take more ownership of the process and the ultimate recommendations to achieve workable solutions.
- Population modeling forces discussion on biological and physical aspects and specification of assumptions, data, and goals. The lack of sufficient data of useable quality rapidly becomes apparent

and identifies critical factors for further study (driving research and decision making), management, and monitoring. This not only influences assumptions, but also the group's goals.

- Population modeling generates credibility by using technology that non-biologically oriented groups can use to relate to population biology and the "real" problems. The acceptance of the computer as a tool for performing repetitive tasks has led to a common ground for persons of diverse backgrounds.
- Population modeling explicitly incorporates what we know about dynamics by allowing the simultaneous examination of multiple factors and interactions - more than can be considered in analytical models. The ability to alter these parameters in a systematic fashion allows testing a multitude of scenarios that can guide adaptive management strategies.
- Population modeling can be a neutral computer "game" that focuses attention while providing persons of diverse agendas the opportunity to reach consensus on difficult issues.
- Population modeling results can be of political value for people in governmental agencies by providing support for perceived population trends and the need for action. It helps managers to justify resource allocation for a program to their superiors and budgetary agencies as well as identify areas for intensifying program efforts.

Modeling Tools: At the present time, our preferred model for use in the population simulation modeling process is called *VORTEX*. This model, developed by Bob Lacy (Chicago Zoological Society), is designed specifically for use in the stochastic simulation of the extinction process in small wildlife populations. It has been developed in collaboration and cooperation with the CBSG PHVA process. The model simulates deterministic forces as well as demographic, environmental, and genetic events in relation to their probabilities. It includes modules for catastrophes, density dependence, metapopulation dynamics, and inbreeding effects. The *VORTEX* model analyzes a population in a stochastic and probabilistic fashion. It also makes predictions that are testable in a scientific manner, lending more credibility to the process of using population-modeling tools.

There are other commercial models, but presently they have some limitations such as failing to measure genetic effects, being difficult to use, or failing to model individuals. *VORTEX* has been successfully used in more than 100 PHVA workshops in guiding management decisions. *VORTEX* is general enough for use when dealing with a broad range of species, but specific enough to incorporate most of the important processes. It is continually evolving in conjunction with the PHVA process. *VORTEX* has, as do all models, its limitations, which may restrict its utility. The model analyzes a population in a stochastic and probabilistic fashion. It is now at Version 9.5 through the cooperative contributions of dozens of biologists. It has been the subject of a series of both published and in-press validation studies and comparisons with other modeling tools. More than 2000 copies of *VORTEX* are in circulation and it is being used as a teaching tool in university courses.

We use this model and the experience we have with it as a central tool for the population dynamic aspects of the Workshop process. Additional modules, building on other simulation modeling tools for human population dynamics (which we have used in three countries) with potential impacts on water usage, harvesting effects, and physical factors such as hydrology and water diversion will be developed to provide input into the population and habitat models which can then be used to evaluate possible effects of different management scenarios. No such composite models are available.

CBSG Resources as a Unique Asset

Expertise and Costs: The problems and threats to endangered species everywhere are complex and interactive with a need for information from diverse specialists. No agency or country encompasses all of the useful expert knowledge. Thus, there is a need to include a wide range of people as resources and analysts. It is important that the invited experts have reputations for expertise, objectivity, initial lack of local stake, and for active transfer of wanted skills. CBSG has a volunteer network of more than 800 experts with about 250 in the USA. More than 3,000 people from 400 organizations have assisted CBSG on projects and participated in workshops on a volunteer basis contributing tens of thousands of hours of time. We will call upon individual experts to assist in all phases of this project.

Indirect cost contributions to support: Use of CBSG resources and the contribution of participating experts provide a matching contribution more than equaling the proposed budget request for projects.

Reports: Draft reports are prepared during the workshop so that there is agreement by participants on its content and recommendations. Reports are also prepared on the mini-workshops (working groups) that will be conducted in information gathering exercises with small groups of experts and stakeholders. We can print reports within 24-48 hours of preparation of final copy. We also have CD-ROM preparation facilities, software and experience.

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