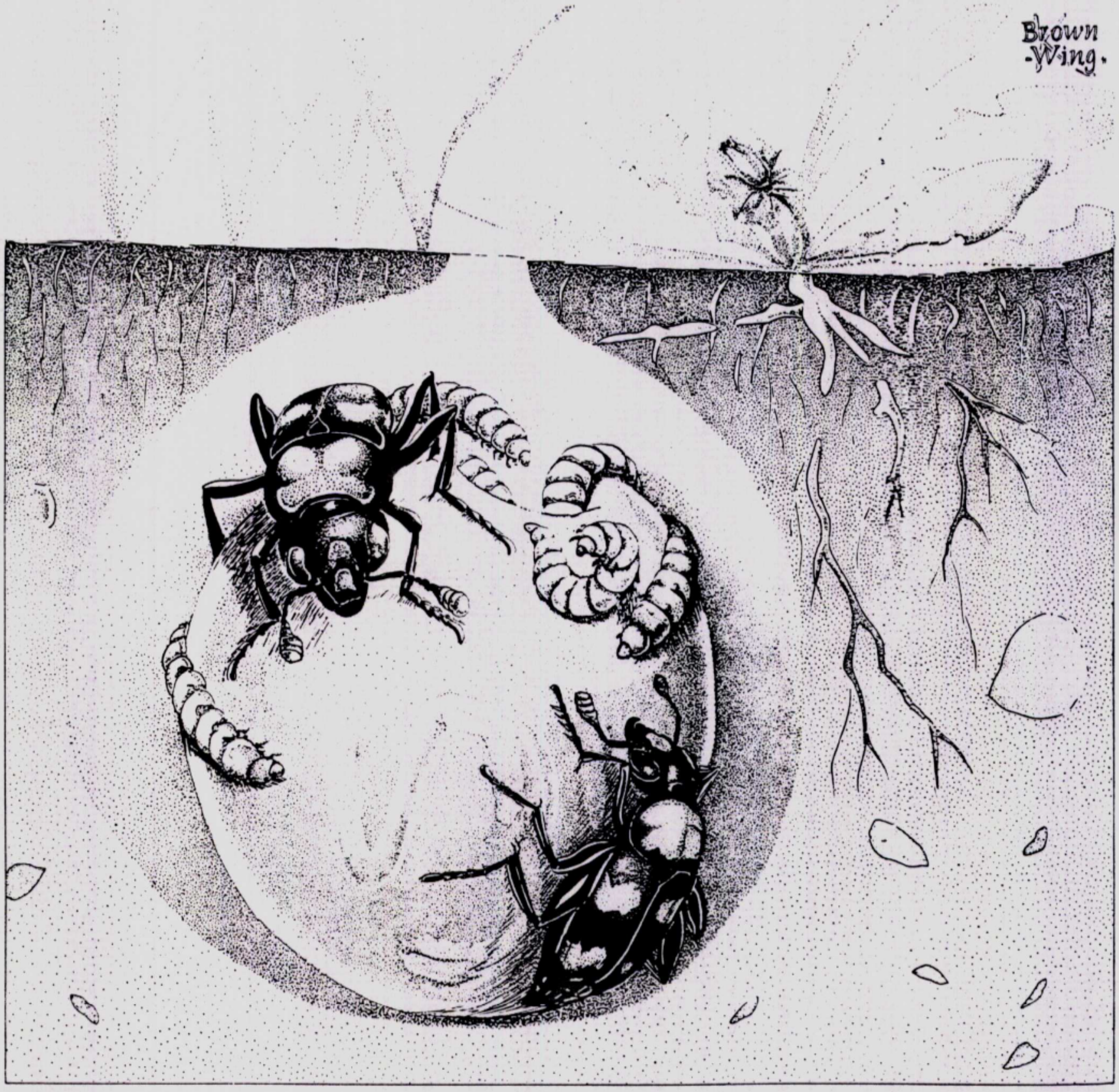
AMERICAN BURYING BEETLE

(Nicrophorus americanus)

RECOVERY PLAN

U.S. Fish and Wildlife Service, Region 5



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EXECUTIVE SUMMARY

American Burying Beetle Recovery Plan

Current Species Status: *Nicrophorus americanus*, formerly distributed throughout temperate eastern North America, now persists in only two widely separated natural populations: a small but apparently stable population on Block Island off the coast of Rhode Island, and a lower-density but more widespread population in eastern Oklahoma. In addition, three laboratory colonies are being maintained, and in 1990 and 1991, about 90 *N. americanus* were reintroduced to historical habitat on Penikese Island, Massachusetts. Based on the drastic decline and extirpation of the species over nearly its entire historical range, the American burying beetle was listed as endangered in July 1989.

Habitat Requirements and Limiting Factors: The Block Island population occurs on glacial moraine deposits vegetated with a post-agricultural maritime scrub plant community. In eastern Oklahoma, N. americanus is known primarily from oak-hickory forest and grasslands of the Ozark uplift, and in the Ouachita Mountains in areas described as forest/pasture ecotone and open pasture. Little is known about the habitats associated with most historical collections of *N. americanus*. Considering the broad geographic range of the species, it is likely that vegetational structures and soil types are not generally limiting for this burying beetle. While it is clear that certain conditions are not suitable for carcass burial (e.g., very xeric, saturated, or loose sandy soils), it is probable that carrion availability in a given area is more important to the species' occurrence than vegetation or soils *per se*. Nevertheless, habitat parameters undoubtedly influence the prey base as well as the presence of competitors for limited carrion resources.

Recovery Objectives: The interim objective is to reduce the immediacy of the threat of extinction to the American burying beetle, and the longer range objective is to improve its status so that it can be reclassified from endangered to threatened.

Recovery Criteria: The interim objective will be met when the extant eastern and western populations are sufficiently protected and maintained, and when at least two additional self-sustaining populations of 500 or more beetles are established, one in the eastern and one in the western part of the historical range. Reclassification will be considered when (a) 3 populations have been established (or discovered) within each of 4 geographical areas (Northeast, Southeast, Midwest, and the Great Lake states), (b) each population contains 500+ adults, (c) each population is self-sustaining for 5 consecutive years, and, ideally, each primary population contains several satellite populations.

Actions Needed:

1. Protect and manage extant populations
2. Maintain captive populations
3. Continue Penikese Island reintroduction effort
4. Conduct studies
5. Conduct searches for additional populations
6. Characterize habitat and conduct vertebrate inventories
7. Conduct additional reintroductions
8. Continue to conduct research into the species' decline
9. Conduct information and education programs

Estimated Cost of Recovery* ($000):

YEAR	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Need 7	Need 8	Need 9	TOTAL
FY1	34.0	2.0	2.0	31.0	62.5		20.0		7.5	159.0
FY2	41.5	4.0	2.0	30.0	62.5	25.0	40.0	7.5	7.5	220.0
FY3	28.5	4.0	2.0	5.0	50.0	25.0	40.0	7.5	7.5	169.5
FY4-20	421.5	48.0	34.0		100.0		100.0		127.5	831.0

* Does not include land acquisition costs.

Date of Recovery: If the recovery criteria are met, reclassification can be initiated in 2012.

* * *

This recovery plan has been prepared by the Rhode Island Division of Fish and Wildlife, Nongame and Endangered Wildlife Project, under contract with Region 5 of the U.S. Fish and Wildlife Service. The purpose of the plan is to delineate reasonable actions needed to restore and/or protect the endangered American burying beetle (*Nicrophorus americanus*). Recovery objectives will be attained and funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities.

The plan does not necessarily represent the views or official position of any individuals or agencies involved in plan formulation, other than the U.S. Fish and Wildlife Service. The approved recovery plan will be modified as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1991. American Burying Beetle (*Nicrophorus americanus*) Recovery Plan. Newton Corner, Massachusetts. 80 pp.

Copies of this plan can be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
301-492-6403
or
1-800-582-3421

Fees vary according to number of pages.

ACKNOWLEDGEMENTS

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PART I. INTRODUCTION

The American burying beetle (Nicrophorus americanus), formerly distributed throughout temperate Eastern North America, is now known only from two widely separated natural populations: on Block Island, off the southern coast of Rhode Island, where the species is apparently stable; and in eastern Oklahoma, where it has been recently recorded in Latimer, Cherokee, Muskogee, and Sequoyah Counties. Since 1980, Nicrophorus americanus has been recorded at only two other localities rangewide: southwestern Missouri and the Platte River Valley in west-central Nebraska. Based on the drastic decline and extirpation of Nicrophorus americanus over nearly its entire range, the species was listed as endangered pursuant to the Endangered Species Act by the Department of the Interior in July of 1989 (Federal Register Vol. 54 (133): 29652-5).

The American burying beetle and other carrion beetles are interesting components of the faunal biodiversity of North America. In general, Nicrophorus species exhibit one of the highest levels of parental care of any beetle in the insect order Coleoptera (Wilson 1971, Milne and Milne 1976), a group which numbers over 350,000 species (Evans 1984). Since extended parental care is quite unusual in non-social insects, Nicrophorus beetles make ideal subjects for investigations in the fields of animal behavior, sociobiology, and coevolution. Further, because carrion beetles bury carcasses found on the ground, they play an important role in the recycling of nutrients. Through the act of burying, they also remove prey from competing flies and ants, and in this way may serve to limit those species, which sometimes reach pest proportions.

The American burying beetle is the largest carrion beetle in North America. Examination of the factors leading to its decline may provide insights into widespread ecological problems as well as relationships between vertebrate and invertebrate populations. Also, since the American burying beetle requires larger carrion to maximize its reproductive output than do congeners, its occurrence in an area may indicate a significant cluster or aggregation of large prey species.

TAXONOMY AND DESCRIPTION

Beetles are generally characterized as having hardened, protective front wings known as elytra that meet in a straight line on the back. N. americanus is a member of the beetle family Silphidae (subfamily Nicrophorinae); these beetles are known by their habit of burying vertebrate carcasses for reproductive purposes and for exhibiting parental care of young. The genus Nicrophorus contains about 70 species world-wide, of which 15 occur in North America (Peck and Kaulbars 1987). Nicrophorus americanus is probably closely related to the similarly sized, but allopatric, Nicrophorus germanicus of the Old World. In both of its extant populations, Nicrophorus americanus is sympatric with N. marginatus, N. tomentosus, and N. orbicollis, from which it differs physically in coloration and size.

Nicrophorus americanus was first described by Olivier in 1790 (Entomologie, II, Paris), with the type locality undesignated. It is the largest species of its genus in North America, measuring 25-35 mm in length (Peck and Anderson 1985). The body of N. americanus is shiny black; the elytra are smooth and also shiny black, and each elytron has two scalloped orange-red markings (Figure 1). The pronotum is flattened at

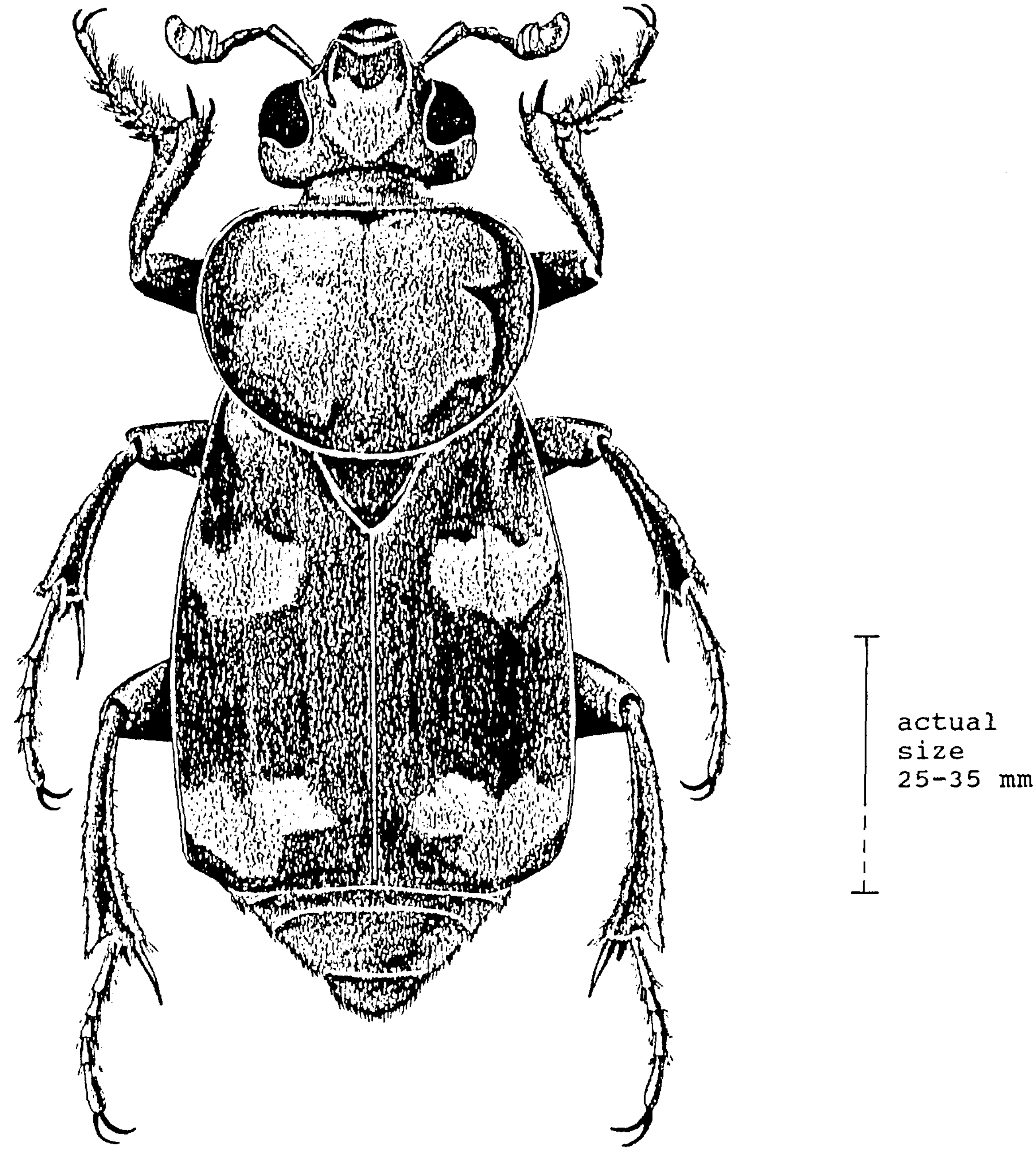

Figure 1. American burying beetle (*Nicrophorus americanus*).

