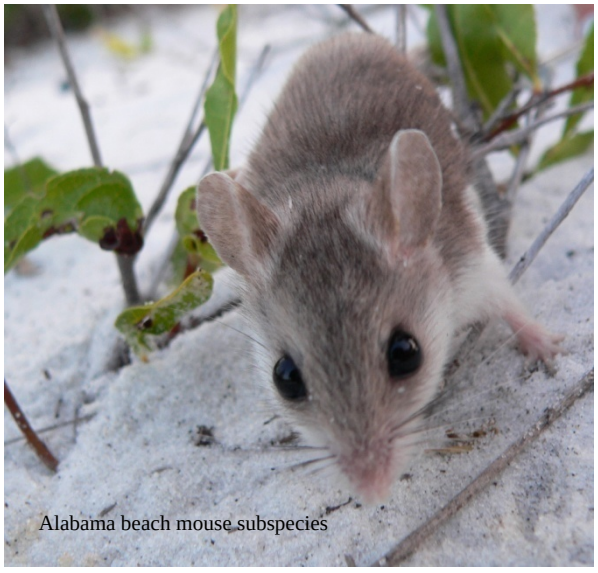
Alabama Beach Mouse
(Peromyscus polionotus ammobates, Bowen 1968*)*

5-Year Review:
Summary and Evaluation



Alabama beach mouse subspecies

U.S. Fish and Wildlife Service
Southeast Region
Alabama Ecological Services Field Office
Daphne, Alabama

5-YEAR REVIEW

Alabama Beach Mouse/*Peromyscus polionotus ammobates*

I. GENERAL INFORMATION

A. Methods used to complete the review

This review was completed by the U.S. Fish and Wildlife Service (Service), Alabama Field Office in Daphne, Alabama. Information sources include the Recovery Plan for the Choctawhatchee Beach Mouse, Perdido Key Beach Mouse, and Alabama Beach Mouse (Service 1987), peer-reviewed scientific publications, unpublished reports, ongoing field survey and research results, information from Service and State biologists, the final rule listing the subspecies, and recently revised critical habitat (72 FR 4329). All literature and documents used for this review are on file at the Alabama Field Office. All recommendations resulting from this review are the result of thoroughly reviewing the best available information on the Alabama beach mouse (ABM). Comments and suggestions regarding this review were received from peer reviewers from outside the Service (see Appendix A). No part of the review was contracted to an outside party. In addition, this review was announced to the public on September 8, 2006 (71 FR 53127) with a 60-day comment period. Comments received were evaluated and incorporated as appropriate.

B. Reviewers

Southeast Region – Kelly Bibb, 404-679-7132

Alabama Ecological Services Field Office (Lead) – Rob Tawes, 251-441-5830; Carl Couret, 251-441-5868; Dianne Ingram, 251-441-5839; Darren LeBlanc, 251-441-6638

South Florida Field Office – Sandra Sneckenberger, 772-562-3909

Bon Secour National Wildlife Refuge – Jereme Phillips, 251-540-7720; Jackie Isaacs, 251-540-8523

Peer Reviewers – Iowa State University – Matt Falcy, Colorado Division of Wildlife - Jonathan Runge, Wildlife Biologist - Claudia Frosch, Alabama Department of Conservation and Natural Resources – Roger Clay

C. Background

1. **FR Notice citation announcing initiation of this review:** September 8, 2006; 71 FR 53127

2. **Species status:** Improving (Recovery Data Call 2009); Alabama beach mouse (ABM) habitat continues to recover following the devastating hurricanes of 2004 and 2005. Hurricanes Gustav and Ike in 2008 had some impact on frontal dunes, but likely did not severely impact the population.

Habitat continues to recover from recent hurricane storm surge impacts. Based on sand tracking, the ABM's range appears to be expanding as habitat recovers to the point at which it can support beach mouse populations.

3. **Recovery achieved:** 2 (26-50% recovery objectives achieved)

4. **Listing history**
   Original Listing
   FR notice: 50 FR 23872
   Date listed: June 6, 1985
   Entity listed: Subspecies
   Classification: Endangered

5. **Associated rulemakings**
   Critical habitat was designated at the 1985 listing and revised on January 30, 2007 (72 FR 4329).

6. **Review History**
   Recovery Plan, August 12, 1987
   Recovery Data Calls: 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, and 2009
   The Service conducted a five-year review for this species in 1991(56 FR 56882). In this review, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors or threats as they pertain to the individual species. The notice stated that the Service was seeking any new or additional information reflecting the necessity of a change in the status of the species under review. The notice indicated that if data were available warranting a change in a species' classification, the Service would propose a rule to modify the species' status. No change in listing classification was found to be appropriate.

7. **Species' Recovery Priority Number at start of review (48 FR 43098):** 3c.
   The ABM is assigned a recovery priority of 3c because the degree of threat to its persistence is high, and its potential for recovery is great if threats can be eliminated or minimized. Recovery of the ABM is in conflict with economic activities, a factor which further elevates its priority ranking.

8. **Recovery Plan**
   Name of plan: Choctawhatchee Beach Mouse, Perdido Key Beach Mouse, and Alabama Beach Mouse Recovery Plan
   Date issued: August 12, 1987

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

1. Is the species under review listed as a DPS? No.

2. Is there relevant new information that would lead you to consider listing this species as a DPS in accordance with the 1996 policy? No.

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria?

No. The approved recovery plan for the ABM (Service 1987) contains objective downlisting criteria (*e.g.*, maintenance of three distinct and self-sustaining populations; minimum 50 percent of the critical habitat is protected and occupied). However, these criteria are not measurable, in part, because of the difficulty in defining "distinct and self-sustaining populations" and "protected and occupied." The Plan also states "…due to the extensive and permanent loss of habitat for these beach mice, it will probably never be possible to safely remove them entirely from the protection of the (Endangered Species) Act." The Plan is currently under revision to provide objective and measurable recovery criteria based upon the most recent information on the subspecies. The subspecies currently does not meet downlisting criteria specified in the Plan.

We currently have one metapopulation of ABM which has been temporarily divided into two local and sustainable subpopulations when storms severely impact the frontal dune system. We conduct periodic monitoring and are in the process of reassessing the Service's sampling protocols to improve its monitoring and management values, revising the recovery plan to incorporate new habitat and population information, and modifying our GIS-based range maps for ABM to better track population demographics. About 60% of the ABM's range (1546 acres) currently occurs on public land. These public lands are adjacent to about 8 miles of Alabama's coastline (Service 2009).

C. Updated Information and Current Species Status

1. Biology and Habitat

The Alabama beach mouse, *Peromyscus polionotus ammobates* (ABM) is one of five subspecies of the oldfield mouse that inhabit coastal dune communities along the northern coast of the Gulf of Mexico. It is a nocturnal rodent that burrows in primary and secondary (i.e., frontal) dunes and scrub (i.e., tertiary and interior scrub) dunes, and feeds on a variety of dune and scrub plants and insects (Rave and Holler 1992, Moyers 1996, Sneckenberger 2001). Its historic range extends from the tip of the Fort Morgan Peninsula in the west to Perdido Pass and Ono Island in the east in Baldwin County, Alabama (50 FR 23872, Holliman 1983, Meyers 1983, Holler and Rave 1991) (Figure 1). For more information on ABM biology, please refer to the listing rule (50 FR 23872) or the 1987 Recovery Plan. For more information on habitat, especially portions of the scrub habitat now considered to be essential to ABM conservation, please refer to the

recent critical habitat proposed and final rules (71 FR 5515 and 72 FR 4329), respectively.

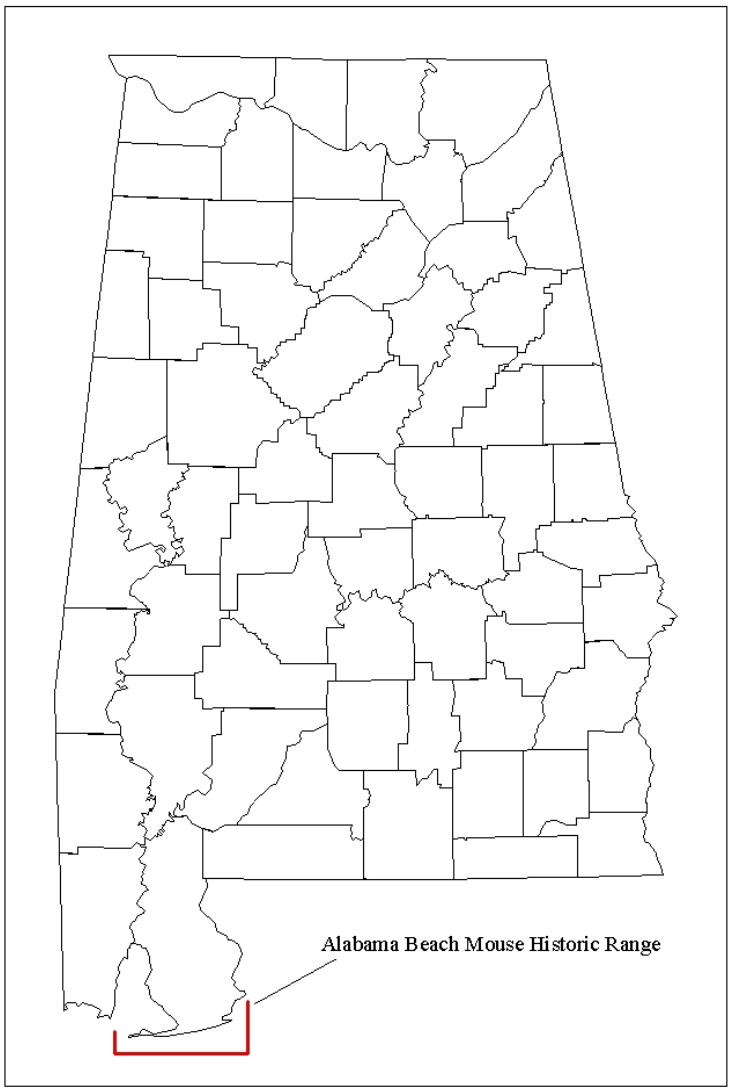


Figure 1: Historic Range of the Alabama Beach Mouse

a. New information on the species' biology and life history

Additional biological and life history information has become available since the 1987 recovery plan. Beach mice are believed to be generally monogamous, but paired males may sire extra litters with unpaired females (Smith 1966, Foltz 1981, Lynn 2000). Beach mice are considered sexually mature at 55 days of age, but some are capable of breeding earlier (Weston 2007). Gestation averages 28 to 30 days (Weston 2007) and the average litter size is four pups (Fleming and Holler 1990). ABM populations reach peak numbers in late autumn continuing into

early spring (Rave and Holler 1992; Holler, *et al.* 1997). During winter, breeding activity and reproductive success are higher, in contrast to the summer when population numbers and reproductive success are lower (Rave and Holler 1992). Apparently, pup survival and subadult recruitment increase in autumn and winter when food resources are more abundant (Rave and Holler 1992). Pregnant and lactating beach mice have been observed in all seasons (Moyers *et al.* 1999). Rave and Holler (1992) and Swilling and Wooten (2002) both observed a 1:1 sex ratio in captured mice.

