Asiatic Black Bears PHVA

Final Report

For Workshop Held
April 18-21, 2001
Seoul, Korea

Organized and Sponsored by
Seoul Grand Park
Seoul National University College of Veterinary Medicine
National Institute of Environmental Research

Supported by
Ministry of Environment
Cultural Properties Administration
Seoul National University School of Agricultural Biotechnology
National Parks Authority
Jambangee.Co., Ltd

In Collaboration with
Conservation Breeding Specialist Group (SSC/IUCN)
Bear Specialist Group (SSC/IUCN)

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

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Executive Summary

Introduction

Endangered species risk assessment is most commonly accomplished through a technique known as population viability analysis, or PVA. In this process, data on the demographic and genetic characteristics of the species or population in question is assembled and a computer model is generally used to project the future growth dynamics of the resulting simulated population under any number of proposed conditions. This type of "traditional" approach focuses almost solely on the biology of the target wildlife species/population with only some relatively vague, qualitative description of the means by which human activities—namely direct species exploitation and local environment exploitation—impact these growth dynamics.

In contrast to this standard approach, the Conservation Breeding Specialist Group (CBSG) of the IUCN's Species Survival Commission has developed an alternative to the traditional PVA approach. CBSG's non-traditional approach, known as a Population and Habitat Viability Assessment or PHVA, is an intense species risk assessment process involving diverse participation by all interested parties showing a stake in the development of management plans for the species or population in question. A PHVA represents a broadening of the traditional methodology to incorporate as much information as possible on the focal species, its habitat, and the ways in which local human populations impact this focal species and its surroundings.

Workshop Process

The CBSG team included Dr. David Garshelis, Minnesota DNR, Mei-Hsiu Hwang, black bear researcher on Taiwan, Dr. Paul Paquet, University of Calgary, Dr. William Rapley, Conservation Director of the Toronto Zoo, Toronto, Canada, Paul Harpley, Project Manager, Toronto Zoo, and Dr. Ulysses S. Seal, Chairman of CBSG/SSC/IUCN with offices in Minnesota, USA. The 4 day workshop, 18-21 April, 2001 was conducted at the Seoul Grand Park Zoo. The 35-45 Korean participants included zoo staff, university researchers, Bear farmers, Park staff, students, and a few NGO representatives.

The workshop was opened with each person introducing themselves and answering two questions concerning their goals for the workshop and their thoughts on the most critical problem facing the survival and conservation of the Korean black bear. These responses served as themes to guide formation of the working groups. The 5 groups included Human Impacts, Habitat Status and Bear Ecology, Local People and Education, Wild and Captive Populations, and Population Biology and Modeling. The reports produced by each of these groups make up the body of this PHVA Workshop report.

The basic workshop design followed a process of rational decision making starting with problem identification and prioritization followed by development of short and long term goals, and then formulation of actions steps that might be implemented by participants. The tasks were developed by brainstorming, consolidation, and priority ranking within each of the groups. About 45-90 minutes was allotted for the initial tasks. Plenary sessions were held each day with the working groups reporting their progress and receiving questions and comments from the other groups. Draft reports were produced daily by the working groups. A full draft report was prepared on the final day of the workshop. A copy of the draft text was left with the organizers for review, editing, and translation into Korean. The final report will be in Korean and English with the illustrations included.

Working Groups Summaries and Recommendations

Priority Actions and Recommendations

Table 1. Paired ranking results of 15 high priority actions composed of three top priority actions from each of the five working groups. This ranking was done in a plenary session and thus represents the combined evaluation of 28 of the workshop participants. These actions are presented in more detail in the working group report sections of the Report.

Action	Sums	Rank
1.Development of conservation / ecology education program.	117	13
2.Organize local people as patrol team and support the people.	164	12
3.Control & prohibit the construction of roads in bear habitat.	181	10
4.Cooperative Research Network Building	215	5
5.Secure research expert in Park Authority.	224	4
6.Training and long-term tenure of wildlife officials.	192	8
7.Expert who knows local conditions	177	11
8.National ownership of National Parks area.	135	15
9.Bear conservation sector system in forest product collection area by local people.	132	14
10. Building networks of bear information and database.	**269**	**1**
11.Molecular phylogenetic study of Korean bears.	208	7
12.Reintroduction into Chirisan.	**253**	**2**
13.Criteria for selection of bears for reintroduction.	**248**	**3**
14.Assess proposals using VORTEX & GIS.	191	9
15.Construct GIS habitat models .	214	6

Human Impacts

Executive Summary

Problems and Goals

1) Poaching
- Short-term goal: Integrate the local people to participate patrol teams and improve the enforcement of relevant laws for halting bear poaching.
- Long-term goal: Eliminate all poaching activity, including bears, through persistent patrol, education and public information system.

2) Development
- Short-term goal: Preserve the bear habitat through controlling the use and construction of roads and buildings in protected areas.
- Long-term goal: Prohibit any further destruction of bear habitats by enhancing the overwhelming legislation for bear conservation.

3) Collection of forest products
- Short-term goal: Gradually reduce the level of collection of forest products by local people through the education program and providing benefits for the local community or individual collectors for non-collection activity.
- Long-term goal: Integrate voluntary participation of local people to bear conservation based on community-based management.

4) Lack of awareness of the importance of nature and bear conservation
- Short-term goal: Publicize the importance of nature and bear conservation through various media.
- Long-term goal: Improve the school education of nature conservation and right of wild species.

5) Inappropriate manner of visitors
- Short-term goal: Prevent habitat disturbance by reducing tourism pressure.
- Long-term goal: Protect the habitat by settling the better manner of visitors.

Priority Actions (by paired ranking):

1. Develop the environmental and bear conservation education programs locally, regionally, and nationally.

2. Develop a bear patrol program composed of local people to take the responsibility of guarding the park routinely and mediating the reward system for reporting the poaching activity from informants

3. Control the use of roads and also prohibit the construction of new roads within the critical habitat of bear.

Habitat Status and Bear Ecology

Executive Summary:

Group team members undertook extensive discussions of key Asiatic Black Bear ecology and habitat information. The material was summarized in a listing of key points of discussion and known facts. The information was led by bear researcher Dr.Kim and National Parks and Seoul National University staffs. A summary list of eleven (11) key problems with Asiatic Black Bear conservation in South Korea was detailed.

Problem issues were grouped into five (5) important areas of problems to be addressed. The issues included the urgent need for more bear and habitat research, the need for public understanding of the issues, human impact of tourism, direct human caused habitat changes and finally national park management policy and activities affecting bears and their habitat. These issues were later reorganized by Paired Ranking.

Suggested solutions to the important five (5) Problem statements were generated by Team members for 14 Short and Long Term Goals. Finally, Goals were prioritized leading to five (5). Tasks of Action Plan, including Short and Long Term Tasks culminating in three (3) key Action Plan components that were considered important and achievable. The central ideas of the plan concentrate on collaboration of different research, government and education people, establishment of a Asiatic Bear Research and Conservation Institute and the suggestion of a new continuity of professional staff positions with long term planning responsibility.

Local People Participation and Education

Executive Summary

Classification of problems which were discussed before were performed by eliminating overlapping part. Then we made a rank about each problem by using paired ranking.

Classified problems are
1. In conservation work, the most basic thing is local people's participation.
2. Government’s recognition is lack about local people.
3. Private property of local people is not secured.
4. Livelihood of local people is opposed to conservation of bears.
5. Government’s behavior to local people is brought up.
6. Local people’s role is ignored in a view, conservation of bears.

Then we made goals, which were expected to achieve within short term and long term, about each problem.

Short Term Goals
1. Secure the professional government official and supervisor.
2. Activate the local people's participation.

3. Try to find a mutual cooperation with local people.
4. Publicize the local people's part and condition in the Asiatic black Bear conservation work.

Long term Goals
1. Prepare the systemic measures to the local people.
2. Establish mid-long term manage system.
3. Perform the continuous monitoring system to the local people's zone of life and bear's habitats.

And we discussed action plan on each goal.

Final results are:

rank 1: Make a recommendation to the Government on disposition of specialist who knows well local condition and conservation work of the Asiatic Black Bear.

rank 2: Go ahead with campaign for nationalization about a whole national park (Carry the whole nation signature-collecting campaign).

rank 3: Implement a responsible charge system for wildlife conservation under forest products gathering zone.

Wild And Captive Population Group

Executive Summary

This group dealt with the status of both wild and captive populations of Asiatic Black Bears in South Korea. We generated a list of problem statements which we eventually combined, prioritized and reduced to four.

