

American Burying Beetle
(Nicrophorus americanus)

**5-Year Review:
Summary and Evaluation**

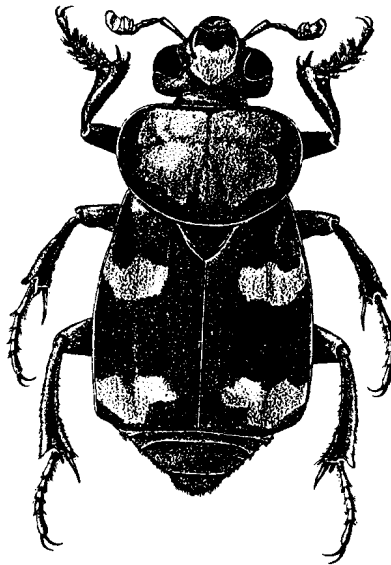


Illustration by Mark Marcuson

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New England Field Office
Concord, New Hampshire**

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5-YEAR REVIEW

Species reviewed: American Burying Beetle (*Nicrophorus americanus*)

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5-YEAR REVIEW

American Burying Beetle *Nicrophorus americanus*

1.0 GENERAL INFORMATION

1.1 Reviewers

This review was completed by Michael Amaral, Sr. Endangered Species Specialist in the U.S. Fish and Wildlife Service's (USFWS) New England Field Office (NEFO) and lead recovery coordinator for the species. Anthony Tur, Jeannine Dube, and Phillip Leeser, also of the NEFO, made significant contributions to this document. USFWS biologists in the offices listed below provided valuable additional information and corrections to a draft of this review.

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1.2 Methodology Used to Complete the Review

This review was initially drafted by Michael Amaral, the USFWS American burying beetle (ABB) recovery coordinator. On June 28, 2007, it was provided to cooperating USFWS Field Offices, and comments and other input were incorporated into subsequent drafts. In addition, the scientific assessment portion of the review was sent to three independent experts for peer review, although no responses were obtained. Sources of data informing this review include the 1991 recovery plan, published scientific literature, unpublished annual survey reports, and consultations with academic, State, and Federal species experts. The USFWS relied heavily on new information resulting from extensive survey efforts in the western portion of the species' range, particularly in Oklahoma and Nebraska. In addition, the USFWS considered new

information made available since listing in more than 20 scientific papers on various aspects of the species' life history, occurrence, and ecology.

1.3 Background

1.3.1 Federal Register Notice announcing initiation of this review:

72 FR 4018, January 29, 2007

1.3.2 Listing history:

Federal Register (FR) notice: 54 FR 29652

Date listed: July 13, 1989

Entity listed: Species

Classification: Endangered

1.3.3 Associated rulemakings: None

1.3.4 Review history:

The ABB was included in a cursory 5-year review of all species listed before 1991 (56 FR 56882, November 6, 1991). Although no other 5-year review has been conducted for the beetle until now, the species has been the focus of considerable research and recovery effort since listing in 1989, as summarized in section 2.3 of this review.

1.3.5 Species Recovery Priority Number at start of 5-year review: 5c

A rank of 5c indicates that the listed taxon is a full species facing a high degree of threat and with a low recovery potential. The suffix "c" connotes conflict with construction or other development projects (48 FR 43098).

1.3.6 Recovery plan:

Name of plan: American Burying Beetle (*Nicrophorus americanus*) Recovery Plan

Date issued: September 1991

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

Not applicable. Only vertebrate populations can be listed as a DPS under the Endangered Species Act (ESA).

2.2 Recovery Criteria

2.2.1 Does the species have a final recovery plan containing approved recovery criteria?

Yes, with regard to reclassification criteria. The plan does not contain delisting criteria. The ABB recovery plan (USFWS 1991) was developed within 2 years of the listing of the species and reflects the best information available at that time. In 1991, the known distribution of the species was limited to two disjunct natural populations at the extremities of its historical range, i.e., four counties in eastern Oklahoma and one island off the Rhode Island coast. The recovery plan noted that, due to the species' profound decline and uncertainty regarding the reasons for that decline, the focus would be on recovery actions targeted to significant near-term improvement in the status of the species rather than addressing the range of objectives and criteria to bring about full recovery. The recovery objectives of the 1991 plan thus are to: (1) "Reduce the immediacy of the threat of extinction ..." and (2) "improve its status so that it can be reclassified from endangered to threatened." The plan contains measurable criteria for achieving these objectives.

2.2.2 Adequacy of recovery criteria:

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat? No.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria? No. None of the five listing factors is explicitly addressed in the recovery criteria, aside from the range curtailment component of Factor A. Factor A (habitat-related threats), Factor D (inadequate regulatory mechanisms), and Factor E (other factors affecting the species' existence) are relevant to ABB recovery. Factor B (overutilization) is not deemed relevant, and the relevance of Factor C (disease or predation) is uncertain.

2.2.3 List the recovery criteria as they appear in the recovery plan and discuss how each criterion has or has not been met, citing information:

Objective 1: Reduce the immediacy of the threat of extinction to the ABB.

The interim objective to reduce the threat of extinction will require the protection and maintenance of the extant population in Rhode Island and the two populations in Oklahoma (Cherokee/Muskogee Counties and Latimer County) and re-establishing (or locating and protecting) at least two additional self-sustaining wild populations of 500 or more animals each, one in the eastern and one in the western part of the species' historic range limits.

Objective 2: Improve its status so that it can be reclassified from endangered to threatened.

Criteria:

- (a) three populations of N. americanus have been re-established (or additional populations discovered) within each of four broad geographical areas of its historical range: the Northeast, the Southeast, the Midwest and the Great Lakes States ...;*
- (b) each population contains a minimum of 500 adults as estimated by capture rates per trap night and black lighting effort; and*
- (c) each population is demonstrably self-sustaining for at least 5 consecutive years (or is sustainable with established long-term management programs).*

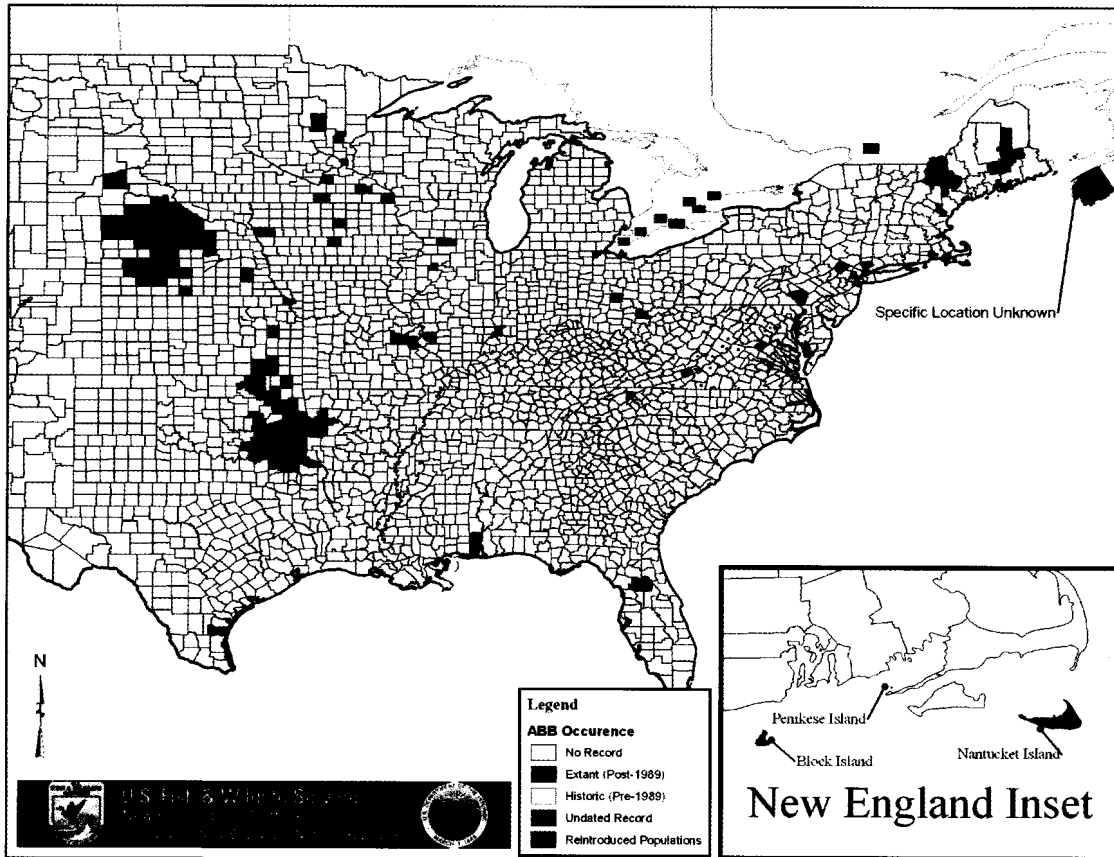
Although the specific criteria identified for Objective 1 above have not been met, the stated intent of this interim objective, i.e., to reduce the immediacy of the threat of extinction, has been attained through the discovery of additional western populations across a considerable geographic area. After 1991, the ABB was found to be distributed more broadly across eastern Oklahoma into western Arkansas and in two large areas of central Nebraska. The Oklahoma-Arkansas population extends peripherally into southern Kansas in the north and into the northeast corner of Texas in the south. The Nebraska population similarly extends into a few southern counties of South Dakota in the north (Figure 1).

Surveys in Rhode Island, Massachusetts, Maine, New York, Michigan, Ohio, Pennsylvania, Iowa, Missouri, North Carolina, Florida, Louisiana, central and eastern Arkansas, and Virginia) have not found additional extant occurrences of the ABB; however, captive breeding programs in Rhode Island, Missouri, and Ohio provide a further hedge against the immediate threat of extinction. In addition, the Block Island (Rhode Island) population is monitored annually (Raithel et al. 2006; Raithel, Section 6 Annual Reports 1996-2006) and has further benefited from habitat restoration, habitat protection through acquisition and conservation easement, and carrion provisioning efforts (USFWS unpubl. data). The immediate threat of extinction has thus subsided in the 18 years since listing.

Objective 2 above addresses the further conservation necessary to reduce the risk of extinction to a point where the ABB meets the definition of a threatened species. The criteria for this objective have not been met except in the Midwest geographic recovery area, where additional occurrences of the ABB have been discovered. As a consequence, the total number of ABB in this recovery area is believed to greatly exceed the numerical target of 1,500 or more animals, with the persistence target of 5 years also being met.

In the Southeast recovery area, there are no known extant ABB populations, and no reintroduction efforts are underway. In the Great Lakes States, there are no known natural populations. Ohio State University maintained a captive propagation program for releases in Ohio from 2002-2005 and started up again in the summer of 2007. In addition, a second captive-rearing facility at the Wilds was established in August 2007.

Figure 1. Historic and Current Occurrences of the ABB in the United States and Canada.



The Ohio Division of Wildlife holds a Federal recovery permit to obtain ABB for propagation and to release captive-bred beetles within the State for reintroduction purposes; one reintroduction effort has been initiated in southeastern Ohio, but preliminary results are not encouraging. The St. Louis Zoo's captive propagation program is intended to lead to the reintroduction of ABB in Missouri. In the East, the natural population on Block Island, Rhode Island is stable, but a newly established ABB population on Penikese Island, Massachusetts, became extirpated 9 years after the last release of beetles. A second long-term reintroduction effort on Nantucket Island, Massachusetts, is still being evaluated and has not yet reached either the population size or persistence target.

In sum, although one of four geographic recovery areas for ABBs (USFWS 1991) has met the criteria for reclassification, the species presumably remains extirpated in most of its historic range. Reintroduction efforts have yet to demonstrate that an extirpated population can become successfully re-established, and survey efforts in much of the species' historic range have failed to locate additional extant populations.

Noting that the criteria in the recovery plan do not address delisting or the five listing factors, this review of the ABB's status and listing classification relies on the five-factor analysis in Section 2.3.2, in conjunction with the 1991 recovery criteria.

2.3 Updated Information and Current Species Status

Although 5-year reviews generally focus on information obtained since the previous status review, this review provides additional context by including some materials that pre-date the ABB's listing and the 1991 recovery plan. Sikes and Raithel (2002) report that research effort focused on *Nicrophorus americanus* was greatly intensified following the disclosure by Davis (1980) and Anderson (1982) that the species was absent from most of its historic range. In the subsequent 20 years from 1982-2002, there were 78 articles published on *Nicrophorus* beetles, and many addressed the ABB.

Following is a list of key publications that discuss and update ABB status with respect to distribution and/or provide other information on life history, ecology and genetics that has become available since the species was listed. Most of these papers, which are listed chronologically, appear in peer-reviewed scientific journals. The complete citation as well as a comprehensive list of all literature referenced in the document is provided in Section 5.0.

U.S. Fish and Wildlife Service, 1991. American Burying Beetle *Nicrophorus americanus* Recovery Plan.

Amaral, 1992. Conservation of the endangered American burying beetle, *Nicrophorus americanus*.

Creighton et al., 1993. Habitat preferences of the endangered American burying beetles (*Nicrophorus americanus*) in Oklahoma.

Kozol et al., 1994. Genetic variation in the endangered burying beetle *Nicrophorus americanus* (Coleoptera: Silphidae).

Kozol, 1995. Ecology and population genetics of the endangered American burying beetle, *Nicrophorus americanus*.

Lomolino et al., 1995. Ecology and conservation of the endangered American burying beetles (*Nicrophorus americanus*).

Lomolino and Creighton, 1996. Habitat selection, breeding success, and conservation of the endangered American Burying beetle *Nicrophorus americanus*.

Ratcliffe, 1996. The carrion beetles (Coleoptera: Silphidae) of Nebraska.

Amaral et al., 1997. Conservation status and reintroduction of the endangered American burying beetle.

Backlund and Marrone, 1997. New records of the endangered American burying beetle, *Nicrophorus americanus* Olivier, (Coleoptera: Silphidae) in South Dakota.