Survival rate estimates (products of true survival and site fidelity) of beach mice along the Gulf Coasts of Florida and Alabama suggested that their average life span is about nine months (Swilling 2000). Rave and Holler (1992) found that 63 percent of ABM lived (or remained in the trapping area) for four months or less, 37 percent lived five months or greater, and two percent lived 12 to 20 months. Interestingly, mice dispersing further away from their natal home range have been shown to have longer persistence times, perhaps due to reduced predation rates (Swilling and Wooten 2002).

Moyers' (1996) study of the food habits of the ABM and two other beach mouse subspecies indicates that beach mice eat a wide variety of fruits and seeds, ranging from sea oats (*Uniola paniculata*) to maritime bluestem (*Schizachryium maritimum*), insects, and arachnids. Sneckenberger (2001) found that ABM also eat scrub oak acorns, and select them frequently during food preference trials.

Trapping data indicate that ABM use of certain habitat types (e.g., frontal and tertiary dunes) is preferential over other habitat types (e.g., dense interior scrub, permanent wetlands and maritime forest) within their range, and the availability of storm refugia (tertiary dune habitat) is critical during hurricanes. These observations are supported by data in a number of surveys and reports, including Holler and Rave (1991), Rave and Holler (1992), Swilling *et al.* (1996, 1998), Swilling (2000), Neal and Crowder (2001), Sneckenberger (2001), Swilling and Wooten (2002), and Service trapping data.

b. Abundance, population trends, demographic features, or demographic trends

ABM detection/non-detection data, along with some demographic data, are collected routinely as part of Habitat Conservation Plan (HCP) and associated Incidental Take Permit (ITP) monitoring efforts. Presently seven multi-family ITP holders trap from one to four times per year in ABM habitat preserved under their HCPs. Occasional range-wide detection/non-detection trapping has also been conducted (Service 2003 and 2008, Danielson and Falcy 2008). These data identify the current temporal and spatial distribution of beach mice, but do not provide us with accurate range-wide population or abundance estimates.

Since the late 1980s, more robust grid-based sampling has been conducted intermittently on various areas within the Bon Secour National Wildlife Refuge (BSNWR) by various researchers and the Service. Analysis of these long-term trapping data has shown that ABM densities are cyclic and fluctuate by orders of magnitude on a seasonal and annual basis (Rave and Holler 1992, Holler, *et al.* 1997, Swilling *et al.* 1998, Sneckenberger 2001). These population fluctuations can be a result of varying reproduction rates, food availability, habitat quality and quantity, catastrophic events, disease and predation pressures (Blair 1951, Bowen 1968, Smith 1971, Hill 1989, Rave and Holler 1992, Swilling *et al.* 1998, Swilling 2000, Sneckenberger 2001). Tropical cyclones and hurricanes have a profound impact on ABM populations and habitat, as seen with Hurricanes Frederic (1979), Elena (1985), Opal (1995), and more recently Ivan (2004) and Katrina (2005) (Holliman 1983, Rave and Holler 1992, Swilling *et al.* 1998, Service 2004 and 2005a, and Conroy and Runge 2008).

Grid trapping data, combined with data from HCP monitoring and other detection/non-detection survey efforts, have given the Service insight into the impact of the 2004 and 2005 hurricane seasons on local ABM populations and habitat recovery following storm events. We have witnessed a slow expansion of occupied ABM habitat over the last three years as mice have begun to recolonize areas previously impacted by Hurricanes Ivan and Katrina (Danielson and Falcy 2008, Service 2008). However, the estimated available ABM habitat has been declining due to habitat loss from coastal development and temporary habitat recovery delays from hurricane impacts since we began tracking in 2003 (Service 2003, 2005b, 2008). Trapping data suggest that ABM were extirpated from Gulf State Park (GSP) and Laguna Key/West Beach after Hurricane Ivan (Volkert 2005), but in 2008 they have begun to recolonize Laguna Key/West Beach (Barbara Allen, U.S. Fish and Wildlife Service (retired), per. comm. 2008). Natural recolonization at GSP is unlikely because it has become isolated from extant ABM populations to the west by high density development in Gulf Shores, and had not recolonized naturally following other extirpation events (Holliman 1983, Holler and Rave 1991, Service 2004 and 2005a, Volkert 2005).

Because of the dramatic fluctuations in local beach mouse populations (both seasonally and in response to tropical cyclones) and limited Service access to privately held ABM habitat, generating robust population estimates with precise confidence levels is difficult at best. Consequently, the Service has chosen to monitor ABM incidental take and status through periodic on-the-ground inspections to ensure that ITP holders are following their permit requirements, and to document changes in the distribution of occupied and available ABM habitat. Spatial distribution and trends are discussed in more detail in section II.C.1.e.

Population Viability Analyses (PVA)

Population viability analyses (PVA) (Shaffer 1981, Woodruff 1989) and population and habitat viability analyses (PHVA) (Lacy 1993/1994) are quantitative models used to assess the varied factors that impact the survival and long-term viability (i.e., extinction risks or population status) of a given species (Morris and Doak 2002). These models organize multiple threats to the survival of a species or population into a single analysis and provide a framework to identify population risk factors (Gilpin and Soulé 1986). There is much debate within the scientific community regarding the value of PVAs in management actions and conservation decision-making. The general consensus is that estimates of extinction probabilities (PE) derived from PVAs should be interpreted with caution and full acceptance of model caveats (Morris *et al.* 1999, Brook *et al*. 2002, Morris and Doak 2002). However, most authors propose that PVAs are extremely valuable for comparing various management scenarios, and identifying data gaps and risk factors (Brook *et al*. 2002, Ellner *et al*. 2002, Morris and Doak 2002).

Various PVAs have been attempted to better understand ABM population dynamics, management scenario effects, and long-term ABM population viability. Initial PVA modeling was conducted by Sankaran (1993), but he did not have the benefit of current ABM demographic information. The Oli *et al*. (2001) PVA model included ABM life history, but did not adequately consider the effects of highly stochastic events, such as hurricanes. In 2004, the Service contracted the Conservation Breeding Specialist Group (CBSG) to conduct a PHVA workshop to assist in the development of PVAs for ABM. The latest information was incorporated into a computer simulation model (*Vortex*) to estimate population persistence over 100 years and identify factors having the greatest effect on ABM survival. This effort indicated that the Perdue Unit of BSNWR and adjacent undeveloped areas currently zoned for high density development are the "stabilizing portion of the overall metapopulation" because they are centrally located within the ABM range and contain most of the higher elevation habitat. This exercise also showed the importance of habitat continuity, invasive species/non-native predator control, and hurricane recovery measures in ABM conservation (Traylor-Holzer *et al*. 2005). Subsequent revisions of the PVA were conducted with CBSG in September 2004 and December 2005 (Traylor-Holzer 2005 and Reed and Traylor-Holzer 2006). These refinements to the PVA model incorporated the effects of Hurricanes Ivan and Katrina in 2004 and 2005, post-storm dune habitat restoration efforts, and adjusted estimates of storm inundation.

In summary, these PVA model simulations demonstrate the large influence tropical cyclones have on ABM population dynamics, the importance of higher elevation habitat above storm surge inundation, and the value of habitat connectivity for beach mouse conservation. Probabilities of extinction over 100 years ranged from 0.18 to 0.47 depending on a wide range of assumptions, scenarios and input values (Traylor-Holzer *et al*. 2005, Traylor-Holzer 2005, Reed and Traylor-Holzer 2006). Sensitivity testing on the model indicated that carrying capacity, storm impacts, and juvenile and adult mortality strongly

influence model results. Species populations with limited distributions can be decimated by local catastrophes such as disease, storms, or floods. Therefore, establishment of additional populations is among the primary recovery actions for this species. Additionally, ABM modeling demonstrated an increase in probability of extinction as population distributions were restricted (e.g., limited to public lands only) (Oli *et al.* 2001, Danielson 2005, Traylor-Holzer 2005, Traylor-Holzer *et al.* 2005, Reed and Traylor-Holzer 2006, Service 2006). A good illustration of the value of multiple populations is the Perdido Key beach mouse whose two remaining populations originated from a GSP population that was subsequently extirpated in 1999 (Holler *et al.* 1999, Sneckenberger 2001).

