American Burying Beetle

Population and Habitat Viability Assessment

14 – 17 November 2005
St. Louis, Missouri

FINAL REPORT

Photos courtesy of US Fish and Wildlife Service.

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

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Thank You!
June 2006

American Burying Beetle

Population and Habitat Viability Assessment Workshop

St. Louis, Missouri

14-17 November 2005

American Burying Beetle

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Final Report

Section I
Executive Summary

Executive Summary

Introduction

A Population and Habitat Viability Assessment workshop was conducted for the American Burying Beetle in St. Louis, Missouri on 14-17 November 2005.

The American burying beetle (ABB) was once abundant in most eastern and central states as well as the southern borders of eastern Canadian provinces. It was found in Missouri as recently as 1980, in Jasper County (USFWS, 1991). At the time it was placed on the U.S. federal endangered species list in 1989, the only known populations occurred on Block Island in Rhode Island and in Latimer County, Oklahoma. However, since then, field surveys have discovered populations in five other states: Arkansas, Kansas, Nebraska, and South Dakota. (Backlund and Marone, 1997; Bedick et al. 1999). In 2005, the ABB was also apparently discovered in northeastern Texas, but further verification of this record is pending.

The decline of the American burying beetle has been underway for nearly a century. The once widespread population was fragmented and greatly diminished by the 1920's (Ratcliffe, 1996). The prevailing theory for this decline points to habitat loss and fragmentation leading to a corresponding decrease in suitable carrion. As more and more land was converted for agricultural use, the changed habitat favored scavenging mammal and bird species that compete with carrion beetles for resources. Passenger pigeons and prairie chickens, ideal carrion size for the beetle, disappeared. Turkey and waterfowl populations declined (Simpson, 1991). Small rodents adapted well to the new habitats and some species flourished. However, most small mammals are too small for the giant carrion beetle (ABB) which requires a 80-200 gram carcass to maximize its reproductive potential. The cutting of forests, tilling and pasturing of the prairies led to more edge habitat, ideal for predators and scavengers that directly compete with the beetles for carrion.

The federally endangered American burying beetle (*Nicrophorus americanus* Olivier) is the largest member of the family *Silphidae* in North America. Easily recognized by their shiny black bodies and red to orange markings on their pronotum, this species offers its young extended parental care, an unusual behavioral trait in beetles. After finding an appropriate-sized carcass, intense inter- and intra-species competition occurs (Kozol, 1990). Together, a victorious pair moves the carcass to a suitable site and buries it. Then they cooperatively prepare it by removing hair or feathers and coating it in preservative oral and anal secretions that retard bacterial and fungal growth. The female beetle lays her eggs near the preserved carcass. After the eggs hatch, the parents move the first instar (stage) larvae to the carcass, where the larvae solicit feeding by stroking the mandibles of the parents. Both parents remain with the carcass and larvae, feeding their offspring with regurgitated meat until the larvae are capable of feeding themselves. Eventually, large third instar larvae burrow a short distance from the now-diminished carcass and form a pupation cell. The new adults then emerge from pupation within 30-45 days (Prospero, 1999).

In May 2004, the Saint Louis Zoo opened its Wild Care Institute, comprised of 12 Conservation Centers around the world where threatened animals and their ecosystems are receiving a focused approach to help in their survival. The Invertebrate Department at the Saint Louis Zoo chose the American burying beetle as its animal of conservation focus and is dedicated to creating a sustainable future for this endangered beetle. Consistent with the goals of the American Burying Beetle Conservation Center, the St. Louis Zoo invited the Conservation Breeding Specialist Group (CBSG) to conduct a Population and Habitat Viability Assessment (PHVA) for the American Burying Beetle.

The PHVA was organized, hosted and generously funded by the St. Louis Zoo's Wild Care Institute. The Workshop involved a variety of stakeholders from eight states and the United Kingdom, including representatives from federal and state wildlife agencies, zoological institutions and the timber industry. The goals of the Workshop were to:

- encourage communication and collaboration with government and non-government conservation programs;
- develop a risk analysis and simulation population model for the American burying beetle;
- formulate practical, scientific management of the American burying beetle throughout its range; and
- suggest research priorities linked to conservation and recovery of the American burying beetle.

The Workshop Process

The PHVA Workshop began on 14 November 2005. Each of the 21 participants was asked to share with the group their personal goal for the workshop. These goals are listed in Section V of this report. Next, presentations were given to ensure that everyone was starting from the same place, familiar with the process and with available scientific information. CBSG introduced the PHVA process and the role of population modeling in the Workshop. Then several scientific presentations were given to bring everyone up to date. Speakers included: Michael Amaral, Chris Davidson, Hayley Dikeman, Jane Stevens, Paul Pearce-Kelly, Lou Perrotti, Chris Reynolds, Chris Raithel, and Wyatt Hoback.

The first Workshop task, a mind mapping exercise, was designed to identify issues and needs related to the long-term survival of the American burying beetle. The issues identified were then organized into topics for further working group discussions. The three working groups were: Captive Populations, Habitat, and Wild Populations. A process of working group sessions, followed by plenary reports and discussion, was used throughout the entire Workshop.

The participants worked together in plenary with Kathy Holzer, the population modeller, to estimate demographic rates and population-specific information used to develop a simulation model for the American burying beetle. Model results were subsequently reported back to workshop participants to evaluate the viability of burying beetle populations and to identify important areas in need of further research.

The working groups consolidated the issues identified on the mind map, where appropriate, and amplified them to ensure clarity and level of importance. Participants were then asked to write an 'issue statement' for each issue and to prioritize these statements. The next step was to brainstorm potential solutions to address high priority concerns. In addition, the groups were asked to identify those solutions with the potential to impact any of the population model input parameters. This enabled alternative management scenarios to be modeled and their impact on burying beetles evaluated. The penultimate step in the workshop process involved the development and prioritization of recommendations for implementation of preferred solutions.

Recommendation presentations were shared with the entire group and included lengthy, animated discussions. The groups then resumed work to respond to the concerns heard in plenary session and to begin developing action plans for implementation of their priority recommendations. Instructions were given for the development of concrete action steps using the SMART criteria. Each action was to be made 'SMART': Specific, Measurable, Attainable, Relevant and Timely, and include: 1) a timeline (when the action will begin and when it will be completed); 2) responsible party; and 3) resource needs. Action steps can be long- or short-term. They are small steps that help to implement stated recommendations. Reports from each working group, including detailed recommendations, can be found in Section II of this document.

Outcomes

Each working group identified a set of recommendations to address the key issues facing the American burying beetle. All recommendations were listed on flip charts and posted at the front of the meeting room. A prioritization exercise was then conducted. Each participant was given three sticky dots and asked to place a dot on the recommendation they feel most needs to be addressed in order to protect the future of the American burying beetle. The sticky dots were counted and the recommendations with the greatest number of dots were considered the top priority outcomes of the Workshop. This was a very powerful exercise and the voice of the Workshop was clearly heard in its prioritization of the need for life history research, surveys and improved communication among stakeholders. The recommendations are listed below in order of priority:

1. Develop research to understand ABB life history requirements (competition, predictive and descriptive habitat modeling, etc) within four core recovery regions designated in the recovery plan. 10 points

2. Conduct field surveys to identify significant new extant populations of ABBs within its historic range that will contribute to meeting recovery objectives (criteria). 7 points

3. Promote collaboration and communication by establishment of a list serve, web site and annual meeting. 7 points

4. Develop and implement health profiling methodology. 6 points

5. Define and identify suitable habitat through development of a working group to a) review existing inventory data, modeling and experimental design, b) build a standardized model

for data collection and analysis (soil, vegetation, carrion, weather disturbances), and c) implement the model in appropriate focus areas. 5 points

6. Promote conservation of core populations on private lands. 4 points

7. Develop and implement genetic profiling methodology. 3 points

8. Retain important core populations with state and federal ownership and explore opportunities to expand these areas and/or connect them with corridors. 3 points

9. Identify and establish "X" number of new reintroduced core populations in order to meet recovery objectives. 3 points

10. Identify, engage, and involve stakeholders in focus areas to protect the ABB. 2 points

11. Develop and implement husbandry management guidelines. 1 point

12. Recovery Plan to recommend and give direction to research and other support needs that can be provided by the *ex situ* community. 1 point

13. Utilize PHVA and revised Recovery Plan to leverage new research dollars. 0 points

14. Centralize existing data and encourage data sharing and collaboration. 0 points

Workshop participants used the best available data to develop a baseline population model for wild American burying beetle populations. Although there is a fair amount of uncertainty regarding many of the demographic rates, this model appeared relatively robust in projecting population persistence over the next 50 years and demonstrated the ability of beetle populations to grow rapidly when resources are abundant. Model results suggest that American burying beetle populations of 1,000 or more are viable long-term in the absence of severe catastrophic events or reduction in carrying capacity through reduced carcass availability, habitat loss or fragmentation. Smaller populations may be more vulnerable to the impacts of stochastic processes and experience reduced viability. Currently, all naturally occurring ABB populations are estimated to be at least 1,000 individuals. The model projects little risk of single population extinction and no risk of metapopulation extinction over the next 50 years given estimated current conditions. More accurate data, particularly on first-year mortality, would strengthen the ability of models to evaluate burying beetle population viability. Management strategies designed to improve survival to breeding age and reproductive success would be beneficial to the conservation of ABB populations.

American Burying Beetle

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Final Report

Section II
Working Group Reports

Wild Populations Working Group Report

Group Participants: *Michael Amaral, Chris Davidson, Jane Stevens, Wyatt Hoback, Mike Fritz, Ana Hiott*

PREAMBLE: Dissemination of the ABB PHVA report will be the responsibility of local U. S. Fish and Wildlife Service (USFWS) Ecological Services Field Offices within the historic range. This report, in addition to all known data on the ABB, also will be available on the web site maintained by the St. Louis Zoo.

Issue 1. Protect Core Populations: It is inefficient and counterproductive to "consult/protect" every ABB habitat occurrence, since the species is highly mobile and a feeding habitat generalist. Rather, we need to identify and prioritize protection needs for the best core populations. This will enable us to diminish regulatory protections for locations with outlying or peripheral ABB occurrences and focus on the habitat for populations most important to the species' long term conservation.

Recommendation: Retain important core populations within state and federal ownership. Explore opportunities to expand these areas and/or connect them with corridors.

Action 1: The USFWS, U. S. Forest Service (USFS), Department of Defense (DOD), and state-owned Wildlife Management Areas (WMAs) and Natural Areas will develop and implement land management plans for public lands that include specific standards to address management of ABB populations and habitat. For those public lands that already have land management plans, these plans should be revised to include specific ABB standards as soon as their specific guidelines require plan revision. Authorities within the Endangered Species Act (ESA) should be used, where necessary, to promote implementation of plans. For those properties without management plans that specifically address the ABB, utilize authorities within the ESA and state T/E (threatened/endangered) acts to promote development and implementation of plans. This is important because core populations are important to recovery and without management plans populations may not remain viable.

Action 2: USFWS will strategically utilize section 7 (ESA) to protect essential features of core population habitat. This should include further defining different thresholds for consultations in core versus peripheral population areas by 2007. For example, within the boundary of a core population habitat, all federally permitted activities that affect 3 or more acres will be reviewed pursuant to section 7. Outside core population habitat, only activities affecting 25 acres or more will be reviewed.

Recommendation: Promote conservation of core populations on private lands.

Action 1: USFWS local field offices will encourage state agencies and Non-governmental Organizations (NGOs) to obtain grant funding (*e.g.* Section 6 (ESA) land acquisition grants) for land acquisition and conservation on an "as needed basis." Identifying stakeholder groups at local levels to increase communication and "get the word out" about various land conservation incentive programs. This is important to expand core population habitat as these areas are identified by state and federal agencies and NGOs.

Action 2: Enroll private lands in conservation easements (NGOs), federal and state incentive programs (state and federal agencies), habitat conservation plans (USFWS), and safe harbor agreements (USFWS). Programmatic (statewide) safe harbor agreements streamline bureaucratic processes and encourage private landowner participation and conservation.

Action 3: NGOs (zoos, museums, TNC, etc.) will begin developing educational materials (*e.g.* videos, brochures, curriculum packages, etc) by 2006 and provide support to state and federal agencies for public outreach. St. Louis Zoo will take lead with other interested individuals in prioritizing materials that will give us the most "bang for our buck".

Issue 2: There may be undiscovered ABB populations that merit protection: These could contribute to the survival and recovery of the species. Until these populations are identified and protected, they remain at risk due to habitat loss, fragmentation or other causes.

<u>Recommendation</u>: Identify areas and conduct field surveys to identify new extant populations within the historic range.

Action 1: USFWS (local field offices) and state heritage programs will review historical collection records and survey effort for all states/sites with post-1970 ABB records by 2007. These include Trigg Co., KY; Jasper Co., MO; Hocking Co., OH; Washington Co., AR; and Ontario, Canada.

Action 2: USFWS (local field offices) and state heritage programs will review pre-1970 collection records and availability of suitable habitat within additional states in historical range, and conduct additional new field surveys by 2008.

Action 3: USFWS (Mike Amaral) will summarize all negative field survey data by spring 2006.

Action 4: Federal and state agencies, NGOs, zoos, and universities will conduct surveys in areas identified in Action 1 through 3 by 2008.

Actions 1 through 4 are needed to locate undiscovered populations that would significantly expand the known extant range.