These were as follows:

1. There is a lack of information on wild populations.
2. It will be difficult to obtain purebred Korean bears (either from captivity or the wild) to reintroduce into Chirisan National Park, where the largest population of wild black bears exists.
3. The population in Chirisan is non-viable without augmentation of more bears.
4. There is a lack of information to enhance production of cubs in captivity for reintroduction into the wild.

We proposed actions to address these problems, which in brief are as follows:

- Collect all currently existing information together in a database maintained by a Bear Conservation Committee. This should be updated at frequent intervals.

- Use genetic material from known Korean bears in captivity to compare against material from bears from other areas (Japan, China) to generate genetic profiles. This information will be used to evaluate other captive bears of unknown origin.
- Breed Korean bears to obtain cubs for reintroduction.
- Contact North Korea to attempt to obtain wild bears that can be translocated to Chirisan. This option is preferred to reintroduction of captive bears because it is likely to be more successful. However, obtaining bears from N. Korea is likely to be difficult to arrange. Therefore, we recommend that a captive-born bear reintroduction program should be initiated.
- Establish a reintroduction program whereby captive-born animals are slow released into Chirisan. All such animals should be radio collared and closely monitored.
- Monitor mortality and reproduction of released, radiocollared bears and utilize this information for evaluating the need for further reintroductions, food supplementation and other management actions.
- Improve the captive breeding program by upgrading facilities, creating a studbook and registry, and initiating the careful monitoring of bear physiology.

Population Biology and Modeling

Executive Summary

Life History: The modeling group began accumulating life history, habitat, and threats information on the first day from workshop participants, the literature on population dynamics of other bear species, the PHVA on the Asiatic black bear in Taiwan and the field work being done on the species in Korea and Taiwan. The briefing book contained copies of publications on the species in China, Japan, and other countries which also provided information. It was immediately recognized that that there is not and can not be substantial information on the population characteristics of the black bear population in the Chirisan region since the population is too small – perhaps 10 animals or less - to provide reliable information. Therefore we have to rely on information from other populations of this species and information from other species to develop a preliminary simulation model for a population in this region. Information on the habitat provided an indication of possible population sizes that might be supported but because of the uncertainties we developed scenarios for a range of population sizes to explore the impact on risk of extinction and to provide ideas for population and habitat goals.

Modeling: The need for and consequences of alternative management strategies can be modeled to suggest which practices may be the most effective in conserving the Korean Asiatic Black Bear population in Chirisan National Park. *VORTEX*, a simulation software package written for population viability analysis, was used as a tool to study the interaction of a number of life history and population parameters treated stochastically (randomly). In addition, we were able to explore which demographic and habitat parameters may be the most sensitive to alternative management practices, and to test the effects of a suite of possible management scenarios.

Results: A reasonable base model for the population under present conditions was developed which indicated that the population is at high risk of extinction. If the habitat carrying capacity is as low as 20 as suggested, then a viable population cannot be sustained. The results of the sensitivity analyses suggested that a population in the range of 30-50 animals can be viable for 100 years, although it will lose more heterozygosity (genetic diversity) than is desirable for long term viability. Reintroduction of animals to Chirisan, either from a captive population or by translocation from wild populations is going to be essential if a viable population is to be achieved. Habitat will have to suitable for a population of 40-50 animals and the population needs to be protected from direct human induced mortality.

Development of a GIS Model for Habitat Identification, Corridor Identification, and Conflict Resolution: The number of bear observations in Chiri Park area is insufficient to create a robust habitat effectiveness model (See Park 2000). Therefore, it might be possible to adopt the rules for modeling Asian black bear habitat developed for the North American black bear, modified (through expert opinion solicitation) to account for habitat issues specific to the Chiri area (See Park 2000). To incorporate into the model the effect of human land use practices on bear movement it is important to include information on the level and type of land use.

Dispersal Corridors [sub-adults in search of suitable habitat]: Many species of terrestrial vertebrates, particularly mammals, have evolved life history strategies where one or both sexes disperse away from their parents as they approach breeding age (after weaning in mammals). If their habitat is fully occupied (at carrying capacity) they may have to travel long distances to find a place to live. Alternatively, they may live marginally, in the interstices between occupied territories or home ranges, until suitable habitat is vacated by death. Those animals that disperse may need to cross expanses of unsuitable habitat, or may use a corridor that has enough resources to sustain them in transit but does not have all the resources necessary to maintain a breeding pair throughout their lifetimes. Dispersal corridors function to maintain gene flow at level 1. Dispersal corridors may require quite different physical attributes for different species.

Problems: As a result of these analyses and discussions the modeling group identified four key problems as outlined below. Goals and actions to solve these problems were identified and are a part of the action plan developed in this group.

Problem I. Insufficient intact habitat for a viable population of Asian black bears in Chiri Park.
Problem II. Wild population is too small to be viable no matter the carrying capacity
Problem III. Human impacts on population reduce viability
Problem IV. Lack of useful models to assist an adaptive management program.

High Priority Actions Recommended:

Establish criteria for a captive population to provide animals for a release program. Consider numbers and sources of animals and projected productivity of the captive population.

Develop GIS models for bear habitat and habitat use by bears. Use as tool to test proposed changes, corridors, and meta population management scenarios

Develop protocols for a release program including: age and sex structure of animals to release; numbers to release; “hard” or “soft” release; monitoring of released animals; and engagement of local human population in project.

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Appendis 1:

IUCN Policy Guidelines
Asiatic Black Bear Literature

IUCN DRAFT POLICY ON THE MANAGEMENT OF *EX SITU* POPULATIONS FOR CONSERVATION – Draft 31 Jan 2001

PREAMBLE

IUCN affirms that the goal of conservation is the maintenance of viable populations of all species in the wild. However, conservation managers and decision-makers should adopt a realistic and holistic approach to conservation implementation. The threats to biodiversity *in situ* continue to grow, and species increasingly have to live in human modified environments. Threats, which include habitat loss, climate change, unsustainable use, and invasive and pathogenic organisms, are often extremely difficult to control. The reality of the current situation is that we shall be unable to ensure the survival of as many species as possible without increasing the role and use of *ex situ* conservation.

If the decision to bring a species under *ex situ* management is left to the last minute, it is frequently too late to effectively implement, risking permanent loss of the species. Moreover, *ex situ* conservation should only be considered an alternative to *in situ* conservation in exceptional circumstances, and effective integration between *in situ* and *ex situ* approaches should be sought wherever possible.

The decision to implement a propagation programme as part of a formalized recovery plan and the appropriate design of such an *ex situ* programme will depend on the species' circumstances and conservation needs. A species-specific propagation plan may involve a range of objectives in reproduction, research, reinforcement, reintroduction, etc., which should be clearly stated and agreed among organisations participating in the programme.

In order to maximise their potential in conservation, *ex situ* propagation facilities and their co-operative networks should conform to guidelines clearly defined by the Convention on Biological Diversity, the International Agenda for Botanic Gardens in Conservation, and the World Zoo Conservation Strategy.

VISION
Current biodiversity levels will be maintained through all available and effective means including, where appropriate, *ex situ* propagation.

GOAL
Those responsible for *ex situ* wildlife populations will use all resources and means at their disposal to maximise the conservation values of these populations for the world's biodiversity, including activities such as awareness raising and education, habitat restoration, reintroduction, genome resource banking, fundraising and capacity building.

Ex situ agencies and institutions should work with range states (with the legal mandate for access and benefit sharing agreements) to collaborate in the precautionary propagation of Vulnerable and Endangered species (according to the IUCN Red List Criteria, 2000). *Ex situ* propagation programmes can operate at the national, regional or international level, and the option of locating the *ex situ* programme outside of the species natural range should be considered if the species is threatened by natural catastrophes, political and social disruptions, or if further propagation facilities are required.

POLICY GUIDELINES

The basis for responsible *ex situ* population management in support of conservation is founded on benefits for both species and habitats.

- The primary objectives of *ex situ* propagation are to support the conservation of a taxon and its natural habitat, and to provide resources to save other ecosystem components. Such propagation should plan to avoid competing for resources with wild populations and habitats.

- While *ex situ* populations may have been established prior to the ratification of the Convention on Biological Diversity, all *ex situ* and *in situ* populations should be managed in an integrated, multidisciplinary manner, and where possible should be initiated and developed with full agreement and support of range states.

- For *ex situ* populations to contribute most effectively to species management in the wild, their propagation should be initiated when the understanding of husbandry and/or cultivation protocols is at a level whereby there is a reasonable probability of success, or where the development of such protocols could be achieved within a reasonable time frame, ideally before the species reaches Vulnerable status.

