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Formosan Pangolin PHVA

Taipei, Taiwan
23-26 October 2004

FINAL REPORT

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Workshop organized by: Taipei Zoo; IUCN/SSC Conservation Breeding Specialist Group (CBSG).

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Additional copies of *Formosan Pangolin Population and Habitat Viability Assessment Final Report* can be ordered through the IUCN/SSC CBSG office (office@cbsg.org or www.cbsg.org).

Formosan Pangolin
Population and Habitat Viability Assessment

Taipei, Taiwan
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SECTION 1

Executive Summary

Executive Summary

Introduction

The Formosan pangolin, *Manis pentadactyla pentadactyla*, is the type subspecies of the Chinese pangolin, one of three pangolin species found in Asia. This solitary, nocturnal mammal can be found in a diversity of habitats, including primary and secondary forests, bamboo forests, grasslands and agricultural fields. Pangolins feed primarily on ants and termites, using their front claws to open insect nests and long sticky tongues to capture their prey. They are largely terrestrial, spend most of the day in underground burrows, and curl into a ball when attacked, protected by thick scales that cover most of their bodies.

Pangolins were thought to be relatively common in Taiwan until the early 20th century. Over the past several decades the population appears to have declined, and field sightings are now very rare. There are no reliable population estimates for Taiwan, due primarily to the difficult nature of censusing this secretive species. The relationship between burrow density and pangolin density is not well understood, making it difficult to monitor the status of this species. Rapid human population and economic growth in Taiwan has led to habitat destruction and stronger hunting pressure on pangolins for their scales and meat. There is some evidence that while pangolins may still be widely distributed across their historical range in Taiwan, population numbers have been greatly reduced.

Little else is known regarding pangolin biology or the status of wild pangolin populations in Taiwan. There is little collaboration among researchers studying Formosan pangolins and no comprehensive management strategy for the species. The Taipei Zoo has cared for many injured or displaced pangolins that have been rescued, and its staff has accumulated some knowledge of pangolin husbandry, but this information has not been widely disseminated. For these reasons, the Taipei Zoo, the Taiwan Forestry Research Institute (TFRI) and the IUCN/SSC Pangolin Specialist Group (PSG) approached the Taiwan Council of Agriculture regarding the need for a population viability assessment and development of a conservation management strategy for the Formosan pangolin.

The PHVA Process

The Conservation Breeding Specialist Group (CBSG) was invited to conduct a Population and Habitat Viability Assessment (PHVA) workshop for the Formosan pangolin to assist in the development of an integrated conservation plan for the species. The PHVA workshop was held 23 – 26 October 2004 at the Taipei Zoo in Taipei, Taiwan and was sponsored by the Taiwan Council of Agriculture (COA). Participants included pangolin researchers, university faculty and graduate students, zoo staff and other biologists involved in pangolin issues (listed in Appendix II of this report).

CBSG was invited to serve as a neutral workshop facilitator and organizer. CBSG is a part of the Species Survival Commission (SSC) of the IUCN - World Conservation Union, and for more than 15 years has been developing and applying a series of science-based tools and processes to assist species management decision-making. One tool CBSG employs is use of neutral facilitators to moderate small working groups, as the success of the workshop is based on the cooperative process of dialogue, group meetings, and detailed modeling of alternative management scenarios.

Information sharing is at the heart of the PHVA workshop process, which takes an in-depth look at the species' life history, history, status, and dynamics, and assesses the threats that may put the species at risk. One crucial by-product of a PHVA workshop is that an enormous amount of information can be gathered and considered that, to date, has not been published. This information can be from many sources; the contributions of all people with a stake in the future of the species are considered.

To obtain the entire picture concerning a species, all of the information that can be gathered is discussed by the workshop participants with the aim of first reaching agreement on the state of current information. These data then are incorporated into computer simulation models to determine: 1) risk of population extinction under current conditions; 2) those factors that make persistence of the species problematic; and 3) which factors, if changed or manipulated, may have the greatest effect on improving the prospects for survival. In essence, these computer-modeling activities provide a neutral way to examine the current situation, identify and prioritize gaps in knowledge, and establish what needs to be changed to meet defined goals.