Holloway and Schnell, 1997. Relationship between numbers of the endangered American Burying beetle, *Nicrophorus americanus* Olivier (Coleoptera: Silphidae) and available food resources.

Carlton and Rothwein. 1998. The endangered American burying beetle, *Nicrophorus americanus* Olivier, at the edge of its range in Arkansas (Coleoptera: Silphidae).

Bedick et al., 1999. Distribution, ecology, and population dynamics of the American burying beetle [*Nicrophorus americanus* Olivier (Coleoptera, Silphidae)] in south-central Nebraska, USA.

Szalanski et al., 2000. Population genetics and phylogenetics of the endangered American burying beetle, *Nicrophorus americanus* (Coleoptera: Silphidae).

Sikes and Raithel, 2002. A review of hypotheses of decline of the endangered American burying beetle (Silphidae: *Nicrophorus americanus* Olivier).

Amaral et al. (eds), 2005. American burying beetle (*Nicrophorus americanus*) population and habitat viability assessment: final report.

Raithel et al., 2006. Population trends and flight behavior of the American burying beetle, *Nicrophorus americanus* (Coleoptera: Silphidae), on Block Island, Rhode Island.

Walker and Hoback, 2007. Effects of invasive eastern red cedar on capture rates of *Nicrophorus americanus* and other Silphidae.

In addition to the publications listed above, in the eastern United States, recovery meetings have been held each year from 1991 to 2007 with the purpose of sharing new information and discussing findings. Participants have included biologists from the USFWS, State wildlife agencies (Massachusetts and Rhode Island), academia (Boston University and University of Rhode Island), several NGOs (the Rhode Island and Block Island offices of The Nature Conservancy, Massachusetts Audubon Society, Nantucket Conservation Foundation, and Maria Mitchell Association), and the Roger Williams Park Zoo.

In March 1995 and March 2003, national conferences were held at the University of Oklahoma in Norman to provide a forum for updating and sharing rangewide information on the ABB. More recently, in November 2005, the St. Louis Zoo hosted a Population and Habitat Viability Assessment (PHVA) workshop, facilitated by the Conservation Breeding Specialist Group, during which the species' status and priority research needs were reviewed and summarized (Amaral et al. [eds] 2005).

In May 2007, another conference was convened in Tahlequah, Oklahoma, during which USFWS, State and university biologists, and other interested parties shared new information on the status and management of ABB populations in the western portion of its range. Abstracts of individual reports from this workshop and some of the PowerPoint presentations can be found at www.fws.gov/ifw2es/Oklahoma/beetle1.htm.

2.3.1 Biology and Habitat

Background: *Nicrophorus* (family Silphidae) is a northern hemisphere genus of about 75 species. Population densities and species diversity are higher in northern localities (Scott 1998). Burying beetle lack of success in southern latitudes is believed to be due to increased competition with ants, flies, and perhaps vertebrates, as well as increased rates of carcass decomposition (Scott 1998).

The endangered ABB is the largest member of the family *Silphidae* in North America (Anderson and Peck 1985) and the largest among a guild of species that breed and rear their young on vertebrate carcasses (Lomolino et al. 1995). Easily recognized by their shiny black bodies and the red-to-orange markings on both their elytra (hardened forewings) and pronotum (anterior dorsal plate), this species offers its young extended parental care, an unusual behavioral trait in beetles. After ABBs find an appropriate-sized carcass, intense inter- and intra-species competition occurs (Kozol 1990). Together, a victorious pair of beetles cooperatively buries and prepares the carcass by removing fur or feathers and coating it with secretions that retard bacterial and fungal growth. The female beetle lays eggs in a brood chamber near the preserved carcass. After eggs hatch, the parents move the altricial, first instar larvae to the carcass, where the larvae solicit feeding by stroking the mandibles of the parents. Both parents may remain with the carcass and larvae, feeding their offspring with regurgitated meat until the larvae are capable of feeding themselves. Eventually, large third instar larvae burrow a short distance from the now-diminished carcass and form pupation cells. Teneral (new) adults emerge from pupation within 30 to 45 days (A. Kozol, M.L. Prospero, pers. comm.). While individual ABBs may be capable of breeding twice in a season, they are generally considered univoltine, with a life span of about 12 months (less in captivity) (A. Kozol, M.L. Prospero, and L. Perrotti, pers. comm.; D. Koch in litt. 2007).

2.3.1.1 New information on the species' biology and life history:

The basic breeding biology and life history of *Nicrophorus* burying beetles has been known for more than half a century (see, for example, Fabre 1918 and Pukowski 1933 in Scott 1998). However, since listing of the ABB, additional research has been published (or come to our attention) on a number of aspects of burying beetle life history and ecology.

Scott et al. (1987) examined the importance of ants as competitors of burying beetles. Ants are abundant omnivorous scavengers and occupy many habitats. Ant colony size is often large and many ant species have quick recruitment systems that allow them to occupy and defend small vertebrate carcasses. Although the sensitive chemoreceptors of *Nicrophorus* burying beetles allow them to locate carrion over long distances, the high density of foraging ant species with well-developed trail communications and chemical or aggressive defense resources may bring ants and burying beetles into direct competition for small vertebrate carcasses. Ants are particularly abundant at southern latitudes where, therefore, competition between ants and *Nicrophorus* beetles will be more acute. Scott et al. (1987) concluded that the inability of *N. carolinus* to successfully

bury carrion provided experimentally in Florida was due to interference by imported fire ants (*Solenopsis invicta*). Only 5 of 48 carcasses were successfully exploited by *N. carolinus*, despite pitfall trapping that demonstrated that *N. carolinus* was locally abundant.

Lomolino et al. (1995) conducted field studies on habitat affinities of the ABB in the western populations in Oklahoma and Arkansas. With habitat defined as vegetation species composition, structure (forest, shrubs, grasslands, etc.), and soil characteristics and depth, they determined that the ABB exhibited a broad niche and was recorded in all habitat categories at the two study sites. They rejected Anderson's (1982) hypothesis that the species is restricted to habitats with deep soils (such as primal forests) but did find that ABB trapping success was correlated with the three soil fractions, sand, silt, and clay. Trapping success increased with percentage of sand and decreased with percentage of silt and clay. For example, at Fort Chaffee, ABB tended to avoid soils with less than 40 percent sand, over 50 percent silt, and 20 percent clay. The authors conclude that because the ABB is the largest carrion beetle in the communities they examined, and requires larger prey, which is less abundant than smaller prey, the ABB must search over a larger home range to locate carrion suitable for reproduction. The requirement to search over a large area in search of carrion results in the ABB being recorded in baited traps set in a variety of habitats, but the species may be "more stenotopic [tolerant of a narrow range of environmental conditions] when selecting sites for carcass burial and breeding."

Lomolino and Creighton (1996) report on research into habitat selection and breeding success of *N. americanus* and six syntopic species in Oklahoma. In this study, over 6,000 individuals of seven *Nicrophorus* species were trapped, and three species were more abundant than the ABB: *N. orbicollis* (>20 times more abundant), *N. tomentosus* (nearly five times more abundant), and *N. marginatus* (greater than two times as abundant). All species of burying beetles, including the ABB, exhibited significant habitat selectivity at the regional scale. Trapping success for the ABB was highest at sites characterized as having moderate to well-developed forests with moderate to deep soils and understory with moderate cover of small shrubs. Lomolino and Creighton (1996) also examined habitat associations at the local scale in the Tiak District of the Ouachita National Forest. The three most common *Nicrophorus* species there, *orbicollis*, *tomentosus*, and *americanus*, were not randomly distributed with respect to habitat conditions; rather, all three exhibited highly significant avoidance of clearcuts, and the ABB exhibited a strong preference for mature forests. In a study comparing breeding success in grassland versus forested sites, 56 percent of ABB pairs provided with a carcass bred successfully in the grassland site, versus 95 percent success in the forest site. The authors attribute the difference to the difficulty of ABBs in securing and burying carcasses in grasslands due to a reduced litter layer, more compact soils, and the competition from vertebrate scavengers such as raccoons, armadillos, and opossums.

Schnell et al. (in press) reported on the factors that influence overwinter survival for the ABB, which overwinters as an adult by burrowing in soil. Schnell et al. found that in the western portion of the species' range (specifically, at Fort Chaffee in Arkansas), ABBs

were interred on average only about 6 cm (2.4 inches) under the surface of the ground (range 0 to 20 cm or 0 to 6 inches). This led them to conclude that soil depth may not be a serious constraint on overwinter survival in this portion of the species' range. Survival rate of ABBs placed in overwintering chambers did not differ among experimental grassland and woodland sites, suggesting that habitat structure is unlikely to be a critical factor. However, ABBs with access to a whole vertebrate carcass in the fall had a survival rate of 77 percent versus a 45 percent survival rate for those ABBs not provisioned with a carcass. All ABBs (provisioned and not provisioned) had a mean survival rate of about 60 percent. It is clear from various trapping studies that ABBs seek carrion in the fall, well after their breeding season has ended, and the Schnell et al. study suggests that there is an overwinter survival benefit to those that find it.

Holloway and Schnell (1997) made an extremely important contribution to the understanding of ABB life history in their study at Fort Chaffee, Arkansas. They found that with habitat defined by vegetation type, the ABB at Fort Chaffee did not appear to be selective and was a habitat generalist when feeding. However, in analyzing bird and mammal species and densities at different locations within the installation, they found significant correlations between occurrence of ABBs and biomass of mammals, biomass of mammals plus birds, numbers of mammal species, and numbers of individual mammals. Holloway and Schnell (1997) concluded that ABBs frequent sites where small vertebrates (particularly mammals) are relatively abundant, irrespective of the predominant vegetation present at the site. Favorable areas for ABB reproduction may occur in more than one habitat as defined by vegetation structure, provided that carrion is available and soils are suitable for carcass burial and brood rearing. This study emphasizes that, with respect to the ABB, no discussion of what constitutes "suitable habitat" is complete without an analysis of the vertebrate species present.

Amaral et al. (1997) reported on the first reintroduction attempt for this endangered species, a 4-year release effort on Penikese Island, Massachusetts. This study demonstrated that captive-raised and wild translocated ABBs could be released successfully and that their progeny were capable of breeding on naturally occurring carrion at the release site. While this experimentally re-established population persisted for 9 generations after the last animals were released, post-release monitoring documented the survival of only modest numbers of progeny, and ultimately the population died out by 2003 (Amaral and Mostello 2007). Amaral et al. (1997) also provided recommendations on the initiation of additional captive breeding programs and criteria that should be considered in evaluating potential reintroduction sites.

Bedick et al. (2004) examined the efficacy of different pitfall trapping methods for ABBs in Nebraska and favored large, 18.9-liter bucket traps with soil, because they minimized beetle crowding, allowed the use of larger bait, afforded easy access, and provided the animals a substrate refugia. They also tested the attractiveness of different types of vertebrate carrion and found that all major classes of animal carrion (e.g., bird, mammal, amphibian, reptile, and fish) successfully attracted *N. americanus*. As early as 1986, Kozol et al. (1988) had demonstrated that the ABBs on Block Island, Rhode Island, utilized bird and mammal carcasses equally. ABB pairs that were provided fish carcasses

on Block Island also reproduced successfully (RI DEM and USFWS unpubl. data). Coyle and Larsen (1998) conducted a bait comparison survey in northeastern Iowa and found that while aged beef liver attracted almost twice as many individual carrion beetles as other baits, aged chicken and fish were the preferred baits, because they attracted the most diverse assemblage of beetle species (8 of 10 species present). No ABBs were captured in that study. Collectively, these studies demonstrate that the ABB is attracted to a wide variety of carrion and is capable of reproducing on bird, mammal, and even fish carcasses, although fish are not likely to be available except in unusual circumstances.

Because carrion is a scarce and ephemeral resource in nature, ABBs must traverse large areas in search of it. By necessity, they are strong flyers capable of covering substantial distances overnight. Schnell et al. (2006a) reported a one-day movement of a marked ABB of 4.25 km (2.6 miles); the previous farthest one-day movement they had noted during ABB studies in Arkansas and Oklahoma was 2.9 km (1.78 miles) (Creighton and Schell 1998). In a Nebraska study, a marked ABB was captured at a distance of 6.1 km from its original capture (Bedick et al. 1999). On average, recaptured marked ABBs at Fort Chaffee in 2006 moved an average of 1.29 km per day (0.8 miles) (Schnell et al. 2006a). Raithel et al. (2006) noted that ABB flight behavior was influenced by weather, dew point, and wind speed; they also noted that wind direction did not affect short-distance movement direction but that most long-distance movements were downwind.

2.3.1.2 Abundance, population trends, demographic features, or demographic trends:

At the time of listing, only two ABB populations were known, one on Block Island, Rhode Island, and one in Latimer County, Oklahoma. Then Creighton et al. (1993) reported the 1991 discovery of a previously unknown ABB population on Cherokee Wildlife Management Area (WMA) and adjacent Camp Gruber in Muskogee and Cherokee counties, Oklahoma, on a site described as a mosaic of grasslands, oak-hickory, and bottomland forests on the western edge of the Ozark uplift. Creighton et al. (1993) surveyed in the three predominant habitats present and determined that ABB captures were highest in oak-hickory forest, followed by grassland sites. They also reported the re-discovery of a single ABB specimen on private land in Sequoyah County.

Between 1992 and 2006, numerous presence/absence surveys for the ABB were conducted in Oklahoma, resulting in the re-discovery of ABBs in 19 other counties in the State (see Figure 3 in section 2.3.1.5). In addition to random presence/absence surveys, priority search areas were identified based on suitable habitat, historic and current range information, and land ownership. Surveys were consequently conducted at the Little River National Wildlife Refuge (NWR) in McCurtain County and Tishomingo NWR in Johnston County in 2005 and 2006. No ABBs were captured at either refuge during the limited survey effort, although additional surveys are planned for Tishomingo NWR. Surveys were also conducted at The Nature Conservancy's (TNC) Tallgrass Prairie Preserve in Osage County and Nickel Preserve in Cherokee County. Surveys in the Tallgrass Preserve in 1999 and 2005 confirmed the presence of the ABB. The 2004 Nickel Preserve surveys were negative for ABBs; additional surveys are planned for this

area. An incidental ABB sighting was reported by Ken Hobson of the University of Oklahoma in 2002 at the TNC's Pontotoc Preserve, with follow-up surveys planned.