- For those threatened species for which husbandry and/or cultivation protocols do not exist, surrogates of closely related taxa can serve important functions, for example in the development of protocols and staff training. The propagation of surrogates in this respect should be encouraged.

- Although there will be species-specific exceptions due to unique life histories, the decision to initiate *ex situ* programmes should be based on one or more of the appropriate IUCN Red List Criteria, including 1) when the species/population is prone to effects of human activities or stochastic events and 2) when the species/population is likely to become Critically Endangered, or Extinct in a very short time.

- Extreme and desperate situations, where species/populations are in imminent risk of extinction, must be dealt with on an emergency basis. SSC is encouraged to establish a rescue intervention protocol to facilitate action.

- All *ex situ* populations must be managed to reduce risk of loss through catastrophe, and of invasive escape from propagation facilities.

- In the interest of successfully establishing wild populations to natural habitats, planning for *ex situ* populations must minimise any deleterious effects of *ex situ* management, such as loss of genetic diversity, artificial selection, pathogen transfer and hybridisation.

- *Ex situ* populations should seek to benefit *in situ* conservation efforts by increasing public awareness, concern and support. This can be achieved through education, fund-raising and professional capacity building programmes, and by supporting direct action *in situ*.

- Where appropriate, the use of *ex situ* methodologies, population data and genetic resources offer material for research and utilisation, the benefits of which should be applied to conservation of *in situ* populations and their ecosystems.

IUCN/SSC Guidelines For Re-Introductions

Prepared by the SSC Re-introduction Specialist Group *
Approved by the 41st Meeting of the IUCN Council, Gland Switzerland, May 1995

INTRODUCTION

These policy guidelines have been drafted by the Re-introduction Specialist Group of the IUCN's Species Survival Commission (1), in response to the increasing occurrence of re-introduction projects worldwide, and consequently, to the growing need for specific policy guidelines to help ensure that the re-introductions achieve their intended conservation benefit, and do not cause adverse side-effects of greater impact. Although IUCN developed a Position Statement on the Translocation of Living Organisms in 1987, more detailed guidelines were felt to be essential in providing more comprehensive coverage of the various factors involved in re-introduction exercises.

These guidelines are intended to act as a guide for procedures useful to re-introduction programmes and do not represent an inflexible code of conduct. Many of the points are more relevant to re-introductions using captive-bred individuals than to translocations of wild species. Others are especially relevant to globally endangered species with limited numbers of founders. Each re-introduction proposal should be rigorously reviewed on its individual merits. It should be noted that re-introduction is always a very lengthy, complex and expensive process.

Re-introductions or translocations of species for short-term, sporting or commercial purposes - where there is no intention to establish a viable population - are a different issue and beyond the scope of these guidelines. These include fishing and hunting activities.

This document has been written to encompass the full range of plant and animal taxa and is therefore general. It will be regularly revised. Handbooks for re-introducing individual groups of animals and plants will be developed in future.

CONTEXT

The increasing number of re-introductions and translocations led to the establishment of the IUCN/SSC Species Survival Commission's Re-introduction Specialist Group. A priority of the Group has been to update IUCN's 1987 Position Statement on the Translocation of Living Organisms, in consultation with IUCN's other commissions.

It is important that the Guidelines are implemented in the context of IUCN's broader policies pertaining to biodiversity conservation and sustainable management of natural resources. The philosophy for environmental conservation and management of IUCN and other conservation bodies is stated in key documents such as "Caring for the Earth" and "Global Biodiversity Strategy" which cover the broad themes of the need for approaches with community involvement and participation in sustainable natural resource conservation, an overall enhanced quality of human life and the need to conserve and, where necessary, restore ecosystems. With regards to the latter, the re-introduction of a species is one specific instance of restoration where, in general, only this species is missing. Full restoration of an array of plant and animal species has rarely been tried to date.

Restoration of single species of plants and animals is becoming more frequent around the world. Some succeed, many fail. As this form of ecological management is increasingly common, it is a priority for the Species Survival Commission's Re-introduction Specialist Group to develop guidelines so that re-introductions are both justifiable and likely to succeed, and that the conservation world can learn from each initiative, whether successful or not. It is hoped that these Guidelines, based on extensive review of case - histories and wide consultation across a range of disciplines will introduce more rigour into the concepts, design, feasibility and implementation of re-introductions despite the wide diversity of species and conditions involved.

Thus the priority has been to develop guidelines that are of direct, practical assistance to those planning, approving or carrying out re-introductions. The primary audience of these guidelines is, therefore, the practitioners (usually managers or scientists), rather than decision makers in governments. Guidelines directed towards the latter group would inevitably have to go into greater depth on legal and policy issues.

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1. DEFINITION OF TERMS

"Re-introduction": an attempt to establish a species(2) in an area which was once part of its historical range, but from which it has been extirpated or become extinct (3) ("Re-establishment" is a synonym, but implies that the re-introduction has been successful).

"Translocation": deliberate and mediated movement of wild individuals or populations from one part of their range to another.

"Re-inforcement/Supplementation": addition of individuals to an existing population of conspecifics.

"Conservation/Benign Introductions": an attempt to establish a species, for the purpose of conservation, outside its recorded distribution but within an appropriate habitat and eco-geographical area. This is a feasible conservation tool only when there is no remaining area left within a species' historic range.

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2. AIMS AND OBJECTIVES OF RE-INTRODUCTION

a. Aims:
The principle aim of any re-introduction should be to establish a viable, free-ranging population in the wild, of a species, subspecies or race, which has become globally or locally extinct, or extirpated, in the wild. It should be re-introduced within the species' former natural habitat and range and should require minimal long-term management.

b. Objectives:
The objectives of a re-introduction may include: to enhance the long-term survival of a species; to re-establish a keystone species (in the ecological or cultural sense) in an ecosystem; to maintain and/or restore natural biodiversity; to provide long-term economic benefits to the local and/or national economy; to promote conservation awareness; or a combination of these.

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3. MULTIDISCIPLINARY APPROACH

A re-introduction requires a multidisciplinary approach involving a team of persons drawn from a variety of backgrounds. As well as government personnel, they may include persons from governmental natural resource management agencies; non-governmental organisations; funding bodies; universities; veterinary institutions; zoos (and private animal breeders) and/or botanic gardens, with a full range of suitable expertise. Team leaders should be responsible for coordination between the various bodies and provision should be made for publicity and public education about the project.

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4. PRE-PROJECT ACTIVITIES

4a. BIOLOGICAL

(i) Feasibility study and background research

- An assessment should be made of the taxonomic status of individuals to be re-introduced. They should preferably be of the same subspecies or race as those which were extirpated, unless adequate numbers are not available. An investigation of historical information about the loss and fate of individuals from the re-introduction area, as well as molecular genetic studies, should be undertaken in case of doubt as to individuals' taxonomic status. A study of genetic variation within and between populations of this and related taxa can also be helpful. Special care is needed when the population has long been extinct.

- Detailed studies should be made of the status and biology of wild populations(if they exist) to determine the species' critical needs. For animals, this would include descriptions of habitat preferences, intraspecific variation and adaptations to local ecological conditions, social behaviour, group composition, home range size, shelter and food requirements, foraging and feeding behaviour, predators and diseases. For migratory species, studies should include the potential migratory areas. For plants, it would include biotic and abiotic habitat requirements, dispersal mechanisms, reproductive biology, symbiotic relationships (e.g. with mycorrhizae, pollinators), insect pests and diseases. Overall, a firm knowledge of the natural history of the species in question is crucial to the entire re-introduction scheme.

- The species, if any, that has filled the void created by the loss of the species concerned, should be determined; an understanding of the effect the re-introduced species will have on the ecosystem is important for ascertaining the success of the re-introduced population.

- The build-up of the released population should be modelled under various sets of conditions, in order to specify the optimal number and composition of individuals to be released per year and the numbers of years necessary to promote establishment of a viable population.

- A Population and Habitat Viability Analysis will aid in identifying significant environmental and population variables and assessing their potential interactions, which would guide long-term population management.

(ii) Previous Re-introductions

- Thorough research into previous re-introductions of the same or similar species and wide-ranging contacts with persons having relevant expertise should be conducted prior to and while developing re-introduction protocol.

(iii) Choice of release site and type

- Site should be within the historic range of the species. For an initial re-inforcement there should be few remnant wild individuals. For a re-introduction, there should be no remnant population to prevent disease spread, social disruption and introduction of alien genes. In some circumstances, a re-introduction or re-inforcement may have to be made into an area which is fenced or otherwise delimited, but it should be within the species' former natural habitat and range.

- A conservation/ benign introduction should be undertaken only as a last resort when no opportunities for re-introduction into the original site or range exist and only when a significant contribution to the conservation of the species will result.