Issue 3. Inadequate baseline/life history information: Adequate baseline/life history data is needed to ensure we know what biological and physical elements are critical to protect populations and manage habitat in order to sustain the species.

- Sub-issue: In order for the core populations to be viable over the long term, we need to know how much habitat is necessary and the minimum viable population size.

<u>Recommendation</u>: Develop research to understand life history requirements within multiple core geographic recovery regions in the Recovery Plan.

Action 1: Conduct research on biotic factors that affect ABB life history (universities or zoos; timeframe =ASAP). Wyatt Hoback (Univ. of Nebraska) will oversee broader implementation.

> *Action 1a*: Utilize new technologies as they become available to track daily movements of ABBs, to find overwintering habitats, and to identify natural reproductive areas in comparative portions of range (east, west, north, south).
>
> *Action 1b*: Investigate genetic variability within and between populations to inform minimum viable population estimates.

Action 2: Conduct research on abiotic factors that affect ABB life history (universities and zoos; timeframe ASAP). Wyatt Hoback will oversee broader implementation.

> *Action 2a*: Investigate effects of artificial lighting, pesticide use, and fire on ABB populations. These effects may be important to one or more core populations and should be investigated accordingly.
>
> *Action 2b*: Determine potential impacts and develop management plans to address the spread of exotic and invasive plant and animal species.

Action 3: Develop Best Management Practices based on Action 2 that private/public land managers can use (universities, state and federal agencies; timeframe ASAP).

Action 4: Preserve dead and moribund animals and identify insect health expert who can conduct baseline health screening (all; timeframe ASAP). See *ex situ* group.

<u>Recommendation</u>: Leverage new research dollars.

Action 1: Utilize PHVA and revised Recovery Plan to justify grants for research. Explore all potential sources for research funding (ongoing basis). This may include a page on the web site that directs researchers to potential funding sources (all researchers and St. Louis Zoo; timeframe ASAP).

<u>Recommendation</u>: Centralize existing data and encourage data sharing and collaboration.

Action 1: St. Louis Zoo will establish a list serve by Feb. 2006.

Action 2: St. Louis Zoo will develop (summer 2006) and operate (continuous) a web site dedicated to the ABB that contains public outreach materials, photographs, and published and unpublished data in a format (pdf) which is readily available to interested parties.

Action 3: All state and federal agencies, universities, and NGOs are encouraged to provide data to St. Louis Zoo to be incorporated into the web site (ongoing basis).

Issue 4. Need to establish new populations within historic range: In order to restore the species to representative areas within its historic range, and to have redundancy (multiple

populations to ensure resiliency), many new populations need to be established (or discovered).

<u>Recommendation:</u> Identify and establish “X” number of new core populations within historic range to meet Recovery Plan objectives.

Action 1: USFWS will develop reintroduction site criteria that can be used to assess and identify suitable habitat for reintroduction sites by 2006 (draft site criteria have been developed and are available on an as-needed basis now).

Action 2: USFWS, state wildlife agencies, universities, and zoos will identify wild populations for translocation source or establish captive breeding populations for reintroduction use.

Action 3: USFWS, state wildlife agencies, universities, and zoos will conduct translocation or reintroduction efforts. This action requires a commitment to follow-up population monitoring.

Habitat Working Group Report

Group Participants: *Peggy Horner, Michael Arduser, Chris Raithel, Hayley Dikeman, Chris Reynolds, Michael Fritz, Brock Blevins*

Overall issue: Define suitable habitat (specifically reproductive, wintering, feeding habitat) in order to identify and establish ABB "focus areas." These are areas of public or otherwise secure land with relatively high ABB concentrations that provide abundant suitable habitat.

Overall Issue Statement: We hypothesize that the distribution, establishment and disappearance of American burying beetle populations is correlated with, and limited by the distribution and variation of certain habitat characteristics. Our goal is to identify these habitat characteristics (both biotic and abiotic) and their variation at local and landscape scales, in order to define suitable and unsuitable American burying beetle habitat. From these data we will construct a "suitable habitat" model to strategically guide survey effort, reintroduction planning and management.

Issue 1: **Identify the abiotic and biotic factors that characterize suitable habitat.**
Three general components of suitable ABB habitat were identified: feeding, reproductive, and overwintering habitats. Detailed knowledge of suitable habitat components is needed to determine where ABBs "really are" in the landscape. We assume that ABB's reproductive and overwintering habitats are more limiting (restrictive) than feeding habitats. Habitat variables include carrion, soil, vegetation, disturbances, weather and landscape influences. Knowledge of where ABBs are occurring will allow us to focus attention and resources. Focusing our efforts will facilitate and maximize the recovery/conservation of the ABB, facilitate coordination between agencies/landowners/academia/states/etc., minimize duplication of efforts, and identify the landowners that need to be involved. This would also facilitate and assist the USFWS in compliance with the ESA.

Biotic Factors
1. Carrion
Assumptions: Availability of carrion of suitable size/weight for reproduction is a limiting factor for ABBs.

Information needed: Is carrion availability actually a limiting factor? How do we assess/measure carrion availability? How do we evaluate competition for carrion?

Known information/info sources: Existing data sources such as breeding bird surveys, quail counts, etc. on ABB areas/non-ABB areas gives us some idea of the carrion base.

Solution: Review existing data, such as breeding bird surveys, quail counts, small mammal surveys, literature on biomass matrix data, other literature, etc.
Develop field experiments to augment data gaps, for example:
1. Measure rates of carrion removal by predators/competitors at selected study sites which are similar in as many ways as possible (soils, land use, carrion base), and preferably close together (i.e., within the same landscape), *except* for absence/presence of ABBs. Assess areas with no

ABBs, and areas <u>with</u> ABBs for rates/frequencies of carrion removal/capture. No differences in carrion removal/capture measures between ABB absent sites and ABB present sites would suggest that competition for carrion is not, by itself, limiting. Higher rates of carrion removal/capture on the non-ABB sites would suggest otherwise.

Abiotic Factors

1. Soil

Assumptions: Reproductive and over wintering habitat is correlated with soil parameters

Information needed: Effects of frost line, temperature, moisture, compaction, types, disturbance, pH, and organic matter on ABBs.

Known information/Info sources: Every state/most counties have Soil Type Maps, many of the ABBs sites have disturbance data. Sources include Fort Chaffee, Camp Gruber, Weyerhaeuser, natural heritage inventory, MO natural areas, state wildlife management areas, federal wildlife refuges, TNC, GAP data, states, USFWS, National forest, and National Parks.

Solutions: Collect known information on soil parameters to determine any trends in correlations, develop an experimental design to collect the data 'gaps,' implement a study in different populations across the range of the species.

2. Vegetation

Assumptions: Non-native plant monocultures (Bermuda, fescue grasses) are limiting factors to ABBs using the area.

Information Needed: Importance of structure, species composition, diversity, and density.

Known information/Info sources: Some information is known from Fort Chaffee, Camp Gruber, Weyerhaeuser, natural heritage inventory, MO natural areas, state wildlife management areas, federal wildlife refuges, TNC, GAP data, states, USFWS, National forest, and National Parks; Nebraska also has some information.

Solution: Review existing vegetation data at ABB known locations or 'Focus Areas,' identify gaps in information, develop a protocol for collecting the information, and implement the new survey experimental design in selected locations across the range.

3. Weather

Assumptions: Weather affects the current distribution and numbers of ABBs.

Information Needed: Weather data where high concentrations of ABBs currently exist and where there is long-term ABB data.

Known information/Info sources: Precipitation, humidity; min, max, average temperatures, snowfall is currently accessible through web sites and military installations.

Solutions: Review and analyze climate data from known weather stations and determine correlations through modeling or other statistical analysis.

4. Disturbance
Assumptions: ABBs are affected by disturbances, whether single large event disturbances (fires, drought) or chronic, smaller scale events (grazing, etc).

Information Needed: Effects of fire (season, habitat type, intensity, frequency), grazing (species, frequency), and haying/mowing on ABB populations.

Known information/Info sources: Camp Gruber has data on their fire regime, troop movements, haying and mowing. It's likely that other areas have this information too.

Solutions: Review and analyze disturbance data at ABB known locations or 'Focus Areas,' identify gaps in information, develop a protocol for collecting the information, and implement the new survey experimental design in selected locations across the range.

5. Landscape
Assumptions: ABBs do less well in the vicinity of human development; rather, they need large, roadless, undeveloped landscapes to maintain vigorous populations.

Information needed: Are things such as roads, utility right of ways, and urbanization affecting ABBs?

Known/Information/Info sources: GIS data, Web data, aerial photography is available to look at historical and current landscapes.

Solutions: Identify large focus areas to conduct research, collect and review existing data, create a measure of human imprint/impact, and correlate to known ABB locations and known unoccupied areas.

6. Survey Methodology:
Assumptions: Baited pitfall traps lure ABBs into areas were they may or may not choose to be independent of the artificial bait provided. They may use a baited area for feeding but we assume they may or may not use this area for reproduction or overwintering.

Information needed: An alternative method of locating and following ABBs in their environment.

Known information/Info sources:

Solutions: Review literature involving ABB monitoring methods, and also for other Nicrophorus species and beetles in general.

OVERALL SOLUTION: Review data, identify data gaps, develop a model to analyze existing data and develop an experimental design to collect needed data, identify areas to conduct the experiment across the range of the ABB, and implement the study.

Issue 2. Coordinate ABB protection and management with land managers and stakeholders.

Assumption: Once Focus Areas are identified, associated landowners need to be involved. Relationships with landowners need to be developed and/or maintained, particularly with private landowners. Best Management Plans (BMPs), based on knowledge of suitable habitat, should be developed to improve/manage ABB habitat.

Information needed: Identification of focus areas and associated landowner identification.

Known information/Info sources: HCPs, Safe Harbors, Partners for Wildlife, Easements, Landowner Incentive Program, EPA 319 projects, NRCS programs, conservation banks, TNC focus areas, NGO's , military SCUBS, Airports/AFBs, community conservation, municipal involvement, zoo exhibits, county agents (County conservation Districts), Agency outreach efforts, tribes, FWS Refuge plans, Military Plans, and State Wildlife Plans.

Solutions: Work with existing agencies to carry the message to land managers (NRCS, County Conservation Districts). Develop a Public relations/public outreach plan (includes media), and identify outreach products we don't currently have. Identify compatible land uses and develop BMPs that are specific to regions. And Investigate community conservation strategies.

Issue 3. Understand how landscape influences suitable habitat.
Once suitable habitat is identified and focus areas are identified, we need to know what size the focus areas need to be to sustain a viable population, and what corridors are needed to allow for movement between metapopulation/populations. We decided it was important to look at the species at the landscape level, defined as the ABB's historic range. We further discussed the importance of habitat fragmentation, loss of habitat, and connectivity/corridors. (See wild population working group report).

Prioritized Recommendations:

Recommendation 1: Form a working group to review existing habitat data in occupied, historic but currently unoccupied, and never occupied ABB areas. Data reviewed should include published and unpublished inventory studies regarding carrion, soil, vegetation, weather, disturbance, and methodology utilized. It is important to know what data we already have and what we need to collect, as well as which methods have worked or have not worked, and the results. In cases where data are robust enough to permit correlational analyses, these should be undertaken to better inform the construction of a standard experimental design (see below).

Action 1. Gather and compile existing information.
A. Who?

One individual from each state. *Hayley will take the lead on this while getting commitments from individuals to participate in the working group as a whole.*

B. When?
Each state to have data assembled by June 1, 2006

C. How?
Literature search, data search/collection (survey data and related vegetation surveys), contact federal, state, NGO, etc., landowners for what data they have on vegetation, soil, disturbance, and weather.

Action 2. Identify information gaps, consistencies, trends, etc.

A. Who?
Working group

B. When?
October 15, 2006

C. How?
Conference Call

Action 3: Review existing data in occupied, historic but currently unoccupied, and never occupied ABB areas. Data reviewed should include inventory data regarding carrion, soil, vegetation, weather, disturbance, and modeling and experimental designs implemented. This group would include representatives from each state that currently has ABBs, US Fish and Wildlife Service, and State Wildlife Agencies. If existing data is robust enough to be useful in addressing the goal of identifying suitable habitat, perform correlational analyses.

Recommendation 2: Assemble a subcommittee from the habitat working group to develop a standard experimental design and model for collecting and analyzing habitat data employing a new sampling method. Additional representatives from each state with ABBs should also be included in the subcommittee. This subcommittee would work together and employ any needed outside experts to finalize an experimental design, protocols and methodology to collect habitat data. Data targets should include soil, vegetation, carrion, and disturbance parameters, as well as any others identified by the subcommittee. Data should be collected in areas of historical ABB areas, currently occupied, and unoccupied areas to determine what habitat parameters are important or affect ABBs, and to determine what habitats need to be protected and managed. The goals are to determine what habitat parameters are important or effect ABBs, and to determine what habitats need to be protected and managed.

Action 1. Evaluate existing and new experimental designs and models, and explore and develop alternative methods other than pitfall trap data to clarify habitat selection by ABBs.

A. Who?
Working group with statistician expert to flush out details and expectations of analyzing existing data and developing a new experimental design for determining ABB preferred reproductive habitat. The expert (graduate student, consultant, or researcher) will finalize the data analysis of the existing data and developing new experimental design methods (about $10,000 will be needed to hire the expert to do this; see Action 2 below). Identify which focus area to use as implementation sites for the new experimental designs.