Illustration by Mark Marcuson.
Used by permission of the University of Nebraska State Museum.

its margins with a raised central portion. The most diagnostic feature of this beetle is the large orange-red marking on the raised portion of the pronotum, a feature shared by no other members of the genus in North America. N. americanus also has an orange-red frons and a single orange-red marking below the frons (rectangular in males and triangular in females). Antennae are large, orange at the tip, and abruptly clubbed.

N. americanus, along with other Nicrophorus species, often carry swarms of orange-colored, phoretic mites (Poecilochirus Vitzhum). Wilson and Knollenberg (1987) report that 14 species of mites from four families disperse phoretically on Nicrophorus in Michigan. While the significance of the relationship between mites and carrion beetles is not entirely clear, it is believed to be mutually beneficial: the beetle provides the mites mobility and access to food, and the mites help keep the beetle and carcass clean by consuming microbes and fly eggs (Wilson 1983, Trumbo 1990).

HISTORICAL AND PRESENT DISTRIBUTION

Nicrophorus americanus has been recorded historically from at least 150 counties in 35 states (including the District of Columbia) in the eastern and central United States (Peck and Kaulbars 1987, Madge 1958), as well as along the southern fringes of Ontario, Quebec, and Nova Scotia in Canada (Peck and Anderson 1985; Appendix 1). Its historical range can thus roughly be described as most of temperate eastern North America (Figure 2). The easternmost record is from Nova Scotia at about 65° west longitude, and the species has been recorded as far west as North Platte, Nebraska at 101° west longitude. A single Montana record is also known. The

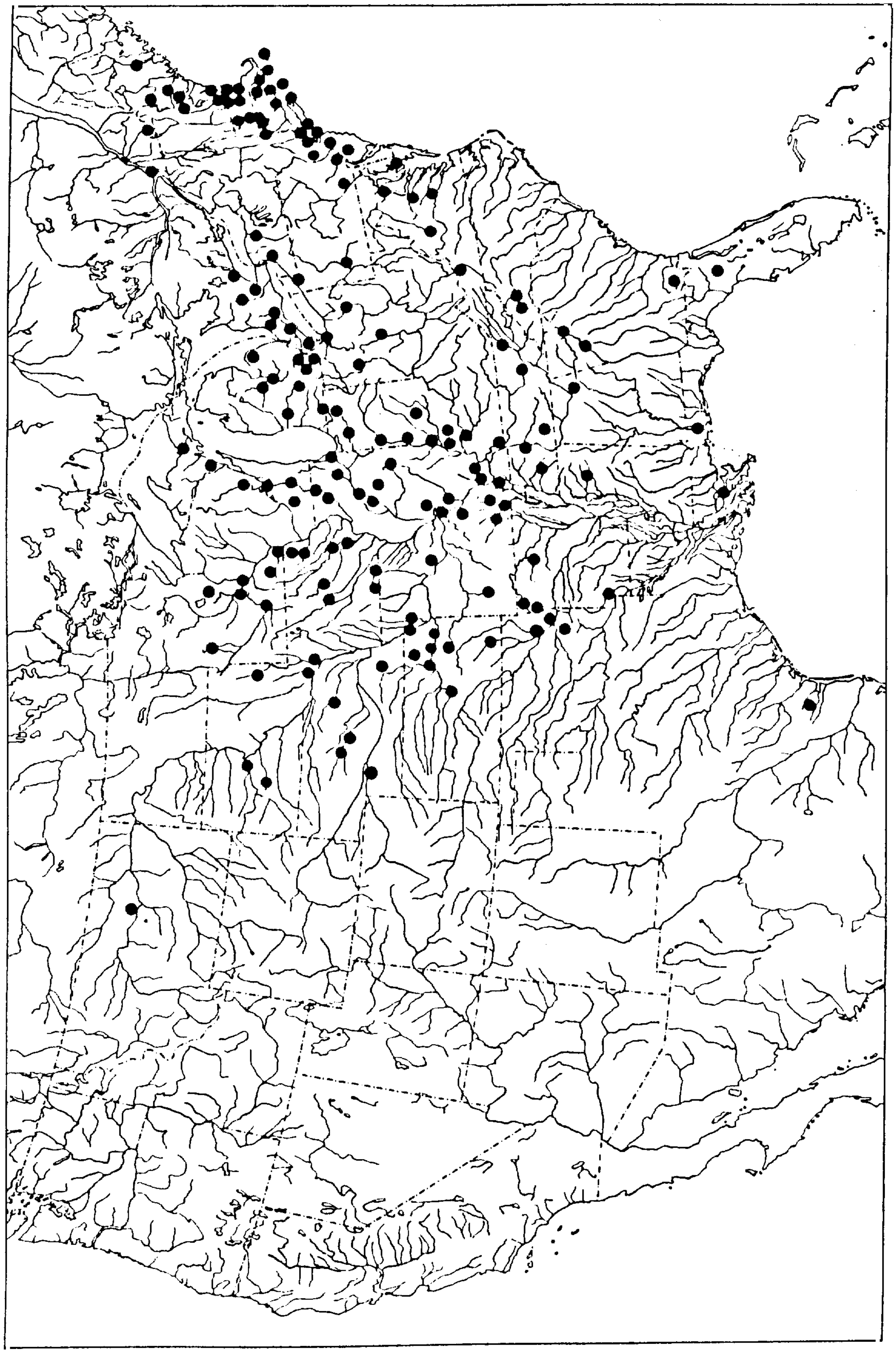

Figure 2. Locality records for Nicrophorus americanus. Indicates geographical extent of known historical range. Adapted from Peck and Kaulbars (1987) and Peck and Anderson (1985).

northernmost record is from the upper peninsula of Michigan at 46° north latitude, with the southern terminus of its range reached at Kingsville, Texas at 27-28° north latitude.

Documentation is not evenly spread across this broad historical range, with many more records occurring in the middle and upper Midwest (including southern Ontario) and in the northeastern United States (from Massachusetts through Virginia) than elsewhere. In general, the historical occurrence of this species is poorly documented from higher elevations of the Appalachian region as well as from the southern Atlantic and Gulf of Mexico coastal plains.

Since 1970, N. americanus has been documented from six states, including the extant population on Block Island in Rhode Island and three extant occurrences in Oklahoma: a population north of Red Oak in Latimer County, a newly discovered population in Cherokee/Muskogee County, and Sequoyah County (1982 and 1991 collection records) (Curtis Creighton, Oklahoma Natural Heritage Inventory, in litt. 1991). More survey effort is needed to determine whether populations persist in the other four states, Kentucky, Arkansas, Missouri, and Nebraska. There is also a single 1972 record from Ontario (Perkins 1983). The extant populations are located on private lands, with the exception of the Cherokee/Muskogee County population, which occurs on a jointly managed state wildlife management area and National Guard installation.

The pattern of the American burying beetle's decline can be inferred from examination of known specimen documentation. East of the Appalachians, extending from New England and the Atlantic seaboard south to northern Florida, the most recent historical collections were in the 1940s. In New England and south through New Jersey, the last mainland specimens were collected in the 1920s (see Table 1). Further, except for the

Table 1. Specimen documentation (representative records)

State or Province	Date of last collection
EXTANT	
Rhode Island (Block Island, Washington County)	1991
Oklahoma (Cherokee, Muskogee, and Latimer Counties)	1991
Oklahoma (Sequoyah County)	1991 (one specimen; an earlier specimen was collected in 1982)
HISTORICAL RANGE EAST OF APPALACHIANS	
Connecticut (Cornwall)	1920
New York (Somers)	1923
New York (Long Island)	1940
North Carolina (Black Mountain)	1940
Massachusetts (Penikese Island)	1940
Maryland (Cambridge)	1947
HISTORICAL RANGE WEST OF APPALACHIANS	
Iowa (Appanoose County)	1932
Kansas (Riley County)	1940
Minnesota (Houston County)	1941
South Dakota (Brookings, Haakon, Union Counties)	1946
Wisconsin (Shawano County)	1948
Tennessee (Cumberland, Madison Counties)	1955
Illinois (Johnson County)	1958
Michigan (Kalamazoo County)	1961
Indiana (Posey County)	1965
Ontario (Harrow)	1972
Kentucky (Trigg County)	1974
Arkansas (Washington County)	1974
Missouri	Early 1980s
Nebraska (Lincoln County)	1988 (one specimen)

North Carolina and Maryland collections, all eastern records of N. americanus since 1940 were collected from islands or peninsulas such as Long Island, New York and Martha's Vineyard in Massachusetts; all but one of these populations eventually became extirpated as well. Such data indicate that in the portion of its range east of the Appalachian Mountains, N. americanus declined generally in a north to south direction and that this decline was well underway -- if not nearly complete -- by 1923.

West of the Appalachians, the decline of N. americanus occurred later. In the Midwest, the decline appears to have proceeded generally from the geographic center of the range outward, with all collections for the species since 1960 occurring along the northern, south-central, southwestern, and western range peripheries.

In general, the oldest historical records are from the vicinity of major metropolitan areas, while more recent records typically occur at least 100 miles from major urban centers. Across the entire range, the decline of N. americanus reflects a pattern of increasing localization prior to extirpation (Anderson 1982).

STATUS OF EXTANT POPULATIONS

The Block Island population has been censused four times since 1986 by A. Kozol, Boston University, using mark-and- recapture methodology (Gazey and Staley 1986). The estimates for Block Island (see Table 2) indicate that the population was relatively stable at a level of approximately 500 animals for the period 1986-1990. However, as pointed out by Kozol (1989 and 1990), the figures should be used only as guides, because burying beetles violate two critical assumptions common to

Table 2. Population estimates of N. americanus on Block Island (Kozol 1990).

YEAR	MEAN	LOW*	HIGH*	REMARKS
1986	391	258	600	
1989	427	265	685	
1990a	612	465	772	All captures, three study areas.
1990b	472	292	714	Main study area only.

* 95% confidence limit

virtually all population estimates, i.e., that population size remain constant for the entire sampling period and that all individuals are available for recapture in each sampling interval.

For the period from 1986 to 1990, the mark and recapture population estimate was based on trapping efforts spanning several weeks. In 1991, trapping and blacklighting efforts at the three primary study areas on Block Island occurred within a single week in mid- to late June. The Gazey and Staley estimate for the 1991 capture data yields a mean of 375 adults, with confidence intervals ranging from 316 to 450 (Andrea Kozol, Boston University, in litt. 1991). Future population censusing efforts on Block Island will follow the mark and recapture protocol established in 1991.

In Oklahoma, 65 N. americanus were recorded through live-trapping efforts in the period 1979-1990 (USFWS Biological

Opinion, 2/11/91; Ken Frazier, USFWS Tulsa, pers. comm.). During a 1989 survey (Mehlhop-Cifelli 1990a), a total of 908 pitfall trap nights yielded captures of only four adult N. americanus, with another two individuals censused at a nearby blacklighting station. In 1990, blacklights and baited pitfall traps were again used, and a total of 17 beetles were recorded north of Red Oak in Latimer County (Mehlhop-Cifelli 1990b). In 1991, survey efforts in eastern Oklahoma were expanded to Cherokee, Muskogee, and Sequoyah Counties. A total of 207 N. americanus were recorded in 1991, with the largest number of captures (195) occurring in a contiguous area of Cherokee and Muskogee Counties. Eleven N. americanus were also recorded in Latimer County, and a single specimen was recorded at the site of a 1982 collection in Sequoyah County (Creighton et al. 1991).

A captive population derived from N. americanus collected on Block Island is currently being maintained in the Biology Department at Boston University. This population consists of 50-200 animals, depending on the time of year and need for release stock. A second captive group has been recently established at the Insectarium of the Cincinnati Zoo and Botanical Garden; these beetles are also derived from Block Island stock.