- The re-introduction area should have assured, long-term protection (whether formal or otherwise).

(iv) Evaluation of re-introduction site

- Availability of suitable habitat: re-introductions should only take place where the habitat and landscape requirements of the species are satisfied, and likely to be sustained for the for-seeable future. The possibility of natural habitat change since extirpation must be considered. Likewise, a change in the legal/ political or cultural environment since species extirpation needs to be ascertained and evaluated as a possible constraint. The area should have sufficient carrying capacity to sustain growth of the re-introduced population and support a viable (self-sustaining) population in the long run.
- Identification and elimination, or reduction to a sufficient level, of previous causes of decline: could include disease; over-hunting; over-collection; pollution; poisoning; competition with or predation by introduced species; habitat loss; adverse effects of earlier research or management programmes; competition with domestic livestock, which may be seasonal. Where the release site has undergone substantial degradation caused by human activity, a habitat restoration programme should be initiated before the re-introduction is carried out.

(v) Availability of suitable release stock

- It is desirable that source animals come from wild populations. If there is a choice of wild populations to supply founder stock for translocation, the source population should ideally be closely related genetically to the original native stock and show similar ecological characteristics (morphology, physiology, behaviour, habitat preference) to the original sub-population.
- Removal of individuals for re-introduction must not endanger the captive stock population or the wild source population. Stock must be guaranteed available on a regular and predictable basis, meeting specifications of the project protocol.
- Individuals should only be removed from a wild population after the effects of translocation on the donor population have been assessed, and after it is guaranteed that these effects will not be negative.
- If captive or artificially propagated stock is to be used, it must be from a population which has been soundly managed both demographically and genetically, according to the principles of contemporary conservation biology.
- Re-introductions should not be carried out merely because captive stocks exist, nor solely as a means of disposing of surplus stock.
- Prospective release stock, including stock that is a gift between governments, must be subjected to a thorough veterinary screening process before shipment from original source. Any animals found to be infected or which test positive for non-endemic or contagious pathogens with a potential impact on population levels, must be removed from the consignment, and the uninfected, negative remainder must be placed in strict quarantine for a suitable period before retest. If clear after retesting, the animals may be placed for shipment.
- Since infection with serious disease can be acquired during shipment, especially if this is intercontinental, great care must be taken to minimize this risk.
- Stock must meet all health regulations prescribed by the veterinary authorities of the recipient country and adequate provisions must be made for quarantine if necessary.

(vi) Release of captive stock

- Most species of mammal and birds rely heavily on individual experience and learning as juveniles for their survival; they should be given the opportunity to acquire the necessary information to enable survival in the wild, through training in their captive environment; a captive bred individual's probability of survival should approximate that of a wild counterpart.

- Care should be taken to ensure that potentially dangerous captive bred animals (such as large carnivores or primates) are not so confident in the presence of humans that they might be a danger to local inhabitants and/or their livestock.

4b. SOCIO-ECONOMIC AND LEGAL REQUIREMENTS

- Re-introductions are generally long-term projects that require the commitment of long-term financial and political support.
- Socio-economic studies should be made to assess impacts, costs and benefits of the re-introduction programme to local human populations.
- A thorough assessment of attitudes of local people to the proposed project is necessary to ensure long term protection of the re-introduced population, especially if the cause of species' decline was due to human factors (e.g. over-hunting, over-collection, loss or alteration of habitat). The programme should be fully understood, accepted and supported by local communities.
- Where the security of the re-introduced population is at risk from human activities, measures should be taken to minimise these in the re-introduction area. If these measures are inadequate, the re-introduction should be abandoned or alternative release areas sought.
- The policy of the country to re-introductions and to the species concerned should be assessed. This might include checking existing provincial, national and international legislation and regulations, and provision of new measures and required permits as necessary.
- Re-introduction must take place with the full permission and involvement of all relevant government agencies of the recipient or host country. This is particularly important in re-introductions in border areas, or involving more than one state or when a re-introduced population can expand into other states, provinces or territories.
- If the species poses potential risk to life or property, these risks should be minimised and adequate provision made for compensation where necessary; where all other solutions fail, removal or destruction of the released individual should be considered. In the case of migratory/mobile species, provisions should be made for crossing of international/state boundaries.

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5. PLANNING, PREPARATION AND RELEASE STAGES

- Approval of relevant government agencies and land owners, and coordination with national and international conservation organizations.
- Construction of a multidisciplinary team with access to expert technical advice for all phases of the programme.
- Identification of short- and long-term success indicators and prediction of programme duration, in context of agreed aims and objectives.
- Securing adequate funding for all programme phases.
- Design of pre- and post- release monitoring programme so that each re-introduction is a carefully designed experiment, with the capability to test methodology with scientifically collected data. Monitoring the health of individuals, as well as the survival, is important; intervention may be necessary if the situation proves unforseeably favourable.

- Appropriate health and genetic screening of release stock, including stock that is a gift between governments. Health screening of closely related species in the re-introduction area.
- If release stock is wild-caught, care must be taken to ensure that: a) the stock is free from infectious or contagious pathogens and parasites before shipment and b) the stock will not be exposed to vectors of disease agents which may be present at the release site (and absent at the source site) and to which it may have no acquired immunity.
- If vaccination prior to release, against local endemic or epidemic diseases of wild stock or domestic livestock at the release site, is deemed appropriate, this must be carried out during the "Preparation Stage" so as to allow sufficient time for the development of the required immunity.
- Appropriate veterinary or horticultural measures as required to ensure health of released stock throughout the programme. This is to include adequate quarantine arrangements, especially where founder stock travels far or crosses international boundaries to the release site.
- Development of transport plans for delivery of stock to the country and site of re-introduction, with special emphasis on ways to minimize stress on the individuals during transport.
- Determination of release strategy (acclimatization of release stock to release area; behavioural training - including hunting and feeding; group composition, number, release patterns and techniques; timing).
- Establishment of policies on interventions (see below).
- Development of conservation education for long-term support; professional training of individuals involved in the long-term programme; public relations through the mass media and in local community; involvement where possible of local people in the programme.
- The welfare of animals for release is of paramount concern through all these stages.

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6. POST-RELEASE ACTIVITIES

- Post release monitoring is required of all (or sample of) individuals. This most vital aspect may be by direct (e.g. tagging, telemetry) or indirect (e.g. spoor, informants) methods as suitable.
- Demographic, ecological and behavioural studies of released stock must be undertaken.
- Study of processes of long-term adaptation by individuals and the population.
- Collection and investigation of mortalities.
- Interventions (e.g. supplemental feeding; veterinary aid; horticultural aid) when necessary.
- Decisions for revision, rescheduling, or discontinuation of programme where necessary.
- Habitat protection or restoration to continue where necessary.
- Continuing public relations activities, including education and mass media coverage.
- Evaluation of cost-effectiveness and success of re- introduction techniques.
- Regular publications in scientific and popular literature.

Footnotes:

1. Guidelines for determining procedures for disposal of species confiscated in trade are being developed separately by IUCN.
2. The taxonomic unit referred to throughout the document is species; it may be a lower taxonomic unit (e.g. subspecies or race) as long as it can be unambiguously defined.
3 . A taxon is extinct when there is no reasonable doubt that the last individual has died

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The IUCN/SSC Re-introduction Specialist Group

The IUCN/SSC Re-introduction Specialist Group (RSG) is a disciplinary group (as opposed to most SSC Specialist Groups which deal with single taxonomic groups), covering a wide range of plant and animal species. The RSG has an extensive international network, a re-introduction projects database and re-introduction library. The RSG publishes a bi-annual newsletter RE-INTRODUCTION NEWS.

If you are a re-introduction practitioner or interested in re-introductions please contact:

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ENGLISH LANGUAGE LITERATURE ON ASIATIC BLACK BEARS
NATURAL HISTORY, ECOLOGY & POPULATION BIOLOGY

D. Garshelis

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Asiatic Black Bears PHVA

Draft Report

for workshop held
April 18-21, 2001
Seoul, Korea

Appendix 2:

Workshop Action Plan Guidelines
Workshop and PHVA

Working Groups Process

Korean Asiatic Black Bear PHVA
18-20 April 2001

TASK 1: Identifying and Defining Problems. Rank them in order of priority. (See the detailed 'Problem Statements' guidelines sheet.)

Develop a list of key problems affecting survival of the species populations and their habitat in Korea. Be specific for each geographical location. Make sure that you write 2-3 sentences specifying the issue in more detail. These sentences should define the issue or problem so that any outside reader can understand what you mean.