B. When?
   January, 2007
C. How?
   Group meeting. Location will be decided during the February 15 conference call. Approximately $2,000 will be needed for host to set up the meeting site.
D. Measure: Formal recommendation from group

Action 2. Statistician/modeler.

A. Who?
   Hayley will find an expert to fill this role by contacting the USFWS, USGS, FS, etc.
B. How?
   Approximately $10,000 will be needed to fund this expert to analyze or develop correlation using existing data in a model, and develop a new experimental design and model for the data collected from the new experimental design.

Action 3. Identify an individual knowledgeable with GIS to manage existing and collected data.

A. Who?
   Hayley will take the lead for getting individuals to participate in the working group.
B. How?
   Identify those most familiar with and capable of providing greatest input.
C. When?
   Have committed individuals participating in working group by end of 2005.

Recommendation 3: Implement the standardized experimental design and sampling protocol in several focus areas (i.e., an area with high ABB numbers and a secure core, relative to ownership) within selected populations (populations identified elsewhere in this PHVA document by the "Wild populations" group).

Action 1. Implement experiments based on newly developed experimental design to collect ABB habitat selection data. Approximately $20,000 to $30,000 will be needed per focus area.

A. Who?
   Working group or consultants/grad students identified by the working group.
B. When?
   Implementation of the experiment needs to done in the 2007 field season. Hiring staff to implement this work needs to be done by the fall of 2006 at the latest.
C. How?
   Hiring staff to conduct work.

Action 2. In areas with current transects, look at presence/absence data at ABB locations at the landscape scale in relation to habitat parameters. All trap efforts (positive or negative) need to be reported.

Action 3. USFWS to standardize and require capture data from permits.

<u>Recommendation 4</u>: Identify, engage, and involve stakeholders in selected focus areas to protect ABB populations.

Ex situ Populations Working Group Report

Group participants: *Lou Perotti, Bob Merz, Steve Shurter, Daniel Koch, Randy Morgan, Sabrina Kirkpatrick, Paul Pearce-Kelly*

Note: Topics listed in order of agreed importance.

Issue 1: *Ex situ* support of the USFWS ABB Recovery Plan.
How this might best be realised will be determined by the Recovery Plan's *ex situ* mandate. Our understanding is that the current Recovery Plan is our working mandate until updated and revised. Potential mandate areas could include:

- Augmenting existing *in situ* populations or helping establish new populations.
  This has been the historic and is the current main focus.

- Providing reservoirs of genetic diversity.
  This has implications in terms of founder base and management regimes.

  Both of these roles raise the issue of the necessary number of participating institutions.

- Addressing specific biological issues (basic biology, life cycle and management issues, both captive and wild).
  Lab conditions provide opportunities to enhance knowledge of particular areas impractical to obtain in the field (e.g. investigating the significance of phoretic mites and other potential symbionts).

- Public education.
  Zoo-based mechanisms are already in place to promote and create support for the various elements of the program.

- Generation of funds.
  Zoo and universities are uniquely positioned to investigate and secure grants and other funding opportunities.

<u>Recommendation</u>: The ABB Recovery Plan (RP) should recognize and give direction to research and other support needs that can be provided by the *ex situ* program.

Action: ABB RP to provide appropriate direction (via RP Updates or Revision) relative to health, genetics, reintroduction, captive management, biological research issues, education, funding, etc. as identified by USFWS with input from stakeholders, with working draft document available for review by next annual meeting (Fall 2006).

Issue 2: There is a pressing need to clarify the health profile of the ABB. This is a key program issue encompassing both wild and captive elements. Without knowledge of wild population health profiles it is impossible to interpret what constitutes an infectious agent in either wild or captive populations (ref: World Conservation Union guidelines 1987, 1995 and 2001).

- The current lack of relevant pathology investigations or pooling of pathology data (including potential model species data) is hindering progress.

- The current lack of pathology/necropsy protocols (for both *in* and *ex situ* populations) prevents the availability of suitable material for health investigations.

Recommendation 1: Produce pathology/necropsy protocols for both *in situ* and *ex situ* populations (example: Fregate Beetle Management Guidelines 2004).

Action: Randy Morgan (Cincinnati Zoo), Lou Perrotti (Roger Williams Park Zoo) and St Louis Zoo will produce a draft protocol by May 2006 (with input from invertebrate pathologist Romain Pizzi) and circulate to Workshop participants for review and comment.

- There is uncertainty as to where this health investigation work should and can be conducted.

Recommendation 2: A collaborative partnership approach should be investigated.

Action: Randy Morgan (Cincinnati Zoo), Lou Perrotti (Roger Williams Park Zoo) and St. Louis Zoo will investigate and approach potential collaborative partners. The use of congener species may provide appropriate modeling.

- There is a current lack of standardized measurements. We see adult body size as being a particularly useful index, but others might also include larval development and aspects of the life cycle.

Recommendation 3: Produce standardized measurement protocols (ref: Fregate beetle MG).

Action: Nebraska, Fort Chaffee and Roger Williams Park Zoo to produce standardized measurement guidelines. These measurement guidelines are to be incorporated into the management guidelines, and will be completed by May 2006.

Issue 3: Captive husbandry and related issues.

- Currently there is variation in keeping systems and breeding results being experienced in different institutions. There is a need to review and summarize historic and current keeping methods and associated results. This should form the basis for the production of comprehensive management guidelines.

Recommendation 1: Review and summarise historic and current keeping methods and associated results.

Action: Lou Perotti (Roger Williams Park Zoo), Randy Morgan (Cincinnati Zoo) and Bob Merz (St Louis Zoo) will review and summarize historic and current husbandry management methods and associated results. Captive populations were (formally kept at Cincinnati Zoo and Boston

University, and are currently maintained at Roger Williams Park Zoo, St Louis Zoo, Ohio State University and Purdue Calumete University. Another colony is planned to be held at The Wilds in 2006.). First draft to be done by May 2006 (Bob Merz to lead).

Recommendation 2: Produce comprehensive management guidelines.

Action: Lou Perrotti (Roger Williams Park Zoo), St. Louis Zoo and Cincinnati Zoo to produce comprehensive husbandry management guidelines. First draft to be produced by 2006 ABB RP annual meeting.

Issue 4: Reintroduction. Reintroduction has been considered an important mandate of the *ex situ* program since its conception. Currently there is no standardized reintroduction protocol (including follow-up assessments).

- The *ex situ* program needs direction from the ABB RP as to specific reintroduction requirements, including population representation and numbers.

- Who conducts reintroductions and determines the parameters of successful reintroductions?

Recommendation: ABB RP needs to clarify specific reintroduction requirements, including population representation and numbers.

Action: ABB RP needs to clarify specific reintroduction requirements, including population representation and numbers. First draft to be produced by 2006 annual meeting.

Issue 5: Genetics. The current uncertainty about the degree of genetic variation in *in situ* populations (natural and introduced) needs to be addressed. This will enable best program management of both *ex situ* and *in situ* populations.

The current uncertainly about the presence/significance of inbreeding depression in this species undermines confidence that best program management is being followed.

- The genetic diversity of the *ex situ* population(s) needs to be representative of the target extant population(s) as determined by the ABB RP management mandate.

Recommendation 1: Investigate and determine if there are genetically distinct wild populations that need to be captured in the *ex situ* program.

Action: ABB RP to clarify and direct in accordance to revision of RP and 2006 annual review meeting.

Recommendation 2: Produce standardized dead specimen preservation guidelines for providing suitable material for genetic investigations. These could either be separate or incorporated into the standardized pathology/necropsy protocol.

Action: Randy Morgan (Cincinnati Zoo), Lou Perrotti (Roger Williams Park Zoo) and St Louis will produce a draft protocol for discussion by the group by May 2006.

Recommendation 3: Identify institution(s) willing to undertake genetic analysis work. This is likely to require the production of an outline proposal.

Action: Randy Morgan (Cincinnati Zoo), Lou Perrotti Roger (Williams Park Zoo) and St Louis to investigate potential lab partners and produce draft outline proposal for circulation to the group by May 2006.

Issue 6: Research role. Is there a research role for *ex situ* populations beyond the areas raised above and, if so, what are the priority areas?

Recommendation 1: The historic and current keeping methods and associated results review can identify immediate research areas pertaining to the *ex situ* program.

Action: St Louis Zoo (Bob Merz to coordinate), Lou Perrotti (Roger Williams Park Zoo), Cincinnati Zoo (Randy Morgan) to identify potential research needs arising from the historic and current husbandry process. First draft to be done by June 2006.

Recommendation 2: An annual review/meeting can identify the wider spectrum priority research areas.

Action: ABB RP needs to recognize and direct research needs in accordance with the updated RP. First draft to be produced by 2006 annual meeting.

American Burying Beetle

Population and Habitat Viability Assessment Workshop

St. Louis, Missouri

14-17 November 2005

Final Report

Section III
Population Modeling Report

Population Modeling Report

Computer modeling is a valuable and versatile tool for assessing risk of decline and extinction of wildlife populations. Complex and interacting factors that influence population persistence and health can be explored, including natural and anthropogenic causes. Models can also be used to evaluate the effects of alternative management strategies to identify the most effective conservation actions for a population or species and to identify research needs. Such an evaluation of population persistence under current and varying conditions is commonly referred to as a population viability analysis (PVA).

The simulation software program *Vortex* (v9.57) was used to examine the viability of American burying beetle populations in the United States. *Vortex* is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild populations. *Vortex* models population dynamics as discrete sequential events that occur according to defined probabilities. The program begins by creating individuals to form the starting population and stepping through life cycle events (e.g., births, deaths, dispersal, catastrophic events), typically on an annual basis. Events such as breeding success, litter size, sex at birth, and survival are determined based upon designated probabilities. Consequently, each run (iteration) of the model gives a different result. By running the model hundreds of times, it is possible to examine the probable outcome and range of possibilities. For a more detailed explanation of *Vortex* and its use in population viability analysis, see Lacy (1993, 2000) and Miller and Lacy (2003).

This population model was designed to assess the viability of the American burying beetle (ABB) population (*Nicrophorus americanus*) in the northeast and central United States. Formerly distributed throughout temperate eastern and central North America, American burying beetles now persist only as remnant populations in the Midwest and a small population on Block Island off the coast of Rhode Island. In addition, a small reintroduced population occurs on Nantucket Island, Massachusetts. Extensive information from field studies of these populations, as well as information gleaned from captive population records, was used by workshop participants to develop a best estimate baseline model for this species.

Vortex Baseline Model Parameters

The final values used in the baseline model are described below. Scenarios were run for 500 independent iterations. The population was modeled for 50 years (representing 50 generations) so that long-term population trends could be observed. This allows results to be viewed in shorter time periods as well, so that short-term and long-term management actions and impacts could be considered.

Demographic and Genetic Parameters

Inbreeding depression: *Yes*

Inbreeding is thought to have major effects on reproduction and survival, especially in small populations, and so was included in the model (as reduced survival of inbred offspring through their first year). No estimates were available on inbreeding impacts in ABB; therefore, data on *Drosophila melanogaster* were used to estimate lethal equivalents through 50 days of age for ABBs (approximate age of eclosure) (Swindell and Bouzat, 2006). The impact of inbreeding was modeled as 5.2 lethal equivalents, with 100% of the effect of inbreeding due to recessive lethal alleles (50% for populations of <1000).

Concordance between environmental variation in reproduction and survival: *No*
Environmental variation (EV) is the annual variation in reproduction and survival due to random variation in environmental conditions. The workshop participants chose not to include this correlation between environmental conditions that affect survival and reproduction (i.e., good years from reproduction are not necessarily good years for survival). Carcass availability in spring and summer affect reproduction, while survival is largely influenced by overwintering conditions.

Mating system: *Short-term polygyny*
ABBs are generally reported to be monogamous, with one pair typically producing and caring for one brood. In some cases, however, males have been observed to abandon the brood during this process, leaving the female to feed and protect the larvae. Workshop participants believed that such males might breed with unpaired females, and that it is most appropriate to model the mating system as polygynous.

Age of reproduction: *1 year*
The ABB has a simple and short life cycle. Eggs are laid and hatch during the summer, and the resulting larvae pupate into adults within a couple of months. These adults overwinter to breed the next summer at age 1 year before dying. This means that all ABB reproduce at 1 year of age.

Brood size: *15*
Kozol (1990a,b) report typical brood size as 12-18, with 31 being the maximum observed in the field. Mean brood size at Cincinnati Zoo was 14.1 (Creamer, 1993), and wild populations averaged 15.5 (Lomolino and Creighton, 1996) in Oklahoma and 14.7 (SD = 5.5) on Block Island (Raithel, pers.comm.). For the *Vortex* model, participants chose a maximum litter size of 30, with a mean brood size of 15 and SD of 5. Sex ratio at birth was assumed to be 50:50 (Kozol *et al*., 1988; Creighton and Schnell, 1998).

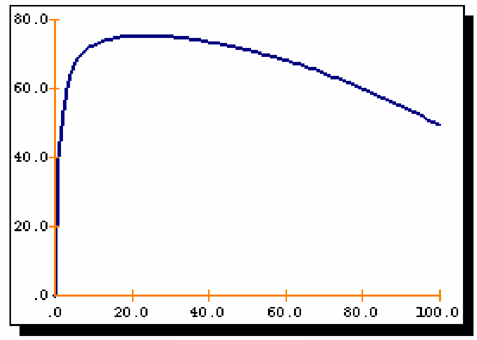
Percent of females breeding: *50-80% (see below)*
Breeding success rates (percent of females producing a brood) observed in wild ABB populations vary from 46% to 100% in a given year (see Table 1). Biber (1998) estimated 66% breeding success by combining data across wild and captive populations (141 out of 213 pairs monitored).

