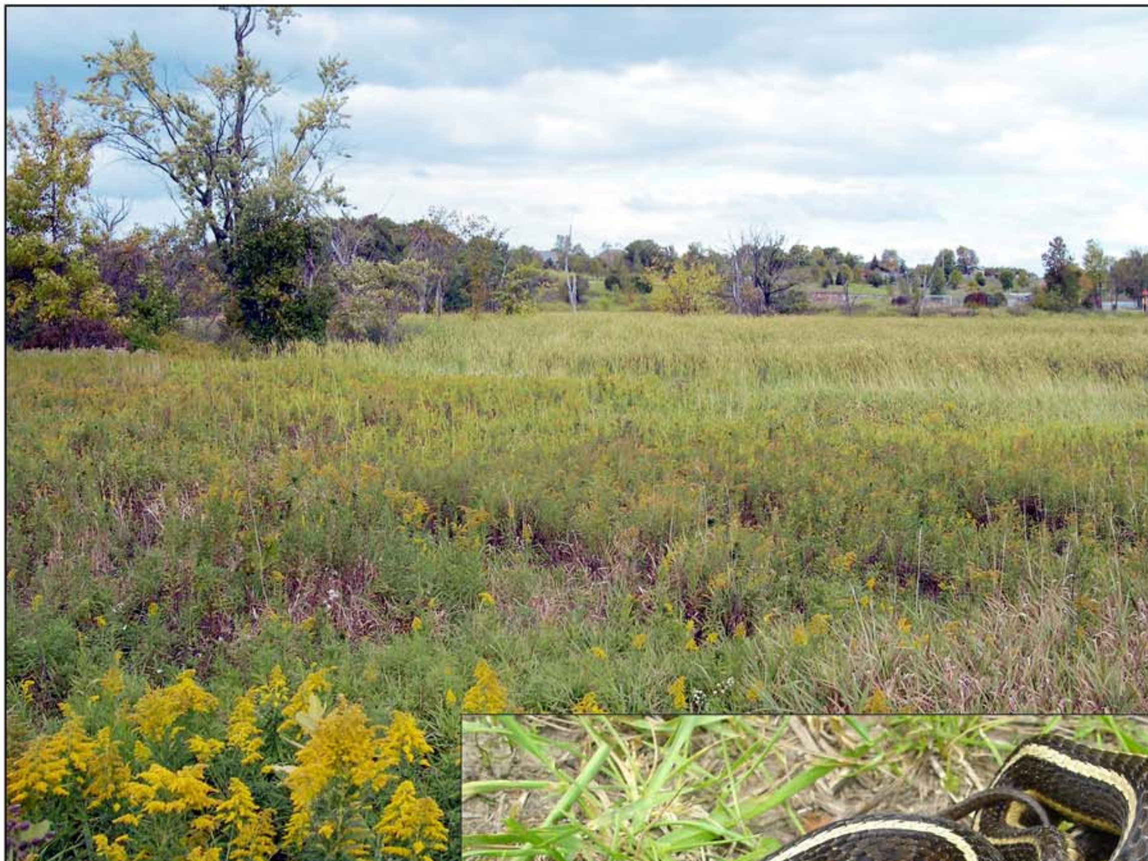
Butler's Gartersnake
Population and Habitat Viability Assessment
The Stakeholder Workshop



Milwaukee County, Wisconsin
5-8 February 2007

CONSERVATION BREEDING SPECIALIST GROUP

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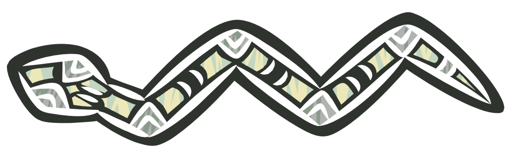
ENDANGERED RESOURCES

Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin: Population and Habitat Viability Assessment The Stakeholder Workshop

5 – 8 February, 2007
Milwaukee County, Wisconsin

Workshop Design and Facilitation:
IUCN / SSC Conservation Breeding Specialist Group

Workshop Organization:
Wisconsin Department of Natural Resources,
Bureau of Endangered Resources



WORKSHOP REPORT

Photos courtesy of Wisconsin Bureau of Endangered Resources.

A contribution of the IUCN/SSC Conservation Breeding Specialist Group, in collaboration with the Wisconsin Department of Natural Resources / Bureau of Endangered Resources.

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Randers Regnskov Tropical Zoo
Ringling Bros., Barnum & Bailey
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Royal Zoological Society - Scotland
Saitama Children's Zoo
San Antonio Zoo
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Taipei Zoo
The Living Desert
Thrigby Hall Wildlife Gardens
Toledo Zoological Society
Twycross Zoo
Union of German Zoo Directors
Utah's Hogle Zoo
Wassenaar Wildlife Breeding Centre
Wilhelma Zoo
Woodland Park Zoo
Zoo Frankfurt
Zoologischer Garten Köln
Zoologischer Garten Rostock
Zoo Zurich
Zoos South Australia (Adelaide)

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Aalborg Zoo
Akron Zoological Park
Banham Zoo and Sanctuary
BioSolutions Division of SAIC
Fairchild Tropical Botanic Garden
FOTA Wildlife Park
Givskud Zoo
Jacksonville Zoo and Gardens
Kerzner International North America, Inc.
Knuthenborg Safaripark
Lincoln Park Zoo
Lisbon Zoo
Little Rock Zoo
Naturzoo Rheine
Nordens Ark
Odense Zoo
Oregon Zoo
Ouwehands Dierenpark
Riverbanks Zoological Park
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Welsh Mountain Zoo
Wildlife World Zoo
Zoo de Granby

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Apenheul Zoo
Arizona - Sonora Desert Museum
Birmingham Zoo
Bramble Park Zoo
Brandywine Zoo
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Ed Asper
Edward & Marie Plotka
Lee Richardson Zoo
Mark Barone
Montgomery Zoo
Racine Zoological Gardens
Roger Williams Park Zoo
Rolling Hills Wildlife Adventure
Sacramento Zoo
Tokyo Zoological Park Society
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Bighorn Institute
Chahinkapa Zoo
Elias Sadalla Filho
International Centre for Birds of Prey
James & Pamela Sebesta
Lincoln Children's Zoo
Lion Country Safari, Inc.
Miami Metrozoo
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Steven J. Olson
Tautphaus Park Zoo

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April 2007

Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin: Population and Habitat Viability Assessment The Stakeholder Workshop

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Executive Summary

Introduction

The Butler's gartersnake (*Thamnophis butleri*) is the smallest of the five species of gartersnake found in Wisconsin. The snake requires both moderately open upland and wetland habitats. In Wisconsin, the species is primarily found in the greater Milwaukee area including parts of Milwaukee, Ozaukee, Washington and Waukesha Counties; a small population is also located in Fond du Lac and Sheboygan Counties (Figure 1). Wisconsin Butler's gartersnakes have been confirmed at approximately 51 sites since 1990. These populations are isolated from other Butler's populations in Indiana, Michigan, northwestern Ohio, and Ontario.

The Wisconsin Department of Natural Resources (WDNR) listed this species as Threatened in 1997, because of extremely high levels of habitat fragmentation and habitat loss within its range. The threat of hybridization at its southern edge with the plains gartersnake (*Thamnophis radix*) was also a factor in its listing. Although the species can be found in degraded and disturbed sites, the biological problems associated with fragmentation can be sever and often lead to the extinction of local populations. As local extinctions accumulate, the very survival of the species in Wisconsin hangs in the balance. At the same time, the future of this species must be considered in the context of a rapidly expanding human population in the greater Milwaukee area. In this context, it is vitally important to strike a balance between the ecological requirements of the snake and a responsible economic development plan for the region that promotes controlled growth in appropriate sections of the landscape.

The Wisconsin Department of Natural Resources developed the Butler's Gartersnake Conservation Strategy in 2004 – 2005, that assembled the latest information on its biology and threats. The strategy defines criteria to evaluate a site's conservation value based on the size and quality of the entire habitat patch. Each site is classified within a 3-tiered system, with protection measures identified for each tier. The agency recognized this document as a "work in progress". The time has now come to incorporate the most current science into the strategy, in a way that involves stakeholders to a greater extent using a workshop process for decision-making and action planning. Specifically, inclusion of a formal population viability analysis (PVA) for the species and a more formal deliberative process of decision-making and action planning have been seen as priorities for a revised Strategy.

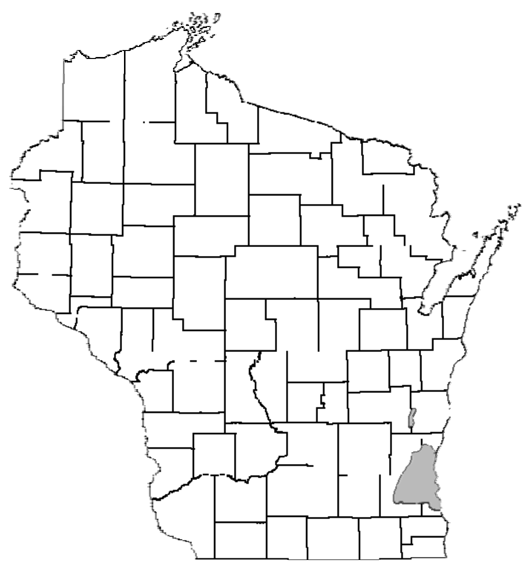

Figure 1. Distribution of Butler's gartersnake (*Thamnophis butleri*) in Wisconsin.

To assist in the completion of this task, the Conservation Breeding Specialist Group (CBSG) of IUCN-The World Conservation Union's Species Survival Commission was invited by The Wisconsin Department of Natural Resources to design and conduct a workshop process that will produce a population viability analysis (PVA) and a set of draft revised conservation strategies for the Butler's gartersnake in Wisconsin. The product of this effort, known as a Population and Habitat Viability Assessment or PHVA, will be a detailed action plan for future management of the Butler's gartersnake and selected elements of its habitat within Wisconsin that can serve as an important component of the statewide Conservation Strategy. This interactive, participatory workshop is designed to broaden stakeholder involvement and enhance information sharing across scientific, social, and economic groups/interests. A number of weeks before this workshop, in order to assemble the biological aspects of the decision-making process for species management, CBSG was asked to conduct a PVA. This analysis consists of a computer simulation that incorporates our knowledge of the biology and ecology of the species – rates of birth and death, population genetic structure, habitat requirements, etc. – and projects the relative performance of gartersnake populations under alternative scenarios of management or lack thereof. Using these alternative projections of population performance, typically described as relative rates of population growth or decline, species managers and interested stakeholders can determine the most effective practices to minimize the risk of extinction of the taxon in Wisconsin.

The PHVA workshop was organized and hosted by the Wisconsin Department of Natural Resources. Participants in the workshop represented a wide variety of stakeholder domains, including local private landowners, state legislators, decision-makers, academic biologists, wildlife managers and other interested parties. The general goals of the workshop were to assist local landowners, biologists, managers and policy makers to: 1) use a demographic simulation model (PVA) to guide and evaluate species management and research activities; 2) formulate priorities for a practical management program for long-term survival of the species in an urbanized environment; and 3) promote effective collaborations between stakeholder domains that foster maintenance of Butler's gartersnake habitat while accommodating thoughtful economic expansion in the region.

The Workshop Process

The PHVA workshop began in the afternoon of 5 February 2007. Nearly 60 participants including private landowners, state wildlife managers, field biologists, academic researchers and NGO representatives gathered together at Milwaukee County's Boerner Botanical Gardens for a brief opening session. Each participant was then asked to introduce themselves and to share with the group their personal goal for the workshop, and to give the group their opinion of the greatest challenge to sustainable management of Butler's gartersnake in a rapidly urbanizing environment. Common themes expressed at this stage revolved around the need for effective communication and cooperation among stakeholders, the current absence of an adequate mechanism for sharing habitat management costs among private landowners, and the importance of using responsible scientific information in the decision-making process. These statements are summarized elsewhere in this report. Next, presentations were given to ensure that everyone was familiar with the process and the available scientific information. The workshop facilitator from CBSG introduced the PHVA process and the role of population modeling in the workshop; presentations then followed on the general biology of the snake, the history and current status of the Conservation Strategy, and the economic development profile of the greater Milwaukee Area. This first day ended with a more detailed presentation on the structure and results of the PVA, conducted before this workshop as a way to inform the biological aspects of gartersnake viability in the context of local land management.

Based on participants' statements of primary conservation challenges and the wealth of information presented throughout the workshop's first day, five working group topics were identified that would form the basis of the workshop's subsequent activities:

- Site Characterization and Prioritization
- Biological Aspects of Habitat Management
- Socio-economic Aspects of Habitat Management
- Population Management
- Communications and Outreach

All workshop participants were invited to choose which group they wanted to join. Through this process of self-selection, workshop participants were provided with the opportunity to contribute their information and perspective in the most effective way.

On the morning of the workshop's second day, the working groups began moving through a set of structured tasks set forth by the workshop facilitator. First, each group was asked to amplify those relevant issues / challenge statements identified the previous day, to identify new challenges of importance to their specific topic, and to prioritize them according to an agreed criterion. The groups were then brought together as a larger group, and each working group shared their information and was able to provide commentary and perspective with their peers. This process of working group sessions, followed by plenary reports and discussion, continued throughout the workshop. Once issues were identified and prioritized, the next working group task centered on assembling the relevant information for each topic in order of priority issue, with an emphasis placed on separating known facts from assumptions, identifying the important justifications around each assumption, and (perhaps most importantly) flagging areas where potentially important information is missing. Through this process, the subsequent identification of management and / or research priorities was greatly enhanced.

Once information assembly was complete, each working group was asked to brainstorm, refine and prioritize goals (one- to five-year activities) designed to address the issues identified previously. Each group brought their top five priority goals to a plenary session on the afternoon of workshop Day 3, and the entire group was then asked to provide an overall sense of priority for these goals based on the importance of achieving these goals for successful management of Butler's gartersnake in a heavily urbanized environment. This was achieved by giving each participant five colored adhesive dots and asking them to distribute those dots amongst those goals they see as both 1) important to resolve, and 2) those they feel they can personally address in a more detailed fashion after the workshop is complete. Since these goals are directly tied to the issues identified in the early stages of the workshop, the workshop design therefore facilitates the resolution of the needs of the diverse stakeholder domains that are present.

With goals in hand, each working group then began the task of identifying specific actions that would achieve those goals. These actions are intended to include important details such as the individual responsible for moving the action forward, a timeline for completion of the action, important collaborators, and specific obstacles to be overcome if the action is to be completed. With this level of detail, those agencies responsible for refining the Conservation Strategy have a valuable set of comprehensive recommendations that can be used to enhance the existing document.

The workshop was not without its contentious moments, which focused largely on the long-standing and difficult issues surrounding conservation of threatened species on private lands. The PHVA workshop process is specifically designed to help stakeholders address these issues and to move towards a shared understanding of the needs of each stakeholder domain with respect to the species conservation challenges put forth at the workshop. Through the structured methods of discussion and analysis discussed here, all participants can make tangible progress in articulating their views and, more importantly, making themselves heard more effectively in the larger community arena. We feel that, with respect to the difficult issues brought out during this workshop, such progress has been made.

Workshop Results

Population Viability Analysis

The PVA analysis used the popular software package *VORTEX*, developed by CBSG for use in the larger conservation planning community. The modeling effort was specifically designed to (*i*) determine those aspects of Butler's gartersnake demography that are primary factors in driving population growth; (*ii*) evaluate known current threats (drought, severe winter, and habitat loss) for their severity in the context of species extinction risk; and (*iii*) investigate the efficacy of alternative management options for the species in Wisconsin, including linking currently isolated patches in a metapopulation configuration or through translocation of individuals among suitable habitat patches.

Our analyses indicate that simulation models of Butler's gartersnake demography are highly sensitive to changes in female juvenile survival rates as well as broader components of adult female reproductive success (i.e., annual frequency of breeding, clutch size, and adult female survival). General management recommendations targeting these aspects of the species' biology are therefore expected to have the greatest positive impact on long-term population viability. Both drought and severe winter were seen to be major factors influencing population viability. More specifically, drought is considered to be most potentially problematic as reproduction is essentially eliminated during periods of extreme rainfall deficit. In addition, the models confirmed expert opinion concerning the impending problems brought about by loss of suitable Butler's gartersnake habitat through invasion of woody vegetation across preferred wetland / upland habitat areas. It is therefore extremely important that high-quality snake habitat is actively managed to reduce the risk of such invasion.

Given our best understanding of Butler's gartersnake biology, we predict that populations composed of less that 40 – 50 adult females are at a significantly higher risk of becoming extinct through demographic instability, compared to their larger counterparts. Moreover, the destabilizing impact of small population size is increased if the population's underlying mortality rates are increased in so-called "urban" habitats, characterized by higher densities of snake predators such as raccoons, domestic cats, etc. compared to more "rural" environments. This observation becomes even more pronounced if we assume that smaller populations are subject to the detrimental effects of inbreeding, usually manifest as a reduction in survival of juveniles produced from matings between relatives. If we are able to create physical linkages between these small populations, through the creation of biological corridors of suitable habitat in otherwise inhospitable terrain, the viability of the individual populations is greatly increased. Such a metapopulation configuration is highly desirable when faced with many populations that, in isolation, are unstable and threatened with extinction.

Finally, preliminary analyses suggest that translocation of groups of snakes, when conducted under optimal conditions, might be possible as a feasible strategy for either augmenting existing snake populations or establishing new populations within patches of suitable habitat. Further research on this subject, however, is still necessary. It is also important to recognize that successful translocation is extremely complicated and requires considerable vigilance if it is to achieve the desired result.

Goals for Management

Shown below is a prioritized list of the top goals identified by each working group, presented in a plenary session on Day 3 of the workshop and then evaluated independently by the entire body of participants. The prioritization was based on each participant's perception of the importance of achieving these goals for successful management of Butler's gartersnake in a heavily urbanized environment.

- Identify and promote potential funding sources and incentives to implement the Conservation Strategy.
- Develop and implement a funding strategy for habitat management.
- Obtain a greater understanding of Butler's gartersnake population density (population size and distribution) in order to refine quantitative targets to ensure self sustaining viable populations in managed lands in southeastern Wisconsin in perpetuity.
- Develop methods to equally and fairly share costs associated with habitat management and protection.
- Maintain existing suitable habitat and enhance poor quality habitat.
- Prioritize sites in greater detail based on both socio-economic and biological issues.
- Determine local and regional planning opportunities to identify lands and potential compatible uses that can significantly affect BGS protection/management.
- Institute a pro-active plan for preservation (survey all sites available and target sites slated for some type of preservation).
- Develop a regulatory framework with flexibility in design and certainty in process.
- Combine effective utilization of protected public lands, where feasible with conservation / education / outreach for all stakeholders.
- Define demographic parameters of Butler's gartersnakes more precisely in order to support management decisions.
- Revise the current Tier system to be more in depth and adaptive to include the latest information available.
- Identify potential suitable habitat sites and linkages between sites.
- Upgrade scientific data as it occurs and providing research opportunities to broad scientific community.
- Revise/simplify and clarify regulations, science, and options to all stakeholders.
- Define suitable BGS habitat more effectively.
- Monitor the habitat of BGS for changes that might be caused by land uses, hydrology changes, and global warming.
- Develop a pool of qualified experts/consultants, while effectively protecting BGS in long term.
- Define the taxonomy of the Butler's/Plains gartersnake species complex through genetic, morphological, and behavioral research.
- Focus all regulatory, management, protection and scientific efforts on priority patches as established by a site characterization group.
- Identify common values and build from them to foster community building through cooperation and compromise.
- Coordinate research to define and prioritize research needs and avoid duplication of efforts.

It is significant to note that resolution of a major point of discussion in this workshop – namely, the difficulties around sharing the cost of Butler's gartersnake management among a more diverse body of stakeholders – was identified as high priority by the full body of participants. This is a testament to the process achieving its goal of interdisciplinary dialog and problem-solving for practical management.

The action steps constructed by each working group, tied to the goals they specified in their own deliberations (and, where appropriate, for those goals classified as high priority overall in plenary), are to be found in each of the individual working group reports within this document.

While the activities of all working groups are critical to the evolution of the current Conservation Strategy, the work of the Site Characterization and Prioritization group was of particular relevance to the clarification of quantitative management targets for the species in the region. This issue has been particularly contentious in the early phases of Strategy development and implementation. This working group ultimately split into two sub-groups along lines of biological or socio-economic expertise in order to develop detailed criteria that could be applied to the characterization of any given site's suitability for long-term Butler's gartersnake conservation. The complexity of such a two-tiered scheme quickly became apparent, but important progress was made at the workshop on completing the protocol. Near the conclusion of the workshop, the full body of participants agreed that this scheme would soon be used to further clarify the value of individual sites for Butler's gartersnake conservation; with such clarity at hand, and with the results of the PVA as further guidance, a revised target for the number of sites required for successful management of the species is possible (see Appendix 1).

By combining the use of rigorous scientific analysis of biological data with thoughtful and structured discussion of the needs of diverse stakeholder domains, the PHVA workshop was a valuable tool for natural resource management priority-setting in the greater Milwaukee area. Those involved in its organization and implementation hope that it will serve as a model for responsible rare species conservation planning in and around the region.

Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin:
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II
Workshop Participants and Preliminary List of Challenges

Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin: Population and Habitat Viability Assessment The Stakeholder Workshop

Workshop Participants

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What, in your view, is the primary challenge for sustainable management of Butler's gartersnake over the next 25 years?

The list below is a compilation of responses to the question stated above, among all PHVA workshop participants on the first day of the process. This is intended to provide the workshop facilitator with a sense of the primary issues to be discussed at the workshop, and is also meant to give all stakeholders a sense of shared appreciation of the challenges they face as they work to provide practical recommendations to the management authorities present at the workshop. The list is presented in no particular order.

- Achieving community involvement and cooperation in land use planning and resource conservation
- Maintaining viable populations of Butler's gartersnakes through habitat conservation and gene flow
- Establishing compensation schemes for individuals affected by conservation – understanding the costs and developing an equitable way to pay
- Increasing urbanization
- Dwindling connection among urban dwellers with the state's natural heritage
- Balancing the competing land value interests (economic, public use) of Butler's gartersnake habitat
- Developing an adequate number of viable sites for Butler's gartersnake habitat
- To arrive at a path to a standard solution that everybody can live with
- Finding a scientifically-based balance between the needs of humans and the needs of Butler's gartersnake
- Appropriating adequate financial resources to protect Butler's gartersnake habitat.
- Finding common ground in our search for sustainable natural resource management
- Development pressure on Butler's gartersnake habitat
- Protecting and maintaining adequate amount of suitable habitat to sustain the species for the next 25 years
- Balancing continued pressure for both development and conservation of snake habitat
- Habitat protection and development of an appropriate management plan for controlling habitat conditions on protected sites
- Finding a balance between responsible habitat management with the needs of landowners to pursue their goals
- To maintain large enough parcels, so preferably contiguous, to sustain successful breeding populations of Butler's gartersnakes in southeast Wisconsin.
- Limiting human encroachment within fragmented Butler's gartersnake habitat.
- To develop a conservation plan that preserves the integrity of Tier 3 sites while allowing for some level of development within those sites – mitigation vs. conservation
- Increasing lack of quality habitat and the associated high costs of conserving what's left
- Fragmentation of habitat, intensifying land use
- Maintaining connectivity between populations
- Working within the specified constraints as a regional agency with the primary purpose of wastewater treatment
- Securing long-term management of sites to maintain suitable habitat
- Securing adequate habitat to maintain genetically viable Butler's gartersnake populations
- To maintain the viability of Butler's gartersnake in the state without having to rely on private lands
- To develop equitable means of sharing the costs of habitat stewardship and management
- Ensuring practicality and flexibility remain within the long-term management strategy

- Learning more about the snake's biology and ecology so that the emerging conservation strategy is as productive as it can be
- To develop an equitable method of cost-sharing when identifying conservation measures
- Moving away from small-parcel management to more effective, cumulative conservation methods
- Balancing snake conservation with advancing the well-being of the local community
- To restore the perception of the Wisconsin DNR to a helpful agency that communicates and cooperates with local citizens, and not an adversarial political agency
- Sharing of the financial burden of snake conservation
- Habitat loss
- Lack of information on species biology – how to manage when little is known?
- Gaining the trust of private landowners in the creation of snake management strategies
- To find a scientifically rigorous conservation strategy that also works with those local individuals that must bear the burden of implementing that strategy
- Identifying and obtaining long-term protection of important sites housing Butler's gartersnake
- Rampant economic development and habitat destruction
- Regional economic growth and preservation / management of snake habitat
- Inadequate funding of scientific research that is used to make species management decisions
- Inadequate funding to implement conservation management decisions
- Providing large enough areas of managed habitat that will allow the snakes to live out their life cycles without significant disturbance from economic development
- Instituting regulations that will truly protect the species and its habitat for the long term
- Communicating the importance of species conservation to the larger issue of biodiversity protection
- Habitat loss – economic development and invasive plant encroachment
- Securing adequate funding for research, management, and other costs associated with implementing the Butler's gartersnake conservation strategy
- To foster the realization that it isn't just about the snakes – that what this is really about us responsible and creative limitation of habitat destruction on a broad scale across the region
- To develop human activities on the landscape in southeastern Wisconsin that are more compatible with the needs of Butler's gartersnake
- How to deal with growing human economic development pressures
- Implementation of the conservation strategy, including protection and management
- Securing adequate funding for proper habitat management
- To reach an agreement among stakeholders within a reasonable time period of the best options for habitat management to ensure Butler's gartersnake survival in the state
- To balance local human population needs with critical needs of the local wildlife

Butler’s Gartersnake (*Thamnophis butleri*) in Wisconsin:
Population and Habitat Viability Assessment
The Stakeholder Workshop

5 – 8 February, 2007
Milwaukee County, Wisconsin

III
Butler’s Gartersnake Population Viability Analysis

Population Viability Analysis for Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin

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In collaboration with

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December 2006 – January 2007

Population Viability Analysis for Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin

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Population Viability Analysis for Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin

Introduction

The Wisconsin Department of Natural Resources developed the Butler's Gartersnake Conservation Strategy in 2004 – 2005, that assembled the latest information on its biology and threats. The strategy defines criteria to evaluate a site's conservation value based on the size and quality of the entire habitat patch. Each site is classified within a 3-tiered system, with protection measures identified for each tier. The agency recognized this document as a "work in progress". The time has now come to incorporate the most current science into the strategy, in a way that involves stakeholders to a greater extent using a workshop process for decision-making and action planning. Specifically, inclusion of a formal population viability analysis (PVA) for the species and a more formal deliberative process of decision-making and action planning have been seen as priorities for a revised Strategy.

The Conservation Breeding Specialist Group, of the IUCN – World Conservation Union's Species Survival Commission, was asked to conduct a PVA in anticipation of the Butler's gartersnake PHVA workshop. This analysis was conducted from early December, 2006 to late January, 2007.

Population viability analysis (PVA) can be an extremely useful tool for investigating current and future risk of Butler's gartersnake population decline or extinction. The need for and consequences of alternative management strategies can be modeled to suggest which practices may be the most effective in managing Butler's gartersnake populations in its wild habitat. *VORTEX*, a simulation software package written for PVA, was used here as a vehicle to study the interaction of a number of Butler's gartersnake life history and population parameters, to explore which demographic parameters may be the most sensitive to alternative management practices, and to test the effects of selected management scenarios.

The *VORTEX* package is a simulation of the effects of a number of different natural and human-mediated forces – some, by definition, acting unpredictably from year to year – on the health and integrity of wildlife populations. *VORTEX* models population dynamics as discrete sequential events (e.g., births, deaths, sex ratios among offspring, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or random variables that follow specified distributions. The package simulates a population by recreating the essential series of events that describe the typical life cycles of sexually reproducing organisms.

PVA methodologies such as the *VORTEX* system are not intended to give absolute and accurate "answers" for what the future will bring for a given wildlife species or population. This limitation arises simply from two fundamental facts about the natural world: it is inherently unpredictable in its detailed behavior; and we will never fully understand its precise mechanics. Consequently, many researchers have cautioned against the exclusive use of absolute results from a PVA in order to promote specific management actions for threatened populations (e.g., Ludwig 1999; Beissinger and McCullough 2002; Reed et al. 2002; Ellner et al. 2002; Lotts et al. 2004). Instead, the true value of an analysis of this type lies in the assembly and critical analysis of the available information on the species and its ecology, and in the ability to compare the quantitative metrics of population performance that emerge from a suite of simulations, with each simulation representing a specific scenario and its inherent assumptions about the available data and a proposed method of population and/or landscape management. Interpretation of this type of output depends strongly upon our knowledge of Butler's gartersnake biology in its habitat, the environmental conditions affecting the species, and possible future changes in these conditions.

The *VORTEX* system for conducting population viability analysis is a flexible and accessible tool that can be adapted to a wide variety of species types and life histories as the situation warrants. The program has been used around the world in both teaching and research applications and is a trusted method for assisting in the definition of practical wildlife management methodologies. For a more detailed explanation of *VORTEX* and its use in population viability analysis, refer to Appendix I, Lacy (2000) and Miller and Lacy (2003).