TASK 2: Develop Goals to achieve to change the conditions identified in the problem statement. Specify minimum and maximum goals to achieve in the next 5 years. Develop goals for each problem. There can be more than one goal but they should be in order of priority.

Briefly list 3-5 promising goals to address each problem.

- Does the goal contribute to reducing risk and work toward recovery?
- Does the goal add to knowledge that would reduce risk?
- Does the goal reduce the uncertainty of the risk estimate?
- How would/could the goal be monitored or evaluated?
- If a habitat goal, to what degree is the goal spatially specific (or not)?
- How are risk assessment and risk allocation questions embedded in the goal?
- Are there ways to make judgements made on what's acceptable or not acceptable?

TASK 3: Develop actions to accomplish with the goals identified under the problems or issues for your group's region, taking into account the information on the taxon data sheets for the species at the location. (See the detailed 'ACTIONS' guidelines sheet.)

Write 2-5 sentences describing in more detail the 3-5 highest priority actions under each priority goal. These should be described well enough that an outside reader would understand what is meant by the strategy. Use the guidelines on the next page.

Under each goal, prioritise the actions. Consider the following points:

- Could the action be accomplished in the short-term?
- Is the action economically feasible?
- Does the action add to knowledge that would decrease risk?
- Would the action be acceptable to most stakeholder sectors?

WORKING GROUP INSTRUCTIONS

Each group will need to select:

1. ***Discussion leader*** (facilitator) **–** to assist organized participation and focused discussions.
2. ***Flip chart note taker*** (may be the discussion leader) **–** to write notes of the ideas and discussions about the task on flip chart pages. The pages provide the 'group memory' of the discussion and provide the visual aid for presentations in plenary sessions.
3. ***Computer note taker* –** notes from the flip charts and the group discussion as basis for the draft report from each working group.
4. ***Presenter* –** to present the results of the working group's discussion to the assembled groups. Usually 5-10 minutes is sufficient for the presentation,
5. ***Time keeper* –** to keep the group on schedule.

TASK 1a. **Brainstorm Problems/Issues** for your group's topic (see attached description of the process). This is not the time to develop solutions or actions or research projects for the problems. This will be done in later steps in the process.

TASK 1b. **Group and consolidate** the ideas and problems generated in the first step into a smaller number of topics – usually less than 10 items. Write a one or two sentence 'problem statement' for each problem (see attached description of the process). Retain a listing of the individual 'brainstorm' problems under the consolidated topics.

TASK 1c. **Prioritize the problem statements**. Use the paired ranking technique (see handout). Report the total score and the rank. This process helps careful examination of each statement and possible further consolidation or better definition. It also assists making choices for the next step if time is limited.

TASK 2a. **Prepare short (1 year) and long-term (5 years) goals** (maximum and minimum) for each problem. See the 'Working Groups Process' handout (Task 2) for more details on how to develop goals. Goals are intended to guided actions to help solve the problem. There will likely be more one goal needed. You also may develop sub-goals for a complex goal.

TASK 2b. **Prioritize all of the goals across each problem and across all of the problems**. Use paired ranking.

TASK 3a. **Develop Action Steps for each of the high priority goals.** You may need 5-10 actions for one goal. Use the handout on Actions for information on the **characteristics** of Action Steps and the **information** to be included with each Action.

TASK 3b. **Prioritize the action steps under each problem.** Use the paired ranking technique. The high priority actions will form the body of the recommendations from the workshop.

TASK 4. **Complete and turn in your group's draft report each day.**

Working Groups – Task 1

Each group will need:
1. FACILITATOR - to assure organized discussions
2. FLIP CHART NOTE-TAKER.
3. COMPUTER NOTE-TAKER
4. PRESENTER - to present the results of the working group's discussions.

TASK:
Expanding Identified Issues/Problems (Part One)

Important Note: This is not the time for developing solutions and research pojects. That will be addressed in later steps.

Steps:

Question: In your view, what is/are the central issue(s) or problem(s) falling under your group's theme?

Process:
1. Brainstorm, briefly, a list of issues or problems. Please use FULL STATEMENTS in your notes/report rather than lists. E.g., "The critical problem(s) for us is.....".

3. Examine the issues identified under your group s topic. Collapse issues under common themes, if they logically fall together.

4. For each identified issue, write 2-3 sentences specifying the issue in more detail. These sentences should define the issue so that any outside reader can understand what you mean.

5. Identify any related issues that fall under your topic that you feel are important yet were not mentioned in the plenary discussion. Follow steps 1-3 for those issues.

TASK:
Prioritizing Identified Issues (Part Two)

Steps:
1. Create a simple list of the identified issues on a flip chart page.
2. Use paired ranking to prioritize the identified issues. Your group may wish to develop and rank a list of criteria against which the identified issues can be evaluated, and then proceed with a paired-ranking process using a matrix. Facilitators can assist you with this process.
3. Number the issues on the flip chart page according to priority.

Brainstorming Groundrules

Every idea is valid.

Even weird, way-out ideas.
Even confusing ideas.
Especially silly ideas.

Suspend judgement.

We won't evaluate each other's ideas.
We won't censor our own ideas.
We'll save these ideas for later discussion.

We can modify this process before it starts or after it ends, but not while it's underway.

State ideas in short statements of 3-5 words. No one explains.

MANAGEMENT ACTION PLAN

ACTIONS

Specific Action Steps that contribute to achieving your goal.

Characteristics of an Action Step:

Specific - for each goal

Measurable - outcome or an indicator

Attainable – can be accomplished under current conditions

Relevant – helps solve the specific problem and needs to be done

Timely – can be undertaken in time to achieve the goal

Information to include in each Action Step

Description - a short statement which can be understood by a non-participant reader. Relate the action to achievement of a specific goal and solving the problem.

Responsibility – who **in the room** is responsible for organizing or doing the action?

Time line – beginning and completion of the action. Dates.

Measurable - outcome or result. A specific product or change in condition.

Collaborators or Partners – who is essential to get the action accomplished?

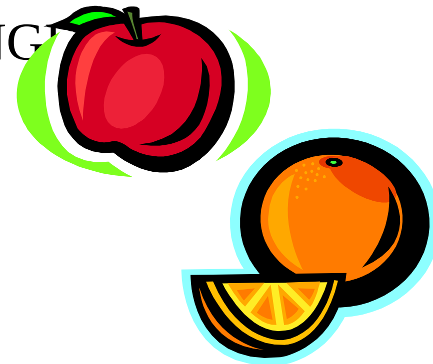
Resources

Personnel and time required
Costs – rough estimate
Special to project

Consequences – Expected impact or outcome or result of the action if accomplished. A change in condition or state of the situation Contribution to achievement of the goal.

Obstacles - For example: Specific conflicts in interests of stakeholders or regulatory requirements or lack of local support that may need to be resolved or specific lack of resources preventing accomplishment of the action.

COMPARING APPLES AND ORANGES
PAIRED RANKING



One simple way to prioritize items on a list is to use paired ranking.

Let's say we wish to rank the five fruits we like best.

PART ONE.

1. First list the fruits in a column one below the other. Ask yourself, which do I like betterr, apples or oranges? Put a mark next to the one that's better. Then ask do I like better, apples or kiwis? Put another mark after the one you prefer.

2. Continue down the list until you have compared apples with each of the other fruits. Then, compare oranges with kiwis, oranges with peaches, and so on. Then, kiwis with peaches and kiwis with apricots, then peaches with apricots.

1st Set		**2^{nd} Set**		**3^{rd} Set**		**4^{th} Set**	
1. Apples	||	1. Apples		1. Apples		1. Apples	
2. Oranges		2. Oranges	|	2. Oranges		2. Oranges	
3. Kiwis	|	3. Kiwis		3. Kiwis	|	3. Kiwis	
4. Peaches	|	4. Peaches	|	4. Peaches		4. Peaches	|
5. Apricots		5. Apricots	|	5. Apricots	|	5. Apricots	

The fruit with the most marks next to it is ranked #1, the second most marks #2, etc. (The sums for each fruit are shown in the 4^{th} Set).

Apples	2
Oranges	1
Kiwis	2
Peaches	3
Apricots	2

Sum = 10

As a check on your accuracy, the total number of ticks should be: N(N-1)/2.
In this example 5(4)/2 = 10.

Thanks for your help.