Table 1. Breeding success rates for wild ABB populations reported in the literature.

Population	Female (pairs) breeding	Years	Reference
Block Island	63, 82%	--	Kozol 1989; Kozol 1990a
Block Island	50% (non-provisioned pairs)	--	Raithel, pers. comm.
Penikese Island	60, 78, 86, 97%	1990-93	Amaral *et al*. 1997
Nantucket Island	100, 46, 71%	1994-96	Prospero
Oklahoma (grassland)	56-66%	1994	Lomolino and Creighton 1996
Oklahoma (forested)	95%	1994	Lomolino and Creighton 1996

Density-dependent reproduction: *Yes*

Reproduction is related to resource (carcass) availability and therefore can be affected by intra- and interspecific competition for limited resources. Reproduction therefore was modeled as being density-dependent. The workshop participants estimated that on average 80% of females breed under low density conditions (high carcass availability) and 50% when population size reaches carrying capacity (increased competition for limited carcasses). Density dependence was modeled as shown by the curve on the right (Allee parameter A = 1 and a steepness parameter B = 2). The graph indicates the percent of females breeding (y-axis) as a function of density. Environment variation was estimated at 5%. All adult males were considered to be potential breeders in this polygynous mating system.



Mortality: *75% (Yr 1), 100% (Yr 2)*
ABBs are univoltine, having one generation per year. First-year mortality incorporates a variety of life stages, from hatching through eclosure and overwintering to the next spring. Second-year mortality is 100%, as breeding adults die before their second winter. Mortality rates do not differ between the sexes. The participants used the following information to estimate first-year mortality. Environmental variation (year-to-year fluctuations) was estimated at 5%.

Estimated survival from larva to teneral adult:
78% (Roger Williams Zoo); 80% (Nantucket); PHVA participants estimated at 80%
Estimated survival from teneral adult to breeding adult (overwinter survival):
44% reported by Lomolino *et al*. (1995); overwinter survival on Block Island averaged over 4 years was 31%; PHVA participants estimated at 31%
80% x 31% = 25% survival from larva to breeding adult = 75% first-year mortality

Population Parameters
Population size:
Estimates of population size for American burying beetles vary both in magnitude and reliability. Contiguous populations are thought to vary from several hundred to over 20,000 beetles. Stochastic processes are much more likely to affect the viability of small populations, while deterministic processes, such as habitat loss, act upon populations of all sizes. The current estimated number of ABBs is too large to model as a metapopulation using *Vortex*; instead, individual populations were modeled separately, incorporating catastrophic threats specific to each population. Estimates of population size and carrying capacity were provided by workshop participants (see later section on *Population-Specific Models*).

The *Vortex* ABB model was also used to investigate the general impact of population size on population viability using the baseline demographic input values. For this analysis, populations varying in size from 100 to 10,000 beetles were modeled. These results may be useful when evaluating long-term viability for specific ABB populations and estimating what might be considered a minimum viable population given the best guess demographic values.

Carrying capacity:
For baseline sensitivity testing scenarios, carrying capacity (K) used for determining density-dependent reproduction was set at 20% above the initial population size (N) so that *r* would on average be positive the first year of the simulation. *Vortex* normally imposes the value entered as carrying capacity by truncating the population (killing animals) if the population size exceeds K. To minimize such a mortality-imposed carrying capacity, the level at which truncation occurred was set higher, at 50% above N_{init}, so that population would be regulated primarily through density-dependent reproduction. The baseline model assumes carrying capacity to be constant. Some individual population models included a projected decline in K.

Catastrophes:
Potential catastrophic events vary in type, probability of occurrence, and impacts among the geographically diverse ABB populations. Four catastrophes – severe drought, tornados, ice storms and hurricanes – were included in the population-specific scenarios. No catastrophes were included in the baseline or sensitivity analyses.

Baseline Model Results

Deterministic Results

The baseline model describes a population that shows strong positive deterministic growth when resources are abundant (r = 0.405), enabling the population to increase by 50% in one year ($\lambda = R_o = 1.50$). This growth rate is similar to the average lifetime reproductive success of 1.35 resulting from Biber's ABB model (1998), which did not include density-dependent effects and used 66% as the breeding success rate. Therefore, at low densities with plentiful resources, populations grow quickly. As high densities are reached, however, carcass availability becomes limited and population growth ceases to be positive. At N/K ≈ 93%, r = 0.000 with about 53% of females breeding. Higher densities lead to lower breeding rates for females, resulting in population decline. This combination of high growth potential, one-year generation length, and density-dependent reproduction leads to model populations that fluctuate in size around a mean at some point below carrying capacity (Figure 1).

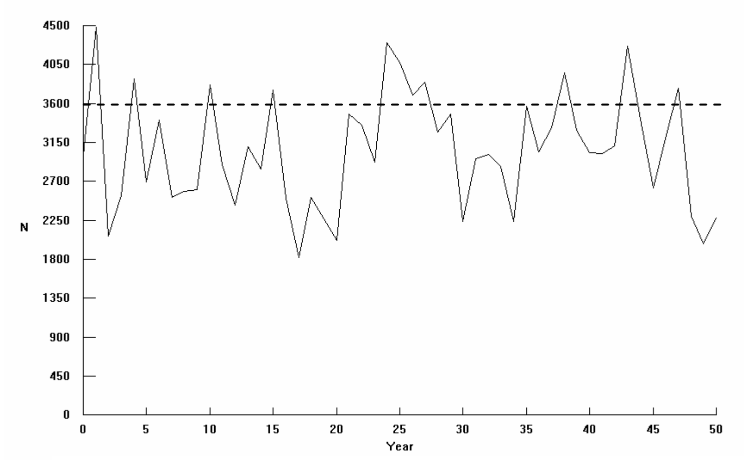


Figure 1. Single iteration of ABB model, with N_{init} = 3,000 and K_{DD} = 3,600 (dashed line).

These deterministic growth rates are those expected based on mean fecundity and mortality rates in the absence of inbreeding and stochastic processes (e.g., skewed sex ratio, environmental variation). In the absence of these forces, populations would be expected to grow to and stabilize at about 93% of the estimated carrying capacity (when r = 0). Stochastic processes produce additional impacts on populations, with small populations being more susceptible. Simulations using the baseline model input values resulted in populations that fluctuated around 83% of K for populations of 1,000 or more.

Sensitivity Testing of Demographic Parameters

To investigate areas of uncertainty in several of the demographic parameter values, sensitivity testing was conducted to explore the sensitivity of the model results to these parameters around plausible ranges as listed below. Baseline values are in boldface. All scenarios were run for 500 iterations with an initial population size of 3,000 and K_{DD} = 3,600.

Inbreeding (# of LE):	*0, 3.2, **5.2**, 7.2*
% females breeding (low density):	*75, **80**, 85, 90*
% females breeding (at K):	*45, **50**, 55, 60*
EV (% females breeding):	*0, **5**, 10*
Mean brood size:	13, 14, **15**, 16, 17
First-year mortality:	*65, 70, **75**, 80, 85*
EV (first-year mortality):	*3, **5**, 7*

Varying demographic rates independently across the range of values tested had little effect on population viability (Table 2). In almost all cases, the probability of extinction within 50 years was zero, and retention of gene diversity was high. The exception to this trend was first-year mortality (see discussion below). Although there was little effect on population persistence and genetic variation, population size was impacted by several of these demographic rates (Figure 2).

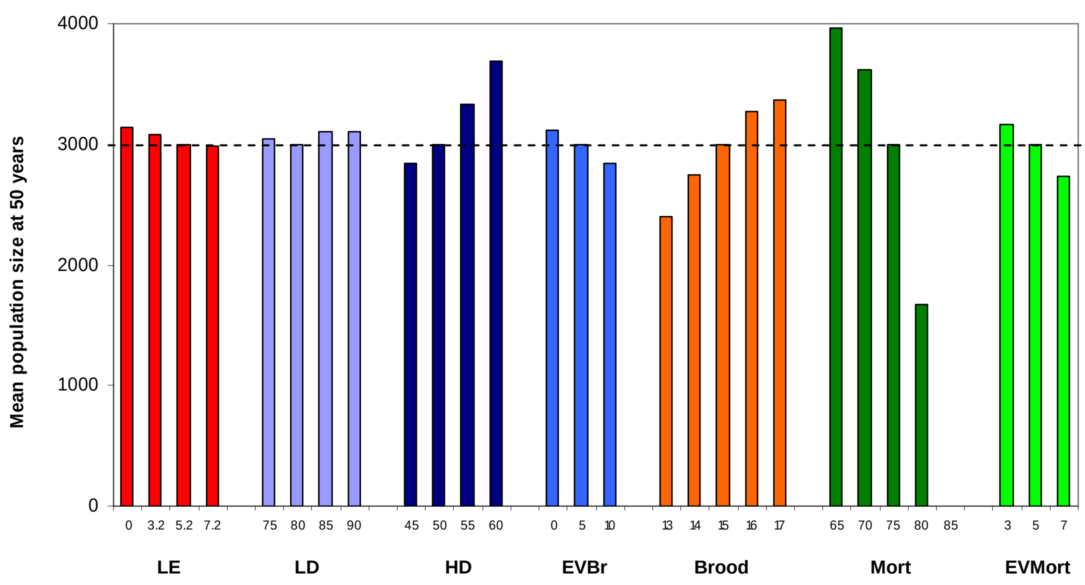


Figure 2. Mean population size after 50 years for scenarios that varied inbreeding lethal equivalents (LE), percent females breeding at low (LD) and high (HD) density and EV (EVBr), mean brood size (Brood), and first-year mortality (Mort) and EV (EVMort). Dashed line indicates mean N using all baseline input values.

Under most conditions, populations maintained an average stochastic growth rate close to zero due to the effects of density-dependent reproduction; in some cases, however, populations experienced either population decline (low brood size or high mortality) or population growth above K not restricted by density-dependent effects (high breeding success or low mortality).

Inbreeding: Increasing, reducing or even removing inbreeding effects had little to no impact on growth rate and probability of extinction at the relatively large (≈3,000) population size modeled, even over 50 generations, as the population was sufficiently large to retain over 98% of the original gene diversity.

Breeding success: Varying breeding success under low density conditions (75% to 90%) had little impact on the population. Breeding success in high density, competitive situations (45% to 60%) demonstrated a larger effect on population size and growth, although not on population persistence over 50 years. These results support the idea that population growth and size are impacted by factors that affect carcass availability, such as changes in habitat and species composition.

Table 2. Effect of varying demographic input values on population viability at 50 years (Stoch.r = stochastic r; PE = probability of extinction; N = mean population size; SD(N) = standard deviation in population size; GD = proportion of gene diversity remaining).

Parameter	Input value	Stoch. r	PE	N	SD(N)	N/K	GD
Inbreeding (LE)	0	0.004	0	3136	776	0.87	0.980
	3.2	0.003	0	3077	727	0.86	0.980
	5.2	**0.002**	**0**	**2994**	**710**	**0.83**	**0.980**
	7.2	0.002	0	2991	695	0.83	0.980
% females breeding (at low density)	75	0.002	0	3040	740	0.84	0.979
	80	**0.002**	**0**	**2994**	**710**	**0.83**	**0.980**
	85	0.003	0	3110	734	0.86	0.980
	90	0.004	0	3103	752	0.86	0.980
% females breeding (at high density)	45	-0.001	0	2837	709	0.79	0.978
	50	**0.002**	**0**	**2994**	**710**	**0.83**	**0.980**
	55	0.010	0	3327	761	0.92	0.982
	60	0.033	0	3693	725	1.03	0.984
EV (% breeding)	0	0.002	0	3112	681	0.87	0.980
	5	**0.002**	**0**	**2994**	**710**	**0.83**	**0.980**
	10	0.004	0.002	2845	859	0.79	0.978
Mean brood size	13	-0.005	0	2402	661	0.67	0.977
	14	-0.002	0	2741	715	0.76	0.979
	15	**0.002**	**0**	**2994**	**710**	**0.83**	**0.980**
	16	0.007	0	3268	754	0.91	0.980
	17	0.014	0	3370	756	0.94	0.980
% first-year mortality	65	0.051	0	3962	587	1.10	0.980
	70	0.019	0	3619	641	1.01	0.981
	75	**0.002**	**0**	**2994**	**710**	**0.83**	**0.980**
	80	-0.015	0.004	1668	812	0.46	0.964
	85	-0.284	0.996	--	--	--	--
EV (% mortality)	3	0.001	0	3165	488	0.88	0.981
	5	**0.002**	**0**	**2994**	**710**	**0.83**	**0.980**
	7	0.003	0.010	2736	977	0.76	0.976

Brood size: Brood weight has been observed to correlate positively with carcass weight (Kozol *et al*., 1988) and can be affected by the availability of carcasses of optimal size. Mean brood size can affect growth rate and resulting population size; however, probability of population extinction remains zero over the brood size range tested and gene diversity remains high.