Specifically, we were interested in using this preliminary analysis to address the following questions:

- Can we build a series of computer simulation models with sufficient detail and precision that describe the dynamics of Butler's gartersnake (BGS) populations across Wisconsin with reasonable accuracy?
- What are the primary demographic factors that drive growth of BGS populations?
- What are the predicted impacts of catastrophic natural events such as drought and severe winter on BGS populations? How might a global warming scenario affect drought and its impacts on BGS population persistence?
- How vulnerable are small, fragmented populations of Greater BGS in Wisconsin to extinction under current management conditions? How small must a population become to increase its risk of extinction to an unacceptable level?
- Can inbreeding depression significantly affect the viability of BGS populations?
- What are the predicted impacts of habitat loss throughout the greater Milwaukee metropolitan area, primarily through the introduction of shrubby vegetation, on the future viability of BGS populations? Are small snake populations at a particularly high risk of rapid extinction in the presence of this threat?
- Can the creation of metapopulations through linking isolated subpopulations increase overall BGS population viability? What role does dispersal play in this scheme?
- Can translocation of BGS into unoccupied habitats be an effective species management tool?

Baseline Input Parameters for Stochastic Population Viability Simulations

There are very few detailed studies on the population demography and biology of Butler's gartersnake in Wisconsin, or across its larger range. It is therefore necessary to use data from demographic and ecological studies from closely-related species, such as Eastern Plains (*T. radix*) or Common (*T. sirtalis*) gartersnakes where appropriate (Ernst and Ernst, 2003; Stanford and King, 2004; Shine and Mason, 2004; Lind et al., 2005). In the absence of field data, expert opinion and estimation was used to arrive at required model input values.

A general characteristic of the models described below is the creation of two different life tables (descriptions of general birth and death rates) based on presumed slight differences in juvenile mortality. These differences in juvenile mortality were assumed to be brought about by differential predation by such animals as raccoons, domestic cats, etc. that are in higher density in what we refer to here as "Urban" environments. This is in contrast to more "Rural" environments where urban modifications to local habitats which promote high predator densities are absent. In order to assess the viability of populations under minimally acceptable growth conditions, we developed an "Urban" life table that results in a slightly positive mean stochastic growth rate ($r_s \approx 0.005$). In contrast, the "Rural" population life table was adjusted via juvenile mortality to produce a mean stochastic growth rate of approximately 0.020. Details on the necessary adjustments are given in more detail below.

These alternative life tables were developed for two reasons: (*i*) since no estimates exist for population growth rate estimates in the field for this species, we wanted to investigate the risks associated with different growth dynamics as a general measure of model sensitivity; and (*ii*) we thought it instructive to analyze relative risks for populations that may be more susceptible to the stresses of an urbanizing environment such as that currently defining the greater Milwaukee area.

Breeding System: We assumed for our analyses that Butler's gartersnake exhibits a polygynous breeding system. In *VORTEX*, a set of adult females are therefore randomly selected each year to breed with a given male. Recent data actually suggest that this and many other snake species may in fact display significant levels of polyandry, in which a single female may mate with multiple males during a given breeding season (Rivas and Burghardt, 2005). From a strictly demographic point of view, either polygyny or polyandry will result in sufficient opportunities for available adult females to engage in breeding; consequently, we do not see fundamental problems associated with assuming polygyny in our models. Comparison of the population genetic consequences of polygyny v. polyandry is more complex; nevertheless, we feel that the genetic costs of inbreeding in the two alternative systems will be sufficiently similar to allow us to confidently use polygyny in our models.

Age of First Reproduction: *VORTEX* considers the age of first reproduction as the age at which the first clutch of eggs is laid, not simply the onset of sexual maturity. Reproductive capability in snakes is defined more accurately in terms of size as opposed to age. However, age – size class statistical analysis allows us to transform size data to age data with acceptable accuracy. Based on these analyses, we assume that females begin reproducing at three years of age, and males at two years of age.

Age of Reproductive Senescence: In its simplest form, *VORTEX* assumes that animals can reproduce (at the normal rate) throughout their adult life. There is no evidence for reproductive senescence in Butler's gartersnake. Mark-recapture data for T. radix in the field suggests that animals can live for up to six years, with an absolute maximum longevity of perhaps as much as eight years. We assumed a longevity of six years in our models.

Offspring Production: Butler's gartersnake mates in early spring and is ovoviviparous, giving birth in July to September. Field coverboard surveys suggest approximately 50% of adult females are gravid at any one observation period, but this is an imprecise estimate that has alternatively been classified as either an under- or overestimate, depending on the perspective of the individual researcher. We ultimately agreed on 70% as the baseline value for annual adult female breeding frequency, defined as the overall percentage of adult females that are expected to produce offspring in a given year.

Annual environmental variation in female reproductive success is modeled in *VORTEX* by specifying a standard deviation (SD) for the proportion of adult females that successfully produce offspring in a given year. In the absence of long-term datasets required to estimate this parameter, we assumed a standard deviation of 10%. Under these conditions, we would expect adult female breeding frequency to vary among years between approximately 50% and 90% (70±2SD).

The maximum number of offspring per breeding event has been set at 12, based on observation of twenty-six Wisconsin litters. A very small number of litters had up to sixteen young, but the group concluded that twelve was a more reasonable upper limit to the larger number of litters produced in our simulation models. Data from ?? suggest an average litter size of 9.17 offspring per litter, with a standard deviation of 3.0. This value was used as our baseline value.

Density-Dependent Reproduction: *VORTEX* can model density dependence with an equation that specifies the proportion of adult females that reproduce as a function of the total population size. In addition to including a more typical reduction in breeding in high-density populations, the user can also model an Allee effect: a decrease in the proportion of females that bread at low population density due, for example, to difficulty in finding mates that are widely dispersed across the landscape.

There are no data to support density-dependent breeding in Butler's gartersnakes, where high levels of breeding success can apparently occur under very high population density conditions. This component was therefore not included in our modeling efforts.

Male Breeding Pool: In many species, some adult males may be socially restricted from breeding despite being physiologically capable. This can be modeled in *VORTEX* by specifying a portion of the total pool of adult males that may be considered "available" for breeding each year. We assume here that each adult male is equally capable of successfully reproducing in a given year, although the actual proportion of successful males may be considerably less for any specific year.

Mortality: *VORTEX* defines mortality as the annual rate of age-specific death from year x to $x + 1$; in the language of life-table analysis, this is equivalent to $q(x)$. Mortality rates are shown below. Since specific mortality data do not exist for Butler's gartersnake populations in Wisconsin, we anchored our analyses on the studies of Eastern Plains gartersnakes by Stanford and King (2004). We were also interested in creating a mortality schedule with slightly higher adult male mortality to reflect the increased competition among males for mates in a polyandrous system.

Age Class	% Mortality (SD)			
	Urban		Rural	
	Females	Males	Females	Males
0 – 1	**64.5 (10.0)**	**64.5 (10.0)**	**62.8 (10.0)**	**62.8 (10.0)**
1 – 2	42.0 (7.0)	35.0 (7.0)	42.0 (7.0)	35.0 (7.0)
2 – 3	35.0 (5.0)	30.0 (5.0)	35.0 (5.0)	30.0 (5.0)
3 - +	25.0 (5.0)	30.0 (5.0)	25.0 (5.0)	30.0 (5.0)

The bold values indicate the quantitative difference between Urban and Rural life tables, with the Rural scenario corresponding to slightly lower predation rates in more "natural" environments.

Catastrophes: Catastrophes are singular environmental events that are outside the bounds of normal environmental variation affecting reproduction and/or survival. Natural catastrophes can be tornadoes, floods, droughts, disease, or similar events. These events are modeled in *VORTEX* by assigning an annual probability of occurrence and a pair of severity factors describing their impact on mortality (across all age-sex classes) and the proportion of females successfully breeding in a given year. These factors range from 0.0 (maximum or absolute effect) to 1.0 (no effect), and in its most basic implementation in *VORTEX*, are imposed during the single year of the catastrophe, after which time the demographic rates rebound to their baseline values. We concluded that (*i*) extreme drought and (*ii*) severe winter would be appropriate natural events that could result in catastrophic reductions in demographic performance among Butler's gartersnake populations.

Using meteorological data to identify significant rainfall deficits in the greater Milwaukee area, we assumed that extreme drought would occur on average once every twenty years, thereby giving an annual probability of occurrence of 5%. When drought was deemed to be in effect, we assumed that adult females directed all their resources to survival; when combined with presumed high levels of juvenile mortality, we assume that such an event effectively eliminates reproduction during drought years.

To further investigate the impacts of drought, we investigated models where the expected frequency of drought would increase due to global warming scenarios. Specifically, we wrote simple mathematical functions for catastrophe frequency that would increase the value in a linear fashion from the baseline level of 5% to either 10% or 15% over a 100-year period.

The impacts of severe winter weather on snake population dynamics have been investigated before (e.g., Altwegg et al., 2005) and have shown that juveniles are affected particularly strongly. We assume a 5% probability of occurrence of severe winter in any given year. Moreover, during a severe winter event we assume that the survival of juvenile Butler's gartersnakes is reduced by 50% (this is implemented in *VORTEX* as an age-specific mathematical function in the Catastrophe Severity field). These two events are simulated as independent processes, meaning that they could both occur in the same year (probability of such a combined event = [0.05] x [0.05] = 0.0025).

Inbreeding Depression: *VORTEX* includes the ability to model the detrimental effects of inbreeding, most directly through reduced survival of offspring through their first year. There are no specific data on inbreeding depression in Butler's gartersnake, but studies focused on other snake species (e.g., Madsen et al., 1996) suggest that the deleterious impacts of inbreeding may be evident in this group of taxa. Consequently, we included a genetic load in selected scenarios in order to gauge its impact on population viability. We chose a genetic load of 3.00 lethal equivalents, which describes the numerical relationship between the extent of inbreeding in a given mating between related individuals and the survival rate of the resultant offspring: the larger the number of lethal equivalents, the more severe the reduction in survival will be. This estimate of genetic load is loosely based on a detailed study of inbreeding effects among more than forty captive mammal species (Ralls et al., 1988).

Initial Population Size: There are currently no data available to estimate the size of Butler's gartersnake populations in southeastern Wisconsin. As a result, our baseline models were initialized with an arbitrary number of 300 individuals. In selected models designed to investigate extinction risk as a function of population size, values for N_0 ranged from 10 to 500 adult females. Baseline model analysis indicated that adult females comprise approximately 18% of the total population at demographic equilibrium. Therefore, total population size in our risk analysis models ranged from approximately 55 to 2700 individuals of all age-sex classes.

VORTEX distributes the specified initial population among age-sex classes according to a stable age distribution that is characteristic of the mortality and reproductive schedules described previously.

Carrying Capacity: The carrying capacity, K, for a given habitat patch defines an upper limit for the population size, above which additional mortality is imposed randomly across all age classes in order to return the population to the value set for K.

The estimation of a carrying capacity for any wildlife population is a very difficult process. These data do not exist for Wisconsin populations of Butler's gartersnake. In their absence, we assumed for our models that the carrying capacity is equivalent to approximately twice the initial population size. Since we are dealing most frequently with simulated populations that have very low to only moderate growth potential (and also have high levels of environmental variability affecting population growth), we do not expect the precise characterization of K to strongly influence extinction dynamics in our analysis.

Table 1 below summarizes the baseline input dataset upon which all subsequent *VORTEX* models are based.

Table 1. Demographic input parameters for the baseline *VORTEX* Butler's gartersnake models. See accompanying text for more information.

Model Input Parameter	Baseline Value
Breeding System	Polygynous
Age of first reproduction (♀ / ♂)	3 / 2
Maximum age of reproduction	6
Annual % adult females reproducing (SD)	70.0 (10.0)
Density dependent reproduction?	No
Maximum litter size	12
Mean clutch size	9.17 (3.0)
Overall offspring sex ratio	0.5
Adult males in breeding pool	100%
% annual mortality, ♀ / ♂ (SD)	
0 – 1 (Urban, Rural)	64.5, 62.8 / 64.5, 62.8 (10.0)
1 – 2	42.0 / 35.0 (7.0)
2 – 3	35.0 / 30.0 (5.0)
3 +	25.0 / 30.0 (5.0)
Initial population size / carrying capacity	300 / 600
Risk analysis range	55 – 2715 / 110 – 5430

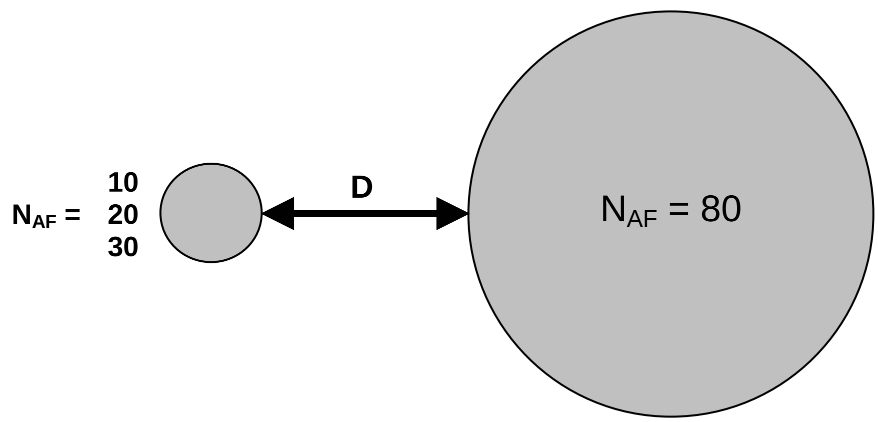
Input Parameters for Additional Management-Based Simulations

Habitat Loss: The introgression of woody vegetation into currently suitable Butler's habitat is seen as a major threat to the continued persistence of the species in the state. Because of demographic instability associated with small population size, snake populations may become extinct even more rapidly than would be predicted under simpler linear projections of loss of habitat carrying capacity. To study this prediction, models were created that included a linear rate of decline in habitat carrying capacity that reduced K to zero in 50 years. It is important to recognize that this is a set of illustrative models and is not meant to describe a precise prediction of habitat loss based on detailed field studies of exotic floral invasions.

Metapopulation Risk Analysis: We constructed a large series of models that simulated the physical linkage of otherwise isolated subpopulations through dispersal, thereby creating a metapopulation. In general, we assumed that all individuals of both sexes, from yearlings to the oldest age classes, were capable of dispersing. We also alternatively assumed either no mortality cost to dispersal, or 25% mortality cost. This component of the model is open to significant additional discussion, as the ecological and demographic characteristics of the dispersal process in gartersnake populations is largely unknown.

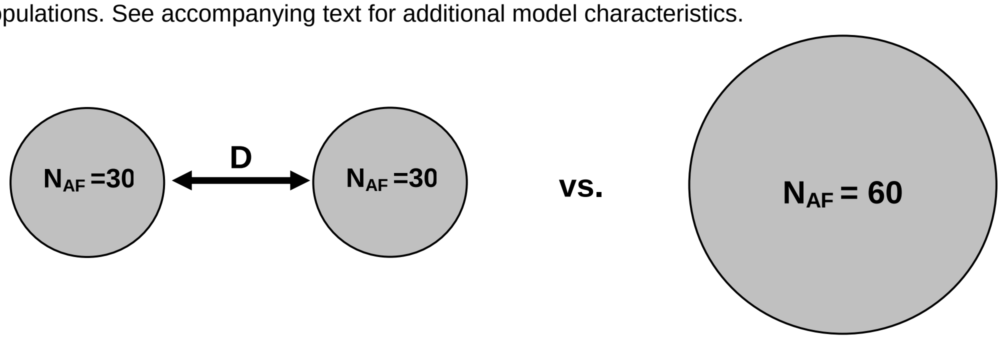
In our first analysis, shown schematically in Figure 1, we linked a large "source" population, composed of 80 adult females, to a smaller "recipient" population composed of 10, 20, or 30 adult females. The symmetric dispersal value, D, defines the probability that an individual will disperse from one population to another in a given year. This parameter was set at various values ranging from 0.0% (no dispersal) to 8.0% per year. Furthermore, we assumed that the larger source population was either in an Urban or Rural setting, thereby modifying its underlying demography and subsequent growth potential. The smaller recipient population was always assumed to be an Urban population.

Figure 1. Metapopulation analysis I population configuration. Two populations composed of different numbers of adult females (NAF) are linked together through a specific rate of symmetric dispersal, D. See accompanying text for additional model characteristics.



In our second metapopulation analysis (Figure 2), we investigated the characteristics required to create two linked populations that would have the same general demographic profile as a single population of equivalent size. All populations are assumed to be in Urban environments, with dispersal rates ranging from 0% (no dispersal) to 10% per year.

Figure 2. Metapopulation analysis II population configuration. Two populations composed of equal numbers of adult females (NAF) are linked together through a specific rate of symmetric dispersal, D. This is compared to a single larger population composed of the sum of the individual populations. See accompanying text for additional model characteristics.



Translocation Analysis: A set of scenarios was developed to investigate the feasibility of using translocation of individuals to initiate new Butler's gartersnake populations. We did this using the Supplementation option in *VORTEX*, where a specified number of individuals of given age-sex classes can be added with a specific frequency during the simulations. We added 5, 10, 15, 20, or 25 adult females and a maximum of 10 adult males to an "empty" habitat at the beginning of the simulation (initial population size set at zero). Additionally, in some scenarios we added an equivalent number of individuals to the habitat in year 2 to represent additional effort in attempting to establish a new population. The translocated individuals are added near the end of the simulation timestep, so their first opportunity for breeding would be at the beginning of the following timestep, with no mortality occurring in the intervening period. *VORTEX* must assign an age to each individual added to the new population, which is equal to the earliest age of adulthood – here, three years for females and two years for males. All translocated individuals are assumed to be unrelated to each other. These alternatives were repeated for both Urban and Rural landscapes, with and without the inclusion of inbreeding depression.

Iterations and Years of Projection: All population projections (scenarios) were simulated 500 times, with each projection extending to 100 years. All simulations were conducted using *VORTEX* version 9.60 (June 2006).

Definitions of Simulation Modeling Results

Results reported for each modeling scenario include:

r_s – The mean rate of stochastic population growth or decline demonstrated by the simulated populations, averaged across years and iterations. This population growth rate is calculated each year of the simulation, prior to any truncation of the population size due to the population exceeding the carrying capacity. Usually, this stochastic *r* will be less than the deterministic *r* predicted from birth and death rates. The stochastic *r* from the simulations will be close to the deterministic *r* if the population growth is steady and robust. The stochastic *r* will be notably less than the deterministic *r* if the population is subjected to large fluctuations due to environmental variation, catastrophes, or the genetic and demographic instabilities inherent in small populations.

P(E) – The probability of population extinction, determined by the proportion of 500 iterations within that given scenario that have declined in population size to zero, or have populations that are composed of only one sex at the end of the simulation.

N_{100} – Mean population size at the end of the simulation, averaged across those simulated populations that are not extinct.

$SD(N_{100})$ -- Variation across simulated populations (expressed as the standard deviation) in the size of the population at each time interval. Standard Deviations greater than about half the size of mean N often indicate highly unstable population sizes, with some simulated populations very near extinction. When SD(N) is large relative to N, and especially when SD(N) increases over the years of the simulation, then the population is vulnerable to large random fluctuations and may go extinct even if the mean population growth rate is positive. SD(N) will be small and often declining relative to N when the population is either growing steadily toward the carrying capacity or declining rapidly (and deterministically) toward extinction.

H_{100} – The gene diversity or expected heterozygosity of the extant populations, expressed as a percent of the initial gene diversity of the population. Fitness of individuals usually declines proportionately with gene diversity (Lacy 1993), with a 10% decline in gene diversity typically causing about 15% decline in survival of captive mammals (Ralls et al. 1988). Impacts of inbreeding on wild populations are less well known, but may be more severe than those observed in captive populations (Miller, 1994; Jiménez et al. 1994). Adaptive response to natural selection is also expected to be proportional to gene diversity. Long-term conservation programs often set a goal of retaining 90% of initial gene diversity (Soulé et al. 1986). Reduction to 75% of gene diversity would be equivalent to one generation of full-sibling or parent-offspring inbreeding.

Baseline Model Projections

Figure 3 shows a representative subset of iterations of Butler's gartersnake population dynamics in a simulated Urban environment. It is important to recognize the high degree of variability that characterizes this set of simulations: while one simulated population declines to extinction after approximately 85 years, another simulation nearly doubles in size after 100 years. This variability in outcome is the product of realistic levels of variability in demographic rates that define our simulation model.

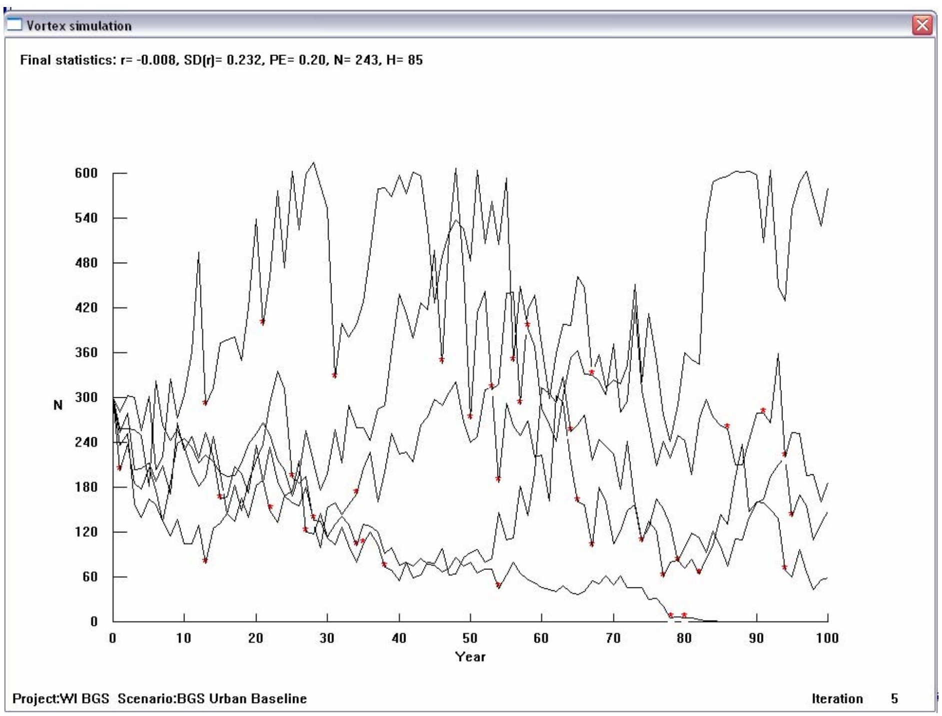


Figure 3. Subset of iterations from the Butler's gartersnake baseline model in an Urban environment. Note extinction in one iteration at year 85, the impact of catastrophes (indicated by asterisks), and the capacity for high levels of population variability across years. See accompanying text for additional information on model construction.

The full trajectories for both Urban and Rural environments, averaged across all extant populations, are shown in Figure 4. The mean stochastic population growth rates are as desired, thereby giving us a reliable starting point for subsequent risk assessment modeling efforts. Additionally, it is useful to note that, even in the presence of positive mean annual population growth ($r_s > 0.0$) in both simulated environments, a risk of population extinction still exists. This is a graphical demonstration of the role that stochastic fluctuation in mean demographic rates, coupled with infrequent catastrophic events, can play in determining the long-term fate of a Butler's gartersnake population. In other words, even if we expect a population to be demographically robust in the long term, there is a chance that bad luck can reduce the stability of a population to the point that it declines to extinction. Out goal in subsequent analyses, then, is to investigate how other factors influence these measures of population performance, and how alternative habitat and/or population management strategies can be used to minimize the risk of population decline and extinction.

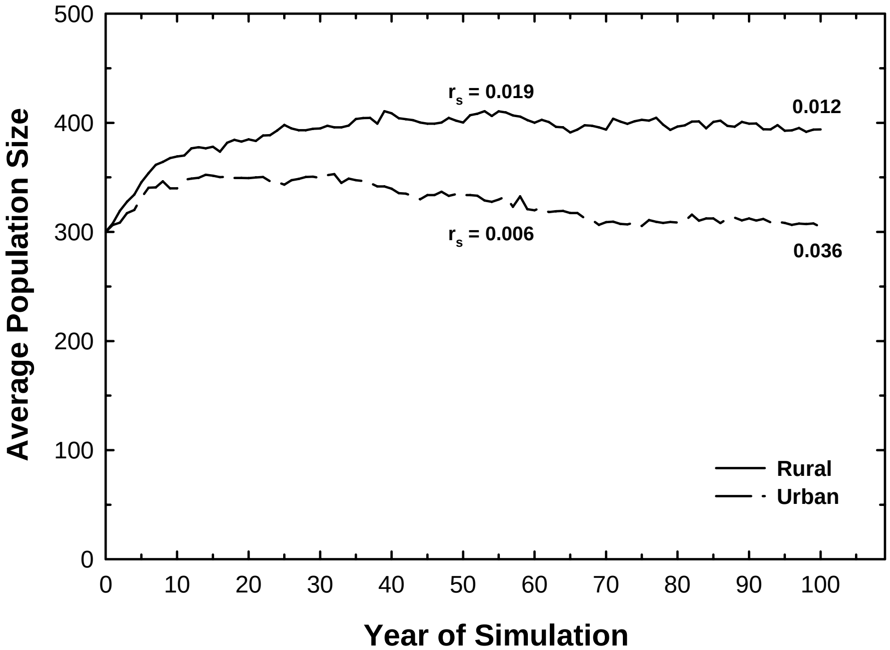


Figure 4. Projections of population size for simulated Butler's gartersnake populations in Urban (dashed line) and Rural (solid line) environments. Average population growth rates are shown, with extinction probabilities (P(E)) given near the right side of each plot. See accompanying text for additional information on model construction.

Demographic Sensitivity Analysis

During the development of the baseline input dataset, it quickly became apparent that a number of demographic characteristics of Butler's gartersnake populations were being estimated with varying levels of uncertainty. This type of measurement uncertainty, which is distinctly different from the annual variability in demographic rates due to extrinsic environmental stochasticity and other factors, impairs our ability to generate precise predictions of population dynamics with any degree of confidence. Nevertheless, an analysis of the sensitivity of our models to this measurement uncertainty can be an invaluable aid in identifying priorities for detailed research and/or management projects targeting specific elements of the species' population biology and ecology.

To conduct this demographic sensitivity analysis, we identify a selected set of parameters from Table 1 whose estimate we see as considerably uncertain. We then developed proportional minimum and maximum values for these parameters (see Table 2). For each of these parameters we constructed two simulations, with a given parameter set at its prescribed minimum or maximum value, with all other parameters remaining at their baseline value. With the ten parameters identified in our analysis, and recognizing that the aggregate set of baseline values constitute our single baseline model, Table 2 allows us to construct a total of twenty additional, alternative models whose performance (defined here in terms of average population growth rate) can be compared to that of our starting baseline model.

All of our sensitivity analysis models assumed a mortality schedule diagnostic of an Urban environment, and were initialized with 300 individuals as in the baseline models previously described. Carrying capacity was set at 600 individuals.

The proportional sensitivity of a given simulation model, *S*, is given by

$$S = [(\lambda_{Min} - \lambda_{Max}) / (0.2^* \lambda_{Base})]$$

Where $\lambda = e^r$ is the annual rate of population growth calculated from the simulation and subscripts *Min*, *Max* and *Base* refer to simulations that include the minimum, maximum, and baseline values of the appropriate parameter, respectively. Using this formulation, model parameters with large *S* values show strong differences in λ when values are manipulated (modified from Heppell et al., 2000).

The results of the sensitivity analysis are shown in tabular form in Tables 2 (rightmost column) and 3 and graphically in Figure 5. Those parameters with the largest S value, and those lines with the steepest slope – namely, juvenile (chick) female mortality, clutch size, and adult female mortality – show the greatest degree of response in terms of population growth rate to changes in those parameters and, hence, the greatest sensitivity.

Table 2. Uncertain input parameters and their stated ranges for use in demographic sensitivity analysis for Butler's gartersnake. Highlighted rows indicate those demographic parameters that show the highest sensitivity, *S*, as listed in the far right-hand column of the table. See accompanying text for more information.

		Estimate		
Model Parameter	Minimum	Baseline	Maximum	*S*
% Juvenile Female Mortality	58.05	64.5	70.95	0.487
Mean Clutch Size	8.25	9.17	10.09	-0.270
% Adult Females Breeding	63.0	70.0	77.0	-0.269
% Adult Female Mortality	22.5	25.0	27.5	0.100
EV, % Adult Females Breeding	9.0	10.0	11.0	0.005
EV, % Juvenile Female Mortality	9.0	10.0	11.0	-0.005
EV, % Adult Male Mortality	4.5	5.0	5.5	-0.005
% Adult Male Mortality	27.0	30.0	33.0	0.000
EV, Mean Clutch Size	2.7	3.0	3.3	0.000
EV, % Adult Female Mortality	4.5	5	5.5	0.000

Those parameters with the greatest sensitivity can then be targeted in subsequent field activities for more detailed research and / or demographic management, where appropriate. However, it is important to remember that sensitive demographic parameters may not always be the subject of demographic impairment through local human activity. Thoughtful analysis of the mechanisms responsible for such impairment should accompany the development of effective population or habitat management strategies.