An Introduction to Simulation Modeling and Population Viability Analysis

A model is any simplified representation of a real system. We use models in all aspects of our lives, in order to: (1) extract the important trends from complex processes, (2) permit comparison among systems, (3) facilitate analysis of causes of processes acting on the system, and (4) make predictions about the future. A complete description of a natural system, if it were possible, would often decrease our understanding relative to that provided by a good model, because there is "noise" in the system that is extraneous to the processes we wish to understand. For example, the typical representation of the growth of a wildlife population by an annual percent growth rate is a simplified mathematical model of the much more complex changes in population size. Representing population growth as an annual percent change assumes constant exponential growth, ignoring the irregular fluctuations as individuals are born or immigrate, and die or emigrate. For many purposes, such a simplified model of population growth is very useful, because it captures the essential information we might need regarding the average change in population size, and it allows us to make predictions about the future size of the population. A detailed description of the exact changes in numbers of individuals, while a true description of the population, would often be of much less value because the essential pattern would be obscured, and it would be difficult or impossible to make predictions about the future population size.

In considerations of the vulnerability of a population to extinction, as is so often required for conservation planning and management, the simple model of population growth as a constant annual rate of change is inadequate for our needs. The fluctuations in population size that are omitted from the standard ecological models of population change can cause population extinction, and therefore are often the primary focus of concern. In order to understand and predict the vulnerability of a wildlife population to extinction, we need to use a model which incorporates the processes which cause fluctuations in the population, as well as those which control the long-term trends in population size (Shaffer 1981). Many processes can cause fluctuations in population size: variation in the environment (such as weather, food supplies, and predation), genetic changes in the population (such as genetic drift, inbreeding, and response to natural selection), catastrophic effects (such as disease epidemics, floods, and droughts), decimation of the population or its habitats by humans, the chance results of the probabilistic events in the lives of individuals (sex determination, location of mates, breeding success, survival), and interactions among these factors (Gilpin and Soulé 1986).

Models of population dynamics which incorporate causes of fluctuations in population size in order to predict probabilities of extinction, and to help identify the processes which contribute to a population's vulnerability, are used in "Population Viability Analysis" (PVA) (Lacy 1993/4). For the purpose of predicting vulnerability to extinction, any and all population processes that impact population dynamics can be important. Much analysis of conservation issues is conducted by largely intuitive assessments by biologists with experience with the system. Assessments by experts can be quite valuable, and are often contrasted with "models" used to evaluate population vulnerability to extinction. Such a contrast is not valid, however, as *any* synthesis of facts and understanding of processes constitutes a model, even if it is a mental model within the mind of the expert and perhaps only vaguely specified to others (or even to the expert himself or herself).

A number of properties of the problem of assessing vulnerability of a population to extinction make it difficult to rely on mental or intuitive models. Numerous processes impact population dynamics, and many of the factors interact in complex ways. For example, increased fragmentation of habitat can make it more difficult to locate mates, can lead to greater mortality as individuals disperse greater distances across unsuitable habitat, and can lead to increased inbreeding which in turn can further reduce ability to attract mates and to survive. In addition, many of the processes impacting population dynamics are intrinsically probabilistic, with a random component. Sex determination, disease, predation, mate acquisition -- indeed, almost all events in the life of an individual -- are stochastic events, occurring with certain probabilities rather than with absolute certainty at any given time. The consequences of factors influencing population dynamics are often delayed for years or even generations. With a long-lived species, a population might persist for 20 to 40 years beyond the emergence of factors that ultimately cause extinction. Humans can synthesize mentally only a few factors at a time, most people have difficulty assessing probabilities intuitively, and it is difficult to consider delayed effects. Moreover, the data needed for models of population dynamics are often very uncertain. Optimal decision-making when data are uncertain is difficult, as it involves correct assessment of probabilities that the true values fall within certain ranges, adding yet another probabilistic or chance component to the evaluation of the situation.

The difficulty of incorporating multiple, interacting, probabilistic processes into a model that can utilize uncertain data has prevented (to date) development of analytical models (mathematical equations developed from theory) which encompass more than a small subset of the processes known to affect wildlife population dynamics. It is possible that the mental models of some biologists are sufficiently complex to predict accurately population vulnerabilities to extinction under a range of conditions, but it is not possible to assess objectively the precision of such intuitive assessments, and it is difficult to transfer that knowledge to others who need also to evaluate the situation. Computer simulation models have increasingly been used to assist in PVA. Although rarely as elegant as models framed in analytical equations, computer simulation models can be well suited for the complex task of evaluating risks of extinction. Simulation models can include as many factors that influence population dynamics as the modeler and the user of the model want to assess. Interactions between processes can 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. In theory, simulation programs can be used to build models of population dynamics that include all the knowledge of the system which is available to experts. In practice, the models will be simpler, because some factors are judged unlikely to be important, and because the persons who developed the model did not have access to the full array of expert knowledge.

Although computer simulation models can be complex and confusing, they are precisely defined and all the assumptions and algorithms can be examined. Therefore, the models are objective, testable, and open to challenge and improvement. PVA models allow use of all available data on the biology of the taxon, facilitate testing of the effects of unknown or uncertain data, and expedite the comparison of the likely results of various possible management options.

PVA models also have weaknesses and limitations. A model of the population dynamics does not define the goals for conservation planning. 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. Because the models incorporate many factors, the number of possibilities to test can seem endless, and it can be difficult to determine which of the factors that were analyzed are most important to the population dynamics. 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 probably underestimate the threats facing the population. Finally, the 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.

The *VORTEX* Population Viability Analysis Model

For the analyses presented here, the *VORTEX* computer software package (Lacy 1993a, Miller and Lacy 1999) 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.

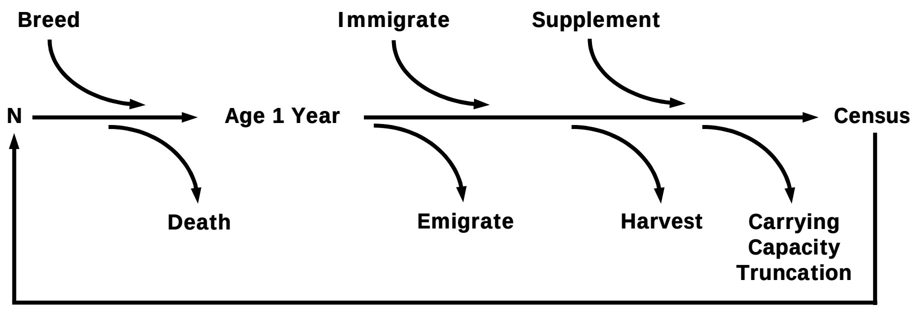
Density dependence in mortality is modeled by specifying a carrying capacity of the habitat. When the population size exceeds the carrying capacity, additional morality is imposed across all age classes to bring the population back down to the carrying capacity. The carrying capacity can be specified 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 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 below.) 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

VORTEX Simulation Model Timeline



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

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 (1993a) and Miller and Lacy (1999).

Dealing with Uncertainty

It is important to recognize that uncertainty regarding the biological parameters of a population and its consequent fate occurs at several levels and for independent reasons. Uncertainty can occur because the parameters have never been measured on the population; limited field data have yielded estimates with potentially large sampling error; independent studies have generated discordant estimates; environmental conditions or population status have been changing over time, and field surveys were conducted during periods which may not be representative of long-term averages; and the environment will change in the future, so that measurements made in the past may not accurately predict future conditions.

Sensitivity testing is necessary to determine the extent to which uncertainty in input parameters results in uncertainty regarding the future fate of the desert bighorn sheep population in New Mexico. If alternative plausible parameter values result in divergent predictions for the population, then it is important to try to resolve the uncertainty with better data. Sensitivity of population dynamics to certain parameters also indicates that those parameters describe factors that could be critical determinants of population viability. Such factors are therefore good candidates for efficient management actions designed to ensure the persistence of the population. The above kinds of uncertainty should be distinguished from several more sources of uncertainty about the future of the population. Even if long-term average demographic rates are known with precision, variation over time caused by fluctuating environmental conditions will cause uncertainty in the fate of the population at any given time in the future. Such environmental variation should be incorporated into the model used to assess population dynamics, and will generate a range of possible outcomes (perhaps represented as a mean and standard deviation) from the model. In addition, most biological processes are inherently stochastic, having a random component. The stochastic or probabilistic nature of survival, sex determination, transmission of genes, acquisition of mates, reproduction, and other processes preclude exact determination of the future state of a population. Such demographic stochasticity should also be incorporated into a population model, because such variability both increases our uncertainty about the future and can also change the expected or mean outcome relative to that which would result if there were no such variation. Finally, there is "uncertainty" which represents the alternative actions or interventions which might be pursued as a management strategy. The likely effectiveness of such management options can be explored by testing alternative scenarios in the model of population dynamics, in much the same way that sensitivity testing is used to explore the effects of uncertain biological parameters.