Multiple, consecutive-year monitoring data are available in Oklahoma from Camp Gruber in Muskogee County, Weyerhaeuser Timber Habitat Conservation Plan (HCP) Management Area (Weyerhaeuser) in McCurtain County, McAlester Army Ammunition Plant (MCAAP) in Pittsburg County, and Ouachita National Forest (Ouachita NF) in portions of Leflore and McCurtain counties. ABB captures at these locations typically fluctuate on an annual basis, but in general ABB numbers appear stable or increasing, with the exception of the Weyerhaeuser HCP area. Likewise, all of these areas except Weyerhaeuser provide large, relatively natural habitat for ABB (H. Dikeman, USFWS, pers. comm.).

Annual monitoring at Camp Gruber from 1992 to 2006 illustrates how captures can fluctuate markedly from year to year, with annual total ABBs captured ranging from 81 in 1999 to 754 in 2006. Overall, however, the survey data indicate a stable to increasing population from 1992 to 2006 at Camp Gruber, with record high numbers of ABBs captured between 2004 and 2006. Monitoring conducted at the MCAAP since 1999 indicates an increasing population (Department of Defense 2005 unpubl. data); however, surveys are conducted only biennially and the sample size is relatively small (4 years of sampling has resulted in only 57 ABBs). In addition, only 168 trap nights are deployed during each sampling period.

During the period from 1997 to 2006, annual surveys on the Weyerhaeuser HCP Area in McCurtain County, Oklahoma, and Little River County, Arkansas, indicate the first apparent collapse of an extant occurrence since the species' listing in 1991. From 1997 to 2006, the following numbers of ABBs were captured: 106, 64, 26, 41, 16, 25, 85, 19, 0, and 0, respectively. Again in 2007, no ABBs were captured (G. Schnell, pers. comm.). Schnell et al. (2006b) suggested that although zero ABB captures for the second year in a row "could be of concern", they had previously noted substantial year-to-year population fluctuations (e.g., range of 16-106 ABBs during 1997-2004). However, during 2005 and 2006, Schnell et al. (2006a) reported record high captures of the ABB at Fort Chaffee, Arkansas, and Smith and Clifford (2006) reported record high captures at Camp Gruber, Oklahoma. In the past, ABB captures at the Weyerhaeuser HCP Area tended to follow the same relative abundance trends as those noted for the species at Fort Chaffee and Camp Gruber. Another alarming result of this study is that the red-imported fire ant, which is absent from Fort Chaffee, was notably more abundant on the Weyerhaeuser area in 2006, and Schnell et al. (2006b) postulated that fire ants may be competing with ABBs for carrion resources such as rodents and ground nesting birds. They also noted that because Fort Chaffee and the Weyerhaeuser HCP area are about 100 miles apart, localized weather patterns (it was dryer in southeastern Oklahoma) could also have affected ABB abundance and trapping success differentially between the sites.

Sex ratio data were also collected in Oklahoma, from 2001 to 2006. A t-test ($p < 0.05$) was conducted, and no significant difference was detected in the ratio of male to female ABBs during this time period.

Despite the more extensive distribution of the ABB in Oklahoma than formerly known, this species is orders of magnitude less abundant than most other sympatric *Nicrophorus* species. Between 2004 and 2006, the average capture rate for the ABB per trap night was 0.021, compared to 0.09 for *N. orbicollis*, 0.072 for *N. marginatus*, and 0.054, for *N. tomentosus* (USFWS, Oklahoma Field Office, unpubl data). More ABBs were captured in Oklahoma surveys than were *N. carolinus* and *N. sayi*, but these species are uncommon in the State.

Ratcliffe and Jameson (1992) reported the rediscovery of the ABB in north-central Nebraska, and Peyton (1994) discovered a population in the south-central area of the State. Bedick et al. (1999) estimated an ABB population size of 1,600 individuals near Gothenburg, Nebraska. Ratcliffe (1996) and Bedick et al. (1999) provide information important to an understanding of current distribution and ecology of ABB populations in Nebraska. These studies examined the mobility of individual ABBs and determined that most ABBs (92 percent) were recaptured within 1 km of the initial marking, albeit one animal moved 6.1 km. Based on these movement distances, Bedick et al. (1999) estimated that the attractiveness of their pitfall traps (extent of area surveyed) was 1 km around each trap. Unfortunately, the traps and bait utilized in this study (five-gallon containers and whole carrion) differ markedly from the recommended survey protocol (Kozol in USFWS 1991); therefore, the results (density of ABB population based on trapping success and extent of area surveyed) are not comparable to most other ABB studies.

Bedick et al. (2004) examined the phenology of Nebraska ABBs and found a bimodal distribution in captures related to age class. Most mature adults were caught during the period from mid-June to the first week of July, a period that corresponds with beetles actively seeking carrion on which to raise their broods. The second peak of activity, August to early September, corresponds with the emergence of teneral adults. Bedick et al. concluded that the ABB is univoltine in Nebraska and begins breeding soon after emergence in late spring (about May 20 through June). In an analysis of nocturnal activity, the study found that ABBs were most active from two to four hours after sunset and at temperatures between 15° to 20° C. A few ABBs may be active at temperatures as low as 12 to 13° C, but temperatures above 24° C may depress activity. Bedick et al. (2004) found few ABBs in the disturbed and fragmented habitats around the south-central Nebraska population they studied, findings they considered consistent with the suggestion that habitat disturbance and fragmentation are factors in the species' decline (USFWS 1991, Lomolino et al. 1995).

In addition to estimating the size of a Nebraska ABB population, Bedick et al. (1999) also found that overwintering causes significant mortality. Winter mortality has only recently begun to be investigated (Schnell et al. in press, Raithel unpubl. data) and may range from 25 percent to about 70 percent, depending on year, location, and availability of carrion in the fall (Schnell et al. in press).

Carlton and Rothwein (1998) report on a 5-year study to survey a low-density ABB population near the eastern limit of the species' range in the Ouachita NF in west-central

Arkansas. The authors utilized trapping success rates to make inferences about ABB population sizes and to make comparisons with other populations for which there are published trapping success rates. They reported an overall trapping success rate “at the species distributional limit” of 0.02 ABBs per trap-night (1 ABB per 50 trap nights), noting this as a probable lower limit to a viable population because it is the lowest trapping success rate known for any area that has been thoroughly surveyed using comparable methods. By comparison, Lomolino et al. (1995) reported trapping success rates of 0.159 (nearly 8 ABBs per 50 trap nights) at Fort Chaffee, Arkansas, and 0.103 (5 ABBs per 50 trap nights) at Camp Gruber, Oklahoma; Backlund and Marrone (1997) reported 0.113 trapping success in a newly discovered population in South Dakota; and Raithel (2004, 2005, 2006) reported a trapping success rate ranging from 0.8 to 2.1 (40-105 ABBs per 50 trap nights) at the high-density Rhode Island population.

The ABB has a life span of about 12 months. Accordingly, population estimates will have limited utility unless continued for several years until a trend emerges. Long-term population monitoring (1992-2006) of the Fort Chaffee population (Schnell et al. 2006a) indicates that the ABB population fluctuates annually within a certain range. High capture rates were reported for Fort Chaffee in 2005 and 2006 compared to earlier years, indicating that the population there may be increasing.

Carlton and Rothwein (1998) suggest that the Oklahoma, Arkansas, and South Dakota populations noted above may represent robust ABB populations (>0.10 ABB trapping success) that merit investigation of the physical and biological conditions favorable for the species. They offer that these sites would be suitable as donor populations for reintroductions. Intermediate population densities are those in the 0.03-0.09 range. In the absence of reliable methods to estimate absolute population sizes, Carlton and Rothwein recommend that trapping success is the best way to assess ABB density and urge researchers to standardize trapping protocols across the species' range. For areas where ABBs occur at or below the 0.02 trapping success rate, the authors suggest that not only will populations be non-viable, but they also are likely to be overlooked (i.e., identified as ABB negative), because trapping success will be so low. As an example, they cite a rapid, large area survey in Kansas (Lingafelter 1995) that failed to detect the ABB, which was subsequently found to be localized in that State (Miller and MacDonald 1977).

In Texas, at Camp Maxey in Lamar County, Godwin and Minich (2006) reported that ABB populations were “dramatically reduced from 2005 levels.” They reported a trapping success rate of 0.53 ABBs per trapnight in 2005 and 0.12 ABBs per trapnight in 2006. Two years of monitoring data, however, are insufficient to draw conclusions about the trend of this small population.

Monitoring of the Block Island, Rhode Island, population has been conducted annually since 1991 (Raithel et al. 2006, Raithel in litt. 2006). Population estimates there went up over the 16-year period, particularly after 1994 when a program was initiated to provision pairs of beetles with carrion to increase reproduction. As in other localities, ABB captures on Block Island vary considerably from year to year, and for the three study sites

surveyed, population estimates range from about 120 to over 600 beetles. Island-wide, there are probably in the range of 1,000-2,000 ABBs present on Block Island. The number of ABB captures during any particular trapping interval is influenced by temperature, dew point, and wind speed (Raithel et al. 2006). The authors caution that their results provide no clear indication about the long-term viability of the ABB population on Block Island if carrion provisioning were to be discontinued.

Most researchers have conducted surveys consistent with the trapping protocol appended to the recovery plan (USFWS 1991). However, some ABB surveys in Kansas, Texas, and Nebraska have adopted a larger, bucket-sized pitfall trap, baited in some instances, with whole carrion. The use of consistent trapping methods facilitates comparison of ABB trapping success per trapping effort both within different habitats and in disparate areas of the species extant range, as shown in Table 1 below.

Table 1. Comparative ABB Capture Success Rates for Selected Populations in Rhode Island, Oklahoma, Arkansas, Kansas, and South Dakota.

<u>Location</u>	<u>Capture Success Rate</u>	<u>Trap Nights</u>	<u>Source</u>
Wilson County, Kansas	0.004	692	Miller and McDonald 1997
Chautauqua & Montgomery counties, Kansas	0.016	120	Guarisco 1997
West-Central Arkansas	0.02	1,156	Carlton and Rothwein 1998
Fort Chaffee, Arkansas	0.103	614	Lomolino et al. 1995
	0.43*	432	Schnell, Hiott and Smyth 2006a
Camp Gruber, Oklahoma	0.103	215	Lomolino et al. 1995
South Dakota	0.113	363	Backlund and Marrone 1997
Block Island, Rhode Island	1.77*	449	Raithel 2004, 2005, 2006 (range 1.06-2.75)

* Figure represents the mean of 3 years trapping effort, 2004-2006.

ABB population estimates based on mark-release-recapture methodologies, e.g., Lincoln-Petersen Index and Sequential Bayes Algorithm (Kozol 1991), have shortcomings due to the possibility of beetle movement into or out of the study area, as well as variable trapping success due the vagaries of weather during the sampling interval (Raithel et al. 2006). Notwithstanding these limitations, this method is believed to be superior to estimates based on ABB density (ABBs caught per trapping effort) extrapolated to an estimate of suitable habitat area. This latter method is less reliable because the ABB is absent from extensive areas that appear suitable based on superficial descriptions of plant species and vegetation structure present (see Appendix A). It is likely that, in addition to a certain vegetation structure, suitability of a landscape to support the ABB is dependent on a favorable composition of the vertebrate and invertebrate species present, and only a

few studies (e.g., Holloway and Schnell 1997, Raithel et al. 2006) have examined the suitability of ABB habitat in that manner.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation:

Kozol et al. (1994) examined ABB genetic variation within and between the Block Island, Rhode Island, population and the largest geographically contiguous population in Arkansas (Sebastian County) and Oklahoma (Latimer and Muskogee counties). Both the Block Island and Arkansas-Oklahoma populations have low levels of genetic variation, and most of the variation occurs within a single population. There were no unique diagnostic bands within either population, but the Arkansas-Oklahoma population is “somewhat more diverse” than the Block Island population. The authors noted that, for other species, the observed reduced genetic variation exhibited by the ABB populations they studied is often a result of founder effect, genetic drift, and inbreeding. They suggest that multiple bottleneck events, small population size, and high levels of inbreeding may be factors contributing to the pattern of diversity in *N. americanus*.

Szalanski et al. (2000) expanded on the genetic study by Kozol et al. (1994) and examined ABBs from five populations: Block Island, Arkansas, South Dakota, Oklahoma, and Nebraska. The authors found little evidence that the five populations have maintained unique genetic variation. The Block Island population was found to have less nucleotide variation than the other populations, but no evidence was found to suggest that any of the five populations should be treated as a separate, independent focus for conservation. Of 10 *Nicrophorinae* species they examined, *N. americanus* formed a distinct clade (taxonomic group sharing features traced to a common ancestor) with *N. orbicollis*.

The authors suggest that because the ABB is phylogenetically close to *N. orbicollis*, the two species may be in more direct competition, as they share geographic range, habitat preference, diel periodicity, and breeding season. Both species also require carrion for reproduction (albeit generally of different size ranges). *N. orbicollis*, although smaller, may dominate in exploitative competition events due to its numerical abundance and extensive distribution.

2.3.1.4 Taxonomic classification or changes in nomenclature: None

2.3.1.5 Spatial distribution, trends in spatial distribution, or historic range:

The ABB formerly occurred in most eastern and central States, as well as the southern borders of three eastern Canadian provinces (see Figure 1). At the time of listing, the only known populations occurred on Block Island and in Latimer County, Oklahoma. When the recovery plan was completed in 1991, the ABB was also known to occur in Sequoyah, Cherokee, and Muskogee counties, Oklahoma. Since then, field surveys have discovered additional occurrences in the following States: Arkansas (Carlton and Rothwein 1998), Kansas (Guarisco 1997, Miller and MacDonald 1997), Nebraska (Ratcliffe 1996; Bedick et al. 1999; W. Hoback and D. Snethen, pers. comm.), Oklahoma

(Lomolino and Creighton 1996; G. Schnell and A. Hiott, pers. comm.), and South Dakota (Backlund and Marrone 1995, 1997). From 2003-2005, the ABB was also discovered in two separate locations in northeastern Texas: Lamar County and a nearby site in Red River County (Godwin and Minich 2005).

