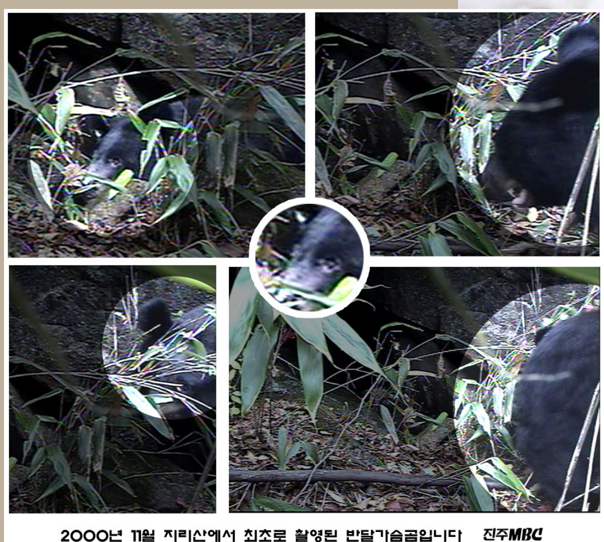
Asiatic Black Bears PHVA



Final Report

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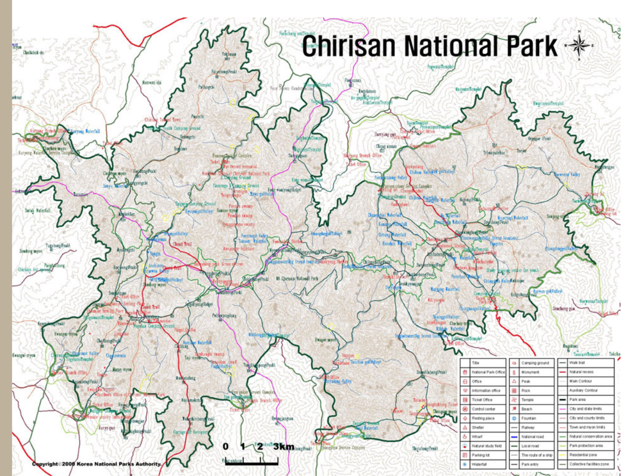

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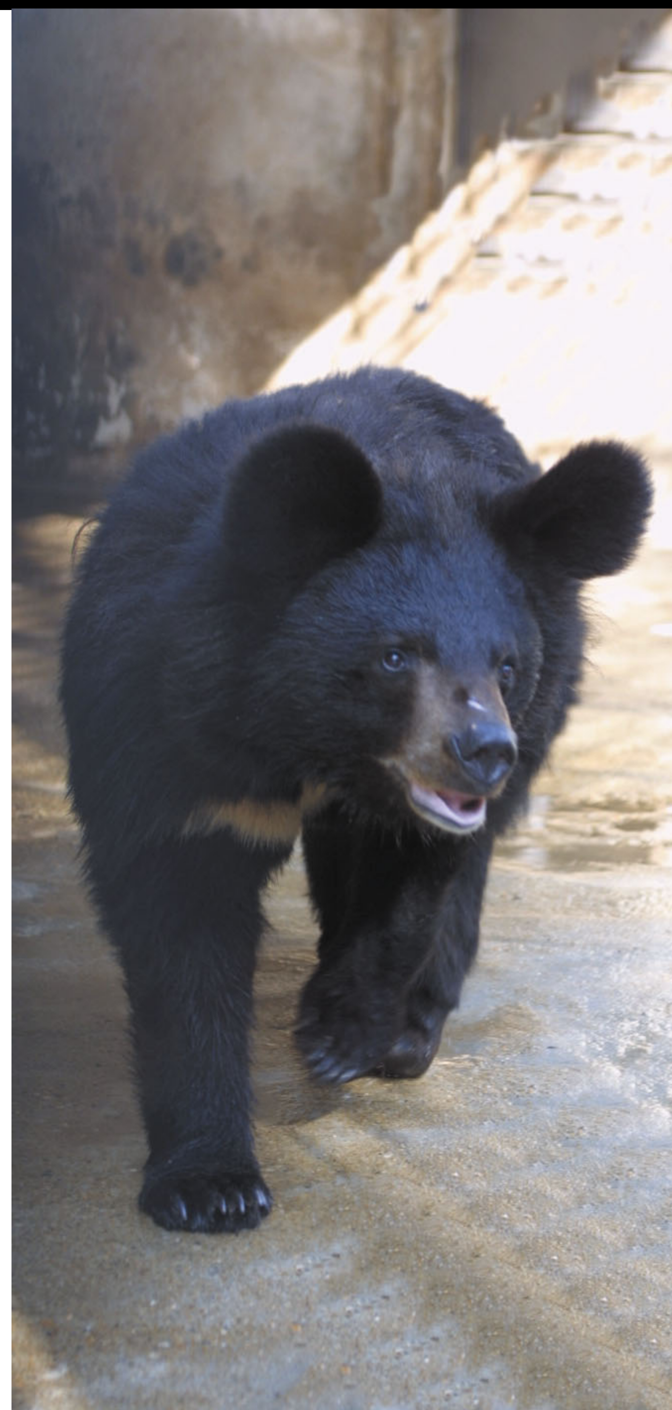
College of Veterinary
Medicine

국립공원관리공단
National Parks Authority

IUCN/SSC Bear
Specialist Group

school of agricultural biotechnology
Seoul National University

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, Korea
Jambangee Co., Ltd.

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

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

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In collaboration with the Conservation Breeding Specialist Group (SSC/IUCN) and the Bear Specialist Group (SSC/IUCN)

Lee, H., D. Garshelis, U. S. Seal, and J. Shillcox (editors). CBSG. 2001. *Asiatic Black Bears PHVA: Final Report.* The Conservation Breeding Specialist Group, Apple Valley, MN, USA.

Additional copies of *Asiatic Black Bears PHVA: Final Report* are available for US$35.00 each from the Conservation Breeding Specialist Group (IUCN/SSC), 12101 Johnny Cake Ridge Road, Apple Valley, MN 55124-8151, USA.

Asiatic Black Bears PHVA

Table of Contents

Asiatic Black Bears PHVA

Final Report

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

Section 1:

Executive Summary & Recommendations

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, 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 with 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 of the Minnesota DNR, Mei-Hsiu Hwang – a black bear researcher in Taiwan, Dr. Paul Paquet of the University of Calgary, Dr. William Rapley of the Toronto Zoo, Paul Harpley of the Toronto Zoo, and Dr. Ulysses S. Seal, Chairman of CBSG/SSC/IUCN. 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 opened with each person introducing themselves and answering two questions concerning their goals for the workshop and their thoughts on the most critical problems facing the survival and conservation of the Korean black bear. These responses served as themes to guide formation of the working groups. The five 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 paired ranking within each of the working groups. Forty five to ninety minutes were allotted for the initial tasks. Plenary sessions were held each day with working groups reporting their progress and receiving questions and comments from other groups. Working groups produced daily draft reports. 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. This final report is in Korean and English, with 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 (in bold)from each of the five working groups. This ranking was done in a plenary session and represents the combined evaluation of 28 of the workshop participants. These actions are presented in more detail in the working group report sections of this 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 rights 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 taking responsibility of guarding the park routinely and mediating the reward system for reporting poaching activity from informants

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

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 using 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 to determine the top five (5). Action plan tasks, including short and long-term tasks culminated into three (3) key action plan components considered important and achievable. The central ideas of the plan concentrate on collaboration of different research, government and education people, establishment of an 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 (discussed before) was performed by eliminating overlapping parts. We established ranks for each problem using paired ranking.

Classified Problems
1. In conservation work, the most basic thing is local peoples' participation.
2. Government's recognition is lacking about local people.
3. Private property of local people is not secured.
4. Livelihood of local people conflicts with bear conservation.
5. Government's behavior to local people is brought up.
6. Local people's role is ignored in a view, conservation of bears.

Next, we created goals, both short-term and long-term, to address each problem.

Short-term Goals
1. Secure the professional government official and supervisor.
2. Activate the local peoples' participation.
3. Find a mutual cooperation with local people.
4. Publicize local peoples' part and condition in 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.

Finally, we discussed action plans for achieving each goal. Final results are:

Rank 1: Make a recommendation to the Government on disposition of a specialist knowledgeable about local conditions 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 are 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.

Asiatic Black Bears PHVA

Final Report

for workshop held
April 18-21, 2001
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Section 2:

Status of Asiatic Black Bear in Korea

Asiatic Black Bear: Pre PHVA Field Trip to Chirisan National Park

From April 15-17, 2001. Dr. David Garshelis, Mei-Hsiu Hwang, Paul Harpley and Dr. Bill Rapley traveled with Hang Lee and his assistants to Mt. Chiri National Park in the Chirisan area of South Korea. The field group included various Non-Government agency members including Woo Doo-Soung and various Government members including National Park staffs and Dr.Won Myong Kim, bear researcher with the Wildlife Division of the National Institute Of Environmental Research.

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April 15, the group met with Hyun-Woo Lee, Park superintendent and staff at Park Headquarters for a presentation on the park and a discussion of Asiatic black bear reports and activities in the Park area. The group visited the Nogodan peak area and discussed the status of the bear that evening.

April 16, we broke into three groups to cover different areas of the park that had documented bear activity in recent years. The field studies included full day hiking treks to bear habitat with extensive searches for evidence of bears. The team visited previous sites where dens, bear damaged trees, occasional scats, and footprints in the snow were previously reported. No new evidence of bears was identified. The Park staff and others estimate that there are about 8-10 bears in the Chirisian Park area. Information was collected about the habitats and the suitability for bears. Dr Kim suggests that the maximum carrying capacity may only be about 20 for the Chirisan area..

April 17, the team visited the office of Woo Doo-Soung, head of a Chirisan area protection agency. Photographic documentation and snares collected in the Park area were examined and evaluated.

Discussion about bear farms in South Korea with the team members revealed that there may be between 1000-2000 bears of various species and backgrounds on the farms. Bile milking is illegal but may occur. Apparently, the farms are used mainly to grow cubs and eventually harvest parts. The farms are not allowed to kill registered bears until 20 years of age but new cubs are not registered.

More extensive investigations will be required to better assess the population status of the Asiatic black bears in the Chirisian Park area. Further scat analysis for DNA and diet composition is needed. Detailed habitat studies would be desirable.

Asiatic Black Bears PHVA

Final Report

for workshop held
April 18-21, 2001
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Section 3:

Human Impacts

Human Impact

Participants:

Han, Chang-Hun	Seoul Grand Park
Ma, Young-Un	Korean Federation for Environmental Movement
Mei-Hsiu Hwang	University of Minnesota
Seo, Chang-Su	Jinju MBC
Hwang, Bo-Yeon	Bukhansan National Park
Lee, Ji-Hyung	Chirisan National Park
Ki, Won-Ju	Naejangsan National Park
Ryu, Byung-Ho	National Institute of Environmental Research
Seo, Young-Son	Seoul National University

Executive Summary

Action Plan

Problems and Goals

1) Poaching

- Short-term goal: Integrate local people to participate in 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 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 by 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 through 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 rights 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.

High Priority Actions

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

- 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

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

Daily Reports

1.) Procedure:

1. 18th April

   Group members raised issues about bear conservation and management and then identified and classified nine problems threatening the subsistence of bears in South Korea. The priorities of these problems, decided by paired ranking, are listed below.

   1) Poaching.
   2) Development of roads and all kinds of buildings.
   3) Collection of forest products like maple sapping, oak, herb, and harvest of wildlife.
   4) Lack of recognition about the multi-values of the environment and wild animals such as black bears.
   5) The inappropriate manner of visitors in the mountainous areas and national parks which may disturb the survival of bears.
   6) Forest fires due to human activity.
   7) Genetic confusion and disease infection of the wild bear population, possibly caused by escaping captive bears into the field.
   8) Habitat disturbance by the construction of Army bases and various military activities.
   9) Legal hunting which continuously exploits the abundance of wildlife resources that are potential food sources for bears.

2. 19th April

   We developed short and long-term goals for the top five problems.

   1) Poaching

   - Short-term goal: Integrate the local people to participate in 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 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.
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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 the rights of wild animals.

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.

We made action plans and decided on three priority actions using paired ranking:

1. Develop environmental and bear conservation education programs locally, regionally, and nationally.
2. Develop a bear patrol program composed of local people taking responsibility for guarding the park routinely and mediating the reward system for reporting poaching activity from informants
3. Control the use of roads and also prohibit the construction of new roads within the critical habitat of bears.

Asiatic Black Bears PHVA

Final Report

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Section 4:

Habitat Status and Bear Ecology

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 using paired ranking.

Suggested solutions to the important five (5) problem statements were generated by Team members for short and long-term goals. Finally, goals were prioritized to determine the top five (5). Action plan tasks, including short and long-term tasks, culminated in three (3) key action plan components 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.

Action Plan

Summary (April 20, 2001)

Task 1
To protect the degraded bear habitat destroyed by human impact.

Short term:
1. Control the entrance of people to bear habitat through media and education.
2. Develop a method to harmonious co-existence between native residents and bear habitat.
3. Increasing the number of park rangers to assist in protection of the bears.

Long term:
1. Gathering the scientific information about the habitat damage made by tourists.
2. More corridors construction for bear conservation.

Task 2
Gathering the ecological information data base and the provision of scientific researchers.

Short term:
Scientific information exchange about Asiatic black bears.

Long term:
1. Program development for bear specialist training by NGO's and others.
2. Establishment of monitoring staff and programs for habitat and bear activity observations.

Task 3
Enhance of government support for conservation.

Short term:
1. Suggestion to Korean government on intensive training of government officers on habitat conservation and long term duty on their position.

Long term:
1. Recommend the Korean government to recruitment more ecology oriented specialist.

Task 4
Establish a professional institute for bear conservation.

Short term:
Establish a system for collaboration between relevant organizations and research centers for study and education.

Long term:
1. Establish black bear conservation center.

Task 5
Encourage public activity for ecosystem restoration and habitat conservation.

Short term:
1. Inform local people to recognize the importance of habitat conservation and activate the prize award system for conservation to organizations and individuals.

Long term:
1. Development and operation of educational programs for bear ecology and protection.

Daily Reports

Summary (April 18,2001)

Habitat status and bear ecology-problem identification divergent thinking:

-working in the field-5 years-12 participants.
-mid-February bear comes out of dens to feed on leaves.
-differences in temperature north to south-3 degrees centigrade.
-bears are looking for food in 1,000 meters area until May.
-Nogodan to Chonwangbong Mt.-movement for free food.
-summer bears eat berries cherry berries around 1,000 meters down.

-wet season perennial food-ants, many other insects.
-autumn- eating bear tree-pick leaves and nuts-Mongolian Oak tree.
-November-first snow-bear goes to den area-range area is narrow now. Bears know where foods are available. Under the Mongolian oak there are many maple trees.
-December-bears go to den.
-breeding season-end of May to July.
-have 2 cubs-2 years.
-home range is 150 square m.=1/3 of Chirisian area. Bears use every habitat area and go to same places for food especially Oak tree area.
-oak tree area in 5th Dr. Kim studied areas. Very sensitive to humans.
-total 8 bears in chiri-3-east, northern part-2, south part-3.
-knowledge of all of S. Korea for bear status.
-knowledge of all of S. Korea for habitat status.
-national park worker-human impact problem on habitat-3 million people per year visit Chiri National Park. Hard to control people in the park in habitat areas.
-Seoul Zoo-trails are in areas of bear home range-huge area.
-tourist season-many people visit Mtn. 200 people together, search leaves on the ground for Mtn. food. This disturbs the bears. People wander outside trails.
-habitat is good-plenty of food - but people invading area. Tracks are confusing…not all bears.
-how many hunters are there?-problem because they make tracks in the habitat.
-5 groups of special bear hunters in Korea-poaching-no control.
-wildlife study group-road pattern west to east in Chiri-fragmentation of bear habitat. Need to look at naturalization of areas to reduce this patchiness. Hard to change roads-ancient landowners etc.
-1988-pave roads-fragmentation-constructed corridors for wildlife as of 3 years ago-does not work well.
-corridors are artificial -not natural-cement under roads.
-Korean corridors are very political - not science based.
-Korean national parks: fees low-use high-destroyed natural condition of habitat-group tour.
-several area trails in park have a restoration year-naturalize more(3 years was usually good.).rest of time -5 years.
-2001-February-closed trails in bear areas. Long term monitoring-hot political issue.
-15 rangers in Chiri searching areas to close trails - is this enough effort?
-nocturnal bear nose sensing for food is 10 times better than humans. Bear knows when more people are there and reluctant to come down to feeding areas.
-many people talk that research is lacking on bears in Korea.
-fund raising is needed for conservation programs.