First-year mortality: The ABB *Vortex* model is much more sensitive to mortality rates and EV than to reproductive and inbreeding parameters across the range of values tested. Mean first-year mortality rates higher than that used in the baseline model (75%) lead to population decline. Mean mortality of 85% leads to virtual certain extinction within 50 years (median = 22 years), since at EV=5 there is a small probability of experiencing 100% mortality in a given year. Conversely, lower mortality rates result in large, more robust populations.

Overwintering may be a significant cause of mortality (Bedick *et al*., 1999) and controls the population size and number of breeders the following spring. The model results suggest that first-year mortality, and perhaps especially overwinter mortality, can significantly affect ABB population viability, suggesting that: 1) more accurate data are needed to better evaluate average mortality rates and yearly variation in those rates to better predict ABB population viability; and 2) management strategies designed to improve first-year survival, including winter survival, will be beneficial to the conservation of ABB populations.

Effect of Population Size and Carrying Capacity

Most ABB populations in the wild are sufficiently large to be relatively unaffected by inbreeding depression and many other stochastic processes that can impact small populations. However, there are a few smaller populations, such as the one on Block Island, which may be vulnerable to these processes. In addition, as recovery efforts continue across the former range of this species, future reintroduced populations may be more restricted in size. Future changes in habitat and species composition may result in smaller, fragmented ABB populations in the future. Finally, extreme environmental events such as catastrophes may reduce even large populations to levels at which stochastic processes can have significant effects. It is therefore useful to investigate the effect of population size and carrying capacity on the viability of ABB populations using the baseline model with the best estimates of demographic parameters for this species.

The baseline model was used to explore the viability of populations ranging from 100 to 10,000. All populations were started below carrying capacity (N = 83% of K_{DD}), the average point around which viable populations fluctuate given the baseline demographic values. The resulting population trends shown in Figure 3 represent averages across 500 iterations for each population size; individual iterations show yearly fluctuations around these averages as shown in Figure 1.

Using baseline values, small populations ($\leq$ 250 beetles) experience significant population decline and loss in genetic variation. Extinction within 50 years is essentially certain when populations are around 100 beetles, while populations of about 250 have an 11% chance of extinction. Populations of about 500 persist but are reduced in size and gene diversity. Starting populations of 1,000 or more are able to maintain initial population size and high levels of genetic variation, and have no risk of extinction (Figures 3; Table 3).

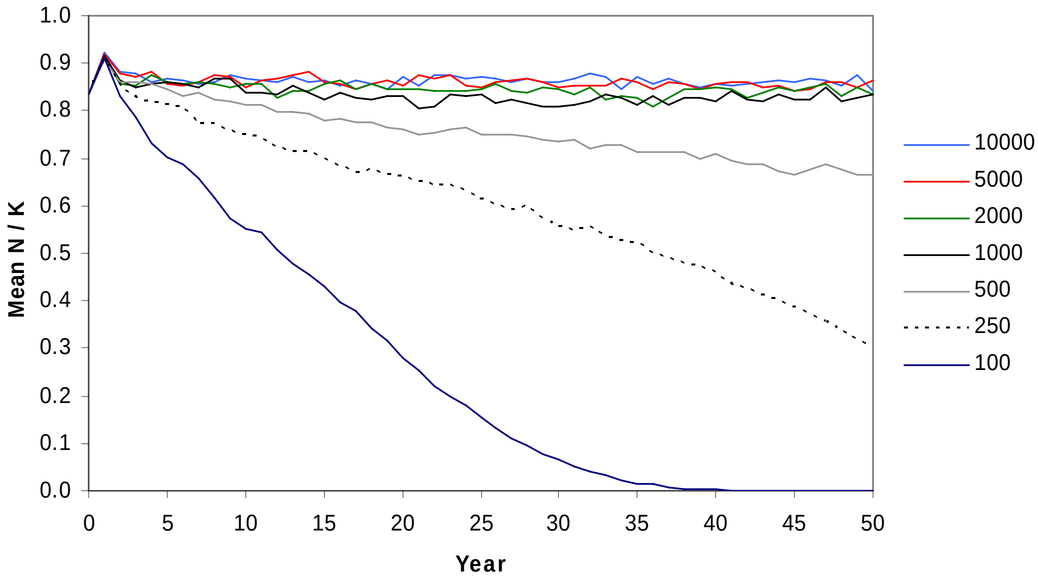


Figure 3. Ratio of mean population size (N) over carrying capacity (K) over 50 years for initial populations of 100 to 10,000 individuals at 83% K_{DD}.

Table 3. Effects of initial population size and carrying capacity on population viability at 50 years (K_{DD} = carrying capacity used for density-dependent reproduction; Stoch.r = stochastic r; PE = probability of extinction; N = mean population size; SD(N) = standard deviation in population size; GD = proportion of gene diversity remaining; TE = mean time to extinction, in years).

Initial N	K_{DD}	Stoch. r	PE	N	SD(N)	N/K	GD	TE
100	120	-0.113	1.000	--	--	--	--	27
250	300	-0.028	0.112	92	65	0.31	0.705	44
500	600	-0.004	0	399	121	0.67	0.876	--
1,000	1,200	0.002	0	1002	256	0.83	0.939	--
2,000	2,400	0.002	0	2007	471	0.84	0.970	--
5,000	6,000	0.003	0	5177	1220	0.86	0.988	--
10,000	12,000	0.003	0	10123	2426	0.84	0.994	--

These results suggest that given the demographic rates used in the baseline model, habitats that are able to maintain ABB populations of 1,000 beetles or more are viable long-term in the absence of severe catastrophic events or reduction in carrying capacity through reduced carcass availability, habitat loss or fragmentation. Smaller populations may be more vulnerable to the impacts of stochastic processes and experience reduced viability. All naturally occurring ABB populations are estimated to be at least 1,000 individuals.

Population-Specific Models

Current ABB populations vary substantially in estimated size, carrying capacity, geographic location, catastrophic threats, and estimated future habitat loss (Figure 4). Population-specific models were developed to better assess the viability of these populations under these conditions. The workshop participants estimated spring population size, habitat carrying capacity for ABB, major potential catastrophic impacts, and projected habitat loss for each of seven ABB populations (Table 4). The recently reintroduced population in Ohio was not modeled due to insufficient information. A more detailed description of these population models and model results are presented below.

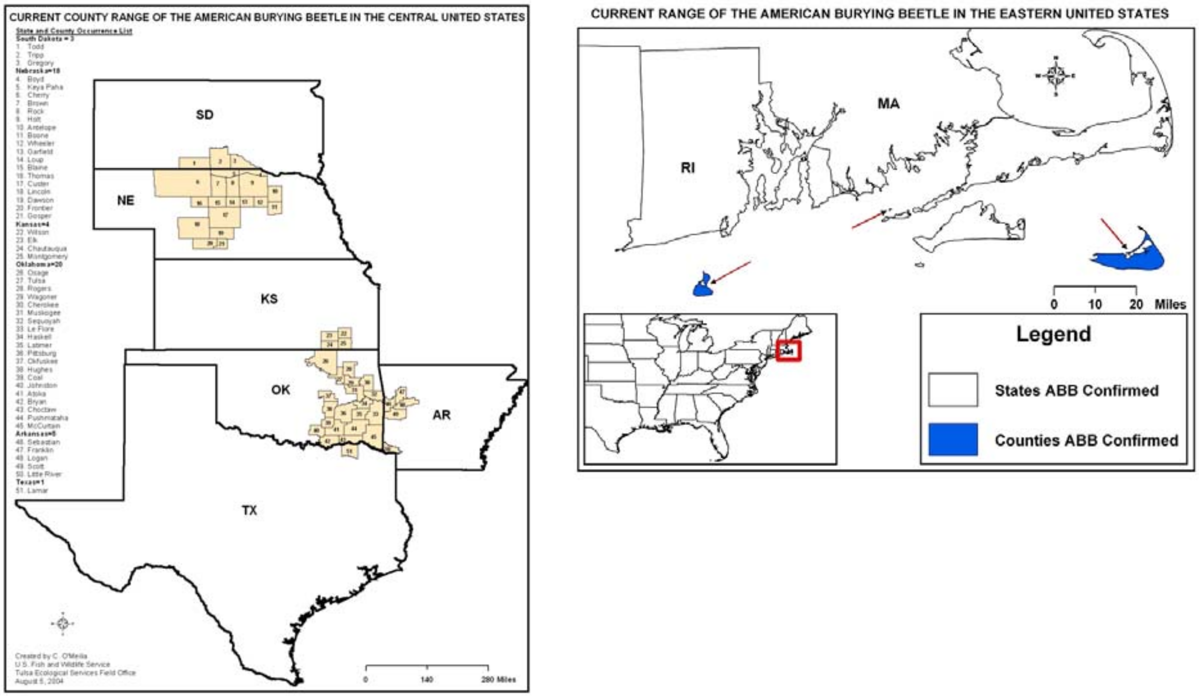


Figure 4. Current ABB distribution maps (from USFWS at www.fws.gov/ifw2es/ Oklahoma/beetle1.htm).

Table 4. Primary ABB populations and estimated values for current population size (N), carrying capacity (K), type and impact of catastrophes, and projected loss in K due to habitat loss. Catastrophic impact is measured by a multiplicative severity factor for reproduction (R) and survival (S).

				Catastrophes			
Population	**Geographic range**	**Est. N***	**Est. K**	**Type**	**Freq.**	**Impact**	**Decline in K**
SD - north NE	North of Interstate 80	10,000+	20,000	Severe drought	1%	R=0.2 S=0.2	--
south NE	Lincoln – Darwin, NE	1,500 to 3,000	3,000 to 6,000	Severe drought	1%	R=0.2 S=0.2	1.5%/yr for 10 yrs
KS - OK	Surrounding Muskogee, OK	20,000+	40,000	Tornado, Ice storm	5%, 5%	R=0.5 S=1.0	2%/yr for 5 yrs
OK – AR	McCurtin, OK – Little River, AR	10,000+	20,000	Tornado, Ice storm	5%, 5%	R=0.5 S=1.0	--
W central AR	Sebastian – Franklin – Logan, AR	3,000 to 5,000	6,000 to 10,000	Severe drought	1%	R=0.2 S=0.2	--
RI	Block Island	1,000	2,000	Hurricane	2%	R=0.25 S=1.0	1%/yr for 5 yrs
MA	Nantucket Island	300	3,000	Hurricane	2%	R=0.25 S=1.0	--
Total		46,000 to 50,000+					

* See Appendix A for a brief description of the methods and assumptions on which these population estimates are based.

Central U.S. Populations
Three of the central populations are quite large (N_{init} > 10,000 and K_{DD} > 20,000). Despite the risk of catastrophe events, these populations maintain population levels at 84-98% of K, retain over 99% gene diversity, and show zero risk of extinction over 50 years. Given the population and demographic estimates used in the model, this suggests that these populations have long-term viability under current conditions.

The westcentral Arkansas population is believed to be geographically separated from adjacent ABB populations and is 50-70% smaller than the larger populations (N_{init} > 3,000-5,000 and K_{DD} > 6,000-10,000). In addition, this population is at risk of an infrequent but severe catastrophe (severe drought) that reduces both reproduction and survival by 80% in any year in which it occurs. Even at its lower estimated size and carrying capacity, this population also fairs very well, maintaining population size at about 93% of K, retaining 98% gene diversity, and showing a very low risk of extinction (0.4%) over 50 years.

The south-central Nebraska ABB population is geographically isolated from the ABB population in northern Nebraska and South Dakota. This is estimated to be the smallest isolated ABB population in the central U.S., with an estimated 1,500 to 3,000 beetles (estimated K_{DD} = 3,000-6,000). This population was also modeled as being susceptible to severe drought effects on reproduction and survival. The invasion of red cedar, which is thought to reduce ABB carrying capacity by 50%, was included in the model as an estimated loss of 15% of ABB carrying capacity over the next 10 years. These factors combine to reduce the viability of this population. The risk of extinction over 50 years ranges from 0.8% to 2%, depending on population size. Mean population is smaller (77-80% of K) but shows no general decline over time, and gene diversity remains high (96-98%).

Overall, model results suggest that ABB populations in the central U.S. are relatively secure given current conditions and projected impacts from catastrophes and habitat loss. Factors that affect reproduction and mortality (e.g., carcass availability), or severely reduce or fragment existing populations, however, have the potential to reduce population viability.

Block Island, Rhode Island Population
This relatively small ABB population (N_{init} = 1,000) is restricted to Block Island off the coast of Rhode Island and is the last naturally-occurring ABB population east of the Mississippi River. There is no gene flow between this population and those in the Midwest, and although these populations are not genetically differentiated from each other, nucleotide variation is lower for the smaller, isolated Block Island population (Szalanski et al., 2000). Intense hurricanes are the primary potential catastrophe, estimated to occur about once every 50 years. An annual 1% decline in available habitat is projected for the next five years; at that time, all developable land will be developed and there should be no further habitat loss.

This population is fairly robust to the effects of hurricanes and 5% reduction in carrying capacity. Although hurricanes can severely reduce the population in a given year, as long as K remains high, the population is capable of rapid growth and recovery. Carrying capacity, in terms of carcass availability, can be maintained following hurricanes, if necessary, through provisioning of carcasses. The risk of extinction over 50 years is zero, and the population retains about 96% of its original gene diversity.