Table 3. Butler's gartersnake PVA. Output from demographic sensitivity analysis models. See text for additional information on model construction and parameterization.

Scenario	r_s (SD)	PE_{100}	N_{100} (SD)	GD_{100}
Baseline	0.006 (0.234)	0.036	323 (187)	0.853
Juv. Female Mortality – Minimum	0.049 (0.229)	0.000	507 (108)	0.918
Juv. Female Mortality – Maximum	-0.049 (0.277)	0.712	65 (92)	0.567
Mean Clutch Size – Minimum	-0.023 (0.253)	0.330	137 (133)	0.734
Mean Clutch Size – Maximum	0.031 (0.233)	0.008	436 (147)	0.900
Adult Females Breeding – Minimum	-0.024 (0.259)	0.336	132 (142)	0.705
Adult Females Breeding – Maximum	0.030 (0.230)	0.004	443 (141)	0.902
Adult Female Mortality – Minimum	0.016 (0.229)	0.018	381 (175)	0.876
Adult Female Mortality – Maximum	-0.004 (0.239)	0.124	257 (180)	0.823
EV, Adult Females Breeding – Minimum	0.007 (0.232)	0.042	323 (179)	0.840
EV, Adult Females Breeding – Maximum	0.006 (0.236)	0.066	319 (185)	0.845
EV, Juv. Female Mortality – Minimum	0.005 (0.235)	0.062	314 (187)	0.845
EV, Juv. Female Mortality – Maximum	0.006 (0.243)	0.044	297 (178)	0.838
EV, Adult Male Mortality – Minimum	0.006 (0.231)	0.042	320 (182)	0.851
EV, Adult Male Mortality – Maximum	0.007 (0.233)	0.044	318 (186)	0.847
Adult Male Mortality – Minimum	0.007 (0.231)	0.054	323 (186)	0.845
Adult Male Mortality – Maximum	0.007 (0.238)	0.044	321 (180)	0.847
EV, Mean Clutch Size – Minimum	0.007 (0.233)	0.054	326 (182)	0.853
EV, Mean Clutch Size – Maximum	0.007 (0.235)	0.034	324 (176)	0.844
EV, Adult Female Mortality – Minimum	0.005 (0.236)	0.056	303 (186)	0.842
EV, Adult Female Mortality – Maximum	0.005 (0.234)	0.048	302 (182)	0.836

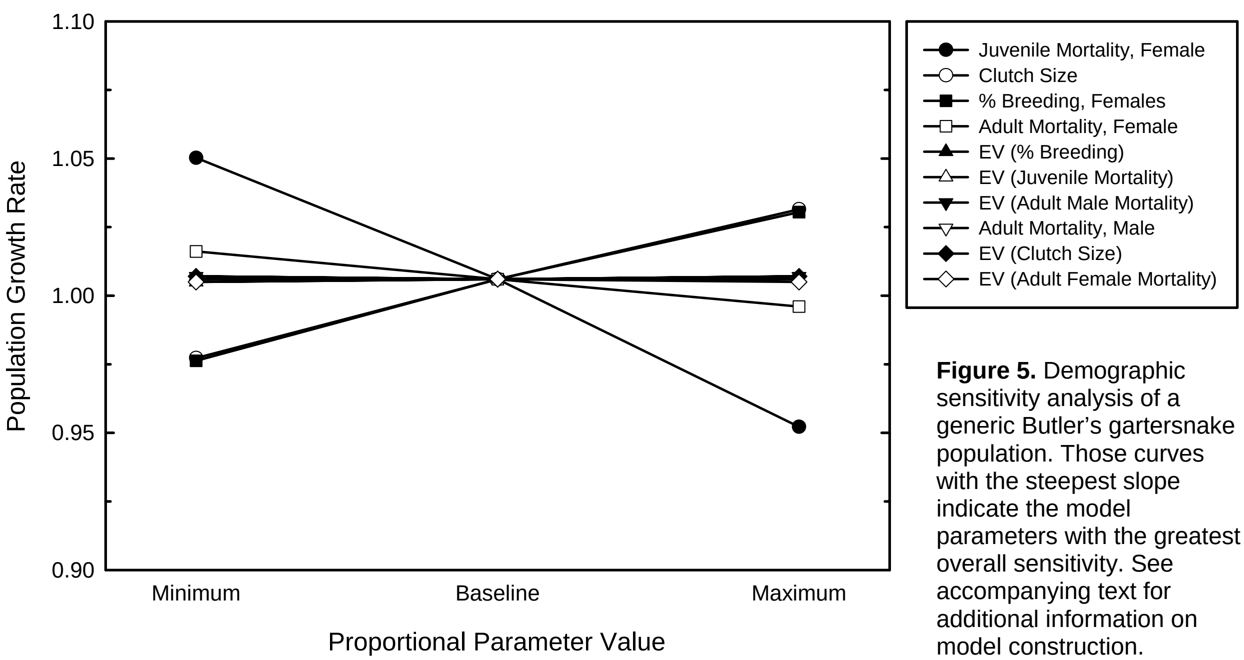


Figure 5. Demographic sensitivity analysis of a generic Butler's gartersnake population. Those curves with the steepest slope indicate the model parameters with the greatest overall sensitivity. See accompanying text for additional information on model construction.

Catastrophe Analysis

Table 4 and Figure 6 shows three separate scenarios that collectively investigate the relative impacts of our two natural catastrophe events: our Baseline model, where both drought and severe winter are included; a Drought model, where severe winter has been removed from the analysis; and a Winter model, where drought has been removed from the analysis. The results show that when winter is removed from the model, leaving only drought, the increase in growth rate over the baseline model is comparatively modest (r_s = 0.015 vs. 0.006). In contrast, when drought is removed from the model, the stochastic growth rate shows a much more robust increase (r_s = 0.023 v. 0.006). In other words, the simulated drought event is a larger factor in determining overall population growth dynamics.

Table 4. Butler's gartersnake PVA. Catastrophe analysis models, including scenarios that feature a linear increase in the expected frequency of drought events to 10% or 15% through global warming. See text for additional information on model construction and parameterization.

Scenario	r_s (SD)	PE_{100}	N_{100} (SD)	GD_{100}
Baseline (Drought and Winter)	0.006 (0.234)	0.036	323 (187)	0.853
Drought, 5% Frequency	0.015 (0.226)	0.016	375 (175)	0.869
Winter, 5% Frequency	0.023 (0.189)	0.004	441 (151)	0.899
Global Warming Scenarios				
Drought, 10% Frequency	0.007 (0.244)	0.042	296 (185)	0.846
Drought, 15% Frequency	-0.004 (0.265)	0.128	203 (166)	0.819

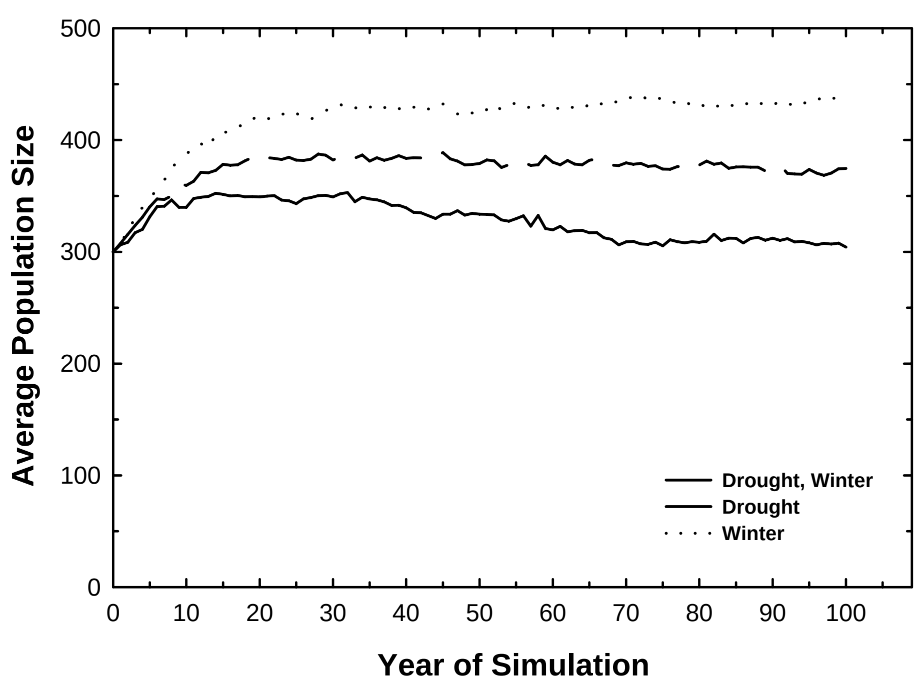


Figure 6. Projections of simulated Butler's gartersnake populations under different conditions of natural catastrophic events. Note the more severe impact of drought on population dynamics, and the nearly additive impact magnitude when both drought and severe winter are added to the baseline model. See accompanying text for additional information on model construction.

This is sensible given the ways in which these two events were characterized in the models. While both events are expected to occur with the same frequency, the drought event leads to the total elimination of reproduction. In contrast, severe winter allows reproduction to occur at the same rate, but leads to a 50% reduction in the overwinter survival of juveniles compared to "normal" winters. Therefore, since drought essentially doubles the impact on production of juveniles into the following spring, we expect it to be more deleterious compared to a severe winter scenario. This prediction is borne out in the models themselves.

The study of drought impacts in a warming environment produces some very interesting dynamics (Figure 7). Doubling the final frequency of drought leads to a 2.6x increase in extinction risk, while tripling the drought frequency results in an 8x increase in extinction risk. In other words, a linear increase in drought frequency is accompanied by an exponential increase in extinction risk. This is because as catastrophic events occur more frequently, the affected population is reduced in size and therefore becomes more unstable. Under these conditions, each subsequent event has a proportionally greater impact on the population, with later events driving the simulated populations to extinction.

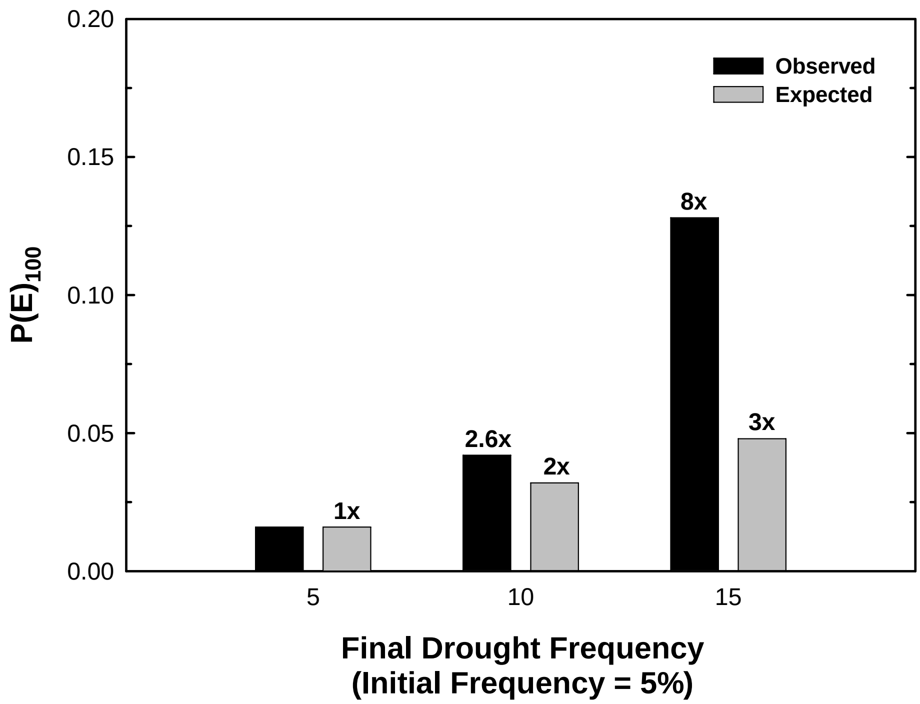


Figure 7. Probability of extinction in simulated Butler's gartersnake populations under increasing drought frequencies through global warming. Frequencies start at 5% in all scenarios, but increase in a linear fashion to 10% or 15% in warming scenarios. "Expected" probabilities follow similar linear increases in risk. See accompanying text for additional information on model construction.

While the absolute risks shown in Figure 7 remain relatively small, the observed relationship between drought frequency and risk of population extinction may nevertheless be of some concern. We have very little field data upon which to make a more informed hypothesis regarding the detailed ecological impacts of a warmer environment in southeastern Wisconsin, and how those ecological impacts may lead to changes in Butler's gartersnake population demography. However, we feel that the scenarios presented here are quite plausible. Since we do not include these global warming drought scenarios in the risk analysis models discussed below, we suggest that the risks identified below may be considered optimistic. As a result, additional research on the nature and consequences of global warming on the herpetofauna of southeastern Wisconsin should be considered important for biodiversity management.

Risk Analysis I: Impacts of Population Size and Inbreeding Effects on Butler's Gartersnake Population Dynamics

Through examination of the results of this analysis shown in Figure 8 and Tables 5 and 6, we can make the following observations regarding the dynamics of extinction risk in Butler's gartersnake populations:

Figure 8. Probability of extinction in simulated Butler's gartersnake populations as a function of initial size of the adult female population (approximately 18% of total population size), in Urban or Rural demographic environments. Top panel, inbreeding depression absent; bottom panel, inbreeding depression present. See accompanying text for additional information on model construction.

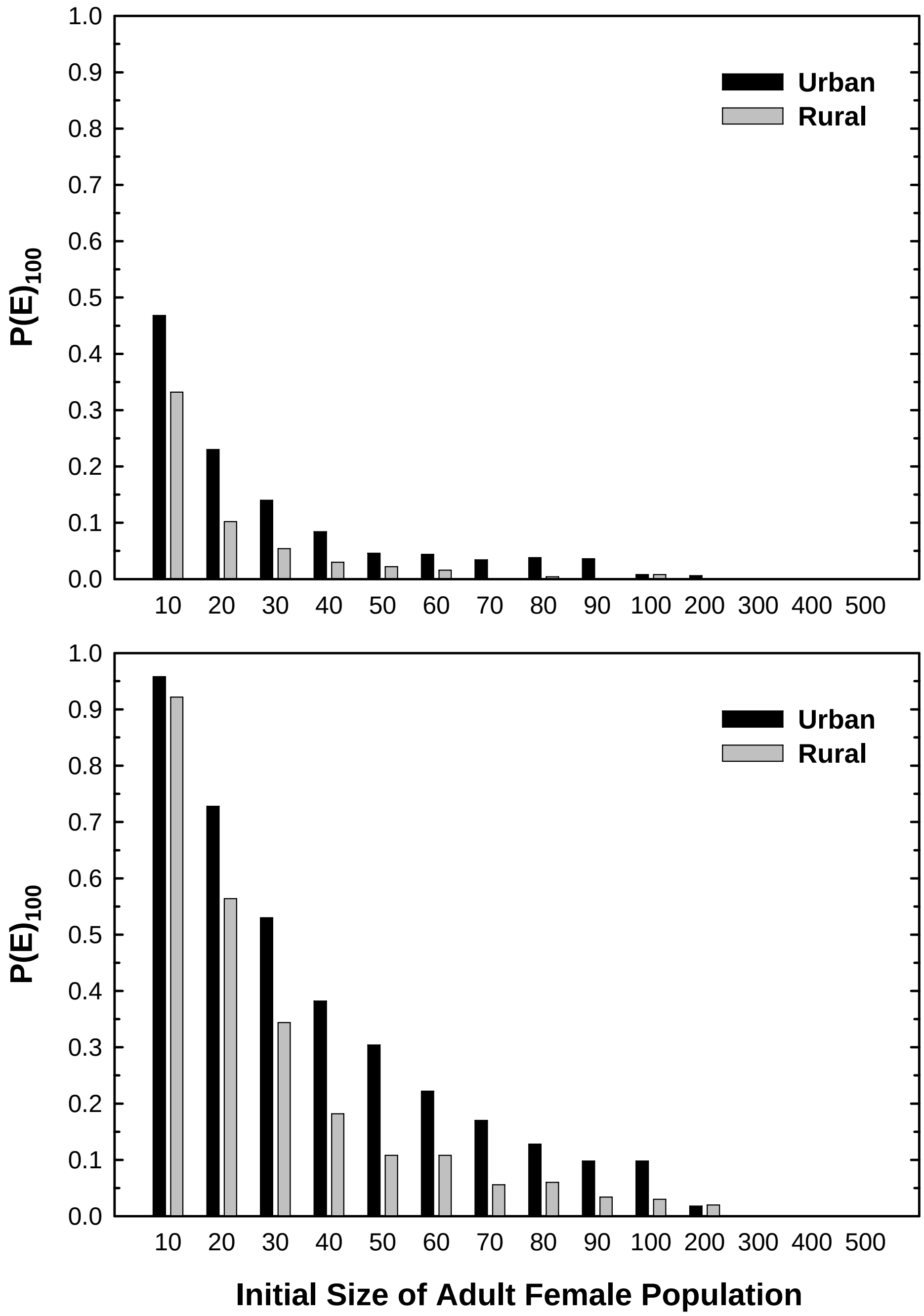


Table 5. Butler's gartersnake PVA. Output from Risk Analysis I models investigating population size and Urban / Rural demography. Inbreeding depression is absent from these scenarios. See text for additional information on model construction.

N_{AF}	Demography	r_s (SD)	PE_{100}	N_{100} (SD)	GD_{100}
10	Urban	-0.003 (0.299)	0.468	56 (32)	0.461
20		0.003 (0.264)	0.230	116 (63)	0.681
30		0.003 (0.248)	0.140	166 (96)	0.744
40		0.005 (0.242)	0.084	226 (131)	0.798
50		0.007 (0.233)	0.046	285 (163)	0.833
60		0.007 (0.234)	0.044	336 (197)	0.854
70		0.008 (0.230)	0.034	401 (233)	0.870
80		0.006 (0.228)	0.038	456 (265)	0.891
90		0.007 (0.227)	0.036	503 (293)	0.900
100		0.008 (0.224)	0.008	574 (341)	0.912
200		0.009 (0.220)	0.006	1183 (645)	0.953
300		0.010 (0.216)	0.002	1812 (970)	0.970
400		0.010 (0.219)	0.002	2467 (1309)	0.977
500		0.010 (0.217)	0.000	2997 (1628)	0.981
10	Rural	0.011 (0.289)	0.332	67 (31)	0.508
20		0.015 (0.254)	0.102	133 (64)	0.690
30		0.016 (0.243)	0.054	204 (93)	0.780
40		0.019 (0.233)	0.030	293 (119)	0.840
50		0.018 (0.232)	0.022	354 (157)	0.870
60		0.018 (0.230)	0.016	436 (186)	0.893
70		0.019 (0.226)	0.002	513 (209)	0.908
80		0.020 (0.225)	0.004	582 (250)	0.914
90		0.020 (0.224)	0.000	657 (286)	0.927
100		0.019 (0.222)	0.008	754 (314)	0.934
200		0.020 (0.219)	0.000	1502 (587)	0.966
300		0.021 (0.218)	0.000	2279 (898)	0.978
400		0.022 (0.217)	0.000	3098 (1145)	0.984
500		0.021 (0.218)	0.000	3825 (1434)	0.987

- Smaller populations have a lower population growth rate, a higher level of annual variability in growth and, consequently, an intrinsically higher risk of extinction in the timeframe of these simulations. This is yet another graphic demonstration of the instability of smaller populations in the face of random fluctuations in demographic rates.
- Populations in Urban habitats have a higher risk of extinction than their Rural counterparts of equivalent size. Moreover, the difference in risk between Urban and Rural populations is magnified at lower initial population size. This is a direct result of the higher mortality that

defines the Urban environment in these simulations, which leads to lower growth rates and higher demographic instability.

Table 6. Butler's gartersnake PVA. Output from Risk Analysis I models investigating population size and Urban / Rural demography. Inbreeding depression is present in these scenarios. See text for additional information on model construction.

N_{AF}	Demography	r_s (SD)	PE_{100}	N_{100} (SD)	GD_{100}
10	Urban	-0.045 (0.307)	0.958	21 (16)	0.508
20		-0.034 (0.278)	0.728	41 (42)	0.588
30		-0.025 (0.260)	0.530	85 (87)	0.702
40		-0.020 (0.248)	0.382	119 (118)	0.764
50		-0.014 (0.242)	0.304	178 (145)	0.818
60		-0.013 (0.239)	0.222	202 (186)	0.818
70		-0.008 (0.234)	0.170	275 (218)	0.851
80		-0.008 (0.232)	0.128	305 (259)	0.868
90		-0.004 (0.226)	0.098	370 (281)	0.889
100		-0.004 (0.226)	0.098	428 (312)	0.890
200		0.005 (0.219)	0.018	1032 (657)	0.952
10	Rural	-0.037 (0.304)	0.922	21 (18)	0.406
20		-0.021 (0.270)	0.564	63 (55)	0.649
30		-0.011 (0.250)	0.344	119 (97)	0.748
40		-0.004 (0.238)	0.182	186 (140)	0.809
50		0.001 (0.233)	0.108	239 (167)	0.837
60		0.004 (0.231)	0.108	322 (207)	0.869
70		0.007 (0.226)	0.056	397 (241)	0.889
80		0.007 (0.226)	0.060	450 (277)	0.904
90		0.009 (0.223)	0.034	524 (308)	0.912
100		0.012 (0.220)	0.030	613 (335)	0.925
200		0.016 (0.219)	0.002	1360 (667)	0.963

- The inclusion of inbreeding depression leads to a significant increase in extinction risk, through increasing juvenile mortality which lowers population growth. The impact of inbreeding depression is most notably seen at intermediate population sizes, where extinction risks are rather low in the absence of the detrimental impacts of inbreeding.

Taken together, these observations suggest that there is a threshold initial population size where the magnitude of extinction risk changes most noticeably. In the simulations presented here, this threshold appears to correspond to approximately 40 – 50 adult females, which corresponds to a total size of approximately 220 – 270 individuals. Especially in the absence of inbreeding, the risk of population extinction begins to rise substantially below this threshold and is essentially unchanged at larger sizes.

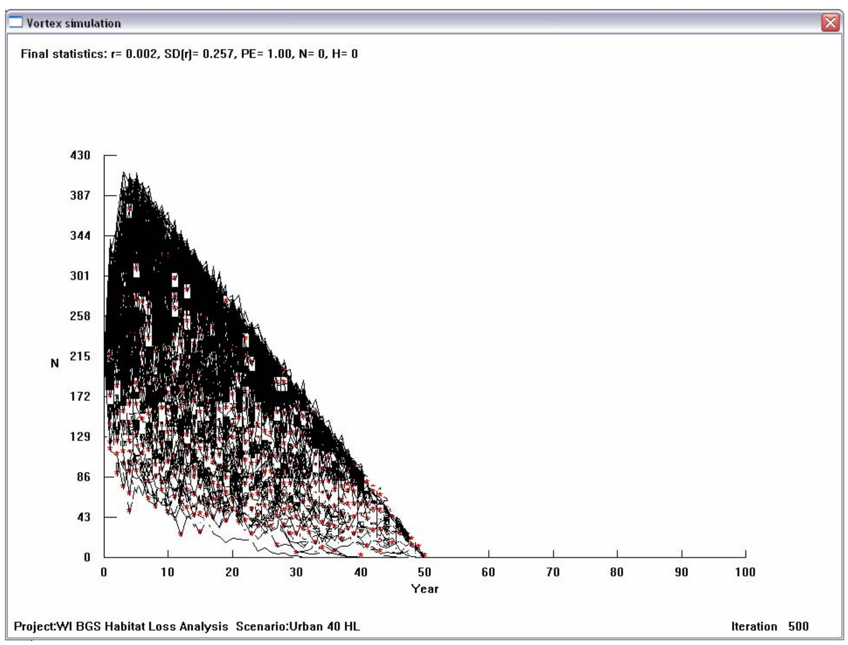
The observation of significant genetic instability leading to enhanced extinction risk is, of course, highly dependent on how we define inbreeding depression in the inputs to our models. While we do not have specific data to precisely define this aspect of our models, we feel justified in exploring this aspect of Butler's gartersnake population biology in the context of outlining future population research or management strategies. Based on these analyses, a detailed study of genetic load in this species appears warranted.

Finally, a more definitive identification of thresholds defining population viability is itself dependent on a specific risk tolerance, defined by an acceptable level of extinction risk. The specification of an acceptable risk is not purely a biological argument; it is largely a function of political approaches to resource management under uncertainty. Therefore, those tasked with such management must come to an agreement, outside the confines of this analysis, of what type and magnitude of risk is tolerable for this species under the alternative future conditions explored here and elsewhere.

Risk Analysis II: Impacts of Habitat Loss Through Woody Vegetation Invasion on Butler's Gartersnake Population Dynamics

From a total of 36 scenarios involving habitat loss that were run as part of this project, almost every scenario displayed dynamics identical to those shown in Figure 9. Specifically, we see very few iterations within a given scenario that become extinct before year 50, when habitat carrying capacity is reduced to zero.

Figure 9. Full set of 500 population projections for a selected Butler's gartersnake habitat loss scenario involving an initial population size of 40 adult females (215 total individuals) in an Urban environment. Carrying capacity is programmed to decline to zero in 50 years. See accompanying text for additional information on model construction.



This observation implies that, in the face of a rather rapid decline in carrying capacity, demographic instability is not large enough to cause significant additional extinction risk above and beyond that which is predicted from simpler deterministic rates of habitat loss. While not "good news" by itself, the results of this analysis suggest that demographic instability is not expected to be a significant contributor to more rapid extinction as habitat availability declines. This conclusion is in part dependent on the rate of habitat loss, with more gradual rates of loss perhaps associated with more frequent extinction through demographic instability. Nevertheless, the overall impact on demographic dynamics does not appear to be appreciable.

Risk Analysis III: A Demographic Assessment of Metapopulation Structure as a Butler's Gartersnake Population Management Tool

Metapopulation Analysis I

Smaller populations that are linked to larger demographic source populations enjoy a significant stabilizing effect, particularly when dispersal is a benign process causing no additional mortality (Figure 10, Table 7). If we take the smallest recipient population (N_{AF} = 10) as an example, we see that the risk of population extinction approaches 0.60 in the absence of connectivity to any neighboring population. However, when this population is linked to a larger source of dispersing individuals, the risk of population extinction declines dramatically to less to 0.10. Moreover, inspection of Table 7 reveals that, under these conditions, the smaller population becomes extinct on average only 1 – 2 times during the 100 years of the simulation. We can therefore conclude that the larger source population is valuable not only for providing individuals to recolonize locally extinct neighboring populations, but also for largely preventing those extinctions in the first place through the periodic injection of individuals into the smaller habitat.

This dramatic increase in stability of the smaller population, and the marked drop in extinction risk, results from the introduction of individuals from the source population. In this case, since the source is quite a bit larger than the recipient, the smaller population is able to increase in size much more rapidly, and to a significantly larger equilibrium size, than it would be able to in isolation (graphical analysis not shown here).

It is important to note, however, that this increased stability we see in the smaller population can come at a demographic cost to the larger source population. As the dispersal rate increases between populations, the number of individuals dispersing from the source to the recipient can exceed its intrinsic growth capacity, and can lead to the onset of decline in the source population. As Figure 10 shows, this effect is more pronounced as recipient population size in smaller, since there are fewer individuals from this smaller population that can provide dispersers to the larger population. At the highest dispersal rates studied here, we even begin to see an upward swing in the predicted risk of extinction in the smaller populations as the overall system begins to destabilize. It appears, therefore, that while all levels of dispersal provide highly significant protection from localized extinction, there is an intermediate level of dispersal that provides optimal protection and stability.

These results also indicate, as expected, that source populations under Rural demographic characteristics are even more effective at bolstering smaller recipient population demographic performance. Under equivalent dispersal rates, Rural source populations maintain higher population growth rates than their Urban counterparts. This makes sense since Rural populations have, by definition, higher growth rates to begin with in each of these simulations.

Figure 11 and Table 8 present analogous results in the case where we assume a 25% mortality cost to dispersal. Under these conditions, the source populations become even more drained of individuals and their growth rates become rather significantly negative at the highest rates of dispersal. Consequently, extinction risks rise markedly at high dispersal rates. The mortality costs of dispersal are completely unknown in this species, and these results suggest this to be an important area of future study if we are to design effective metapopulation structures across the landscape of southeastern Wisconsin.

Figure 10. Butler's gartersnake metapopulation analysis I. Extinction risk of smaller population (bars, left axis) and mean stochastic growth rate of larger population (lines, right axis) for different initial sizes of the small population and under either Urban (top panel) or Rural (bottom panel) demographic environments. Both graphs assume no additional mortality cost to dispersal. Dashed horizontal line denotes stochastic growth rate = 0.000. See accompanying text for additional information on model construction.