Summary: Problems

1. There is a lack of information on wild black bears and their habitat in South Korea.
2. People invitation of habitat in South Korea is a major problem for black bear conservation.
3. There is an important need for action on the poaching problem in South Korea.
4. Increasing paved roads in black bear habitat and habitat fragmentation are problems.
5. There is an increasing lack of natural corridors for bears to use.
6. Lack of specific black bear and habitat research projects in various places in the country.
7. Political support and funding for research and education is low.
8. National park use fees are low and do not support enough wildlife and habitat management.
9. Seasonal management of trail use is a problem for bear management.
10. Institute of conservation of bears is not existing now.

Group presentation by professor Suh-Yung Yang, Inha University, Biology department.

Task 1C) Ranking by paired ranking.

Grouping	**Ranking**	
A. Bear and habitat research:1,6,7,10	1	3
B. Public understanding: 11		
C. Human impact:2,3	4	1
D. Direct human habitat changes:4.5	3	2
E. National park management policy affecting bear conservation;8,9	0	4
	8	

A.1. Human impact
B.2. lack of resources and lack of information on ecosystem
C.3. political / management
D.4. lack of bear research institution
E.5. lack of public understanding of recovery of ecosystem

Dr. Kim reported to workshop.

Task 2A) One person in each group wrote down ideas of how to solve each problem listed. They were then listed on a large board to let everybody see.

	Points	Goals
A.1.	34	short-term: gather the destructive ecological information -increase the man power for conservation of habitat -co-operate with local people for habitat conservation long-term: corridors
B.2.	27	short-term: share information with each other. -hire employee, wildlife specialist. -recognize bear nutrition, plant structure, ecosystems etc. -plan for amateur bear specialist, establish education program long-term: establishment of research task step by step for bear conservation
C.3.	16	short-term: political specialist-administrative staff keep positions 5 years long-term: get more above personnel.
D.4.	13	short-term: national park authorities-Asian black bears conservation center in park long-term: Man power to run center and financial support-to do education research and management.
E.5.	12	short-term: public relations through the media . price award to the contributors. long term: enhancement of ecosystem education in text books including field exercises continuous P.R. though the media

Task 2B) Prioritize all goals.

Put them together and divide them into the five categories. Dr. Kim - bear researcher. Integrating all goals together into long and short-term. actions will follow.

Short-term:
1. A. control entry to the bear habitat.
2. B. exchange the information of bears and increase the research man power
3. C. Develop a specific education program for bear specialist
4. D. continuous P.R. to the media

Long-term:
1. E. improve the habitat of bears
2. F. expansion of the habitat of bears
3. G. try to establish the bear conservation center.
4. H. continuous P.R. and education

Prioritize the goals: short and long term. This was done by the whole group, each individually paired ranking them.

Short term: 1.C; 2.A; 3.D; 4.B

Long term: 1F; 4H; 2E; 3G

Task 3B) Develop action steps under each problem.

Action Plan

Short-term:
1. protect habitat and limit public into bear areas
2. securing the people who manage natural areas-training long term continuance in this

Long-term:
1. government to secure qualified manager for ecological field.
2.professional and amateur bear researchers

Task 1: Protect the degraded bear habitat destroyed by human impact.

Short-term:
1. control the entrance of people to bear habitat.
2. increasing the number of local park rangers to assist in protection of the bears
3. co-operate with local people for habitat conservation

Long-term:
1. gathering the scientific information about the degree of destruction by tourists and to bear habitat
2. action to control the removal of plants from the national park.
3. plan to establish corridors to reverse habitat fragmentation and enlarge effective bear habitat

Task 2: Improve the ecological information base and the provision of scientific researchers

Short-term:
1. increase the exchange of information about Asiatic black bears and research data

Long-term:
1. develop ecological education programs for amateur and NGO persons who are going to bear specialist
2. establishment of monitoring staff and programs for habitat and bear activity observations

Task 3: Strengthen ministry of the environment awareness and action of the bear conservation problem.

Short-term:
1. suggest that specialized bear issue staff not be moved around but remain in their positions for long term assignments for program continuity.

Long-term:
1. recommend the Korean government to increase the specialist for ecological research and ?? relating to bear issues.

Task 4: Secure professional organization for bear conservation

Short-term:
1. system of collaboration between relevant organizations and research center for study and education

Long-term:
1. establish black bear conservation center.

Task 5: Reverse deficiency of knowledge of habitat conservation and ecological system restoration

Short-term:
1. main media-system to manage how right information gets out.
2. program of giving prize to best conservation organization or individual

Long-term:
1. for protecting and experiencing bear-protect and manage-intensify education-children.

Rank for action plan-group2.

1. Collaboration between relevant organization and research center for study and education of bears issue.

2. Special need for monitoring and habitat ecological study for bears in institute in national park.

3. Professional people to be kept in their specialty area.

Asiatic Black Bears PHVA

Final Report

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

Section 5:

Local People and Education

Local People and Education

Executive Summary

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

Classified Problems
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.

Daily Progress Reports

18,April, 2001 Day 1

Member: Kwon, Min-Jung (Wildlife group)
Lee, Byung-chae (The federation of raising movement for Chiri Mt.)
Jung, Youn-Kyun (The association of sap collectors in Hadong)
Cho, Hyun-Kyo (The association of sap collectors in Kurye)
Kwon, Su-Duk (Korea Forest Research Institute)
Kang, Byung-Tak (The Seoul National University)
Hong, Won-Woo (The Seoul National University)
Paul C. Paquet (University of Calgary)
Mun, Ho-Sung (Chiri Mt. Bakmudong – local resident)
Park, So-Young (National Parks Authority)

First, we discussed about local people participation and education in conservation of Asiatic black bears.

PROBLEMS

1. In conservation work, the most important thing is local people's participation.

2. Government's position is that there is a relation between painted maple sap gathering and conservation of Asiatic black bear.

3. Local people think that Korea National Parks Authority has low understanding of the local peoples' activities for everyday life, such as painted maple sap gathering. They feel the government has little regard for local people and imposes its will on them. Local people who live around the mountain earn their living by selling painted maple sap and wild greens, which are gathered in the Chiri Mt. where is habitats of Asiatic black bear. The local people think that there is small area where painted maple can grow and it could not be harm to the Asiatic black bear in the Chiri Mt. Government's one-sided policy to the painted maple sap gathering of local people make mistrust to the government.

4. The wrong recognition of Asiatic black bear's habitat destruction by local people makes it hard for voluntary participation in black bear conservation efforts.

5. The government should take steps to deal with the realistic situation of private land using and the right to live.

6. The fact that local people poach wildlife and the Asiatic black bear is not a correct thought.

7. Korea National Parks Authority wants to solve the environment problem by controlling the local people, not the visitor and facilities construction restriction.

8. The local people want to conserve the Asiatic black bear on condition of local people' living.

19, April, 2001 Day 2

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

Classified Problems

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.

The ***rank*** of problems are:

1st set		2nd set		3rd set		4th set		5th set		Total
1	18									18
2	3	2	13							16
3	3	3	5	3	9					17
4	7	4	5	4	6	4	7			25
5	8	5	9	5	8	5	8	5	8	**41**
6	0	6	0	6	2	6	1	6	0	3

Total number: 120

20, April, 2001 Day 3

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.

Action plan **on short term goals.**

Goal 1: Secure the professional government official and supervisor

- Make a recommendation to the Government on disposition of specialist who knows well local condition and conservation work of the Asiatic black bear.

Goal 2/3/4: Activate the local people's participation/ Try to find a mutual cooperation with local people/ Publicize the local people's part and condition in the Asiatic black bear conservation work.

- In alliance with the other private organization (including local people), carry wildlife conservation work and inform to the public.
- Collect the education program for conservation work (Need a aid from Environmental organization, Research organization, Government).
- Activate public opinion and support for the organization management.
- In alliance with local unit and Seoul Grand Park, publicize role of local people to customer who visit Seoul Grand Park.

Action plan **on long term goals**.

Goal 1/ 2: Prepare the systemic measures to the local people/ Establish mid-long term manage system.

- Demand on permission of temporary forest products gathering, which is limited to local people.
- Implement a responsible charge system for wildlife conservation under forest products gathering zone.
- Go ahead with campaign for nationalization about a whole national park (carry the whole nation signature-collecting campaign).
- Weigh economical loss by wildlife and demand on a methodic compensation.

Goal 3: Perform the continuous monitoring system to the local people's zone of life and bear's habitats.

- Propose relation research to organizations (research organization, environment organization, government).
- Educate and publicize research results to local people and the public.

Then we made a ***rank*** to each action plan by using paired ranking. Results are:

1. Make a recommendation to the Government on disposition of specialist who knows well local condition and conservation work of the Asiatic black bear (37 points)………….**rank 1**

2. In alliance with the other private organization (including local people), carry wildlife conservation work and inform to the public (23 points).

3. Collect the education program for conservation work. (Need a aid from Environmental organization, Research organization, Government) (17 points).

4. Activate assistance and public opinion to manage the organization (20 points).

5. In alliance with local unit and Seoul Grand Park, publicize role of local people to customer who visit at Seoul Grand Park (9 points).

6. Demand on permission of temporary forest products gathering, which is limited to local people (25 points).

7. Implement a responsible charge system for wildlife conservation under forest products gathering zone (32 points)...............**rank 3**

8. Go ahead with campaign for nationalization about a whole national park (carry the whole nation signature-collecting campaign) (37 points).........**rank 2**

9. Weigh economic loss by wildlife and demand on a methodic compensation (27 points).

10. Propose relation research to organization (research organization, environment organization, government, etc)(26 points).

11, Education and publicize research result to local people (22 points).

	1	2	3	4	5	6	7	8	9	10	11
Total	37	23	17	20	9	25	32	37	27	26	22

total number: 275

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.

Asiatic Black Bears PHVA

Final Report

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

Section 6:

Wild and Captive Populations

Wild And Captive Population Status

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 with more bears.
4. There is a lack of information to enhance production of cubs in captivity for reintroduction into the wild.

We propose 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 to 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, radio collared 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.

Action Plan

Problem statements listed in priority order. Only top 4 considered for actions.

1. There is a lack of information on the status of wild Korean black bears.

It is known that some bears exist in Chirisan National Park, at the south end of the peninsula, and probably also a few bears in some other more northern sites, like Soraksan National Park (near DMZ), Odaesan National Park (slightly south of Soraksan), Taebak Provincial Park (further south), and Sokrisan National Park (possible bear escaped from captivity). We chose to deal only with Chirisan bears, where the largest population is believed to exist, and where the most research effort has been conducted. This research, though, has involved several separate organizations (National Institute of Environmental Research; National Parks Authority; NGOs; MBC television). Much local knowledge also exists, but all of this information has not been synthesized and maintained in a way that it can be accessed and examined.

***Short-term Goal*:** **Establish a database of all presently available information about wild Korean bears.**

<u>Actions:</u>

- Identify all sources of information.
- Get specialists and other knowledgeable people together.
- Create a Bear Conservation Committee.
- Put person in charge of maintaining a database.
- Find an office where all information will be stored (Bear Conservation Center).
- Create database (computer file) including information such as: source of information, date, location, type of information (e.g., sighting, tracks, scat, den), accuracy of information (degree of uncertainty), additional notes.
- Create maps associated with computer database.

Long-term Goal: **Monitor changes in population size.**

<u>Actions:</u>

- Establish a field station for research efforts.
- Use radiotelemetry on all *reintroduced* bears to monitor mortality, reproduction, dispersal, etc.
- Collect and store scats for DNA analysis, to identify individual bears and their sex (and also examine for hormones to detect reproductive females).
- Continue recording tracks and other sign.

2. It is difficult to obtain pure-bred Korean bears for release into the wild.

Most of the bears on bear farms are of unknown origin, or at least the origin, if known, may not be readily disclosed. Most are suspected to be from Japan or China. Only 5 bears of Korean origin (1 South Korea, 4 North Korea) exist in Seoul Grand Park (zoo). Although these bears may eventually produce cubs, other potential sources of Korean bear cubs need to be located to have enough bears for reintroduction.

Short-term Goal: **Identify characteristics (genetic, morphological) of Korean bears and use these to find other Korean bears on bear farms.**

Actions:
- Find all known Korean bears by interviewing bear farmers.
- Obtain genetic samples and morphological measurements of all known Korean bears, as well as Asiatic black bears of other known areas to develop criteria for differentiating the two.
- Use genetic and morphological characteristics to locate other Korean bears on bear farms.

Medium-term Goal: **Breed Korean bears to obtain cubs for eventual release into the wild (Chirisan).**

Actions:
- Match pairs of Korean bears for matings.
- Enhance reproductive output.
- Train cubs for early release into the wild (e.g., 1 year old).

Long-term Goal: **Obtain wild bears from North Korea for translocation to South Korea (Chirisan).**

Actions:
- Make contacts in North Korea to obtain information on availability of bears.
- Obtain financial support for obtaining bears.
- Develop a sister relationship with Pyongyang Zoo.
- Create co-organization for bear conservation between North and South Korea.

3. Wild populations of bears in Korea are non-viable.

The population of bears in Chirisan is estimated to be not more than 10, and the other S. Korean populations combined may be less than that. Although the actual numbers of bears in the wild are unknown, we are reasonably certain that none of the populations are viable in the long term, even with added protection from human-related sources of mortality. The primary focus here is on solving this situation in Chirisan, at least initially.

Short-term Goal: **Supplement population in Chirisan with additional bears.**

Actions:
- Search literature and contact other biologists experienced in reintroductions to obtain information on appropriate methods.
- Obtain cubs from captive Korean bears.
- Create semi-wild enclosure for preparing bears for introduction to the wild (natural foods, etc.).
- Construct release facility in Chirisan.
- Radio collar all animals that will be released.
- Reintroduce bears and closely monitor them using radiotelemetry.

- If possible, translocate wild bears from North Korea for reintroduction. This should take priority over release of captive bears, if it is feasible. However, captive-born bears should be used initially if this option is not immediately available.

Long-term Goal: **Manage population in Chirisan as necessary, until it is self-sustaining.**

Actions:
- Continue to supplement the population with additional bears as necessary (i.e., depending on the status of radio marked released bears: whether they survived, dispersed, produced cubs, etc.).
- Provide artificial feeding sites if necessary (to keep bears within certain areas, to boost reproduction, etc.).

4. There is a lack of adequate information in Korea on reproductive biology of Asiatic black bears.

Since much of the focus will likely be on the production of cubs for eventual release, an effort must be made to ensure that the Korean bears in captivity produce sufficient numbers of cubs. As the number of Korean mated pairs will likely be quite low, enhanced productivity will be necessary.

Short-term Goal: **Synthesize information on reproduction in Asiatic black bears.**

Actions:
- Collect available information from the literature.
- Contact zoos and studbook keepers for additional information on Asiatic black bears.
- Maintain records of weights and blood chemistry of captive Korean bears.
- Use ISIS to obtain information.

Medium-term Goal: **Set up studbook for captive populations of Asiatic black bears in Korea.**

Actions:
- Organize meeting of bear farms and zoos.
- Identify studbook keeper.
- Create registry of all animals (identifications with photos, transponder chips, etc.)

Long-term Goal: **Increase productivity of captive Korean bears.**

Actions:
- Improve captive conditions for breeding.
- Identify a reproductive biologist to oversee captive breeding.
- Evaluate hormones, semen, cub-rearing behaviors, etc.
- Store semen samples (sperm bank).
- Use artificial insemination, if needed.