In an effort to promote reproduction of N. americanus in Latimer County, Oklahoma, three male and three female American burying beetles were collected during August 1990. Unfortunately, these animals perished without reproducing. Since the beetle is an annual species (A. Kozol pers. comm.), they may have simply reached their life expectancy. Efforts to establish an Oklahoma laboratory colony continued in 1991. Three pairs of American burying beetles captured in Latimer County were taken to the Oklahoma Natural Heritage Inventory, and two pairs successfully reproduced.

In 1990 and 1991, American burying beetles were reintroduced to a historical locality on Penikese Island in Buzzard's Bay, Massachusetts. This new population consists of 100-200 animals.

LIFE HISTORY/ECOLOGY

In general, field studies and laboratory experiments on the Block Island population by A. Kozol indicate that the biology of N. americanus is similar to that of other species in the genus, aside from the size of carrion selected for reproductive purposes.

The rangewide activity period for N. americanus is generally late April through September, although a number of historical collections were reported between the months of February and October, with very early or late seasonal observations usually occurring in the southern parts of the range. Adults are fully nocturnal and are usually active only when nighttime temperatures exceed 15° C (60° F). When not engaged in brood-rearing, adults feed on a broad range of available carrion, and may also capture and consume live insects (Scott and Traniello 1989).

Most reproductive activity and carcass burial on Block Island occurs in the months of June and July (Kozol 1990). Preliminary evidence suggests that N. americanus may breed as early as late April or as late as mid-August in Oklahoma (C. Creighton pers. comm.). Reproduction depends upon the availability of vertebrate carrion of an appropriate size and weight -- a discrete, unpredictable, and patchily distributed resource. The carrion selected by N. americanus tends to be larger than that utilized by other burying beetles, with an optimum weight between 100 and 200 grams. Field studies have demonstrated that N. americanus can bury and successfully produce a brood with small carcasses (as small as 35 g), but Kozol et al. (1988) demonstrated that there is a significant positive relationship between carcass weight and fecundity (brood weight).

Using keen antennal chemoreceptors, most burying beetles are attracted to carrion at night, generally soon after dark. Upon discovery of a suitable carcass, males may broadcast pheromones to attract potential mates (Eggert and Muller 1989, Bartlett 1987). Males and females compete among themselves and with congeneric competitors until one pair remains on the carcass, with greater size being the prime determinant of success in claiming this resource. These individuals bury the carcass, usually before dawn of the first morning. The carrion may be moved laterally for some distance (up to a meter). Eventually a burial chamber is formed by the movements of the beetles and the carcass is cleaned of feathers or fur and coated with anal and oral secretions, which retard decay and contamination.

Eggs are laid in an escape tunnel adjacent to the carrion and at least one parent, usually the female, remains with the eggs and subsequent larvae until larval development is complete (Wilson and Fudge 1984, Wilson et al. 1984).

Parental care by at least one parent, usually the female, appears to be critical for survival of the young (Wilson and Fudge 1984). Scott and Traniello (1989) suggest that the advantage of male attendance appears to be the added defense of the carcass and brood from congeneric and conspecific intruders, who could kill the existing brood and usurp the carcass for their own reproductive use. Adult Nicrophorus not only guard their offspring, but tend and feed them also (Fetherston et al. 1990). This degree of parental care in a non-social insect is quite rare, and Wilson (1971) states that

Nicrophorus have the highest level of sociality attained by the Coleoptera.

Larvae pupate in soil near the brood chamber and emerge (eclose) as adults in about 48-60 days. N. americanus is generally considered to be univoltine (one generation per year), and occasionally individuals succeed in rearing two broods of young in a single summer (Kozol 1990). Preliminary field investigations in Oklahoma, which has a longer and warmer summer than Rhode Island, suggest that teneral adults (i.e., recently molted individuals) may be reproductively active, raising the possibility of two generations per year (C. Creighton in litt. 1991).

Insofar as is known for the Block Island population, the teneral adults, which emerge in July and August, overwinter and do not reproduce until the following summer season. It is presumed that adults of one season die off after reproduction or during the subsequent winter, and it is doubtful that adults remain reproductively viable for more than a single season. During 1990 on Block Island, a total of 241 individuals were captured, but none of the 109 beetles captured and marked during 1989 were observed (Kozol 1990).

Vertebrate carcass weight is probably more critical to successful reproduction than carrion source. In a "choice" study conducted on Block Island in 1986, Kozol et al. (1988) found that birds and mammals were utilized equally and were preferred to other types of carrion items provided. Brood sizes in the laboratory varied between one and 30 teneral adults eclosed, with a significant positive correlation noted between carcass weight and both number of tenerals eclosed and total brood weight (Kozol et al. 1988). Brood sizes in the field varied from three to 31 individuals, and a positive correlation between carrion weight and number of larvae was observed (Kozol 1990).

Wilson and Fudge (1984) suggest that smaller Nicrophorus species have higher reproductive rates than larger species. On this basis, it is suspected that N. americanus has a lower reproductive rate than most congeners.

HABITAT/ECOSYSTEM REQUIREMENTS

Little is known about the habitats associated with most historical collections of N. americanus. Until recent investigations of the conditions at the Block Island and eastern Oklahoma sites, there was only one published description of the vegetational characteristics of a N. americanus capture locality (Walker 1957). During 1952, Walker collected nine N. americanus in a forested area described as "a park-like stand of large deciduous trees with little shrub layer and a few small trees," which was associated with the floodplain of Badger Creek, eight miles southeast of Camden in Benton County, Tennessee. Dominant canopy tree species included Quercus falcata, Quercus alba, Liquidambar styraciflua, Carya ovata, Nyssa sylvatica, and Liriodendron tulipifera, with hornbeam (Carpinus carolinus) comprising most of the tree understory; grasses and sedges were dominant in the sparse ground cover.

Historical records for N. americanus in Nebraska indicate that the species occurred along water courses where riparian deciduous forests or scrub forests were the predominant habitat (Jameson and Ratcliffe 1989). Peck and Kaulbars (1987) broadly characterized the distributions for 32 species of nearctic carrion beetles. These authors placed N. americanus in the category "Eastern deciduous forest region".

The Block Island population currently occurs on glacial moraine deposits vegetated with a post-agricultural maritime scrub plant community. Vegetation includes extensive stands of bayberry (*Myrica*), shadbush (*Amelanchier*), goldenrod (*Solidago*), and numerous exotic plant species. Vegetation structure varies from shrub thickets to large mowed and grazed fields. Block Island was totally deforested by the mid-1700's (Livermore 1877), and only in very recent decades has vigorous woody growth reappeared following the abandonment of grazing and agricultural practices.

The Latimer County, Oklahoma localities are located in the ridge and valley belt of the Ouachita Mountains. The collection localities for the Sequoyah, Cherokee, and Muskogee County records are on the western edge of the Ozark uplift (C. Creighton pers. comm.). Habitat at the Latimer County locality features a mosaic of vegetation types ranging from deciduous and coniferous forests on slopes and ridgetops to deciduous riparian corridors and extensive pasturelands on the valley floor. Mehlhop-Cifelli (1990a) reported that the few specimens encountered in 1989 were in sites described as forest/pasture ecotone and open pasture. Soils in the vicinity of the 1989 captures included Shermore fine sandy loam (present at three capture sites), Neff and Nexor silt loam (one capture site), and Counts-Wing Complex silt loam (one capture site). A clay component was noted at most capture sites (Mehlhop-Cifelli 1990a), and all capture sites have relatively level topography, well-drained soils, and a well-formed detritus layer at the ground surface.

In 1991, the Oklahoma Natural Heritage Inventory concentrated survey efforts in a large, relatively undisturbed area of western Cherokee and eastern Muskogee counties. Three habitat types were sampled, oak-hickory forest (second or third growth), grassland, and bottomland forest. Of the habitats sampled, slightly more *N. americanus* were captured in the grasslands study area than in the oak-hickory forest, with far fewer captures in the bottomland forest (C. Creighton pers.

comm.). However, these data are preliminary and more information on the habitat preferences of N. americanus in Oklahoma will become available as survey efforts there continue.

Although historical data on exact collection sites and vegetational preferences are imprecise, some generalities can be drawn. In the northeastern part of the species' range, including New England and the mid-Atlantic states, nearly all N. americanus historical collections were made at a time when much of the virgin forests had been cleared and large areas were actively farmed for pasturage, hay cutting, and row crops. Most of the available terrestrial habitats thus consisted of open agricultural land (Cronon 1983). At least two recent historical collection localities (Ontario in 1972 and Maryland in 1947) were also in or near large agricultural areas.

Considering the broad geographic range of N. americanus, it is unlikely that vegetational structures and soil types were historically limiting for this species, at least in a general sense. Further, the apparent persistence of N. americanus on Block Island suggests broad vegetational (landscape) tolerances, given the history of dramatic alteration of vegetation structure there (Schweitzer and Master 1987). While it is clear that certain situations and soil types are not suitable for carcass burial (very xeric, saturated, or loose sandy soils, for example), it is suspected that carrion availability in a given area is more important to N. americanus occurrence than the vegetation or soil structure per se. However, the physical parameters of a habitat undoubtedly influence the potential prey base available for this carrion beetle. In the same way, these parameters affect the occurrence and density of both vertebrates and invertebrates which compete with N. americanus for limited carrion resources.

The vertebrate composition of Block Island is depauperate compared to the mainland faunal assemblage, with a notable lack of scavenging and predatory mammals such as raccoons, opossum, mustelids, and canids. Under such conditions, certain vertebrates which do occur on the island reach population levels higher than those found on the mainland, due to less interspecific competition and predation. Qualitative and quantitative investigations of the size classes of the vertebrate biomass present on Block Island during the summer indicate that at any one time, the number of small (< 100 g) bird and mammal carcasses available is at least two orders of magnitude greater than the number of large (> 100 g) carcasses available. In addition, these investigations suggest that only about six species of the optimum size class (all are birds) are abundant enough and found in the right situations (i.e., terrestrial species) to provide consistent, naturally-occurring carrion for N. americanus reproduction.

The ring-necked pheasant and the American woodcock stand out as two species which reach exceptional abundance on this island compared to the mainland and the rest of the eastern region. Of the two, the ring-necked pheasant is more likely to be a source of carrion for N. americanus due to its abundance (fifth most common landbird on the island), its high reproductive potential, and a nestling mortality rate of about 35% (Allen 1956). The ring-necked pheasant was introduced to Block Island in 1923 (Ferren 1991), at a time when mainland N. americanus populations were nearly gone from the Northeast.

While it is certain that no single vertebrate species has been responsible for providing all the carrion for N. americanus rangewide, it is possible that this species depended historically on abundant aggregations of large (100-200 g) carcasses which, except in the case of artificial situations such as agricultural fertilization using whole fish, would occur near dense, breeding aggregations of optimally-sized vertebrate species.

THREATS TO THE SPECIES

There are perhaps fewer than 1,000 individuals in the only remaining population known east of the Mississippi River, and the eastern Oklahoma populations are of uncertain size. The cause(s) of the species' decline is a complex and difficult question; however, an understanding of the possible factors involved in the decline is necessary in order to implement an effective recovery program, as well as to develop a search image for additional populations, if any exist.

Several authors have commented on the increasing localization and decline of N. americanus rangewide (Davis 1980, Anderson 1982, Peck and Anderson 1985), as reflected by a lack of recent collections of the species. Wells et al. (1983) stated that the current status of this species "must represent one of the most disastrous declines of an insect's range ever to be recorded." Although several theories have been advanced to explain this decline -- including past spraying of insecticides such as DDT, the presence of a non-native and species-specific pathogen (USFWS 1989), and the loss of habitat, i.e., primary forest (Anderson 1982) -- none adequately explain why N. americanus declined when congeneric species are still relatively common rangewide. These theories are briefly discussed below.

The apparent timing and pattern of decline exhibited by N. americanus, particularly in the Northeast, suggest that DDT could not have been responsible for most extirpations, since populations were largely gone a full 25 years before organochlorine compounds were broadly applied as pesticides.

In addition, some populations persisted following DDT spraying in Oklahoma, Nebraska, and Missouri, while other unsprayed areas within its historical range no longer support the species. In the Midwest, however, several N. americanus populations disappeared during or right after the general period from 1940 to 1972, when DDT was actively applied as a pesticide.

No evidence of a disease or pathogen capable of decimating N. americanus while leaving other Nicrophorus populations intact has surfaced, despite the fact that the decline of N. americanus has been underway for almost a century. Nonetheless, this possibility cannot be totally discounted at present.

As to direct habitat loss, data show that species in the family Silphidae are generally widely distributed and occur in many habitat types (Peck and Kaulbars 1987). Given the historical distribution of N. americanus across eastern and midwestern North America, this species must certainly exhibit broad habitat tolerances (Schweitzer and Master 1987).

Nonetheless, there is little doubt that habitat loss and alteration affect this species at local or even regional levels, and could account for the extirpation of populations once they become isolated from others. In this regard, a proposed highway, coal mining, and construction of natural gas pipelines may constitute continuing threats to the American burying beetle population in Oklahoma.