Complementary to the modeling process is a communication process, or deliberation, that takes place during a PHVA. Workshop participants work together to identify the data parameters to be entered into the *Vortex* model. During the PHVA process, participants work in small groups to discuss key issues. Each working group produces a report, which is included in the PHVA final report. A successful PHVA workshop depends on determining an outcome where all participants, coming to the workshop with different interests and needs, "win" in developing a model that best represents the reality for the species and is reached by consensus. The workshop report is developed by the participants and is considered advisory to the relevant management authorities for the species.

Immediately prior to the Formosan Pangolin PHVA workshop, CBSG conducted a 1.5 day training course on the use of *Vortex*. Many of the *Vortex* trainees also attended the PHVA, and they were able to come to the workshop with a better understanding of the model before applying it to the pangolin population. The PHVA workshop itself began with an introduction to the CBSG workshop process followed by a series of presentations regarding the current state of knowledge on wild and captive Formosan pangolins. The participants then generated a list of the primary issues affecting pangolin viability in Taiwan. Habitat loss/fragmentation and hunting were identified as the top concerns and became the basis of working groups focused on habitat issues and human-caused threats to pangolins. Everyone worked together in a plenary session to estimate population parameter values for the pangolin Vortex model; a third working group was then formed to complete development of the Vortex model and to identify research needs for future model improvement.

Each working group discussed and analyzed the problems for this species, formulated goals to address those problems, and recommended specific actions to accomplish those goals, resulting in the framework of a conservation action plan for Formosan pangolins. At each stage of the process each working group presented their conclusions to all workshop participants during plenary sessions to provide everyone with the opportunity to contribute to the work of the other groups and to assure that issues were carefully reviewed and consensus achieved. Sections 2 through 4 of this report contain detailed results from each of the working groups. Summaries of the results of each working group report are presented below.

Working Group and Model Results

The *Habitat Improvement Working Group* addressed those issues associated with pangolin habitat, an area of major concern among the workshop participants. All habitat-related concerns were categorized as related to habitat loss, habitat fragmentation, habitat degradation, or lack of knowledge regarding pangolin habitat requirements. Ten primary land use activities were identified and defined with respect to their impact on pangolins (in decreasing order of impact): road construction, housing, agriculture, stream channelization, golf courses, grave yards, temples, exercise activities, forest recreation areas, and tree plantations. The working group identified four major goals: reduce habitat loss; reduce habitat fragmentation; reduce habitat degradation; and increase understanding of pangolins. Specific actions were recommended to work toward these goals with respect to the top three land use activities of concern (road construction, housing and agricultural abuse).

Threats posed to pangolin populations by various human activities were discussed by the *Human-Caused Threats Working Group*. The group believed that the most serious threats are posed by predation by feral dogs and direct poaching of pangolins. Human development and human activities also threaten pangolins and their habitat (an area also addressed by the Habitat Improvement Working Group). The impact of pesticides on pangolins is unknown but may be a potential threat. Likewise, little is known about the possible existence of exotic pangolin populations (Malayan pangolins, *Manis javanicus*) and the potential for hybridization between Malayan and Formosan pangolins. The working group developed one or more goals and associated specific actions (with timelines and responsible parties) to address all identified threats. The group also recognized the lack of knowledge related to husbandry and veterinary care of pangolins among many who care for injured or displaced pangolins. Some of this expertise has been developed at the Taipei Zoo and should be standardized and disseminated, while other research is still needed.

The *Population Biology/Modeling Working Group* was tasked with developing a *Vortex* population model for the Formosan pangolin. The paucity of information made this a challenging task and limited the ability to use the model to test alternative management scenarios. The working group felt reasonably comfortable with the baseline model, which projected a slow decline in the pangolin population. Sensitivity testing was used to identify those parameters most critical to the model results. This enabled the working group to develop a prioritized list of research needs for a more complete assessment of the viability of wild pangolin populations, which included suggestions regarding methodology and potential responsible parties.