Vortex models produce single measures of risk and are strongly sensitive to model assumptions (Oli *et al.* 2001, Traylor-Holzer *et al.* 2005, Traylor-Holzer 2005, Reed and Traylor-Holzer 2006). Consequently, we view these model results as qualitative assessments of the species' well being and as estimates of relative responses of each modeled subpopulation under certain scenarios (Hamilton and Moller 1995, Service 2006).

Ongoing Analyses

In an effort to review existing trapping protocol and investigate opportunities for improvement, the Service contracted with Conroy and Runge (2008) at the University of Georgia/U.S. Geological Survey Georgia Fish and Wildlife Cooperative Unit to review all existing trapping data. Their report indicates that past trapping protocols for ABM used procedures that could lead to incorrect inferences. They believe that linear trap transects would sample target areas in a non-random and non-representative manner which could lead to false estimates of abundance, density and other parameters in patchily distributed local populations, such as ABM. They also believe that conducting trapping sessions 1 to 3 times per year would not capture important seasonal and annual variation in local ABM abundance and recruitment. They suggested an alternative design that involves 2-stage sampling to jointly estimate occupancy and abundance. The first stage would involve collecting ABM presence/absence data (track/sign, track tubes or traps) (MacKenzie *et al.* 2006) and the second stage would involve collecting capture-recapture data, if ABM are present (Williams *et al.* 2002).

Researchers from Iowa State University are also conducting detection/non-detection trapping throughout the range of the ABM, to investigate population expansion following the 2004 and 2005 hurricane seasons. Data gleaned in this effort will also be used to develop a new stochastic PVA. This study is also investigating the physical and biological attributes of those areas where mice are found. An interim report in February 2008 (Danielson and Falcy 2008) suggested that ABM distribution has expanded since the 2004-2005 hurricane seasons; however, ABM densities on the Perdue Unit of the BSNWR remained extremely low until 2008-2009 when the habitat recovered sufficiently to support current population levels.

c. Genetics, genetic variation, or trends in genetic variation

An electrophoretic study conducted on 30 populations of *Peromyscus polionotus*, including ABM, estimated that the level of allozyme variation found in beach mouse populations was at least 40 percent lower than the level of variation in nearby inland populations (Selander *et al.* 1971). Wooten *et al.* (1999) isolated five microsatellite ABM loci (non-coding nuclear gene locations) and found 7-10 times the gene diversity found by Selander *et al.* (1971). Wooten and Holler (1999) examined genetic diversity of ABM through the analysis of three microsatellite loci from ABM on the Perdue Unit of the BSNWR prior to and following Hurricane Opal (1995). Interestingly, allele diversity at these three loci actually increased following the storm, suggesting hurricanes may actually increase genetic diversity by forcing mixture of local ABM populations. Hoekstra *et al.* (2006) studied an allele coding for light pelage color that was present in Florida Gulf coast beach mouse populations, but not present in ABM, inland *P. polionotus* or Atlantic coast beach mice. This suggests that light coloration in Atlantic beach mice and ABM may be a form of convergent evolution coded for by different alleles, indicating ABM are a distinct subspecies. Tenaglia *et al.* (2007) analyzed the genetic relationships of jointly captured ABM from an eight-year grid based mark-recapture study on the BSNWR and found that adult male/female joint captures were the least related genetically. They hypothesized that this may indicate kin recognition in the subspecies, a mechanism that reduces the effects of inbreeding in species with restricted distribution. This has also been supported by work on *P. p. rhodasi* (Ryan & Lacy 2003).

d. Taxonomic classification or changes in nomenclature

Since the subspecies' listing, further research concerning the taxonomic validity of beach mice subspecies has been initiated and/or conducted. Preliminary results from these studies support the separation of beach mice from inland forms, and support the currently accepted (Bowen 1968) taxonomy that each beach mouse group represents a unique and isolated subspecies (Hoekstra and Vignieri per. comm. 2006 and 2008, ITIS 2008,Van Zant 2006). Moderate levels of genetic variation, and low dispersal rates and distances are supported in Swilling and Wooten 1998, Wooten and Holler 1998, and Van Zant 2006. Van Zant 2006 also asserts that ABM populations have clusters of similar genotypes, or genetical spatial structure, that reduces the rate of genetic decay in this species.

e. Spatial distribution, trends in spatial distribution

The ABM historically occurred along about 33.5 miles of coastline in Baldwin County, Alabama, including the Fort Morgan Peninsula, Gulf Shores and Orange Beach, and Ono Island (50 FR 23872, Holliman 1983, Meyers 1983, Holler and Rave 1991). A study conducted by Holliman (1983) concluded that ABM were confined to only 333 acres of habitat and had been extirpated from Ono Island by

1982. At the time of listing, 10.6 miles of coastline were designated as critical habitat which was then occupied by the ABM (50 FR 23872). This original critical habitat designation consisted almost entirely of primary and secondary dunes. Primary constituent elements were defined as dunes and interdunal areas, and associated grasses and shrubs that provide food and cover (50 FR 23872). Because of the availability of new information on beach mouse habitat requirements and population distribution, ABM critical habitat was recently revised to cover about 1,211 ac (72 FR 4329). As of May 2008, the Service estimated that the ABM's current distribution was contained within 2,450 acres of frontal, tertiary and interior scrub habitat along an estimated 13 miles of Alabama coastline (Service 2009).

Habitat loss and fragmentation associated with residential and commercial real estate development are the primary threats contributing to the endangered status of beach mice (Holler 1992, Humphrey 1992, 71 FR 5515 and 71 FR 44976). Holliman (1983) estimated that 62 percent of all beach mouse habitats in Alabama had been lost to development between 1921 and 1983. More recent studies (Douglass *et al.* 1999, South Alabama Regional Planning Commission [SARPC] 2001) document continued growth. Coastal development has fragmented beach mouse habitat and created disjunct local populations (*e.g.*, GSP). Isolation of habitats by imposing barriers to species movement is an effect of fragmentation that equates to reduction in total habitat (Noss and Csuti 1997). Furthermore, the isolation of small local populations of animals (*e.g.*, beach mice) reduces or precludes gene flow between these populations and can result in the loss of genetic diversity (Mech and Hallett 2001).

f. Habitat or ecosystem conditions (*e.g.*, amount, distribution and suitability of the habitat or ecosystem)

The primary and secondary dunes (frontal dunes) were previously considered optimal beach mouse habitat since it is where the mice were thought to reach their highest densities (Blair 1951, Meyers 1983, Holler 1992). Because the scrub dunes appeared to support lower densities of beach mice, this habitat was believed to be of lower quality (Blair 1951, Bowen 1968). As a result, the scrub dunes were not considered of great importance to beach mice and little attention was paid to this habitat (Sneckenberger 2001). However, recent evidence indicates that scrub dunes can be an important component of beach mouse habitat (Swilling 2000, Sneckenberger 2001). Furthermore, portions of the scrub dunes appear to serve as refugia for beach mice during and after tropical storm events (Holliman 1983, Swilling *et al.* 1998), and to provide a population source for recolonization of recovering dune systems (Swilling *et al*. 1998, Sneckenberger 2001). The 2007 revision of ABM critical habitat now includes portions of the scrub dune habitat along Fort Morgan Peninsula.

g. Other natural factors (hurricanes)

The Service used 1-foot contour interval Light Detection and Ranging Data (LIDAR) aerial photography (Baldwin County 2005) and storm surge models to estimate the habitat available following various tropical cyclone events. The estimation of uninundated habitat is extremely important because beach mice surviving in these storm refugia are the individuals that recolonize impacted areas following storms. According to LIDAR data, about 232 acres of ABM habitat occur above the 12-foot contour interval (estimated wrack line elevation from aerial photography of Gulf Highlands after Hurricane Ivan). According to an overlay of ABM habitat with a storm surge estimates from the SLOSH (for Sea, Lake, and Overland Surge from Hurricanes) model used in the Alabama Hurricane Evacuation Study (U.S. Army 2001), about 382 and 185 acres would remain above flood waters during Category 3 and 5 hurricanes, respectively. A study completed by ENSR (2004) employing different models and methods estimated that 841 acres would not be inundated along the Fort Morgan Peninsula during the 100-year flood event. Finally, Chen & Wang (2007) estimated that 393 acres, primarily tertiary dunes and scrub, would remain uninundated along the Peninsula during the 100-year flood event.

2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

a. Present or threatened destruction, modification or curtailment of its habitat or range:

Habitat loss and fragmentation: Habitat loss and fragmentation associated with residential and commercial real estate development are the primary threats contributing to the endangered status of beach mice (Holler 1992, Humphrey 1992, 71 FR 5515, 71 FR 44976). Isolation of small local populations of beach mice reduces or precludes gene flow between these populations and can result in the loss of genetic diversity. Demographic factors, such as predation (particularly by cats), disease and competition, are intensified in small, isolated local populations which may be rapidly extirpated by these pressures. Especially when coupled with events, such as tropical storms, reduced food availability and/or reduced reproductive success, isolated local populations may experience severe declines or extirpation (Caughley and Gunn 1996, 71 FR 5515).

The 1987 Recovery Plan states “Alteration and destruction of beaches have been, and continue to be, the greatest threats to survival of the three beach mice.” This continues to be true today, although it is not just the alteration and destruction of primary, secondary and tertiary dunes but also scrub habitat. The ABM’s distribution currently lies within about 2,450 acres. It is likely that the amount of habitat available to this subspecies, and possibly its distribution, will be reduced from the cumulative effects of continued development, such as Batch 4 (permit for 41 low impact single-family residences impacting about 4 acres), General Conservation Plan (permit for the remaining undeveloped single-family residential lots potentially impacting up to 75 acres), and the Beach Club West-

Gulf Highland Project (seven condominiums and associated facilities impacting up to 60 acres).