- Use premature cub removal (hand-rearing) to promote annual reproduction, if needed.

Daily Progress Reports   (2001.04.18-20)

18 April 2001

Group IV Population Status : Wild and Captive   10 participants. 3 members of The Bear Farmers Association., David, Bill, 2 Zoo, 1 vet school, 1 National Park.

List of Problems:
There is a lack of Asiatic black bear Identification and Genetics: Unknown domestic bear alleles need to be studied. There is need for genetic analysis of wild bears from various sites including North Korea.

We do not know how many bears in the wild (in situ).

There are no studies on reintroduction from captive bears from the zoo or bear farm to the wild.

No studies have been done for Asiatic black bears in South Korea including Cheju Island. There is no apparent historical distribution summaries or detailed range maps.

There is no knowledge of bears in North Korea. Number and status and genetic makeup is unknown. Potential translocation to South Korea has important potential for this species.

There is an absence of captive records and a registration system for all bears in captivity.

There is a need for detailed information on individuals. There is a need to organize a studbook of all bears in captivity.

There is a need for an identification system and detailed records e.g. transponder, photo, genetic for all bears in Korea.

There is a lack of source information for bears. Determine native versus non-native bears by DNA analysis of captive and wild population.

There are no reproduction studies of wild populations. How much is happening. Cub production.

There is a lack of reproductive studies in Asiatic black bears. Basic reproduction needs to be researched. Hormonal studies and genome banking such as semen freezing would be desirable.

19 April 2001

Summary of Problems: Asiatic black bears in Korea

Are the populations in South Korea viable?
Do inbreeding or genetic defects exist in wild or captive populations.

There is no accurate animal identification system or studbook.

Do we need to import animals to the wild population? How would this be accomplished? Captive bred or translocation releases?

There is a lack of information on bears in North Korea. Can they be translocated or introduced to South Korea?

There is a lack of information on diseases. There needs to be a study and evaluation of possible health effects of disease on the wild populations. Historical cases may exist in pathology system.

There is a lack of information on reproduction in wild. Lack of information on reproductive biology.

Gall bladder production. Does this create a market for wild poaching? How does this effect wild populations?

Cannot tell farm bear products from wild bear sources. This is difficult to control and allows for poaching.

There is a lack of organized historical distribution data on Asiatic black bears in Korea. There is a need for examination of previous ranges to see if potential exists for reintroduction or translocation sites.

Bears are found on three mountains at this time. There are possibly about 20 bears in the wild. Other mountains should now be considered for potential bear populations that exist. In addition other locations may be required for future reintroduction programs in long term planning. For example the national park north of the Mt Chiri site location visited had bears until 25 years ago.

Summary Points: (Combining problems)

1. We do not know that the minimum number needed for a viable population and the way to make the population viable by supplementation.
2. Difficult to collect a purebred Asiatic black bear in Korea.

3. There is a lack of information on genetics of wild bears.

4. There is a lack of information on the Korean Black Bear in North Korea and possibility of translocation from North Korea to South Korea.

5. There is a lack of information on disease of Korean bears.

6. There is a need for information on physiology including reproduction of Korean Bears.

7. The effects of gall bladder production on bear populations is not known..

8. Need methods to distinguish wild from captive bears.

9. There is need for summarizing information on the distribution of bears historically and the suitability of the previous habitat for reintroduction or translocation in the long term planning .

Ranking by priority: 4,2,3,1,5,8,6,9,7.

Asiatic black bear Goals: Concentrate on the Chirisan area first.

20 April 2001 Korean Bear PHVA 3

GOALS:

1. Investigation of individual information of A.A.B. Population information. Number, sex, age, genetics, etc Start with Chiri Mountain
   Short term goal to establish a data base on information available.
   Long term: Data collection centralized from other habitats.
2. Securing of purebred population. Identify what is a Korean bear. Establish list of Korean Bears in captivity. Genetic assessment.
   Long term goal: Obtain North Korea bears and possibility of translocation to South Korea.
3. Small viable or sustainable population in Korea (Mt. Chiri). Determination of the Carrying Capacity in Situ. Long term is a. to supplement the population. B. to manage the sustainable population.
4. Increase productivity of reproduction of bears in captivity and the wild.
   Investigate ABB's Physiology. Including reproduction. Literature search. Long term to research bears if required.
5. Establish a studbook for the captive population.
6. Long Term goal: To increase reproductive rate of Korean bears in wild\captivity.

ACTIONS:

A. Research

1. Research all information about ABB.
2. Breed Centre/Office e.g. Seoul Grand Park Zoo.
3. Establish Bear Conservation Centre.
4. Get specialists together to create a data base and system.

B. Population Size Monitoring in situ.
   1. National Park staff.
   2. Records of tracks and scat collection.
   3. Telemetry of reintroduced animals.
   4. DNA analysis of all scats.
   5. Establish a field research station in Chirisan.

C. Difficult to obtain purebred Korean bears
   1. Identify characteristics of Korean bears e.g. Large ears.
   2. Find all known Korean bears.
   3. Obtain genetic samples from all Korean bears and all other sources to develop genetic markers.
   4. Medium term Identify Korean bears in captivity. Apply genetic markers to suspected Korean bears.
   5. Long term. Obtain bears from North Korea.

D. Make contacts with North Korea to obtain information on availability of bears. Financial support to North Korea for bears.

E. Sister relationship between Seoul and Pyunyang Zoos.

F. Co-organization for bear conservation between N. and S. Korea.

G. Population of bears in Chirisan is non-sustainable.

H. Augment population. Research methods for reintroduction and training people.

I. Breed Korean bears to obtain cubs form reintroduction.

J. Create a semi-wild area (buffer zone) for training bears for reintroduction.

K. ALL reintroduced bears should be radio-collared.

L. Priority for reintroduction should be wild bears.

M. Long term: Manage a self-sustaining population. Continue to supplement the population. as necessary (Depending on the results of monitoring).

N. If necessary provide artificial feeding sites.

Asiatic Black Bears PHVA

Final Report

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

Section 7:

Population Biology and Modeling

Population Biology & Modeling

Executive Summary

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.

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.

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 or the present population is only 5 animals then a viable population cannot be sustained. The results of the sensitivity analyses suggested that a population in the range of 40-60 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. Furthermore, the habitat will have to be suitable for a population of 40-60 animals and the population needs to be protected from direct human induced mortality.

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 Chirisan 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.

Vortex Simulation 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.

VORTEX is a simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild populations. *VORTEX* models population dynamics as discrete sequential events (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 stepping through the series of events that describe the typical life cycles of many organisms.

VORTEX is not intended to give absolute answers, since it is projecting the interactions of the many parameters used as input to the model and because of the random processes involved in nature. Interpretation of the output depends upon our knowledge of the biology of the bear, the environmental conditions affecting a given population, and possible future changes in these conditions. In fact, it quickly became clear during this workshop that a detailed analysis of individual Asiatic black bear populations' viability would not be possible due to the lack of suitable demographic data from the field. Consequently, the model was used to demonstrate the kinds of analyses that are possible using data from American black bear field studies and the ways in which it can be used to guide future research and management efforts. For a more detailed explanation of *VORTEX* and its use in population viability analysis, refer to Miller and Lacy (1999) and Lacy (2000).

Our initial goal in this *VORTEX* modeling effort was to develop a realistic base model of the Asiatic black bear population inhabiting Chirisan National Park, now and in the recent past. By attempting this initial retrospective analysis, we will focus on the development of a model that we hope will reasonably accurately portray the observed growth (decline) dynamics of the actual population and its risk of extinction.

INPUT PARAMETERS FOR SIMULATIONS

Global Parameters

Model Conditions: The simulation scenarios were run 500 times for 100 years with a reporting interval of 10 years using Vortex 8.41. Data were stored for graphing and preparation of summary tables.

Extinction: Extinction was defined as either only bears of one sex or no surviving animals.

Populations: One population was modeled since the focus was on Chirisan National Park and the two possible other populations (5 or fewer bears in each) are not connected to Chirisan by a natural corridor. The probable fate of these other populations might be reflected in the scenarios for the sensitivity analysis which included populations of starting sizes of 5 or 8 bears.

Inbreeding Depression: *VORTEX* includes the ability to model the detrimental effects of inbreeding through reduced survival of young animals. We decided to include inbreeding depression in our models because of the estimated small population size and the low carrying capacity in a closed system which may be assumed to restrict population growth even if other limiting factors were removed. The small population size and the low carrying capacity has and will result in a rapid rate of inbreeding in this population. We elected to include inbreeding depression in most of the models using the median mammal value of 3.14 lethal equivalents with 50% of them (1.57) not eliminated by selection and thus remaining in the population. One set of scenarios (#122-133) were run with inbreeding depression removed to illustrate the possible magnitude of the inbreeding depression effects.

Environmental Concordance of Reproduction and Survival: We chose to consider these as not correlated since a female would survive the loss of cubs or the failure to reproduce in a bad year. Adult males would also be unaffected.

Catastrophes: We included two catastrophes. One at a 2% frequency for the occasional severe typhoon with a 0.5 severity effect on reproduction (loss of 50% of reproduction in the year of the event) and no effect on survival. The second catastrophe was included at 50% frequency (no effect on reproduction and 0.95 effect on mortality) to incorporate the effects of human induced mortality on the population as a proportion rather than using the harvest module with the removal of absolute numbers of animals. The effect of snares on mortality likely will be random across age and sex classes.

Breeding System: The species is polygynous and all adult males may be considered to be in the breeding pool. Males will breed with more than one female given the opportunity. With current very low population sizes of unknown age and sex structure, this is not likely to be an issue except for possible Allee effects of low densities and the difficulties of finding a mate.

Male Breeding Pool: This parameter defines the proportion of the total adult male population that is capable of breeding in a given year. This is not solely dependent on physiological capability, but may also be a measure of social standing. Highly social species may strongly limit the proportion of males that can establish territories or find females. Data from American black bears and captive Asiatic black bears indicates that all adult males are equally capable of successful mating. Hence, we identify 100% of all adult males available for breeding.

Stage Structure: Age of First Breeding: *VORTEX* precisely defines breeding as the age at which offspring are born, not simply the age of sexual maturity. In addition, the program uses the mean age rather than the earliest recorded age of offspring production. Data from both wild and captive individuals indicates that females on average will begin breeding at five years of age, and males will breed when they are five years old. Park assumed 33% of juveniles (males &

females) would become breeding adults (age = 3).We did not test this value as present data suggest that maturation at this early age is uncommon in black bears.

Maximum Breeding Age: *VORTEX* assumes that animals can breed (in its simplest form, at the normal specified rate) throughout their adult life. American black bear data indicate that 30 is a maximum age so we used this value in all of the scenarios.

Sex Ratio of Offspring at Birth: Field and captive population data on bears indicate no appreciable deviation from an equal sex ratio at birth.

Maximum Litter Size: This was set at two based on reports from field and captive studies of Asiatic black bears. Litter sizes of three and four occur, but appear to be uncommon in this species.

Density Dependence and Allee Effect: Park assumed a ceiling-Allee model. From what we could determine the Allee effect was set by Park using a local extinction threshold of 10% of carrying capacity. We did not include density dependence or the Allee effect in these models since the populations are considered to be below carrying capacity but the size of the area is small relative to the daily travel distances and dispersal ability of the bears. However the populations were truncated to K by random removals across age and sex classes whenever their size exceeded the set carrying capacity.

POPULATION PARAMETER VALUES FOR MODELING:

Proportion of Females Breeding: We used pooled data from various field studies of the American black bear since there are few data for the Asiatic black bear. This yielded an average interbirth interval of 2.2 years (range 2.0 – 2.4). Park assumed adult females would breed every other year (i.e., period between litters = 2 years), but this seemed overly optimistic, in our view. Kim felt that reproduction is lower in this population so we chose to use an interbirth interval of 3.3 years (i.e. 30% of adult females breed each year). This provides a conservative estimate reflecting current conditions of disturbance.

Total Suitable Area: 259 km^2 (13.58% of study area (1907 km^2), > 59% of Park). Park = 440 km^2. Note that 90 % of potential habitat is in National Park (i.e. 234 km^2)

Estimated Carrying Capacity: The habitat carrying capacity, K, defines an upper limit to population size. When the population exceeds this level at the end of any given year, additional mortality is imposed across all age-sex classes in order to return the population to the value set for K. Dr. Kim estimated carrying capacity of only 20 bears in the National Park. We used values of 20, 30, 40, and 50 in a sensitivity analysis.

Current Abundance: Estimated abundance: range = 3-13 (3,5, 8, 13). No survey results were provided or identified. We initialized our baseline model with a total of 5 or 8 individuals based upon personal observations and expereinces of people at the workshop plus the paucity of sign seen in a brief field trip. To initialize the model, these were distributed among age-sex classes according to the stable age distribution calculated from the reproduction and mortality schedules.

Dispersal Distance: Park estimated dispersal distances of 9 km, 16 km, and 24 km. Although dispersal potential is probably higher,movements are limited by inhospitable area around park. If necessary for GIS modelling, better estimates might be available by utilizing data from other black bear populations. These distances tend to argue against an Allee effect in this habitat.

Dispersal Rate: Unknown, also no place to disperse and no population to measure. If necessary for GIS, estimates could be obtained from other black bear populations. No basis for a metapopulation analysis.

Litter Size: Mean litter size calculated from various studies was 1.8 which corresponds to the median value provided by Park. This was entered as 20% of litters with one cub and 80% of litters with two cubs. These values were used in all of the simulations.

Illegal and Accidental Human Caused Mortalities: Accidental snaring and intentional poaching have been major causes of mortality. The present rate of human caused mortality rate is unknown. Park used 1% and 2% when population growth rate was 1.026. She varied among 1%, 5%, and 7% when population growth rate was 1.074. We modelled human-related losses using the catastrophe module of Vortex to provide losses proportional to population size. We used a frequency of 50% and a severity effect of 0.95 or an increase of 5% which would be about 2.5% per year incremental mortality across age and sex classes. Catastrophes are singular environmental events that fall outside the bounds of normal environmental variation affecting reproduction and/or survival. For some species hurricanes, floods, disease, etc. could wipe out a large part of a population in a single year. These events are modeled in Vortex by assigning a probability of occurrence and a severity factor ranging from 0.0 (maximum or absolute effect) to 1.0 (no effect).

Mortality Schedule: The mortality schedule was taken from the American black bear studies as we did on Taiwan since there are no direct field data for the Asiatic black bear. The EV (SD) was taken as 25% of the mean value entered. Note that male cub and juvenile mortality are higher than female values.

30.000000 *FMort age 0	8.000000 ***EV
5.000000 *FMort age 1	1.250000 ***EV
5.000000 *FMort age 2	1.250000 ***EV
5.000000 *FMort age 3	1.250000 ***EV
5.000000 *FMort age 4	1.250000 ***EV
5.000000 *Adult Fmort	1.250000 ***EV
40.000000 *MMort age 0	10.000000 ***EV
10.000000 *MMort age 1	2.500000 ***EV
10.000000 *MMort age 2	2.500000 ***EV
10.000000 *MMort age 3	2.500000 ***EV
10.000000 *MMort age 4	2.500000 ***EV
5.000000 *Adult Mmort	1.250000 ***EV

Carrying Capacity: K was set at one of four fixed values: 20, 30, 40, or 50 – with no environmental variance included and no changes over time.

Table 1. Estimates of parameters used in the model (From Park 2000, Dr. Kim, and North American black bear studies).

PARAMETER	LOWER	ESTIMATED MEAN	UPPER
Carrying Capacity	20		
Initial Abundance		5 or 8	
Age of First Reproduction for Females	4.0	4.5	5.0
Age of First Reproduction for Males	4.0	4.5	5.0
Maximum Breeding age		30	
Proportion of Breeding Females	0.2	0.3	0.4
Breeding Interval Females		3.3	
Litter Size	1.5	1.8	2.0
Poaching Level		10%/2 years	
Survival Cubs (females)	.5	.7	.9
Survival Cubs (males)	.3	.6	.9

In part from Park, S. 2001. Habitat-based population viability analysis for the Asiatic black bear in Mt. Chiri National Park Korea. CBM Skriftserie, Uppsala 2000.