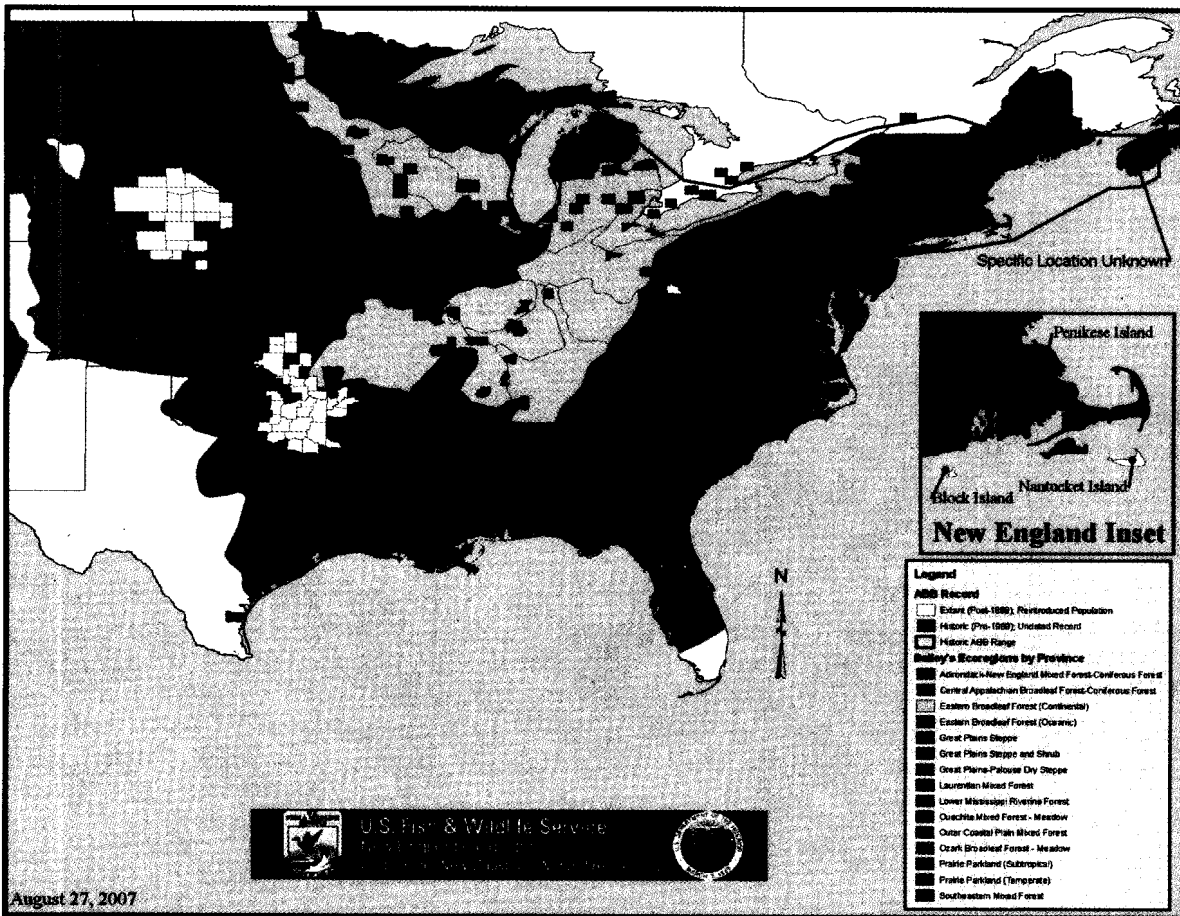
Conversely, for over 15 years biologists have attempted unsuccessfully to rediscover extant occurrences of the ABB within its historic range east of the Mississippi River and in additional portions of its western range. Appendix A provides a partial listing of surveys that were unable to locate additional undiscovered occurrences.

In order to gauge the improvement in the species' status from 1991 to the present, and to compare current and historic distribution, ABB records were plotted within the Bailey's Eco-regional Provinces in which they occurred (Figure 2, http://www.fs.fed.us/colorimagemap/ecoreg1_divisions.html). It appears that, historically, the ABB occurred in about 15 eco-regional provinces, including the Laurentian mixed forest of Maine and Nova Scotia, Canada, in the north and east, south to the outer coastal plain mixed forest in Florida, and west to the prairie parkland of eastern Oklahoma and Great Plain-steppe of Nebraska and South Dakota. In 1991, ABB occurrences were known from only two to three eco-regions, the eastern broadleaf forest (oceanic) province (Rhode Island) and the prairie parkland/Ouachita mixed forest-meadow province in Oklahoma. With the discovery of the additional extant occurrences, the ABB is now known from about six eco-regions, with distribution in the eastern and western parts of the range differing markedly: west of the Mississippi River, the ABB now occurs in five of the nine eco-regions where it was once found, and east of the Mississippi it occurs in one of seven eco-regions. The ABB appears to have reasonably large population clusters (i.e., populations estimated at >1,000 individuals and persistent over several years) in about four eco-regions (Amaral et al. [eds] 2005).

Documentation that the ABB occurs throughout a more extensive extant range than that known at the time of listing is the most significant new information pertinent to this status review. Recently reported (post-1989) occurrences of the ABB in a total of 21 counties in Oklahoma and about 20 counties in central Nebraska account for the greatest expansion of the known range for the species. In addition, capture records at TNC's Prairie Preserve in western Osage County and near Durant in western Bryan County extend the western boundary for the ABB in Oklahoma beyond that reported in the recovery plan (Figure 3).

Oklahoma contains at least one large concentration of ABBs at Camp Gruber in Muskogee County (754 ABBs captured there in 2006). Smaller concentrations of ABBs in Oklahoma include the MCAAP in Pittsburg County and the four-county area of Atoka, Coal, Hughes, and Pittsburg counties. Additional survey effort in this four-county area may confirm the occurrence of another large, self-sustaining population in Oklahoma (H. Dikeman, pers. comm.).

Figure 2. Ecoregional Provinces in the United States and Canada and Historic and Current Occurrences of the ABB.



Nebraska ABB occurrences are often depicted as being a collection of 20 contiguous counties (e.g., <http://www.fws.gov/southwest/es/oklahoma/beetle1.htm>); however, the south-central Nebraska occurrence is geographically isolated from the ABB population in northern Nebraska and South Dakota (W. Hoback, pers. comm.; Amaral et al. [eds] 2005) (Figure 4). ABB occurrences in Lincoln and Cherry Counties in Nebraska are the westernmost known for the species. While the overall status of the ABB in Nebraska has appeared stable during the decade 1996-2006, some population decline in the Loess Hills region is noted and thought to be the result of drought, causing a reduction in carrion sources for the beetle (Nebraska FO, USFWS, in litt. 2007).

The distribution and relative density of the ABB in southern South Dakota has been monitored annually since extant occurrences of the species were discovered there in 1995 (Backlund and Marrone 1997, Marrone 2006). Backlund and Marrone reported that the

Figure 3. ABB Current Range and Historic Distribution in Oklahoma.

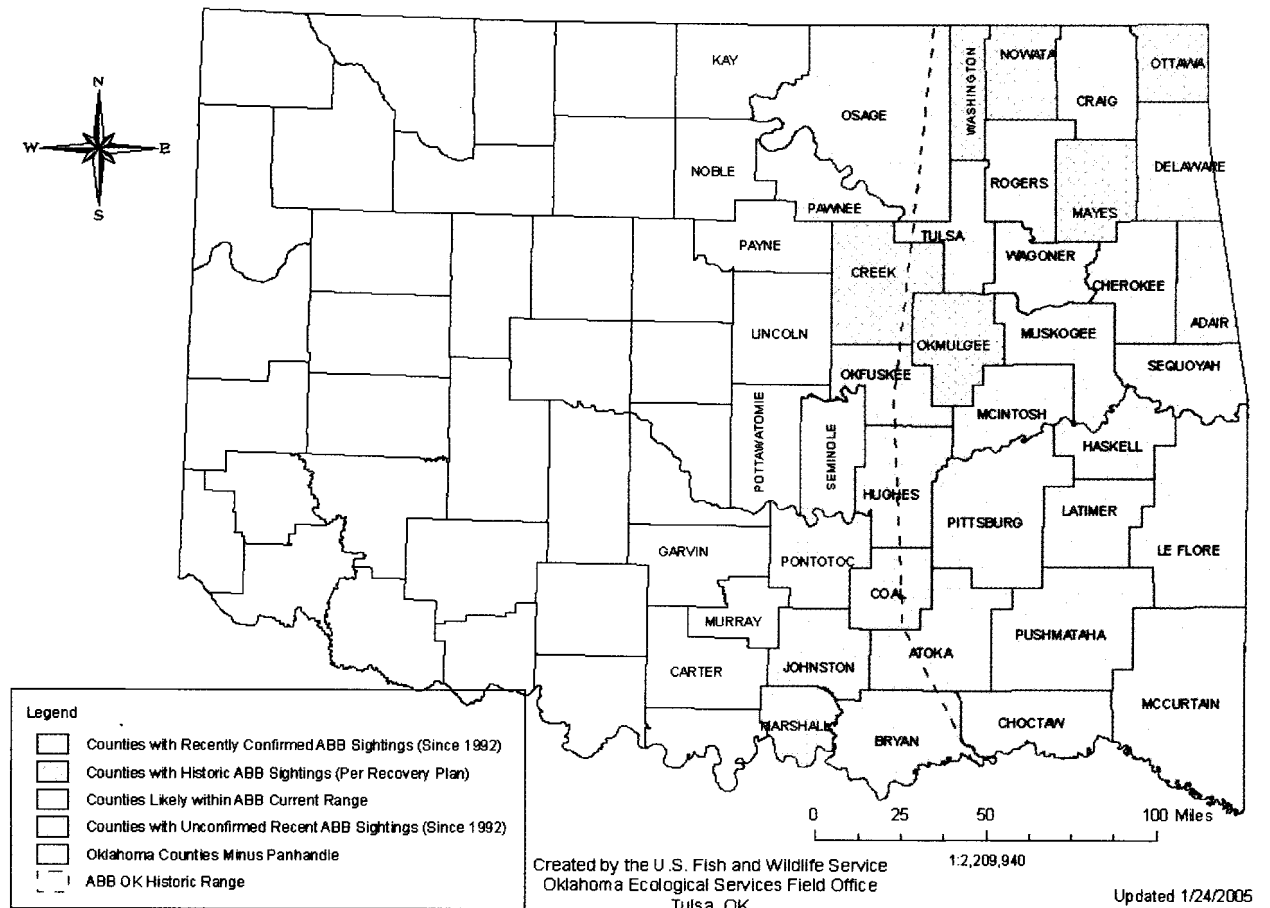
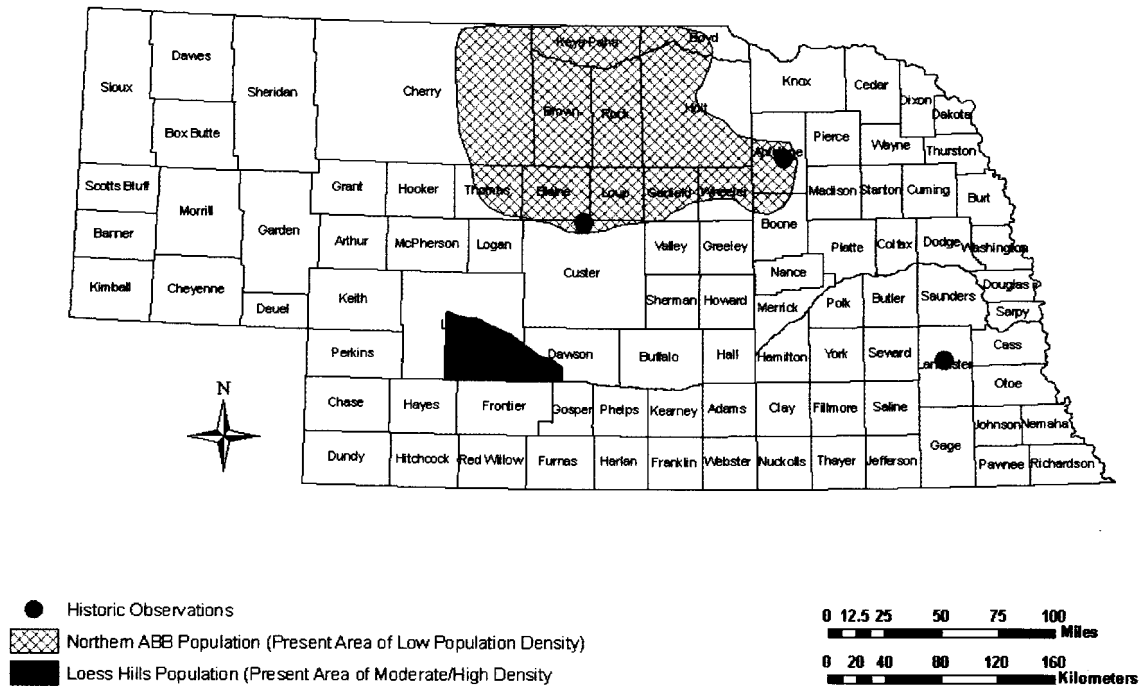


ABB population occupies about a 100-square-mile area centered in southern Tripp County and extending into southwestern Gregory County and peripherally into eastern Todd County. From the center of abundance in southern Tripp County, they surveyed for the species “east, north and west of this area” and noted that they always found “that the abundance drops off to zero with an occasional stray catch as far north as Winner, S.D.” (Backlund and Marrone 1997). Another recent sighting was also recorded from Bennett County (D. Sneath, in litt. 2007). Marrone reported that in more than 10 years of study, the range and abundance of the ABB in South Dakota have remained unchanged (except for an unusually high capture rate in 2006), and the ABB appears to have a small but stable distribution in the State (Figure 5). Distribution, status, and abundance of ABB in South Dakota are provided at <http://www.sdgfp.info/Wildlife/Diversity/ABB/ABB>.