Interspecific Nicrophorus competition may also affect populations at the local level. Kozol (1989) demonstrated that N. orbicollis was about eight times more abundant than N. americanus on Block Island, while Walker (1957) collected 19 times more N. orbicollis (175) than N. americanus (nine) in the single trapping array where the latter species was encountered in Tennessee. These limited data, in conjunction with Latham's anecdotal statement, "N. americanus was always the most common of the genus here (Orient, N.Y.)," suggest that congeneric species with which N. americanus competes for carrion resources (to some extent) may have actually increased (been "released") in areas where N. americanus disappeared.

At this time, the prevailing theory regarding the species' decline involves habitat fragmentation, as described for bird species in Lynch and Whitcomb (1978), Robbins et al. (1989), and Yahner et al. (1989). Fragmentation of large expanses of natural habitat that historically supported high densities of indigenous species (exacerbated by direct taking, ca. 1900, of birds and other vertebrates) may have been a contributing factor in the decline of N. americanus by changing the species composition and lowering the reproductive success of prey species required for optimum reproduction. Likewise, by increasing edge habitat there may have been a concomitant increase in the occurrence and density of vertebrate predators and scavengers such as the American crow, raccoon, fox, opossum, and skunk, which compete with N. americanus for available carrion. In the Midwest, windbreaks, hedgerows, park development, and urban plantings have all provided new "edge" habitat for these scavengers, and even dogs. All these animals take carrion that may be suitable for N. americanus (Brett Ratcliffe, University of Nebraska State Museum, in litt. 1991). In this way, fragmented habitats not only support fewer or lower densities of indigenous species that historically may have supported N. americanus populations, but there is a great deal more competition for those limited resources among the "new" predator/scavenger community.

Even for a winged and moderately mobile animal such as the American burying beetle, movement to and from isolated habitat fragments would be reduced. Loss of genetic variation through drift could leave isolated populations inbred and of low viability and/or fecundity, and thus potentially unable to adapt to further environmental changes (Schonewald-Cox et al. 1983, Templeton et al. 1990).

Agricultural and grazing practices within the range of N. americanus compound the changes in vertebrate species composition and densities caused by habitat fragmentation. Phillips (1936) documented that some species (e.g., deer mouse, Peromyscus maniculatus) responded positively to cattle grazing in Oklahoma and were most abundant in moderately overgrazed pastures, whereas other species (e.g., hispid cotton rat, Sigmodon hispidus) responded negatively to grazing and were most abundant in ungrazed areas. At 15-25 g body weight, deer mice are below optimum size for N. americanus reproduction, while the hispid cotton rat, at 50-150 g, is of optimum size.

Peck and Kaulbars (1987) suggest that the eclectic occurrences of the Silphidae are probably due to carrion being a finite resource widely scattered in space and time. Recent quantification of the vertebrate prey base potentially available to N. americanus on Block Island supports the contention that the primary mechanism for the species' rangewide decline lies in its dependence on carrion of a larger size class relative to that utilized by all other North American Nicrophorus species, and that the optimum-sized carrion resource base has been reduced throughout the species' range over time.

Since the middle of the 19th century, two species of birds in the favored weight range for N. americanus, the passenger pigeon (Ectopistes migratorius) and the greater prairie chicken (Tympanuchus cupido), have been eliminated from the eastern North American fauna. These two bird species were once abundant, with the passenger pigeon estimated at one time to have been the most common bird in the world, numbering billions of individuals. Further, several other birds in this weight class, particularly certain gallinaceous birds such as the wild turkey (poults), waterfowl, and shorebirds, have severely declined rangewide. Wild turkeys, for example, occurred throughout the range of the American burying beetle, and until recently, were extirpated from much of their former range. By contrast, at least in the eastern portions of N. americanus' historical range, no similarly-sized mammals have been documented as declining to the same extent.

It is therefore plausible that the decline of N. americanus can be attributed primarily to habitat loss and fragmentation, which lead to a reduction in optimum reproductive carrion resources. This loss has probably been exacerbated by changing land use patterns, including more intensive agricultural practices and grazing. The fecundity and general population levels of large birds, many of which are ground-nesting species, have clearly been affected by habitat loss and fragmentation, and probably also by a vast increase of scavenging and predatory mammals, which not only reduce carrion production via increased egg and young predation but also actively compete for available carrion resources. The cessation of fertilizing agricultural fields with whole fish (prohibited, for example, by law on Long Island about 1920 according to Robert Latham in litt.), probably resulted in large-scale carrion reductions in areas where this practice was formerly common, particularly along coasts or rivers. Factors such as pesticide spraying could have contributed to other local extirpations and further isolation of existing populations.

Although much of the evidence suggesting the reduction of carrion resources as a primary mechanism of decline is circumstantial, this scenario fits the temporal and geographical pattern of the disappearance of N. americanus (Figure 3), and is sufficient to explain why americanus

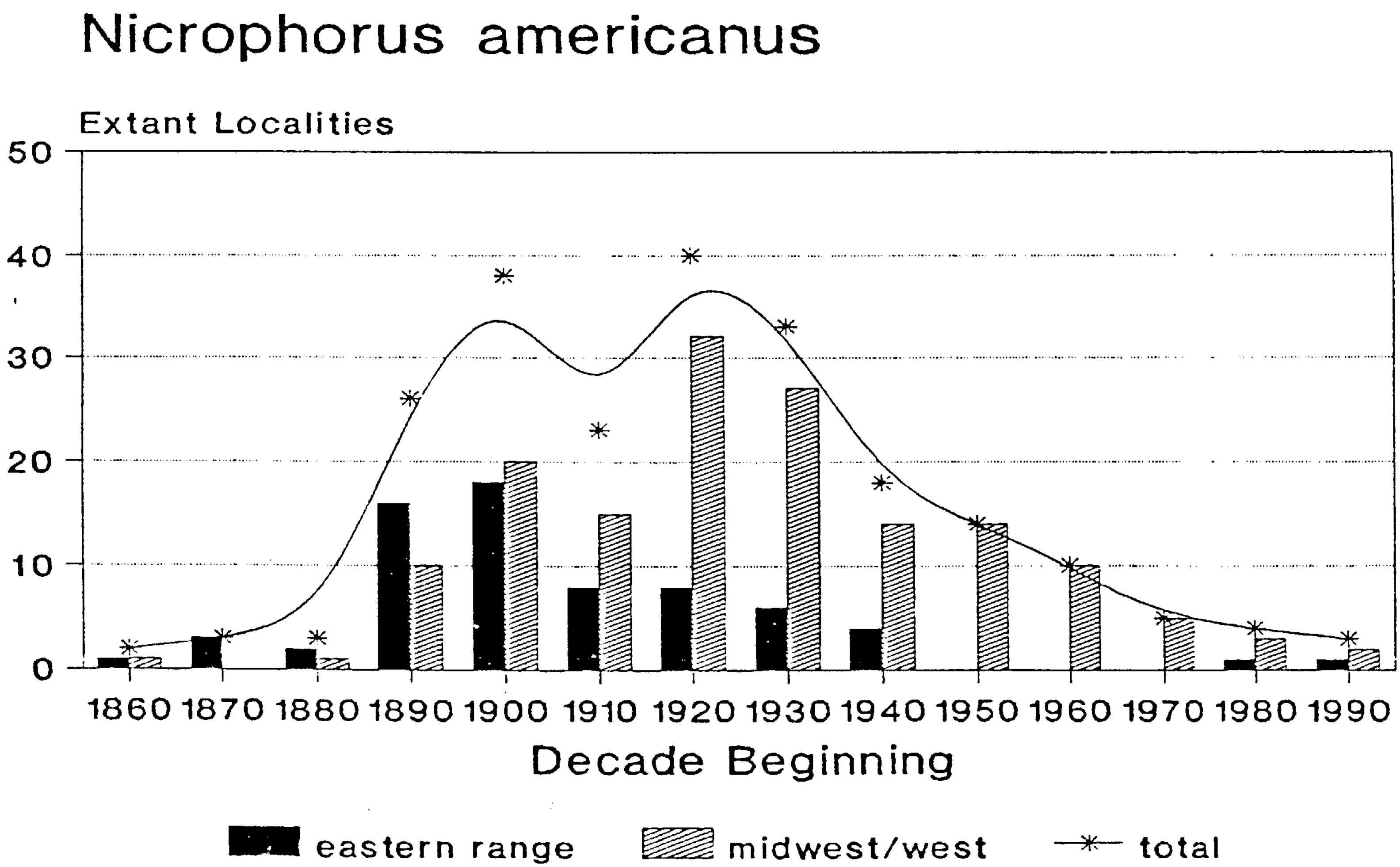

Figure 3. Temporal decline of specimen collections

declined while congeneric species did not. It has been shown that, in a fragmented ecosystem, larger species are negatively affected before smaller species, a process which has been well-documented with carrion and dung beetles in South America (Klein 1989).

CONSERVATION MEASURES

Several significant conservation efforts have been initiated that will add to our understanding of the life history of this species and promote its recovery. These actions include publicizing the plight of the American burying beetle, soliciting information on all collection records, field and laboratory studies of reproductive ecology and population status, investigation into the factors responsible for the species' decline, establishment of captive breeding populations, surveys of historical collection localities and de novo surveys, and the reintroduction of captive raised beetles to historical habitat. Major efforts are summarized below.

Surveys and Searches: Prior to its listing as an endangered species, Perkins (1983) compiled rangewide specimen documentation for N. americanus, based on searches of major entomology collections and extensive correspondence with collectors and museum personnel throughout North America. While this effort was sufficient to determine the species' general historical range, many additional historical specimen records have been discovered since 1983. This has led to a recent review of all available historical N. americanus documentation to consider additional records not cited by Perkins. It is likely that searches of insect collections at smaller universities and private collections will yield additional historical documentation for this species.

In another pre-listing effort, a Global Status Survey for N. americanus was coordinated by The Nature Conservancy's Eastern Regional Task Force (Schweitzer and Master 1987). Information was solicited from collectors, and additional field sampling was conducted with the goal of confirming current viability of N. americanus at several recent historical collection localities, particularly in Pennsylvania, Arkansas, Missouri, and Tennessee. However, recent historical records from Trigg County, Kentucky (1974) and Harrow, Ontario (1972) were not investigated during this survey, and no known subsequent trapping efforts have been conducted at these two localities. No new populations of N. americanus were found during the surveys, and additional sampling conducted since 1987 has also been negative, with the exception of a single 1988 record of N. americanus from Lincoln County, Nebraska.

To encourage survey efforts that may result in the location of additional extant populations, the species' description, life history information, and survey methods have been provided to biologists in 40 states and three Canadian provinces. Recent survey efforts resulted in the discovery of a significant new population in Cherokee/Muskogee Counties, Oklahoma (Oklahoma Natural Inventory).

Monitoring: During 1986, laboratory and field investigations were initiated by Kozol, Scott, and Traniello (1988) to elucidate various aspects of the natural history of N. americanus that had heretofore received little attention. As one component of this study, the size of the Block Island population was estimated. During 1989 and 1990, Kozol's work on N. americanus continued at this locality, and the population size was again estimated for these years. Kozol's population estimates for the Block Island locality involved laborious mark-and-recapture methodology (effective for intensive short-term studies) that resulted in quantification of the entire population. Efforts to appraise the status and extent of the species in eastern Oklahoma have been ongoing since 1988 (Mehlhop-Cifelli 1990a, C. Creighton in litt. 1991).

Management: Management efforts to date have been limited to simple distribution of carcasses of optimal weight, with adult pairs of beetles placed directly on carrion and covered with inverted buckets. This technique was used effectively by Kozol on Block Island, but does depend to some extent on the availability of male and female beetles within the same general time frame.

Reintroduction: Given the high potential for the extinction of this species in the wild, a reintroduction of N. americanus was conducted on Penikese Island, Massachusetts on July 3-4, 1990. Penikese Island, part of the Elizabeth Island chain, was selected for this introduction because N. americanus had been observed there historically (in 1923 and 1947), and because the island is small, protected by state ownership, and lacks predatory mammals. During 1989 and 1990, extensive sampling for carrion beetles was conducted on Penikese and other nearby Elizabeth Islands (by Tom French, Massachusetts Division of Fisheries and Wildlife, et al.) in order to ascertain any possible occurrence of N. americanus prior to reintroduction. Then, during June of 1990, qualitative and some quantitative analysis of the vertebrate composition of the island was conducted. Following completion of this work in June 1990, 25 N. americanus pairs were placed on 80-130 g carrion items and confined under buckets to promote carcass burial. An additional nine individuals were released but not provided with carrion. The total founding population of N. americanus on Penikese Island was thus 59 individuals, provided from the captive population at Boston University (Block Island stock). After one night, 15 of 25 carcasses were completely buried and nine of the remaining 10 carcasses were partially buried. A follow-up visit was made to Penikese on July 13, 1990, whereupon 17 of 25 buried carcasses were exhumed to determine viability of larvae and brood size. Of the 17 carcasses examined, 11 contained viable young, although two other broods had recently failed. The first generation founding population from this experimental release is estimated at 209 animals.

Nonlethal pitfall trapping was conducted on Penikese Island in July 1991 to determine whether beetles from the first release had successfully eclosed and over-wintered. The capture of 16 individuals during three nights of trapping effort suggests that several of the progeny from the release survived. Twelve additional pairs and six individuals from the Boston University laboratory colony were released on carrion on the island in July 1991 to supplement the original release. Other actions taken to benefit this new population include pairing wild caught beetles and carrion provision, as well as removing potential congeneric competitors caught during trapping efforts. The Penikese Island population will be intensively monitored to assess the methodology and results of this reintroduction effort.