Southern Baldwin County, which lies on the Gulf of Mexico, is a rapidly growing recreational and residential area, and is also attracting commercial interests (Alabama Gulf Coast Chamber of Commerce 2007). Much of the privately owned land along the gulf shoreline has been developed for these purposes. Shoreline developments consist of hotels, motels, restaurants, high- and low-rise condominiums, single-family dwellings, duplexes and golf courses. Areas from the Florida-Alabama state line west to Gulf Shores are more intensively developed than are areas of the Fort Morgan Peninsula, which extend westward from Gulf Shores for approximately 15 miles, terminating at Fort Morgan. Low- to moderate-density single-family residences, many of which are rented to vacationers or seasonal residents, are still the dominant developmental feature of the Peninsula shoreline. Few large, undeveloped beachfront tracts in private hands remain on the Fort Morgan Peninsula. According to Baldwin County Planning and Zoning Department, the region of the Peninsula with the most development activity is the region between the Little Point Clear Unit and the Perdue Unit of BSNWR.

The Coastal Programs Section of the Alabama Department of Conservation and Natural Resources contracted the SARPC to produce a document that, while not directly addressing area economics, included factors which impact the local economy of the Fort Morgan Peninsula (SARPC 2001). Based on capacity population projections, SARPC (2001) concluded that Ft. Morgan would ". . . likely be comparable to seasonal and permanent populations of the cities of Gulf Shores and Orange Beach. However, the opportunity still exists to manage the associated development to allow for the protection of the environment and the provision of public access to beaches." SARPC (2001) suggested that, only by undertaking a strategic planning process that includes projecting future conditions, could decision makers of today plan for providing essential services such as emergency response and environmental protection.

In April 2003, Federal Emergency Management Agency (FEMA) conducted a review of the National Flood Insurance Program (NFIP) in Baldwin County and the City of Gulf Shores. FEMA determined that these programs had not been in compliance with NFIP regulations. As a result, FEMA formally recommended that no building permit applications for the Fort Morgan Peninsula be issued until the individual applicant can demonstrate that full compliance with the Act has been achieved. Compliance can be met through either gaining a letter from the Service indicating that the project is not likely to take endangered or threatened species or through obtaining an ITP or section 7 incidental take authorization for the project.

Douglass *et al.* (1999) noted that 72 percent of beachfront areas in Baldwin County were undeveloped in 1970, and that only three percent of beachfront

development comprised parcels with hotels and condominiums. By 1996, the percentage of undeveloped beachfront land decreased to 39 percent, and condominiums/hotels comprised 22 percent of County beachfronts. Beachfront lands with single-family homes demonstrated modest increases from 25 percent in 1970 and 33 percent in 1983 to 39 percent in 1996. Overall, development of Baldwin County's beachfront lands more than doubled between 1970 (28 percent) and 1996 (61 percent). Large portions of the undeveloped beachfront tracts are within Fort Morgan Unit, (448 acres/2.4 shoreline miles) and the Perdue Unit of the BSNWR (2,628 acres/3.7 shoreline miles) (SARPC 2001). In addition, Gulf State Park contains 130 ac/2.2 shoreline miles of mostly undeveloped beachfront.

Development on the Fort Morgan Peninsula (i.e., the western half of Baldwin County's coastal lands) was extremely limited prior to 1980 (SARPC 2001). By 1996, lands amenable to further development in Orange Beach and Gulf Shores had dwindled. Major features of the Peninsula now include single-family units along roads, residential subdivisions, duplexes, small condominiums, and large, high-rise condominiums.

The conservation of multiple large, contiguous tracts of habitat is essential to the persistence of beach mice. At present, large parcels exist mainly on public lands. Protection, management and recovery of beach mice on public areas have been complicated by increased recreational use as public lands are rapidly becoming the only natural areas left on the coast. Public lands and their managers are now under pressure to manage for both the recovery of endangered species and recreational use. Where protection of large contiguous tracts of beach mouse habitat along the coast is not possible, establishing multiple and widely distributed independent local populations is likely the best defense against range-wide extinctions due to storms and other stochastic events (Shaffer and Stein 2000, Oli *et al.* 2001, Danielson 2005, 71 FR 5515 and 71 FR 44976).

Habitat connectivity also becomes essential where mice occupy fragmented areas lacking one or more habitat types. For instance, when food or burrow sites are scarce in the frontal dunes (e.g., seasonally or after hurricanes), beach mouse access to connected tracts (e.g., scrub or other frontal dune habitat) that provide these resources is important in maintaining local beach mouse populations and distributions. Trapping data suggests that beach mice occupying the scrub following hurricanes recolonize the frontal dunes once vegetation and some dune structure have recovered (Swilling *et al.* 1998, Sneckenberger 2001). Similarly, when frontal dune habitat is lacking from a tract and a functional pathway to frontal dune habitat does not exist, beach mice may not be able to obtain the resources necessary to expand the local population and reach the densities necessary to persist through the harsh summer season or the next storm. Functional pathways may allow for natural behavior, such as dispersal and exploratory movements, as well as gene flow, to maintain genetic variability of the population within fragmented or isolated areas. To that end, contiguous tracts

or functionally connected patches of suitable habitat are essential to the long-term conservation of beach mice.

Despite the ABM's restricted range, a number of guidelines, conservation measures, and regulatory mechanisms are in place to minimize impacts to ABM and their habitat. The Service is involved in almost all projects occurring throughout its range via sections 7 (consultations) or 10 (habitat conservation plans) of the Endangered Species Act. Through consultation and coordination with Service biologists, many project-related impacts on ABM are avoided or minimized by the implementation of conservation measures, such as reducing development footprint sizes, using native landscaping, employing wildlife friendly outdoor lighting, controlling free-roaming house cats, using scavenger-proof trash containers, and construction of dune walkovers on beachfront lots. Other regulatory protections (see II.C.2.d.) also exist for the subspecies.

Several projects are underway that aid in ABM recovery, such as annual beach dune revegetation partnerships with local schools, a cost-share dune restoration project for private lands in participation with the Baldwin County Soil and Water Conservation District, dune restoration workshops, and artificial lighting workshops.

In the past, ABM persisted in spite of local extirpations from storms and other harsh, stochastic events in coastal ecosystems. Historically, increasing beach mouse populations from adjacent occupied or refuge habitats would rapidly invade areas where local populations had been eliminated or early succession habitat created. These new local populations would expand for several years until habitat succession progressed and habitat suitability declined. This would lead to localized, often dramatic fluctuations in allele frequencies (Wooten 1994). This naturally dynamic nature of ABM populations is well suited to persistence in changing habitat, such as coastal dunes. The species' ability to withstand bottlenecks suggests that it can recover very well from population size reductions (Wooten 1994), provided sufficient habitat is available for population expansion. With continued fragmentation from residential and commercial development, beach mice are unable to recolonize these areas as they did in the past (Holliman 1983). The current distribution of ABM along the Alabama coastline is much more restricted and fragmented as compared to historic conditions. Consequently, it is more likely that a hurricane making landfall in or near Alabama could impact the entire range of the subspecies. It is reasonable to conclude that the restoration of relatively contiguous tracts of suitable ABM habitat over a wider area with multiple independent local populations would improve the probability of ABM persistence (Shaffer and Stein 2000, Oli *et al.* 2001, Danielson 2005, 71 FR 5515 and 71 FR 44976).

b. Overutilization for commercial, recreational, scientific, or educational purposes

Overutilization of the species for commercial, recreational, and educational purposes has never been a threat for this subspecies. There have been mortalities in the past from trapping activities (*e.g.*, some Service-sponsored research and HCP monitoring efforts). Mice are occasionally caught in live trap doors or killed by fire ants (*Solenopsis invicta*). For this reason, we completed a programmatic biological opinion on the issuance of section 10(a)(1)(A) permits. This opinion provides trapping protocol, guidelines and procedures. The opinion allows the incidental take of eight ABM per year for scientific purposes.

c. Disease or predation

Natural predators: Beach mice have a number of natural predators including, but not limited to, the coachwhip (*Masticophis flagellum*), corn snake (*Elaphe guttata guttata*), pygmy rattlesnake (*Sistrurus miliarius*), Eastern diamondback rattlesnake (*Crotalus adamanteus*), short-eared (*Asio flammeus*) and great-horned owl (*Bubo virginianus*), great blue heron (*Ardea herodias*), northern harrier (*Circus cyaneus*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), skunk (*Mephitis mephitis*), weasel (*Mustela frenata*), and raccoon (*Procyon lotor*) (Blair 1951, Bowen 1968, Holler 1992, Novak 1997, Moyers *et al.* 1999, Van Zant and Wooten 2003). Natural predation of beach mouse populations that have sufficient recruitment and habitat availability is generally not a concern. However, excessive predation pressure from natural and non-native predators may result in the extirpation of small, isolated local populations of beach mice, especially after hurricanes when both predators and prey are more concentrated in smaller and often isolated habitat patches.

Non-native predators: Free-roaming and feral cats are believed to have a devastating effect on beach mouse persistence (Bowen 1968, Linzey 1978) and are considered to be the main cause of the loss of at least one local population (Ono Island) of ABM (Holliman 1983). Past *Vortex* modeling exercises indicate that ABM could be extirpated within any model unit within a few years, assuming one cat kills one ABM per day (Traylor-Holzer *et al*. 2005). Several predators, including some coyotes, bobcats and raccoons, were removed from ABM habitat within the BSNWR and the Fort Morgan State Historic Site due to increased predation pressure immediately following Hurricane Ivan under a contract with the U.S. Department of Agriculture's Animal and Plant Health Inspection Service. Incidental take permits issued for beach mice require all developments to keep cats indoors and use scavenger-proof trash. All permits prohibit the presence of free-roaming cats.