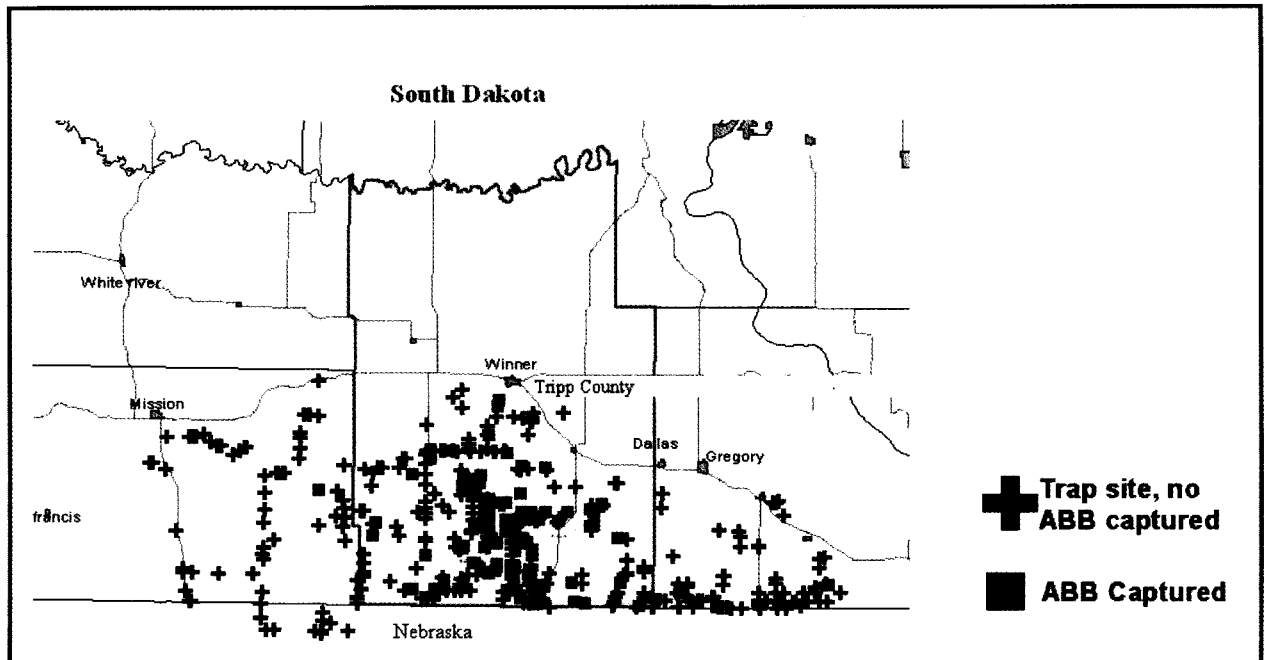
Figure 4. ABB Distribution in Nebraska, 2007.



The ABB was found to occur in five western Arkansas counties (Logan, Sebastian, Franklin, Scott, and Little River). Despite suspicion that the ABB may also occur in several adjacent counties within habitat that appears suitable, a five-year (1992-1996), county-by-county Statewide survey (Carlton in litt. 1996, Carlton and Rothwein 1998) did not find the species elsewhere in that State. The eastern distributional limit of the ABB in Arkansas proposed by Carlton after surveying 65 of Arkansas' 75 counties is supported by Warriner (2004). Warriner could not locate ABBs in three WMA in Hempstead and Logan counties and noted that it is unknown why ABB densities decrease from Fort Chaffee eastward. Within Arkansas, one of the largest remaining ABB concentrations occurs in the Arkansas River Valley north of the Ouachita National Forest on Fort Chaffee, in Sebastian and Franklin Counties (Figure 6). Similar to Nebraska, the ABB does not occur throughout the five-county area within its extant Arkansas range; rather, the west-central Arkansas population is believed to be geographically separated from other ABB occurrences in the State (C. Davidson, USFWS, pers. comm).

The discovery of the ABB at Camp Maxey in Lamar County, Texas, in 2003 and at TNC's Lennox Woods, 26 miles to the east in Red River County, in 2004 indicate that the geographically large ABB population in southeastern Oklahoma extends into the northeast corner of this State as well (Godwin and Minich 2005). Camp Maxey is a Texas National Guard facility of about 6,000 acres in size, and Lennox Woods is 375

Figure 5. Trap and Capture Locations for the ABB in Tripp, Gregory and Todd Counties, South Dakota (courtesy of D. Backlund, South Dakota Department of Game and Fish).

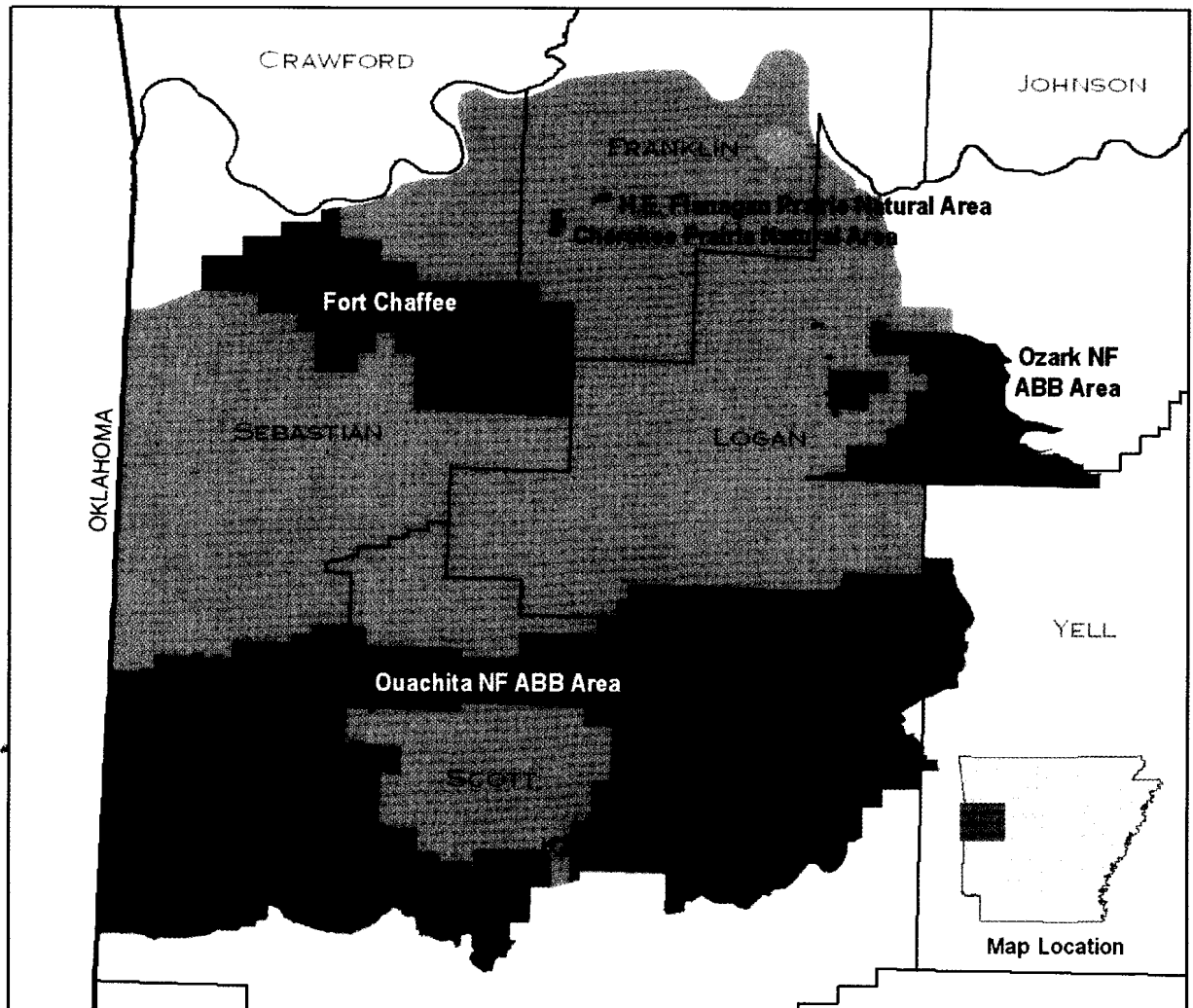


acres in size. Godwin and Minich (2005) describe Camp Maxey as having one of the largest forest patches in the area with apparently healthy populations of ground nesting birds such as quail and turkey. TNC describes Lennox Woods as “one of the most pristine old-growth forests in the State.” Godwin and Minich (2005) report that despite taking precautions, fire ants and vertebrate scavengers, such as coyotes, disturbed more than 20 percent of the pitfall traps they set for ABBs. They also recorded mortality of ABBs due to ant predation and noted that wild hogs could be a potential threat. These Texas counties are the southernmost limit of the species’ current distribution. Other data collected in the region by Godwin and Minich (2006) indicate that the ABB population at Camp Maxey does not extend more than 40 miles to the east, west, or south. Previous efforts to document extant occurrences in the Stephen F. Austin Experimental Forest and Tucker Estate (Nacogdoches County) and the Davy Crockett National Forest (Houston County) did not result in the capture of any ABBs (C. Rudolf, USFWS/Texas, in litt. 2007).

While there have been a large number of surveys for the ABB in certain portions of its range, only a small number of populations (termed “sentinel” populations) are monitored annually or biennially. These include Block Island, Fort Chaffee, Camp Gruber, the Weyerhaeuser HCP area, MCAAP, and Tripp County. Except in the locations noted

Figure 6. Estimated Occurrence of ABB Populations in Sebastian, Franklin, Logan and Scott Counties, Arkansas.

Dark gray areas denote Federal and State properties with ABB occurrences and light gray area denotes private property with potential for ABB occurrences. Hempstead County is not illustrated because it has been several years since the last ABB was collected there.



above, little is known about the demographic status of the ABB in other States and counties where it is believed to be present. Whether ABB populations (and range) are expanding, stable, or contracting in size and vital rates (survival, reproduction, and movement) is virtually unknown for the ABB in much of Arkansas and Kansas and parts of Nebraska and Oklahoma.

Since listing, the ABB has been successfully reared at several universities and zoos. Captive-reared and direct-translocated ABBs have been released at three sites in attempts to re-establish populations in the wild. Releases of only 211 ABBs on Penikese Island,

Massachusetts, from 1990-1993 resulted in a small population that persisted until 2002, about nine generations; however, no ABBs were documented on the island from 2003-2006 (Amaral and Mostello 2007). A much more ambitious reintroduction effort on Nantucket Island involved the release of nearly 3,000 ABBs during a 13-year period, 1994-2006 (McKenna-Foster et al. 2006). Post-release monitoring of this effort began in 2007 and will require additional time for evaluation. Lastly, 1,013 ABBs were released on public land in southeastern Ohio during the years 1998-2000 and 2003-2006 (G. Keeney, S. Selbo, pers. comm.; Ohio State University 2007). This is the first mainland attempt to restore the species to its former range, and thus far post-release monitoring surveys have caught relatively few ABBs.

2.3.1.6 Habitat or ecosystem conditions:

General ecosystem conditions

Although wildlife biologists often describe “suitable habitat” in terms of vegetation structure and plant species present (e.g., oak-hickory forest or bluestem short-grass prairie), the limiting factors for the ABB are the presence of carrion of a size suitable for reproduction, vertebrate and invertebrate competitors for carrion, and adequate soil for carcass burial (USFWS 1991, Holloway and Schnell 1997, Sikes and Raithel 2002). Thus, in addition to vegetation and soil, the essential habitat features of ABB habitat require an understanding of the vertebrate and invertebrate animal assemblages present.

The prevailing theory of the ABBs decline, underway for nearly a century and a serious concern by the 1920s (Ratcliffe 1996), points to habitat loss, degradation, and fragmentation leading to a corresponding decrease in suitable carrion (USFWS 1991, Sikes and Raithel 2002). As more and more land was developed or converted for agricultural and other uses, the resulting altered habitats favored scavenging mammal and bird species that compete with carrion beetles for resources.

On the contemporary landscape, vegetational aspects of ABB habitat across large areas of the species’ historic range, particularly east of the Mississippi River, are no longer suitable because of development, habitat conversion for agricultural crops, grazing, or alterations that preclude the presence of carrion resources required by the burying beetle to thrive. In the East, pre-Columbian forests were removed by European settlers, converted to farms and pasture, then abandoned in the 1800s and allowed to convert back to forest. Second- and third-growth forests were again cut in the 1900s for timber and other uses. In the Southcentral United States (eastern Oklahoma, Arkansas, and Texas), pre-Columbian forests were cleared around the early 1900s. In the central United States, tall- and short-grass prairies were tilled and replaced with managed agricultural crops, and converted to non-native pasture for livestock. In many areas, native grasslands and prairies have been replaced by opportunistic plant communities, including non-native invasive plant species.

While some small rodents may have adapted well to the new habitats, most small mammals are too small for the ABB, which prefers an 80-100 gram carcass upon which to raise its young (Kozol et al. 1988). The cutting of forests and tilling and pasturing of

the prairies not only led to declines in ground nesting birds, but also created more edge habitat, ideal for predators and scavengers that directly compete with the ABB for carrion.