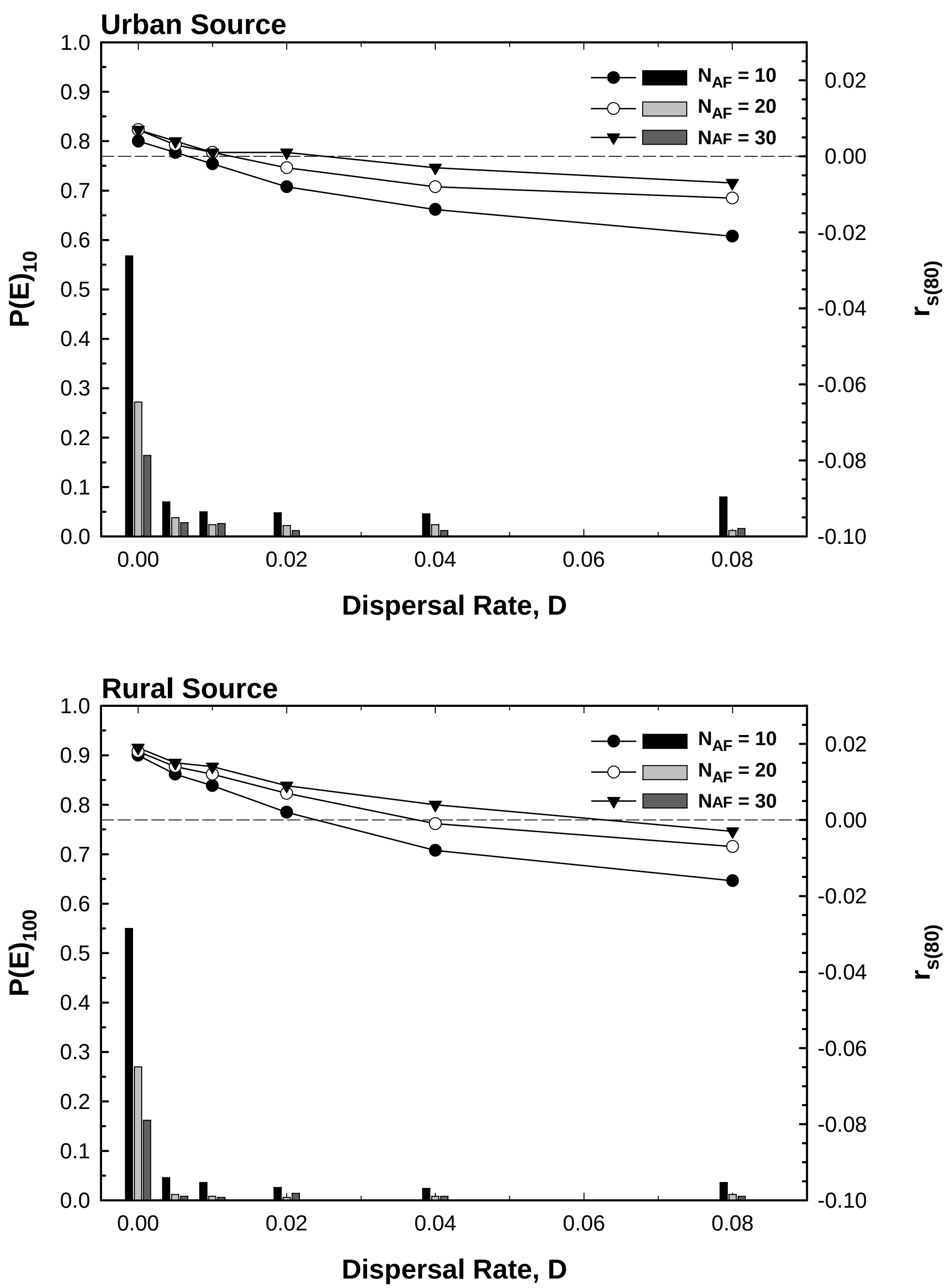


Table 7. Butler's gartersnake PVA. Output from Metapopulation Risk Analysis I models, where one small population is linked by dispersal to a larger population initialized with 80 adult females (total population size is 435 individuals). All models described here assume no additional mortality cost to dispersal. D, dispersal rate; "Small", reference to smaller of two subpopulations comprising the metapopulation; N(E), average number of extinction events in the small population among those simulations where at least one extinction event occurred in that population. See text for additional information on model construction.

		r_s				P(E)		
$N_{AF, Small}$	D	Small	80	Meta	$N(E)_{Small}$	Small	80	Meta
Urban Source: 0% Mortality Cost								
10	0.000	-0.008	0.004	0.006	284.0	0.568	0.044	0.032
	0.005	0.027	0.001	0.007	1.8	0.070	0.050	0.032
	0.010	0.042	-0.002	0.008	1.6	0.050	0.050	0.040
	0.020	0.057	-0.008	0.007	1.6	0.048	0.048	0.032
	0.040	0.074	-0.014	0.008	1.4	0.042	0.046	0.040
	0.080	0.071	-0.021	0.007	1.5	0.080	0.084	0.076
20	0.000	-0.000	0.007	0.009	136.0	0.272	0.034	0.016
	0.005	0.016	0.003	0.009	2.1	0.038	0.036	0.022
	0.010	0.024	0.001	0.010	1.5	0.024	0.022	0.020
	0.020	0.031	-0.003	0.009	1.3	0.022	0.028	0.020
	0.040	0.041	-0.008	0.009	1.3	0.024	0.026	0.022
	0.080	0.047	-0.011	0.011	1.4	0.012	0.022	0.010
30	0.000	0.002	0.007	0.010	82.0	0.164	0.036	0.008
	0.005	0.013	0.004	0.010	1.5	0.028	0.024	0.012
	0.010	0.016	0.001	0.008	1.7	0.026	0.024	0.016
	0.020	0.025	0.001	0.011	2.0	0.012	0.014	0.010
	0.040	0.031	-0.003	0.011	1.4	0.012	0.020	0.012
	0.080	0.032	-0.007	0.009	1.3	0.016	0.014	0.014
Rural Source: 0% Mortality Cost								
10	0.000	-0.007	0.017	0.017	275.0	0.550	0.012	0.010
	0.005	0.032	0.012	0.016	2.1	0.046	0.020	0.016
	0.010	0.052	0.009	0.018	1.7	0.036	0.032	0.024
	0.020	0.077	0.002	0.017	1.5	0.026	0.016	0.014
	0.040	0.097	-0.008	0.016	1.6	0.024	0.026	0.016
	0.080	0.090	-0.016	0.015	1.6	0.036	0.036	0.034
20	0.000	-0.001	0.018	0.018	135.0	0.270	0.018	0.006
	0.005	0.021	0.014	0.018	2.3	0.012	0.010	0.008
	0.010	0.029	0.012	0.018	1.4	0.008	0.010	0.006
	0.020	0.041	0.007	0.017	1.0	0.006	0.008	0.004
	0.040	0.055	-0.001	0.017	2.2	0.008	0.004	0.002
	0.080	0.063	-0.007	0.018	1.8	0.012	0.012	0.010
30	0.000	0.002	0.019	0.019	81.0	0.162	0.008	0.004
	0.005	0.015	0.015	0.018	1.5	0.008	0.004	0.004
	0.010	0.022	0.014	0.018	1.6	0.006	0.002	0.002
	0.020	0.027	0.009	0.016	1.6	0.014	0.012	0.010
	0.040	0.038	0.004	0.017	1.0	0.008	0.006	0.006
	0.080	0.045	-0.003	0.016	1.2	0.008	0.010	0.008

Figure 11. Butler’s gartersnake metapopulation analysis I. Extinction risk of smaller population (bars, left axis) and mean stochastic growth rate of larger population (lines, right axis) for different initial sizes of the small population and under either Urban (top panel) or Rural (bottom panel) demographic environments. Both graphs assume 25% additional mortality cost to dispersal. Dashed horizontal line denotes stochastic growth rate = 0.000. See accompanying text for additional information on model construction.

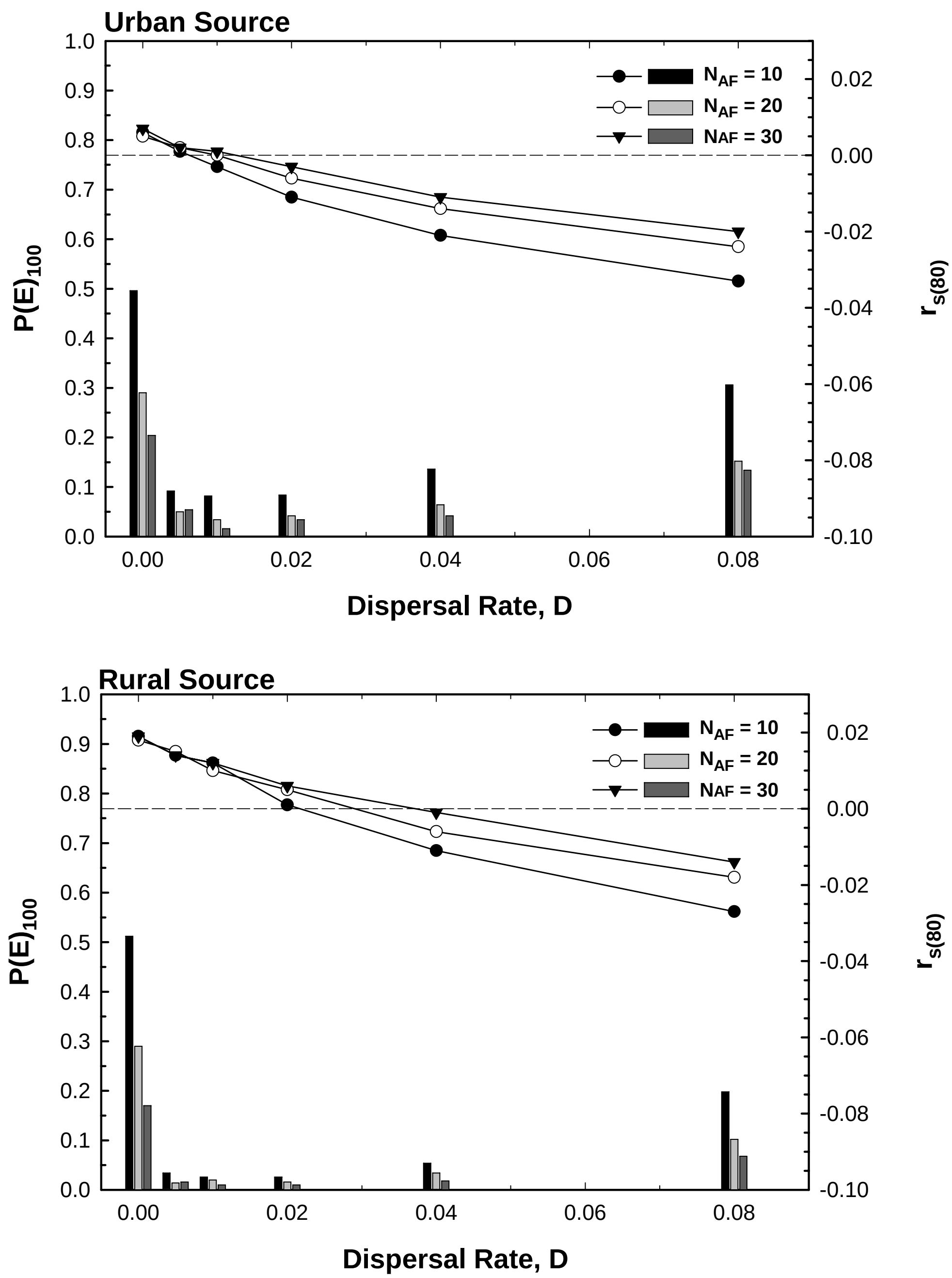


Table 8. Butler's gartersnake PVA. Output from Metapopulation Risk Analysis I models, where one small population is linked by dispersal to a larger population initialized with 80 adult females (total population size is 435 individuals). All models described here assume a 25% additional mortality cost to dispersal. D, dispersal rate; "Small", reference to smaller of two subpopulations comprising the metapopulation; N(E), average number of extinction events in the small population among those simulations where at least one extinction event occurred in that population. See text for additional information on model construction.

		r_s				P(E)		
$N_{AF, Small}$	D	Small	80	Meta	$N(E)_{Small}$	Small	80	Meta
Urban Source: 25% Mortality Cost								
10	0.000	-0.008	0.004	0.006	284.0	0.568	0.044	0.032
	0.005	0.021	0.001	0.006	2.0	0.092	0.048	0.026
	0.010	0.031	-0.003	0.005	1.8	0.082	0.066	0.046
	0.020	0.040	-0.011	0.001	1.5	0.084	0.082	0.068
	0.040	0.044	-0.021	-0.004	1.5	0.136	0.122	0.104
	0.080	0.026	-0.033	-0.017	1.4	0.306	0.298	0.274
20	0.000	-0.000	0.007	0.009	136.0	0.272	0.034	0.016
	0.005	0.013	0.002	0.007	1.8	0.050	0.036	0.024
	0.010	0.017	-0.000	0.006	1.9	0.034	0.034	0.020
	0.020	0.022	-0.006	0.004	1.6	0.042	0.036	0.024
	0.040	0.021	-0.014	-0.001	1.5	0.064	0.052	0.044
	0.080	0.006	-0.024	-0.013	1.4	0.152	0.152	0.138
30	0.000	0.002	0.007	0.010	82.0	0.164	0.036	0.008
	0.005	0.011	0.002	0.008	1.5	0.054	0.036	0.020
	0.010	0.013	0.001	0.007	2.1	0.016	0.018	0.012
	0.020	0.015	-0.003	0.005	1.5	0.034	0.026	0.022
	0.040	0.011	-0.011	-0.002	1.3	0.042	0.048	0.034
	0.080	0.001	-0.020	-0.013	1.4	0.134	0.130	0.116
Rural Source: 25% Mortality Cost								
10	0.000	-0.007	0.017	0.017	275.0	0.550	0.012	0.010
	0.005	0.029	0.014	0.018	2.1	0.034	0.014	0.010
	0.010	0.041	0.012	0.018	1.8	0.026	0.008	0.006
	0.020	0.057	0.001	0.013	1.5	0.026	0.030	0.020
	0.040	0.065	-0.011	0.006	1.6	0.054	0.046	0.038
	0.080	0.042	-0.027	-0.009	1.5	0.198	0.208	0.180
20	0.000	-0.001	0.018	0.018	135.0	0.270	0.018	0.006
	0.005	0.016	0.015	0.017	1.5	0.014	0.006	0.004
	0.010	0.022	0.010	0.015	1.3	0.020	0.014	0.012
	0.020	0.031	0.005	0.014	1.7	0.016	0.008	0.006
	0.040	0.032	-0.006	0.007	1.4	0.034	0.034	0.028
	0.080	0.019	-0.018	-0.005	1.5	0.102	0.096	0.092
30	0.000	0.002	0.019	0.019	81.0	0.162	0.008	0.004
	0.005	0.012	0.014	0.016	1.4	0.016	0.010	0.008
	0.010	0.016	0.012	0.016	1.5	0.010	0.010	0.002
	0.020	0.019	0.006	0.012	1.1	0.010	0.010	0.006
	0.040	0.023	-0.001	0.009	2.2	0.018	0.016	0.014
	0.080	0.009	-0.014	-0.005	1.3	0.068	0.066	0.060

Metapopulation Analysis II

In our second metapopulation analysis, we found that only rather moderate dispersal rates among smaller linked Urban populations are required to create a demographic profile essentially identical to that of a single larger population composed of the same total number of individuals (Figure 12). Through dispersal among smaller subpopulations, growth rates are increased and extinction risks are decreased compared to an analogous situation where each subpopulation is in isolation.

Taken together, these two metapopulation analyses point out the dramatic benefits that can come from providing opportunities for dispersal among otherwise isolated – and often imperiled – populations. Moreover, the results are expected to be even more beneficial when the genetic component of population viability is taken into account, as dispersal within a metapopulation leads to overall higher levels of gene diversity and lower levels of inbreeding. It is also clear that the characteristics of the dispersal process are vital to the overall success of metapopulation management. Currently, little is known about the dispersal capabilities of Butler's gartersnake. Perhaps more important, we have very little knowledge of the ecological characteristics that are necessary for a given habitat corridor to support a given level of gartersnake dispersal. Studies designed to shed more light on this subject will become critical to the successful management of Butler's gartersnake metapopulation in this region.

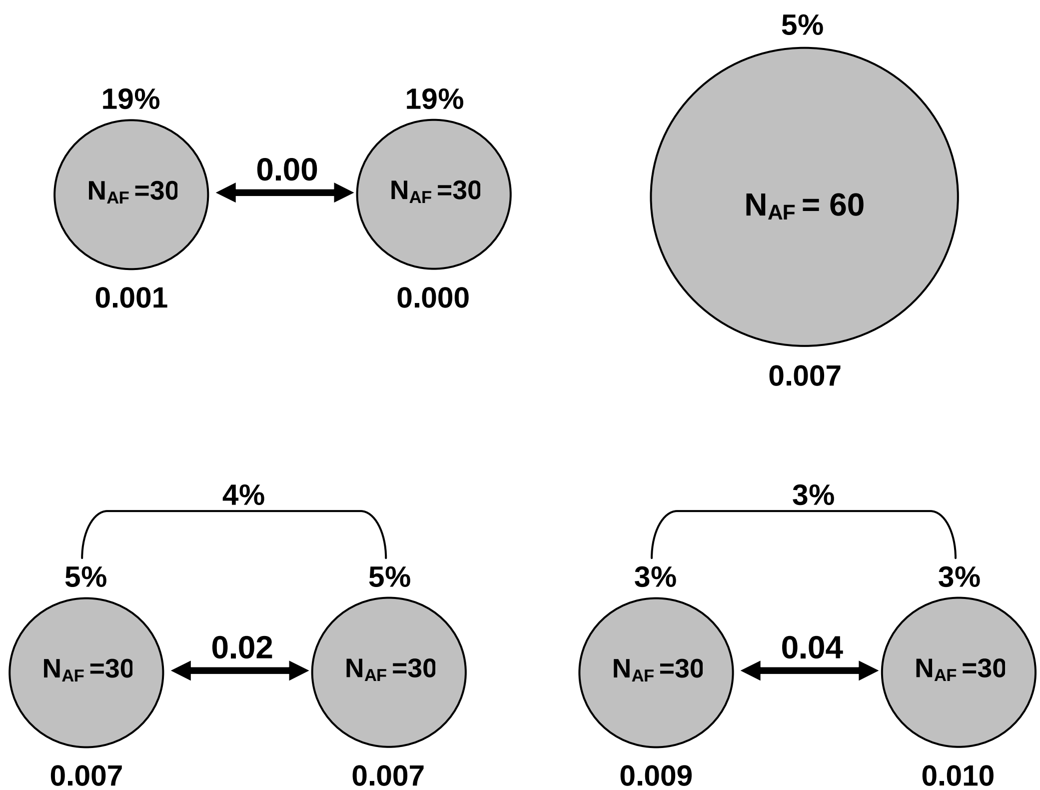


Figure 12. Schematic diagram of results from Butler's gartersnake metapopulation analysis II. NAF, initial number of adult females. Percentages give probability of extinction for individual (sub)populations as well as for aggregate metapopulations (denoted by bracketed values). Proportional values below populations are mean stochastic population growth rates, and those immediately above the arrows connecting subpopulations indicate dispersal rates. See accompanying text for additional information on model construction.

Risk Analysis IV: A Demographic Assessment of Translocation as a Butler's Gartersnake Population Management Tool

Our translocation analysis models suggest that opportunities for successful establishment of new Butler's gartersnake populations exist using this method. Figure 13 indicates that two years of snake introductions into a Rural environment give us the best chance of success. General trend analysis suggests that a minimum of 15 adult females should be translocated each year to have the highest chances for successful establishment. Even with a single year of introductions into an Urban environment, a translocation has approximately 70% chance of success based on our simulations of Butler's gartersnake demography. Clearly, larger number of females available for translocation are likely to increase this chance of success, but the increase in success rate drops off noticeably beyond about 20 adult females.

The top panel of Figure 13 assumes no inbreeding depression in our newly-introduced population. If genetic instability is added to our models, the chances for successful translocation decline dramatically (bottom panel). Moreover, our models may actually underestimate this effect since Vortex assumes that all translocated individuals are unrelated – which may not be the case in practice, where individuals suitable for translocation may be collected from a single location. This analysis once again points out the importance of studying the genetic structure of Butler's gartersnake populations so that a more accurate estimate of inbreeding depression may be derived.

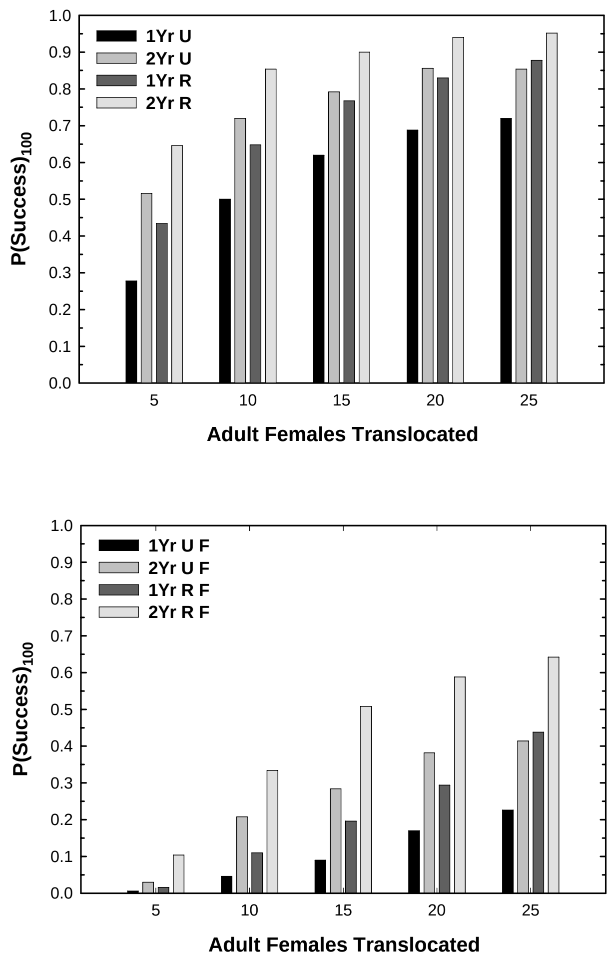


Figure 13. Probability of success of alternative translocation programs for Butler's gartersnakes in the absence (top panel) or presence (bottom panel) of inbreeding depression affecting newly-established populations. Translocations take place for either one year or two years at the beginning of a simulation, in either Urban or Rural habitats. See accompanying text for additional information on model construction.

Finally, it is very important to remember that this analysis of translocation is concerned only with the demographic characteristics and consequences of the processes involved. There is an admitted danger that these results could be used to promote translocation as an easy and "foolproof" method of managing Butler's gartersnake populations. Unfortunately, the reality of translocation biology and our understanding of species specificity in program design forces us to think otherwise. Moving individuals to new habitats may induce considerable stress, leading to increased mortality, dispersal into unsuitable habitats, novel disease exposure, etc. Careful attention must be directed to the design of translocation programs so that behavioral and ecological complexities can be addressed most effectively. If these standards are met, our analyses suggest that translocation can succeed.

Conclusions

We may conclude our analysis of Butler's gartersnake population viability by returning to the original set of questions that provided the foundation for our study.

- *Can we build a series of computer simulation models with sufficient detail and precision that describe the dynamics of Butler's gartersnake populations across Wisconsin with reasonable accuracy?*

  Our demographic analyses indicate that we are indeed capable of building such models. It is extremely important to remember, however, that reliance on the absolute outcome predicted by any one modeling scenario must always be interpreted with extreme caution due to the inherent uncertainty in model input parameterization. A comparative analysis between models, in which a single factor (or at most two factors) is studied while all other input parameters are held constant, provides a much more robust environment in which alternative management scenarios can be evaluated for their effectiveness in increasing the viability of the target species.

- *What are the primary demographic factors that drive growth of Butler's gartersnake populations?*

  Our models show the highest sensitivity to rates of juvenile female survival and adult female reproductive success, namely, the percentage of adult females that breed in a given year, the mean clutch size, and the survival of adult females. For those sensitive aspects of the species' biology that can be addressed through management, this type of analysis is extremely important in identifying priorities for action.

- *What are the predicted impacts of catastrophic natural events such as drought and severe winter on Butler's gartersnake populations? How might a global warming scenario affect drought and its impacts on population persistence?*

  Since we assume that drought and severe winter affect the juvenile age classes most harshly, we feel that the impacts of catastrophes can be significant. Drought appears to be more severe as there is elimination of reproduction during the event.

  If global warming increases the frequency of drought in the area, the demographic impacts may be more severe than expected due to the instability of population decline.

- *How vulnerable are small, fragmented populations of Butler's gartersnakes in Wisconsin to extinction under current management conditions? How small must a population become to increase its risk of extinction to an unacceptable level?*

  Under conditions simulated here, populations with less than about 40-50 adult females begin to show disproportionally higher risk of extinction. At these intermediate population sizes, rural populations show markedly higher levels of viability through reduced predation-based mortality. Additional discussions on acceptable risk levels must follow quantitative analysis.

- *Can inbreeding depression significantly affect the viability of Butler's gartersnake populations?*

  Reductions in juvenile mortality through inbreeding depression can have a major impact on Butler's gartersnake population viability. Research (*ex situ*?) on extent and nature of genetic load in natural Butler's populations would establish validity of including this phenomenon in future PVA-based analyses.

- *What are the predicted impacts of habitat loss throughout the greater Milwaukee metropolitan area, primarily through the introduction of shrubby vegetation, on the future viability of Butler's gartersnake populations? Are small snake populations at a particularly high risk of rapid extinction in the presence of this threat?*

  If loss of habitat goes unchecked, Butler's populations will decline to extinction. This decline operates largely deterministically, i.e., there is little noticeable increase in the rate of decline due to stochastic population demography.

- *Can the creation of metapopulations through linking isolated subpopulations increase overall Butler's gartersnake population viability? What role does dispersal play in this scheme?*

  Metapopulation viability is determined by a complex interplay of dynamic ecological and demographic processes. Connectivity to a larger source population can give significantly greater stability to a smaller recipient population, but higher rates of dispersal can destabilize the larger source. Therefore, it follows that "rural" populations – those with higher individual survival rates and more robust growth potentials – would make more suitable source populations.

  The success of a given metapopulation strategy can depend critically on the characteristics of the dispersal corridor, in particular, the <u>cost</u> of dispersal as individuals move across lower-quality intervening habitat.

- *Can translocation of Butler's gartersnakes into unoccupied habitats be an effective species management tool?*

  Under conditions simulated here, new Butler's populations can be established in patches with sufficient suitable habitat with a relatively small number of adult females. The presence of demographic impacts of inbreeding depression can dramatically compromise these chances for success. The chances for successful establishment also are determined by the predation pressures that exist in this new habitat.

References

Altwegg, R., S. Dummermuth, B.R. Anholt, and T. Flatt. 2005. Winter weather affects asp viper *Vipera aspis* population dynamics through susceptible juveniles. *Oikos* 110:55-66.

Beissinger, S.R., and D.R. McCullough, eds. 2002. *Population Viability Analysis*. Chicago: University of Chicago Press.

Ellner, S. P., J. Fieberg, D. Ludwig, and C. Wilcox. 2002. Precision of population viability analysis. *Conservation Biology* 16**:**258–261.

Ernst, and Ernst. 2003. *Snakes of the United States and Canada*.

Heppell, S.S., H. Caswell, and L.B. Crowder. 2000. Life histories and elasticity patterns: Perturbation analysis for species with minimal demographic data. *Ecology* 81:654-665.

Jiménez, J.A., K.A. Hughes, G. Alaks, L. Graham, and R.C. Lacy. 1994. An experimental study of inbreeding depression in a natural habitat. *Science* 266:271-273.

Lacy, R.C. 1993. Impacts of inbreeding in natural and captive populations of vertebrates: implications for conservation. *Perspectives in Biology and Medicine* 36:480-496.

Lacy, R.C. 2000. Structure of the *VORTEX* simulation model for population viability analysis. *Ecological Bulletins* 48:191-203.

Lotts, K.C., T.A. Waite, and J.A. Vucetich. 2004. Reliability of absolute and relative predictions of population persistence based on time series. *Conservation Biology* 18:1224-1232.

Ludwig, D. 1999. Is it meaningful to estimate a probability of extinction? *Ecology* 80**:**298–310.

Miller, P.S. 1994. Is inbreeding depression more severe in a stressful environment? Zoo Biology 13:195-208.

Miller, P.S., and R.C. Lacy. 2003. *VORTEX: A Stochastic Simulation of the Extinction Process. Version 9 User's Manual*. Apple Valley, MN: Conservation Breeding Specialist Group (SSC/IUCN).

Ralls, K., J.D. Ballou, and A. Templeton. 1988. Estimates of lethal equivalents and the cost of inbreeding in mammals. *Conservation Biology* 2:185-193.

Reed, J. M., L. S. Mills, J. B. Dunning Jr., E. S. Menges, K. S. McKelvey, R. Frye, S. R. Beissinger, M. Anstett, and P.S. Miller. 2002. Emerging issues in population viability analysis. *Conservation Biology* 16**:**7–19.