Results

Results reported for each scenario include:

Deterministic r -- The deterministic population growth rate, a projection of the mean rate of growth of the population expected from the average birth and death rates. Impacts of harvest, inbreeding, and density dependence are not considered in the calculation. When $r = 0$, a population with no growth is expected; $r < 0$ indicates population decline; $r > 0$ indicates long-term population growth. The value of r is approximately the rate of growth or decline per year.

The deterministic growth rate is the average population growth expected if the population is so large as to be unaffected by stochastic, random processes. The deterministic growth rate will correctly predict future population growth if: the population is presently at a stable age distribution; birth and death rates remain constant over time and space (i.e., not only do the probabilities remain constant, but the actual number of births and deaths each year match the expected values); there is no inbreeding depression; there is never a limitation of mates preventing some females from breeding; and there is no density dependence in birth or death rates, such as a Allee effects or a habitat "carrying capacity" limiting population growth. Because some or all of these assumptions are usually violated, the average population growth of real populations (and stochastically simulated ones) will usually be less than the deterministic growth rate.

Stochastic r -- The mean rate of stochastic population growth or decline demonstrated by the simulated populations, averaged across years and iterations, for all those simulated populations that are not extinct. 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, for example, 500 iterations within that given scenario that have gone extinct in the simulations. “Extinction” is defined in the VORTEX model as the lack of either sex.

N -- mean population size, averaged across those simulated populations which are not extinct.

SD(N) -- variation across simulated populations (expressed as the standard deviation) in the size of the population at each time interval. SDs 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. SD(N) will also decline considerably when the population size approaches and is limited by the carrying capacity.

H -- 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 1993b), 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 (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.

OVERVIEW OF THE VORTEX SIMULATION SOFTWARE FOR POPULATION VIABILITY ANALYSIS MODELING

Bob Lacy
Brookfield Zoo

Broadly, population viability analysis (pva) is any assessment of the viability of a biological population. Such an assessment must be based on some “model” of the processes that can threaten viability. The model can be conceptual, qualitative, and heuristic, or it could be an analytical formulation derived from hypothesized mathematical properties of population dynamics, or it could be a simulation model that mimics the events and processes that we believe to be important in order to generate representations of plausible and likely futures for the population. Most pvas use this last approach, because the number and complexity of processes that influence population viability are so great as to be difficult (or even impossible?) To encapsulate within either a simple conceptual model or a single analytical equation. An advantage of a simulation model is that the structure of the model and how it works can be made very explicit and actually simple. Simulation models just do very quickly what could be done by hand, even by people with minimal mathematical skills. A coin-tossing exercise can be used to demonstrate how the randomness of demographic processes can be simulated to project possible trajectories for a population. Such an exercise always quickly shows why the inherent uncertainty in the dynamics of biological populations makes small populations especially vulnerable to extinction.

Before a PVA is begun, it is important to decide what will be the criteria for defining “viability”. If there isn’t agreement on this before the analyses are completed, then interpretations of the results of the PVA may be very different among people, and it may not even be apparent to all that they have different views about whether the population is deemed to be viable. Viability may not be an all-or-none thing, but instead more of a quantity or value that is considered in relation to other quantities (such as dollars, or amount of effort, or some other measure of cost). Thus, even if there is preliminary agreement on the definition of viability, that definition may be revisited and revised as the participants in a PVA begin to see how different definitions of viability require different costs.

The most common kind of definition of viability is that the probability of extinction (PE) is kept below some acceptably low level for some defined number of years or generations into the future. Thus, for a given conservation assessment, it may be decided that Viability is PE < 5% for 100 years. Conservation advocates and biologists often set criteria for viability in the range of PE < 1% for perhaps 200 to 1000 years, while industry representatives may feel that a criterion of PE < 10% for 50 years is adequate. Until this definition is set, however, it is impossible to use a PVA to determine whether a given conservation or management plan is adequately achieving the goal of “viability”.

Other definitions of viability may include criteria of minimum numbers of animals or minimum acceptable rates of population growth. (E.g., the Alberta government specified that their goal for grizzly bears is to maintain a population that remains at least as large as it is at present.) Viability may also be defined in terms of a maximum acceptable loss of genetic diversity, or a minimum area occupied, or even a minimum level of fulfilling some ecological role in the ecosystem. Multiple criteria may be used, with the recognition that some conservation plans could meet some criteria but not others.

Further discussion of Vortex and PVA are provided in the references given below. Following that is an outline of properties and considerations in using the Vortex model for doing PVA. A simple exercise for exposing people to the use of Vortex for doing PVA is also provided.

Some Vortex References

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Lindenmayer, D.B., M.A. Burgman, H.R. Akçakaya, R.C. Lacy, and H.P. Possingham. 1995. A review of the generic computer programs ALEX, RAMAS/space and VORTEX for modelling the viability of wildlife populations. Ecological Modelling 82:161-174.

Lindenmayer, D.B., R.C. Lacy, and M.L. Pope. 2000. Testing a simulation model for Population Viability Analysis. Ecological Applications 10:580-597.

Miller, P.S. and R.C. Lacy. 1999. VORTEX Version 8 users manual. A stochastic simulation of the simulation process. IUCN/SSC Conservation Breeding Specialist Group. Apple Valley, Minnesota.

Why use PVA modeling for conservation planning?

Collect data
Synthesize data
Assess vulnerability; project distribution of future trajectories *if* things don't change
Examine sensitivities, determine key factors
Test uncertainties
Test options
Generate predictions for adaptive management
Objective (more or less) forum for testing hypotheses
Forces specification of data and assumptions, allows testing and improvement of

hypotheses

(so make sure that you do these things when using PVA!)

Processes driving biological populations are too many and too complex and too intertwined to be amenable to intuition, single-factor experimentation and control, or undocumented hand-waving

PVA is risk assessment for biological populations, so how could we not use it?

Properties of Vortex:

Simulation

generates variation of the system, produces estimates of probabilities (frequencies) for risk assessment, not predictions of the future

Individual based

processes are emergent from the simulation, not analytically predicted;
results are emergent from the simulation, not analytically predicted;
a tool for experimentation, not a method for deriving generalities;
but also a tool to test theory, while relaxing assumptions and avoiding approximations

Generates demographic stochasticity (intrinsic to population dynamics)

Samples from specified environmental variation in rates (extrinsic)

Simulates catastrophes

Models genetic loss and effects of inbreeding

Rate variables can be specified as functions (of time, density, genetics, population age structure, or whatever) or as constants

Vortex needs (data to be input):

iterations
Definition of "extinction" (lower threshold)
populations
Pairwise probabilities of dispersal among populations
Severity of effects of inbreeding
"lethal equivalents" = slope of regression of log(offspring survival) vs. inbreeding
i.e., parameter b in $S = S_0 * e^{-bF}$, in which F is the inbreeding coefficient
Percent of inbreeding effects that can be removed by natural selection
Correlation among populations
Concordance between variation in survival and reproduction
Sex-specific age of breeding
Maximum age
Reproductive system (monogamy vs polygyny, short-term vs long-term)
Reproductive rates, with annual variation (EV)
Age and sex-specific mortality rates, with EVs
Probabilities and impacts of catastrophes
Proportion of adult males breeding
Initial population size (and, optionally, age structure)
Maximum population size (carrying capacity, K), with trends
Rates of harvest or supplementation

Vortex users need:

lots of DATA!
estimates of variability in data
knowledge of uncertainty in data
expert or at least intuitive assessments of variables with no data
understanding of demography, genetics, stochastic processes
exploratory nature
creativity and persistence
fast fingers for testing lots of options in the program

Vortex gives, as output:

Probability of extinction (PE)
Mean population size (N), and trajectory over time
Uncertainty in N over iterations (SD[N])
Mean population growth rate (r)
Fluctuation in r (SD[r])
Loss of gene diversity
Accumulation of inbreeding
Metapopulation dynamics (PE-local, prob. of recolonization, time to recolonization)

DO PVA SIMULATION MODELS WORK?

Aussie studies (Brook et al.): Yes, for single populations with simple structure; but (Lindenmayer et al.): Use with caution when there is complex social structure (e.g., monogamy, important roles for non-breeders), complex interactions with other species, rapidly changing environment, highly heterogeneous environments, or complex metapopulation structures. Hard to know if we have the right model or just one of a number of plausibly good models.

Plans and ideas for the future:

Windows version, expected release date early 2001
- Windows interface; Help, Prompts, Definitions
- "Project" approach
- Ease of sensitivity testing
- Flexible and diverse graphic and tabulation capabilities
- Notes on input data
- Built-in report writer
- Cut-and-paste, import/export

Greater capabilities/flexibility to model complex population dynamics
- Social structure
- Metapopulation structure

- Temporal changes
- Genetic/evolutionary processes
- Multi-species interactions?