RECOVERY STRATEGY

Due to the vulnerable status of N. americanus in the wild, the overriding priority for recovery is to protect and maintain the known natural populations (Block Island, Rhode Island and the localities in eastern Oklahoma).

A second component of recovery will be the continued maintenance of captive populations for reintroduction of the species to historical habitat. Boston University and the Cincinnati Zoo currently maintain laboratory colonies for research and propagation. The Oklahoma Natural Heritage

Inventory, a program of the Oklahoma Biological Survey, is also maintaining a small breeding colony of animals from the Oklahoma population. Collectively, these animals will be the source of future genetic research and reintroduction attempts. It may be advisable to initiate further reintroduction efforts as soon as possible. Potential areas and methods involved in reintroduction will necessarily evolve following the 1991 evaluation of the Penikese Island release, through further analysis of extant and recent historical populations and prey bases, and pending the results of additional sampling rangewide. Translocating wild caught beetles to unoccupied habitats or as a means of bolstering threatened local population is another possible method for re-establishing populations, provided that secure donor populations are used.

Yearly monitoring will be conducted on Block Island to gauge population levels there. Survey efforts in Oklahoma should continue, to determine the geographic extent, habitat preferences and ecological requirements of the populations there. In the long term, management will involve identifying preferred habitat(s) and the carrion-producing vertebrates found there, and managing the habitat(s) for those species.

The most important way to promote recovery of N. americanus may be to conduct surveys for and secure any remnant populations. Although such discoveries would have great significance in and of themselves, locating additional wild populations is also desirable in order to retain genetic diversity of the species, as well as to more effectively compare ecological relationships between a larger sample size of populations. Even if N. americanus is not encountered in additional sampling rangewide, certain intensively sampled areas may serve as potential reintroduction or translocation sites once it is confirmed that the species is not extant and other factors appear favorable.

Further investigations into ecological relationships also appear to be warranted. If carrion availability is indeed a limiting factor for N. americanus, then testing of hypotheses regarding a reduction of carrion resources for N. americanus may provide insight into the reasons this species declined, an understanding of which is virtually essential to effectively prioritize sampling, management, and reintroduction efforts for this species.

Finally, although the decline of the prey base for N. americanus is thought to be the most important factor for the decline of the species in the eastern portion of its range, other factors are undoubtedly involved in the species' rangewide decline. Among these are habitat loss through development or intensive agricultural practices, the possibility of a species-specific pathogenic agent, a particular susceptibility to some chemical contamination, impacts due to artificial lights (which are known to attract and disorient many species of nocturnal insects), and other environmental or anthropogenic causes. The degree to which such impacts are investigated will depend on additional input from scientists familiar with these impacts on other species groups.

PART II. RECOVERY

Recovery is the process by which the decline of a listed species is arrested or reversed, and threats to its survival are neutralized so that its long-term existence in nature can be ensured. Due to this species' profound decline and uncertainty regarding the reasons for that decline, this plan focuses on recovery actions that will lead to significant improvement in the status of Nicrophorus americanus rather than addressing the issues involved in full recovery.

RECOVERY OBJECTIVES

The objectives of the recovery program described in this plan are to (1) reduce the immediacy of the threat of extinction to the American burying beetle, and (2) improve its status so that it can be reclassified from endangered to threatened.

Criteria:

1. 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[1] or more animals each, one in the eastern and one in the western part of the species' historical range limits.

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[1] Minimum viable population size: Franklin (1980), Soule (1980), and Salwasser et al. (1982) proposed the effective population number of 500 breeders as the minimum threshold size for a biological population to maintain long-term adaptability.

2. Reclassification will be considered when:

(a) three populations[2] 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 Lake states (see Figure 4),

(b) each population contains a minimum of 500 adults as estimated by capture rates per trap night and blacklight effort, and

(c) each population is demonstrably self-sustaining for at least five consecutive years (or is sustainable with established long-term management programs).

Ideally, each primary population should contain several satellite occurrences to which beetles disperse and from which new habitats are colonized. However, while this is a desirable distributional pattern, it is not a required factor for reclassification.

The estimated time to achieve reclassification is 20 years.

It is not known how much suitable habitat (including soil, faunal, and floral components) remains within the historical range of this species. The area and other factors necessary for the long-term viability of a Nicrophorus americanus population are similarly unknown, and the factors contributing to the decline of this species may still be operative. For these reasons, no delisting criteria are proposed at this time, although delisting remains the ultimate objective of the recovery program.

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[2] Population is defined as interbreeding members of a species isolated or separated from others.

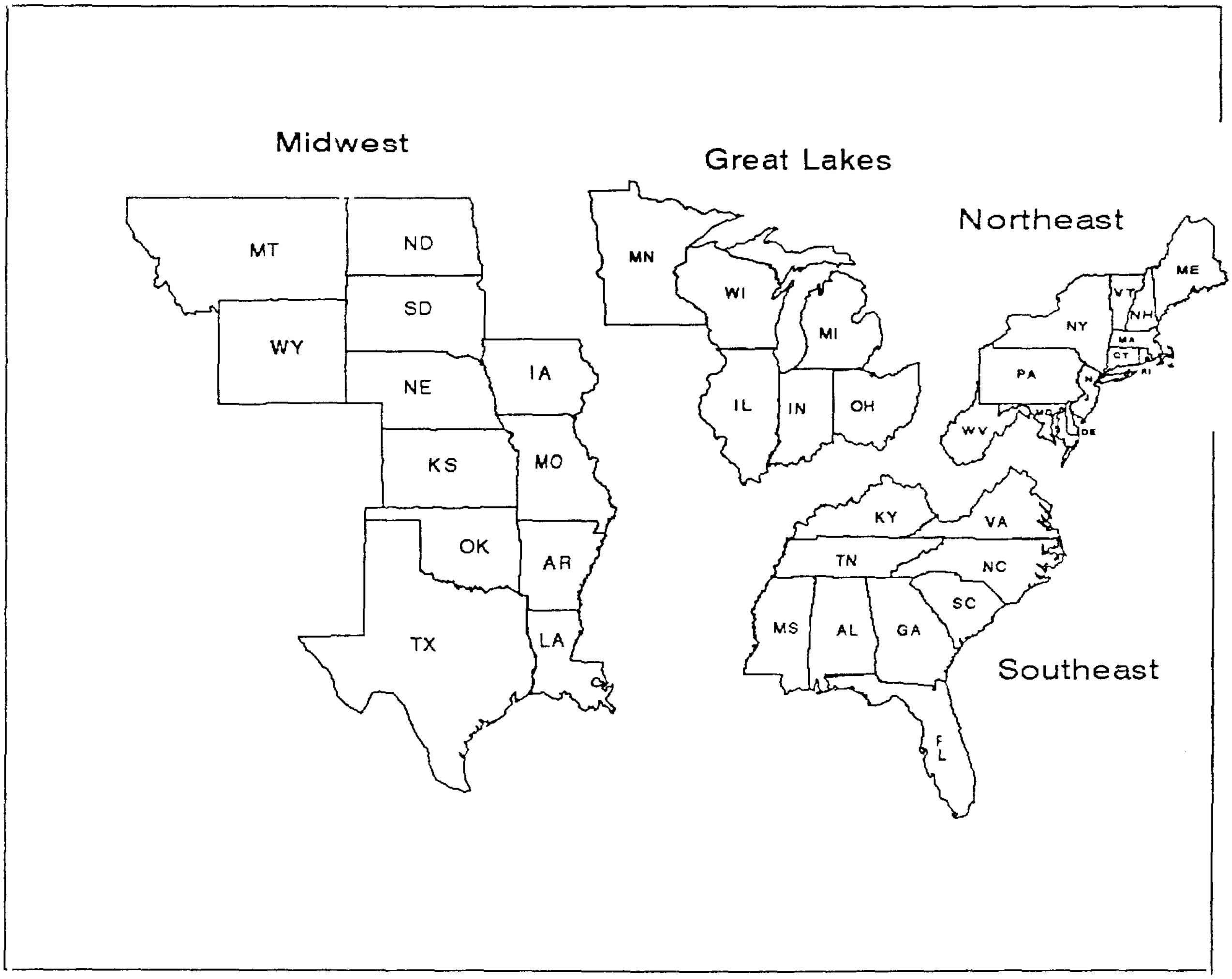

Figure 4. The four Geographic Recovery Areas

STEPDOWN RECOVERY OUTLINE

1. PROTECT AND MANAGE EXTANT N. AMERICANUS POPULATIONS
    - 1.1 Monitor existing wild populations
        - 1.11 Monitor the Oklahoma population
        - 1.12 Monitor the Block Island population
    - 1.2 Protect existing wild populations
        - 1.21 Review Federal, state, and private activities
        - 1.22 Determine ownership
        - 1.23 Explore all measures necessary to provide long-term protection
    - 1.3 Manage existing wild populations
        - 1.31 Using information from Task 4, develop management strategies for the Oklahoma population
        - 1.32 Contingent upon population status, manage the Block Island population
            - 1.321 Supplement carrion resources
            - 1.322 Manage vegetation
            - 1.323 Manage competition for carcasses
2. MAINTAIN CAPTIVE POPULATIONS
    - 2.1 Maintain existing captive populations for purposes of research and propagation
        - 2.11 Develop methodologies and determine the genetic diversity within the wild populations
        - 2.12 Rear beetles for reintroduction purposes
    - 2.2 Establish additional captive populations
3. CONTINUE PENIKESE ISLAND REINTRODUCTION EFFORT
    - 3.1 Monitor reintroduced population
    - 3.2 Release additional captive reared beetles
    - 3.3 Supplement carrion resources
    - 3.4 Reduce competition for carcasses

4. CONDUCT STUDIES

   4.1 Conduct population modeling

   4.2 Investigate ecological relationships at the Oklahoma population

      4.21 Qualify and quantify vertebrate composition

      4.22 Investigate interspecific competition by other Nicrophorus species

      4.23 Investigate historical land use in the Oklahoma localities

      4.24 Evaluate other potential limiting factors

   4.3 Investigate land use/vertebrate composition trends at more recent historical N. americanus localities

5. CONDUCT SEARCHES FOR ADDITIONAL POPULATIONS

   5.1 Prioritize areas to survey for additional wild N. americanus populations

      5.11 Distribute search pattern and survey protocol information

      5.12 Conduct an assessment of the vertebrate prey base

   5.2 Conduct surveys for additional extant N. americanus populations rangewide

   5.3 Provide protection and management for additional populations

6. CHARACTERIZE HABITAT AT ALL KNOWN LOCALITIES

7. CONDUCT ADDITIONAL REINTRODUCTIONS

   7.1 Assess areas and habitats for potential N. americanus reintroduction efforts rangewide

   7.2 Conduct reintroductions

   7.3 Intensively monitor and manage introduced populations

8. CONTINUE TO CONDUCT RESEARCH INTO THE SPECIES' DECLINE

9. CONDUCT AN INFORMATION AND EDUCATION PROGRAM

RECOVERY TASKS

1. Protect and manage extant N. americanus populations.

1.1 Monitor existing wild populations. Long-range monitoring is necessary at the current known extant populations, but the goal of such monitoring should be to generate an index of population levels rather than quantification of the entire population. To the extent practical, a standardized monitoring scheme should be developed, covering the season and conditions involved, trapping methodology, and effort expended. Data generated from such simplified monitoring should be comparable between years. Standardization of monitoring efforts between Oklahoma and Block Island is desirable, but not as important as the standardization of methodology between sampling seasons at any single locality.

1.11 Monitor the Oklahoma population. The eastern Oklahoma population should be monitored annually to evaluate population status and identify future management efforts. Monitoring and presence/absence surveys have been underway since the summer of 1989, and should continue. Kozol's survey protocol (Appendix 2) and methods developed by the Oklahoma Natural Heritage Inventory should be used, with results presented as captures of N. americanus/suitable trap-night effort. "Suitable" refers to all trapping effort conducted within seasonal and weather-related activity periods as defined by Kozol's survey protocol (Appendix 2).

1.12 Monitor the Block Island population. As part of A. Kozol's doctoral research through Boston University, Block Island N. americanus were intensively monitored during 1989 and 1990 using mark-and-recapture methodology. Since this method of monitoring may be impractical over the long term, future Block Island monitoring efforts will be geared toward developing a population index using standardized trapping methodology. On Block Island, the peak interval for censusing is mid- to late June. It is anticipated that monitoring efforts on Block Island will be a cooperative effort between The Nature Conservancy, which manages the primary habitat, the U.S. Fish and Wildlife Service, and the Rhode Island Division of Fish and Wildlife. The Block Island population is thought to be stable, with intensive management not an immediate priority but a potential future necessity.

Block Island monitoring should consist of standardized (equipment and location) pitfall arrays in conjunction with blacklighting during the peak seasonal and weather conditions for N. americanus activity. Results should consist of total captures/suitable trap-nights (and/or captures/hours blacklight). A non-individualized marking scheme should be devised to avoid multiple counting of recaptures (e.g., all captured individuals marked on pronotum with blue enamel spot). N. americanus should be monitored on at least three areas of Block Island, including the primary areas of occurrence and one other location where the species is less densely encountered. In this manner, it may be possible to detect declines at the fringes of the population before the core of the Block Island range is affected. Data on congeneric species should also be collected while sampling for N. americanus.