Rivas, J.A., and G.M. Burghardt. 2005. Snake mating systems, behavior, and evolution: The revisionary implications of recent findings. *Journal of Comparative Psychology* 119:447-454.

Shine, R., and R.T. Mason. 2004. Patterns of mortality in a cold-climate population of gartersnakes (*Thamnophis sirtalis parietalis*). *Biological Conservation* 120:201-210.

Soulé, M., M. Gilpin, W. Conway, and T. Foose. 1986. The millennium ark: How long a voyage, how many staterooms, how many passengers? *Zoo Biology* 5:101-113.

Stanford, K.M., and R.B. King. 2004. Growth, Survival, and Reproduction in a Northern Illinois Population of the Plains Gartersnake, *Thamnophis radix*. *Copeia*:465-478.

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Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin: Population and Habitat Viability Assessment The Stakeholder Workshop

5 – 8 February, 2007
Milwaukee County, Wisconsin

IV
Working Group Report: Site Characterization and Prioritization

Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin: Population and Habitat Viability Assessment
The Stakeholder Workshop
Site Characterization and Prioritization Working Group Report

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* Part-time participant
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Issues and Problems

- Re-evaluation of the Tier system/Tier 3 sites
- Capture the biological and social parameters necessary for species conservation
- Genetics
- Parameters we utilize should be adaptive/dynamic (do sites change over time)
- Soil types that are viable
- Time/$$ involved in reviewing the site (burden to landowner/DNR)
- Inadequate information for property owners
- Data quality/old air photo (in house evaluation vs. field evaluation)
- Quality of land (% of site and size)
- Number of snakes found on a particular site
- Size of parcel
- Who owns the property/ public vs. private

- Acreage needed and connectivity for viable population
- How much weight do we give artificial sites
- Isolation of species and effect of natural disaster
- How the snake is distributed throughout the range
- Public knowledge of known snake populations
- Parcel size (large/small) and what effect snake has on use of property
- Relocation and viability
- Site preservation driven by review of site rather than quality of habitat (pro-active)
- Time factor related to value of a site (snake study)
- Review by regulators/doing it the same

Prioritized Problems

(Prioritization is based on both importance as well as the order in which the problems need to be addressed.)

1. Insufficient consideration and definition of biological and social issues.
2. Tier system is incomplete and inadequate.
3. Sites are not properly prioritized.
4. Review sites pro-actively rather than reactively.
5. Current system is not sufficiently adaptive.

Data Assembly and Analysis

The Data Assembly and Analysis session was used to brainstorm possible criteria, both biological and socio-economic, to evaluate sites.

Biological
- Snake presence
- Area
- Metapopulation potential
- % area upland
- Upland quality
- Wetland quality
- Perimeter
- Genetics
- Soil type
- Spatial distribution
- Population size/density - snakes
- Biological threats
- SEWRPC

<u>Socio-economic</u>

- Ownership
- Social threats
- Public land type
- # and % private landowners
- Private landowner type (e.g. single, corporation, developer)
- Zoning
- SEWRPC – Butler's Habitat in Environmental Corridors: inclusion of entire critical species habitat areas, long term management of BGS habitat, management responsibility
- Economic cost/land value (assessed land value/acre)

Identified Goals

1. Prioritize sites in greater detail based on both socio-economic and biological issues.
2. Revise Tier system to be more in depth and adaptive to include the latest information available.
3. Institute a pro-active plan for preservation (survey all sites available and target sites slated for some type of preservation).

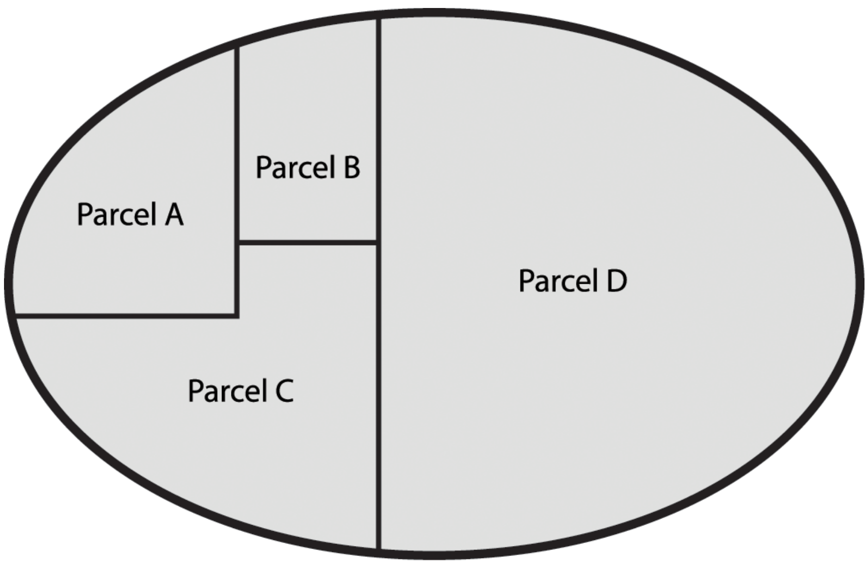
Actions

1. Establish appropriate socio-economic criterion and implement effective rating/ranking system as part of the parcel preservation/acquisition prioritization process.
2. Establish appropriate biological criterion and implement effective rating/ranking system as part of the parcel preservation/acquisition prioritization process.
3. Revise Conservation Strategy/Tier system. This Strategy should be adaptive so that it incorporates recent data.
4. Prioritize sites (based on 1. and 2. above).
5. Review sites proactively rather than reactively.

The Site Characterization and Prioritization Group divided into two sub groups, the Biological Sub Group and the Socio-economic Sub Group. The task of the Biological Sub Group was to create a filter that would rank suitable Butler's Gartersnake (BGS) habitat so as to identify the most biologically suitable and desirable habitat patches for the BGS. The task of the Socioeconomic Sub Group was to create a filter that would determine how the BGS habitat would impact society and the economy. The result of the filter is intended to show that Patches with the highest score have the greatest socioeconomic impact or cost.

Patch vs. Parcel

A Habitat Patch has also been referred to as a Habitat Site. So as not to create confusion, this sub group report will not use the word Site and will refer to the Patch as being the biological habitat in which the snakes are found. A Parcel will be defined as an individual ownership piece within the Habitat Patch. For example, the following figure represents a Habitat Patch that is broken up into four Parcels, Parcel A through D.



Habitat Patch

The socio-economic effect of a Habitat Patch will be derived by the combined score of each individual Parcel.

f(Patch) = (Characteristics of Parcels)

or

f(P) = (XA + XB + XC + . . .)

Parcel Score

The Parcel Score will be dependent on four parameters:

1. Relative Size of Parcel
2. Percentage of BGS Impact
3. Parcel Ownership
4. Economic Value of Parcel

Each parameter will use a score of 1 to 5, where 5 represents the greatest cost.

Parameter 1. Relative Size of Parcel

The Relative Size of the Parcel is intended to represent the percentage of the Parcel within the Patch. It has been discussed that Parcels that are very small in comparison to the Patch are more difficult to mitigate than are their larger counterparts. For example, if the Patch is 500 acres and there are two Parcels and one is 20 acres and the other is 480 acres, the first Parcel will find it much more difficult to mitigate their land if not impossible because of restrictions put on the Parcel due to the setbacks from wetlands and the potential need to create new habitat for the BGS.

The value for this parameter is determined first by dividing the Parcel Acres by the Patch Acres.

$$\frac{\text{Parcel Acres}}{\text{Patch Acres}}$$

This parameter is then given a score based on it's percentage. This is where further discussion needs to occur. The decision needs to made as to what percentage range is given to each value. For now, 0% to 15% will be considered Small, 16% to 50% will be considered Medium, and 51% to 100% will be considered Large.

0% - 15%	=	Small
16% - 50%	=	Medium
51% - 100%	=	Large

This parameter is then given a score of Small, Medium, or Large where each is given the value of 5, 3, and 1 respectively.

Small = 5
Medium = 3
Large = 1

Parameter 2. Percentage of BGS Impact

The percentage of developable BGS habitat is important to see how much developable land is being consumed by the BGS habitat on the Parcel. This excludes wetlands and other non-developable land (setbacks from roads and rivers??).

The formula to acquire this data would be the Buildable Acres taken by BGS Habitat divided by the Total Buildable Acres.

$$\frac{\text{Buildable Acres taken by BGS Habitat}}{\text{Total Buildable Acres}}$$

The Buildable Acres taken by BGS Habitat includes the current non-wetland habitat, suitable upland habitat, and new habitat that would need to be created, i.e. 75-300 foot buffer around wetlands.

The percentage obtained from this formula would receive a score and fit into one of three rankings, Small, Medium, or Large. Again, what the ranges should be is yet to be determined. For now, 0% to 33% will be considered Small, 34% to 66% will be considered Medium, and 67% to 100% will be considered Large.

0% - 33%	=	Small
34% - 66%	=	Medium
67% - 100%	=	Large

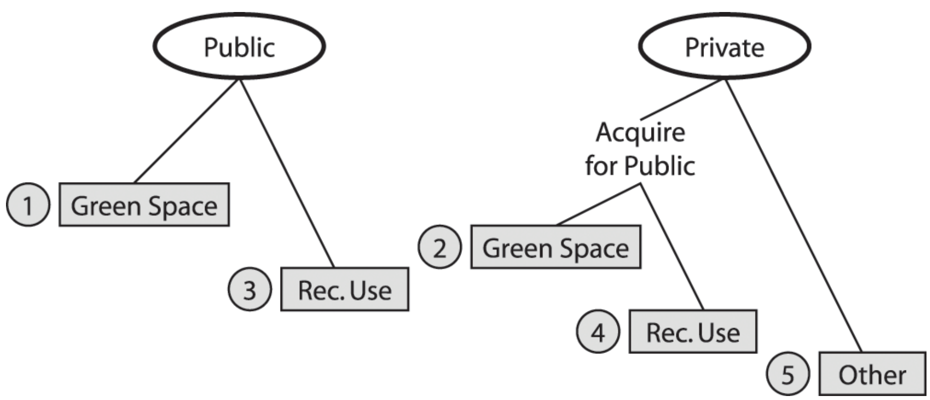
This parameter is then given a score of Small, Medium, or Large where each is given the value of 1, 3, and 5 respectively.

Small = 1
Medium = 3
Large = 5

Therefore, the more BGS habitat uses developable land on a Parcel, the greater the socio-economic cost.

Parameter 3. Parcel Ownership

The parameter that deals with Parcel Ownership is divided into two groups, Public and Private Ownership. From a socioeconomic standpoint, the cost of protecting and managing suitable BGS habitat should be spread out over all of society that benefits from it’s existence, and not a small number of private landowners. Therefore, the first type of ownership that should be considered is Public Ownership, which is divided into two parts. The first part is Open/Green Space Public Land and the second part is Public Recreational Use. Private lands are divided into three parts. Within Private lands there are two subcategories: Private lands slated to be acquired for Public use and other private landowners, or simply Other. Private lands that are to become Public are divided into the same two categories that Public lands are, Open/Green Space and Recreational Use.



<u>Definitions</u>

Open/Green Space: This needs to be defined
Recreational Use: This needs to be defined
Other: All other private land that is not currently slated to be acquired for public use.

Priority Ranking

The Land Ownership parameter is determined by the following scores.

1. Public Open/Green Space
2. Private Open/Green Space
3. Public Recreational Use
4. Private Recreational Use
5. Other

Parameter 4. Economic Value of Parcel

The Economic Value of Parcel parameter is acquired by determining the estimated market value of the Parcel. The estimated market value is defined as being more accurate than an assessed value and less accurate than an appraisal. Where an estimated market value is not available, the assessed value may be used until the estimated market value is determined. This parameter is represented as a per acre unit. Thus, the formula is:

$$\frac{\text{Estimated Market Value}}{\text{Parcel Acres}}$$

The per acre value is then used to score this parameter as one of three values: Low, Medium, or High. The range in each value needs to be determined and agreed upon. For now Low will set at $1/acre to $50,000/acre, Medium at $50,001/acre to $150,000/acre, and High at $150,001 and up.

$1 - $50,000	=	Low
$50,001 - $150,000	=	Medium
$150,001 and up	=	High

This parameter is then given a score of Low, Medium, or High where each is given the value of 1, 3, and 5 respectively.

Low = 1
Medium = 3
High = 5

Parcel Weight

Each of the four parameters receives a weighted score. This weighting was briefly discussed and determined that each parameter should have the following weighting scheme:

1. Relative Size of Parcel 20%
2. Percentage of BGS Impact 20%
3. Parcel Ownership 40%
4. Economic Value of Parcel 20%

This weighting scheme reflects the sub-group's consensus that the most important parameter was Parcel Ownership.

Parcel Score Summary

The following table summarizes all of the data described in the preceding Parcel Score paragraphs.

Parcel Parameters	Formula	Variable	Value	Score
1. Relative Size of Parcel	(Parcel Acres) ÷ (Patch Acres)	Small	0% - 15%	5
		Medium	16% - 50%	3
		Large	51% - 100%	1
2. Percentage of BGS Impact	(Buildable Acres by BGS Habitat) ÷ (Total Buildable Acres)	Small	0% - 33%	1
		Medium	34% - 66%	3
		Large	67% - 100%	5
3. Parcel Ownership		Public Open/Green Space		1
		Private Open/Green Space		2
		Public Recreational Use		3
		Private Recreational Use		4
		Other		5
4. Economic Value of Parcel	(Estimated Market Value) ÷ (Parcel Acres)	Low	\$1 - \$50,000	1
		Medium	\$50,001 - \$150,000	3
		High	\$150,001 and up	5

After being weighted, the final Parcel Score will range from 1.0 to 5.0.

Biological Parameters	Category (& Rank Score)					Overall Weight in Equation
Metapopulation Potential (categories)	High	Medium	Low	None		0.33
Metapopulation Potential rank	10	5	1	0		
Upland Quality	Good	Moderate	Poor			0.165
Upland Quality rank	10	5	1			
Wetland Quality	Good	Moderate	Poor			0.165
Wetland Quality rank	10	5	1			
Suitable Wetland Perimeter (feet)	(potentially important for future considerations)					0.0825
Suitable wetland perimeter rank value						
Restorable Wetland buffer (feet sq.)	(potentially important for future considerations)					0.0825
Restorable wetland buffer rank value						
Area categories (acres)	>300	101-300	71-100	41-70	20-40	0.0825
Area rank value	10	8	6	4	2	
% Area Upland	>30%	16-29%	0-15%			0.0825
% Area upland rank	10	5	1			

Notes on Biological Parameters:

- Upland Quality: To include consideration of soils and vegetative succession

- Suitable Wetland Perimeter: Potentially important for future considerations. Break down as we did site area. Find range of perimeters and assign them a value of 2, 4, 6, 8, or 10.

- Restorable Wetland buffer: Potentially important for future considerations. Break down as we did site area. Find range of wetland buffer areas and assign them a value of 2, 4, 6, 8, or 10.

- % Area Upland: Percent area upland within 300 ft of wetland. Will eventually need actual percentage of upland not guestimate rounded to five or ten.

Un-scored Metrics:

- Snake Presence: Want to include potential sites in analysis, but if action is taken snake presence must first be confirmed. If it is found that there are no snakes at site, the site would be listed as "not present".

- Spatial Distribution by Range: A number can't be applied to it, but it is important to consider. Spatial analysis would insure that sites are distributed throughout the snakes range.

- Spatial Distribution by Genetics: Sites harboring unique genetic material would be scored higher, with the intent to preserve the genetic diversity of the species.

- Population Size/# Snakes/ Density: Can be used to both validate the model and evaluate sites as data becomes available. Future use as a scored metric.

Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin: Population and Habitat Viability Assessment The Stakeholder Workshop

5 – 8 February, 2007
Milwaukee County, Wisconsin

V
Working Group Report: Biological Aspects of Habitat Management

Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin: Population and Habitat Viability Assessment The Stakeholder Workshop Biological Aspects of Habitat Management Working Group Report

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Problem Statements

1. Maintain Habitat Suitability/Preservation
    a) Control invasives/exotics
    b) Fragmentation
    c) Maintain connectivity
    d) Habitat mitigation
    e) External factors
        - Global warming
        - Catastrophes
        - Drought
            - We can manage hydrologic change, but can't manage for global climate change
            - Controllable vs. uncontrollable
2. Balance Needs of Humans and Wildlife
3. Development Pressure
4. Public vs. Private Management Requirements
5. Long Term Management Guidelines
6. Communicate
    a) Keeping landowners engaged
    b) Public education
    c) Funding

The problem identified is habitat loss. From there we can look at it as permanent vs. temporary habitat loss. That then breaks down to direct habitat loss and habitat degradation.

- Under degradation we discussed the issues of fragmentation, catastrophic events and external factors, and the negative effects and expansion of invasive and exotics species. Species vs. species.
- Under direct loss of habitat we discussed development pressure, fragmentation, human vs. wildlife needs, and catastrophic events including hydrology changes. Several of these problems and issues were identified under both direct habitat loss and habitat degradation.
- Past, present and future……

How do you manage lands? Private versus public land ownership is an issue. This is a separate problem because ownership depends on how you can enforce management requirements. Feel we are getting better management on private lands than public lands.

- Funding is another problem.
- Why is there habitat loss?
    - Changes in hydrology, invasion of exotic species, suppression of fire, soil disturbed, development, we didn't know what all the habitat needs are for BGS were.

Prioritized Problems:

1. Habitat Loss
    - Acres lost per year per habitat type
2. Permanent Loss of Habitat
    - Practicably irreversible
3. Temporary Impact
    - Controllable and reversible
4. Land Management (private vs. public)
    - Logical step after defining habitat loss priorities
    - Achievable, sustainable
5. Funding
    - Private vs. public
    - Presence/absence
    - Sustainability
    - Sufficiency

Data Assembly and Analysis

1. <u>Habitat Loss</u>
    a) Assumptions:
        - Habitats have been mapped from the 1980's. We know pre-settlement vegetation. We can estimate the range of BGS from the 1980's habitat data.
        - Future loss
        - That we know the suitable habitat
    b) Facts
        - The Primary Environmental Corridor (PEC) makes up 85% of the Tier 3 sites

- Know the aerial extent of reed canary grass dominant plant coverage
- Know WWI wetland types and open water

c) Data Gaps

- Shrub coverage
- What are the ideal conditions of a dispersal habitat

2. Permanent Loss

a) Data Gaps

- Proof of permanent irreversible loss (but this could be obtained)
- How hydrology will change
- Global climate change impacts
- How small of a site can BGS sustain on? The current conservation strategy makes some assumptions

b) Facts

- Habitat loss has occurred

c) Assumptions

- Future loss
- Human/Wildlife needs – overall data gaps. Future needs unknown.
- Known- ecological footprints have historically increased
- Catastrophic Events – data gaps

3. Temporary Loss

a) Assume – temporary loss is reversible
b) Assume – that you can restore suitable habitat including farmland
c) Assume – fragmentation will continue to occur (see permanent)
d) Assume – invasives will get worse (see permanent)
e) Assume – catastrophic events will occur (see permanent)
f) Assume – that wetland hydrology can be restored (see permanent)
g) Unknown – species vs. species needs (two listed T&E species with competing management goals). Through NHI know historic occurrences of some T&E species are located.
h) Unknown – Is there sufficient habitat managed for Butler's?

4. Management

a) Unknown – amount of managed sites

- Is there sufficient habitat being protected for Butler's?
- Is sufficient habitat being managed sustainably?

b) Known – current research. Inundated areas of wetlands are not suitable habitat. Sites dominated by reed canary grass are not suitable habitat.
c) Unknown – dispersal distance. Corridor passage criteria. Impact of burn management. Impact of mowing and vegetative management.
d) Known – majority of diet consists of earthworms. Where they winter.
e) Known – buffer zone distances from wetlands that BGS will use. Separate from dispersal.
f) Unknown – 75 foot buffer zone – is this sufficient?
g) Unknown – impact of adjacent land use
h) Unknown – mating and birthing location (biological requirements of reproduction)
i) Known – relationship to crayfish burrows

- Constructed hibernaculum have been used for BGS.

j) Assumption – habitat requirements of the BGS

5. Funding
    a) Known – grant funds available. Habitat management. Invasive species. Stewardship funds.
    b) Unknown – how much is available?
    c) Known – many times matching funds are required and certain ownership is required for the future. Many times need to front the money and then be reimbursed.
    d) Unknown – How long will this funding be available from private, Federal programs/grants?
    e) Assumptions – mitigation and labor costs

Identified Goals

Habitat Loss
- Reverse BGS habitat loss.
- Define a more accurate description of suitable BGS habitat.
- Maintain and/or enlarge existing species range.
- Protect and manage BGS habitat within Primary Environmental Corridors.

Permanent/Irreversible Loss
- Identify potential habitat links to reduce fragmentation.
- Monitor future land use, hydrological, and climate changes that could affect habitat.
- Maintain a geographic distribution of suitable habitat sites within the BGS range to minimize impacts from catastrophic events.

Temporary Impacts
- Manage temporary impacts to insure that the current protocol is being followed.
- Identify and prioritize manageable sites for invasive species control.

Public/Private Management
- Maintain existing suitable habitat, as well as modify and enhance poor quality habitats.
- Encourage/establish agreements to manage BGS habitat on private, public, and corporate lands.

Funding
- Identify a funding strategy that includes existing and new sources (possibly start a BGS management endowment).
- Develop tax incentives for habitat protection (preservation & management).

Lumping of Goals

- Define a more accurate description of suitable BGS habitat.
- Identify potential habitat links to reduce fragmentation.
- Identify and prioritize manageable sites for invasive species control.
- Maintain a geographic distribution of suitable habitat sites within the BGS range to minimize impacts from catastrophic events.
- Manage temporary impacts to insure that the current protocol is being followed.
- Maintain existing suitable habitat, as well as modify and enhance poor quality habitats
- Monitor future land use, hydrological, and climate changes that could affect habitat.
- Manage/monitor temporary impacts to insure that the protocol is being followed.
- Identify a funding strategy that includes existing and new sources (possibly start a BGS management endowment).
- Develop tax incentives for habitat protection (preservation & management).

Prioritized Goals and Actions

1. Goal: Maintain existing suitable habitat and enhance poor quality habitat.

Action: Obtain map sites.

- Update maps to most recent aerial photos.
- Map shrub invasive (being done SEWRPC).
- Incorporate Reed Canary Grass GIS layer (mapped by WDNR).
- Revise mapped PECs to include BGS habitat (SEWRPC).

Responsible Parties: SEWRPC and WDNR
Timeline: 1 year
Outcome: A more accurate inventory of potential viable habitat sites.
Collaborators: Use ground-truthing through students, municipalities, property owners, land managers, and consultants. Possibly use air national guard (West Bend).
Costs: $8,000 - $12,000. SEWRPC budget from WDNR, CARS.

Action: Determine where habitat management is already occurring.

- Obtain and map location information from the WDNR-BER, NRCS, CRP, and USFWS.

Responsible Parties: WDNR-BER and WDNR
Timeline: 1 year
Outcome: More accurate information on where management is occurring; allowing focus to turn to unmanaged habitat.
Collaborators: Land trusts and consultants.
Costs: $5,000 - $10,000. SEWRPC budget from WDNR.

Action: Modify existing management plans for public properties.

- Determine process for modifying management plans.
- Encourage local units of government to modify/ implement plans.

Responsible parties: WDNR, municipalities, UWEX, land trusts and consultants.
Timeline: 2 years and beyond
Cost: Unknown, it’s a major outreach component.
Outcome: Suitable and effective management on public lands for BGS.

Consequences: If funding is not available it will not happen or people will lose interest.

<u>Action</u>: Write a land management guide for BGS habitat (so all necessary management information is in one place).

- Adaptable for new information.
- Identify methods for developing linkages.
- Monitor effectiveness of linkage techniques.

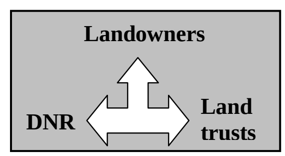
Timeline: within 1 year
Responsible Parties: WDNR-BER
Cost: $5000 for labor; $10,000 for print and distribute.
Collaborators: Consultants, researchers, and land managers
Outcome: An agreement policy and procedure that can implemented and sustainable.

<u>Action</u>: Maintain a geographic distribution of suitable sites within the BGS range.

- Evaluate range distribution from the new maps.
- Identify gaps and linkage potentials.
- Select any necessary sites to fill the gaps.
- Acquire and manage the available sites to fill the gaps (proactive).
- Develop a strategy for acquiring unavailable sites (proactive).

Timeline: 1-3 years and ongoing.
Costs: Site identification - $10,000-$15,000; Acquisition – BIG BUCKS.
Responsible Parties: Site identification – WDNR, researchers, land trusts, SEWRPC; Acquisition – everyone
Consequences: If not implemented: Missed opportunities, which lead to higher costs. More fragmentation can reduce population viability. If implemented: Buffer against catastrophic events and perseveres habitat and open space. Spin-off benefits to enhance other ecosystems and species.

<u>Action</u>: Establish habitat management agreements



- Create partnerships with land conservation organizations.
- Agreements/partnerships between WDNR, land trusts, and landowners (homeowners associations, others) altogether that also works on distributing costs.
- Establish endowments and tax incentives (tax assessments). Land trusts are a major component of this step.
- Encourage legislative changes to tax codes to favor habitat preservation and maintenance.

Responsible Parties: WDNR, land trusts, homeowners, builder associations, legislature.
Timeline: Immediate and ongoing, 2-5 years for tax changes.
Costs: BIG BUCKS, perpetual.
Consequences: If not implemented: Very limited participation and action without incentives. Loss of BGS habitat. If implemented: Protection and management of habitat. Increased property value, open space.

<u>Action</u>: Manage temporary impacts

- Update and improve protocols for management activities.
- Include in management guides.
- Initiate and continue outreach and education about availability of guidelines.
- Provide quicker turnaround time for BGS habitat notification from the WDNR-BER.

Responsible Parties: WDNR-BER, consultants, land mangers, developers
Timeline: 1 year; Initiate/continue outreach and education about availability of guidelines.
Cost: Include within the habitat management plan.
Outcome: Temporary impacts can be controlled now (early in the process).
Consequences: If implemented: Increased compliance with the ER rules. Minimize impacts to BGS.

2. Goal: Develop and implement a funding strategy for habitat management.

3. Goal: Better define suitable BGS habitat.

Actions:
- Define minimum sustainable size.
- Determine/refine habitat preferences by collecting more data.
- Define maximum length, minimum width and vegetation cover.
- Establish minimum number of acres required to sustain viable populations.
    - Apply population research to number of acres needed (e.g., density).

4. Goal: Identify potential suitable habitat sites and linkages between sites.

Actions:
- Update SEWRPC PEC map.
- Overlay land use layer on PEC layer to try and link habitat areas.
- Check license agreements between SEWRPC and WDNR-BER.
- Overlay private/public land ownership to identify potential linkage.

5. Goal: Monitor the habitat of BGS for changes that might be caused by land uses, hydrology changes, global warming, and for effectiveness of linkage techniques.

Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin: Population and Habitat Viability Assessment The Stakeholder Workshop

5 – 8 February, 2007
Milwaukee County, Wisconsin

VI
Working Group Report: Socio-economic Aspects of Habitat Management

Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin:
Population and Habitat Viability Assessment
The Stakeholder Workshop
Socio-economic Aspects of Habitat Management
Working Group Report

Working Group Participants:
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Mark Eisenmann, Landowner
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Susan Schumacher, WE Energies
Kristen Wilhelm*, River Revitalization Foundation
*Part-time participants

Issue and Problem Identification

Brainstorming/Discussion of Issues and Problems

- What does this mean? It seems like this topic might overlap with communication and economics. Funding is an issue a lot of us are looking at planning and development costs rather than DNR values.
- A lot of people are looking at the landowner rights and as part of that what are the future conservation easement issues? The battle between the publics issue with the snake.
- What is the definition of public? What is the importance of preserving the snake and how the costs are diversified who has the burden?
- We are talking about a specific species of snakes, not a cuddly perspective. How they are viewed plays a big role in how they are viewed as a value?
- Define the value of the species? Yes, would like to identify the value of the species. "Snakes are poisonous, are bad". How do you communicate that this snake is important and valuable?
- What is the value of 1 endangered species, why should I care? "Snake baggage"
- Working with land trusts/other agencies to protect and Tier III. Similar to partnership building to address needs, etc.
- Lack of resources, not enough DNR staff. There are development pressures which put groups in a tight place and there doesn't seem to be enough help.
- Cost trade-offs, looking for other options. Also look at who these rules are affecting, keep in mind inner-city

- Looking at incidental take process. Using this process to streamline the incidental take processes, what is the optimal process, is there a way to streamline this further. And further streamline the certification process. We are seeing a bottleneck where there are too few that are able to identify [There is a training session]
- Compatible uses that the private and the public use that work.
- Funding across the board. Providing enough services to make this work. This fall we met with developers and others to develop ways and utilize innovative tools, etc.
- **Who's responsible?**
- For a few projects after the 3-5 years we step away and the site goes, there is a disconnect in long term planning. Who's responsible?
- The snakes are a bit mysterious. The money upfront to find out what you have. The public perception, when it falls on them they don't understand why they are responsible for the burden of the snake.
- There is a disconnect between the issue and what people really mean. Other issues are really what are brought in, if they say what they mean.
- **What are the problems?**
- There are various levels of sophistication and that affects all actions of our practice, the small guy is disadvantaged.
- Confidentiality of heritage database and the need to know.
- There are 2 different concerns
- On developer side what is usable and can pay accordingly
- Landowner, it takes value away. It's only worth what you sell it for. Villages, towns cities
- There is an element of society, the element of regulatory environment. Look at what is out there.
- Something has to trigger the permit process. There is a jackpot mentality that may be real or not.
- Maintaining the park system. Recreational burden of management.