Although there was a limited amount of available data on wild pangolin populations going into the PHVA, this workshop was very beneficial in improving pangolin conservation. It provided the needed impetus to improve knowledge about pangolins by increasing communication and cooperation among the participants and identifying research needs. With the knowledge and expertise present, the workshop participants were able to develop prioritized goals and recommended actions that can serve as a framework for a pangolin conservation management strategy. Finally, the PHVA and associated *Vortex* course provided additional training in modeling and the PHVA process that can be applied across a diversity of species in Taiwan.

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SECTION 2

Habitat Improvement Working Group Report

Habitat Improvement Working Group Report

Members: Jung-Tai Chao, Yi-Ming Chen, Chung-Yen Fan, Hsin-I Hsieh, Chin-Ying Ko, Ching-Yuan Lee, Ping-Jung Lee, Chen-Yang Lin, Ting-Ting Lin, Pei-Jung Wang, Hsiao-Wei Yuan.

Refining the Topic

During the initial plenary session, workshop participants identified habitat loss and fragmentation as one of the major issues affecting wild pangolin populations in Taiwan. This working group was tasked with addressing those issues related to habitat loss and fragmentation, including the availability of food resources for pangolins and the lack of data on pangolin habitat requirements.

The group first conducted a brainstorming session to create a list of potential problems for pangolins related to habitat:

Habitat Loss / Fragmentation

- Housing development causes habitat loss, while road expansion associated with housing causes habitat fragmentation.
- Poor agricultural practices and plantations cause habitat loss and degradation.
- Landslides associated with earthquakes cause short-term habitat loss.
- Forest recreation areas may impact pangolin habitat.
- GIS can be used to determine the status of habitat fragmentation.
- There is a lack of data of habitat requirements for pangolins.
- Different types of roads result in different levels of impact.
- Will stream channelization prevent pangolins from crossing rivers, leading to habitat fragmentation?
- Do water resources and quality affect pangolin distribution, and how? How important are water resources to habitat selection? According to the current field knowledge, water resources have little effect on pangolins.

Food Resources

- Food abundance decreases along with habitat fragmentation. If there is sufficient habitat, then food may not be a problem.
- Pangolins prefer ants and termites. If termite nests are too deep, pangolins are unable to reach them.
- It may be necessary to study the distribution of ants and termites, and how different forest age and types affect these insects.
- We need to understand pangolin dietary needs and foraging strategies. For example, do pangolins feed on only part of an ant nest during a single feeding session (meaning that the same nest could provide ants for several feedings) or do they destroy the entire nest? How much preference is shown in food selection? Are any observed food preferences due to local availability as opposed to a true food preference?
- If habitats are well managed, food resources should become available and be less of a concern.
- Priorities for research depend upon the situation. For example, the abundance of food could be an indicator of population size when habitat qualities are equal.
- Do vegetation cover and soil types matter more than food abundance?

Soil / Climate

- Which soil types are preferred by pangolins?
- What is the depth of pangolin burrows?
- How does the climate affect pangolins? Climate and other environmental factors could be integrated into GIS.

These topics were clustering into four main topic areas – habitat loss, habitat fragmentation, habitat degradation, and lack of knowledge regarding habitat requirements – outlined below.

Habitat Loss: Pangolins no longer use the area.

1. Housing

The distorted real estate market makes people invest in houses but not actually use the space. The overabundance of houses destroys pangolin habitat. In particular, huge mansions and communities are usually built on hillsides, which is where pangolins are found. The lack of an EIA in the past has contributed to the rapid loss of habitat.

2. Forest recreation area

This is not a very serious habitat loss problem because the vegetation remains intact and the manager has the ability to enforce conservation polices. The group suggests that a limit in the number of visitors (carrying capacity) be established for these areas.

3. Golf courses

Golf courses with fences directly remove habitat from pangolins.

4. Illegally human use of original habitats

These usages include poor agricultural practices, certain buildings such as temples, grave yards and golf courses, and intensive facilities on suburban hills.