RESULTS FROM SIMULATION MODELING

Baseline model results: Using the input parameters discussed above, we were able to develop a model that we feel provides a useful tool for sensitivity analyses to explore the effects of small population size and limited carrying capacity on the probability of persistence of the Asiatic black bear population in Chirisan national park. It allows evaluation of the potential benefits of supplementation of this population with either captive bred or translocated bears and of the benefits of reducing human-induced mortality.

Carrying Capacity Effects: Specifically, the population stochastic growth rate r was -0.016 and the probability of extinction = 0.980 with a carrying capacity of 20 under the base conditions (File #4) considered to most closely represent the conditions in Chirisan National Park. Mean size of these populations shrank slowly and more than half of the populations went extinct in 20 years regardless of carrying capacity. With current conditions, a starting population of 5 is not viable no matter what the carrying capacity is (Figures 1 & 2).

File #	K	N	%Bred	det.r	stoc.r	SD(r)	PE	N-allt	SD(N)	Het	SD(H)	MeanTE
4	**20**	**5**	**30**	**0.010**	**-0.016**	**0.204**	**0.980**	**0.15**	**1.33**	**0.3859**	**0.2390**	**22.9**
5	40	5	30	0.010	-0.014	0.195	0.970	0.30	2.30	0.5019	0.1638	23.4
6	60	5	30	0.010	-0.0149	0.196	0.970	0.32	2.69	0.4560	0.1938	24.0

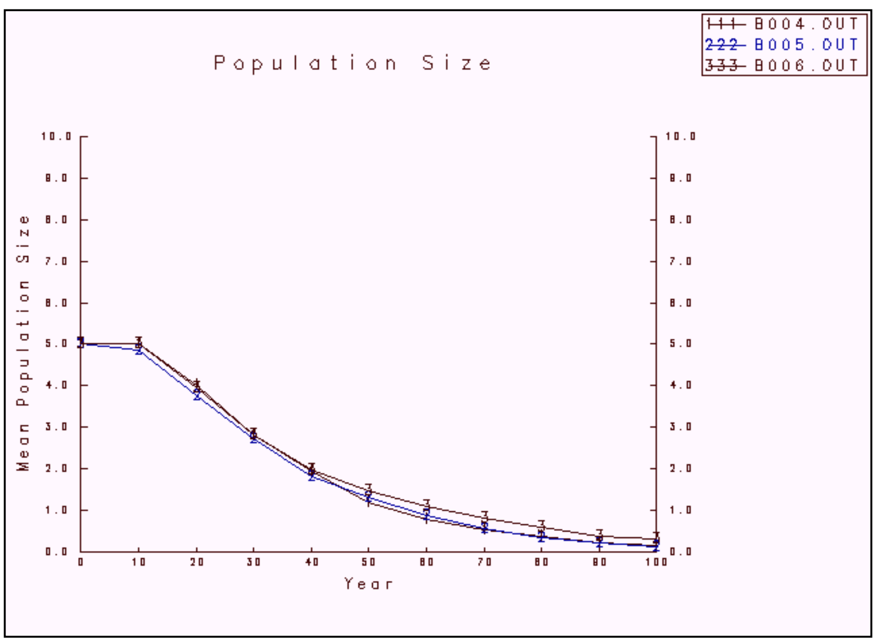

Figure 1. Effect of carrying capacity on the mean population sizes over 100 years at carrying capacities of 20 (B004, curve #1), 40 (B005, curve #2), and 60 (B006, curve #3) bears with a starting population of 5 bears. These scenarios include increased mortality of 5% per year due to human impacts and 30% of females breeding each year. Inbreeding depression is included.

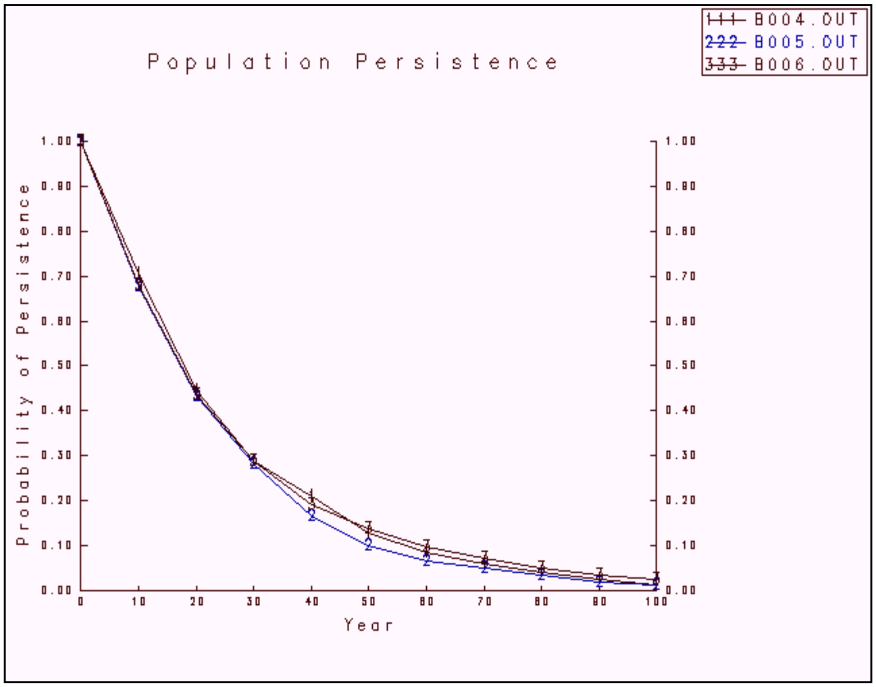

Figure 2. Effect of carrying capacity on population persistence (probability of survival) over 100 years at carrying capacities of 20 (B004, curve #1), 40 (B005, curve #2), and 60 (B006, curve #3) bears with a starting population of 5 bears. These scenarios include increased mortality of 5% a year due to human impacts and 30% of females breeding each year. Inbreeding depression is included.

Supplementation effects and human-induced mortality: A one time addition of 10 four-year-old bears to the starting population at 5th year is not sufficient to significantly reduce the risk of extinction with human-induced mortality rate of 5% a year (N = 5 + 10 = 15). However, if the supplementation is coupled with reduction of human impact levels, the resultant decrease of extinction probability is dramatic. For example, a one time supplementation of 10 bears coupled with a reduction of human-caused mortality from 5% a year to none (i.e., no poaching at all) results in the dramatic increase of the population survival probability from 3% to 99.6% with the carrying capacity of 40 bears. However, the loss of heterozygosity is still larger than desirable (Figures 3 & 4).

File #	K	N	%Br ed	%Hu man Impa ct	det.r	stoc.r	SD(r)	PE	N-all	SD(N)	Het	SD(H)	Mean TE
16	20	15	30	5	0.010	0.000	0.222	0.894	1.06	3.14	0.4934	0.1688	50.4
17	40	15	30	5	0.010	0.000	0.208	0.696	4.74	8.96	0.6018	0.1826	47.0
18	60	15	30	5	0.010	0.000	0.206	0.718	5.32	10.45	0.5999	0.1974	47.4
19	20	15	30	2.5	0.036	0.020	0.174	0.322	8.76	7.11	0.5657	0.1614	51.7
20	40	15	30	2.5	0.036	0.026	0.154	0.118	27.80	13.01	0.7251	0.1093	38.4
21	60	15	30	2.5	0.036	0.027	0.152	0.108	42.44	20.59	0.7574	0.1084	34.3
22	20	15	30	0	0.061	0.046	0.150	0.032	16.67	4.67	0.6336	0.1348	36.4
23	40	15	30	0	0.061	0.055	0.131	0.004	38.19	4.02	0.7765	0.0636	8.0
24	60	15	30	0	0.061	0.057	0.128	0.004	58.29	5.30	0.8197	0.0540	9.3

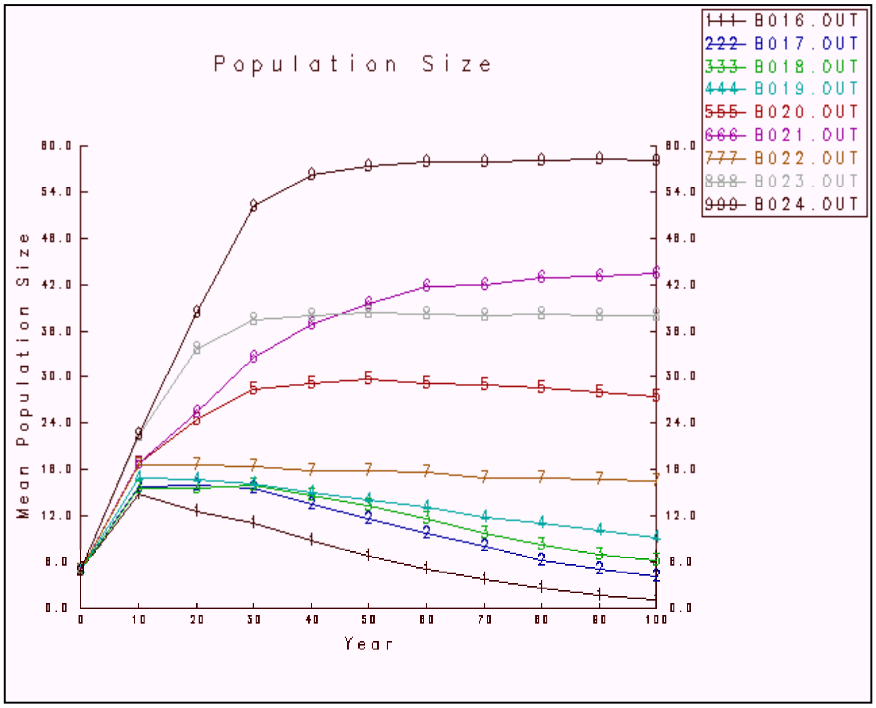

Figure 3. Effect of one time supplementation coupled with the reduction of human-induced mortality on the mean population size over 100 years at various values of carrying capacities. Curves #1 (B016), #2 (B017), and #3 (B018) represent changes of mean population sizes with carrying capacity of 20, 40, and 60 respectively and **5% a year** human-induced mortality rate. Curves #4 (B019), #5 (B020), and #6 (B021) represent changes of mean population sizes with carrying capacity of 20, 40, and 60 respectively and **2.5% a year** human-induced mortality rate. Curves #7 (B022), #8 (B023), and #9 (B024) represent changes of mean population sizes with carrying capacity of 20, 40, and 60 respectively and **0% a year** human-induced mortality rate. These scenarios include starting population of 5 bears and 30% of females breeding each year. Inbreeding depression is included.

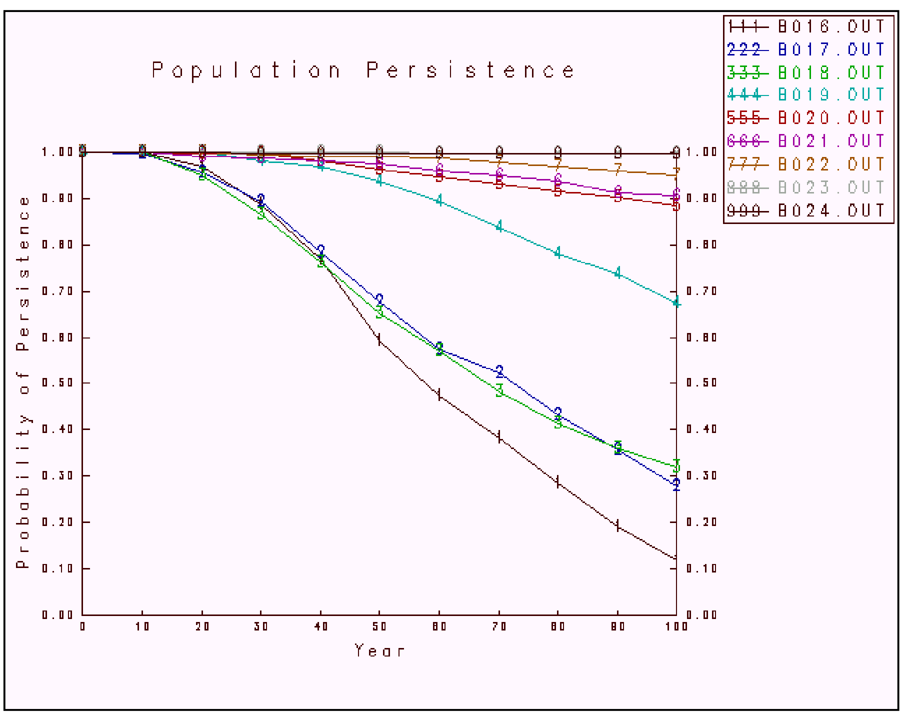

Figure 4. Effect of one time supplementation coupled with the reduction of human-induced mortality on the population persistence (probability of survival) over 100 years at various values of carrying capacities. Curves #1 (B016), #2 (B017), and #3 (B018) represent population persistence probabilities with carrying capacity of 20, 40, and 60 respectively and **5% a year** human-induced mortality rate. Curves #4 (B019), #5 (B020), and #6 (B021) represent population persistence probabilities with carrying capacity of 20, 40, and 60 respectively and **2.5% a year** human-induced mortality rate. Curves #7 (B022), #8 (B023), and #9 (B024) represent

population persistence probabilities with carrying capacity of 20, 40, and 60 respectively and **0% a year** human-induced mortality rate. These scenarios include starting population of 5 bears and 30% of females breeding each year. Inbreeding depression is included.

Human-induced mortality: Removal of excess mortality, reflecting possible losses to snares and deliberate poaching that was included as a catastrophe, resulted in a significant increase in population growth rate and reduction in the risk of extinction (Figures 5 & 6) suggesting that any reduction in this mortality will be important for the long term viability of this population. However, the extinction probability is still not acceptable for a viable population indicating that the prevention of poaching alone is not sufficient for the long term viability.

File #	K	N	%Bred	%Hum Impact	det.r	stoc.r	SD(r)	PE	N-all	SD(N)	Het	SD(H)	Mean TE
1	20	5	30	10	-0.044	-0.043	0.243	1.000	0.00	0.00	0.0000	0.0000	11.5
4	20	5	30	5	0.010	-0.016	0.204	0.980	0.15	1.33	0.3857	0.2390	22.9
7	20	5	30	2.5	0.036	0.003	0.161	0.770	2.92	5.81	0.4336	0.2170	34.9
10	20	5	30	0	0.061	0.029	0.128	0.302	11.72	8.28	0.5344	0.1590	31.3

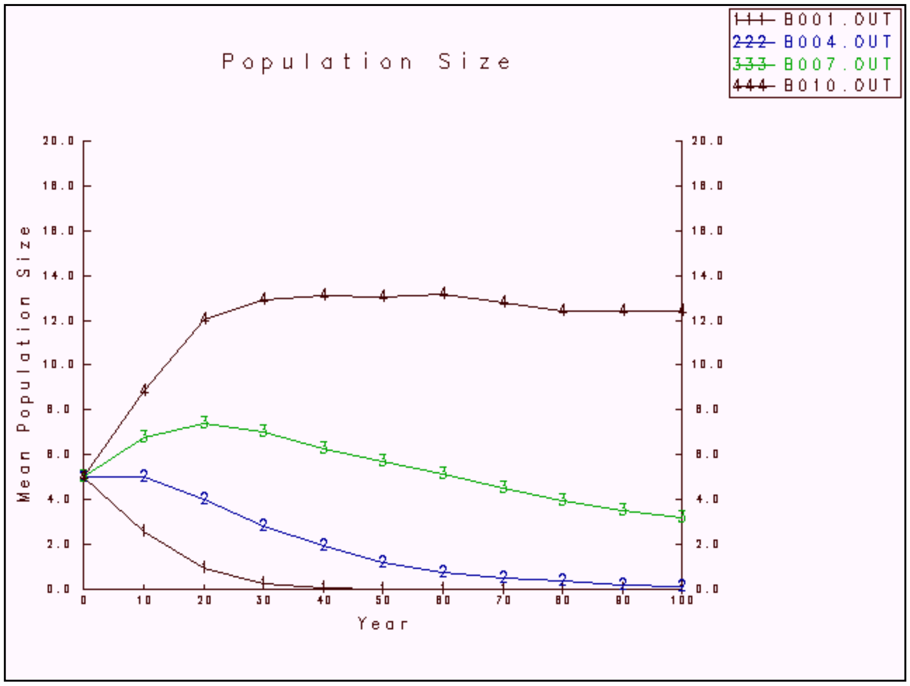

Figure 5. Effect of change of human-caused excess mortality on the mean bear population size over 100 years at carrying capacity of 20 with a starting population of 5 animals. Curves #1 (B001), #2 (B004), #3 (B007), and #4 (B010) represent changes of mean population sizes with human-induced mortality rate of 10%, 5%, 2.5%, and 0% a year respectively. The populations represented by the curve #4 reach about 60% of K.