Grouping of Issues

1. Funding Issues
    a) Economics
    b) Magnitude
    c) Costs?
        - grant funding
        - management preservation costs
        - land preservation acquisition
        - planning costs
        - site identification
    d) Who's responsible
    e) Lack of tax base
    f) WDNR staffing
    g) Reluctance to add project costs (who responsible)
    h) Enforcement/responsibility
2. Public Education
    a) Community perception
    b) Importance of conservation (lay public/local officials/landowners)
    c) Permit review
    d) Value of species to public

3. Regulatory
    a) Landowner rights
    b) Conservation rights/ easements and what are the limits
    c) Review process
    d) Permit review timing
    e) Partnership building for preservation
    f) Cost reduction alternatives
    g) Trade offs($)
    h) Further streamline existing take authorization process
4. Planning
    a) Better planning of preservation areas
    b) Compatible uses

<u>Problem Prioritization:</u>

1. **Regulatory:** There is a lack of flexibility within the current regulatory mandate.
    - *Discussion: the timeline is long, the estimation is poor*

2. **Planning:** Current planning efforts do no predict the competing interests of human and snake interaction.
    - *Discussion: Processes don't address the educational needs of people and interrelation needs for snakes and people.*

3. **Funding**: There is insufficient knowledge of the magnitude, source, availability, and opportunities for funding for species survival.
    - *Discussion: Insufficient funding to address the multitude of costs of snake mgmt.*

4. **Education:** Land use and habitat preservation decisions are not being made within an informed constituency.

Data Assembly

1. **Regulatory:** There is a lack of flexibility within the current regulatory mandate.
    a) What are the facts we know about this issue?
        - ER 29
        - Conservation strategy v.2.3 (3/05)
        - Incidental Take Tier 1, 2, Temporary
        - NR 151, 216
        - The statute governing the heritage database and confidentiality
        - Staffing could be an issue. 1 person @ Central just does incidental take. 1 biologist, ½ asst. biologist, ½ early permit review
        - How does the Water Management Staff affect?
        - Testing can only take place in small period of time.

    Discussion: How does the permitting process work? During the 30 days there is a full permitting process. That includes storm water, etc. However until then there is not knowledge.

b) What are the assumptions surrounding this issue?
- The level of knowledge the public/reg party as far as who and what is regulated.
- There's not flexibility in this process, or is it fact.
- Increased staff will fix problem. Is there really a need for more staff?
- 65 path sites are necessary for survival/long-term protection.

Discussion: If the application was done well and not incomplete and the DNR identified of the issue then it wouldn't. There is the possibility of making and that would offer more flexibility. We are talking an awful lot about the process but haven't identified the longevity of the habitat. We don't know that we are protecting the habitat through this process. Does it result in protection?

How does the translocation idea work, but we are doing that when we create a habitat on those parcels that are already

There is the assumption that the project team would identify the issue early enough in the process. The earlier it is known that there is a possibility

DNR has the ability to work with applicants.

Early identification can help. DNR see some owners come in with the property they can't do what they wanted with it.

There are only 2 choices according to some. There is the ability for survey on the property. Is the flexibility the DNR sees actually helpful to the landowner?

Presence of the snake actually impacts the viability of the property.

Also, will it really impact the project timeline. And if snakes are found many think that the snake presence throws out the possibility

How do we justify our assumptions?

c) What important data are missing?
- Spring/fall survey, if it fails in fall does that mean that they have to redo in spring?
- Regulation results in species survival

2. **Planning:** Current planning efforts do not predict the competing interests of human and snake interaction.

a) What are the facts we know about this issue?
- NHI database
- Local land use plans and zoning don't include Butler's info
- Landowner has what they have and they can't change
- The tools have improved to help everyone.
- For tier 3 sites the regulation is triggered regardless of the quality of the habitat

b) What are the assumptions surrounding this issue?
- Everyone is doing early environmental reviews. We don't know if they do. DNR does but you never know.
- Land use planning actually affects what happens on the ground.
- Planning uses heritage info to identify ecologically significant areas.
- There isn't enough
- Habitat preservation is more important than economic development or vice versa.
- Private property owners may have to expand habitat in certain scenarios.

Discussion:

Then what are the uses and are they compatible?

There is no regulatory or planning change if there is no consensus building with the community/decision makers. What is good planning with regards to the species in an increasingly urbanized government? Is there any evidence that this would be good snake habitat in the future?

There is no long term check from the DNR that the maintenance of the habitat is on-going after 2 year. There is no auditing. For wetlands there is, but not for the snakes.

There is an assumption that the planning reflects public opinion,

There is a rough complexity to having 1 level of government waiting for permitting from another.

How do we justify our assumptions?

c) What important data are missing?
- Knowledge gap, that the tools are out there but do the right people know how to use them?

3. **Funding:** There is insufficient knowledge of the magnitude, source, availability, and opportunities for funding for species survival.

a) What are the facts we know about this issue?
- State/private funding sources exist
- long-term efforts have cost
- Permittees are responsible for surveys, review, mitigation, monitoring, etc.
- DNR is responsible for costs/staffing review
- Conservation strategy
- Butler's protection is a statewide concern.

b) What are the assumptions surrounding this issue?
- that everyone is able to find funding, to pay for this
- Upland habitat is valuable

c) Missing Data
- Knowledge gap within design community

Discussion: For wetlands there is a burden for identification put on the permitee. The DNR can choose to review or not. There has been $ spent on research.

There is an issue as far as what is out there is working. If it is and you take the idea that this is field and you understand that this is wetland and you layer on a snake issues then you say that there is a 300 ft of upland. I think it is similar to the wetland issue,. But it is under the same idea of the wetland. This is actual habitat. Where I think they differ is that here has been farmed, here is good snake habitat (drawing). The landowner understands that here there is the 75ft offset and so potentially. the disconnect is that there I have plowed, etc, I know that there are no snakes on this land that I have plowed and I know snakes are over here. But I've plowed which means that there are no snakes (I've killed them).

There is flexibility with the storm water and wetland.

Goal Identification

1. **Regulatory:** Develop regulatory framework for all stakeholders to implement and a pool of qualified and experienced consultants while effectively protecting BGS in long term.
    a) Develop regulations and information distribution system that satisfies impacted developers/landowners as well as the species preservation goal.
    b) Develop regulatory framework that is flexible/easy to implement for all stakeholders, and a pool of experts/consultants; while effectively protecting BGS in the long term.
    c) Developing ideas or methods to equally/fairly cost share the cost associated with habitat preservation/management.
    d) Develop management plan that establishes responsibility and ensures long-term effectiveness.
    e) Develop regulatory framework with flexibility in design and certainty in the process.

    Discussion: There is a concern because our conversation yesterday with a DNR Rep said that the regulatory environment was flexible. But our problem statement says other wise…is this right?

    The BGS is a state listed species; you can't expect 1 property owner to pick up the millions of dollars of cost. So if you were disadvantaged as a middle guy, if I am concerned that

    You can't structure the funding methods in a way that says the costs can be assumed by the ones that actually have the land.

    Early on we had a black and white issue with wetlands and butlers was the same. But now we are getting into the grey and there is a concern when these little projects come in that they are asking for consideration. The way 29 was written there was no way for them to say, "Yes, this outcome is crazy… but we have to do it, that's the way it's written."

    On the regulatory side are we dealing with the

    The fencing is something that the DNR feels confident about.

    Developing an auditing program and using that info to further enhance existing and future habitat

    If we had flexibility that would help the species that would be fine, but if we had the opposite then that wouldn't benefit the species. We want flexibility that says we can

2. **Planning:** Determine local and regional opportunities where we identify lands and potential compatible uses that can significantly affect BGS protection/management are identified.
    a) Get local municipalities, counties, MMSD involved in planning process earlier.
    b) Determine local and regional planning opportunities to identify lands and potential compatible uses that can significantly affect BGS protection/management.

    Discussion: There is a lot with the planning process that seems to be an issue and there is not a lot written, maybe that is why. There should be some intergovernmental cooperation as far as planning. Everyone should work together to assess planning opportunities and bring up issues like this BGS.

3. **Funding:**
    a) Determine # of patch sites needed and the cost of protection (e.g., management costs, real estate costs, regulatory implementation costs, lost revenue costs).
    b) Determine biological needs for long term protection of BGS that results in acceptable costs for stakeholders and public.
    c) Focus all regulatory, management, protection, scientific efforts on priority patches established by site assessment characterization group.

Discussion: The really touchy and emotional issue is that there are landowners that think they are loosing something that they never actually had to begin with. The idea that you thought you had 40 lots and now you only have 13. It's important to remember that the lost revenue is a real issue.

The biz side needs a number that we can get to. That is encouraging, and it seems like with a number and the department provides the "best" sites not just the 1st grouping, then there would be an interest on the private side to help with funding.

Based on a risk based analysis of what the snake needs to satisfy the habitat preservation.

The issue of delisting, it is out there and to the layperson it does seem to be success. It is like the bald eagle. You can see them now and that means success.

If there were funding to improve the habitat in some areas, it would go toward that goal of protecting the snake long term. There is no way that would happen, because it would be seen as throwing money away. As an agency we have philanthropic dollars, and it comes down to what is spent and what we want spent. We have to build in subtle increments for funding this so it is almost unseen. If you could get out of regulation then we improve the species. DNR has certain resources available and we have thrown them at the regulatory end of it because it is the most immediate.

There may be a lot of good sites, what happens if they get to be the most expensive. The other group might be taking care of it. Let's focus all efforts on patches and not just biological needs.

Prioritizing Goals Process

Ranking Criteria:

- Likelihood of success?
- Ease of Implement ability/implementation?

Paired Ranking Results (number/letter corresponds with above goals)

Goal		Participant 1	2	3	4	5	6	7	8	9	vote tally	rank
Regulatory (#1)	a	3	4	2	5	1	1	1	5	8	30	
Regulatory (#1)	**b**	**4**	**8**	**7**	**5**	**8**	**9**	**4**	**7**	**4**	**56**	**1**
Regulatory (#1)	**c**	**3**	**6**	**9**	**1**	**3**	**4**	**7**	**7**	**7**	**47**	**3**
Regulatory (#1)	d	2	5	0	7	1	5	5	4	2	31	
Regulatory (#1)	**e**	**6**	**5**	**6**	**4**	**8**	**7**	**2**	**1**	**2**	**41**	**4**
Planning (#2)	a	4	2	2	2	4	3	7	1	9	34	
Planning (#2)	**b**	**3**	**5**	**5**	**11**	**6**	**7**	**8**	**5**	**6**	**56**	**1**
Funding (#3)	a	9	1	2	0	2	0	0	2	2	18	
Funding (#3)	b	3	3	4	1	4	3	3	9	3	33	
Funding (#3)	**c**	**9**	**5**	**8**	**9**	**7**	**3**	**7**	**3**	**3**	**54**	**2**

Prioritized Goals and Actions:

Workgroup guiding principles:

- Flexibility in Permit project design
- Certainty in regulatory process
- Reduce Cost/minimize private property impacts
- Easy to understand
- Meet Statutory requirements
- Regulations must share burdens of cost
- Continually increase management/mitigation options

Discussion: There is income and other income included. Some don't see the magic solution there isn't the full amount of money. This action plan will most likely show that if the money is not available these actions are able to work and get things done.

Which actions are the most important? To some it is the prioritization of sites.

We split into 2 groups and identify.

1. **GOAL: Determine local and regional planning opportunities to identify lands and potential compatible uses that can significantly affect BGS protection/management.** (Scored 17)
   a) Revise strategy to encourage BGS site compatible uses
      - DNR to organize a workgroup to identify compatible uses. Assemble a group herpetologists/ landscape architects/ NRCS/ Zoning officials and other stakeholders who will be responsible to create this listing of compatible land uses by 1 July, 2007.
        - o Develop list of what is allowed and what isn't for distribution
          a. Examples:
             i. Trails with certain limitations
             ii. Agricultural uses
             iii. X-country with a warming hut
             iv. Structures above land
             v. Storm water
             vi. Protective planting could help minimize loss

   b) Develop guidelines and encourage gov't to use them.
   c) Organize tool kits including strategies/outlines that could be presented for use on future developments. Serve as educational resource to sites subject to BGS protection/management by 7/07
      - Examples:
        - o Model ordinance that could be adopted to guide – propose that SEWRPC develop an ordinance by 1 July, 2007.
        - o Property owner/developer toolkit for those Tier III properties – Metro – builders Assn will collect these tools where they have been successfully applied by 1 July, 2007.
          a. "If BGS are found to be on property than these may apply…"
          b. Lessons learned
          c. List of consultants (goal scored 5)
             i. Develop a pool of qualified experts/consultant

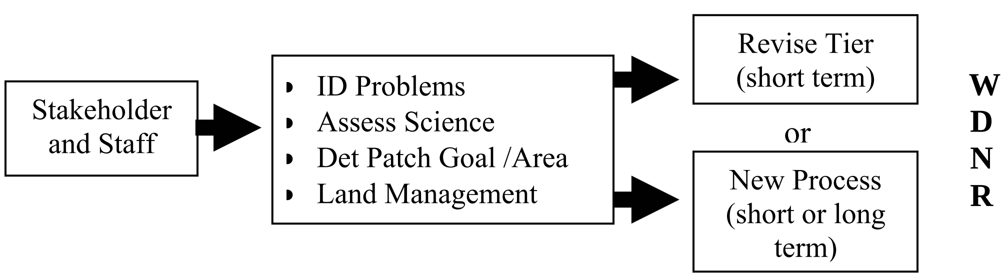
d) Inform local units of gov't of the data that accessible from the DNR for planning, preservation, research needs.
   - DNR
   - SEWRPC
   - WAPA
   - Towns/Counties Assn
   - Comp planning

e) Create a statutory reference that includes endangered resources as a focus area in the Smart Growth Initiative or other statutory language. Options to be pursued include:
   - Options for mitigation
   - Density bonus – for enhancement of BGS habitat.
   - Sale of credits or banking BGS of habitat units.
      - o Out of patch options?

2. **GOAL**: **Developing regulatory framework with flexibility in design and certainty in process. (Scored 12)**

   a) <u>Actions</u>:
   - Industry in cooperation with WDNR
   - Create Workgroup- Stakeholders
      - o Initiate a new stakeholders group to re-develop the regulatory framework with flexibility in design and certainty in process.
         a. Consist of the DNR regulators, industry, commercial, residential, utility, MMSD, local municipal official representatives to develop a big picture perspective of the issue.
   - Staff Support
      - o B. Hay, WDNR attorney, SEWRPC
   - Identify problems- then either
      - o Revise tier (short term)
      - o New Process (short/long term)

   b) The new system has to be easy to understand, reduce complexity, reduce costs to land developers, establish alternatives within the process.



3. **GOAL**: **Develop methods to equally and fairly share costs with management and protection of habitat. (Scored 27)**
    a) **<u>Actions</u>:**
        - Create workgroup and establish cost allocation by stakeholder
        - Establish budget/projection
        - Identify list of grant options of cost, identify funding resources, develop cost saving approaches.
        - Prioritize costs for science/management/acquisition
        - Recommend expenditures to WDNR

    Discussion: There was some thought that originally this meeting was to solve this issue but now we are working on other actions to solve that. So creating more meetings and more groups seems like it's a bit too much.

    How do we organize this so that there is another group responsible for the actual implementation- people that can make it happen? NGOs that could take over ownership of those BGS areas? Identify existing funding? Coastal zone, Stewardship grants, Conservation funds

4. **<u>GOAL</u>**: **Focus all regulatory, management, protection and scientific efforts on priority patches as established by a site characterization group (Scored 4)**

Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin:
Population and Habitat Viability Assessment
The Stakeholder Workshop

5 – 8 February, 2007
Milwaukee County, Wisconsin

VII
Working Group Report: Population Management

Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin: Population and Habitat Viability Assessment The Stakeholder Workshop Population Management Working Group Report

Working Group Participants:
Craig Berg, Milwaukee County Zoo
Owen Boyle, Wisconsin Department of Natural Resources
Lesley Brotkowski*, Cedarburg Science
Gary Casper`, University of Wisconsin-Milwaukee Field Station
Billie Harrison, Urban Ecology Center
Terrell Hyde*, Wisconsin Department of Natural Resources
Craig Pelke, Milwaukee County Zoo

*Part-time participant
`Consultant

Identified Problems and Issues

- The impression that zoos are "Arks"
- Range/habitat fragmentation or isolation
    - Genetic problems?
    - Hybrid vigor?
- Lack of knowledge of the BGS demographic data
    - Urban vs. rural
    - Predator/prey issues (feral cats)
- Lack of researchers/coordination
- Lack of funding for research
- Perceptions of snakes/reptiles
- Feasibility of viable translocation/augmentation (biological & social/management aspects- unknown)
- Indeterminate zone (regulatory impact)-should the "hybrids" be protected as a special gene pool?
- Evaluation of sampling methods (part of researcher coordination?)

Challenges:
- Proving the endangered/threatened listing
- Proving whether the BGS is a separate sub-species or species from the eastern populations
- Level of inbreeding
- Coordination among researchers
- Funding for researchers

Demographic Unknowns:
- Accurate population size/density (5 and 10 years)
    - Long-term study

- Inbreeding depression occurring (2-3 years, captive?)
- % of females reproducing? (1-2 years)
- Number of males reproducing? (1-2 years)
- Clutch size information needed (1-2 years)
- Dispersal ability/distance/cost (1-2 years)
- Life expectancy in the wild (WI) (5-10 years)
- Age of first breeding episode (2-3 years)
- Age-based mortality (survivorship) rates (4-6 years)
- Morphology (1-2 years)

Lack of accurate demographic information of BGS in SE WI

- How to prioritize?
- Resources available?
- Timeframe?
- Supportive of updated conservation strategy?

Problem Statement:

The absence of accurate population size estimates, population trends, and demographic structure continues to hinder adaptive management efforts while the level of hybridization occurring within the species and the genetic relatedness of populations remains speculative among experts. Additional information is required to achieve effective and relevant management goals that promote genetic diversity and reduce the further loss of individuals. This uncertainty leads to considerable difficulty in identifying defensible quantitative targets for successful population management.

Criteria for Prioritization:

- Important Data Gap (determined in PVA)
- Management application
- Public Value

Priority #1: Demographics

Find answers to the demographic unknowns through field research. Solve researcher and funding questions to get demographic data. The added information (% of females breeding, litter size, age of 1st reproduction) can allow us to make more conclusive decisions in the management of the species.

1. **Complete the BGS Life Table**
    a) Population size/density (3-5 years)
        - -habitat quality
    b) Survivorship (6-10 years)
        - % of females reproducing (1-2 years)
        - Age of 1st reproduction (2-3 years)
        - Genetics & Morphology (2-3 years)
        - Population trends (5-10 years)
            - -habitat quality
        - Life expectancy in the wild (SE WI) (? Years)
2. **Hybrid Genetics**

Priority #2: **Translocation**
Find out if translocation if feasible.
Field work needed

Data Assembly and Analysis

Facts known-

1. Litter size
2. There is a great need for field study/research on the BGS demographics

Assumptions-

1. Where they occur, the numbers seem dense, but research is needed

Facts Unknown-

1. Problem Statement clearly states that there is a large amount of unknown information concerning BGS and how many are out there.
2. Is translocation a viable option?
3. Who is going to do the field work to gather the data?
4. Taxonomic issues (genetics and morphology)
5. BGS (different subspecies or species?)
6. Hybrid (new species?)

Prioritized Goals and Actions

1. **Goal**: Coordinate research to define and prioritize research needs and avoid duplication of efforts.
   Action: Coordinate Research
   Responsible Party: WI-DNR (BER) and research team
   Timeline: End of March '07, and continue every year
   Measurable Outcome: Begin research in a planned fashion; annual review of research progress and reporting; communicate progress and information to stakeholders; simultaneously collect data for multiple studies in population densities, taxonomy/genetics, and demographics to the greatest extent possible
   Collaborators: WI-DNR, University of Wisconsin-Milwaukee, Urban Ecology Center, Milwaukee County Zoo, Association of Zoos and Aquaria ; American Zoological Association (AZA), and advisors
   Costs: Borne by collaborators and responsible parties
   Consequences: Coordinated research efforts
   Consequences of inaction: Uncoordinated research, duplicated efforts, inefficiencies
   Obstacles: Scheduling and timeframe

2. **Goal**: To obtain a greater understanding of Butler's gartersnake population density (population size and distribution) in order to refine quantitative targets to ensure self sustaining viable populations in managed lands in SE WI in perpetuity.
   Action: Obtain BGS Population Density Data
   Responsible Party: WI-DNR (BER) and research team
   Timeline: Starting Spring 2007, point data 2 years, trend data 10 years
   Measurable Outcome: Density data from habitat patches of variable quality and size, and examine trends in populations; increase predictive ability via annual data collection
   Collaborators: WI-DNR, University of Wisconsin-Milwaukee, Urban Ecology Center, Milwaukee County Zoo, American Zoological Association (AZA), and advisors
   Costs: $2000/site
   Consequences: Ability to construct and implement a well informed conservation strategy
   Obstacles: Availability and timing of funding; developing the standard sampling; timeframe, inability to gain access to selected sites; availability of safe sites

3. **Goal**: To define the taxonomy of the Butler's/Plains gartersnake species complex through genetic, morphological, and behavioral research.
   Action: To collect accurate data for taxonomic elucidation, on:
   - Genetic
   - Morphological
   - Behavioral

   Responsible Party: WI-DNR (BER) and research team
   Timeline: Starting Spring 2007, continue for 3-5 years
   Measurable Outcomes:
   - Define Butler's gartersnakes
   - Define Plains gartersnakes
   - Define hybrids
   - Determine the estimates of inbreeding at the population level

   Collaborators: WI-DNR, University of Wisconsin-Milwaukee, Urban Ecology Center, Milwaukee County Zoo, American Zoological Association (AZA), and advisors
   Costs: Collection costs of genetic and morphological data absorbed by other density and demography collection studies; $50-$100/sample for DNA processing; behavioral data collected on separate study-costs indeterminate at this time
   Consequences: Morphologically based identification key is developed and supported by the genetic and behavioral data;
   Consequences of inaction: Continued uncertainty and controversy over regulated populations
   Obstacles: Inability to gain access to selected sites; ability to find safe sites; funding

4. **Goal**: To define the demographic parameters of Butler's gartersnakes in order to support management decisions.

Action: To collect demographic data in the following categories:

- Establishment of Lifetable-Survivorship (6-10 years)
- % of Females reproducing (1-2 years)
- Age of first reproduction (2-3 years)
- Life expectancy in the wild (?)
- Dispersal ability/immigration/emigration (3-4 years)
- Number of male reproductive events/season-how many times a year (lab) (1-2 years)
- Inbreeding Depression (lab) (5-10 years)

Responsible Party: WI-DNR (BER) and research team
Timeline: See above
Measurable Outcome: Refined prediction ability of PVA and metapopulation models
Collaborators: WI-DNR, University of Wisconsin-Milwaukee, Urban Ecology Center, Milwaukee County Zoo, American Zoological Association (AZA), and advisors
Costs: Field studies borne by multiple studies; lab separate
Consequences: Refined prediction ability of PVA and metapopulation models
Obstacles: Availability and timing of funding; developing the standard sampling; timeframe, inability to gain access to selected sites

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VIII
Working Group Report: Communications and Outreach

Butler's Gartersnake (*Thamnophis butleri*) in Wisconsin: Population and Habitat Viability Assessment The Stakeholder Workshop Communications and Outreach Working Group Report

Working Group Participants:
Mathew Haasch, Landowner
Delene Hanson, Milwaukee Area Land Conservancy
Terrell Hyde, Wisconsin Department of Natural Resources
Larry Kascht, Retzer Nature Center and Waukesha County Parks
Chuck Matyska, Wisconsin Wildlife Federation
Sheri Mount, Waukesha County-Division of Planning & Zoning
Corinne Sommers, Landowner
Michael Thompson, Wisconsin Department of Natural Resources, SE Region

Communication and Collaboration Problems - Data Assembly and Analysis Issues

1) Stakeholder communications are not well coordinated.

a. In some examples, the responsibility for long-term maintenance and management of conservation easements has been delegated to County Government, when County Government wasn't involved in any planning discussions. Lack of readily available information creates uncertainty for all stakeholders. Stakeholders often do not understand or communicate effectively with each other. These issues contribute to distrust. Late stakeholder coordination/involvement creates problems and delays in the process. Poor property owner, municipality, local and state government cooperation causes problems and delays. Stakeholders' assumed expectations of each others roles and responsibilities can cause miscommunication and mistrust. Regulatory staff turnover along with poor documentation can contribute to inconsistency and un-necessarily revisiting prior agreements. The negative perception of government regulation can cause uncertainty and mistrust. Evolving regulations can cause negative perceptions. Inconsistency causes uncertainty and mistrust among many stakeholder groups. What is the role of homeowners and homeowners' organization groups in long term BGS habitat management?

- Fact: Transparency is required.
- Fact: Consistency is required.
- Assumption: Stakeholders want an efficient process to implement BGS Conservation Plan.
- Fact: There are multiple regulations that may apply to the development of BGS sites.
- Fact: Stakeholders want clarity of responsibilities.
- Fact: Stakeholders want a consistent and predictable process for identifying and resolving BGS issues.
- Fact: Scientific and technical information is incomplete.

b. No one knows where snake habitat is. There are no maps shared with property owners. How can property owners know whether they need to be concerned about BGS? Why do snake locations need to be secret? How come information can not be shared with stakeholders? Current conservation plans and regulations are ambiguous and not well communicated.

- Fact: BGS element occurrence information is confidential.
- Fact: Property owners and the public have an expectation that they can easily obtain land information from government (i.e. GIS)
- Assumption: It would be beneficial to make BGS habitat area and BGS Tier I, II, III GIS information available on-line.
- Assumption: The GIS information will allow BGS stakeholders to make better-informed decisions.

c. The current regulations are still evolving and must be applied to current development proposals. The public expectation is that government regulatory approvals and intergovernmental activities will be transparent and consistently applied to small property owners, large companies (natural gas pipeline projects), and state government (DOT) projects.

- Fact: BGS information is still being collected.
- Fact: The October 2004 BGS Stakeholders' Group Conservation Plan and regulations are still evolving.
- Data Gap: What changes are proposed for Conservation Plan.
- Assumption: There will likely be changes to Tier III site identification and regulation.

2) Shared Financial Responsibilities are not well defined.

a. Who should pay and in what circumstances? The utilization of public and private lands for BGS unclear and problematic. Individual financial circumstances vary. There should be more discussion of financial responsibilities.

- Data Gap: Can BGS conservation plan be implemented solely or mostly on public lands?
- Data Gap: What are costs for BGS conservation plan?
- Data Gap: Should there be compensation for private property owners? This may be ultimately a management issue.
- Data Gap: What are private property and takings legal frame works?
    1. Data Gap: What is "reasonable use"?
    2. Data Gap: How does "reasonable use" compare to "highest and Best Use?
- Data Gap: What are funding opportunities?
    1. State Wildlife Grants?
    2. Landowner Incentive Program?
    3. Stewardship Grant?
    4. Private Land Trusts?

3) **Stakeholders have widely divergent values of BGS. Common values have not been well identified.**

a. The lack of BGS appeal may not motivate affected private property owners to value or preserve the BGS. Common Values should be identified.
   - Fact: The Stakeholders do value BGS.
   - Fact: The Stakeholders do share value of efficient BGS process.
   - Data Gap: The technical and scientific issues are disputed.

Prioritized Goals and Actions

Goal 1) Revise, simplify, and clarify regulations, science, and options to all stakeholders, in order to:

- develop a transparent, consistent, efficient, predictable, process to resolve BGS issues;
- assure clarity of responsibility and consistent application; clear vision of the process;
- provide process steps and contact lists for all participants: landowners, developers, municipalities;
- make science transparent, consistent, credible, and accessible;
- layout the path on how to gain knowledge; and
- provide better definitions/explanations of compensation and perceived takings.