Certain faunal aspects of ABB habitat have undergone dramatic changes on a continental scale. The passenger pigeon (*Ectopistes migratorius*) and eastern prairie chicken (or heath hen, *Tympanichus cupido*) chicks and juveniles were ideal carrion size for the beetle. These species and the wild turkey disappeared from eastern grasslands and forests (Bent 1932). The extinction of the once abundant passenger pigeon and the heath hen altered the carrion base for the ABB after about 1900 (Bent 1932, Sikes and Raithel 2002). Circumstantial evidence that the passenger pigeon could have been an essential carrion source for the ABB includes sympatry in range, timing of breeding, and the optimum size of squabs. With an estimated total population size of 3 to 5 billion, there were once as many passenger pigeons within the approximate historic range of the ABB as there are numbers of birds of all species overwintering in the United States today (Ellsworth and McComb 2003). Wild turkeys also disappeared from many eastern forests. Simultaneously, the removal of top-level carnivores such as the gray wolf and eastern cougar, as well as land use changes that fragmented native forests and grasslands, creating more edge habitats, resulted in meso-carnivores becoming more abundant. These mid-sized carnivores prey on small mammals and birds and directly compete with burying beetles by scavenging for carrion. Except on some off-shore islands, where many mainland mammal species are absent and the ring-necked pheasant has become naturalized following its introduction in the 1890s (Bent 1932), vertebrate competition for carrion is now likely to be much greater than in historical times.

In the southeastern United States, the red-imported fire ant has extended its range in the southeastern and south central United States, and this aggressive and communal species is having a significant effect on the ecology of animal communities where it occurs. According to United States Department of Agriculture-Animal Protection Health Inspection Service (USDA-APHIS) (Imported Fire Ants: An Agricultural Pest and Human Health Hazard, 2003), the red-imported fire ant was introduced into Mobile, Alabama, in the 1930s and has since spread to 14 States and Commonwealths (see Appendix B). Carlton in litt. (1996) notes that within infested counties fire ants are not evenly distributed; rather, they tend to be more numerous in open, disturbed habitats. Mature oak-hickory and pine forests (in Ouachita and Nevada counties in Arkansas, for example) and mixed, mesophytic beech-magnolia forests along the Gulf Coast of Louisiana likely have relatively low densities of fire ants.

Ecosystem conditions at the State level

Oklahoma and Nebraska support the highest proportion of extant occurrences of the ABB, with Arkansas supporting the next largest concentration. As stated above, the highest concentration of ABBs in Oklahoma is at Camp Gruber. Camp Gruber comprises 32,000 acres of cross-timber habitat, where oak-hickory forest meets the tallgrass prairie, forming a mosaic of prairie and wooded patches. This ecosystem has been and continues to be maintained through fire resulting from military live-fire training, wildfires, and prescribed burning.

Two other large, federally managed areas supporting the ABB in Oklahoma include the MCAAP and Ouachita NF. The Oklahoma portion of the Ouachita NF consists of oak-pine-hickory forest type (USDA 2005), where management for pine-bluestem habitat is considered highly suitable for both the red-cockaded woodpecker and the ABB (DeBano et al. 1998, Wright and Bailey 1982). Although the Ouachita NF has been managing lands for pine-bluestem habitat in Arkansas for several years, in Oklahoma management for this habitat type is just beginning. A large portion of the forested habitat in Oklahoma has a denser basal area than that which occurred prior to European settlement and before the suppression of fire. In response, the Ouachita NF in both Oklahoma and Arkansas has a prescribed fire program and a timber-harvesting program aimed at restoring the native basal area and specific management actions for pine-bluestem areas.

In general, forested habitats in eastern Oklahoma and western Arkansas have changed since pre-European times due to fire suppression, resulting in an increase in basal area (more trees per acre) and a decrease in the species richness and abundance of small mammals (DeBano et al. 1998, Wright and Bailey 1982). Fire suppression is also altering prairie habitats in Oklahoma (Collins and Wallace 1990) by allowing encroachment of woody species, particularly eastern red cedar. Other activities resulting in alteration of the ecosystem in Oklahoma include conversion of grassland/prairie habitats to aquatic and agricultural habitat (cropland and improved pasture), numerous man-made lakes, gas production, and development.

In Nebraska, the ABB is found in two discrete areas. One is a moderate-to-high density occurrence (> 500 individuals) in the south-central part of the State known as the Loess Hills (Bedick et al. 1999, Peyton 2003). The other geographically larger but lower density population occurs in the Sand Hills of north-central Nebraska. Habitats where ABBs currently occur in Nebraska consist of grassland prairie, forest edge, open woodlands with grasslands, and scrubland. No strong correlation with soil type or land use has been identified for the species in Nebraska (Bishop et al. 2002, Bishop and Hoback, unpubl. data). No ABBs have been observed in apparent suitable habitat in counties that would connect the two Nebraska populations. Areas where the ABB occurs in Nebraska and South Dakota generally have low human population densities, minimal night-time artificial lights, and are primarily used for grazing of beef cattle and some agriculture (Bedick et al. 1999; D. Backlund, pers. comm.). The condition of the grassland ecosystem that supports the ABB in Nebraska and South Dakota varies with the intensity of grazing, water withdrawal rates, and tilling for agriculture. Native prairie grass species, such as little bluestem, occur in many areas, but introduced weedy brome species are found in areas of overgrazing (Bedick et al. 1999). Eastern red cedars are invading into both Nebraska and South Dakota; Walker and Hoback (2007) attribute the expansion of cedar into Nebraska grasslands to fire suppression and improper land management.

In Kansas, the ABB is locally found in the southeastern part of the State in the physiographic region known as the Chautauqua Hills. Much of the area occupied by the ABB is privately owned native grass pasture and scattered woodlands of blackjack oak (*Quercus marilandica*) (Miller and MacDonald 1997). No ABB surveys or habitat assessments have been conducted there since 2001 (USFWS, unpubl. data).

In Texas, the ABB is restricted to Camp Maxey in Lamar County. Recent efforts to re-confirm the presence of the ABB on private property in Red River County were unsuccessful. At Camp Maxey, plant communities are described as post-oak black hickory woodlands, shortleaf pine forest, savanna, little bluestem-Indian grasslands, and water oak-willow oak riparian forest (TMS 2006).

In Rhode Island, the only extant occurrence of the ABB is on Block Island, about 14 miles south of the Rhode Island coast. The 6,000+-acre island is primarily privately owned, but about one-third is in private, State, and Federal conservation ownership, while another third is considered developed in rural residential with roads and facilities consistent with a tourist-based economy. The island, once forested, was cleared in the 1700s by European settlers (Livermore 1877 *in* USFWS 1991). Present habitats include moraine grasslands, freshwater ponds and wetlands, shrub thickets, sand dunes, and beaches. Land values are extremely high, consistent with other Atlantic beach resort locales, but due to local zoning, very little additional land is developable. The “ecosystem” that supports the ABB on Block Island is generally conservation lands comprised of fields, meadows, and grasslands. From a faunal perspective, the most important vertebrate is likely the ring-necked pheasant, and there are very few vertebrate species that compete with the beetle for carrion.

2.3.2 Five-factor analysis

Sikes and Raithel (2002) published a review of the hypotheses that attempt to answer the question, “What caused the decline of the ABB?” That review addresses the possible factors that contributed to the disappearance of the species from about 90 percent of its historic range, including DDT/pesticide use, artificial lighting, species-specific pathogens, habitat loss and fragmentation, vertebrate competition, loss of ideal carrion, and congener competition; the primary factors that continue to contribute to the species’ biological status are discussed below. In addition to previously identified factors, Warriner 2004, Hoback *in* Amaral et al. (eds) 2005, and others have suggested that introduction of invasive species may have affected the viability of ABB populations, with concerns focused on the red-imported fire ant and eastern red cedar. General concerns have also been raised about the effects of global climate change and the potential for epizootic disease.

2.3.2.1 Factor A. Present or threatened destruction, modification, or curtailment of its habitat or range:

The ABB was once widespread across most of eastern North America but is currently restricted to the easternmost and western portions of its historic range. Since listing, the body of scientific literature confirming the adverse effects of habitat modification and fragmentation on burying beetle abundance, diversity, and success has been growing (e.g., Trumbo and Bloch 2000, Sikes and Raithel 2002, Wolf and Gibbs 2005, Schnell et al. 2006a). Habitat-related threats and conservation measures across the current range of the ABB are described below.

In Oklahoma, fire suppression has altered forested and prairie habitats in Oklahoma (Collins and Wallace 1990). Lack of fire allows encroachment by woody species, particularly eastern red cedar; although red cedar is native to eastern Oklahoma, it is expanding its range into areas that were, until recently, open grasslands. Other factors that have altered the eastern Oklahoma ecosystem include the conversion of grassland/prairie habitats to aquatic and agricultural habitat (cropland and improved pasture). Numerous man-made lakes have been created in Oklahoma: there are more than one million surface acres of water in these lakes statewide. Large areas of native habitats have also been converted to agriculture. Oklahoma ranks fourth in the nation in the production of wheat, fourth in cattle and calf production, fifth in pecans, sixth in peanuts, and eighth in peaches (State of Oklahoma 2007). Conversion of native forest and prairie habitats to agriculture results in direct loss of ABB habitat and causes fragmentation of remaining intact native habitats.

Oklahoma is also the third largest gas-producing State in the nation. Thousands of acres of habitat are affected by pipelines, access roads, drill pads, and other facilities associated with petroleum and natural gas drilling, development, and transportation. Based on the Oklahoma Corporation Commission's petroleum data from 1992 to 2002, an average of 433 new wells were drilled per year in eastern Oklahoma. In addition, approximately 4,545 acres of land are disturbed annually from new pipelines in Oklahoma (USFWS [Tulsa] Biol. Op. 2005) and this number is increasing.

The USFWS Oklahoma Field Office consulted on approximately 1,562 proposed actions in fiscal year (FY) 2003 and 1,320 proposed actions in FY 2004. Of those, 785 (51 percent) and 591 (45 percent), respectively, were projects proposed for implementation in the 34 counties where the ABB is known or suspected to occur. Project types evaluated included construction of pipelines, roads, communication towers, residential housing development, bridges, mining, petroleum production, commercial development, recreational development, transmission lines, and water and wastewater treatment facilities.

Land in Oklahoma is 97 percent privately owned, and surveys have confirmed that there are many ABB occurrences on private land. The most prominent example is the Weyerhaeuser HCP area, where alteration of forested habitats that once supported the ABB is likely to have contributed to the decline of the area's ABB population. In Lomolino and Creighton's (1996) study of three *Nicrophorus* species in this area, all exhibited highly significant avoidance of clearcuts, and the ABB exhibited a strong preference for mature forests. The mature forest component of habitat in the Weyerhaeuser HCP area has been steadily reduced during the past 10 years through harvest and ice storm damage. At the same time, fire ants appear to have increased concomitant to the opening of forest canopy and new road construction.

In response to management and conservation needs, Weyerhaeuser Timber Company developed an HCP for the ABB, which the USFWS approved in 1996. The Weyerhaeuser HCP is valid for 35 years and identifies the following as foreseeable activities likely to be implemented by Weyerhaeuser over the period: 28,000 acres

(average of 800 acres per year) of forest will potentially be harvested; 16 ponds constructed; 10 or fewer food plots planted; the Environmental Protection Agency-approved application of pesticides for control of pales weevil damage to planted pine seedlings; ROW vegetation control; 2 miles of road construction; 20 acres of mineral, oil, or gas exploration; and no more than 600 acres of cattle grazing. From 1997 to 2007, Weyerhaeuser lands were surveyed for the ABB annually, and habitat sampling was conducted to determine effects from timber management on ABBs. Over that time, numbers declined steadily from 106 in 1997 to 0 in 2005-2007; although no ABBs have been caught since 2005, additional research is needed to fully understand the relationship between forest management and ABB population dynamics at this site.

The highest concentrations of ABBs in Oklahoma occur on publicly owned lands, notably Camp Gruber and Cherokee WMA; ABBs are also known from MCAAP and TNC's Tallgrass Prairie. In general, these lands are managed compatibly with ABB presence. Two large land areas near TNC Tallgrass Prairie are enrolled in the Bureau of Land Management's program for maintaining wild horses taken from Federal land in the West. At least one more wild horse facility is proposed in this same general area. These facilities, depending on stocking rates, could be incompatible with habitat maintenance for small birds and mammals.

Fire suppression and improper land management, such as cattle overgrazing, appear to be associated with the advance of eastern red cedar into traditional grassland habitats such as the Loess Canyons of southeastern Lincoln County, Nebraska, an area that supports a large ABB population (Walker and Hoback 2007). Red cedar has encroached on more than 30 percent of the Loess Canyons area in the past 3 decades and is increasing at a rate of 2 percent per year. Walker and Hoback (2007) found that red cedar encroachment reduces the numbers of most silphid species present and degrades the habitat for burying beetles by limiting their ability to forage for carrion. Elsewhere in Nebraska, expanding residential development and associated light population of the night-time sky is cause for concern (Ratcliffe 1996, W. Hoback, pers. comm.); residential sprawl in the Loess Hills region near the City of North Platte is an instance of this. An expected increase in the demand for corn may result in rangelands that now support the ABB being converted from grassland to row-crops, a condition inimical to the species. In addition to the degradation of ABB habitat associated with tilling of grassland and prairie, row-crop agriculture may also include pesticide spraying, e.g., for grasshopper control, which may have more direct harmful effects on the ABB. (These same threats are applicable to the ABB for all Great Plains States, not just Nebraska.) The majority of ABB records in Nebraska are from private lands and public rights-of-way (ROW). The ABB is also found on four Federal properties, including the Valentine NWR, and on about nine State properties, including several WMA. If unchecked, the invasion of red cedar could reduce the carrying capacity of the ABB by 50 percent in portions of Nebraska (W. Hoback *in* Amaral et al. [eds] 2005).