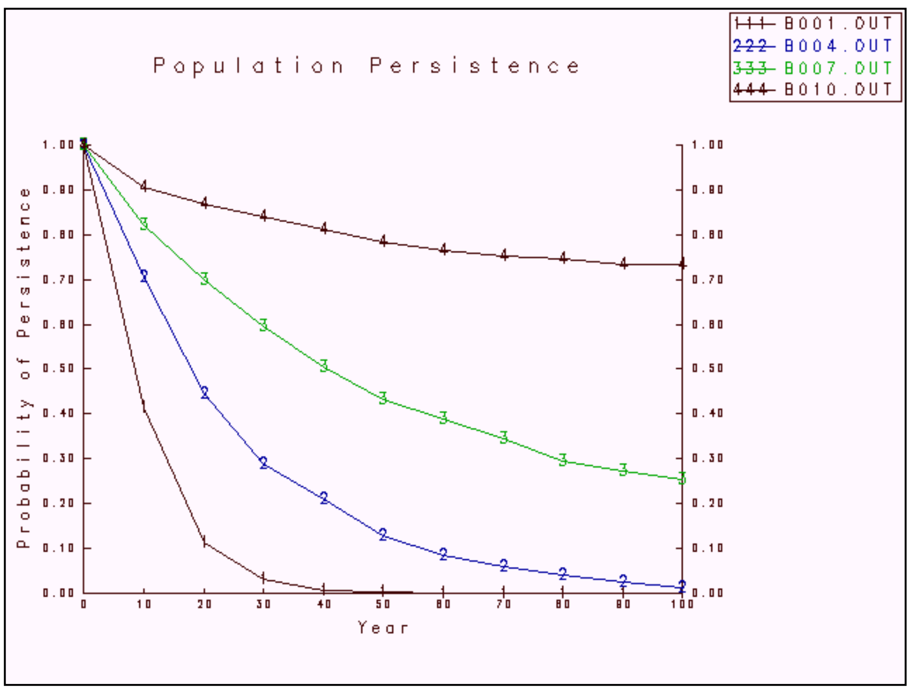

Figure 6. Effect of change of human-caused excess mortality on the population persistence (probability of survival) over 100 years at carrying capacity of 20 with a starting population of 5 animals. Curves #1 (B001), #2 (B004), #3 (B007), and #4 (B010) represent population persistence probabilities with human-induced mortality rate of 10%, 5%, 2.5%, and 0% a year respectively. The reduction of human impact from 10% a year to none increased the probability of survival by 70%.

Carrying capacity effects with reduced human-induced mortality and N=8: Reduction of excess mortality (5% a year to 2.5% a year) with a starting population of 8, reflecting most optimistic conditions for Chirisan population, resulted in a significant increase in population growth rate (Figures 7 & 8; compare with Figures 1 & 2), but the risk of extinction is still high (about 50%) suggesting that eight bears is still too small a population for long-term viability. The inbreeding depression effects are a significant negative factor (see Figures 9, 10, & 11).

File #	K	N	%Bred	%Hum Impact	det.r	stoc.r	SD(r)	PE	N-all	SD (N)	Het	SD(H)	Mean TE
43	20	8	30	2.5	0.036	0.004	0.149	0.612	5.00	6.93	0.5085	0.1754	47.6
44	40	8	30	2.5	0.036	0.008	0.135	0.442	15.21	15.78	0.6189	0.1740	44.0
45	60	8	30	2.5	0.036	0.009	0.131	0.450	21.81	23.98	0.6432	0.1561	39.7

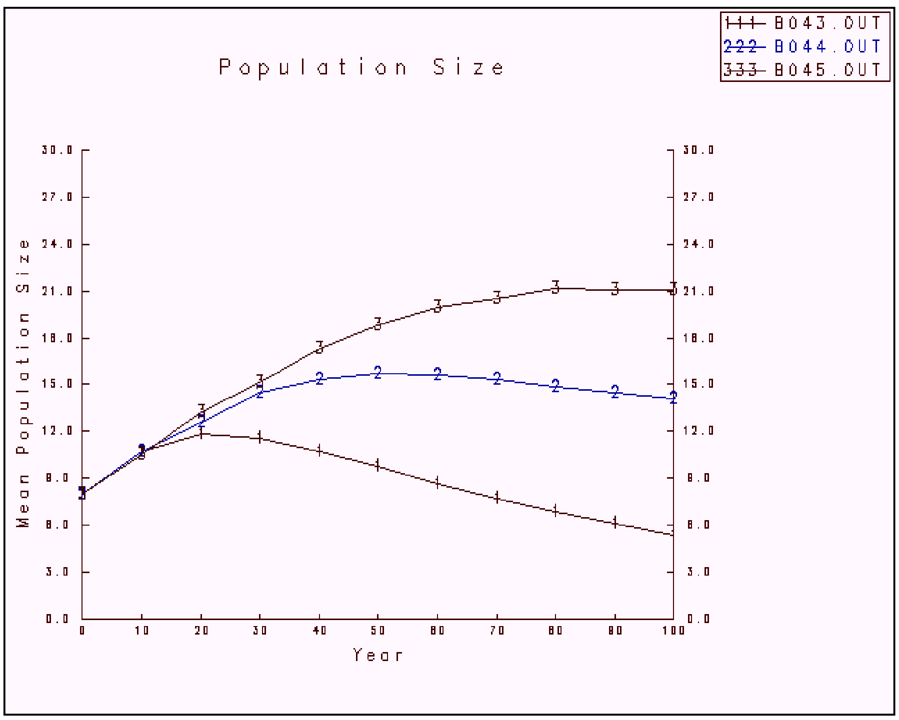

Figure 7. Effect of carrying capacity on the mean population sizes over 100 years at carrying capacities of 20 (B043, curve #1), 40 (B044, curve #2), and 60 (B045, curve #3) bears with a starting population of 8 animals. These scenarios include increased mortality of 2.5% a year due to human impacts and 30% of females breeding each year. Inbreeding depression included. Compare with results in Figure 1 with starting population of 5 bears and human-induced mortality of 5% a year.

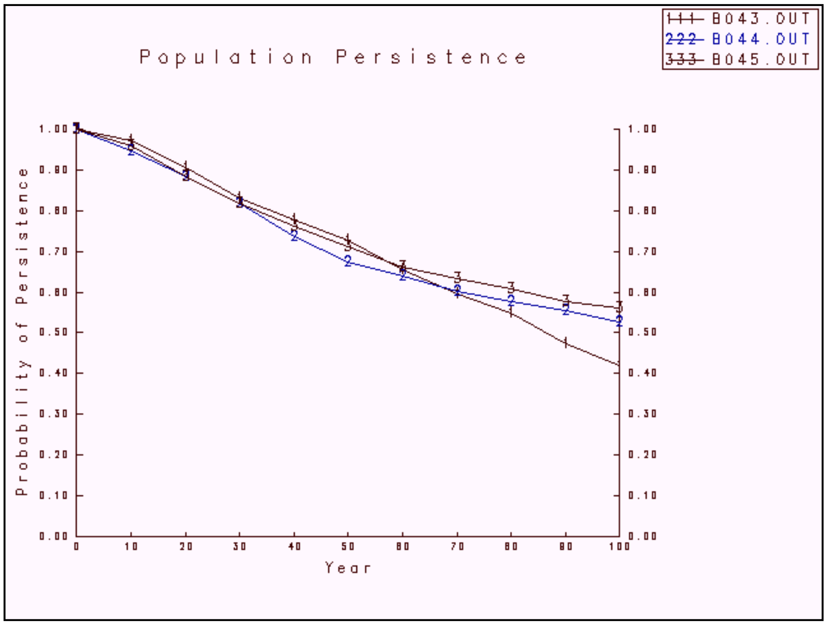

Figure 8. Effect of carrying capacity on the bear population probability of persistence (probability of survival) over 100 years at carrying capacities of 20 (B043, curve 1), 40 (B044, curve 2), and 60 (B045, curve 3) bears with a starting population of 8 animals. These scenarios include increased mortality of 2.5% a year due to human impacts and 30% of females breeding each year. Inbreeding depression included. Compare with results in Figure 2 with starting population of 5 bears and human-induced mortality of 5% a year.

Removal of inbreeding depression: Evidence from many other species ranging from mammals to fruit flies indicated that the effects are likely to be deleterious. The safest assumption for conservation with limited opportunity for experimental testing is that it is detrimental so it was included in most of these scenarios.

File #	K	N	%Bred	%Hum Impact	det.r	Stoc.r	SD(r)	PE	N-all	SD(N)	Het	SD(H)	MeanTE
43	20	8	30	2.5	0.036	0.004	0.149	0.612	5.00	6.93	0.5085	0.1754	47.6
44	40	8	30	2.5	0.036	0.008	0.135	0.442	15.21	15.78	0.6189	0.1740	44.0
115	20	8	30	2.5	0.036	0.025	0.143	0.282	11.88	8.07	0.5170	0.1804	35.9
116	40	8	30	2.5	0.036	0.028	0.126	0.248	26.90	16.30	0.6250	0.1474	29.1

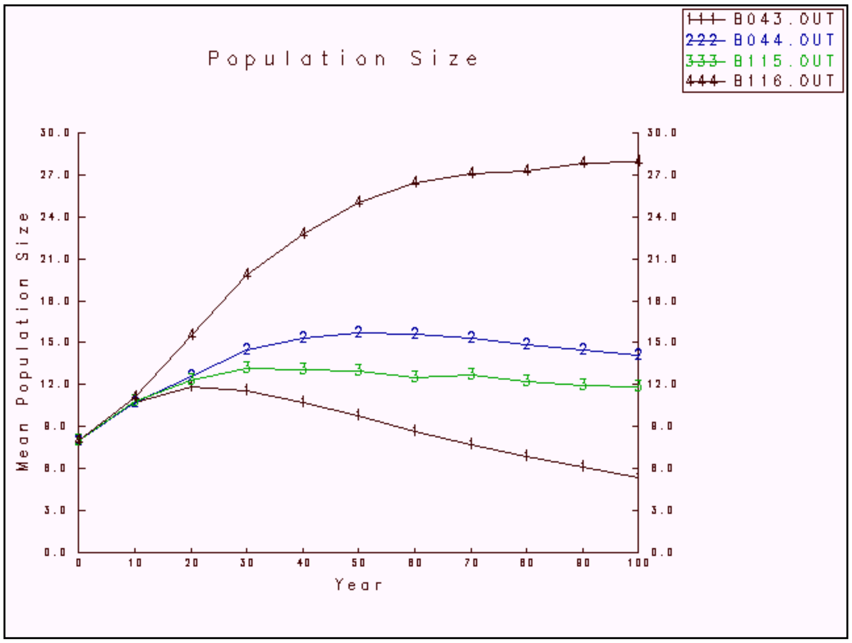

Figure 9. Positive effects of removing inbreeding depression and increased carrying capacity on mean population size at 100 years with N= 8 animals, increased mortality of 2.5% a year due to human impacts, 30% of females breeding each year, and with no supplementation. Many populations go extinct over the 100 years of the simulations. Carrying capacity of 20 with inbreeding depression (B043, curve #1) and without (B115, curve #3). Carrying capacity of 40 with inbreeding depression (B044, curve #2) and without (B116, curve #4).

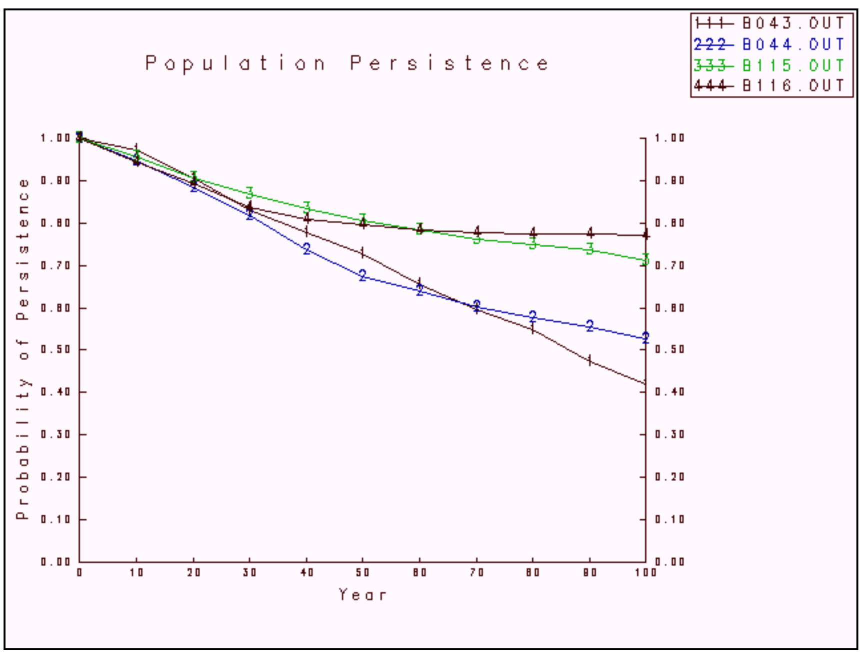

Figure 10. Effect of removing inbreeding depression and carrying capacity on population persistence (probability of survival) with starting population of 8 animals, increased mortality of 2.5% a year due to human impacts, 30% of females breeding each year, and no supplementation. Note: Many populations go extinct over the 100 years of the simulations. Carrying capacity of 20 with inbreeding depression (B043, curve #1) and without (B115, curve #3). Carrying capacity of 40 with inbreeding depression (B044, curve #2) and without (B116, curve #4).

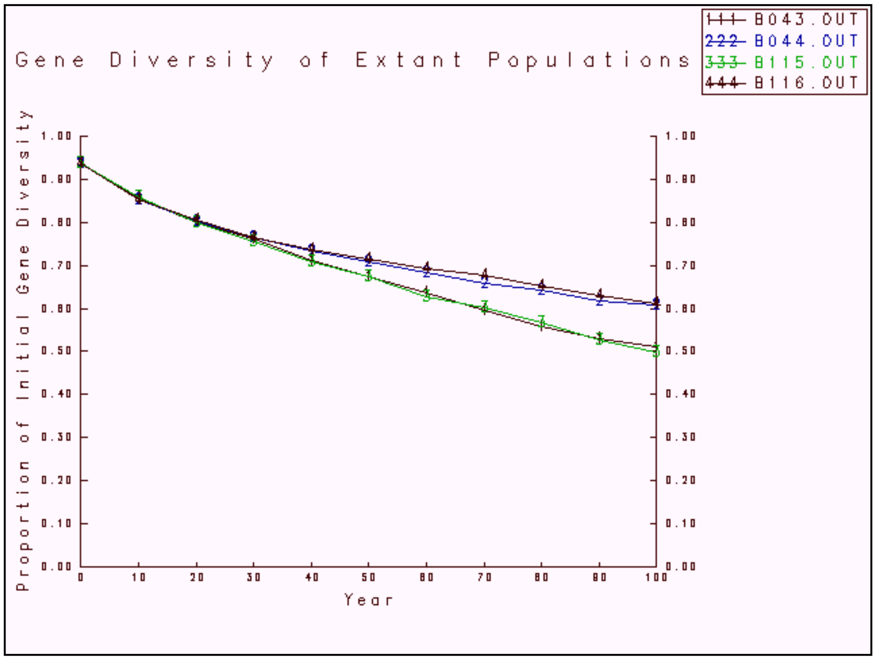

Figure 11. Effect of removing inbreeding depression and carrying capacity on loss of heterozygosity with a starting population of 8 animals, increased mortality of 2.5% a year due to human impacts, 30% of females breeding each year, and with no supplementation. Note that many populations go extinct over the 100 years of the simulations. Carrying capacity of 20 with inbreeding depression (B043, curve #1) and without (B115, curve #3). Carrying capacity of 40 with inbreeding depression (B044, curve #2) and without (B116, curve #4).