Action 1A: Hire a Butler's Gartersnake Conservation Strategy Coordinator
Description: Coordinator will serve to help implement the strategy. Coordinator will serve as the main contact for front-line questions concerning regulations, science, and stakeholder options. Additional duties may include: Organize consultants training; Explore options for flexibility; Identify and promote funding opportunities; Trust-building via communication.
Responsibility: WDNR
Time line: Short-term immediate hire upon securing funds; full time for 2 years; after 2-years assess process/need.
Measurable: Hired Coordinator
Collaborators or Partners: Potential funders
Resources: $40,000 a year ($80,000 for 2 years)
Consequences: Increase ability to implement the Conservation Strategy; and address stated goal.
Obstacles: Funding (2-year grant). Unclear of how permanent this position will be and how great the duties will be; Candidate responsibilities are expansive and unique and it will be crucial to find the right the fit.

Action 1B: Flow-chart (similar to a dichotomous key) of process steps (state and local) with well articulated options and opportunities for flexibility as defined in the updated Butler's Gartersnake Conservation Strategy.
Description: A document (hardcopy or on Website) that provides a visible frame-work/flow-chart for various courses of action within the Butler's Gartersnake Conservation Strategy. May contain contact lists, downloadable forms, fact sheet, science at-hand.
Responsibility: Lead is the WDNR-Conservation Strategy Coordinator
Time line: Short-term action is to have a flow-chart of the revised process posted on the WDNR-ER Conservation Strategy website; Long-range time line is populating and keeping the links active and appropriate.

Measurable: A document (hardcopy or electronic on website) which is useful, simple, and current.
Collaborators or Partners: Gathering Waters, Counties, Municipalities, Land Trusts, Consultants, or others who will be linked to are responsible for providing information elements of the conservation strategy implementation
Resources: See WDNR NR2.16 process as example; Google-Earth as example for design; Current Review Process flow-chart (updated)
Consequences: Better communication and more transparency of the process
Obstacles: Funding for a web creator/designer; Pros and Cons of having all data in one place for all organizations/people, as data may become dated and who is responsible for updating it.

Goal 2) Combine effective utilization of protected public lands, where feasible; with proactive conservation/education/outreach for all stakeholders, in order to:

- Identify/invite new stakeholder groups;
- Share locations of known habitat patches to all landowners (private, public, NGO); Focus on the highly ranked sites identified in the site characterization and prioritization working group;
- Layout financial incentives to all stakeholders;
- Layout better decision making tools/processes;
- Support Citizen Science Programs;
- Make aware the conservation issues in the state/country: Engage those people/organization beyond those that are directly impacted (extended stakeholders);
- Encourage appropriate management for the species;
- Educate citizens of communities of the opportunities for protection/mitigation/habitat banking within their community; and
- Develop outreach/education programs.

Action 2A: Identify public lands and develop management plans
Description: Inform public land managers/owners of their property's conservation potential/value as determined by Site Characterization and Prioritization Working Group.
Responsibility: Public lands managers/owners responsibility: to develop habitat management plans and educate/inform public; WDNR responsibility: Assistance/advice/identification of sites
Time line: Inform public land managers within 6 months of Conservation Strategy approval.
Measurable: Number of cooperative projects
Collaborators or Partners: State, county, municipal, land trusts (those with public access)
Resources: Current cooperative relationships
Consequences: Greater public value/use of public lands (or publicly available); and increased shared responsibility; May lead to greater proactive and cooperative protection of highly ranked conservation sites
Obstacles: Funding/Conservation Strategy Coordinator/Cooperation

Action 2B: Develop a proactive conservation/education/outreach program for all stakeholders.
Description: Identify non-public sites with high conservation value (as determined Site Characterization and Prioritization Working Group); develop educational materials; disseminate materials effectively; highlight/promote opportunities and options.
Responsibility: WDNR-Coordinator and partner groups
Time line: On-going contact and development of programs
Measurable: Number of "contacts" made

Collaborators or Partners: Land Conservancies; State and local governments agencies; Nature Centers; public/private school systems; Citizen Science programs; Conservation Organizations
Resources: Existing education/outreach programs; Infrastructure of above stated collaborators/partners.
Consequences: Greater awareness for landowners who have highly valued properties for the BGS; Greater cooperation between stakeholders;
Obstacles: Funding; May be difficult to coordinate partner groups; lack of interest by affected groups

Goal 3) Provide research opportunities to the broader scientific community and make the upgraded scientific information available to stakeholders.

Action 3A: Encourage additional research by professional scientists, graduate students, etc.
Description: Make the gaps in the current knowledge base known to these groups in order to facilitate targeted studies.
Responsibility: WDNR
Time line: within the next 6 months
Measurable: actual data as a result of the studies
Collaborators or Partners: Universities, professional organizations, Zoological Societies, WDNR, conservation organizations, etc.
Resources: Grants, funding organizations (conservation groups), charitable foundations, etc.
Consequences: Better base of scientific information on which to make informed decisions.
Obstacles: Funding, timing, uncertainty of participation; the localized nature of the species and the need for immediate results may limit potential scientific interest.

Action 3B: Make the upgraded scientific information available to stakeholders
Description: Post/disseminate/distribute new scientific information. Use multiple media outlet, like Newspapers, Newsletter, Web, Direct Mailing
Responsibility: WDNR-Coordinator
Time line: As new data occurs; Post existing studies
Measurable: Posted/distributed information
Collaborators or Partners: Scientific Community; Stakeholders
Resources: Existing electronic libraries/publications
Consequences: Equitable access to information; and will enable more proactive approaches.
Obstacles: Funding, timing, uncertainty of participation; the localized nature of the species and the need for immediate results may limit potential scientific interest.

Goal 4) Implement the Conservation Strategy through funding to include programs for: Management; Protection; and Compensation.

Action 4A: Locate, identify, encourage, and promote funding sources to support the actions identified in the Conservation Strategy as well as the Stakeholder Working Group reports.
Description: Encourage grant-giving organizations/foundations to support the implementation of the Conservation Strategy. Encourage development of and application of tax-relief/incentive programs. Locate acquisition programs/organizations. Encourage local zoning changes, which would allow creative avoidance/mitigation opportunities (i.e., density credits).
Responsibility: WDNR-Coordinator responsibility to identify and make known the existing funding sources; Local governments Zoning Laws

Time line: On-going; Immediate action to identify existing funding sources
Measurable: Posted/distributed information, as well as creation of new funding sources/avenues.
Collaborators or Partners: Federal, State and Local Governments; Grant-giving organizations
Resources: Existing Funding sources; Philanthropy organizations
Consequences: Equitable access to information; and will enable more proactive approaches.
Obstacles: Local governments' willingness to share the responsibility; Lack of Funding;

Goal 5) Meta-Goal to be a component and driving force of all the previously defined goals and actions. Identify common values and build off of them to foster community building through cooperation and compromise. Common values we identified were: Ability to choose (Individual right to choose - options); 2) Want to be informed/equal access/voice to be heard; 3) Fairness; 4) Appreciation of esthetic value of natural areas – which adds to quality of life.

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IX
Appendices

Appendix 1

Butler's Gartersnake Conservation Target-Setting Workshop 13 March, 2007

Workshop Results

Introduction

To support implementation of the 2005 Butler's Gartersnake Conservation Strategy, experts in snake biology and ecology and conservation biology concluded that a minimum of 65 significant conservation patches (populations) is required to assure the long-term survival of the species in Wisconsin. This number of patches was based on the WDNR's and scientific community's current knowledge of population characteristics, patch security/habitat threats, genetic factors, and patch size. Since 2005, there is new science on genetics factors, population characteristics, and patch size and how they can interact to influence gartersnake population persistence. In light of what we now know, there is scientific justification to revise this target to a lower threshold while retaining the ecological conditions necessary for long-term species persistence. However there are still gaps in our understanding of the species biology, the precise location of suitable habitat patches, and the typical density of snakes that may occupy those patches. Given this incomplete knowledge of the species and its habitat, we must try to remain conservative in the process of revising our conservation target.

Near the conclusion of the Butler's Gartersnake Population Habitat Viability Assessment (PHVA) workshop conducted in February 2007, the full body of participants agreed that a revision of the conservation target was acceptable. Moreover, the participants identified the value of using a site characterization and prioritization scheme, finalized at the workshop, to further clarify the value of individual patches for Butler's gartersnake conservation. With the additional information generated by this scheme in hand, and with the results of a Population Viability Analysis (PVA) conducted in anticipation of the PHVA workshop as further guidance, a revised target for the number of patches required for successful management of the species was possible.

Within weeks of the conclusion of the PHVA workshop, The WDNR applied the biological characterization and prioritization scheme to the State's list of 161 known Tier 3 patches. Upon completion of this task, a subset of the PHVA and PVA workshop participants reconvened to revise the number of patches required to ensure the long-term conservation of the species. The subset of participants was mostly comprised of scientists having expertise in population dynamics, Butler's gartersnake life history and ecology, and genetics. Representatives from the Metropolitan Builders Association were also invited to provide important additional perspective and to ensure transparency of the process. The meeting took place at the University Wisconsin Pyle Center on March 13th 2007. The meeting was broadcast over the Internet and archived to DVD.

The characterization of potential Butler's gartersnake conservation patches using the Tier system is an important component of the current Conservation Strategy. Tier definitions are given below.

Tier 1: Total suitable habitat patch size is less than 10 acres, regardless of habitat quality; OR Total suitable habitat patch size is between 10 to 20 acres with poor habitat quality

Tier 2: Total suitable habitat patch size is between 10 to 20 acres with moderate to good habitat quality; OR Total suitable habitat patch size is between 20 to 30 acres with poor to moderate habitat quality

Tier 3: Total suitable habitat patch size is between 20 to 30 acres with good habitat quality; OR Total suitable habitat patch size is greater than 30 acres regardless of habitat quality

The Workshop Process

We used a deliberative process based on the Population Viability Analysis conducted in late 2006 – early 2007 by the Conservation Breeding Specialist Group, our knowledge of the species range and genetics, and expert judgment to revise the number of required conservation targets. To guide our discussions, we used the following definition of the conservation target: *The minimum number of significant conservation sites (populations) needed to assure the long-term survival of the species in Wisconsin based on current knowledge.*

PVA results guiding the Conservation Target: Our detailed demographic analyses of Butler's gartersnake population dynamics identified the significant extinction risks that small populations face when isolated. In other words, isolated populations of perhaps fifty of fewer adult female snakes were shown to have a significantly higher risk of declining to extinction in the next few decades, compared to larger populations that display essentially identical long-term rates of survival and reproduction. This increased risk stems from that fact that annual random variability in birth and survival rates act to destabilize smaller populations, leading to an overall decline in the growth rate of these populations. These smaller populations can be demographically "rescued", however, if they are physically linked to other populations nearby. Using environmental corridors to facilitate movement of individuals among populations, this "metapopulation" approach to species conservation can be a very effective way to increase the long-term stability of otherwise isolated, relatively unstable populations.

Biological characterization of potential conservation patches: PHVA workshop participants identified a total of seven different parameters that, collectively, would describe the biologically-based conservation value of a potential Butler's gartersnake patch. These parameters, and the methods by which they would be scored, are presented in Table 1. The parameters were then weighted, with broad categories of metapopulation potential (connectivity), habitat quality, and habitat quantity receiving equivalent weighting. Overall weighting within the habitat quality and habitat quantity categories was equally subdivided among multiple parameters that collectively made up a given category.

Table 1. Biological parameters used to characterize potential conservation sites for Butler's gartersnake in southeastern Wisconsin.

Biological Parameters	Category (& Rank Score)					Overall Weight in Equation
Metapopulation Potential (categories)	High	Medium	Low	None		0.33
Metapopulation Potential rank	10	5	1	0		
Upland Quality	Good	Moderate	Poor			0.165
Upland Quality rank	10	5	1			
Wetland Quality	Good	Moderate	Poor			0.165
Wetland Quality rank	10	5	1			
Suitable Wetland Perimeter (feet)	(potentially important for future considerations)					0.0825
Suitable wetland perimeter rank value						
Restorable Wetland buffer (feet sq.)	(potentially important for future considerations)					0.0825
Restorable wetland buffer rank value						
Area categories (acres)	>300	101-300	71-100	41-70	20-40	0.0825
Area rank value	10	8	6	4	2	
% Area Upland	>30%	16-29%	0-15%			0.0825
% Area upland rank	10	5	1			

Geographic distribution of patches: Tier 3 patches with confirmed or unknown presence are shown in Figure 1. At the Conservation Target-Setting Workshop we looked at the sixteen metapopulation clusters and how they were arranged geographically. In addition, we identified large isolated (or low metapopulation potential) patches that may play an important role in bolstering species-level stability in the state.

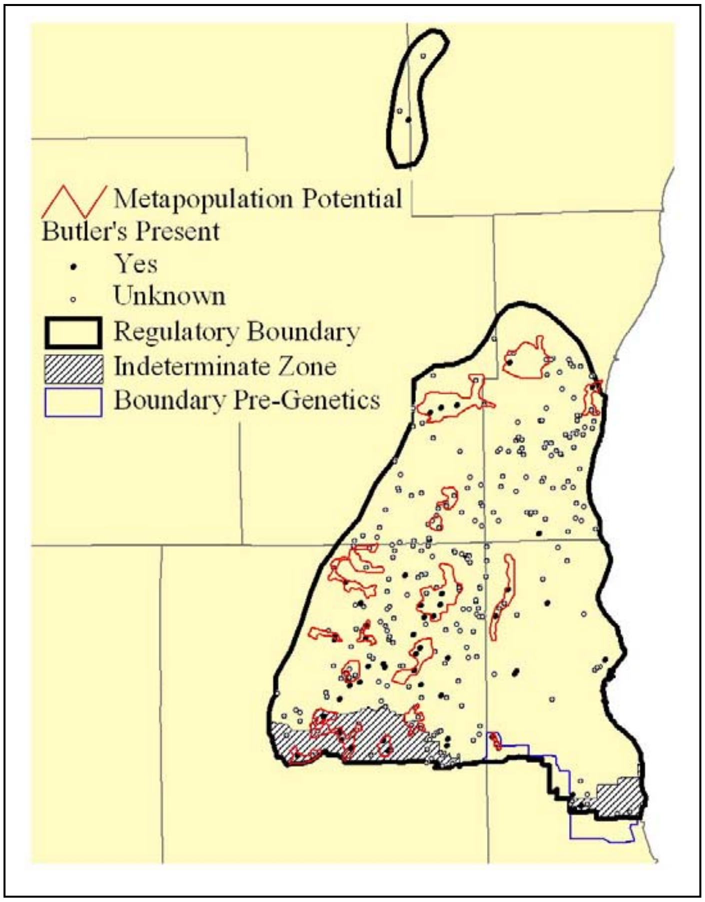

Figure 1. Map of Butler's gartersnake distribution in southeastern Wisconsin, showing those patches with confirmed or unknown presence of the species, and the primary potential metapopulation units.

Unique genetic haplotype distribution: Gordon Burghardt, of the University of Tennessee, provided data on the distribution of important genetic variation among Butler's gartersnake populations sampled throughout the species' distribution in Wisconsin. These data are presented graphically in Figure 2.

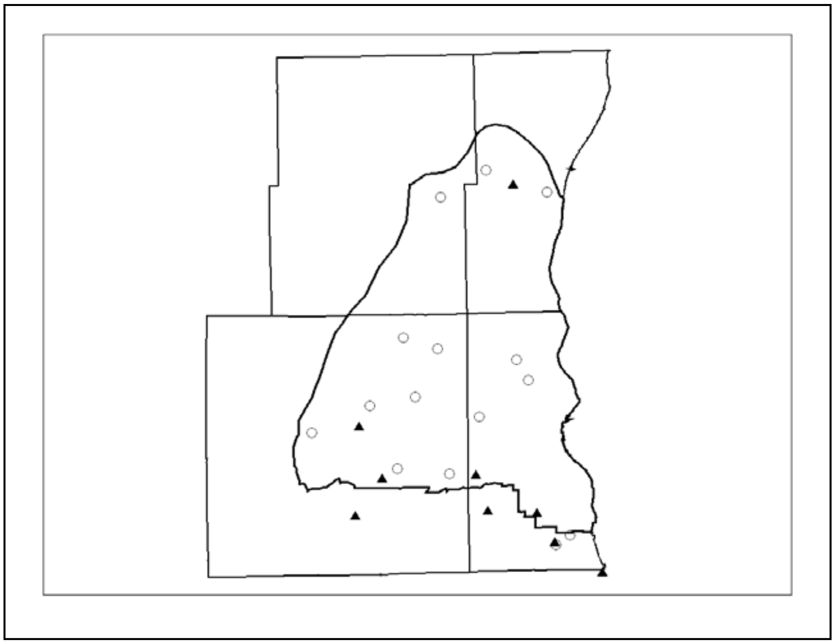

Figure 2. Distribution of genetic variates in studied Butler's gartersnake populations in southeastern Wisconsin. Open circles represent sampling locations that lack unique haplotypes, while triangles represent sampling locations that include unique haplotypes.

Sideboards Used to Guide the Workshop

1. We have to complete our work (derive the number) by the end of the workshop.

2. Our recommendations should be science-based and rest on best available information and the expertise and judgment of workshop participants.

Workshop Results

Following a full day of deliberation, the workshop participants reached a consensus agreement on the acceptable number of Tier 3 sites (conservation target) required for conservation of Butler's gartersnake in Wisconsin. Specifically, the group agreed that a minimum of 40 Tier 3 patches are needed to assure the survival of the species in Wisconsin based on current knowledge. Among these 40 patches, the group agreed that a minimum of 28 patches should have moderate to high meta-population potential as characterized, and the remaining sites can be isolated patches that are (1) representative of unique genetic (haplotypes) characteristics and geographic distribution, and (2) sufficiently large to show acceptable levels of demographic stability on their own, i.e., in the absence of metapopulation linkage. In our discussions, we defined a meta-population as being composed of at least three patches.

Further Work Identified

1. Further field work to survey potential patches for Butler's gartersnake presence/absence.
2. Finalization and application of the socio-economic characterization and prioritization scheme.

Participant List

Craig Berg	Milwaukee County Zoo
Dr. Gordon Burghardt	University of Tennessee
Curtis Bjurlin	University of Wisconsin-Madison
Gary Casper	Casper Consulting
Craig Donze	Simon Group
Terrell Hyde	WDNR-Endangered Resources
Robert Hay	WDNR-Endangered Resources
Dr. Josh Kapfer	University of Wisconsin-Milwaukee
Dr. Richard King	Northern Illinois University
J. Scott Mathie	Metropolitan Builders Association
Rori Paloski	WDNR-Endangered Resources
Dr. Philip Miller (Facilitator)	Conservation Breeding Specialist Group

Appendix 2

Population Viability Analysis and Simulation Modeling

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Introduction

Thousands of species and populations of animals and plants around the world are threatened with extinction within the coming decades. For the vast majority of these groups of organisms, this threat is the direct result of human activity. The particular types of activity, and the ways in which they impact wildlife populations, are often complex in both cause and consequence; as a result, the techniques we must use to analyze their effects often seem to be complex as well. But scientists in the field of conservation biology have developed extremely useful tools for this purpose that have dramatically improved our ability to conserve the planet's biodiversity.

Conservation biologists involved in recovery planning for a given threatened species usually try to develop a detailed understanding of the processes that put the species at risk, and will then identify the most effective methods to reduce that risk through active management of the species itself and/or the habitat in which it lives. In order to design such a program, we must engage in some sort of predictive process: we must gather information on the detailed characteristics of proposed alternative management strategies and somehow predict how the threatened species will respond in the future. A strategy that is predicted to reduce the risk by the greatest amount – and typically does so with the least amount of financial and/or sociological burden – is chosen as a central feature of the recovery plan.

But how does one predict the future? Is it realistically possible to perform such a feat in our fast-paced world of incredibly rapid and often unpredictable technological, cultural, and biological growth? How are such predictions best used in wildlife conservation? The answers to these questions emerge from an understanding of what has been called "the flagship industry" of conservation biology: Population Viability Analysis, or PVA. And most methods for conducting PVA are merely extensions of tools we all use in our everyday lives.

The Basics of PVA

To appreciate the science and application of PVA to wildlife conservation, we first must learn a little bit about population biology. Biologists will usually describe the performance of a population by describing its demography, or simply the numerical depiction of the rates of birth and death in a group of animals or plants from one year to the next. Simply speaking, if the birth rate exceeds the death rate, a population is expected to increase in size over time. If the reverse is true, our population will decline. The overall rate of population growth is therefore a rather good descriptor of its relative security: positive population growth suggests some level of demographic health, while negative growth indicates that some external process is interfering with the normal population function and pushing it into an unstable state.

This relatively simple picture is, however, made a lot more complicated by an inescapable fact: wildlife population demographic rates fluctuate unpredictably over time. So if we observe that 50% of our total population of adult females produces offspring in a given year, it is almost certain that more or less than 50% of our adult females will reproduce in the following year. And the same can be said for most all other demographic rates: survival of offspring and adults, the numbers of offspring born, and the offspring sex ratio will almost always change from one year to the next in a way that usually defies precise prediction. These variable rates then conspire to make a population's growth rate also change unpredictably from year to year. When wildlife populations are very large – if we consider seemingly endless herds of wildebeest on the savannahs of Africa, for example – this random annual fluctuation in population growth is of little to no consequence for the future health and stability of the population. However, theoretical and practical study of population biology has taught us that populations that are already small in size, often defined in terms of tens to a few hundred individuals, are affected by these fluctuations to a much greater extent – and the long-term impact of these fluctuations is always negative. Therefore, a wildlife population that has been reduced in numbers will become even smaller through this fundamental principle of wildlife biology. Furthermore, our understanding of this process provides an important backdrop to considerations of the impact of human activities that may, on the surface, appear relatively benign to larger and more stable wildlife populations. This self-reinforcing feedback loop, first coined the "extinction vortex" in the mid-1980's, is the cornerstone principle underlying our understanding of the dynamics of wildlife population extinction.

Once wildlife biologists have gone out into the field and collected data on a population's demography and used these data to calculate its current rate of growth (and how this rate may change over time), we now have at our disposal an extremely valuable source of information that can be used to predict the *future* rates of population growth or decline under conditions that may not be so favorable to the wildlife population of interest. For example, consider a population of primates living in a section of largely undisturbed Amazon rain forest that is now opened up to development by logging interests. If this development is to go ahead as planned, what will be the impact of this activity on the animals themselves, and the trees on which they depend for food and shelter? And what kinds of alternative development strategies might reduce the risk of primate population decline and extinction? To try to answer this question, we need two additional sets of information: 1) a comprehensive description of the proposed forest development plan (how will it occur, where will it be most intense, for what period of time, etc.) and 2) a detailed understanding of how the proposed activity will impact the primate population's demography (which animals will be most affected, how strongly will they be affected, will animals die outright more frequently or simply fail to reproduce as often, etc.). With this information in hand, we have a vital component in place to begin our PVA.

Next, we need a predictive tool – a sort of crystal ball, if you will, that helps us look into the future. After intensive study over nearly three decades, conservation biologists have settled on the use of computer simulation models as their preferred PVA tool. In general, models are simply any simplified representation of a real system. We use models in all aspects of our lives; for example, road maps are in fact relatively simple (and hopefully very accurate!) 2-dimensional representations of complex 3-dimensional landscapes we use almost every day to get us where we need to go. In addition to making predictions about the future, models are very helpful for us to: (1) extract important trends from complex processes, (2) allow comparisons among different types of systems, and (3) facilitate analysis of processes acting on a system.

Recent advances in computer technology have allowed us to create very complex models of the demographic processes that define wildlife population growth. But at their core, these models attempt to replicate simple biological functions shared by most all wildlife species: individuals are born, some grow to adulthood, most of those that survive mate with individuals of the opposite sex and then give birth to one or more offspring, and they die from any of a wide variety of causes. Each species may have its own special set of circumstances – sea turtles may live to be 150 years old and lay 600 eggs in a single event, while a chimpanzee may give birth to just a single offspring every 4-5 years until the age of 45 – but the fundamental biology is the same. These essential elements of a species' biology can be incorporated into a computer program, and when combined with the basic rules for living and the general characteristics of the population's surrounding habitat, a model is created that can project the demographic behavior of our real observed population for a specified period of time into the future. What's more, these models can explicitly incorporate random fluctuations in rates of birth and death discussed earlier. As a result, the models can be much more realistic in their treatment of the forces that influence population dynamics, and in particular how human activities can interact with these intrinsic forces to put otherwise relatively stable wildlife populations at risk.

Many different software packages exist for the purposes of conducting a PVA. Perhaps the most widely-used of these packages is *VORTEX*, developed by the IUCN Conservation Breeding Specialist Group (CBSG) for use in both applied and educational environments. *VORTEX* has been used by CBSG and other conservation biologists for more than 15 years and has proved to be a very useful tool for helping make more informed decisions in the field of wildlife population management.

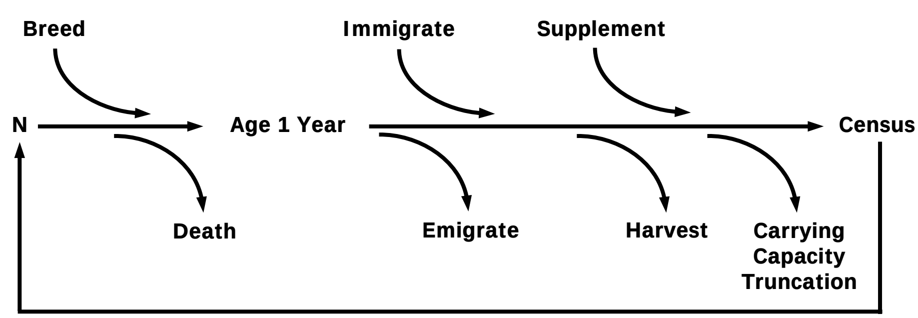
The *VORTEX* Population Viability Analysis Model

For the analyses presented here, the *VORTEX* computer software (Lacy 1993a) for population viability analysis was used. *VORTEX* models demographic stochasticity (the randomness of reproduction and deaths among individuals in a population), environmental variation in the annual birth and death rates, the impacts of sporadic catastrophes, and the effects of inbreeding in small populations. *VORTEX* also allows analysis of the effects of losses or gains in habitat, harvest or supplementation of populations, and movement of individuals among local populations.

Density dependence in mortality is modeled by specifying a carrying capacity of the habitat. When the population size exceeds the carrying capacity, additional morality is imposed across all age classes to bring the population back down to the carrying capacity. The carrying capacity can be specified to change linearly over time, to model losses or gains in the amount or quality of habitat. Density dependence in reproduction is modeled by specifying the proportion of adult females breeding each year as a function of the population size.

VORTEX models loss of genetic variation in populations, by simulating the transmission of alleles from parents to offspring at a hypothetical genetic locus. Each animal at the start of the simulation is assigned two unique alleles at the locus. During the simulation, *VORTEX* monitors how many of the original alleles remain within the population, and the average heterozygosity and gene diversity (or "expected heterozygosity") relative to the starting levels. *VORTEX* also monitors the inbreeding coefficients of each animal, and can reduce the juvenile survival of inbred animals to model the effects of inbreeding depression.

VORTEX Simulation Model Timeline



Events listed above the timeline increase N, while events listed below the timeline decrease N.

VORTEX is an *individual-based* model. That is, *VORTEX* creates a representation of each animal in its memory and follows the fate of the animal through each year of its lifetime. *VORTEX* keeps track of the sex, age, and parentage of each animal. Demographic events (birth, sex determination, mating, dispersal, and death) are modeled by determining for each animal in each year of the simulation whether any of the events occur. (See figure above.) Events occur according to the specified age and sex-specific probabilities. Demographic stochasticity is therefore a consequence of the uncertainty regarding whether each demographic event occurs for any given animal.

VORTEX requires a lot of population-specific data. For example, the user must specify the amount of annual variation in each demographic rate caused by fluctuations in the environment. In addition, the frequency of each type of catastrophe (drought, flood, epidemic disease) and the effects of the catastrophes on survival and reproduction must be specified. Rates of migration (dispersal) between each pair of local populations must be specified. Because *VORTEX* requires specification of many biological parameters, it is not necessarily a good model for the examination of population dynamics that would result from some generalized life history. It is most usefully applied to the analysis of a specific population in a specific environment.

Further information on *VORTEX* is available in Lacy (2000) and Miller and Lacy (2003).

Strengths and Limitations of the PVA Approach

When considering the applicability of PVA to a specific issue, it is vitally important to understand those tasks to which PVA is well-suited as well as to understand what the technique is not well-designed to deliver. With this enhanced understanding will also come a more informed public that is better prepared to critically evaluate the results of a PVA and how they are applied to the practical conservation measures proposed for a given species or population.

The dynamics of population extinction are often quite complicated, with numerous processes impact the dynamics in complex and interacting ways. Moreover, we have already come to appreciate the ways in which demographic rates fluctuate unpredictably in wildlife populations, and the data needed to provide estimates of these rates and their annual variability are themselves often uncertain, i.e., subject to observational bias or simple lack of detailed study over relatively longer periods of time. As a result, the elegant mental models or the detailed mathematical equations of even the most gifted conservation biologist are inadequate for capturing the detailed nuances of interacting factors that determine the fate of a wildlife population threatened by human activity. In contrast, simulation models can include as many factors that influence population dynamics as the modeler and the end-user of the model wish to assess. Detailed interactions between processes can also be modeled, if the nature of those interactions can be specified. Probabilistic events can be easily simulated by computer programs, providing output that gives both the mean expected result and the range or distribution of possible outcomes.