Disease: Little is known about the diseases *Peromyscus* species may carry and their susceptibility to those diseases. In addition, *Peromyscus* are variably susceptible to parasites and many do not show up during routine fecal tests (CBSG 2007). Although diseases and parasites have been documented in beach mice (CBSG 2007), it is not known at this time if they constitute significant threats to the subspecies.

d. Inadequacy of existing regulatory mechanisms

Protections under sections 7, 9 and 10 of the Endangered Species Act of 1973 (as amended) apply to protecting ABM. The State of Alabama does not have a state endangered species act; however the ABM is protected under Nongame species regulation 220-2-.92. The Alabama Natural Heritage Program lists the species as State Protected with the highest conservation priority rank of P1. The Nature Conservancy Natural Heritage Program ranks ABM as S1, and G5T1 (species is globally secure, subspecies is critically imperiled). There are also other supportive state and city regulations and ordinances, including:

1. *Alabama Department of Environmental Management (ADEM) Coastal Area Management Program*
    a. *Coastal Construction Control Line* – ADEM requires that a permit be issued for any new construction or substantial modification of an existing structure that intersects or lies south of the coastal construction control line (CCL). This line (originally 300 feet inland from mean high tide) is described in ADEM's Administrative Code (Chapter 335-8-1) at http://www.alabamaadministrativecode.state.al.us/docs/adem/. However, only a small portion of the frontal dune system falls south of this line. As a result, the CCL affords only limited protection to ABM coastal habitats.

    b. *Other Regulations for Coastal Activities*

    ADEM Administrative Code Chapter 335-8-2: Regulates beach access and beach cleaning, and preserves beach front beaches and dunes minimizing some direct and indirect impacts to ABM and their habitat.

2. *City of Gulf Shores Lighting Ordinance* (No.1461) – This recent ordinance restricts artificial lighting to protect marine turtle nesting habitat and to prevent objectionable light trespass and glare across the property lines, and/or direct glare at any location on or off the property. The more stringent restrictions occur within a designated marine turtle conservation zone that covers most of the ABM's range, with the exception of GSP, northern portion of West Beach, BSNWR and Ft. Morgan State Historic Site. Light pollution is generally minimal or controlled at the GSP, BSNWR and Ft. Morgan State Historic Site. This ordinance provides a mechanism for protection from light pollution within ABM habitats and, as full implementation is achieved, is expected to provide increasing ABM benefits.

3. *City of Gulf Shores Setback Ordinance* – This ordinance addresses

minimum distances (10-40 feet) between structures and other boundaries, such as rights-of-way and property lines, for various zoning designations. These setbacks are not related to ABM or its habitats, but may provide space for limited dune development and/or ABM habitat preservation.

4. *Bon Secour National Wildlife Refuge* – The refuge protects some of the last remaining undisturbed ABM habitat within its range. The Refuge's Comprehensive Conservation Plan (Service 2005c) outlines the management focus as protecting sufficient space to support ABM populations and movement corridors to support genetic exchange.

e. Other natural or manmade factors affecting its continued existence

Development. According to SARPC (2001), and in Douglass *et al.* (1999), the Fort Morgan peninsula is a growing recreational and residential area. The protection, management and recovery of beach mice on public and private lands have been complicated by increased recreational use. Recreational activities and foot traffic in ABM habitat may loosen substrates, destroy vegetation, and cause the dune system to be more susceptible to erosion from wind and wave action (Service 1987). All beachfront multi-family developments and, as of 2003, single-family homes, in ABM habitat that are built under conditions of an HCP are required to build dune walkovers. This alleviates much of the problem; however, if tropical storms destroy walkovers, there is often a lag time in rebuilding the walkovers while habitat is developing.

Lighting. Artificial lighting continues to impact isolated areas of habitat throughout ABM range. The negative effects of artificial lighting are well documented for sea turtles (Witherington and Martin 2003); however, the effects of artificial lighting within the habitat of the beach mouse have not been extensively studied. Natural illumination of the dune systems due to moon phases is known to have a direct effect on beach mouse activity. As natural illumination increases beach mouse activity levels decrease (Blair 1951, Wolfe and Summerlin 1989). Bird *et al.* (2004) found that beach mouse foraging behavior was altered as a result of artificial light. They found mice behavior was altered in two ways: 1) reduction in use of foraging patches around illuminated areas, and 2) reduction in seed harvest. They also suggested that artificial lights may cause habitat fragmentation due to altered movement patterns of mice. Artificial lighting increases the risk of predation and influences beach mouse foraging patterns and natural movements as it increases their perceived risk of predation. This alteration in behavioral patterns causes beach mice to avoid otherwise suitable habitat and decreases the amount of time they are active (Bird 2004). Efforts are in place, proposed or on-going to address beachfront lighting within the range of the subspecies. In 2006, the City of Gulf Shores passed a lighting ordinance (No. 1461) that helps reduce artificial lighting impacts on beach mouse habitat. The Service is also working with the City of Orange Beach to draft a beachfront lighting ordinance. Funds may be available for retrofitting lights through the

Service's cost-share agreement with the Baldwin County Soil and Water Conservation District or other sources. The Service conducted an artificial lighting workshop in 2008 and is available to provide technical assistance for artificial lighting alternatives.

Competition with native species. Danielson and Falcy (2009) hypothesized that as ABM habitat is restricted from habitat loss due to development and hurricanes, ABM competition with native hispid cotton rats for remaining habitat may lead to extinction. Removal trials where cotton rats were relocated from areas where both species were present showed an increase in ABM captures after the cotton rats were relocated. Danielson and Falcy determined these results indicate competition for resources, not simply co-existence; removal of cotton rats would not result in an increase in ABM captures if competition for resources was not present.

Non-native species. Any activities that modify coastal dune habitats (e.g., road building, land grading and development) can create avenues for non-native species (*e.g.*, cogon grass, fire ants, house mice, and feral cats) to invade ABM habitats and impact local ABM populations. Invasive species, such as cogon grass and fire ants, prefer disturbed and/or open areas. Cogon grass is established on the Fort Morgan Peninsula and can replace native plants in ABM habitat. Native plants are important in maintaining the structure and continuity of ABM habitat, and provide food resources for the ABM. Fire ants have been known to attack beach mice in live traps and may have impacts on nesting females and their pups (D. LeBlanc pers. comm. 2008, Danielson and Falcy 2009). Conservation measures for reducing impacts from invasive species are routinely included in Endangered Species Act consultations on the Fort Morgan Peninsula. Some of these measures include: discouraging use of hay bales or Christmas trees in landscaping or habitat restoration that spread fire ants and non-native plants, equipment used in ground-disturbing activities in cogon grass areas must be washed off-site before returning, prohibiting outdoor cats, and requiring rodent-proof garbage receptacles. These conservation measures help reduce new invasions; however, invasives may need direct intervention to reduce existing impacts.

Sea Level Rise. Efforts to relate sea level rise with beach loss along Alabama's coast have been attempted by the Service, resulting in estimates up to 1 m of beach inundated for every 1 cm rise in sea level (i.e., 1 inch sea level rise $\simeq$ 8.3 ft of beach width lost by inundation (Service files). Therefore, we are concerned global climate change and sea level rise could have adverse effects on coastal ecosystems and their associated wildlife populations, including ABM. About half of the 55-mile open-water shoreline along southern Alabama has been receding 2-5 feet per year in recent decades (Bush *et al.* 2001**)**. The receding shoreline appears to be a physical response to a combination of natural events and human-caused activities such as tropical storm erosion, inland erosion, development practices, sea level rise, and basic barrier island dynamics. The rate of shoreline

retreat from sea level rise is considered a function of the slope of the inundated land and the rate of sea-level rise. In coastal areas with gentle slopes, a very small increase in sea level would cause more substantial island migration (Bush *et al.* 2001). Estimates of sea level rise along the Gulf coast range between 38 and 60 cm (15 and 24 in) during the next century (Titus and Narayanan 1995 and 1996, Wigley 1999, Davenport 2007). However, such implications for coastal change are far from clear and would likely be influenced by a number of locally varying factors, such as slope, elevation and underlying structure of the shoreline, sand availability and transport, erosion rate, and storm frequency, duration and magnitude (Emanuel 2005, Trenberth 2005, Webster *et al.* 2005, and Landsea 2005).

Hurricanes. Habitat surveys conducted after Hurricanes Ivan (2004) and Katrina (2005) (category 3 storms) indicated that detrimental impacts had occurred to most of the ABM habitat as a result of storm surge and wind-driven salt/sand spray. These hurricanes eliminated or severely damaged about 90-95 percent of the primary and secondary dune system, as well as an undetermined amount of tertiary dune and scrub dune habitat (Service 2004 and 2005a). Additional hurricane impacts included the deposition of sand and woody debris within the ABM's range and a substantial reduction in coastal dune vegetation. Flood damage also occurred to ABM habitat as a result of heavy rainfall during April 2005 which inundated much of the interior scrub habitat. More recent impacts to ABM habitats occurred when two strong category 2 hurricanes, Gustav and Ike, made landfall in central Louisiana on September 1, 2008, and west Texas on September 13**,** 2008, respectively. However, their effects were limited ($\leq$ 10 percent of ABM rangewide habitat impacted) and mainly within the primary dune system (Darren LeBlanc, per. comm. 2008). Most impacts occurred on the western half of the peninsula, particularly at Fort Morgan where about 1.0 mile of post-Katrina sand fencing and dune restoration was destroyed (Jereme Phillips and Darren LeBlanc, per. comm. 2008).

Hurricanes affect beach mouse population densities to varying degrees. Possible mechanisms for adverse effects include direct mortality of individuals, relocation/ dispersal, predator/competitor relationships and subsequent long-term effects of habitat alterations (*i.e.*, impact on food resource availability and dune structure). Habitat impacts can be isolated and limited to low lying areas along the coast, or widespread and encompass the entire range of the subspecies (Service 2004, 2005a).