1.2 Protect existing wild populations.

1.21 Review Federal, state, and private activities. There is little foreseeable non-FWS Federal activity that would affect habitat at either the Block Island or Penikese Island locations. However, Federal activities in the vicinity of the Latimer County, Oklahoma population should be closely reviewed vis-a-vis Section 7 of the Endangered Species Act to minimize further loss (or fragmentation) of beetle habitat and to prevent activities that result in the taking of beetles. Federal activity at the Cherokee/Muskogee County population as well as any other newly discovered N. americanus populations should also be carefully reviewed. State and private actions that may adversely affect habitat or result in the taking of beetles should be reviewed to the extent possible under Federal and State law.

1.21 Determine ownership. The ownership of areas occupied by all known populations should be determined in order to evaluate the degree of threat to the population and its habitat, as well as the need for protection measures.

1.23 Explore all measures necessary to provide long-term protection. Identify and implement measures as needed to provide known habitats with long-term protection. This may include voluntary registries, management agreements, acquisition of development rights, and land or easement acquisition on a willing seller basis.

1.3 Manage existing wild populations. Different factors may be operating to limit the Block Island and Oklahoma populations. Based on results of studies on ecological requirements, limiting factors, and population status (Tasks 1,4,6, and 8), it may be necessary to implement one or more of the following actions: provide supplemental carrion, reduce competition, manage to enhance prey populations, enhance pair formation and reproduction, or supplement populations with new individuals through reintroduction/translocation.

Suitable carrion could be supplied to populations at the peak reproductive season, with cage-like exclosures over some of the carrion to ensure that it will not be scavenged by vertebrate predators. Such a technique has greater application in locations where a population is thought to be small and where carrion availability is uncertain. The simple distribution of carcasses should not negatively affect existing populations and may increase available reproductive opportunities. In order to ensure that some reproduction does occur, adult pairs of beetles could be placed directly on carrion, then covered with inverted buckets. Further, if a specific prey base can be identified at extant *N. americanus* populations, management schemes designed to increase this prey base will have application.

1.31 Develop management strategies for the Oklahoma population. Management needs of the Latimer County and the newly discovered Cherokee/ Muskogee County populations should be assessed as soon as possible. Information obtained through Tasks 4, 6, and 8 will indicate management strategies appropriate to specific locations. Management techniques that prove to be successful in increasing the Cherokee/ Muskogee or Latimer populations could also be useful when reintroducing N. americanus in areas where the species has been extirpated. Preliminary consideration should be given to the following management techniques:

(a) Carrion resources could be supplemented by providing optimally sized (100- 200 g) carcasses. Whole carrion items (such as pen-reared chickens or pheasant chicks) would be distributed near the center of the population (if ascertainable) and throughout the activity period of N. americanus, as judged by field personnel involved with monitoring.

Freshly dead carcasses should be used in order to reduce initial competition from flies, ants, and other organisms, and should be placed out of sight of avian scavengers (e.g., under vegetation). Carrion may be stored frozen and thawed 24 hours prior to use.

(b) In order to reduce competition for carrion, a percentage of these carcasses could be protected from mammalian and avian scavenging with small welded wire exclosures. The aperture size of such exclosures should be between 1" x 1" and 2" x 4", which would allow N. americanus access while eliminating most vertebrate competition for these carcasses. Exclosures should be covered to protect carcasses from aerial scavengers such as crows, and have a radius exceeding the reach of the largest predator of the area. A smaller aperture size may decrease minimum radius requirements for exclosures.

(c) In order to enhance pair formation and reproduction among beetles occurring at low densities, pairs of locally-captured N. americanus could be placed on carcasses and placed under inverted buckets until burial is completed. The inverted buckets (or large flower pots) should be replaced with a wire exclosure after burial is completed. This will provide the beetles and the developing brood some protection from vertebrate scavengers and predators.

1.32 Manage the Block Island population, as appropriate. As indicated previously, the Block Island population is thought to be relatively stable at about 500. However, management may be warranted if a significant population decline is detected during annual monitoring efforts.

1.321 Supplement carrion resources. While the major purpose of this management activity would be to offset any population decline on the island, this practice should also involve determining the species of carrion beetle utilizing the carcasses, and their reproductive success.

1.322 Manage vegetation. Management efforts could be undertaken to benefit potential prey species such as the ring-necked pheasant (and possibly woodcock). The primary Block Island habitat is currently mowed annually by the Rhode Island Division of Fish and Wildlife specifically to manage for woodcock and other species of state concern, such as the Regal fritillary butterfly, upland sandpiper, and grasshopper sparrow, which are also located in this area. Keeping brushy cover minimized and broken up, reducing edge to the extent practical, and renewing the lease for grazing livestock on the property would continue to bemefit pheasant. Some old fields near and within Rodman's Hollow could also be mowed and opened to transition grassland habitats, which would provide nesting habitat and food for pheasant. Any vegetation manipulation designed to benefit woodcock or pheasant could be performed within the Rhode Island Division of Fish and Wildlife's W-22-D Project, pending funding availability.

1.323 Manage competition for carcasses. Although this aspect of *N. americanus* recovery is not currently a high priority on Block Island, any carcasses that are provided should be visually shielded from crows, which learned to associate the presence of carrion with surveyors tape during Kozol's 1990 field work.

2. Maintain captive populations.

2.1 Maintain existing captive populations for purposes of research and propagation. The colonies of *N. americanus* at Boston University, the Oklahoma Biological Survey, and the Insectarium at the Cincinnati Zoo and Botanical Garden should be maintained and bred to preserve genetic variability and reduce the potential that deleterious genes will be manifested. The cooperation of the American Association of Zoological Parks and Aquariums (AAZPA) should be enlisted to coordinate propagation efforts. Captive populations should be periodically supplemented with larvae culled from wild stock.

2.11 Develop methodologies and determine genetic diversity within the wild populations. It is unknown how long the Rhode Island and Oklahoma populations have been isolated from one another and whether they have diverged genetically. Genetic analysis of these and any other newly discovered demes could yield valuable information on the amount of genetic variability remaining in the species. This information will be used to preserve existing alleles and conduct controlled breeding programs.

2.12 Rear beetles for reintroduction purposes. Beetles should be reared in order to have sexually mature adult pairs available at the optimal season and date for reintroduction purposes.

2.2 Establish additional captive populations. At least two additional captive populations should be established to reduce the risk that an unforeseeable event could eliminate a large percentage of all captive individuals available for reintroduction. Ideally, additional captive populations should be initiated with beetles from newly-discovered wild populations, particularly if such populations occur at low density levels. If no new wild populations are discovered by the autumn of 1992 (given a reasonable sampling effort), at least two additional captive populations should be established using existing Oklahoma and Block Island stock (1+ each). Founding individuals for new laboratory populations should be animals taken from the wild, rather than from the respective captive populations, to maintain genetic diversity in the total captive population.

3. Continue Penikese Island reintroduction effort.

A founding population of 89 *N. americanus* from Boston University's captive breeding program was introduced to Penikese during the summer of 1990 and 1991. Preliminary results in 1990 indicated that two-thirds of the pairs successfully reared broods. Follow-up monitoring in 1991 confirmed that several beetles from the 1990 release successfully eclosed and overwintered. In order to reduce the threat of extinction that currently faces the species, it is crucial that this reintroduced population succeed. It is also important to monitor the progress of this introduction over several field seasons in order to ascertain the applicability of reintroduction methods elsewhere within the historical range.

In order to maximize the chances for this population to become well established and increase to a self-sustaining level, one or more of the following subtasks are appropriate.

3.1 Monitor reintroduced population. Surveys will be conducted annually to determine the occurrence and abundance of adult beetles. Since the island is relatively small (about 75 acres), effort should be made to quantify the entire island population. If numbers of N. americanus are found, they should be paired, and released on an appropriate sized carrion. Monitoring is essential to provide an indication of the viability of the population and pairing and carcass supplementation will promote reproductive success. Monitoring will also be used to assess the effectiveness of the reintroduction methodology.

3.2 Release additional captive reared beetles. Additional releases will almost certainly increase the likelihood of a successful reintroduction, since N. americanus must compete with a resident, well-established silphid beetle community. New release animals will be paired and placed on carrion suitable for burial and reproduction.

3.3 Supplement carrion resources. Carrion could be broadcast on the island, and the number, species of carrion beetle, and success of the reproductive effort could be determined. This would promote reproduction of those N. americanus not encountered during census efforts. In addition, the adequacy of the vertebrate prey base on Penikese Island to support a population of N. americanus over the long term should be evaluated. This will provide insights into the need for continued carrion supplementation.

3.4 Reduce competition for carcasses. Reduce interspecific competition by removing all N.

orbicollis encountered in pitfall trapping efforts. N. orbicollis is very abundant on Penikese and removal of individuals caught during censusing for N. americanus may be beneficial to N. americanus by improving its chances for access and utilization of carrion.

All or most of these activities should be carried out annually for a period of at least three years to provide the population with an optimal chance of becoming well established. Subsequently, one or more of the management actions can be withdrawn and the effect on the population monitored during annual censusing.

4. Conduct studies.

4.1 Conduct population modeling. Using data generated by Kozol at Boston University and on Block Island, and by Creighton in Oklahoma, it may be possible to model a N. americanus population and its theoretical response to varying amounts of certain size-classes of available carrion. A model of this nature would be valuable in providing a clearer picture of the species' decline, and nearly essential for generating future management schemes for this species. Block Island may be the most likely population for this effort, since the N. americanus population is still relatively stable and has been well-quantified. Also, there is a fair understanding of the vertebrate prey base available on the island. Modeling could provide insights to questions such as how much reproduction and recruitment must occur for population stability.

4.2 Investigate ecological relationships at the Oklahoma population. The likelihood that the decline of N.

americanus is related to a reduction in carrion resources during the last 100+ years should be substantiated insofar as possible. The vertebrate composition of Block Island is in the process of being quantified, and suggests that an abundant nesting population of ring-necked pheasant is the likely source for most of the optimum carrion available to *N. americanus* there.

In order to investigate the relationship between *N. americanus* and vertebrate prey bases elsewhere, it will be necessary to qualify and quantify the vertebrate prey base of the Oklahoma localities. This process will become more revealing if additional extant populations can be discovered.

4.21 Qualify and quantify vertebrate composition. The species composition and relative densities of potential prey should be evaluated for the extant populations. Data from these surveys should be analyzed according to abundances by weight class, and compared to Block Island data.

4.22 Investigate interspecific competition by other *Nicrophorus* species. While monitoring for *N. americanus* at the Oklahoma localities and Block Island, data on congeneric species should also be obtained. Data on other *Nicrophorus* species in Oklahoma and on Block Island, as well as in areas where *N. americanus* is no longer extant, may be useful in assessing interspecific competition, as well as the overall suitability of *N. americanus* habitat. Trend analysis of congeneric species may therefore be a useful addendum to *N. americanus* monitoring in an attempt to understand the dynamics of carrion beetle populations.

4.23 Investigate historical land use in the Oklahoma localities. Assimilate any available data regarding trends of "large" vertebrate species. If optimum carrion availability is currently limiting the small Oklahoma population, there may be data demonstrating an historical decline of optimally-sized vertebrate species in this area. Such data would be much more likely to exist for bird populations than other vertebrate groups, and may be found in Christmas Bird Count data (for non-migratory species), Breeding Bird Survey (BBS) route data, or in state game agencies which may be monitoring gallinaceous species, waterfowl, and woodcock.

A more detailed study of the land use trends in eastern Oklahoma is desirable, and should include any historical evidence of "artificial" carrion supplementation (such as rodent control), which may have affected *N. americanus* populations there.

4.24 Evaluate other potential limiting factors. Any other potential limiting factors identified through ongoing studies should be evaluated in terms of their importance to the recovery effort.

4.3 Investigate land use/vertebrate composition trends at more recent historical *N. americanus* localities. Not only are recent historical collection localities such as Lincoln County, Nebraska (1988); Harrow, Ontario (1972); Trigg County, Kentucky (1974); and Cambridge, Maryland (1947) priorities for future searching (see 5.1 below), but trend analysis of vertebrate populations and historical land use may be revealing in determining the causes for N. americanus decline in these areas. Vertebrate sampling data, particularly for upland gamebirds, may exist for areas where N. americanus occurred historically, and examination of such data may reveal declines in certain potential prey base species at these locations. Mammal populations are not easily quantified without protracted sampling, but mammal faunas should be at least qualified in these areas.

5. Conduct searches for additional populations.
Based on certain ecological and habitat parameters observed on Block Island, augmented with similar information from Oklahoma and recent historical sites, a search pattern may emerge that will assist in the identification of general geographical areas that should be surveyed. Specific search areas will necessarily have to be determined by personnel more familiar with local habitats and faunal compositions. When de novo searching is conducted, it should be done intensively due to the difficulty (as documented in Oklahoma) of detecting this species where populations may occur in low densities. Large areas under Federal, state, or private conservation agency management should receive priority, because these areas offer the most favorable chance for protecting remnant populations.