PVA models have also been shown to stimulate meaningful discussion among field biologists in the subjects of species biology, methods of data collection and analysis, and the assumptions that underlie the analysis of these data in preparation for their use in model construction. By making the models and their underlying data, algorithms and assumptions explicit to all who learn from them, these discussions become a critical component in the social process of achieving a shared understanding of a threatened species' current status and the biological justification for identifying a particular management strategy as the most effective for species conservation. This additional benefit is most easily recognized when PVA is used in an interactive workshop-type setting, such as the Population and Habitat Viability Assessment (PHVA) workshop designed and implemented by CBSG.

Perhaps the greatest strength of the PVA approach to conservation decision-making is related to what many of its detractors see as its greatest weakness. Because of the inherent uncertainty now known to exist in the long-term demography of wildlife populations (particularly those that are small in size), and because of the difficulties in obtaining precise estimates of demographic rates through extended periods of time collecting data in the field, accurate predictions of the future performance of a threatened wildlife population are effectively impossible to make. Even the most respected PVA practitioner must honestly admit that an accurate prediction of the number of mountain gorillas that will roam the forests on the slopes of the eastern Africa's Virunga Volcanoes in the year 2075, or the number of polar bears that will swim the warming waters above the Arctic Circle when our great-grandchildren grow old, is beyond their reach. But this type of difficulty, recognized across diverse fields of study from climatology to gambling, is nothing new: in fact, the Nobel Prize-winning physicist Niels Bohr once said "Prediction is very difficult, especially when it's about the future." Instead of lamenting this inevitable quirk of the physical world as a fatal flaw in the practice of PVA, we must embrace it and instead use our very cloudy crystal ball for another purpose: to make **relative**, rather than **absolute**, predictions of wildlife population viability in the face of human pressure.

The process of generating relative predictions using the PVA approach is often referred to as sensitivity analysis. In this manner, we can make much more robust predictions about the relative response of a simulated wildlife population to alternate perturbations to its demography. For example, a PVA practitioner may not be able to make accurate predictions about how many individuals of a given species may persist in 50 years in the presence of intense human hunting pressure, but that practitioner can speak with considerably greater confidence about the relative merits of a male-biased hunting strategy compared to the much more severe demographic impact typically imposed by a hunting strategy that prefers females. This type of comparative approach was used very effectively in a PVA for highly threatened populations of tree kangaroos (*Dendrolagus* sp.) living in Papua New Guinea, where adult females are hunted preferentially over their male counterparts. Comparative models showing the strong impacts of such a hunting strategy were part of an important process of conservation planning that led, within a few short weeks after a participatory workshop including a number of local hunters (Bonaccorso et al., 1998), to the signing of a long-term hunting moratorium for the most critically endangered species in the country, the tenkile or Scott's tree kangaroo (*Dendrolagus scottae*).

PVA models are necessarily incomplete. We can model only those factors which we understand and for which we can specify the parameters. Therefore, it is important to realize that the models often underestimate the threats facing the population, or the total risk these threats collectively impose on the population of interest. To address this limitation, conservation biologists must try to engage a diverse body of experts with knowledge spanning many different fields in an attempt to broaden our understanding of the consequences of interaction between humans and wildlife.

Additionally, models are used to predict the long-term effects of the processes presently acting on the population. Many aspects of the situation could change radically within the time span that is modeled. Therefore, it is important to reassess the data and model results periodically, with changes made to the conservation programs as needed (see Lacy and Miller (2002), Nyhus et al. (2002) and Westley and Miller (2003) for more details).

Finally, it is also important to understand that a PVA model by itself does not define the goals of conservation planning of a given species. Goals, in terms of population growth, probability of persistence, number of extant populations, genetic diversity, or other measures of population performance must be defined by the management authorities before the results of population modeling can be used.

Further Reading

Beissinger, S. and D. McCullough (eds.). 2002. *Population Viability Analysis*. University of Chicago Press, Chicago.

Bonaccorso, F., P. Clark, P.S. Miller and O. Byers. 1999. Conservation Assessment and Management Plan for the Tree Kangaroos of Papua New Guinea and Population and Habitat Viability Assessment for Matschie's Tree Kangaroo (*Dendrolagus matschei*): Final Report. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, MN.

Gilpin, M.E., and M.E. Soulé. 1986. Minimum viable populations: processes of species extinction. Pages 19 – 34 in: Soulé, M.E. (ed.). *Conservation Biology: The Science of Scarcity and Diversity*. Sinauer Associates, Sunderland, MA.

Jiménez, J.A., K.A. Hughes, G. Alaks, L. Graham, and R.C. Lacy. 1994. An experimental study of inbreeding depression in a natural habitat. *Science* 266:271-273.

Lacy, R.C. 1993. Impacts of inbreeding in natural and captive populations of vertebrates: implications for conservation. *Perspectives in Biology and Medicine* 36:480-496.

Lacy, R.C. 2000. Structure of the *VORTEX* simulation model for population viability analysis. *Ecological Bulletins* 48:191-203.

Lacy, R.C., and P.S. Miller. 2002. Incorporating human activities and economics into PVA. Pages 490 – 510 in: Beissinger, S. and D. McCullough (eds.), *Population Viability Analysis*. University of Chicago Press, Chicago.

Miller, P.S., and R.C. Lacy. 2005. *VORTEX: A Stochastic Simulation of the Extinction Process. Version 9 User's Manual*. IUCN SSC Conservation Breeding Specialist Group, Apple Valley, MN.

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

Nyhus, P.J., F.R. Westley, R.C. Lacy, and P.S. Miller. 2002. A role for natural resource social science in biodiversity risk assessment. *Society and Natural Resources* 15:923-932.

Ralls, K., J.D. Ballou, and A. Templeton. 1988. Estimates of lethal equivalents and the cost of inbreeding in mammals. *Conservation Biology* 2:185-193.

Reed, J.M., L.S. Mills, J.B. Dunning Jr., E.S. Menges, K.S. McKelvey, R. Frye, S.R. Beissinger, M.-C. Anstett, and P.S. Miller. 2002. Emerging issues in population viability analysis. *Conservation Biology* 16:7-19.

Soulé, M., M. Gilpin, W. Conway, and T. Foose. 1986. The millennium ark: How long a voyage, how many staterooms, how many passengers? *Zoo Biology* 5:101-113.

Westley, F.W., and P.S. Miller (eds.). 2003. *Experiments in Consilience: Integrating Social and Scientific Responses to Save Endangered Species*. Island Press, Washington, DC.

Appendix 3

IUCN Position Statement on Translocation of Living Organisms

INTRODUCTIONS, REINTRODUCTIONS AND RE-STOCKING
Prepared by the Species Survival Commission in collaboration with the Commission on Ecology, and the Commission on Environmental Policy, Law and Administration
Approved by the 22nd Meeting of the IUCN Council, Gland, Switzerland, 4 September 1987

FOREWORD

This statement sets out IUCN's position on translocation of living organisms, covering introductions, re-introductions and re-stocking. The implications of these three sorts of translocation are very different so the paper is divided into four parts dealing with Introductions, Re-introductions, Re-stocking and Administrative Implications, respectively.

DEFINITIONS:

Translocation is the movement of living organisms from one area with free release in another. The three main classes of translocation distinguished in this document are defined as follows:

- **Introduction** of an organism is the intentional or accidental dispersal by human agency of a living organism outside its historically known native range.
- **Re-introduction** of an organism is the intentional movement of an organism into a part of its native range from which it has disappeared or become extirpated in historic times as a result of human activities or natural catastrophe.
- **Re-stocking** is the movement of numbers of plants or animals of a species with the intention of building up the number of individuals of that species in an original habitat.

Translocations are powerful tools for the management of the natural and man made environment which, properly used, can bring great benefits to natural biological systems and to man, but like other powerful tools they have the potential to cause enormous damage if misused. This IUCN statement describes the advantageous uses of translocations and the work and precautions needed to avoid the disastrous consequences of poorly planned translocations.

PART I

INTRODUCTIONS

BACKGROUND

Non-native (exotic) species have been introduced into areas where they did not formerly exist for a variety of reasons, such as economic development, improvement of hunting and fishing, ornamentation, or maintenance of the cultures of migrated human communities. The damage done by harmful introductions to natural systems far outweighs the benefit derived from them. The introduction and establishment of alien species in areas where they did not formerly occur, as an accidental or intended result of human activities, has often been directly harmful to the native plants and animals of many parts of the world and to the welfare of mankind.

The establishment of introduced alien species has broken down the genetic isolation of communities of co-evolving species of plants and animals. Such isolation has been essential for the evolution and maintenance of the diversity of plants and animals composing the biological wealth of our planet.

Disturbance of this isolation by alien species has interfered with the dynamics of natural systems causing the premature extinction of species. Especially successful and aggressive invasive species of plants and animals increasingly dominate large areas having replaced diverse autochthonous communities. Islands, in the broad sense, including isolated biological systems such as lakes or isolated mountains, are especially vulnerable to introductions because their often simple ecosystems offer refuge for species that are not aggressive competitors. As a result of their isolation they are of special value because of high endemism (relatively large numbers of unique local forms) evolved under the particular conditions of these islands over a long period of time. These endemic species are often rare and highly specialised in their ecological requirements and may be remnants of extensive communities from bygone ages, as exemplified by the Pleistocene refugia of Africa and Amazonia.

The diversity of plants and animals in the natural world is becoming increasingly important to man as their demands on the natural world increase in both quantity and variety, notwithstanding their dependence on crops and domestic animals nurtured within an increasingly uniform artificial and consequently vulnerable agricultural environment.

Introductions, can be beneficial to man. Nevertheless the following sections define areas in which the introduction of alien organisms is not conducive to good management, and describe the sorts of decisions that should be made before introduction of an alien species is made.

To reduce the damaging impact of introductions on the balance of natural systems, governments should provide the legal authority and administrative support that will promote implementation of the following approach.

Intentional Introduction

General

1. Introduction of an alien species should only be considered if clear and well defined benefits to man or natural communities can be foreseen.
2. Introduction of an alien species should only be considered if no native species is considered suitable for the purpose for which the introduction is being made.

Introductions to Natural Habitats

3. No alien species should be deliberately introduced into any natural habitat, island, lake, sea, ocean or centre of endemism, whether within or beyond the limits of national jurisdiction. A natural habitat is defined as a habitat not perceptibly altered by man. Where it would be effective, such areas should be surrounded by a buffer zone sufficiently large to prevent unaided spread of alien species from nearby areas. No alien introduction should be made within the buffer zone if it is likely to spread into neighbouring natural areas.

Introduction into Semi-natural Habitat

4. No alien species should be introduced into a semi-natural habitat unless there are exceptional reasons for doing so , and only when the operation has been comprehensively investigated and carefully planned in advance. A semi-natural habitat is one which has been detectably changed by man's actions or one which is managed by man, but still resembles a natural habitat in the diversity of its species and the complexity of their interrelationships. This excludes arable farm land, planted ley pasture and timber plantations.

Introductions into Man-made Habitat

5. An assessment should be made of the effects on surrounding natural and semi-natural habitats of the introduction of any species, sub-species, or variety of plant to artificial, arable, ley pasture or other predominantly monocultural forest systems. Appropriate action should be taken to minimise negative effects.

Planning a Beneficial introduction

6. Essential features of investigation and planning consist of:
    - an assessment phase culminating in a decision on the desirability of the introduction;
    - an experimental, controlled trial;
    - the extensive introduction phase with monitoring and follow-up.

THE ASSESSMENT PHASE

Investigation and planning should take the following factors into account:

a) No species should be considered for introduction to a new habitat until the factors which limit its distribution and abundance in its native range have been thoroughly studied and understood by competent ecologists and its probable dispersal pattern appraised.

Special attention should be paid to the following questions:

- What is the probability of the exotic species increasing in numbers so that it causes damage to the environment, especially to the biotic community into which it will be introduced?
- What is the probability that the exotic species will spread and invade habitats besides those into which the introduction is planned? Special attention should be paid to the exotic species' mode of dispersal.
- How will the introduction of the exotic proceed during all phases of the biological and climatic cycles of the area where the introduction is planned? It has been found that fire, drought and flood can greatly alter the rate of propagation and spread of plants.
- What is the capacity of the species to eradicate or reduce native species by interbreeding with them?
- Will an exotic plant interbreed with a native species to produce new species of aggressive polyploid invader? Polyploid plants often have the capacity to produce varied offspring some of which quickly adapt to and dominate, native floras and cultivars alike.
- Is the alien species the host to diseases or parasites communicable to other flora and fauna, man, their crops or domestic animals, in the area of introduction?
- What is the probability that the species to be introduced will threaten the continued existence or stability of populations of native species, whether as a predator, competitor for food, cover, breeding sites or in any other way? If the introduced species is a carnivore, parasite or specialised herbivore, it should not be introduced if its food includes rare native species that could be adversely affected.

b) There are special problems to be considered associated with the introduction of aquatic species. These species have a special potential for invasive spread.

- Many fish change trophic level or diet preference following introduction, making prediction of the results of the re-introduction difficult. Introduction of a fish or other species at one point on a river system or into the sea may lead to the spread of the species throughout the system or area with unpredictable consequences for native animals and plants. Flooding may transport introduced species from one river system to another.
- introduced fish and large aquatic invertebrates have shown a great capacity to disrupt natural systems as their larval, sub-adult and adult forms often use different parts of the same natural system.

c) No introduction should be made for which a control does not exist or is not possible. A risk-and-threat analysis should be undertaken including investigation of the availability of methods for the control of the introduction should it expand in a way not predicted or have unpredicted undesirable effects, and the methods of control should be socially acceptable, efficient, should not damage vegetation and fauna, man, his domestic animals or cultivars.

d)When the questions above have been answered and the problems carefully considered, it should be decided if the species can reasonably be expected to survive in its new habitat, and if so, if it can reasonably be expected to enhance the flora and fauna of the area, or the economic or aesthetic value of the area, and whether these benefits outweigh the possible disadvantages revealed by the investigations.

THE EXPERIMENTAL CONTROLLED TRIAL

Following a decision to introduce a species, a controlled experimental introduction should be made observing the following advice:

- Test plants and animals should be from the same stock as those intended to be extensively introduced.
- They should be free of diseases and parasites communicable to native species, man, his crops and domestic livestock.
- The introduced species' performance on parameters in 'the Assessment Phase' above should be compared with the pre-trial assessment, and the suitability of the species for introduction should be reviewed in light of the comparison.

THE EXTENSIVE INTRODUCTION

If the introduced species behaves as predicted under the experimental conditions, then extensive introductions may commence but should be closely monitored. Arrangements should be made to apply counter measures to restrict, control, or eradicate the species if necessary.

The results of all phases of the introduction operation should be made public and available to scientists and others interested in the problems of introductions.

The persons or organisation introducing the species, not the public, should bear the cost of control of introduced organisms and appropriate legislation should reflect this.

ACCIDENTAL INTRODUCTIONS

1. Accidental introductions of species are difficult to predict and monitor, nevertheless they "should be discouraged where possible. The following actions are particularly important:
    - On island reserves, including isolated habitats such as lakes, mountain tops and isolated forests, and in wilderness areas, special care should be taken to avoid accidental introductions of seeds of alien plants on shoes and clothing and the introduction of animals especially associated with man, such as cats, dogs, rats and mice.
    - Measures, including legal measures, should be taken to discourage the escape of farmed, including captive-bred, alien wild animals and newly-domesticated species which could breed with their wild ancestors if they escaped.
    - In the interest of both agriculture and wildlife, measures should be taken to control contamination of imported agricultural seed with seeds of weeds and invasive plants.
    - Where large civil engineering projects are envisaged, such as canals, which would link different biogeographical zones, the implications of the linkage for mixing the fauna and flora of the two regions should be carefully considered. An example of this is the mixing of species from the Pacific and Caribbean via the Panama Canal, and the mixing of Red Sea and Mediterranean aquatic organisms via the Suez Canal. Work needs to be done to

consider what measures can be taken to restrict mixing of species from different zones through such large developments.

2. Where an accidentally introduced alien successfully and conspicuously propagates itself, the balance of its positive and negative economic and ecological effects should be investigated. If the overall effect is negative, measures should be taken to restrict its spread.

WHERE ALIEN SPECIES ARE ALREADY PRESENT

1. In general, introductions of no apparent benefit to man, but which are having a negative effect on the native flora and fauna into which they have been introduced, should be removed or eradicated. The present ubiquity of introduced species will put effective action against the majority of invasives beyond the means of many States but special efforts should be made to eradicate introductions on:
    - islands with a high percentage of endemics in the flora and fauna;
    - areas which are centres of endemism;
    - areas with a high degree of species diversity;
    - areas with a high degree of other ecological diversity;
    - areas in which a threatened endemic is jeopardized by the presence of the alien.
2. Special attention should be paid to feral animals. These can be some of the most aggressive and damaging alien species to the natural environment, but may have value as an economic or genetic resource in their own right, or be of scientific interest. Where a feral population is believed to have a value in its own right, but is associated with changes in the balance of native vegetation and fauna, the conservation of the native flora and fauna should always take precedence. Removal to captivity or domestication is a valid alternative for the conservation of valuable feral animals consistent with the phase of their evolution as domestic animals.

    Special attention should be paid to the eradication of mammalian feral predators from areas where there are populations of breeding birds or other important populations of wild fauna. Predatory mammals are especially difficult, and sometimes impossible to eradicate, for example, feral cats, dogs, mink, and ferrets.
3. In general, because of the complexity and size of the problem, but especially where feral mammals or several plant invaders are involved, expert advice should be sought on eradication.

BIOLOGICAL CONTROL

1. Biological control of introductions has shown itself to be an effective way of controlling and eradicating introduced species of plants and more rarely, of animals. As biological control involves introduction of alien species, the same care and procedures should be used as with other intentional introductions.

MICRO-ORGANISMS

1. There has recently been an increase of interest in the use of micro-organisms for a wide variety of purposes including those genetically altered by man.
    Where such uses involve the movement of micro-organisms to areas where they did not formerly exist, the same care and procedures should be used as set out above for other species.

PART II

THE RE-INTRODUCTION OF SPECIES*

Re-introduction is the release of a species of animal or plant into an area in which it was indigenous before extermination by human activities or natural catastrophe. Re-introduction is a particularly useful tool for restoring a species to an original habitat where it has become extinct due to human persecution, over-collecting, over-harvesting or habitat deterioration, but where these factors can now be controlled. Re-introductions should only take place where the original causes of extinction have been removed. Re-introductions should only take place where the habitat requirements of the species are satisfied. There should be no re-introduction if a species became extinct because of habitat change which remains unremedied, or where significant habitat deterioration has occurred since the extinction.

The species should only be re-introduced if measures have been taken to reconstitute the habitat to a state suitable for the species.

The basic programme for re-introduction should consist of:

- a feasibility study;
- a preparation phase;
- release or introduction phase; and a
- follow-up phase.

THE FEASIBILITY STUDY

An ecological study should assess the previous relationship of the species to the habitat into which the re-introduction is to take place, and the extent that the habitat has changed since the local extinction of the species. If individuals to be re-introduced have been captive-bred or cultivated, changes in the species should also be taken into account and allowances made for new features liable to affect the ability of the animal or plant to re-adapt to its traditional habitat.

The attitudes of local people must be taken into account especially if the reintroduction of a species that was persecuted, over-hunted or over collected , is proposed. If the attitude of local people is unfavorable an education and interpretive programme emphasizing the benefits to them of the re-introduction, or other inducement, should be used to improve their attitude before re-introduction takes place.

The animals or plants involved in the re-introduction must be of the closest available race or type to the original stock and preferably be the same race as that previously occurring in the area.

Before commencing a re-introduction project, sufficient funds must be available to ensure that the project can be completed, including the follow-up phase.

THE PREPARATION AND RELEASE OR INTRODUCTORY PHASES

The successful re-introduction of an animal or plant requires that the biological needs of the species be fulfilled in the area where the release is planned. This requires a detailed knowledge of both the needs of the animal or plant and the ecological dynamics of the area of re-introduction. For this reason the best available scientific advice should be taken at all stages of a species re-introduction.

This need for clear analysis of a number of factors can be clearly seen with reference to introductions of ungulates such as ibex, antelope and deer where re-introduction involves understanding and applying the significance of factors such as the ideal age for re-introducing individuals, ideal sex ratio, season, specifying capture techniques and mode of transport to re-introduction site, freedom of both the species and the area of introduction from disease and parasites, acclimatization, helping animals to learn to forage in the wild, adjustment of the gut flora to deal with new forage, 'imprinting' on the home range, prevention of wandering of individuals from the site of re-introduction, and on-site breeding in enclosures before release to expand the released population and acclimatize the animals to the site. The re-introduction of other taxa of plants and animals can be expected to be similarly complex.

FOLLOW-UP PHASE

Monitoring of released animals must be an integral part of any re-introduction programme. Where possible there should be long-term research to determine the rate of adaptation and dispersal, the need for further releases and identification of the reasons for success or failure of the programme.

The species impact on the habitat should be monitored and any action needed to improve conditions identified and taken.

Efforts should be made to make available information on both successful and unsuccessful re-introduction programmed through publications, seminars and other communications.

PART III

RESTOCKING

1. Restocking is the release of a plant or animal species into an area in which it is already present. Restocking may be a useful tool where:
    - it is feared that a small reduced population is becoming dangerously inbred; or
    - where a population has dropped below critical levels and recovery by natural growth will be dangerously slow; or
    - where artificial exchange and artificially-high rates of immigration are required to maintain outbreeding between small isolated populations on biogeographical islands.
2. In such cases care should be taken to ensure that the apparent nonviability of the population, results from the genetic institution of the population and not from poor species management which has allowed deterioration in the habitat or over-utilization of the population. With good management of a population the need for re-stocking should be avoidable but where re-stocking is contemplated the following points should be observed:

    a) Restocking with the aim of conserving a dangerously reduced population should only be attempted when the causes of the reduction have been largely removed and natural increase can be excluded.

    b) Before deciding if restocking is necessary, the capacity of the area it is proposed to restock should be investigated to assess if the level of the population desired is sustainable. If it is, then further work should be undertaken to discover the reasons for the existing low population levels. Action should then be taken to help the resident population expand to the desired level. Only if this fails should restocking be used.
3. Where there are compelling reasons for restocking the following points should be observed.

    a) Attention should be paid to the genetic constitution of stocks used for restocking.

    - In general, genetic manipulation of wild stocks should be kept to a minimum as it may adversely affect the ability of a species or population to survive. Such manipulations modify the effects of natural selection and ultimately the nature of the species and its ability to survive.

- Genetically impoverished or cloned stocks should not be used to re-stock populations as their ability to survive would be limited by their genetic homogeneity.

b) The animals or plants being used for re-stocking must be of the same race as those in the population into which they are released.

c) Where a species has an extensive natural range and restocking has the aim of conserving a dangerously reduced population at the climatic or ecological edge of its range, care should be taken that only individuals from a similar climatic or ecological zone are used since interbreeding with individuals from an area with a milder climate may interfere with resistant and hardy genotypes on the population's edge.

d) Introduction of stock from zoos may be appropriate, but the breeding history and origin of the animals should be known and follow as closely as possible Assessment Phase guidelines a, b, c and d (see pages 5-7). In addition the dangers of introducing new diseases into wild populations must be avoided: this is particularly important with primates that may carry human zoonoses.

e) Restocking as part of a sustainable use of a resource (e.g. release of a proportion of crocodiles hatched from eggs taken from farms) should follow guidelines a and b (above).

f) Where restocking is contemplated as a humanitarian effort to release or rehabilitate captive animals it is safer to make such releases as re-introductions where there is no danger of infecting wild populations of the same species with new diseases and where there are no problems of animals having to be socially accepted by wild individuals of the species.

PART IV

NATIONAL, INTERNATIONAL AND SCIENTIFIC IMPLICATIONS OF TRANSLOCATIONS

NATIONAL ADMINISTRATION

1. Pre-existing governmental administrative structures and frameworks already in use to protect agriculture, primary industries, wilderness and national parks should be used by governments to control both intentional and unintentional importation of organisms, especially through use of plant and animal quarantine regulations.
2. Governments should set up or utilize pre-existing scientific management authorities or experts in the fields of biology, ecology and natural resource management to advise them on policy matters concerning translocations and on individual cases where an introduction, re-introduction or restocking or farming of wild species is proposed.
3. Governments should formulate national policies on:
   - translocation of wild species;
   - capture and transport of wild animals;
   - artificial propagation of threatened species;
   - selection and propagation of wild species for domestication; and
   - prevention and control of invasive alien species.

4. At the national level legislation is required to curtail introductions:

   Deliberate introductions should be subject to a permit system. The system should apply not only to species introduced from abroad but also to native species introduced to a new area in the same country. It should also apply to restocking.

   Accidental introductions

   - for all potentially harmful organisms there should be a prohibition to import them and to trade in them except under a permit and under very stringent conditions. This should apply in particular to the pet trade;
   - where a potentially harmful organism is captive bred for commercial purposes (e.g. mink) there should be established by legislation strict standards for the design and operation of the captive breeding facilities. In particular, procedures should be established for the disposal of the stock of animals in the event of a discontinuation of the captive breeding operation;
   - there should be strict controls on the use of live fish bait to avoid inadvertent introductions of species into water where they do not naturally occur.

   Penalties

5. Deliberate introductions without a permit as well as negligence resulting in the escape or introduction of species harmful to the environment should be considered criminal offences and punished accordingly. The author of a deliberate introduction without a permit or the person responsible for an introduction by negligence should be legally liable for the damage incurred and should in particular bear the costs of eradication measures and of habitat restoration where required.

INTERNATIONAL ADMINISTRATION

Movement of Introduced Species Across International Boundaries

1. Special care should be taken to prevent introduced species from crossing the borders of a neighboring state. When such an occurrence is probable, the neighboring state should be promptly warned and consultations should be held in order to take adequate measures.

   The Stockholm Declaration

2. According to Principle 21 of the Stockholm Declaration on the Human Environment, states have the responsibility 'to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states'.

   International Codes of Practice, Treaties and Agreements

3. States should be aware of the following international agreements and documents relevant to translocation of species:
   - ICES, Revised Code of Practice to Reduce the Risks from introduction of Marine Species, 1982.
   - FAO, Report of the Expert Consultation on the Genetic Resources of Fish, Recommendations to Governments No L 1980.
   - EIFAC (European Inland Fisheries Advisory Commission), Report of the Working Party on Stock Enhancement, Hamburg, FRG 1983.
   - The Bonn Convention MSC: Guidelines for Agreements under the Convention.

- The Berne Convention: the Convention on the Conservation of European wildlife and Natural Habitats.
- The ASEAN Agreement on the Conservation of Nature and Natural Resources.
- Law of the Sea Convention, article 196.
- Protocol on Protected Areas and Wild Fauna and Flora in Eastern African Region.

In addition to the international agreements and documents cited, States also should be aware of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). International shipments of endangered or threatened species listed in the Appendices to the Convention are subject to CITES regulation and permit requirements. Enquiries should be addressed to: CITES Secretariat**, Case Postale 456, CH-1219 Chatelaine, Genève, Switzerland; telephone: 41/22/979 9149, fax: 41/22/797 3417.

Regional Development Plans

4. International, regional or country development and conservation organizations, when considering international, regional or country conservation strategies or plans, should include in-depth studies of the impact and influence of introduced alien species and recommend appropriate action to ameliorate or bring to an end their negative effects.

Scientific Work Needed

5. A synthesis of current knowledge on introductions, re-introductions and re-stocking is needed.
6. Research is needed on effective, target specific, humane and socially acceptable methods of eradication and control of invasive alien species.
7. The implementation of effective action on introductions, re-introductions and re-stocking frequently requires judgements on the genetic similarity of different stocks of a species of plant or animal. More research is needed on ways of defining and classifying genetic types.
8. Research is needed on the way in which plants and animals are dispersed through the agency of man (dispersal vector analysis).

A review is needed of the scope, content and effectiveness of existing legislation relating to introductions.

IUCN Responsibilities

International organizations, such as UNEP, UNESCO and FAO, as well as states planning to introduce, re-introduce or restock taxa in their territories, should provide sufficient funds, so that IUCN as an international independent body, can do the work set out below and accept the accompanying responsibilities.

9. IUCN will encourage collection of information on all aspects of introductions, re-introductions and restocking, but especially on the case histories of re-introductions; on habitats especially vulnerable to invasion; and notable aggressive invasive species of plants and animals.

Such information would include information in the following categories:

- a bibliography of the invasive species;
- the taxonomy of the species;
- the synecology of the species; and
- methods of control of the species.

10. The work of the Threatened Plants Unit of IUCN defining areas of high plant endemism, diversity and ecological diversity should be encouraged so that guidance on implementing recommendations in this document may be available.
11. A list of expert advisors on control and eradication of alien species should be available through IUCN.

Note:
* The section on re-introduction of species has been enhanced by the Guidelines For Re-Introductions
** The address of the CITES Secretariat has been updated.