Specifically, hurricanes affect ABM habitat in the following ways:

1) tidal surge and wave action over wash habitat leaving a flat sand surface denuded of vegetation;
2) sand deposition completely or partially covers vegetation;
3) blowouts occurs between the Gulf and inland areas leaving a patchy landscape of bare sand, dune and scrub habitat;

4) the frontal portion of the primary dune habitat is sheared (damage to landward areas varies in severity);
5) vegetation is killed by salt spray; and
6) islands may be breached entirely and channels between the Gulf and inland waters may be created.
7) post-hurricane clean up activities and recovery efforts may inadvertently introduce or transport exotic plants (cogon grass) that outcompete native plants, directly impact surviving animals by heavy equipment moving sand, and leave debris piles that may provide refuge for predators and/or competitors.

Although hurricanes can significantly alter ABM habitat and population densities in certain habitats, some physical effects may benefit the subspecies. Hurricanes are responsible for maintaining coastal dune habitat upon which beach mice depend through repeated cycles of destruction, alteration and recovery of dune habitat. Hurricanes could function to "break up" local populations and familial subgroups, and force population mixing (Holler *et al.* 1999). The resultant breeding between members of formerly isolated subgroups increases genetic heterogeneity and could moderate effects of genetic drift and bottlenecks (Holler 1994, Wooten and Holler 1999).

D. Synthesis

No change is recommended to the classification or priority ranking of the endangered Alabama beach mouse. The degree of threat to its persistence remains high. It is a subspecies with a high level of taxonomic distinctness, and its potential for recovery is great if continuing potential threats (*e.g.*, habitat loss and fragmentation from development) are reduced/minimized. However, ABM recovery is often in conflict with economic activities, more so today than at the time of listing, which justifies its endangered classification and further elevates its priority ranking.

The approved recovery plan for ABM (Service 1987) does not contain recovery criteria, and the downlisting criteria are not entirely objective and measurable. The Plan does not contain the latest information on the species' life history, habitat use, population status and current threats. The subspecies currently does not meet downlisting criteria specified in the Plan. Impacts to ABM and ABM habitat, both natural and anthropogenic, are continuing. While the population has been recovering from the active 2004 and 2005 hurricane seasons, there has been a net loss of habitat from development actions. Although up to about 2,450 acres of ABM habitat remain, much of this area is subject to erosion, inundation and/or salt spray during storm events. To date, the eastern portion of West Beach and all of GSP (totaling about 130 ac along 3 miles of shoreline) remain unoccupied by ABM as a result of Hurricanes Ivan/Katrina. Consequently, the distribution of ABM across its range has been substantially reduced since these 2004-5 hurricanes, and will remain so until ABM reintroductions are successfully accomplished at GSP.

Regulatory mechanisms are in place to avoid and minimize impacts to privately-held ABM habitat to the maximum extent practicable, and to minimize impacts to (and recover) the subspecies on public lands. However, the subspecies' rangewide habitat requirements, and extent of ABM resilience to hurricane impacts, and tolerance of fragmentation from human development are not fully known. In view of this information, we conclude that the subspecies remains vulnerable to extinction throughout all or a significant portion of its range, and therefore should remain on the endangered list.

III. RESULTS

A. Recommended Classification

__X__ No change is needed

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

A. Revise the 1987 ABM Recovery Plan

The revision of the 1987 Recovery Plan should be completed to reflect the current status and threats to the ABM, and measurable recovery criteria, objectives and tasks should be developed.

B. Emergency Response Plan

A contingency plan should be developed to outline actions taken in case of severe threats to the persistence of ABM (*e.g.*, Category 4-5 hurricanes). This emergency response plan should be developed with the aid of the captive breeding feasibility workshop's findings (*i.e.*, temporary emergency action if large storm forecasted and population deemed at serious risk) (CBSG 2007). Supplemental feeding of ABM under extreme circumstances (e.g., major loss of forage due to storm surge and/or salt spray) should be considered.

C. Land Acquisition

Appropriate parcels for land acquisition should be identified using LIDAR data and storm surge models (for high-elevation habitat identification) and current knowledge of ABM movements and habitat use (*e.g.*, lands at Fort Morgan that are being leased to the Service). Land could potentially be purchased through a variety of means, including section 6 land acquisition grants, the State of Alabama's Forever Wild program, or through an in-lieu fee mitigation program.

D. Outreach/ Education

Opportunities to convey the importance of coastal dune habitat to the public should be continued and expanded. Outreach should focus on the larger coastal ecosystem and role of the beach mouse in this ecosystem, instead of adopting a single-species focus. Efforts should stress the importance of healthy environments for both people (through the protection of infrastructure and aesthetics) and beach mice. In addition,

an outreach/education program focused on the threats that feral cats pose to wildlife should also be developed.

E. Additional Research: Corridor Size, Persistence, Habitat Values, and Habitat Mitigation/Enhancement

Develop methods for estimating ABM population parameters in scrub and beach dune habitats with various levels of human development. In addition, conduct research to determine dispersal potentials between local populations in beach/scrub habitats and in response to tropical cyclone events. Research objectives are to quantify the relative importance of various habitats to ABM, and identify the habitat parameters or conditions necessary for ABM persistence and movement between habitat patches.

Test methods to improve or create ABM habitats, particularly in scrub dunes, and document responses by invasive species such as cogon grass. The ability to create habitat could increase the quantity or quality of existing habitat, particularly high elevation habitat. For example, Gulf State Park is the only remaining public parcel within ABM habitat where the mice no longer persist; however, the site lacks high elevation habitat. Studies to determine if high elevation habitat can be created would increase the chances of ABM persisting at this site.

Danielson and Falcy (2008) suggested that: (1) "preemptive" *(i.e.*, pre-hurricane event) habitat management efforts in scrub may be more beneficial to local population viability than "*post-facto*" (*i.e.*, post-hurricane event) management efforts in frontal dunes habitat; and (2) cotton rats appear to outcompete beach mice in some microhabitats which may be important during post-hurricane periods. These two issues should be explored further.

Conduct research to determine whether or not diseases and/or parasites are significant threats to ABM and if wet/dry weather patterns are a factor in ABM population trends.

F. Develop an Overarching Conservation Strategy for the ABM

The subspecies is restricted to suitable areas within about 2,450 acres of coastal habitat, and there are presently no acceptable options for mitigation. The development of a conservation strategy will identify baseline conditions, potential impacts, expected species responses, conservation objectives, and management options for the conservation (including long-term survival and recovery) of the ABM. Management options in the Strategy would contribute to the overall goal of protecting and improving ABM habitats and movement corridors to provide adequate feeding, breeding and sheltering needs across its range. Maintaining adequate numbers, genetic diversity, and distributions within core ABM populations (*e.g.*, Ft. Morgan, Perdue Unit, and eventually GSP) will allow the species to persist over the long-term and core populations to recover from stochastic events (*e.g.*, hurricanes, flooding, disease).

G. Re-establishment of Sustainable ABM Population at Gulf State Park

GSP, west of Perdido Pass, is at the easternmost extent of the ABM's range. This local population is small and isolated, and has been extirpated three times in the last three decades, most recently by Hurricane Ivan in 2004 (Holliman 1983, Holler and Rave 1991, Service 2004 and 2005a, Volkert 2005). Nonetheless, GSP is important to the conservation of the subspecies by helping establish multiple local populations of ABM over a wider range which is crucial for the subspecies long-term persistence (Shaffer and Stein 2000, Oli *et al.* 2001, Danielson 2005). For example, in 1986, the last remaining population of Perdido Key beach mice was located in Gulf State Park east of Perdido Pass in Alabama. Following translocation 1986-1988 to Gulf Islands National Seashore, this source population at GSP was subsequently lost following Hurricane Opal in1995. Plans should be developed to translocate ABM to GSP in conjunction with control of feral cats and other threats. However, if ABMs are translocated to GSP in the future, it should be recognized that it is unlikely they would survive after hurricanes until sufficient high elevation storm refugia becomes available at this location.

H. Fertilization, habitat quality improvement projects

Habitat restoration projects should continue to be developed and implemented to improve the habitat quality of areas recovering from hurricane damage. Boyd *et al.* 2004 showed that sand fencing and application of fertilizer have yielded greater vegetative cover and greater densities of beach mice (Boyd *et al.* 2004). Recent dune restoration research suggests there is no benefit to using sand fencing or fertilizer in addition to vegetative cover if planted at the proper time of year (Debbie Miller per. comm. 2009). Following Hurricane Ivan (2004) and the 2005 Hurricane Season, the Service was successful in securing emergency habitat restoration funds from Congress. These funds were used to re-establish dunes at GSP and on the BSNWR. They were also used to establish a cooperative agreement with the Baldwin County Soil and Water Conservation District to restore ABM habitat on private lands on a cost-share basis. Thus far, this program has assisted over 100 coastal landowners, many of which are along the Fort Morgan Peninsula. Such efforts are of paramount importance to ABM recovery and generating public support for ABM conservation efforts and should be continued.

V. REFERENCES

Alabama Gulf Coast Chamber of Commerce, 2007. Website: *http://alagulfcoastchamber.com*.

Baldwin County, Alabama. 2005. Unpublished Light Detection and Ranging (LIDAR) elevation data from the Fort Morgan Peninsula. Bay Minnette, Alabama.

Bird, B. L. 2004. Effects of coastal lighting on foraging behavior of beach mice. Conservation Biology 18: 1435-1439.

Blair, W. F. 1951. Population structure, social behavior, and environmental relations in a natural population of the beach mouse (*Peromyscus polionotus leucocephalus*). Contributions from the Laboratories of Vertebrate Biology 48:1-47.

Bowen, W. W. 1968. Variation and evolution of Gulf Coast populations of beach mice, *Peromyscus polionotus*. Bulletin of Florida State Museum of Natural History 12:1-91.