5.1 Prioritize areas to survey for additional wild N. americanus populations. Based on ecological and habitat relationships observed for N. americanus on Block Island, and pending further comparison with

Oklahoma information, general geographical areas will be prioritized for N. americanus sampling during the field seasons of 1992 and 1993. Initially, this search pattern will focus on large areas of oak-hickory forest, pseudo-prairie, or light agricultural grasslands, where terrestrial bird or small mammal populations are high and/or mammalian competition for carrion is absent or reduced (as on certain islands).

5.11 Distribute search pattern and survey protocol information to all pertinent states and Canadian provinces.

5.12 Conduct preliminary bird and mammal sampling to quantify vertebrate biomass ratios in potential search areas. Sampling of avian nesting populations can be accomplished using methodology similar or identical to the U.S. Fish and Wildlife Service's BBS routes. Bird and mammal sampling data should be reviewed to detect abundance of species in certain body weight categories. Even if N. americanus is not subsequently found in these areas, sampling data may be useful in assessing the current suitability of habitat for potential reintroductions, and may suggest management strategies to maintain future reintroduced populations.

5.2 Conduct surveys for additional extant N. americanus populations rangewide. Locating additional wild populations of N. americanus would facilitate recovery efforts for this species, would provide additional genetic diversity for captive populations, and would allow better analysis of ecological relationships between _N_. _americanus_ and its habitat and vertebrate prey bases. It is recommended that surveying for _N_. _americanus_ in priority areas be intensive, since survey efforts in Latimer County suggest that the species is difficult to detect where it occurs at low densities. One thousand suitable trap nights per field season (e.g., 50 traps set for 20 nights) should be the goal of this inventory in relatively large areas, supplemented by blacklighting where practical. For smaller areas (like islands), less trapping should be sufficient to locate the species if it occurs.

An adequate trapping effort is also essential to determine whether or not the species is present prior to reintroduction efforts.

5.3 Provide protection and management for additional populations.

6. Characterize habitat at any localities where N. americanus is found to be extant.

The habitat and vertebrate composition of the _N_. _americanus_ population on Block Island has been investigated to the extent currently practical. Studies have been initiated to determine the habitat preferences of _N_. _americanus_ at extant localities in Oklahoma. These efforts are focused on the occurrence of _N_. _americanus_ in three habitat types: oak-hickory forest, grasslands, and bottomland forest. These ongoing studies should continue and should endeavor to identify the most significant biotic and abiotic factors present.

7. Conduct additional reintroductions.

7.1 Assess areas and habitats for potential N. americanus reintroduction efforts rangewide. The assessment of areas for potential reintroduction efforts will involve several components, including sampling to determine the vertebrate species present, and a survey of the carrion beetle community to ascertain the presence or absence of N. americanus. Other factors to consider will include area size, ownership and protection, and the potential for habitat management, including augmentation of the carrion resources present. All reintroductions should carefully consider the genetics of source and recipient populations, and should occur within the general historical range of the species.

7.2 Conduct reintroductions. Conduct reintroductions of N. americanus in suitable areas within each of four selected geographical recovery areas: the northeastern states, the southeastern states, the Midwest, and the Great Lakes states.

7.3 Intensively monitor and manage introduced populations until such time as it can be demonstrated that they are self-sustaining. Long-term self-sustainment of all wild N. americanus populations will ultimately depend on managing and sustaining vertebrate populations (and thus carrion availability) in a given area. Once a N. americanus population is relatively stable, monitoring at a less intensive level will remain necessary, with a population index generated yearly as per Block Island.

8. Continue to conduct research into the species' decline. Conduct research to ascertain other potential mechanisms of decline in N. americanus populations. Although carrion reduction is currently thought to be an important cause in the decline of N. americanus, several other factors may have contributed to this process. A partial list of these includes habitat fragmentation and population isolation, impacts from blacklights or mercury vapor street lights, a particular susceptibility to chemical contamination via pesticides or rodenticides, and susceptibility to an as yet unidentified pathogen, toxin, or environmental factor. All such theories and any others that may arise should be investigated until they can be demonstrated as being unimportant in the decline (and recovery) of N. americanus.

9. Conduct an information and education program. News releases, media articles, brochures, slide and film presentations, and displays should be used to inform and educate agency personnel, landowners, and the general public about the American burying beetle. These efforts should address the value of preserving biological diversity and will result in a more informed and supportive public. The publication of articles and notices in scientific journals would also increase awareness of this endangered species within the academic community.

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PART III. IMPLEMENTATION

The following Implementation Schedule outlines actions and estimated costs for the recovery program. It is a guide for meeting the objectives discussed in Part II of this plan. This schedule indicates task priorities, task numbers, task descriptions, duration of tasks, the responsible agencies, and lastly, estimated costs. The tasks, when accomplished, should bring about the stabilization and partial recovery of the American burying beetle and protect its habitat. It should be noted that the estimated monetary needs for all parties involved in recovery are identified and, therefore, Part III reflects the total estimated funding requirements for the recovery of this species.

Key to Implementation Schedule (column 1)

Task Priority

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to meet the recovery objectives.

Key to Agency Roles (column 5)

AAZPA	-	American Association of Zoological Parks and Aquariums (ITAG)
ASRI	-	Audubon Society of Rhode Island
BIC	-	Block Island Conservancy
BU	-	Boston University
CZBG	-	Cincinnati Zoo and Botanical Garden
FWE	-	Division of Fish and Wildlife Enhancement within the U.S. Fish and Wildlife Service

MADFW - Massachusetts Division of Fish and Wildlife
OFA - Other Federal land managing agencies such as the U.S. Forest, National Park Service, Bureau of Reclamation, Tennessee Valley Authority, Department of Defense (including Corps of Engineers, Army, Air Force and Marine Corps), Public Utilities Commission, Rural Electrification Administration, Federal Highway Administration, and Bureau of Indian Affairs
OKDWC - Oklahoma Department of Wildlife Conservation
OKNG - Oklahoma National Guard, Camp Gruber
OKNHI - Oklahoma Natural Heritage Inventory
OKU - Oklahoma University
Realty - Realty Office within U.S. Fish & Wildlife Service
RIDFW - Rhode Island Division of Fish and Wildlife
TNC - The Nature Conservancy
SHP - State Heritage Programs
SNGP - State Nongame and Endangered Species Programs
UNSM - University of Nebraska State Museum

IMPLEMENTATION SCHEDULE
American Burying Beetle

September 1991

Priority	Task Description	Task Number	Duration	Responsible Agency: USFWS	Responsible Agency: Other	Cost Estimates ($000): FY1	FY2	FY3	Comments
1	Monitor existing wild populations.	1.1, 1.3	Annually						Since *Nicrophorus* is an annual species, annual monitoring is needed to determine status.
	Oklahoma	1.11, 1.31		R2 FWE	OKDWC OKNHI	10.0	10.0	10.0	
	Rhode Island	1.12, 1.32		R5 FWE	TNC RIDFW ASRI	2.0	2.0	2.0	
1	Maintain existing captive populations.	2.1, 2.12	10-15 years			1.5	1.5	1.5	Captive populations are maintained for research and propagation.
				R2 FWE R3 FWE R5 FWE	OKNHI CZGB BU				
1	Continue Penikese Island reintroduction effort.	3.	5+ years	R5 FWE	MADFW BU	1.5 .5	1.5 .5	1.5 .5	3 years for population to become established, then gradual reduction of management intervention.
1	Prioritize areas and conduct surveys for additional populations.	5.	3-5 years	R2 FWE	OFA	10.0	10.0	10.0	Additional populations should be identified in order to ensure their protection.
				R3 FWE	SHP	10.0	10.0	10.0	
				R4 FWE	SNGP	10.0	10.0	10.0	
				R5 FWE	(all regions)	10.0	10.0	10.0	
				R6 FWE	UNSM	10.0	10.0	10.0	
1	Conduct additional reintroductions and manage new populations.	7.	5 years	R2 FWE	SHP	10.0	10.0	10.0	Actions will not be required in every region each year. R3 reintroductions will most likely be initiated after FY3.
				R3 FWE	SNGP				
				R4 FWE	(all		10.0	10.0	
				R5 FWE	regions)	10.0	10.0	10.0	
				R6 FWE			10.0	10.0	

American Burying Beetle Implementation Schedule (continued), September 1991

Priority	Task Description	Task Number	Duration	Responsible Agency USFWS	Responsible Agency Other	Cost Estimates ($000) FY1	FY2	FY3	Comments
2	Characterize habitat at all known localities.	6.	2 years	R2 FWE R3 FWE R4 FWE R5 FWE R6 FWE	SHP SNGP (all regions)		5.0 5.0 5.0 5.0 5.0	5.0 5.0 5.0 5.0 5.0	Funding in Regions 3, 4, and 6 contingent upon the discovery of additional populations.
3	Establish additional captive populations.	2.2	R2 FWE	AAZPA	2.5	2.5	2.5		
3	Conduct population modeling.	4.1	1 year	R5 FWE		1.0			
3	Investigate land use and ecology of recent collection localities.	4.3	2 years	R2 FWE R3 FWE R4 FWE R5 FWE R6 FWE	SHP SNGP (all regions)	5.0 5.0 5.0 5.0 5.0	5.0 5.0 5.0 5.0 5.0		
3	Continue to conduct research into the species' decline.	8.	3 years	R2 FWE R5 FWE			5.0 2.5	5.0 2.5	These costs will continue into FY4.
3	Conduct information and education programs.	9.	Ongoing	R2 FWE R3 FWE 54 FWE R5 FWE R6 FWE	SHP SNGP (all regions)	1.5 1.5 1.5 1.5 1.5	1.5 1.5 1.5 1.5 1.5	1.5 1.5 1.5 1.5 1.5	

American Burying Beetle Implementation Schedule (continued), September 1991

Priority	Task Description	Task Number	Duration	Responsible Agency USFWS	Responsible Agency Other	Cost Estimates ($000) FY1	FY2	FY3	Comments
2	Review Federal activities.	1.21	Ongoing		OFA				Surveys will be required in localities with recent historical collections.
	Oklahoma			R2 FWE		5.0	5.0	5.0	
	Rhode Island			R5 FWE		.5	.5	.5	
	Other			R3,R4,R6 FWE		3.0	3.0	3.0	
2	Determine ownership and protect existing habitat.	1.22, 1.23	3 years						
	Rhode Island			R5 FWE/ Realty	TNC/BIC	2.5	5.0	5.0	Does not include land costs.
	Oklahoma			R2 FWE/ Realty	OKNG OKDWC	5.0	10.0	15.0	Does not include land costs.
2	Manage existing populations.	1.3	Annually						Management needs still to be determined, particularly in Oklahoma. Costs uncertain.
	Develop management strategies for the Oklahoma population.	1.31		R2 FWE	OKDWC OKNHI	5.0	5.0	5.0	
	Manage the Rhode Island population, as appropriate.	1.31		R5 FWE	TNC ASRI RIDFW	1.0	1.0	1.0	
2	Determine genetic diversity within and between wild populations.	2.11	1 year	R5 FWE R2 FWE	BU OKU	2.5			$10,000 was spent in FY91.
2	Investigate ecological relationships at the Oklahoma population.	4.2	3 years	R2 FWE	OKDWC OKNHI	5.0	5.0	5.0	

APPENDIX 1. COLLECTION LOCALITIES AND LAST DATE OF OCCURRENCE

The following list indicates all known United States counties and Canadian provinces of distribution, based on specimen collections with most recent date of occurrence.