Interaction of starting population size and carrying capacity: The pattern of population extinction is strongly dependent on the starting population size rather than habitat carrying capacity for these small populations. For N=5, the simulations indicate greater than 70% probability of extinction in 100 years with extinctions evident in the immediate future for K = 20, 40, and 60 (bottom set of curves in Figure 12). For N=15, the risk of extinction is greatly reduced except for K =20 but here the populations persist for 40 - 50 years before significant extinctions occur.

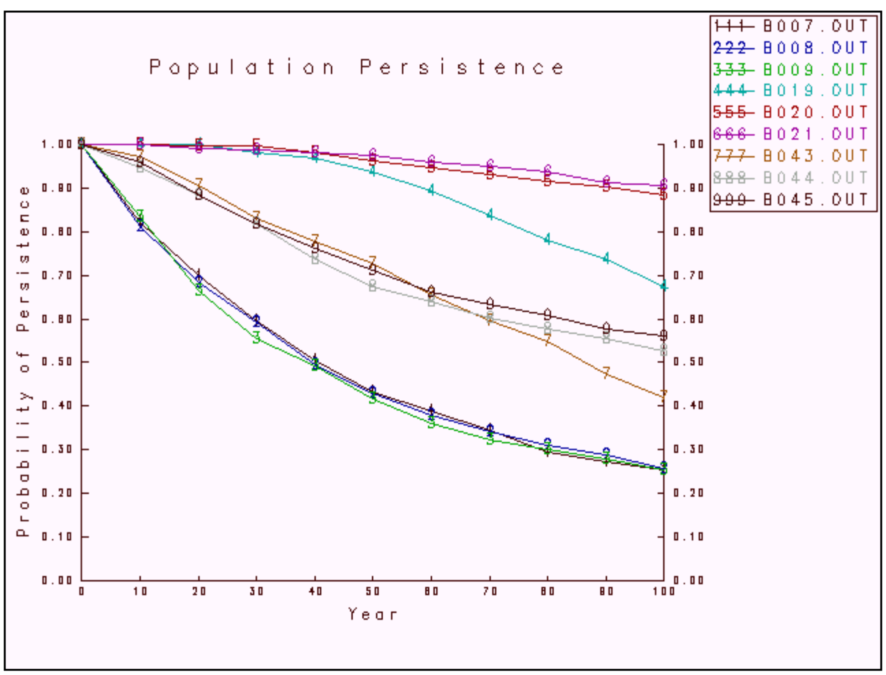

Figure 12. Probability of population persistence (or population survival) with K=20, 40, or 60 in each set of curves. The projections are dominated by the starting population size and the three groups of curves are for N = 5 (B007, curve #1; B008, curve #2; B009, curve #3), N = 8 (B043, curve #7; B044, curve #8; B045, curve #9), or N = 15 (B019, curve #4; B020, curve #5; B021, curve #6). Inbreeding depression and periodic losses due to removals by people (2.5% a year) are included.

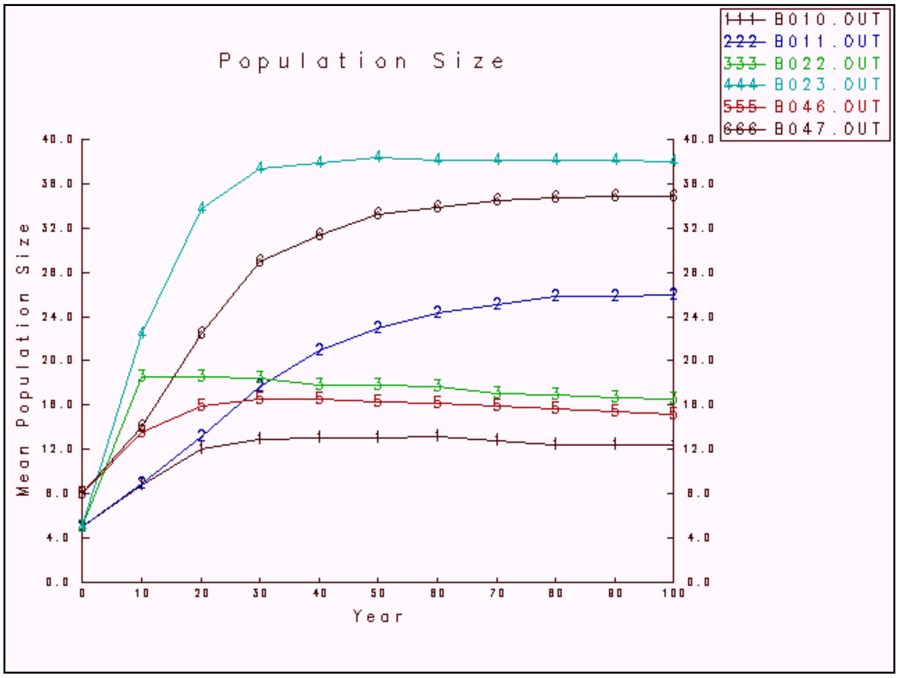

Figure 13. Comparison of the mean population sizes over 100 years with starting N = 5, 8, or 15 and K = 20 or 40 (N = 5, K = 20: B010, curve #1; N = 5, K = 40: B011, curve #2; N = 8, K = 20: B046, curve #5; N = 8, K = 40: B047, curve #6; N = 15, K = 20: B022, curve #3; N = 15, K = 40: B023, curve #4). The larger starting population sizes do better initially but converge over time to similar sizes but with much different probabilities of extinction. Populations will continue to go extinct at K = 20. Human impact removed.

RECOMMENDATIONS, ACTION PLAN, AND FUTURE DIRECTIONS

Recommendations

The recommendations of the population and modeling working group are the actions suggested to help achieve each of the goals. Three high priority actions were selected from the list of 22 actions for inclusion in the list of 15 recommendations reviewed and prioritized by all members of the workshop. All of these actions are presented with partial information on responsibilities, time required for completion, and resources required. Some can begin immediately, others will require several years, and many will be an ongoing part of an adaptive management approach to black bear management in Chirisan National Park. It will be important that working groups be formed to undertake these projects such as preparing and implementing a reintroduction program – a high priority for the modeling group and all participants in the workshop. This project will require integration of planning for the captive and wild population, research on genetics, habitat evaluation, and establishing a monitoring program for the released bears.

Action Plan - Population Biology

Problems And Goals

Problem I. Insufficient intact habitat for a viable population of Asian black bears in Chirisian Park.

- Goal 1: Estimate K needed for a viable population for 100 years, with $P_E \leq 5\%$.
- Goal 2: Gather information and evaluate effects of habitat loss and fragmentation.

Problem II. Wild population is too small to be viable no matter the carrying capacity.

- Goal 1: Estimate N needed to maintain a viable population for 100 years with retention of 90% of genetic diversity and ≤ 5% probability of extinction.
- Goal 2. Develop scenarios and models for a reintroduction program to augment population.
- Goal 3. Define a viable population for the short and long term.

Problem III. Human impacts on population reduce viability.

- Goal 1. Assemble information on present and past human impacts and evaluate models with sensitivity analyses.
- Goal 2. What conditions allow for coexistence of bears and people?
- Goal 3. Identify kinds of human activities that most threaten bears.
- Goal 4. Identify human activities bears tolerate or benefit from.
- Goal 5. Identify thresholds for levels of acceptable development and human activities.

Problem IV. Lack of useful models to assist an adaptive management program.

- Goal 1: Construct a VORTEX simulation model with available information and start sensitivity analyses.
- Goal 2. Gather additional available information on wild and captive populations and continue development of population model.

ACTIONS

Problem I. Insufficient intact habitat for a viable population of Asian black bears in Chirisian Park.

(1) (Estimate carrying capacity (K))
  - (a) Using VORTEX, do sensitivity analyses on K at this workshop for $P_E \leq 5\%$; $\Delta H \geq 0.09$; at 100 years.
  - (b) Suggest methods for increasing K of available habitat.
  - (c) Organize a working group on habitat to evaluate status, historical information, and future changes. Include local participants for local uses and needs.

(2) (Habitat Loss and Fragmentation)
  - (a) Develop scenarios and models for habitat loss and fragmentation. Develop scenarios and models for corridors between adjacent populations and other potential habitat.
  - (b) Develop scenarios for long-term expansion of habitat to connect North and South Korea populations and habitat

Problem II. Wild population is too small to be viable no matter the carrying capacity.

(1) (N for a viable population)
  - (a) Develop short and long term population goals for Chiri population based on genetic and demographic criteria. Test scenarios in models.
  - (b) Test field techniques for practical monitoring of population size and distribution over time.

(2) (Reintroduction Scenarios)
  - (a) 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.
  - (b) 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.
  - (c) Use models for testing a sensitivity analysis of all proposed scenarios as adaptive management tool.
  - (d) Establish working group to develop release program (and use IUCN guidelines as a reference for developing program).

(3) (Viable Population)
  - (a) Assemble criteria for viability and establish population goals. Consider genetic, demographic, and environmental criteria.
  - (b) Establish goals for 10, 50, and 100 years.

Problem III. Human impacts on population reduce viability.

(1) (Information)
  - (a) Prepare GIS maps of present and planned roads and trails (linear developments) in bear habitat

(b) Use GIS to model effects of roads on bear movements.
(c) Model effects of roads on human access to bear habitat
(d) Assemble information on human presence and distribution of activities in bear habitat
(e) Model effects of human presence on bear use of habitat – especially food resources and reproduction and mortality

Problem IV. Lack of useful models to assist an adaptive management program.

(1) (VORTEX working model)
  (a) Continue to test and develop VORTEX model constructed in this workshop using available information and new information as acquired. Use as adaptive management tool.
  (b) Develop GIS models for bear habitat and habitat use by bears. Use as tool to test proposed changes, corridors, and meta population management scenarios
(2) (Captive and wild populations)
  (a) Develop disease risk scenarios and decision models for release program

Future Directions: GIS Model and Corridors

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.

Components of a GIS Model

Ecological Submodel

The ecological component of the model will be an empirically derived simulation, which quantitatively assesses the probability of black bears using and moving through a defined area. We will compose this component of three submodels, which assess changes in habitat fragmentation, habitat effectiveness, and connectivity that occur because of human disturbance.

Habitat layer: We will use biophysical coefficients derived from literature review, ground tracking, and radiotelemetry to create a landscape surface that reflects the effectiveness of habitat to support black bears without the presence of humans. The model will assume no anthropogenic activities have occurred in the past or are occurring presently (null model). The probability that a species will use a certain habitat or travel a particular path will be expressed as a function of behavioral characteristics, physical environment, and distribution of resources (water, cover, prey). Included will be the effects of physiography on the distribution, size, geometry, and juxtaposition of habitat patches and behavioral responses of carnivores to the natural physical environment. The model output will display graphically the probability of any given area being of high survival value to carnivores.

Displacement layer: We will calculate current habitat effectiveness by overlaying the zones of influence (footprints) of physical structures and human disturbance. The former will include, linear developments, point developments, and developments within polygons. The latter will capture behavioral responses of carnivores to human activities, and the influence of wildlife management and land use. The resulting probability surface will represent the survival value of each pixel resulting from the interaction of biophysical features and natural and human disturbance.

Connectivity layer: We will produce the movement sub component of the model in probabilistic form based on habitat effectiveness (submodels 1 & 2) and empirical observations of black bear behavior. Different landscape elements, human activities, and physical structures variably inhibit movements. Other features enhance movements by attracting different species (e.g., high densities of food resources) or allowing them to move more efficiently through the landscape (e.g., plowed winter roads, trails).

We will place simulated black bears into the rasterised landscape and have them move to a target area. A least cost pathway analysis will be used to simulate movements and calculate the cost of travel. Simulated animals should select travel routes that provide an optimal combination of security, habitat quality, and energetic efficiency. Conversely, bears will variably avoid human facilities and activities, terrain that is difficult to negotiate, and habitat of low quality. For example, bears might avoid humans and be attracted to concentrations of food..

The integrated model should allow us to examine how black bears might have used an area in pristine conditions and how it is currently used.[1] Future scenarios, based on current rates of growth, can also be considered with and without mitigation of human activities.

Socio/economic Submodels

A similar procedure will be used to develop spatially explicit models that capture human needs and desires within the pilot study region. If data are available, we will develop independent models for social and economic aspects. The models will incorporate current zoning, land use designation, current land use, and land use preferences of different user groups. Model runs will identify the actual and perceived importance of areas within the study region for different activities.

Finally, we will combine the models using a method that will rank priorities within the study region. The needs of the black bears will drive the first iteration of the model (i.e., all other activities will subsume). The second iteration will rank human activities according to current land use designations and applicable legislation. In some areas, the needs of black bears will be secondary to human activities. For example, land plans might designate an area as a commercial development zone with low conservation value. The final output of the combined models will help identify areas where there is a high probability of conflict because of convergent needs of different users. The model will also highlight the most probable areas for conserving, restoring, and protecting habitat and travel linkages for carnivores. Consequently, we can determine if the current status allows for development of a landscape design that will sustain black bears or if alternatives need to be explored.

A REVIEW OF CORRIDOR CONCEPTS

ECOLOGICAL CORRIDORS IN MOUNTAINOUS AREAS

Dispersal Corridors [subadults 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

[1]We define "pristine conditions" as the absence of human activities on the landscape.

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.

Home Range Corridors

In contrast to dispersal corridors where an individual leaves one place to settle in another place and probably never returns, animals often need to move within their home ranges from one type of habitat to another. These movements can be regular and predictable depending upon the species and the season, or they can be stochastic in nature; depending upon varying climatic conditions and availability of food or other resources.

Migratory corridor-between established winter and summer range

For many ungulates, such as elk, pronghorn antelope, and bighorn sheep, the greatest movements and use of corridors occur during annual migrations between summer and winter ranges. As mentioned above, dispersal and consequent gene flow in these species occurs when herds come into contact on seasonal ranges or when individuals wander within the seasonal range.

Occasional corridor-dependent upon annual climatic factors: Black bears use many foods, most of which vary in abundance from year to year, and season to season. During years with good berry crops, bears will move to those areas in the fall to forage. Seasonal movements also vary depending upon sex and age class. For example, if good berry habitat is dominated by aggressive, adult males, females and subadult males will avoid those areas and forage in less desirable habitat.

After winters of heavy snowfall, black bears may be restricted in their movements and foraging by late-melting snow packs. They may travel to other areas where food is available earlier or use more patchy food sources.

Within territories: Animals that occupy discrete ranges, such as black bears, may use different habitats within those ranges at different times of the year. Depending upon the availability of food they may move long distances, through corridors with few resources, to seasonal use areas. In the fall they will generally move to a den site and remain there until the spring. In most part of the range of the Asiatic black bear animals do not den at all. In some place they den for a short time.

Corridors within seasonal range- using different foods: In mountainous environments black bears may move from lower elevations to higher elevations as food becomes available, and then back to lower elevations as high elevations become snow covered. Dr. Kim describes stream corridors as being important for crayfish in March and April and strawberries during July. Strawberries represent one of the few foods available for bears during July. Hikers frequently use these stream corridors and possibly displace bears.

Daily or weekly use corridors: A black bear's use of habitat may vary throughout the day and from day to day. In the mountains, some bears will move down from foraging habitat and escape terrain to drink from streams or water holes once a day. Often, regular corridors of movement are used.

Many black bears move regularly between resting and foraging habitat. If they feed in meadows in the early morning they may move to more secure, perhaps shaded, habitat during midday to rest, and return to foraging areas in the evening. These local movement corridors are particularly important where they are constrained by human development.