Boyd, R.S., J.M. Moffett, and M.C. Wooten. 2004. Effects of post hurricane dune restoration and revegetation techniques on the Alabama beach mouse. Cooperative Agreement 1434-HQ-97-RO-01550. Auburn University, Alabama.

Brook, B. W., J. A. Burgman, H. R. Akcakaya, J. J. O'Grady, and R. Frankham. 2002. Critiques of PVA ask the wrong questions: throwing out the heuristic baby out with the numerical bath water. Conservation Biology 16:262-263.

Bush, D.M., N.J. Longo, W.J. Neal, L.S. Esteves, O.H. Pilkey, D.F. Pilkey, and C.A. Webb. 2001. Living on the Edge of the Gulf: The West Florida and Alabama Coast, Duke University Press. 368pp.

Caughley, G. and A. Gunn. 1996. Conservation biology in theory and practice. Blackwell Science, Oxford.

Chen, J. Q., and L. Wang. 2007. Effects of Hurricane Storm Surge and Wave Activity on Alabama Beach Mouse Habitat Part I: Fort Morgan Peninsula. Louisiana State University. Baton Rouge, LA. 75 pp.

Conroy, M.J. and J.P. Runge. 2008. Trapping Protocols, Sampling, and Viability Analysis for the Alabama Beach Mouse (*Peromyscus polionotus ammobates*). Final report submitted to the U.S. Fish and Wildlife Service on April 14, 2008. Georgia Cooperative Fish and Wildlife Research Unit, University of Georgia, Athens.

Conservation Breeding Specialist Group (CBSG). 2007. Beach mouse captive population feasibility workshop – final report. Topsail Hill Preserve State Park, Florida. Issue paper and presentation to Alabama beach mouse recovery team. March 7-9, 2007. Organized by U.S. Fish and Wildlife Service and IUCN/SSC Conservation Breeding Specialist Group.

Danielson, B. J. 2005. Importance of multiple independent populations of Alabama beach mice. Issue paper and presentation to Alabama beach mouse recovery team. May 16, 2005.

Danielson, B. J. and M. Falcy. 2008. Post-storm population survival and recovery of Alabama and Perdido Key beach mice – Interim report. Iowa State University. Feb. 18, 2008.

Davenport, L.J. 2007. Climate change and its potential effects on Alabama's plant life. Dpt. of Biological and Environmental Sciences, Samford University, Birmingham, AL. 75 pp.

Douglass, S.L., T.A. Sanchez, and S. Jenkins. 1999. Mapping Erosion Hazard Areas in Baldwin County, Alabama and the Use of Confidence Intervals in Shoreline Change Analysis. Journal of Coastal Research, SI(28), pp. 95-105.

Ellner, Sp. P., J. Fieberg, D. Ludwig, and C. Wilcox. 2002. Precision of population viability analysis. Conservation Biology 16(1):258-261.

Emanuel, K. 2005. Increasing destructiveness of tropical cyclones of the past 30 years. Nature 436(7051):686-688.

ENSR Corporation. 2004. Assessment of Alabama beach mouse habitat flooding on the Fort Morgan Peninsula using FEMA DFIRM and the Coastal Hazard Assessment Program.

Fleming, K.L. and N.R. Holler. 1990. Reproduction in captive Santa Rosa beach mice (*Peromyscus polionotus leucocephalus*) and Choctawhatchee beach mice (*P.p. allophrys*). Journal of the Alabama Academy of Science 61: 143.

Foltz, D. W. 1981. Genetic evidence for the long-term monogamy in a small rodent, Peromyscus polionotus. American Naturalist 117:665-675.

Gilpin, M. E. and M. E. Soule'. 1986. Minimum viable populations: the processes of species extinctions. Pages 19-34 *in* M. E. Soule' (editor). Conservation Biology: the science of scarcity and diversity. Sinauer Assoc., Sunderland, MA. 584 pp.

Hamilton, S. and H. Moller. 1995. Can PVA models using computer packages offer useful conservation advice? Sooty shearwaters (*Puonus griseus*) in New Zealand as a case study. Biological Conservation 73: 107-117.

Hill, E. A. 1989. Population dynamics, habitat, and distribution of the Alabama beach mouse. M.S. Thesis. Auburn University, Alabama.

Hoekstra, H.E., Hirschmann, R.J., Bundey, R.A., Insel, P.A., and J.P Crossland. 2006. A single amino acid mutation contributes to adaptive beach mouse color pattern. Science 313:101-104.

Holler N. R. 1992. Perdido Key beach mouse. *In* Rare and Endangered Biota of Florida, Volume 1. Mammals. Ed. S.R. Humphrey. University Presses of Florida, Tallahassee. pp 102-109.

Holler, N. R. and E. H. Rave. 1991. Status of endangered beach mouse populations in Alabama. Journal of Alabama Academy of Science. 62:18-27.

Holler, N. R., M. C. Wooten, and C. L. Hawcroft. 1997. Population biology of endangered Gulf coast beach mice (*Peromyscus polionotus*): conservation implications. Technical Report. Alabama Cooperative Fish and Wildlife Research Unit.

Holler, N.R., M.C. Wooten, and M. Oli. 1999. Viability analysis of endangered Gulf coast beach mice (*Peromyscus polionotus*) populations. Project report for agreement 1448-0004-94-9174, mod. 2, Obj. 2 for the U.S. Fish and Wildlife Service, Panama City, Florida. 16 pp. With graphs and tables.

Holliman, D.C. 1983. Status and habitat of Alabama gulf coast beach mice *Peromyscus polionotus ammobates* and *P. p. trissyllepsis*. Northeast Gulf Science 6: 121-129.

Humphrey, S.R. 1992. Rare and endangered biota of Florida, Volume 1. Mammals. University Presses of Florida, Tallahassee.

Integrated Taxonomic Information System. 2008. *Neotoma floridana smalli* Sherman, 1955. http://www.itis.usda.gov/index.html [Accessed September 16, 2008].

Landsea, C. 2005. Hurricanes and global warming. Nature 438 E11-13.

Lacy, R.C. 1993/1994. What is population (and habitat) viability analysis? Primate Conservation 14/15:27-33.

Linzey, D.W. 1978. Perdido Bay beach mouse. Pages 19-20 in J.N. Layne, editor. Rare and Endangered Biota of Florida, Volume 1. Mammals. University Presses of Florida, Gainesville.

Lynn, W.J. 2000. Social organization and burrow-site selection of the Alabama Beach Mouse *Peromyscus polionotus ammobates*). M.S. Thesis. Auburn University. Auburn, Alabama.

Mackenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. *Occupancy estimation and modeling: Inferring patterns and dynamics of species occurrence.* Academic Press, Burlington, MA.

Mech, S.G., and J.G. Hallett. 2001. Evaluating the effectiveness of corridors: a genetic approach. Conservation Biology. 15:467-474

Meyers, J.M. 1983. Status, microhabitat, and management recommendations for

Peromyscus polionotus on Gulf Coast beaches. Unpublished report to U.S. Fish and Wildlife Service, Atlanta, Georgia.

Morris, W., D. Doak, M. Groom, P. Kareiva, J. Fieberg, L. Gerber, P. Murphey, and D. Thomson. 1999. A Practical Handbook for Population Viability Analysis. The Nature Conservancy. Arlington, Virginia.

Morris, W.F., and D.F. Doak. 2002. Quantitative Conservation Biology: Theory and Practice of Population Viability Analysis. Sinauer, Sunderland, MA.

Moyers, J. 1996. Food habitats of gulf coast subspecies of beach mice *Peromyscus polionotus spp.*). M.S. thesis, Auburn University, AL.

Moyers, J.E., N.R. Holler, and M.C. Wooten. 1999. Species status report, current distribution and status of the Perdido Key, Choctawhatchee and St. Andrew Beach Mouse. U.S. Fish and Wildlife Service Grant Agreement No. 1448-0004-94-9174.

Neal, W.A. and J.P. Crowder. 2001. Gulf Highlands Area Conservation Plan for the Alabama Beach Mouse, June 2001. Revision.

Noss, R.F., and B. Csuti. 1997. Habitat fragmentation, pp. 269–304. in G.K. Meffe and R.C. Carroll (eds.), Principles of Conservation Biology. Second edition. Sunderland, MA: Sinauer Associates.

Novak, J. A. 1997. Home range and habitat use of Choctawhatchee beach mice. M.S. thesis. Auburn University, Auburn, Alabama.

Oli, M.K., N.R. Holler, M.C. Wooten. 2001. Viability analysis of endangered Gulf Coast beach mice (*Peromyscus polionotus*) populations. Biological Conservation 97: 107-118.

Rave, E.H. and N.R. Holler. 1992. Population dynamics of beach mice (*Peromyscus polionotus ammobates*) in southern Alabama. Journal of Mammalogy 73:347-355.

Reed, D.H. and K.R. Traylor-Holzer. 2006. Revised Population Viability Analysis III for the Alabama Beach Mouse (*Peromyscus polionotus ammobates*). Report to the U.S. Fish and Wildlife Service. June 2006. pp 24.

Ryan, K. K. and R. C. Lacy. 2003. Monogamous male mice bias behavior towards females according to very small differences in kinship. Animal Behaviour 65 (2) 379-384.

Sankaran, M. 1993. Population dynamics of the beach mouse (*Peromyscus polionotus trissyllepsis*): A simulation study. M.S. Thesis, Auburn University, Auburn, Alabama.

Selander, R.K., M.H. Smith, S.Y. Yang, W.E. Johnson, and J.B. Gentry. 1971. Biochemical polymorphism and systematics in the genus *Peromyscus*. I.

Variation in the old-field mouse (*Peromyscus polionotus*). University of Texas Studies in Genetics 6: 49-90.

Shaffer, M.L., 1981. Minimum population sizes for species conservation. Bioscience 1:131-134.