Nantucket Island, Massachusetts Population

This small population is a result of reintroduction efforts starting in 1994 using captive-reared individuals of Block Island origin. Nantucket Island was selected as a reintroduction site in part due to its size (12,955 ha, with about 4,818 ha in conservation reserves) (Amaral *et al.*, 1997). The current population is estimated at about 300 ABBs in spring. Like Block Island, the Nantucket Island population is vulnerable to the effects of hurricanes. The high potential growth rate of this species under low density conditions (in the presence of abundant resources) makes it fairly resilient to the effects of single hurricane events. Using K = 3,000, there is zero risk of extinction over 50 years and high retention of gene diversity (97%).

Overall the small island populations demonstrate resiliency to the effects of hurricanes and other stochastic factors as long as carrying capacity remains high, either naturally or through carcass provisioning. Lower rates of breeding success, higher mortality, or greater environmental variation in demographic rates may make these populations more vulnerable to decline or extinction risk.

Table 5. Results of population-specific ABB models at 50 years (Stoch.r = stochastic r; PE = probability of extinction; N = mean population size; SD(N) = standard deviation in N; GD = gene diversity remaining).

Parameter	Stoch. r	PE	N	SD(N)	N/K	GD
*South Dakota – northern Nebraska	0.014	0	19652	6441	0.98	0.993
Southcentral Nebraska	0.006 0.008	0.020 0.008	2319 4812	918 1749	0.77 0.80	0.960 0.976
*Kansas - Oklahoma	0.019	0	25254	5947	0.84	0.997
*Oklahoma to southern Arkansas	0.013	0	18427	6101	0.92	0.996
Westcentral Arkansas	0.011 0.013	0.004 0.004	5585 9552	2036 3346	0.93 0.96	0.980 0.989
Block Island, Rhode Island	0.013	0	1806	560	0.90	0.964
Nantucket Island, Massachusetts	0.045	0	2842	874	0.95	0.970

* *Reproduction was suspended in some iterations for these populations due to maximum of 30,000 individuals allowed in Vortex*

Reintroduction Considerations

Fecundity and survival rates interact to determine the potential growth rate of an ABB population. While catastrophes and other sources of stochasticity have the potential to negatively impact population viability, particularly at small population sizes, stochastic processes do not appear to be a major driving factor of ABB populations. As discussed above, the estimated demographic rates for ABBs result in strong potential growth when resources are plentiful. If, however, reproductive and survival rates of reintroduced beetles vary from those hatched into the population, then population growth rate may be less robust.

Table 6 demonstrates how fecundity (presented here as percent of females breeding) interacts with first-year mortality to affect deterministic growth rates. Stochastic rates may be lower, especially for smaller populations. With the baseline estimated value of 75% for first-year mortality, populations are generally able to grow except at densities near carrying capacity (when reproductive success falls to 50%). Higher levels of first-year mortality, up to 80-85%, require much higher reproductive success to maintain or grow the population. Increased fecundity can be achieved not only through a higher percent of females breeding but also through larger litter size.

Reintroduced beetles are typically provisioned with carcasses to promote reproductive success. There was some discussion at the workshop regarding possible higher mortality rates in these first-generation offspring. Higher first-year mortality (from hatching through enclosures and overwintering) could lead to a declining population. *Vortex* simulations suggest that reintroduction efforts can be successful with the reintroduction of 100 pairs per year for only a few years provided survival rates are high enough to allow some wild-hatched ABBs to survive the winter to reproduce, and that these wild-hatched beetles demonstrate reproductive and survival rates similar to those estimated for wild populations. Exact reintroduction strategies needed to successfully establish an ABB population will depend upon the fecundity and survival of released pairs and upon the effectiveness of management strategies, such as carcass provisioning, in promoting reproduction and survival.

Table 6. Deterministic growth rate (r) for ABB populations under various combinations of first-year mortality and percent of females breeding.

First-year mortality	% females breeding						
	50	55	60	65	70	75	80
75%	- 0.065	0.031	0.118	0.198	0.272	0.341	0.405
80%	- 0.288	- 0.192	- 0.105	- 0.025	0.049	0.118	0.182
85%	-.0.575	- 0.480	- 0.393	- 0.313	- 0.239	- 0.170	- 0.105

Summary of Model Projections for ABB Populations

Participants at this PHVA workshop used the best available data to develop a baseline population model for wild American burying beetle populations using the *Vortex* simulation program. Although *Vortex* is more suitable to small K-selected vertebrate species, the unusual life history of this beetle enabled the use of *Vortex* to examine population dynamics and viability. This model assumes that conditions that affect demographic rates, population size and carrying capacity will remain constant over time unless otherwise specified in the model. There is a fair amount of uncertainty regarding ABB demographic rates, and some of the values used were based on data from captive or provisioned populations. This model seems to be relatively insensitive to these uncertainties when predicting population persistence over the next 50 years. However, factors that affect the recruitment of new breeding adults in the spring, primarily first-year mortality and to a lesser extent breeding success rate and brood size, can have significant impacts on population size and viability. Inaccuracies in estimating the means and variation in these parameters may lead to different conclusions, at least for small ABB populations.

Model results suggest that given the demographic rates used in the baseline model, ABB populations in habitats that are able to maintain 1,000 beetles or more are viable long-term in the absence of severe catastrophic events or reduction in carrying capacity through reduced carcass availability, habitat loss or fragmentation. Smaller populations may be more vulnerable to the impacts of stochastic processes and experience reduced viability. Currently, all naturally occurring ABB populations are estimated to be at least 1,000 individuals. The ABB model projects little risk of single population extinction and no risk of metapopulation extinction over the next 50 years given estimated current conditions. More accurate data, particularly on first-year mortality, would strengthen the ability of models to evaluate ABB population viability. Management strategies designed to improve first-year survival and reproductive success would be beneficial to the conservation of ABB populations.

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Section IV
Participant List and Introduction Questions

Participant List

First	Last	Organization	Address	City	State	Zip	E-mail
Michael	Amaral	U.S. Fish and Wildlife Service	70 Commercial St. Ste 300	Concord	NH	03301	michael_amaral@fws.gov
Michael	Arduser	Missouri Department of Conservation	c/o Jane Stevens				
Brock	Blevins	Henry Doorly Zoo	3701 S 10 St	Omaha	NE	68107	repro@omahazoo.com
Onnie	Byers	CBSG	12101 Johnny Cake Ridge Rd	Apple Valley	MN	55124	onnie@cbsg.org
Chris	Davidson	U.S. Fish and Wildlife Service	110 South Amity Rd. Ste 300	Conway	AR	72032	chris_davidson@fws.gov
Hayley	Dikeman	U.S. Fish and Wildlife Service	222 South Houston	Tulsa	OK	74127	hayley_dikeman@fws.gov
Michael	Fritz	Nebraska Game and Parks Commission	2200 N. 33rd St.	Lincoln	NE	68503	mike.fritz@ngpc.ne.gov
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Kathy	Holzer	CBSG	12101 Johnny Cake Ridge Rd	Apple Valley	MN	55124	kathy@cbsg.org
Peggy	Horner	Missouri Department of Conservation	2901 W. Truman Blvd	Jefferson City	MO	65102	peggy.horner@mdc.mo.gov
Daniel	Koch	Saint Louis Zoo	1 Government Drive	St. Louis	MO	63110	Koch@stlzoo.org
Bob	Merz	Saint Louis Zoo	1 Government Drive	St. Louis	MO	63110	Merz@stlzoo.org
Randy	Morgan	Cincinnati Zoo & Botanical Garden	3400 Vine Street	Cincinnati	OH	45220	randy.morgan@cincinnatizoo.org
Paul	Pearce-Kelly	London Zoo	Regent's Park	London	UK		paul.pearce-kelly@zsl.org
Lou	Perrotti	Roger Williams Park Zoo	1000 Elmwood Ave	Providence	RI	02907	LPerrotti@rwpzoo.org
Chris	Raithel	Rhode Island Division of Fish and Wildlife	PO Box 218	West Kingston	RI	02892	craithel@netsense.net
Chris	Reynolds	Weyerhaeuser Co.	PO Box 1060	Hot Springs	AR	71902	chris.reynolds@weyerhaeuser.com
Steve	Shurter	The WILDS	3375 Steel Ridge Rd	Sheridan	OR	97378	sshurter@thewilds.org
Jane	Stevens	Saint Louis Zoo	1 Government Drive	St. Louis	MO	63110	Stevens@stlzoo.org

Participant Introduction Questions

1. What do you hope to see accomplished in this workshop?

- To learn as much as possible about the ABB. Learn about wild and captive population success and failures, reintroduction success and failures. This all in hopes to reintroduce back into the wild and get ABB off the endangered species list.
- Develop criteria/model regarding the population status, trends and potential conservation approaches for the ABB, based on habitat, threats and conservation actions throughout its range.
- Prioritize the steps of the recovery plan; get all the involved parties on the same page; set goals for the next 5-10 years.
- Advance the conservation of the ABB through the sharing of information, in particular bringing into sharper focus what is needed to successfully recover this species.
- Broad based collaboration to create an optimal and effective recovery program.
- An "action" plan …what do we need to do next for recovery efforts for this species?; participants involved in the process of sharing info and establishing a strategy for recovery.
- Grasp a better understanding of the mechanisms leading to declines; determine where to focus our attention; "recovery plan".
- Prioritized and coordinated list of conservation and research projects that need support.
- A comprehensive review of the current status (*in* and *ex situ* elements); a comprehensive species management plan.
- Increased cooperation among involved organizations; identification of research points to answer critical questions on beetle life cycle and related to reintroductions (over-wintering, etc.).
- As an employee of an AZA accredited institution, I wish to assist facilitation, learn from the PHVA workshop process, gain experience for future workshops as well as report on status of ABB to HDZ; also to keep our eyes open to possible involvement in conservation efforts we can assist in.
- Coordination of wild beetle studies and laboratory reintroduction efforts.
- Meet and have a more cooperative approach to managing the ABB.
- A tool that enables us to better coordinate and implement recovery efforts for the ABB.
- What parameters are needed to find a reintroduction into Missouri; what will make a captive population carry on genetically.
- Information sharing and gathering to learn what is going on with the ABB range wide; there is a lot of unpublished data; range-wide status assessments, updates, priorities of recovering the ABB.

2. What do you hope to contribute to this workshop?

- Knowledge/experiences of raising captive populations of ABBs and surveying. Also in reintroductions of wild ABBs.
- Information on the ABB concerning its distribution, numbers, habitat and threats in the Central Great Plains, NE and SD. Provide background on studies conducted to date.
- Information and data compiled in 11 years of captive breeding.
- 16 years of experience working with this species in the states of RI and Mass. And enthusiasm for the recovery program.
- Past experience keeping and breeding this species in captivity at the Cincinnati Zoo.
- A state wildlife agency perspective; recovery is more than biology…how to get stakeholders in a state engaged in conservation.
- Provide intellectual insight from forest industry perspective.

- I'm not an expert – more about learning about ABB and its conservation needs
- Any related experience that might be useful; share Romain Pizzi's contribution regarding disease management considerations.
- Represent Ohio ABB program; help to develop ABB "network".
- I can offer assistance and possible resources to ABB conservation efforts.
- A surveyor of wild populations; whatever is useful
- My personal experiences and observations for my populations of ABB.
- Knowledge of the status of ABB populations in Arkansas and threats and hurdles facing the recovery efforts in AR.
- Everything I have which can fill in the blanks.
- What the status of ABB is in Oklahoma; how OK is participating in the ABB recovery; the limitations in the recovery process.

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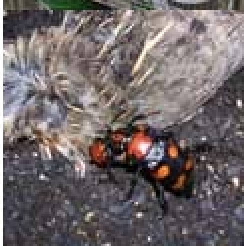
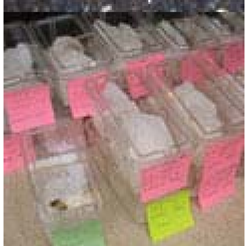
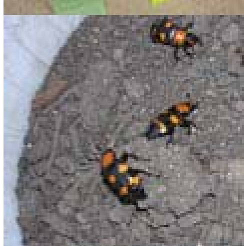
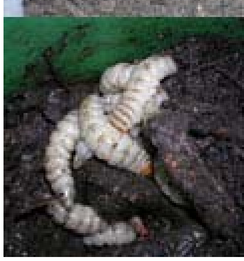
Section V
Invitation and Invitation List

American Burying Beetle Workshop



The Saint Louis Zoo and the Saint Louis Zoo WildCare Institute are proud to host the Population Habitat Viability Assessment (PHVA) Workshop for the American Burying Beetle!

Monday, November 14 – Thursday, November 17
9 a.m. - 6 p.m. Daily
Saint Louis Zoo

The Saint Louis Zoo WildCare Institute, with the support of its Conservation Fellows, takes a holistic approach to troubled ecosystems by addressing three key ingredients in conservation success with each of its 12 conservation centers: wildlife management and recovery, conservation science, and support of the human populations that coexist with wildlife. One of the centers is dedicated to the conservation of the American Burying Beetle.

In its efforts to help with the conservation of the American Burying Beetle, the WildCare Institute has invited IUCN's Conservation Breeding Specialist Group (CBSG) to conduct a PHVA for the American Burying Beetle. The goals of the workshop are:

1. Bring together and analyze the latest information on the status of AMBB.
2. Develop a risk analysis and population simulation model for the species that can be used to guide and evaluate management and research activities.
3. As a collaborative, formulate priorities for a practical program to assist in the management of species.