Conservation efforts for the ABB in Nebraska have taken several forms. Survey efforts have been conducted through section 7 consultations with other Federal agencies. A Memorandum of Agreement between the Burlington Northern Santa Fe Railway

Company (BNSF) and the Sand Hills Task Force (STF) has been established, where funds contributed to the STF will provide for restoration and/or protection of habitat for the ABB, offsetting adverse effects to the species. A Cooperative Agreement between the USFWS, Nebraska Game and Parks Commission (NGPC), Federal Highway Administration, and Nebraska Department of Roads (NDOR) is in development due to the volume of transportation projects that have the potential to adversely affect the species and to conflicts that arise during the highway construction/maintenance season. This group hopes to work cooperatively toward achieving more research and conservation of habitat for the species. In 2007, NDOR provided ABB research funding to Dr. Wyatt Hoback at the University of Nebraska at Kearney; Dr. Hoback has also received section 6 grants for ABB research. NGPC is administering a five-year Landowner Incentive Program grant for a private landowner in Lincoln County to remove eastern red cedars on 79 acres of Loess Canyon Rangeland and minimize grazing regimes, which will benefit ABB habitat conservation, albeit it is uncertain whether this effort will continue beyond the five-year time frame.

In Arkansas, the primary habitat for the ABB is on Fort Chaffee, which provides opportunities for both protection and management. Increases in training activity at Fort Chaffee pose a risk of reducing the quality and/or quantity of ABB habitat on the installation, but these threats should be addressed in the conservation plan currently being developed by the installation in consultation with the USFWS. Although habitat conditions are thought to be stable or improving on federal lands with ABB populations in Arkansas, these habitats require ongoing management. Programmatic biological opinions address impacts on federal lands managed by the U.S. Forest Service, Department of Defense, Federal Highway Administration, and Bureau of Land Management. Areas bordering federally- and State-managed lands and in outlying areas in the five-county area of occurrence have been degraded by ongoing overgrazing, urbanization, oil and gas development, and silvicultural activities.

In Kansas, all known occurrences of the ABB occur on private land. The USFWS lacks reliable data to indicate whether the habitat base is stable within the four-county area of occurrence. Land use within this area has fragmented the landscape, with much agricultural as well as commercial and residential development interspersed within native habitats. This region of Kansas is also currently the subject of considerable speculation for potential development by the energy industry, including oil and gas, coal-bed methane, ethanol production (which requires more land for growing corn), and wind power. At least one large property in the region has been enrolled in the Bureau of Land Management's program for maintaining wild horses taken from federal land in the West, which, depending on stocking rates, could be incompatible with habitat maintenance for small birds and mammals. Expansion of eastern red cedar continues to impact native grasslands here as in other areas of the Midwest.

There is no apparent upward or downward trend in the extent or quality of habitat available to the ABB in South Dakota. This and ABB capture data for the past 10 years suggest a stable condition for the species centered in southern Tripp County. There is, however, an increasing demand for rural water system development, which could lead to

increased residential development in the future. Most landowners in South Dakota remove cedars to keep the land open for grazing (C. Bessken, USFWS, unpubl. data).

Virtually all known ABB habitat in Texas is located within Camp Maxey, which operates under a final Integrated Natural Resource Management Plan (INRMP) that provides for both carrying out the military training mission and protection of natural resources. The INRMP addresses fire and invasive species management and monitoring of the ABB population there.

The availability of habitat for the ABB on Block Island in Rhode Island is stable. Modest losses of habitat to residential development have been at least partially offset by additions to the conservation land base for the island and conversion of low quality habitat (*Mryca*-dominated shrub thickets) to higher quality habitat (grass- and forb-dominated meadows).

Overall, the habitat-related factors under Factor A continue to affect the species within its current range. A number of areas occupied by ABB are on public lands and are being managed with habitat conservation as an objective. Habitat on private lands remains subject to land use changes and incompatible land management, although in some areas, e.g., South Dakota, habitat conditions appear to be stable. Although habitat availability based on vegetation and soil characteristics does not appear to be limiting, available habitat may be substantially reduced if animal assemblages essential for ABB are taken into account. Range curtailment, a primary reason for the original listing, has been somewhat offset by a broader distribution of ABB in the western portion of its range, albeit this is attributable to better knowledge rather than to repatriation of previously unoccupied habitat, and the species remains extirpated throughout most of its historic range.

2.3.2.2 Factor B. Overutilization for commercial, recreational, scientific, or educational purposes:

The removal of small numbers of ABB from the wild has been authorized for reintroduction efforts and in order to conduct research on different aspects of the species' life history. Beetles removed from the wild and bred in captivity in order to obtain larger sample sizes to meet scientific standards for study design have not affected the viability of the species, as they were derived from source populations such as Fort Chaffee and Block Island, where annual monitoring confirms robust populations. In addition, on Block Island, ABBs are generally removed only in the form of a few culled larvae from broods of >10 which have been established through carrion provisioning of captured wild adults. A small percentage of ABBs (1 to 5 percent) captured in pitfall traps during surveys for population monitoring or for presence/absence determinations sometimes die from heat stress, ants, drowning, and unknown causes. This mortality is not known to have affected the viability of any ABB population.

Overutilization for commercial, recreational, scientific, or educational purposes was not identified as a threat to the species at the time of listing in 1989, and it is not considered a threat to the species' continued existence today.

2.3.2.3 Factor C. Disease or predation:

Although disease is not known to be a factor in the decline of the ABB, it must be noted that the science of insect diseases is in its infancy. A species-specific pathogen affecting *N. americanus* and not other species within the genus would explain the present ABB distribution, which is characterized by peripheral, widely separated occurrences and no extant populations at the core of its range. Further, Sikes and Raithel (2002) noted a phylogenetic analysis by Peck and Anderson (1985), which reported that *N. americanus* was phenotypically and evolutionarily distant from New World *Nicrophorus* groups, indicating potential susceptibility to a pathogen that would not affect sympatric congeners. However, no empirical evidence has become available to verify that a species-specific pathogen was responsible for gaps in the range of the species.

Direct predation is not believed to be an important mortality factor for the ABB, but ABBs captured in pitfall traps are killed by ants (*Lasius* sp. and *S. invicta*). More importantly, vertebrate predators have the potential to compromise the persistence of ABB occurrences by impacting the carrion resources upon which the ABB depends. For example, feral cats on Block Island may be a potential predator of ring-necked pheasants, which have become naturalized on the island and are believed to be a primary carrion source for the ABB on the island (Sikes and Raithel 2002).

In sum, Factor C involves a high degree of uncertainty regarding the role of disease in both past declines and projected extinction risks. It is clearer that the role of predation as it relates to competition for carrion resources affects at least some extant populations.

2.3.2.4 Factor D. Inadequacy of existing regulatory mechanisms:

The ABB is capable of moving considerable distances across the landscape (e.g., 1 km per night) in search of carrion for both food and reproduction. This characteristic, along with the practical reality that they must be lured into traps to determine presence, makes it difficult to accurately define and delineate ABB essential habitat in need of protection. Except in specific areas (for instance, southern Block Island, Tripp County, Fort Chaffee, and Camp Gruber), it is difficult to clearly distinguish between an area that constitutes ABB habitat and a nearby area that does not. Therefore, in many situations it is difficult to apply the protective provisions under sections 7 and 9 of the ESA, because the use of baited pitfall traps may successfully capture beetles in locations where it is simply transient or present only opportunistically due to the carrion provided in the trap. As such, it is not that the regulatory mechanisms of the ESA and or State laws patterned on the Federal statute are inadequate; rather, it is that the species' unique life history and ecology make the implementation of available protective measures to perpetuate the essential features of ABB habitat particularly challenging. Finding a uniform approach that utilizes regulatory mechanisms and/or incentives to adequately protect essential habitats while de-emphasizing habitat protection where ABBs occur only at very low densities is among the biggest obstacles to advancing ABB recovery. Simply put, the ecology of this species requires landscape-level conservation rather than a perpetual attempt to protect specific ABB occurrences in response to smaller-scale project reviews.

The ABB is State-listed in only half the States where it is extant (Nebraska, Oklahoma, and Kansas) and in two States (Massachusetts and Ohio) where reintroductions are being attempted. It is not State-listed in Rhode Island, Arkansas (special concern only), South Dakota, or Texas. Currently, there is no protection under State law for the habitat supporting the ABB in Arkansas, South Dakota (D. Backlund in litt. 2007), or on private land in Rhode Island.

Despite the problematic aspects of implementing regulatory protections for the species, laws and regulations provide an important safeguard for the ABB in lieu of landscape-level conservation measures. At the current time, regulatory protection is provided primarily through the ESA, the removal of which could leave local populations more vulnerable to population- and/or habitat-related impacts through the species' current range.

2.3.2.5 Factor E. Other natural or manmade factors affecting its continued existence:

Competition for carcasses by scavengers is thought to be an important factor in the decline of ABB (USFWS 1991, Sikes and Raithel 2002). Matthews (1995) experimentally placed 64 carcasses in various habitats in Oklahoma where *N. americanus* and *N. orbicollis* had been previously documented, then tracked the organisms that scavenged them. Eighty-three percent of the carcasses were consumed by ants, flies, and vertebrate scavengers; about 11 percent were claimed by *N. orbicollis*, and *N. americanus* buried only one. This demonstrated that even in a location where ABB is considered locally abundant (see H. Dikeman's estimate in Amaral et al. [eds] 2005), competition for carrion can be a limiting factor. Further, Pukowski (1933) and Matthews (1995) suggest that *N. americanus* may frequently be unwilling to bury a carcass unless a suitable mate is found at the same time. Therefore, exploiting a reproductive opportunity depends on the concurrent availability of both suitable carrion and a mate, and on being able to inter the carcass before it is lost to competitors. Essentially, optimal size carrion for the ABB is now not only much rarer but there is also more competition for it (see Sikes and Raithel 2002).

Warriner (2004) noted that one factor in the decline of the ABB not considered by Sikes and Raithel (2002) is introduction of exotic invasive species. Warriner reported that one of the State WMA he surveyed "and southern Arkansas in general has been invaded by the red-imported fire ant." The red-imported fire ant was introduced into the southeastern United States in the 1930s at Mobile, Alabama (Lennartz 1973 *in* Warriner 2004) and has subsequently spread throughout the Southeast (Calcott and Collins 1996 *in* Warriner 2004). These ants now infest all or part of Alabama, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, New Mexico, North Carolina, Oklahoma, Puerto Rico, South Carolina, Tennessee, and Texas (USDA 2003). In 1996, an estimated 291 million acres in the southeastern United States were infested or partially infested with non-native fire ants.

The red-imported fire ant has become a formidable competitor for carrion and a potential source of mortality for *Nicrophorus* beetles when they co-occur at a food source (Warriner 2004, Godwin and Minich 2005). The diet of foraging worker ants consists of dead animals, including insects, earthworms, and vertebrates (Collins and Scheffrahn 2005). Warriner noted that insects in traps he set for *Nicrophorus* burying beetles that were discovered by fire ants were generally dead, and Vinson and Sorenson (1986) in Collins and Scheffrahn (2005) noted that red-imported fire ants may reduce ground-nesting populations of rodents and birds and, in some instances, may completely eliminate ground-nesting species from a given area.

The spread of the red-imported fire ant into many habitats in the southeastern United States will make restoration and recovery of ABB populations there difficult. Furthermore, fire ants are likely to continue to extend their range north as a result of a warming climate and human-induced habitat fragmentation and the unintentional movement of ants in shipments of horticultural products and other materials from infested areas into uninfested areas. As a result, habitats that are now supporting ABB populations may be adversely affected in the future.

Weather extremes, such as droughts, wildfires, hurricanes, and ice storms, may affect the viability of existing populations; their effect in reducing carrying capacity of different populations is estimated in Amaral et al. (eds) (2005). Robust populations, such as those at Fort Chaffee and Camp Gruber and in central Nebraska are believed to be resilient to the effects of stochastic weather events. Although the potential effects of global climate change, including frequency of extreme weather events, have not been assessed, there is some possibility that, in addition to allowing northward movement of fire ants, climate change could exacerbate other factors such as habitat and disease.

2.4 Synthesis

At the time of listing, only two highly disjunct populations of a formerly widespread species were known to be extant. Since then, numerous searches and presence/absence surveys have resulted in the discovery of additional ABB occurrences in Oklahoma, Nebraska, Arkansas, Texas, Kansas, and South Dakota. The species is now known to occur in five of the nine eco-regions where it was once found west of the Mississippi and in one of seven eco-regions east of the Mississippi; about four eco-regions support ABB populations estimated at >1,000 individuals. Based on extinction modeling by K. Holzer, Amaral et al. (eds) (2005) surmised that populations of this size have the potential to remain demographically viable over the long term in the absence of severe catastrophic events or reductions in carrying capacity through reduced carcass availability, habitat loss, or fragmentation. The question, then, is whether and to what extent the threats to the species described in the five-factor analysis reduce the likelihood of long-term population viability.

Recent studies have reinforced the longstanding hypothesis that reduction in carrion availability due to land use changes and increased competition was the overriding cause of the species' decline; the distribution pattern of remaining populations also points to disease as a possible contributing factor, although this remains purely theoretical. Habitat changes and competition

for limited carrion resources, primary factors in the species' listing as endangered, continue to affect extant ABB populations across their current range.

Although several ABB populations occur on public lands or private conservation organization properties, most of the protected lands supporting ABB require ongoing management to ensure the species' continued presence. Elsewhere in the range (Nebraska, South Dakota, and Kansas), the species occurs almost exclusively on private land. The species thus receives varying levels of habitat protection across its current range. Given the ephemeral availability of carrion for ABB reproduction, it is unlikely that populations isolated by habitat fragmentation will be self-sustaining over the long term. Habitat fragmentation remains a risk across much of the species' current range, particularly because habitat conservation at the landscape level has not been initiated. In addition, little is known about ABB population size and trends in much of the species' current range, making it difficult to design appropriate habitat conservation strategies.

In addition to ongoing concerns about habitat fragmentation, reductions in carrion availability, and increasing competition for carcasses, newly identified threats of invasive plants (red cedar) and animals (red-imported fire ants) are growing problems in the portion of the range where all except one of the natural populations occur. Further, disease and effects of climate change on the species have not been ruled out as concerns. These types of factors pose risks irrespective of land protection measures.