Shaffer, M. and B.A. Stein. 2000. Safeguarding our Precious Heritage. Chapter 11 in Stein, B.A., L.S. Kutner, J.S. Adams (eds). Precious Heritage: The Status of Biodiversity in the United States. Oxford University Press. New York. 399pp.

Smith, M. H. 1966. The evolutionary significance of certain behavioral, physiological, and morphological adaptations of the old-field mouse, *Peromyscus polionotus*. Ph.D. dissertation, University of Florida, Gainesville, 187 pp.

Smith, M. H. 1971. Food as a limiting factor in the population ecology of *Peromyscus polionotus* (Wagner). Annals of Zoological Fennici. 8:109-112.

Sneckenberger, S.I. 2001. Factors influencing habitat use by the Alabama beach mouse (*Peromyscus polionotus ammobates*). Master's thesis. Auburn University, Auburn, Alabama.

South Alabama Regional Planning Commission. 2001. Fort Morgan Peninsula Resource Assessment. Alabama Department of Conservation & Natural Resources. Mobile, Alabama.

Swilling, W.R. 2000. Ecological dynamics of the endangered Alabama beach mouse (*Peromyscus polionotus ammobates*). M.S. thesis. Auburn University, Alabama.

Swilling, W.R., W. J. Lynn, N. R. Holler, and M.C. Wooten. 1996. Sink or swim: Alabama beach mice *Peromyscus polionotus ammobates*) respond to Hurricane Opal. Poster presentation, 76th Annual Meeting of the American Society of Mammalogists. June 15-19, 1996. University of North Dakota. Grand Forks, North Dakota.

Swilling, W.R. Jr., M.C. Wooten, N.R. Holler, and W.J. Lynn. 1998. Population dynamics of Alabama beach mice (*Peromyscus polionotus ammobates*) following Hurricane Opal. American Midland Naturalist 140: 287-298.

Swilling, W.R., and M.C. Wooten. 2002. Subadult dispersal in a monogamous species: the Alabama beach mouse (*Peromyscus polionotus ammobates*). Journal of Mammalogy 83(1): 252-259.

Tenaglia, K.M., Van Zant, J.L., and M.C. Wooten. 2007. Genetic relatedness and spatial associations of jointly captured Alabama beach mice (*Peromyscus polionotus ammobates*). Journal of Mammalogy. 88(3):580-588.

Titus, J.G. and V. Narayanan. 1995. The Probability of Sea Level Rise. Washington, D.C. EPA 230-R95-008. 186 pp.

Titus, J.G. and V. Narayanan. 1996. A Delphic Monte Carlo Analysis in which Twenty Researchers Specify Subjective Probability Distributions for Model Coefficients within their Respective Areas of Expertise. Climatic Change 33: 151-212.

Traylor-Holzer, K. 2005. Revised Population Viability Analysis for the Alabama Beach Mouse Peromyscus polionotus ammobates. Report to the U.S. Fish and Wildlife Service. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota. 31pp.

Traylor-Holzer, K., R. Lacy, D. Reed, and O. Byers. 2005. Alabama beach mouse population and habitat viability analysis: Final report. Conservation Breeding Specialist Group. Apple Valley, Minnesota.

Trenberth, K. 2005. Uncertainty in hurricanes and global warming. Science 308(5729):1753-1754.

U.S. Army Corps of Engineers, 2001. Alabama Hurricane Evacuation Study-Technical Data Report for Mobile and Baldwin Counties. Mobile, AL. 91 pp.

U.S. Fish and Wildlife Service. 1987. Recovery plan for the Alabama beach mouse (*Peromyscus polionotus ammobates*), Perdido Key beach mouse (*P. p. trisyllepsis*), and Choctawhatchee beach mouse (*P. p. allophrys*). U.S. Fish and Wildlife Service, Atlanta, Georgia.

U. S. Fish and Wildlife Service. 2003. Alabama beach mouse suitable habitat maps. November 2003. Ecological Services Field Office, Daphne, Alabama.

U.S. Fish and Wildlife Service 2004. Preliminary assessment of Alabama beach mouse (*Peromyscus polionotus ammobates*) distribution and habitat following Hurricane Ivan. Daphne, Alabama.

U.S. Fish and Wildlife Service. 2005a. Preliminary assessment of Alabama beach mouse (*Peromyscus polionotus ammobates*) distribution and habitat following 2005 hurricane season. November 8, 2005. Ecological Services Field Office, Daphne, Alabama.

U.S. Fish and Wildlife Service. 2005b. Revisions to the ABM habitat range map. Alabama Field Office, Daphne, Alabama.

U.S. Fish and Wildlife Service. 2005c. Bon Secour National Wildlife Refuge Comprehensive Conservation Plan. 170 p.

U.S. Fish and Wildlife Service. 2006. Biological Opinion and Conference Report: Incidental Take Permit for the Alabama Beach Mouse (*Peromyscus polionotus ammobates*) for the

Beach Club West and Gulf Highlands Condominiums Project in Baldwin County, Alabama. December 29, 2006. Alabama Field Office. Daphne, Alabama.

U.S. Fish and Wildlife Service. 2008. November 2007 rangewide Alabama beach mouse monitoring**:** preliminary report – April 15, 2008. Alabama ES Field Office, Daphne, AL. 5 pp.

U.S. Fish and Wildlife Service. 2009. Revisions to the ABM habitat range map. Alabama Field Office, Daphne, Alabama.

Van Zant, J.L. and M.C. Wooten. 2003. Translocation of Choctawhatchee beach mice (*Peromyscus polionotus allophrys*): hard lessons learned. Biological Conservation, 112(3): 405-413.

Van Zant, J.L. 2006. Molecular Ecology of *Peromyscus polionotus*. Ph.D. dissertation. Auburn University, Alabama.

Volkert and Associates. 2005. Alabama beach mouse trapping survey – Gulf State Park, Gulf Shores, Alabama. Volkert Contract No. 500531.12. June 14, 2005. 8 pp.

Webster, P.J., G.J. Holland, J.A. Curry, and H.R. Chang. 2005. Changes in tropical cyclone number, duration, and intensity in a warming environment. Science 309(5742)1844-1846

Weston, J. 2007. Captive breeding of beach mice. Peromyscus Genetic Stock Center, University of South Carolina, Columbia.

Wigley, T.M.L.. 1999. The Science of Climate Change: Global and U.S. Perspectives. Pew Center on Global Climate Change, Arlington, Virginia, 48 pp.

Williams, B. K., J. D. Nichols, and M J. Conroy. 2002. Analysis and management of animal populations. Academic, San Diego.

Witherington, B.E. and R.E. Martin. 2003. Understanding, assessing, and resolving light pollution problems on sea turtle nesting beaches. 3rd ed. Rev. Florida Marine Research Institute Technical Report TR-2. 73pp.

Wolfe, J.L., and C.T. Summerlin. 1989. The influence of lunar light on nocturnal activity of the old-field mouse. Animal Behavior 37:410-414.

Woodruff, D. S. 1989. The problems of conserving genes and species. Pages 76-88 *In:* Conservation for the Twenty First Century (D. Western and M. Pearl, editors). Oxford University Press, New York, NY.

Wooten, M. C. 1994. Estimation of genetic variation and systematic status of populations of the beach mouse, *Peromyscus polionotus*. Final Report. Florida Game and Fresh Water Fish Commission. 38 pp.

Wooten, M.C., K.T. Scribner, and J.T. Krehling. 1999. Isolation and characterization of microsatellite loci from endangered beach mice, *Peromyscus polionotus*. Molecular Ecology. 8:157-158

Wooten, M. C. and N. R. Holler. 1999. Genetic analyses within and among natural populations of beach mice. Final report to U.S. Fish and Wildlife Service. Atlanta, Georgia.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF THE
ALABAMA BEACH MOUSE, (*Peromyscus polionotus ammobates)*

Current Classification Endangered

Recommendation resulting from the 5-Year Review

X No change is needed

Review Conducted by Rob Tawes and Carl Couret, and updated by Dianne Ingram

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 10/30/09

The lead Field Office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.

REGIONAL OFFICE APPROVAL:

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

Acting
Lead Regional Director, Fish and Wildlife Service

Approve _____ Date 11/23/09

The Lead Region must ensure that other regions within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. If a change in classification is recommended, written concurrence from other regions is required.

APPENDIX A: Summary of peer review for the 5-year review of the Alabama beach mouse (*Peromyscus polionotus ammobates*)

A. Peer/Intraservice Review Method: A draft version of the 5-year review was sent to four independent reviewers (two from academia, one from State government, and one from the private sector) and Service biologists, all with expertise in beach mice biology.

B. Peer/Intraservice Review Charge: Reviewers were asked to review and provide comments on the underlying science and overall assessment of the data in the document.

C. Summary of Peer Review Comments/Report

Peer reviewers recommended clarification and provided editorial comments. Additional information was provided concerning population viability analysis, informal field observations, literature sources, and research direction for consideration.

One reviewer questioned the length of discussion on climate change due to its uncertain results and our control over the results is beyond our sphere of influence. The reviewer also expressed concern with re-establishing a subpopulation of ABM at Gulf State Park if the likelihood of success was tenuous, as has happened in the past. Another reviewer commented that field observations of wet and dry weather patterns are more of a factor in ABM population trends than is addressed in the document.

D. Response to Peer Review

All clarifications, substantive editorial comments and additional information were incorporated into the final document, where appropriate. Several changes were not made, such as if wording was taken as direct quote from other sources, and a suggestion to limit discussions on climate change was not made. While we agree the long-term success of re-establishing a subpopulation of ABM at Gulf State Park may be difficult, we feel it is imperative that we maintain several subpopulations to protect the species. We did not include additional discussion on weather patterns as a factor in ABM population trends because data was not found to support it; however, this topic was added as future research needs.