A draft report will be prepared during the workshop. The final report will be reviewed, revised and distributed within six months after the PHVA.

Even if you are unable to attend the workshop, please fill out the Vortex data form and send it to Onnie Byers with CBSG so that a base line model of the population can be developed. If you have information regarding the species' life history, ecology, threats, habitat or management, please submit the information to Onnie for inclusion in the workshop-briefing book.

Meeting Host

Jane Stevens
Curator of Invertebrates
Saint Louis Zoo
stevens@stlzoo.org
(314) 781-0900, ext. 326

Invitation List

1. Michael Amaral, USFWS
2. Michael Arduser, Missouri Department of Conservation
3. Doug Backlund, South Dakota Dept of Game, Fish and Parks
4. Brock Blevins, Henry Doorly Zoo
5. Evan Blumer, The Wilds
6. Jeff Brigler, Missouri Department of Conservation
7. Carolyn Caldwell, Ohio Division of Wildlife
8. Nicole Cavender, The Wilds
9. Lisa Dabek, Roger Williams Park Zoo
10. Chris Davidson, USFWS
11. Haley Dikeman, USFWS
12. Peter Fasbender, USFWS
13. Michael Fritz, State of Nebraska
14. Anna "Kiki" Hiott, Sam Noble Museum of Natural History, Oklahoma
15. Wyatt Hoback, University of Nebraska at Kearney
16. Dr. Dave Horn, Ohio State University
17. Peggy Horner, Missouri Division of Wildlife
18. George Keeney, Ohio State University
19. Leroy Koch, USFWS
20. Doug Ladd, The Nature Conservancy
21. Doug La Doux, Arkansas
22. Paul MacKenzie, USFWS
23. Bob Merz, Saint Louis Zoo
24. Eric Miller, St. Louis Zoo
25. Randy Morgan, Cincinnati Zoo & Botanical Garden
26. Lou Perotti, Roger William Park Zoo
27. Paul Pierce-Kelly London Zoo
28. Romain Pizzi, Royal School of Veterinary Studies
29. Foster F. Purrington, Ohio State University
30. Brett Ratcliffe, University of Nebraska Museum, Lincoln
31. Chris Raithel, R.I. Division of Fisheries and Wildlife
32. Chris Reynolds, Weyerhauser Company
33. Amy Salveter, USFWS
34. Gary Schnell, Sam Noble Museum of Natural History, Oklahoma
35. Steve Shurter, The Wilds
36. Jane Stevens, St. Louis Zoo
37. Michael D. Warriner, Arkansas Natural Heritage Commission
38. Angela Zimmerman, USFWS

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Section VI
Glossary of Acronyms

Glossary of Acronyms

ABB - American burying beetle
AFBs - Air Force Bases
BMP – Best Management Practice
CBSG – Conservation Breeding Specialist Group
DOD – Department of Defense
EPA – Environmental Protection Agency
ESA – Endangered Species Act
GIS – Geographic information systems
HCP – Habitat Conservation Plan
NGO - Non-governmental organization
NRCS – Natural Resources Conservation Service
PHVA – Population and Habitat Viability Assessment
RP – Recovery plan
SHA – Safe Harbor Agreement
TNC –The Nature Conservancy
USFS - United States Forest Service
USFWS – United States Fish and Wildlife Service
USGS - United States Geological Survey
WMAs – Wildlife Management Areas

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Section VII
Working Group Notes

Wild Populations Working Group Notes

Protection of best extant populations

Issue clarification/ addition of new issues pertinent to wild populations.
Survey for populations –location, range, size.
Life history- determine baseline data needed in any protection plan.
Discussion about spatial scale and how large a disturbance would be important.

1. Issue: It is inefficient (and politically counterproductive) to "consult/protect" every ABB habitat occurrence, so we need to identify and prioritize protection needs for the best core populations. This will enable us to diminish regulatory protections for outlying or peripheral populations and focus on the populations most important to the species long term conservation.

Define population integrity
Predictive model for ABB occurrence- useful for improving population estimates based on amount of suitable habitat only.

Protection of best populations
Sub issues: need for identification of core populations.
Size and scale- what are the criterion we will use to identify what a core population is, e.g., ABB density.
Health issues (pathogens, introduced Species, pesticides) genetic fitness.
Where are the core areas, and are there corridors connecting them.
Discussed a larger Conservation Focus area in which are embedded one or more best extant populations.

2. Issue: There may be undiscovered populations that merit protection because they will contribute to survival and recovery of the species. Until these populations are identified and protected, they remain at risk due to habitat loss, fragmentation or other causes.

Issue: Inadequate baseline life history data are available to ensure we know what biological and physical elements to protect in order to sustain the species there.
Sub-issue: In order for the core populations to be viable over the long term, we need to know what how much habitat is necessary and minimum viable population.

Data Assembly and Analysis
Issue 1. Identify and prioritize protection needs for best core populations:

1. Muskogee Co., OK
2. McCurtain Co., OK–Little River , AR
3. Sebastian-Franklin-Logan Co., AR
4. Rock-Keya Paha-Blaine-Brown counties, NE-Tripp and Greggory, SD
5. Lincoln-Dawson Co, NE
6. Block Island, RI

Data sources include the following:

Sam Noble OK museum of Nat His and OK Biol Survey, OKFO USFWS Files, ARFO USFWS files, New England FO USFWS files, RI DFW reports, section 6 reports, U of NE reports, published and unpublished literature.

Prioritize protection needs (assumptions: we understand the biological and habitat requirements of the species and can make educated speculations on threats).

1. Muskogee: Threats- human activities that convert large, contiguous tracts of pasture and other suitable habitat types into less suitable and unsuitable uses. Retain public ownership.
2. same as above and increase in invasive exotics such as fire ants. Retain public ownership.
3. same as above and retain public ownership.
4. threats are increasing agriculture lands, center pivot circle irrigation, and grasshopper spraying.
5. Red cedar invasion, drought, exacerbated by human water demands such as irrigation, and light pollution related to expanding residential development.
6. Protect ring necked pheasant populations (potential threats include hunting harvest, feral cats, stochastic weather events), and habitat degradation due to high white tailed deer densities.

Issue 2: There may be undiscovered populations that merit protection.
Need to locate undiscovered populations that would significantly expand the known extant range.

Issue 3. Inadequate baseline life history data

a. Biological parameters we need to know.
   Dynamics of species comprising the carrion resources for feeding and breeding . Level of competition for carrion (fire ant mgt.). Consideration of unique genetic conservation units.

b. Physical parameters: What are specific habitat requirements for all life stages. Determine moisture and soil types required. Maintain an open, native vegetative structure.

c. What are the “normal” health parameters for individual and populations of ABBs of which we should be aware?

d. Minimum Viable Habitat Size for Core Populations: >5,000 acres based on persistence of Block Is. Pop. But ABBs persist in a favorable situation there and larger areas are required for western populations.

Smaller areas (2500-3000 acres) may be considered viable for reintroduction purposes if adequate buffers are present and other factors (carrion resources) are favorable.

Potential solutions

Issue 1. Protect Core Populations

1. Retain important core populations within state and federal ownership. Explore opportunities to expand these areas and/or connect them with corridors.

Section 6 land acquisition grants
NG conservation organization purchases or easements

3. Promote /utilize ESA Conservation Bank concept.
5. Utilize section 7 consultation process to protect essential features of habitat
4. Utilize wide range of federal – state conservation incentive programs, LIP, WHIP, Partners, etc.
2. Develop management plans (BMPs) unique to each core population. Be sure to address most important exotic (e.g., fire ant) or invasive native (red cedar) species issues.

Issue 2: There may be undiscovered populations that merit protection.
Need to locate undiscovered populations that would significantly expand the known extant range.

1. Review historical collection records and survey effort for all states/sites with post 1970 ABB records. These include Trigg Co., Kentucky; Jasper Co., MO; Hocking Co., OH; Washington Co., AR; and Ontario, Canada.
2. Review pre-1970 collection records and availability of suitable habitat within additional states in historical range and conduct additional de novo surveys.
3. Summarize all negative survey data.

Issue 3. Inadequate baseline life history information - Potential Solutions (priority #).

4. Utilize new technologies as they become available to track daily movements of ABBs.
2. Make unpublished data readily available to others who may mine-it for results.
6. Investigate over wintering habitat requirements in comparative areas (east west north south).
12. Investigate the effects of fire on ABB life history.
11. Investigate the effects of pesticide use on Nicrophorus congeners (e.g., grasshopper spraying that is on-going in NE).
10. Investigate effects of artificial lighting on ABB populations.
5. Develop a descriptive and predictive habitat model for suitable habitat (useful to prioritize survey effort and to id reintroduction areas).
7. Develop BMPs that private/public land mgrs can use.
8. Investigate the impact of congeneric and other competition.
3. Survey mammal and bird populations to correlate vertebrate densities with ABB occurrence.
1. Utilize PHVA and revised recovery plan to leverage new research dollars.
9. Investigate genetic variability within and between populations to inform mvp estimates.
13. Preserve dead and moribund animals and identify insect health expert who can conduct baseline health screening.

Issue 4. Identify and Establish "X" number of new core populations within historic range to meet Recovery Plan objectives.

1. Assess and identify suitable habitat for reintroduction sites.
2. Identify wild populations for translocate source or establish captive breeding populations for reintroduction use.
3. Conduct translocation or reintroductions.
4. Monitor results.

Task 5 & 6: Recommendations/Actions

Issue 1. Protect Core Populations
It is inefficient (and politically counterproductive) to "consult/protect" every ABB habitat occurrence, we need to identify and prioritize protection needs for the best core populations. This will enable us to diminish regulatory protections for outlying or peripheral populations and focus on the populations most important to the species long term conservation.

Recommendation: Retain important core populations within state and federal ownership. Explore opportunities to expand these areas and/or connect them with corridors.

Action 1: By 2010 the USFWS, USFS, DOD, State owned WMAs and Natural Areas will develop land management plans for public lands that include specific standards that address management of ABB populations and habitat. This is important because core populations are important to recovery and without management plans populations may not remain viable.

Action 2: Strategically utilize section 7 (ESA) to protect essential features of core population habitat. This should include further defining different thresholds for consultations in core versus peripheral population areas by 2008.

Recommendation: Promote conservation of core populations on private lands.

Action 1: Encourage state agencies and NGOs to obtain grant funding (*e.g.* Section 6 (ESA) land acquisition grants) for land acquisition and conservation on an "as needed basis". This is important to expand core population habitat as these areas are identified by state and federal agencies and NGOs.

Action 2: Enroll private lands in conservation easements, federal and state incentive programs, habitat conservation plans, and safe harbor agreements. Programmatic (statewide) safe harbor agreements stream line bureaucratic processes and encourage private landowner participation and conservation.

Action 3: NGOs (zoos, museums, TNC, etc.) will develop educational materials (*e.g.* videos, brochures, curriculum packages, etc) by 2008 and provide support to state and federal agencies for public outreach.

Issue 2: There may be undiscovered populations that merit protection.
These populations will contribute to survival and recovery of the species. Until these populations are identified and protected, they remain at risk due to habitat loss, fragmentation or other causes.

Recommendation: Identify areas and conduct surveys to identify new extant populations within the historic range.

Action 1: USFWS and state heritage programs will review historical collection records and survey effort for all states/sites with post 1970 ABB records by 2010. These include Trigg Co., Kentucky; Jasper Co., MO; Hocking Co., OH; Washington Co., AR; and Ontario, Canada.

Action 2: USFWS and state heritage programs will review pre-1970 collection records and availability of suitable habitat within additional states in historical range and conduct additional de novo surveys by 2010.

Action 3: USFWS will summarize all negative survey data by 2010.

Action 4: Conduct surveys (all) in areas identified in Action 1 through 3 by 2010.

Actions 1 through 4 are needed to locate undiscovered populations that would significantly expand the known extant range.

Issue 3. Inadequate baseline/life history information: Adequate baseline/life history data is needed to ensure we know what biological and physical elements are critical to protect populations and manage habitat in order to sustain the species.

⇒ Sub-issue: In order for the core populations to be viable over the long term, we need to know what how much habitat is necessary and minimum viable populaiton.

Recommendation: Develop research to understand life history requirements (competition, descriptive/predictive model, etc.) within four core recovery regions in the Recovery Plan.

Action 1: Conduct research on biotic factors that affect ABB life history (universities or zoos; timeframe ASAP).

Action 1a: Utilize new technologies as they become available to track daily movements of ABBs, to find overwintering habitat and to identify natural reproductive areas in comparative portions of range (east, west, north, south).

Action 1b: Investigate the impact of congeneric and other competition by conducting laboratory and semi-natural field studies in comparative portions of range (east, west, north, south).

Action 1c: Investigate genetic variability within and between populations to inform minimum viable population estimates.

Action 2: Conduct research on abiotic factors that affect ABB life history (universities and zoos; timeframe ASAP).

Action 2a: Investigate effects of artificial lighting, pesticide use, and fire on ABB populations. These effects may be important to one or more core populations and should be investigated accordingly.

Action b:: Determine potential impacts and management plans to address the spread of exotic and invasive plant and animal species.

Action 3: Develop a descriptive and predictive habitat model based on Actions 1A and 1B for suitable habitat (useful to prioritize survey effort and to identify reintroduction areas) (universities and zoos; timeframe ASAP).

Action 4: Develop Best Management Practices based on Action 2 that private/public land managers can use (universities, state and federal agencies; timeframe ASAP).