Threats to extant populations are a heightened concern because although husbandry and captive rearing methods for the species are now reasonably well-established (A. Kozol in litt. 1990, Perrotti 2005), efforts to reintroduce populations through the release of captive-reared or wild translocated beetles have met with mixed results. Of the three reintroduction efforts to date, the Penikese Island effort failed, the ongoing reintroduction in southeastern Ohio has demonstrated few signs of success, and the ongoing Nantucket Island reintroduction will require several more years of post-release monitoring to determine population persistence. Thus, at the current time the long-term viability of the species appears to be contingent on the persistence of naturally occurring populations, and these populations appear to be at some level of risk throughout the current range of the species.

In addition to population resiliency, the ABB recovery plan clearly treats distribution as a central consideration in the species' status as shown by both its interim and reclassification objectives. Conserving a representative distribution of a formerly widespread species allows for redundancy, an essential hedge against catastrophic losses or reduced carrying capacity in portions of the range. The plan's interim objective of eliminating the risk of immediate extinction has been met. The reclassification objective is based on demonstrating that the risk of extinction is no longer probable, and the criteria for this objective focus on the re-establishment of a representative distribution of the species in all four geographic portions of its former range. Although the Midwest geographic recovery area has met the conditions for reclassification, efforts to locate extant populations in the Southeast, Great Lakes, and Northeast recovery areas have been unsuccessful, and, as noted above, it is not yet known whether reintroduced populations can be successfully established.

Overall, information available for this review leads us to conclude that threats to the species have not been abated sufficiently to show that the ABB is no longer in danger of extinction. Although the demographic outlook for the species is brighter than thought at the time of listing, extant ABB populations vary in level of protection, there is little understanding of population trends and biological limiting factors for most populations, and most if not all populations continue to be exposed to the factors that led to listing as well as factors that have come to light since then. Further, although the threats to the species vary in scope and severity, for the most part they may be difficult to reverse, and population viability appears to be reliant to some degree upon continuing habitat management and/or provision of carrion.

It should be noted that this review neither supersedes nor nullifies the approved reclassification criteria for the species. When the recovery plan is revised, reclassification (and delisting) criteria can be reconsidered in view of the marked differences in abundance and distribution between the eastern and western portions of the species' range and in view of the threats that continue to face extant populations. Based on the information available at this time, we find that the ABB remains endangered throughout its current range and thus meets the ESA definition of endangered, i.e., a species that is in danger of extinction throughout all or a significant portion of its range. Given our conclusion that the species is endangered throughout its range, a "significant portion of the range" analysis is moot at this time.

3.0 RESULTS

3.1 Recommended Classification

Retain as endangered.

Even with the discovery of additional ABB populations, the species remains extirpated from about 90 percent of its historic range, and there is a significant disparity in distribution between the eastern and western portions. Population trend information is available for only the small number of populations that have been monitored annually over the past 10+ years. The biological and ecological factors that are sustaining ABB populations in different locations within the species' range and the threats to those factors remain poorly understood for most occurrences.

3.2 Recommended Recovery Priority Number

Retain as 5c.

Recovery potential is limited by the low rate of reintroduction efforts and success and by the difficulty of abating threats related to availability of carrion resources.

3.3 Listing and Reclassification Priority Number

Not applicable

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS:

1. Revise the recovery plan, to include:
 - a. updating all the new species biology, ecology and distribution information that has become available since listing,
 - b. setting a goal to return the ABB to a distribution within its historic range that is based on the use of physiographic, eco-regional provinces rather than State boundaries and that embraces the conservation biology principles of representation, resiliency, and redundancy,
 - c. setting reclassification and delisting criteria that address the five listing factors,
 - d. providing clear recommendations and direction to the *ex situ* community as to how the American Zoological Association can best serve the recovery program for this species, and
 - e. taking into consideration the conservation of genetic material within populations and the need for connectivity between populations.
2. Investigate declining ABB populations, such as the Weyerhaeuser HCP Area, to better understand the relationship and correlation with forest stand conversion (timber harvest), road construction, and ice storm damage with the increase of the red-imported fire ant and the concurrent decline of the ABB.
3. Standardize survey protocol methodology so that trapping success rates and ABB density estimates are comparable across the species range.
4. Develop conservation strategies that emphasize the protection of essential features of large occupied habitats (minimally fragmented landscapes with abundant carrion species) and de-emphasize small scale, site specific project reviews.
5. Develop Programmatic Biological Opinions with Federal agencies where appropriate to address section 7 consultation regarding the ABB at the landscape level, rather than by individual projects. This will not only afford the ABB protection and minimization of take but can better aid in the long-term conservation of the ABB.
6. Encourage the development of Statewide or multi-county HCPs and Safe Harbor Agreements in States where there are many scattered ABB occurrences and more efficient methods are needed to address small incremental losses and/or fragmentation of habitat.
7. Seek opportunities to partner with the Natural Resource Conservation Service and large private landowners to enroll ABB habitat in the Conservation Reserve Program CRP program and to utilize other USDA and USFWS programs to restore or enhance ABB

habitat through native species management.

8. Pursue long-term management and monitoring agreements with State and Federal agencies, and non-profit resource agencies, such as the U.S. Forest Service, Federal Highway Administration, National Park Service, Bureau of Land Management, National Guard Bureau, U.S. Army Corps of Engineers, and The Nature Conservancy, many of which have already demonstrated support for the recovery program. Emphasize the importance of establishing “sentinel” populations in each State or eco-regional province that shall be monitored annually.
9. Conduct recovery coordination meetings every three years during which information can be shared on research, changes in status and protection efforts.
10. Utilize the ABB PHVA (Amaral et al. [eds.] 2005), which provides the ranked research needs of the ABB, to guide implementation of research priorities for the ABB. Update research priority ranking as needed.

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Links to ABB (*Nicrophorus americanus*) websites:

1. <http://ecos.fws.gov/speciesProfile/SpeciesReport.do?scode=I028>
2. <http://www.dnr.ohio.gov/wildlife/Resources/projects/beetle/beetle.htm>
3. <http://www.fws.gov/southdakotafieldoffice/BEETLE.HTM>
4. <http://www.stlzoo.org/wildcareinstitute/americanburyingbeetlesinmi>
5. <http://www.texasento.net/ABB.htm>
6. <http://www.dnr.state.oh.us/wildlife/Resources/projects/beetle/beetle.htm>
7. <http://www.fws.gov/southwest/es/Oklahoma/beetle1.htm>
8. http://www.digimorph.org/specimens/Nicrophorus_americanus/
9. <http://www.ivyhall.district96.k12.il.us/4th/kkhp/1insects/amburyingbeetle>
10. <http://www.rogerwilliamsparkzoo.org/conservation/beetlerecovery.cfm>
11. <http://www.sdgifp.info/Wildlife/Diversity/ABB/ABB>
12. <http://collections2.eeb.uconn.edu/collections/insects/CTBnew/ctb.htm>
13. <http://collections2.eeb.uconn.edu/nicroweb/nicrophorus.htm>
14. http://www.ucalgary.ca/~dsikes/sikes_lab
15. <http://pie.midco.net/dougback/abb>
16. http://www.fs.fed.us/colorimagemap/ecoreg1_divisions.html

U.S. FISH AND WILDLIFE SERVICE FIVE-YEAR REVIEW
Species: American burying beetle (*Nicrophorus americanus*)

Current Classification: Endangered

Recommendation Resulting from the Five-Year Review: No change

Review Conducted by: Michael Amaral, New England Field Office

FIELD OFFICE APPROVAL:

New England Field Office Supervisor, U.S. Fish and Wildlife Service

Approve _____ Date _____

REGIONAL OFFICE APPROVAL:

Regional Director, U.S. Fish and Wildlife Service Region 5

Approve _____ Date _____

REGIONAL CONCURRENCE:

ACTING Regional Director, U.S. Fish and Wildlife Service Region 2

Signature  _____ Date 4-4-03

Regional Director, U.S. Fish and Wildlife Service Region 3

Signature _____ Date _____

Regional Director, U.S. Fish and Wildlife Service Region 4

Signature _____ Date _____

Regional Director, U.S. Fish and Wildlife Service Region 6

Signature _____ Date _____

U.S. FISH AND WILDLIFE SERVICE FIVE-YEAR REVIEW

Species: American burying beetle (*Nicrophorus americanus*)

Current Classification: Endangered

Recommendation Resulting from the Five-Year Review: No change

Review Conducted by: Michael Amaral, New England Field Office

FIELD OFFICE APPROVAL:

New England Field Office Supervisor, U.S. Fish and Wildlife Service

Approve _____ Date _____

REGIONAL OFFICE APPROVAL:

Regional Director, U.S. Fish and Wildlife Service Region 5

Approve _____ Date _____

REGIONAL CONCURRENCE:

Regional Director, U.S. Fish and Wildlife Service Region 2

Signature _____ Date _____

Assistant Regional Director, Ecological Services, U.S. Fish and Wildlife Service Region 3

Signature Lynn M Lewis Date 4/18/08

Regional Director, U.S. Fish and Wildlife Service Region 4

Signature _____ Date _____

Regional Director, U.S. Fish and Wildlife Service Region 6

Signature _____ Date _____

U.S. FISH AND WILDLIFE SERVICE FIVE-YEAR REVIEW

Species: American burying beetle (*Nicrophorus americanus*)

Current Classification: Endangered

Recommendation Resulting from the Five-Year Review: No change

Review Conducted by: Michael Amaral, New England Field Office

FIELD OFFICE APPROVAL:

New England Field Office Supervisor, U.S. Fish and Wildlife Service

Approve _____ Date _____

REGIONAL OFFICE APPROVAL:

Regional Director, U.S. Fish and Wildlife Service Region 5

Approve _____ Date _____

REGIONAL CONCURRENCE:

Regional Director, U.S. Fish and Wildlife Service Region 2

Signature _____ Date _____

Regional Director, U.S. Fish and Wildlife Service Region 3

Signature _____ Date _____

Regional Director, U.S. Fish and Wildlife Service Region 4

Signature *Nancy E. Walsh* Date *1/8/08*

Regional Director, U.S. Fish and Wildlife Service Region 6

Signature _____ Date _____

U.S. FISH AND WILDLIFE SERVICE FIVE-YEAR REVIEW

Species: American burying beetle (*Nicrophorus americanus*)

Current Classification: Endangered

Recommendation Resulting from the Five-Year Review: No change

Review Conducted by: Michael Amaral, New England Field Office

FIELD OFFICE APPROVAL:

New England Field Office Supervisor, U.S. Fish and Wildlife Service

Approve _____ Date _____

REGIONAL OFFICE APPROVAL:

Regional Director, U.S. Fish and Wildlife Service Region 5

Approve _____ Date _____

REGIONAL CONCURRENCE:

Regional Director, U.S. Fish and Wildlife Service Region 2

Signature _____ Date _____

Regional Director, U.S. Fish and Wildlife Service Region 3

Signature _____ Date _____

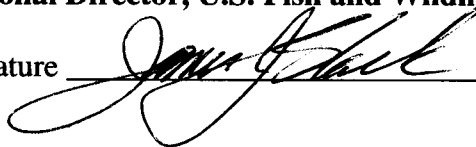
Regional Director, U.S. Fish and Wildlife Service Region 4

Signature _____ Date _____

Regional Director, U.S. Fish and Wildlife Service Region 6

Acting

Signature _____



Date 3-28-08

U.S. FISH AND WILDLIFE SERVICE FIVE-YEAR REVIEW
Species: American burying beetle (*Nicrophorus americanus*)

Current Classification: Endangered

Recommendation Resulting from the Five-Year Review: No change

Review Conducted by: Michael Amaral, New England Field Office

FIELD OFFICE APPROVAL:

New England Field Office Supervisor, U.S. Fish and Wildlife Service

Approve _____ Date 7/28/07

REGIONAL OFFICE APPROVAL:

Acting

Regional Director, U.S. Fish and Wildlife Service Region 5

Approve _____ Date 6/16/08

REGIONAL CONCURRENCE:

Regional Director, U.S. Fish and Wildlife Service Region 2

Signature _____ Date _____

Regional Director, U.S. Fish and Wildlife Service Region 3

Signature _____ Date _____

Regional Director, U.S. Fish and Wildlife Service Region 4

Signature _____ Date _____

Regional Director, U.S. Fish and Wildlife Service Region 6

Signature _____ Date _____

APPENDICES

Appendix A.

Partial Listing of *Nicrophorus* Surveys in Fifteen States Where No American Burying Beetles Were Found, 1990-2006

<u>Location</u>	<u>Year</u>	<u>Source</u>
Mainland Rhode Island and Aquidneck Island Nantucket Island	Mult. years, 1990s	C. Raithel
Massachusetts Three Elizabeth Islands, Massachusetts	1994	M. Northrup, K. Beattie
Matinicus Island, Maine	1990	T. French, M. Amaral, A. Kozol
Northern New Jersey	1993	D. Mairs
Virginia, seven+ counties	1994	J. Sciascia
Two counties, No. Carolina	1991-2006	S. Roble
Shelter Island, New York	1990	S. Trumbo
Western Pennsylvania	1991	M. Scheibel
Big Charity Island., Lake Huron, Michigan	1993	C. Bier
Kalamazoo, Marquette and Menominee counties, Michigan	1992	P. Higman
Ohio, over 50 counties	1995	D. Cuthrell, J. Legge
Missouri, about 28 counties	1992-2006	D. Horn, G. Keeney
Twenty + counties, Missouri	1990-1991	K. Simpson
Iowa, 4 northeast counties WMAs in Logan and Hempstead Counties,	2006	J. Stevens, R. Jean, M. Jean, C. Barnhart, R. Merz
Arizona	1996	D. Coyle and K. Larsen
23 counties, Kansas	2004	M. Warriner
65 counties, Arkansas	1995	S. Lingafelter
Northwestern Louisiana	1996	C. Carlton and F. Rothwein
	1995	V. Moseley and D. Ganaway

Appendix B.
Distribution of the Imported Fire Ant in the South Central and Southeastern United States
Based on USDA-APHIS Quarantine Areas