Stepping stones

A corridor for black bears may need not consist of contiguous habitats. A corridor may be composed of stepping stones of habitat connecting areas of seasonal or even daily use. Some stepping stones may be used as brief stops to rest, whereas others that are next to good foraging habitat may be used for several days.

GENE FLOW CORRIDORS

In the context of corridors, gene flow can be considered to occur at three different rates in the table above.

Gene flow 1 occurs within a single generation. This generally occurs when a dispersing individual (often a subadult male) moves from its natal home range to a more distant area where gene frequencies in the local population are somewhat different from its own. The immigration of a single successfully-breeding individual per generation is sufficient to maintain the same alleles in both populations; although the relative frequencies of those alleles may be quite different. The temporal and geographic scales at which gene flow occurs depend upon the ecology and life history strategy of the species in question: in general, larger-bodied animals travel over greater distances. For black bears gene flow 1 can occur through regional corridors; for marmots it will occur through local corridors.

Gene flow 2 represents the movement of alleles from one population to another over several generations. Alleles are passed on from one individual who disperses, to its offspring who also disperse, to their offspring who also disperse. Some original alleles are lost through segregation along the way, and populations separated at this scale maintain alleles that are locally unique. Again, the temporal and geographic scales at which this occurs depend upon the ecology and life history strategy of the species in question. For example, gene flow 2 occurs in black bear populations on a continental scale, but in marten or fisher on a regional scale.

Gene flow 3 can be conceived of as the movement of alleles over even longer genetic distances: it requires many generations for an allele to be introduced from one population to another. Populations connected by gene flow at this rate are quite distinct from one another; they have unique alleles and probably unique, co-evolved gene complexes. In a genetic sense such populations may be regarded as subspecies with local adaptations. Gene flow 3 occurs over evolutionary, rather than ecological, time. Again, the temporal and geographic scales at which this occurs depend upon the ecology and life history strategy of the species in question.

Table 2. Output results from the VORTEX scenario simulations for the Korean Asiatic Black Bear. The scenarios are in blocks of 12 with 3 habitat carrying capacities (K = 20, 40, or 60) and 2 starting population sizes (N = 5 or 8). All scenarios included a second catastrophe for additional mortality as a result of human activities. The frequency was 50% with reproduction factor of 1.0 (no effect) and survival factor (severity) of 0.8, 0.9, 0.95, or 1.0 (20%, 10%, 5%, or 0% reduction in survival randomly distributed across age and sex classes). Detailed parameter values are described in the text. The models were run for 100 years with 500 iterations.

The base scenario for the Chirisan National Park population is file #4 in the table. The stochastic growth rate was – 0.016 in contrast to the positive calculated deterministic growth (r = 0.01). The probability of extinction (Pe) was 0.98 at 100 years and 0.55 at 20 years. The population is in imminent risk of extinction.

File #	**K**	**N**	**Sev.**	**Supp.**	**det.r**	**stoc.r**	**SD(r)**	**PE**	**N-all**	**SD (Nall)**	**Het**	**SD (Het)**	**Mean TE**
Scenarios with human impact on mortality (N = 5)													
1	20	5	0.8	N	-0.044	-0.043	0.243	1.000	0.00	0.00	0.0000	0.0000	11.5
2	40	5	0.8	N	-0.044	-0.049	0.245	1.000	0.00	0.00	0.0000	0.0000	10.2
3	60	5	0.8	N	-0.044	-0.047	0.247	1.000	0.00	0.00	0.0000	0.0000	10.7
4	**20**	**5**	**0.9**	**N**	**0.010**	**-0.016**	**0.204**	**0.980**	**0.15**	**1.33**	**0.3857**	**0.2390**	**22.9**
5	40	5	0.9	N	0.010	-0.014	0.195	0.970	0.30	2.30	0.5019	0.1638	23.4
6	60	5	0.9	N	0.010	-0.014	0.196	0.970	0.32	2.69	0.4560	0.1938	24.0
7	20	5	0.95	N	0.036	0.003	0.161	0.770	2.92	5.81	0.4336	0.2170	34.9
8	40	5	0.95	N	0.036	0.005	0.157	0.744	6.41	12.36	0.5751	0.1564	30.5
9	60	5	0.95	N	0.036	0.006	0.154	0.720	9.56	18.04	0.5895	0.1556	29.0
10	20	5	1	N	0.061	0.029	0.128	0.302	11.72	8.28	0.5344	0.1590	31.3
11	40	5	1	N	0.061	0.034	0.113	0.240	27.66	16.47	0.6438	0.1371	26.6
12	60	5	1	N	0.061	0.035	0.112	0.266	40.34	26.08	0.6590	0.1412	25.8
Same scenarios with one time supplementation of 10 bears (N = 5 + 10)													
13	20	5	0.8	10*1	-0.044	-0.023	0.315	1.000	0.00	0.00	0.0000	0.0000	21.2
14	40	5	0.8	10*1	-0.044	-0.026	0.312	1.000	0.00	0.00	0.0000	0.0000	21.9
15	60	5	0.8	10*1	-0.044	-0.026	0.318	1.000	0.00	0.00	0.0000	0.0000	21.4
16	20	5	0.9	10*1	0.010	0.000	0.222	0.894	1.06	3.14	0.4934	0.1688	50.4
17	40	5	0.9	10*1	0.010	0.000	0.208	0.696	4.74	8.96	0.6018	0.1826	47.0
18	60	5	0.9	10*1	0.010	0.000	0.206	0.718	5.32	10.45	0.5999	0.1974	47.4
19	20	5	0.95	10*1	0.036	0.020	0.174	0.322	8.76	7.11	0.5657	0.1614	51.7
20	40	5	0.95	10*1	0.036	0.026	0.154	0.118	27.80	13.01	0.7251	0.1093	38.4
21	60	5	0.95	10*1	0.036	0.027	0.152	0.108	42.44	20.59	0.7574	0.1084	34.3
22	20	5	1	10*1	0.061	0.046	0.150	0.032	16.67	4.67	0.6336	0.1348	36.4
23	40	5	1	10*1	0.061	0.055	0.131	0.004	38.19	4.02	0.7765	0.0636	8.0
24	60	5	1	10*1	0.061	0.057	0.128	0.004	58.29	5.30	0.8197	0.0540	9.3
Same scenarios with supplementation of 10 bears (2 bear/2 year * 5 times; N = 5 + 10)													
25	20	5	0.8	2*5	-0.044	-0.004	0.233	1.000	0.00	0.00	0.0000	0.0000	32.8
26	40	5	0.8	2*5	-0.044	-0.009	0.231	1.000	0.00	0.00	0.0000	0.0000	34.4
27	60	5	0.8	2*5	-0.044	-0.009	0.232	0.996	0.01	0.19	0.5278	0.1179	34.0
28	20	5	0.9	2*5	0.010	0.009	0.178	0.826	1.75	3.87	0.5456	0.1676	60.3
29	40	5	0.9	2*5	0.010	0.007	0.154	0.484	8.70	11.20	0.6563	0.1537	61.6
30	60	5	0.9	2*5	0.010	0.009	0.148	0.398	13.78	16.12	0.7020	0.1510	63.6
31	20	5	0.95	2*5	0.036	0.027	0.146	0.302	8.98	7.16	0.5855	0.1518	70.4
32	40	5	0.95	2*5	0.036	0.035	0.114	0.020	32.19	9.01	0.7717	0.0798	35.4

33	60	5	0.95	2*5	0.036	0.037	0.106	0.004	52.37	10.29	0.8285	0.0537	9.6
34	20	5	1	2*5	0.061	0.053	0.123	0.034	16.68	4.63	0.6417	0.1217	57.6
35	40	5	1	2*5	0.061	0.061	0.100	0.000	38.46	2.86	0.7963	0.0634	1.9
36	60	5	1	2*5	0.061	0.064	0.091	0.000	58.61	2.94	0.8485	0.0442	2.0
Scenarios with human impact on mortality (N = 8)													
37	20	8	0.8	N	-0.044	-0.059	0.239	1.000	0.00	0.00	0.0000	0.0000	16.2
38	40	8	0.8	N	-0.044	-0.058	0.241	1.000	0.00	0.00	0.0000	0.0000	15.9
39	60	8	0.8	N	-0.044	-0.057	0.231	1.000	0.00	0.00	0.0000	0.0000	15.9
40	20	8	0.9	N	0.010	-0.018	0.184	0.936	0.56	2.39	0.4591	0.2223	34.6
41	40	8	0.9	N	0.010	-0.016	0.178	0.912	1.27	4.62	0.5457	0.1776	36.9
42	60	8	0.9	N	0.010	-0.018	0.182	0.940	1.09	5.12	0.5430	0.2432	36.8
43	20	8	0.95	N	0.036	0.004	0.149	0.612	5.00	6.93	0.5085	0.1754	47.6
44	40	8	0.95	N	0.036	0.008	0.135	0.442	15.21	15.78	0.6189	0.1740	44.0
45	60	8	0.95	N	0.036	0.009	0.131	0.450	21.81	23.98	0.6432	0.1561	39.7
46	20	8	1	N	0.061	0.032	0.118	0.126	14.76	6.57	0.5780	0.1496	47.7
47	40	8	1	N	0.061	0.038	0.099	0.070	34.64	10.80	0.7061	0.1069	33.9
48	60	8	1	N	0.061	0.041	0.093	0.076	53.09	16.20	0.7351	0.0935	32.4
Same scenarios with one time supplementation of 10 bears (N = 8 + 10)													
49	20	8	0.8	10*1	-0.044	-0.030	0.275	1.000	0.00	0.04	0.0000	0.0000	27.5
50	40	8	0.8	10*1	-0.044	-0.034	0.286	1.000	0.00	0.00	0.0000	0.0000	26.0
51	60	8	0.8	10*1	-0.044	-0.031	0.282	1.000	0.00	0.04	0.0000	0.0000	27.3
52	20	8	0.9	10*1	0.010	-0.004	0.196	0.862	1.44	3.76	0.5143	0.1885	55.6
53	40	8	0.9	10*1	0.010	-0.002	0.175	0.638	6.36	10.20	0.6308	0.1559	59.8
54	60	8	0.9	10*1	0.010	-0.003	0.176	0.620	8.33	13.85	0.6524	0.1440	56.0
55	20	8	0.95	10*1	0.036	0.017	0.155	0.348	8.66	7.22	0.5864	0.1561	68.9
56	40	8	0.95	10*1	0.036	0.025	0.130	0.074	29.37	11.86	0.7378	0.0977	61.8
57	60	8	0.95	10*1	0.036	0.027	0.124	0.062	46.85	17.35	0.7784	0.1008	56.8
58	20	8	1	10*1	0.061	0.045	0.129	0.046	16.74	4.74	0.6252	0.1352	68.1
59	40	8	1	10*1	0.061	0.053	0.109	0.000	38.32	3.33	0.7781	0.0687	3.5
60	60	8	1	10*1	0.061	0.055	0.103	0.000	58.35	3.21	0.8326	0.0462	0.0
Same scenarios with supplementation of 10 bears (2 bear/2 years * 5 times; N = 8 + 10)													
61	20	8	0.8	2*5	-0.044	-0.015	0.221	1.000	0.00	0.00	0.0000	0.0000	35.3
62	40	8	0.8	2*5	-0.044	-0.021	0.219	0.998	0.04	0.85	0.5305	0.0000	37.6
63	60	8	0.8	2*5	-0.044	-0.022	0.220	0.998	0.01	0.14	0.4444	0.0000	38.1
64	20	8	0.9	2*5	0.010	0.005	0.168	0.800	2.03	4.38	0.5068	0.1885	62.9
65	40	8	0.9	2*5	0.010	0.004	0.144	0.412	9.97	11.44	0.6758	0.1287	67.8
66	60	8	0.9	2*5	0.010	0.004	0.140	0.356	15.65	17.08	0.7044	0.1545	70.4
67	20	8	0.95	2*5	0.036	0.025	0.137	0.272	9.80	7.06	0.5923	0.1567	69.9
68	40	8	0.95	2*5	0.036	0.032	0.105	0.004	32.58	8.08	0.7710	0.0787	49.0
69	60	8	0.95	2*5	0.036	0.033	0.097	0.010	52.12	10.76	0.8304	0.0550	50.6
70	20	8	1	2*5	0.061	0.049	0.117	0.038	16.55	4.71	0.6508	0.1195	62.7
71	40	8	1	2*5	0.061	0.057	0.092	0.000	38.10	3.52	0.7928	0.0648	2.0
72	60	8	1	2*5	0.061	0.061	0.084	0.000	58.73	2.92	0.8529	0.0384	0.0
Inbreeding depression removed; no supplementation													
109	20	8	0.8	N	-0.044	-0.056	0.248	1.000	0.00	0.00	0.0000	0.0000	15.9
110	40	8	0.8	N	-0.044	-0.049	0.238	0.998	0.01	0.22	0.0000	0.0000	17.7
111	60	8	0.8	N	-0.044	-0.052	0.241	0.998	0.02	0.54	0.4063	0.0000	16.3
112	20	8	0.9	N	0.010	-0.004	0.182	0.796	2.82	5.90	0.4340	0.1885	35.8
113	40	8	0.9	N	0.010	-0.002	0.171	0.704	7.25	12.83	0.5272	0.1971	31.9

114	60	8	0.9	N	0.010	-0.002	0.171	0.720	9.34	17.54	0.5305	0.1984	32.0
115	20	8	0.95	N	0.036	0.025	0.143	0.282	11.88	8.07	0.5170	0.1804	35.9
116	40	8	0.95	N	0.036	0.028	0.126	0.248	26.90	16.30	0.6250	0.1474	29.1
117	60	8	0.95	N	0.036	0.029	0.122	0.232	42.03	24.68	0.6447	0.1609	32.3
118	20	8	1	N	0.061	0.053	0.120	0.044	17.75	4.42	0.5585	0.1669	27.6
119	40	8	1	N	0.061	0.056	0.100	0.024	37.92	6.66	0.6900	0.1077	18.3
120	60	8	1	N	0.061	0.056	0.094	0.048	56.23	12.94	0.7282	0.1060	24.0

Table 3. Line-by-line Vortex input file for the base scenario of N=5, K=20, and % of adult females breeding each year = 30%.

```
B004.OUT     ***Output Filename***
Y     ***Graphing Files?***
N     ***Details each Iteration?***
500     ***Simulations***
100     ***Years***
10     ***Reporting Interval***
0     ***Definition of Extinction***
1     ***Populations***
Y     ***Inbreeding Depression?***
3.140000     ***Lethal equivalents***
50.000000     ***Percent of genetic load as lethals***
N     ***EV concordance between repro and surv?***
2     ***Types Of Catastrophes***
P     ***Monogamous, Polygynous, or Hermaphroditic***
5     ***Female Breeding Age***
5     ***Male Breeding Age***
30     ***Maximum Breeding Age***
50.000000     ***Sex Ratio (percent males)***
2     ***Maximum Litter Size (0 = normal distribution) *****
N     ***Density Dependent Breeding?***
Pop1
30.00  **breeding
7.50  **EV-breeding
20.000000     ***Pop1: Percent Litter Size 1***
30.000000  *FMort age 0
8.000000  ***EV
5.000000  *FMort age 1
1.250000  ***EV
5.000000  *FMort age 2
1.250000  ***EV
5.000000  *FMort age 3
1.250000  ***EV
5.000000  *FMort age 4
1.250000  ***EV
5.000000  *Adult FMort
1.250000  ***EV
40.000000  *MMort age 0
10.000000  ***EV
10.000000  *MMort age 1
2.500000  ***EV
10.000000  *MMort age 2
2.500000  ***EV
10.000000  *MMort age 3
2.500000  ***EV
10.000000  *MMort age 4
2.500000  ***EV
5.000000  *Adult MMort
1.250000  ***EV
2.000000     ***Probability Of Catastrophe 1***
0.500000  ***Severity--Reproduction***
1.000000  ***Severity--Survival***
50.000000     ***Probability Of Catastrophe 2***
1.000000  ***Severity--Reproduction***
0.900000  ***Severity--Survival***
Y     ***All Males Breeders?***
Y     ***Start At Stable Age Distribution?***
5     ***Initial Population Size***
20     ***K***
0.000000     ***EV--K***
N     ***Trend In K?***
```

```
N       ***Harvest?***
N      ***Supplement?***
Y      ***AnotherSimulation?***
```