Add-on modules

- Epidemiology
- Human population growth and impacts
- Links to GIS?
- Genetic management

Link to SIS (or other) web site to get default/preliminary data for any species
Student versions, instruction modules

A few useful terms:

Project – a set of analyses focused on one or a few populations of a species, in a given environmental, political, and social context.
Scenario – a set of parameters defining a hypothesized description of the population and situation to be modeled.
Iteration (or Run) – one simulated projection of a possible fate of a scenario.
Simulation – a model of the future trajectory. Usually repeated many times to determine the distribution of possible outcomes.
Population Viability Analysis (PVA) – an assessment of the viability (often defined in terms of the probability of extinction over a specified time) of a biological population. Usually includes analysis of multiple alternative descriptions of the population.

Participant List

Name	Affiliation	Position	Days Participated 18	19	20
Ulysses Samuel Seal	Conservation Breeding Specialist Group/SSC/IUCN	Chairman	O	O	O
Lee, Hang	Seoul National University	Professor	O	O	O

group1	Name	Affiliation	Position	18	19	20
	Han, Chang-Hoon	Seoul Grand Park	Conservation Team Leader	O	O	O
	Ma, Yong-Un	Korean Federation for Environmental Movement	Wildlife Protection Group Leader	O	O	O
	Mei-hsiu Hwang	University of Minnesota	Graduate Student	O	O	O
	Seo, Chang-Soo	Jinju Munwha Broadcasting Company	Producer	O	O	O
	Hwang, Bo-Yeon	Bukhansan National Park	Ecology Section	O	O	O
	Lee, Ji-Hyung	Chirisan National Park	Ecology Section	O	O	
	Ki, Won-Ju	National Parks Authority	Ecology Section	O	O	O
	Ryu, Byung-Ho	National Institute of Environmental Research	Head of Wildlife Division	O		
	Seo,Young-Sun	Seoul National University	Research Assistant	O	O	O
	Lee, Sang-Don	Environmental Impact Assessment Division, Korea Environment Institute	Associate Fellow		O	

group2	Name	Affiliation	Position	18	19	20
	Kim,Won-Myung	National Institute of Environmental Research	Researcher	O	O	O
	Min, Mi-Sook	Seoul National University	Research Associate	O	O	O
	Kim, Eun	Seoul Grand Park	Chief Clerk	O	O	O
	Cho, Sin-Il	Seoul Grand Park	Teacher	O	O	O
	Choi, Tae-Young	Graduate School of Environment, Seoul National University	Graduate Student	O		
	An, Jung-Hwa	Seoul National University	Graduate Student	O	O	O
	Mun, Kwang-Sun	Chirisan National Park	Ecology Section	O	O	O
	Paul Harpley	Toronto Zoo	Project Manager	O	O	O
	Lee, Bae-Keun	National Parks Authority		O	O	O

	Name	Affiliation	Position	18	19	20
	Son, Je-Min	Wildlife Conservationist Group	Member	O	O	O
	Kim, Soung-Su	Kwangjin Animal Hospital	Wildlife Veterinarian	O	O	O
	Yang, Seo-Young	Biology, Inha University	Emeritus Professor	O	O	

group3	**Name**	**Affiliation**	**Position**	**18**	**19**	**20**
	Kwon, Min-Jung	Wildlife Conservationist Group	Veterinary Student	O	O	O
	Lee, Byung-Chae	The Federation of Raising Movement for Chirisan	President	O		
	Jung, Yun-Kyun	The Association of Sap Collectors in Hadong	Representative	O	O	O
	Cho, Hyun-Kyo	The Association of Sap Collectors in Kurye	President	O	O	O
	Kwon, Su-Duk	Nambu Forest Experimental Station, Korea Forest Research Institute, Lab. Of Special Forest Products	Researcher	O	O	
	Kang, Byung-Tak	Seoul National University	Graduate Student	O	O	O
	Hong, Won-Woo	Seoul National University	Assistant Fellow	O	O	O
	Paul C. Paquet	Conservation Biology Institute, Canada	Senior Scientist	O	O	
	Mun, Ho-Sung	Baekmudong, Chirisan	Representative of the local residents	O	O	O
	Park, So-Young	National Parks Authority	Researcher	O	O	O
	Park, Sun-Ho	Seoul Grand Park	Researcher		O	O

group4	**Name**	**Affiliation**	**Position**	**18**	**19**	**20**
	Yeom, Kwang-Ho	Bear Farmer Association	Member	O		
	Cho, Jeon-Ho	Bear Farmer Association	Member	O		
	Pak, Sin-Il	Bear Farmer Association	President	O		
	Kim, Young-Jun	Seoul National University	Assistant Fellow	O	O	O
	David L. Garshelis	Minnesota Department of Natural Resources, USA	Bear Project Leader	O	O	O
	Kim,Young-Keon	Seoul Grand Park	Zoo Director	O	O	O
	Eo, Yong-Jun	Seoul Grand Park	Veterinarian	O	O	O
	Byun, Hong-Seop	National Parks Authority	Ecology Section	O	O	O
	William A. Rapley	Toronto Zoo, Canada	Executive Director, Biology and Conservation	O	O	O

	Kang, Yeon-Ju	Seoul National University	Graduate Student	O	O	O
	Kim, Yeun-Hee	Seoul National University	Graduate Student	O	O	O
	Cho, Dong-Joon	Seoul National University	Assistant Fellow	O	O	O

Attendents not participated in the group meetings	**Name**	**Affilation**	**Position**	**18**	**19**	**20**
	Lee, Ho	Dukyusan National Park	Ecology Section	O		
	Shin, Jung-Tae	Soraksan National Park	Ecology Section	O		
	Lee, Byoung-Dong	Livestock Team, Research Institute of Public Health and Environment, Seoul Metropolitan Gov.	Team Leader	O		
	Lee, Yang-Soo	Inspection Team, Research Institute of Public Health and Environment, Seoul Metropolitan Gov.	Team Leader	O		
	Kim, Chul-Hun	Korea Hunting Association	Managing Director	O		
	Lee, Jong-Ik	The Nature and Hunting (Hunting Magazine)	Publisher and President	O		
	Kim, Chang-Hoe	The Ministry of Environment		O		
	Kim, Sang-Ho	Ecosystem Conservation Division, The Ministry of Environment	Assistant Junior Official	O		
	Jang, Joo-Young	Green Korea United (NGO)	Wildlife Campaign	O		
	Han, Seong-Yong	Wildlife Institue of Korea	President	O		
	Yang, Doo-Ha	Ghayasan National Park	Ecology Section	O		
	Park, Yun-Hee	Hankyung Univ.	Student	O		
	Lee, Jun-Yong	Seoul National University		O		
	Park, Do-Hwan	Forest Produccts Division, Korea Forest Service	Assistant Director	O		
	Byun, Seong-Woo	Hankyung University	Student	O		
	Mok, Young-Kyu	National Parks Authority	Head of Conservation Department	O		
	Seo, In-Kyo	National Parks Authority		O		
	Choi, Chang-Sun	Everland Zoo		O		
	Kim, Jong-Bum	Inha University		O		

No, Jung-Rae	Seoul National Univ.		O
Kim, Seong-Man	The Korean Association of Bird Protection	President	O
Lee, Jung-Jae	Folklore institute, Kyunghee univ.	Folklorist	O
Woo, Doo-Seong	The Society for Chirisan Natural Ecosystem Conservation	President	O
Chang, Soo-Ghil	Seoul Grand Park	President	O
Jung, Kwan-Hun	Seoul Grand Park		O
Kwon, Sun-Ho	Seoul Grand Park	Head of Wildlife Research Center	O
Lee, Mi-Hwa	Environmental Daily Newspaper		O
Kim, Myung-Jin	Environmental Daily Newspaper		O
Kim, Ki-Gun	Seoul Grand Park	Chief of the Veterinary Section	O
Cho, Ryun	Seoul Grand Park	Chief of Animal Department	O
Son, Hong-Rock	Seoul Grand Park	Vet. Team Leader	O
Jin, Kyung-Sun	Seoul Grand Park	Pathology Team	O
Lee, Kang-Soo	Seoul Grand Park	Dolphin Team leader	O
Kim, Young-Kyu	Genetica Inc.		O
Lim, Chan-Ho	Genetica Inc.		O
Won, Chang-Man	National Institue of Environmental Research	Researcher	O
Lee, Woo-Shin	Seoul National University	Professor	O
Lee, Jae-Hyup	College of Law, Kyunghee University	Professor	O