State	County	Last Known Occurrence
AL	Mobile	?
AR	Benton	1956
	Cleburne	1969
	Hempstead	1875
	Washington	1973
CT	Hartford	1875
	Litchfield	1920
DE	New Castle	1897
FL	Marion	?
GA	Charlton?	1912
	Fulton	1940
	Haralson	1908
IL	Calhoun	1944
	Champaign	1955
	Cook	1913
	Greene	1902
	Johnson	1958
	Kane	1909
	Lake	1930
	Marshall	1939
	McHenry	1907
	McLean	1895
	Ogle	?
	Peoria	1941
	Putnam	1932
	Stark	?
	St. Clair	?
	Tazewell	1883
	Union	1907
	Winnebago	1934

State	County	Last Known Occurrence
IN	Elkhart	1917
	Knox	?
	Lake	1896
	Monroe	1906
	Porter	1934
	Posey	1965
	Starke	1913
	Vanderburgh	1927
IA	Appanoose	1932
	Dickenson	1916
	Fayette	1929
	Franklin	?
	Johnson	1909
	Linn	1906
	Story	?
	Winneshiek	1921
	Woodbury	?
KS	Doniphan	1922
	Douglas	1927
	Montgomery	1926
	Osage	?
	Pottawatomie	1922
	Riley	1940
	Saline	?
	Shawnee	1923
KY	Henderson	1921
	Trigg	1974
LA	Plaquemines	1928
ME	Oxford	?
	Penobscot	?
	Dorchester	1947

State	County	Last Known Occurrence
MA	Berkshire	1890
	Bristol	1905
	Dukes	1940
	Essex	1907
	Hampden	1899
	Hampshire	1901
	Middlesex	1910
	Nantucket	1898
	Norfolk	1891
	Suffolk	1906
MI	Alger	1918
	Barry	1933
	Bay	1945
	Berrien	1930
	Huron	1908
	Ingham	1906
	Kalamazoo	1961
	Kent	?
	Menominee	1940
	Midland	1944
	Oakland	1934
	Washtenaw	1933
	Wayne	?
MN	Crow Wing	?
	Douglas	1940
	Hennepin	1916
	Houston	1941
	Kanabec	1934
	Le Sueur	1923
	Olmstead	?
	Pope	1929
	Ramsey	1935
	Rice	[?]
	Washington	?
MS	Lafayette	1949
MO	Bollinger	1918
	Boone	1966
	Franklin	?
	Howard	1959
	Jasper?	1982
	Jefferson	?
	Mississippi	1914
	St. Louis	1937
	Wayne	1955
MT	Phillips (or Valley)	1913
NE	Antelope	?
	Custer	1970
	Lancaster	1921
	Lincoln	1988
	Thomas	1969
NH	Coos	1898
	Merrimack?	1897
	Rockingham	1902
	Strafford	?
NJ	Camden	1910
	Essex	?
	Gloucester	1906
	Mercer	1919
	Ocean	1912
	Passaic	1903
	Sussex	
NY	Bronx	?
	Erie	?
	Monroe	?
	Westchester	1923
	Richmond	?
	Kings	1905
	Nassau	1930
	Suffolk	1937
NC	Buncombe	1940
OH	Auglaize	?
	Franklin	?
	Lucas	?
	Wayne	1920
OK	Sequoyah	1991
	Latimer	extant
	Cherokee/ Muskogee	extant
PA	Alleghany	?
	Erie	?
	Lancaster	?
	Philadelphia	1904

State	County	Last Known Occurrence
RI	Kent	1897
	Providence	?
	Washington	extant
SC	Unknown	?
SD	Brookings	1945
	Haakon	?
	Union	1945
TN	Benton	1952
	Cumberland	1955
	Lawrence	1955
	Madison	1955
	Washington	?
TX	Kleberg	?
VA	Richmond (city)	?
	Montgomery	?
	Nelson	1896
	Spotsylvania	?
WI	Dane	1920
	Dodge	1912
	Shawano	1948
	Winnebago	?
DC	(city)	1931

Country	Province	Last Known Occurrence
CANADA	Nova Scotia	?
	Ontario	1972
	Quebec	?

APPENDIX 2. SURVEY PROTOCOL FOR NICROPHORUS AMERICANUS

Survey Protocol for *Nicrophorus americanus*, the American Burying Beetle

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Natural History

Nicrophorus species require carrion as a reproductive resource and therefore utilize small vertebrate carcasses which can be buried quickly or rolled down a hole and concealed. Males and females are attracted to carrion and intrasexual competition occurs within each sex until usually only one male and female remain. Although a single beetle is capable of burying a carcass alone, a male and female generally cooperate in burying the carrion where it is, or after moving it to a suitable location. During the process of burial the carcass is rolled into a ball, fur or feathers are removed, and both parents walk around the corpse applying anal and oral secretions to reduce the growth of microbes. The process of walking around the carrion compacts the surrounding soil and creates a brood chamber in which the carcass rests. About 36-48 hours after burial the female lays eggs in a tunnel leading off the brood chamber, and larvae hatch approximately six days after the carcass is buried. The newly hatched larvae are fed regurgitated food by both parents particularly during the first instar, although parental feeding may continue into the third instar. Larvae generally complete development by 12-16 days after burial and wander away from the carcass to pupate in the soil nearby. After eggs are laid either the male or female can rear a brood alone but typically both parents remain for several days and at least one parent, usually the female, remains with the brood until larval dispersal.

Identification

The American burying beetle is the largest of 15 *Nicrophorus* species in North America. Adults can range from 25 to 45 mm in length. This species is easily distinguished from all other *Nicrophorus* species by the presence of an orange-red disc on the pronotum and an orange-red frons. Facial markings can be used to sex individuals. Males have a large orange-red rectangular marking below the frons, while females have a smaller, orange-red triangle in the same location.

Trapping Methods

Three methods of trapping can be used to capture Nicrophorus species: pitfall traps, blacklight traps, and whole carrion. The most effective way to survey a large area is to use pitfall traps. The other methods are more useful as supplementary traps if time and labor permit.

Pitfall Traps - Bait

Baited pitfall traps provide a powerful odor attractant for burying beetles. A number of items can be used as bait, depending on cost and availability, including beef kidney, beef liver, chicken liver, fish, or small vertebrate carcasses (i.e. mouse, chick). It is critical that the bait be fully ripened before using. I use beef kidney for bait because it is very inexpensive and readily available. Before using kidney to trap with, I divide it into pieces (approximately 20 g), seal them in a plastic container and let them sit outside in a warm place for 2-4 days. The more powerful the odor of the bait, the more successful it will be at attracting Nicrophorus species.

Pitfall Traps - Design

Wide-mouth containers, such as quart-size glass Ball Mason jars or plastic ice cream containers can be used as pitfall traps. Metal cans should be avoided because as soon as any rust appears, the beetles can walk out of the trap.

Each trap should be sunk into the ground so that the opening of the trap is flush with the surface of the soil. Soil should be packed around the opening of the trap so the beetles have unobstructed access to it. Nicrophorus individuals attracted to a pitfall trap usually fly to the area, land within a meter of the trap, and walk into it. The bait should be placed inside the trap in such a way that the beetles do not come into contact with it. This is important because if the bait is semi-solid, which it frequently is when fully ripened, the beetles can get stuck to it, or can become covered with it and die of asphyxiation from blocked spiracles. I place the bait inside a small jar (i.e. baby food jar) inside the larger pitfall trap. The small jar is fitted with a fine mesh screen lid so it is odor permeable. The bait can also be isolated by wrapping it in cheesecloth and suspending it with thin wire from the top of the trap. While bait that is too wet can present a problem for trapped beetles, bait that is dried out is not very effective at attracting beetles. I have found the jar inside a jar method to be preferable because it is easier to keep the bait moistened with this system. If traps are set up in an area with very low humidity, where the bait may dry out quickly, I recommend using small jars to hold the bait and squirting the bait with a bit of water to prevent desiccation.

Pitfall traps should be fitted with two lids; one to keep out vertebrate scavengers and the other to deflect rain. A piece of wide mesh screen (i.e. 2 cm) or chicken wire, held in place with stakes or large rocks, covering the entire pitfall trap will discourage dogs, raccoons, skunks, crows, etc. from stealing the bait. If there is any possibility of rain, a raised plywood lid should be used to keep water out of the trap. The plywood can be propped up with a rock placed on the wire lid. A second rock put on top of the plywood will keep it firmly in place. Nicrophorus beetles can drown very easily in even a small amount of water so it is important to use a large solid lid to prevent water from getting into the traps.

Pitfall traps should not be sunk in the ground within several meters of ant colonies. When a group of ants gets inside the trap, they can kill the beetles that have been captured. This has been documented with a common field ant Lasius neoniger. If an ant colony is encountered when a hole is dug to sink the trap, change the intended location for the trap to one that is free of ant colonies.

Pitfall Traps - Layout and Monitoring

Pitfall traps should be set up along a transect at 15 to 25 meter intervals depending on the size of the area to be trapped. If surveying a large area, 60-75 pitfall traps should be set up in 5 or 6 separate trap lines. If separate transects are used, they should be at least 2 km apart as Nicrophorus beetles are strong fliers and can travel long distances in search of carrion. I recommend using a minimum of 15 traps in a line. Although N. americanus is found in areas with maritime shrub thickets, coastal moraine grasslands, and agricultural pastures on Block Island, the preferred habitat for this species across its former range has not been determined so traps can be set up in forested areas as well as in open fields. The location of each trap should be marked with surveyor's tape so it can be relocated easily.

Traps should be baited and opened by 1 hour before sunset as N. americanus becomes active at dusk. It is fine to bait traps in the morning and leave them open all day if this is easier to schedule, provided that the bait does not dry out in the sun and heat. Traps should be cleared of beetles every day, preferably by 9 a.m. Exposure to full sunlight and temperatures over 25°C for even a few hours can result in mortality for Nicrophorus spp.

Pitfall Traps - Trapping Conditions

The best time to trap for Nicrophorus spp. using pitfall traps is approximately 3 to 8 weeks after the onset of seasonal activity in the late spring and early summer. On Block Island, N. americanus can be caught in very small numbers in late May and early June depending on the annual variation in temperature. Pitfall captures are highest from mid- June through early July, and decrease significantly in late-July and August. Although it is still easy to attract N. americanus to carrion baits in late July, it is difficult to catch them in pitfall traps.

On a nightly basis, pitfall captures are highest when the overnight low temperature is above 15°C. If the overnight low is predicted to drop below 12°C, the probability of capturing Nicrophorus beetles is very unlikely. If trapping is conducted between 3 and 8 weeks after the onset of seasonal activity, if the overnight low temperatures are above 15°C, and if captures of Nicrophorus species other than N. americanus are high, 3 good nights of trapping can be considered sufficient before moving the traps to a new location.

All Nicrophorus beetles captured in pitfall traps should be identified to species before being released in order to have a measure of the effectiveness of the trapping opportunities. If an N. americanus is captured a photograph should be taken to verify the identification. If it is necessary to transport any live Nicrophorus, it is critical to avoid high temperatures. The beetles should not be left in the sun for even a short period of time and they can not be left in a hot car or they will die in minutes.

Trapping Methods - Blacklight

A trap can be constructed by hanging a white sheet from a rope two meters high and suspending a blacklight aimed at the sheet at the same height approximately one meter away. Reflection off the sheet will provide a bright ultraviolet attractant for the beetles. N. americanus are attracted to the light, but generally land on the ground nearby, not on the sheet as many other flying insects do. Nicrophorus individuals are located by a thorough ground search with a flashlight in a three meter radius around the blacklight trap every 5-10 minutes. Although N. americanus can be captured at a blacklight, this method of trapping is much less effective than pitfall trapping.

Trapping Methods - Whole Carrion

Carrion can be used to supplement pitfall trapping but should not be used in competition with pitfall traps, therefore carrion baits should not be placed in the same area simultaneously with a pitfall trap line. Carcasses can be put out at a site several kilometers away to survey a larger area more effectively.

Small vertebrate carcasses, ranging in size from 50-150 g can be placed along a transect at 15-25 m intervals to attract Nicrophorus spp. Carcasses should be placed on the ground with a one meter piece of dental floss or string attached to a limb so the carcass can be followed underground if it is buried. The other end of the dental floss should not be attached to anything, i.e. a branch, as the beetles will simply cut through it if it interferes with the burial process. To prevent interference from vertebrate scavengers, a raised 2 cm mesh screen can be used to cover all carcasses. As with the pitfall traps, this cover should be staked down so that it can not be lifted easily. The location of each carcass should be marked with surveyor's tape.

Carcasses can be checked any time within ten days of being put out. If a carcass has been buried, it should be dug up to identify which species has buried it. The dental floss can be followed to the location where the beetles have buried the carcass. The surrounding soil should be moved away as gently as possible, but it is likely that the parent(s) will be aware of the disturbance and will attempt to escape. The best strategy is to be quiet but quick. Once the carcass is located it can be pulled carefully out of the brood chamber. Search the brood chamber and the carcass for the parent(s). If a parent can not be located but larvae are present on the carcass, a specimen should be taken for identification as the majority of species can be identified from the larvae. The remaining larvae can be put back in the brood chamber with the carcass to finish development, but may need to be protected from scavengers by replacing the wire screen.

Larger carcasses (above 200 g) can be used but they must be checked throughout the night in order to verify which Nicrophorus species have visited. Nicrophorus individuals will feed on large carcasses which they can not bury, but they will generally depart before morning. I recommend using large carrion only when the investigator has most of the evening free to check the carcasses on an hourly basis.

SUMMARY RECOMMENDATIONS

1. Pitfall traps are the best trapping method to use to survey an area for the presence of N. americanus.

2. Pitfall trapping should be conducted from 3 to 8 weeks after the onset of seasonal activity in the spring. On Block

Island pitfall trapping is most successful between mid-June and mid-July. For central and southern states the best dates for trapping may be significantly earlier.

3. Bait to be used in pitfall traps should be fully ripened.

4. Pitfall traps must be cleared every morning to avoid mortality of Nicrophorus from exposure to heat.

5. Pitfall traps should be covered with a wide mesh screen lid to deter vertebrate scavengers.

6. All pitfall traps should be covered with a large, raised solid lid (plywood or a shingle) to deflect rain.

7. Trapping conditions are best when the overnight low temperature is above 15°C.

8. Fifteen or more pitfall traps should be set up in a line at 15-25 m intervals and separate trap lines should be more than 2 km apart.

9. Pitfalls should not be placed within three meters of ant colonies. If more than a few ants are found in a trap, it should be moved.

*** All captures of N. americanus should be reported to the nearest office of the U.S. Fish and Wildlife Service.

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The comments and suggestions received during the recovery planning process were reviewed and incorporated, to the extent appropriate, into this document. Agencies, organizations, and individuals who participated in review of the draft plan are listed below.

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