Table 4. Vortex data output file for the base scenario, described in Table 3..

```
VORTEX 8.41 -- simulation of genetic and demographic stochasticity

B004.OUT

  1 population(s) simulated for 100 years, 500 iterations

  Extinction is defined as no animals of one or both sexes.

  Inbreeding depression modeled with 3.14000 lethal equivalents per individual,
    comprised of 1.57000 recessive lethal alleles,
    and 1.57000 lethal equivalents not subject to removal by selection.

  First age of reproduction for females: 5   for males: 5
  Maximum breeding age (senescence): 30
  Sex ratio at birth (percent males): 50.000000

Population: Pop1

  Polygynous mating; all adult males in the breeding pool.

   30.00 percent of adult females produce litters.
   EV in % adult females breeding = 7.50 SD

   Of those females producing litters, ...
    20.00 percent of females produce litters of size 1
    80.00 percent of females produce litters of size 2

   30.00 percent mortality of females between ages 0 and 1
    EV in % mortality = 8.000000 SD
   5.00 percent mortality of females between ages 1 and 2
    EV in % mortality = 1.250000 SD
   5.00 percent mortality of females between ages 2 and 3
    EV in % mortality = 1.250000 SD
   5.00 percent mortality of females between ages 3 and 4
    EV in % mortality = 1.250000 SD
   5.00 percent mortality of females between ages 4 and 5
    EV in % mortality = 1.250000 SD
   5.00 percent mortality of adult females (5<=age<=30)
    EV in % mortality = 1.250000 SD
   40.00 percent mortality of males between ages 0 and 1
    EV in % mortality = 10.000000 SD
   10.00 percent mortality of males between ages 1 and 2
    EV in % mortality = 2.500000 SD
   10.00 percent mortality of males between ages 2 and 3
    EV in % mortality = 2.500000 SD
   10.00 percent mortality of males between ages 3 and 4
    EV in % mortality = 2.500000 SD
   10.00 percent mortality of males between ages 4 and 5
    EV in % mortality = 2.500000 SD
   5.00 percent mortality of adult males (5<=age<=30)
    EV in % mortality = 1.250000 SD

    EVs may be adjusted to closest values possible for binomial distribution.
    EV in mortality will be concordant among age-sex classes
       but independent from EV in reproduction.

  Frequency of type 1 catastrophes: 2.000 percent
    multiplicative effect on reproduction = 0.500000
    multiplicative effect on survival = 1.000000

  Frequency of type 2 catastrophes: 50.000 percent
    multiplicative effect on reproduction = 1.000000
```

```
    multiplicative effect on survival = 0.900000

  Initial size of Pop1:        5
    (set to reflect stable age distribution)
 Age 1     2     3     4     5     6     7     8     9    10    11    12    13
14    15    16    17    18    19    20    21    22    23    24    25    26
27    28    29    30    Total
     0     1     0     0     0     0     0     0     0     1     0     0     0
0     0     0     0     0     0     0     0     0     0     0     0     0
0     0     0     0        2  Males
     0     1     0     0     0     0     1     0     0     0     0     0     0
0     0     0     1     0     0     0     0     0     0     0     0     0
0     0     0     0        3  Females

  Carrying capacity = 20
    EV in Carrying capacity = 0.00 SD

Deterministic population growth rate
  (based on females, with assumptions of
  no limitation of mates, no density dependence, no functional dependencies,
and no inbreeding depression)

     r =  0.010     lambda = 1.010     R0 =     1.126
   Generation time for:  females = 12.12    males = 12.12

Stable age distribution:  Age class    females    males
                                0        0.081      0.081
                                1        0.053      0.046
                                2        0.048      0.039
                                3        0.043      0.033
                                4        0.038      0.028
                                5        0.034      0.023
                                6        0.030      0.021
                                7        0.027      0.019
                                8        0.024      0.017
                                9        0.022      0.015
                               10        0.019      0.013
                               11        0.017      0.012
                               12        0.015      0.011
                               13        0.014      0.010
                               14        0.012      0.009
                               15        0.011      0.008
                               16        0.010      0.007
                               17        0.009      0.006
                               18        0.008      0.005
                               19        0.007      0.005
                               20        0.006      0.004
                               21        0.006      0.004
                               22        0.005      0.003
                               23        0.005      0.003
                               24        0.004      0.003
                               25        0.004      0.002
                               26        0.003      0.002
                               27        0.003      0.002
                               28        0.003      0.002
                               29        0.002      0.002
                               30        0.002      0.001

Ratio of adult (>= 5) males to adult (>= 5) females: 0.690

Population 1: Pop1

Year 10
     N[Extinct] =     150, P[E] =  0.300
```

```
     N[Surviving] =   350, P[S] =  0.700
     Mean size (all populations) =    4.81 (   0.16 SE,    3.49 SD)
  Means across extant populations only:
     Population size =            6.20 (   0.17 SE,    3.20 SD)
     Expected heterozygosity =    0.777 (  0.004 SE,   0.070 SD)
     Observed heterozygosity =    0.990 (  0.002 SE,   0.042 SD)
     Number of extant alleles =    5.88 (   0.10 SE,    1.79 SD)
     Lethal alleles / diploid =    1.50 (   0.04 SE,    0.75 SD)

Year 20
     N[Extinct] =     272, P[E] =  0.544
     N[Surviving] =   228, P[S] =  0.456
     Mean size (all populations) =    3.65 (   0.19 SE,    4.16 SD)
  Means across extant populations only:
     Population size =            6.87 (   0.28 SE,    4.16 SD)
     Expected heterozygosity =    0.713 (  0.006 SE,   0.094 SD)
     Observed heterozygosity =    0.930 (  0.008 SE,   0.118 SD)
     Number of extant alleles =    4.79 (   0.10 SE,    1.49 SD)
     Lethal alleles / diploid =    1.44 (   0.05 SE,    0.78 SD)

Year 30
     N[Extinct] =     358, P[E] =  0.716
     N[Surviving] =   142, P[S] =  0.284
     Mean size (all populations) =    2.50 (   0.18 SE,    4.01 SD)
  Means across extant populations only:
     Population size =            7.51 (   0.37 SE,    4.45 SD)
     Expected heterozygosity =    0.644 (  0.010 SE,   0.123 SD)
     Observed heterozygosity =    0.832 (  0.014 SE,   0.170 SD)
     Number of extant alleles =    4.13 (   0.12 SE,    1.45 SD)
     Lethal alleles / diploid =    1.29 (   0.06 SE,    0.76 SD)

Year 40
     N[Extinct] =     416, P[E] =  0.832
     N[Surviving] =    84, P[S] =  0.168
     Mean size (all populations) =    1.56 (   0.15 SE,    3.45 SD)
  Means across extant populations only:
     Population size =            7.75 (   0.52 SE,    4.73 SD)
     Expected heterozygosity =    0.596 (  0.016 SE,   0.147 SD)
     Observed heterozygosity =    0.741 (  0.022 SE,   0.202 SD)
     Number of extant alleles =    3.69 (   0.15 SE,    1.41 SD)
     Lethal alleles / diploid =    1.14 (   0.08 SE,    0.74 SD)

Year 50
     N[Extinct] =     444, P[E] =  0.888
     N[Surviving] =    56, P[S] =  0.112
     Mean size (all populations) =    1.03 (   0.14 SE,    3.03 SD)
  Means across extant populations only:
     Population size =            8.00 (   0.66 SE,    4.92 SD)
     Expected heterozygosity =    0.574 (  0.022 SE,   0.168 SD)
     Observed heterozygosity =    0.717 (  0.032 SE,   0.241 SD)
     Number of extant alleles =    3.48 (   0.18 SE,    1.37 SD)
     Lethal alleles / diploid =    1.03 (   0.11 SE,    0.80 SD)

Year 60
     N[Extinct] =     464, P[E] =  0.928
     N[Surviving] =    36, P[S] =  0.072
     Mean size (all populations) =    0.71 (   0.12 SE,    2.62 SD)
  Means across extant populations only:
     Population size =            8.78 (   0.80 SE,    4.81 SD)
     Expected heterozygosity =    0.562 (  0.033 SE,   0.201 SD)
     Observed heterozygosity =    0.696 (  0.043 SE,   0.261 SD)
     Number of extant alleles =    3.39 (   0.22 SE,    1.32 SD)
     Lethal alleles / diploid =    0.97 (   0.12 SE,    0.69 SD)
```

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Year 70
     N[Extinct] =     472, P[E] =  0.944
     N[Surviving] =    28, P[S] =  0.056
     Mean size (all populations) =    0.51 (   0.10 SE,    2.24 SD)
  Means across extant populations only:
     Population size =             8.36 (   0.93 SE,    4.94 SD)
     Expected heterozygosity =    0.530 (  0.040 SE,   0.214 SD)
     Observed heterozygosity =    0.691 (  0.055 SE,   0.289 SD)
     Number of extant alleles =    3.04 (   0.22 SE,    1.14 SD)
     Lethal alleles / diploid =    0.78 (   0.11 SE,    0.57 SD)

Year 80
     N[Extinct] =     484, P[E] =  0.968
     N[Surviving] =    16, P[S] =  0.032
     Mean size (all populations) =    0.30 (   0.08 SE,    1.70 SD)
  Means across extant populations only:
     Population size =             8.38 (   1.17 SE,    4.66 SD)
     Expected heterozygosity =    0.522 (  0.057 SE,   0.229 SD)
     Observed heterozygosity =    0.638 (  0.083 SE,   0.332 SD)
     Number of extant alleles =    3.00 (   0.26 SE,    1.03 SD)
     Lethal alleles / diploid =    0.66 (   0.16 SE,    0.63 SD)

Year 90
     N[Extinct] =     486, P[E] =  0.972
     N[Surviving] =    14, P[S] =  0.028
     Mean size (all populations) =    0.21 (   0.07 SE,    1.45 SD)
  Means across extant populations only:
     Population size =             6.86 (   1.49 SE,    5.59 SD)
     Expected heterozygosity =    0.475 (  0.053 SE,   0.199 SD)
     Observed heterozygosity =    0.665 (  0.086 SE,   0.321 SD)
     Number of extant alleles =    2.57 (   0.20 SE,    0.76 SD)
     Lethal alleles / diploid =    0.72 (   0.18 SE,    0.69 SD)

Year 100
     N[Extinct] =     490, P[E] =  0.980
     N[Surviving] =    10, P[S] =  0.020
     Mean size (all populations) =    0.15 (   0.06 SE,    1.33 SD)
  Means across extant populations only:
     Population size =             7.30 (   2.02 SE,    6.38 SD)
     Expected heterozygosity =    0.386 (  0.076 SE,   0.239 SD)
     Observed heterozygosity =    0.485 (  0.110 SE,   0.346 SD)
     Number of extant alleles =    2.20 (   0.29 SE,    0.92 SD)
     Lethal alleles / diploid =    0.62 (   0.23 SE,    0.72 SD)

In 500 simulations of Pop1 for 100 years:
  490 went extinct and 10 survived.

This gives a probability of extinction of 0.9800 (0.0063 SE),
  or a probability of success of          0.0200 (0.0063 SE).

490 simulations went extinct at least once.
Median time to first extinction was 18 years.
Of those going extinct,
    mean time to first extinction was 22.87 years (0.85 SE, 18.80 SD).

Means across all populations (extant and extinct) ...
Mean final population was 0.15 (0.06 SE, 1.33 SD)

   Age 1       2       3       4   Adults    Total
    0.00    0.00    0.00    0.00    0.04      0.05  Males
    0.01    0.01    0.00    0.01    0.07      0.10  Females

Means across extant populations only ...
Mean final population for successful cases was 7.30 (2.02 SE, 6.38 SD)
```

Age 1	2	3	4	Adults	Total	
0.00	0.00	0.00	0.00	1.90	2.30	Males
0.00	0.00	0.00	0.00	3.60	5.00	Females

Across all years, prior to carrying capacity truncation,
mean growth rate (r) was -0.0157 (0.0019 SE, 0.2044 SD)

Final expected heterozygosity was	0.3857	(0.0756 SE,	0.2390 SD)
Final observed heterozygosity was	0.4849	(0.1095 SE,	0.3464 SD)
Final number of alleles was	2.20	(0.29 SE,	0.92 SD)
Number of lethal alleles per diploid	0.62	(0.23 SE,	0.72 SD)

Asiatic Black Bears PHVA

Final Report

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

Appendix 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.

---

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

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Asiatic Black Bears PHVA

Final Report

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

Appendix 2:

Workshop Action Plan Guidelines,
Workshop and PHVA Process,
And Participant List

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)

<u>Important Note</u>: This is <u>not</u> 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?

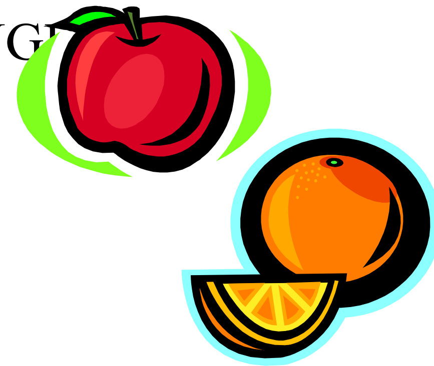
Resources

- 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 ORANG
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.

<table>
<tr><th colspan="2">1st Set</th><th colspan="2">2nd Set</th><th colspan="2">3rd Set</th><th colspan="2">4th Set</th></tr>
<tr><td>1. Apples</td><td>||</td><td>1. Apples</td><td>||</td><td>1. Apples</td><td>||</td><td>1. Apples</td><td>||</td></tr>
<tr><td>2. Oranges</td><td></td><td>2. Oranges</td><td>|</td><td>2. Oranges</td><td>|</td><td>2. Oranges</td><td>|</td></tr>
<tr><td>3. Kiwis</td><td>|</td><td>3. Kiwis</td><td>|</td><td>3. Kiwis</td><td>||</td><td>3. Kiwis</td><td>||</td></tr>
<tr><td>4. Peaches</td><td>|</td><td>4. Peaches</td><td>||</td><td>4. Peaches</td><td>|||</td><td>4. Peaches</td><td>|||</td></tr>
<tr><td>5. Apricots</td><td></td><td>5. Apricots</td><td>|</td><td>5. Apricots</td><td>|</td><td>5. Apricots</td><td>||</td></tr>
</table>

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 4th 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.

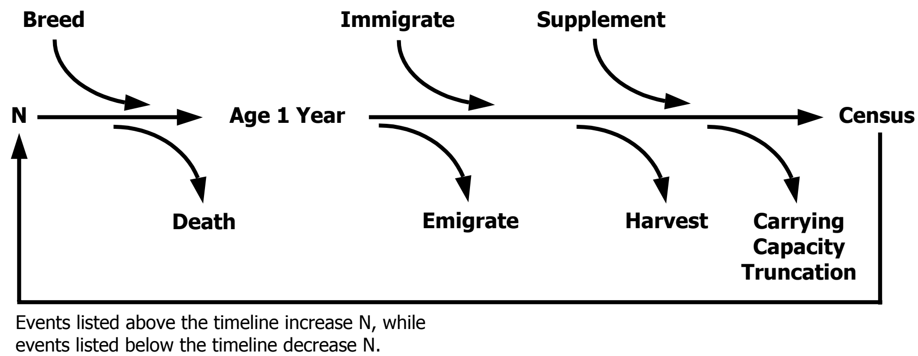
Density dependence in mortality is modeled by specifying a carrying capacity of the habitat. When the population size exceeds the carrying capacity, additional morality is imposed across all age classes to bring the population back down to the carrying capacity. The carrying capacity can be specified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



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:

<u>Deterministic r</u> -- 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.

<u>Stochastic r</u> -- 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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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

	Name	Affilation	Position	18	19	20
	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

Asiatic Black Bears PHVA

Final Report

for workshop held
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Seoul, Korea

Korean Final Report