Action 5: Preserve dead and moribund animals and identify insect health expert who can conduct baseline health screening (all; timeframe ASAP).

<u>Recommendation</u>: Leverage new research dollars.

Action 1: Utilize PHVA and revised recovery plan to justify grants for research. Explore all potential sources for research funding (ongoing basis). This may include a page on the web site that directs researchers to potential funding sources (all researchers and St. Louis Zoo; timeframe ASAP).

<u>Recommendation</u>: Centralize existing data and encourage data sharing and collaboration.

Action 1: St. Louis Zoo will establish a list serve by 2007.

Action 2: St. Louis Zoo will develop (2007) and operate (continuous) a web site dedicated to the ABB that contains public outreach materials, photographs, and published and unpublished data in a format (pdf) which is readily available.

Action 3: All state and federal agencies, universities, and NGOs are encouraged to provide data to St. Louis Zoo to be incorporated into the website (ongoing basis).

Issue 4. Need to establish new populations within historic range.
In order to adequately conserve and recovery the species, new populations need to be established within its historic range.

<u>Recommendation:</u> Identify and establish "X" number of new core populations within historic range to meet Recovery Plan objectives.

Action 1: Assess and identify suitable habitat for reintroduction sites.

Action 2: Identify wild populations for translocation source or establish captive breeding populations for reintroduction use.

Action 3: Conduct translocation or reintroduction efforts. This action requires population monitoring.

Habitat Working Group Notes

Group Topic
The general group topic was habitat, in its broadest sense. We discussed the types of data needed to understand, manage and recover the ABB, and how to refine this topic to be more specific. Below we present our refined focus, and the discussion that occurred around this topic.

Overall Issue Statement
We hypothesize that the distribution and establishment of American burying beetle populations is correlated with, and limited by the distribution and variation of certain habitat characteristics. Our goal is to define suitable American burying beetle habitat by identifying these habitat characteristics (biotic and abiotic) and their variation range-wide, then construct a model(s) from this information to strategically guide survey effort, reintroduction planning and management. Below we break this issue statement into several sub-issues.

Prioritized Issue Statements

1. There is a need to have more information on suitable habitat. The abiotic issues include: soil, moisture, organic matter, and precipitation. 4 dots

2. There is a need for more information on carrion availability and competition. Can we even determine this? Competition? Biotic factors. 4 dots

3. The need to understand landscape conservation …are we talking about in regards to preserves 4 dots

3. The need to know what is proper management? We don't know what proper management looks like? (Pre – European settlement?) 3 dots

DISCUSSION INVOLVING TASK 1
This is a suitable habitat issue – what do we need to be managing? Not every acre of ABB habitat, particularly feeding habitat, needs to be saved. Is it a regulatory issue? Some of it is consultation with FWS to provide take. Federal actions involving disturbance of natural resources are required by law to undergo consultation with the FWS in regards to the Endangered Species Act.

There's feeding habitat and there's also reproductive and overwintering habitat…they are feeding habitat generalists, but reproductive and potentially overwintering habitat specialists. "Suitable" habitat is defined to include habitat used for feeding, reproduction and overwintering. General components include vegetation, soil, carrion, and disturbance factors.

Assumption: ABBs are more selective in habitat choices involving reproduction and overwintering than they are for feeding. Reproductive and overwintering habitats are a subset of general feeding habitat. We do not know definitively if ABBs are more selective in choosing their reproductive habitat and overwintering habitat (compared to genera feeding habitat), but it is likely that they are. So in order to conserve and recover this species we need to know if this assumption is correct.

Reproductive habitat. Why is it an issue? We need to know what habitat to protect. Why? Because we are focusing our efforts to do the most good.

We should look at ABB "suitable habitat conservation" at the landscape scale. We think the largest view of the landscape level should be the ABBs historic range. We also need to look at the spatial arrangement of existing ABB concentrations at this landscape level, and evaluate existing and potential corridors, and the amount and arrangement of fragmentation, loss, and conversion of suitable habitat. This scale would be best for identifying preserves that would connect, via corridors, existing ABB areas.

Knowing that ABBs do have more selective habitat requirements would allow us to better maximize our resources. Why? We could focus our efforts on select high priority areas. Why? To conserve the species sustainably through proper management of the focus areas.

Ex situ Populations Working Group Notes

***Ex situ* support of the USFWA ABB Recovery Programme.**
How this might best be realised will be wholly determined by what the Recovery Programme's *ex situ* mandate is. Our understanding is that the current recovery Plan needs to be regarded as the current mandate for the next couple of years. Potential mandate areas could include:

- Augmenting existing *in situ* populations or to help the establishment of new populations.

This has been the historic and current main focus.

- Providing reservoirs of genetic diversity.

This has implications in terms of founder base and management regimes.

Both of these roles raise the issue of the necessary number of participating institutions.

- Addressing specific biological issues (basic biology and life cycle and management issues, both captive and wild).

Lab conditions provide opportunity to enhance knowledge of particular areas impractical to obtain in the field (e.g. investigating the significance of phoretic mites and other potential symbiants).

- Public education.

Zoo based mechanisms are already in place to promote and create support for the various elements of the programme.

- Generation of funds.

Zoo and universities are uniquely positioned to investigate and secure grants and other funding opportunities.

ABB RP to provide clarification as to prioritized direction of the *ex situ* programme mandate.

Health issues
There is a pressing need for clarification of the health profile of this species. This is a key programme issue encompassing both wild and captive elements. Without a knowledge of wild population health profiles it is impossible to interpret what constitutes an infections agent in either the wild or captive populations. (ref IUCN guidelines 1987, 95 and 2001).

- Current lack of relevant pathology investigations or pooling of pathology data (including any potential model species data) is hindering progress.
- Current lack of pathology/necropsy protocols (for both *in* and *ex situ* populations). This prevents the availability of suitable material for health investigation.

- **Produce pathology/necropsy protocols (for both *in* and *ex situ* populations (ref Fregate MG)).**

- There is uncertainty as to where this health investigation work should and can be conducted.

- **A collaborative partnership approach should be investigated.**

- There is a current lack of standardised measurements. We see adult body size as being a particularly useful index, but could also include larval development and other aspects of the life cycle.

- **Produce standardised measurement protocols (ref Fregate beetle MG).**

Captive husbandry and related issues

- Currently there is variation in keeping systems and breeding results being experienced in different institutions.

Need to review and summarise historic and current keeping methods and associated results. This should form the basis for the production of comprehensive management guidelines.

Review and summarise historic and current keeping methods and associated results. Produce comprehensive management guidelines.

Reintroduction

Reintroduction has been considered an important mandate of the *ex situ* programme since its conception. No standardized reintroduction protocol (including follow up assessments).

- The *ex situ* programme needs direction from the ABB RP as to specific reintroduction requirements, including population representation and numbers

- Who conducts the reintroduction and determines the parameters of a successful reintroduction?

- **ABB RP to clarify specific reintroduction requirements, including population representation and numbers**

- **An annual review/meeting of ABB RP programme performance and associated *in situ* and *ex situ* actions.**

Genetics

The current uncertainty as to degree of genetic variation in the *in situ* populations (natural and introduced) needs to be addressed to enable best programme management.

The current uncertainly as to the presence/significance of inbreeding depression in this species undermines confidence in how to realize best program management.

- The genetic diversity of the *ex situ* population(s) needs to be representative of the target extant population(s) as determined by the SRP management mandate.

Investigate if there are distinct wild populations that need to be captured in the *ex situ* programme?

Highlight the role of the standardized pathology/necropsy protocol in providing suitable material for enabling genetic investigations to be advanced.

Research role

Is there a research role for *ex situ* populations beyond the areas raised above and if so what are the priority areas?

The historic and current keeping methods and associated results review can identify immediate research areas pertaining to the *ex situ* programme.

An annual review/meeting can identify the wider spectrum priority research areas.

American Burying Beetle

Population and Habitat Viability Assessment Workshop

St. Louis, Missouri

14-17 November 2005

Final Report

Section IX
Appendix A

Methods and Assumptions on which Table 4 Population Estimates are Based

Nebraska

Nebraska currently contains two known populations of the American burying beetle. The southern population is centered in Lincoln and Dawson Counties in an area known as the "loess hills." This population has been extensively surveyed since 1994 and several trends have appeared. This area of Nebraska has been in a severe drought for the past 5 years and the numbers of ABB have declined substantially. Population estimates each year are based on 8 to 12 pitfall traps spaced more than 1/2 mile apart. Attracted ABB are measured, marked and released and the number of recaptures is tracked. A program "Ecosim" is used to estimate populations. A second threat in this area appears to be encroachment of eastern red cedar into grasslands.

A second population of ABB occurs in north central Nebraska and is centered in Rock, Loup, Blaine, and Brown Counties. This population extends north into South Dakota. The habitat used by this population is primarily sub-irrigated wet meadows and beetle numbers for this area can be very high (up to 33 ABB collected in a single trap night in one 5-gal trap). These wet-meadow habitats have not been affected by drought like the southern population. The area is large and the main form of agriculture is grazing and haying. Population estimates based on 4 traps with an assumed attraction area of 16 square miles indicate more than 500 individuals in some areas. However, sampling of many areas that appear suitable have not revealed ABB. Potentially the absence of ABB in these areas is a result of grasshopper spraying. Based on the high estimated populations for relatively small geographic areas, we estimate a population of 10,000 beetles within the 1,000 square miles of potentially suitable habitat.

Oklahoma

The Service herein provides an estimate of population size in Oklahoma using available presence/absence surveys. Long-term ABB survey data from throughout eastern Oklahoma is lacking. In estimating the overall population size for ABBs in Oklahoma, all previous positive survey records were used in conjunction with a crude estimate of the acreage of suitable ABB habitat. Only counties having documented ABB records, either voucher specimens or reported captures, were assumed to have existing populations. Our data revealed 20 Oklahoma counties met this criterion. While several additional counties, at least 13, likely have ABB populations, based on the occurrence of suitable habitat and proximity to known populations, these counties were not included in the analysis.

We also assumed that ABBs were uniformly dispersed throughout suitable habitat because we lack specific information on ABB dispersion patterns. The Service determined the extent of suitable ABB habitat by subtracting the acreage of unsuitable ABB habitat from the total acreage for each county. We assumed areas that are permanently flooded or frequently flooded are not suitable habitat. We also excluded areas that undergo repeated soil disturbance, primarily areas such as cropland that are frequently tilled.

Lacking any accurate measures of density, we attempted to estimate density based on capture data and the extent of suitable habitat within each county of occurrence. The Service then estimated the area that each transect would effectively trap. We believe each transect effectively lures beetles from an area bounded by a 0.25 mile perimeter around a transect. As such, the effective trapping area (ETA) for one transect is about 153.5 acres. Using the ETA and number of ABBs collected, by county, we could estimate the mean ABB density (*i.e.*, the number of ABB per acre) for each county. The density was then used in conjunction with our estimate of suitable habitat to calculate the number of ABBs for each county with known populations.

Determining suitable habitat for the ABB is particularly difficult. The ABB is considered a feeding habitat generalist and the Service lacks definitive information on ABB preferred breeding and over wintering habitat. For purposes of this population estimate, we assumed that natural habitats, such as prairies and forests, which provide suitable foraging habitat also contained suitable breeding and over wintering habitat. In doing so, we likely have overestimated the abundance of the ABB throughout its known range in Oklahoma.

Arkansas

No precise population estimate is possible for the ABB in Arkansas. However, the 10-year average for Ft. Chaffee is 370 captures (excluding recaps). Fort Chaffee contains about 40,000 acres of potential habitat for the ABB. Captures of the ABB on USFS and Weyerhauser lands in AR are so small that they do not contribute substantially to the total population estimate for the state. A state owned tall grass prairie area, Cherokee Prairie Natural Area, near Fort Chaffee recorded 244 ABBs in one year [1997], but has not been surveyed adequately since. A crude estimate of 3,000-5,000 ABBs in western AR was based on these capture data indicating presence and relative abundance, then extrapolated across the amount of potential habitat available in this area.

Block Island

The Block Island, Rhode Island, population of the American burying beetle has been surveyed annually since 1991 with standardized protocols. Three sampling transects are monitored during the peak reproductive season in the third week of June. The survey effort consists of 50 pitfall traps maintained for three days; i.e., 150 trap-nights. Transects are located in the southwest portion of the island and span about 1.8 miles. Since 1991, this effort has produced an average of 205 captures and 166 total individuals. Using a Lincoln-Pertersen Index with Bailey correction, this population has been estimated at 225 individuals (1 S.E. $\approx$ 60), but recent totals have been much higher. The four most recent survey estimates have averaged 507 animals. We do not know how much area these traps are sampling, but we do know that other parts of the island do not support as many beetles and some areas do not have any. So, to generate an island estimate, we estimated an area of trap coverage for our standard survey and extrapolated spatially across the island, considering also the habitat (fields) that is available in other areas.

Nantucket

The estimate for the current population of ABB on Nantucket Island, MA is based on 12 years of releases of a known number of ABB pairs and follow-up exhumation of 30-50% of broods to assess the resulting F1 generation. In addition, pre- and post-release trapping and monitoring of both "wild" (progeny of previous years release) and newly released ABBs occurred in most years. This data made it possible to formulate an educated guess (best professional judgment) on the number of ABBs that survived over winter and became established through the reintroduction program. Annual reports summarizing these releases and trapping efforts are available for most years.