The first three involve legal uses of habitat. The working group suggests minimizing these effects with the development of corridors among areas of available pangolin habitat. Regarding illegal activities, the group suggests better enforcement of laws prohibiting these activities. Any fines obtained through enforcement should be used as conservation funds.

Habitat Fragmentation: There may be little loss in actual habitat area, but the movement and dispersal of pangolins within a population is reduced.

1. Road construction

2. Stream channelization

3. Edge effect

Habitat Degradation: The quantity of habitat remains unchanged, but the quality declines.

1. Golf courses without fences

2. Change in forest types (may recover in the future)

3. Human exercise activity, small scale (e.g., mountain climbing, hiking)

4. Pollution from pesticides and herbicides.

5. Disturbance during construction (e.g., noise)

Lack of Knowledge: With regard to habitat requirements of pangolins.

1. Food

More information is needed about pangolin dietary requirements, including distribution of food sources, foraging strategies, plant structure, climate effects, and water resources.

2. Burrows

Information is needed regarding pangolin requirements related to soil structure, topography effects, vegetation cover effects, climates effects, and position aspects.

Identifying and Prioritizing the Issues

The working group discussed all probable situations related to pangolin habitat. Both legal and illegal types of land use were considered, and research was eliminated from the discussion. This discussion resulted in 10 important land use issues related to habitat; each issue was then defined and described with respect to its effects on pangolin habitat.

Housing

Definition: Expanding residential area (community housing) on the hillside under 1500 m in elevation, mostly legal.
Effects: Habitat loss
Disturbance: Activities of residents
Other: Noise and other disturbance during construction

Forest Recreation Areas / National Parks

Definition: Areas established by government for public recreational purposes.
Effects: Habitat loss: Tourist center, including buildings and parking lots
Habitat degradation: Tourism
Disturbance: Tourist activities

Golf Courses

Definition: Golf courses, including buildings on hillside.
Effects: Habitat loss
Habitat degradation: Tree removal, application of pesticides and herbicides

Agricultural Abuse

Definition: Agriculture lands on the hillside under 1500 m in elevation; poor land use practice or illegal expansion.
Effects: Habitat loss: Rice paddies and vegetable gardens
Habitat degradation: Tea, fruit, betel nut and bamboo plantations. Food sources (termites and ants) decline after trees are removed.
Disturbance: Human activities
Other: Impacts of pesticides and herbicides

Temples

Definition: Temples on the hillside under 1500 m in elevation (recently expanding).
Effects: Habitat loss: Visitor facilities, including buildings, parking lots and gardens
Disturbance: Visitors, noise

Grave Yards

Definition: Grave yards on the hillside under 1500 m in elevation.
Effects: Habitat loss: Tree removal and huge concrete construction
Disturbance: Human activities
Other: Pesticide and herbicide application

Human Exercise

Definition: Hiking, camping, morning exercising and other activities on suburban hills.
Effects: Habitat degradation: Heavy trampling of ground
Disturbance: Noise and garbage from human activities

Road Construction

Definition: Highway and other roads with asphalt or concrete, logging roads and farm roads.

Effects: Habitat loss: Tree removal
Habitat fragmentation: Separation of continuous habitat
Habitat degradation: Decline in habitat quality by the roadside. Traffic causing interruption of dispersal and increased mortality due to road kills.
Disturbance: Traffic noise, harsh light, road construction and maintenance
Other: Construction of logging and farm roads induces hunting

Stream Channelization

Definition: Construction to change stream flow, bank and structure to avoid mud flows, using lots of concrete. It is popular to use cement to pave a streamside to prevent erosion in mountain areas. This civil engineering practice prevailed in the past decades.

Effects: Habitat loss: Construction to change stream flow, bank and structure
Habitat fragmentation: The steep and smooth cement riverbanks trap animals in the streams.
Habitat degradation: Decline in habitat quality along the riverside, interrupting dispersal
Other: Difficult for animals to access water from stream

Tree Plantation

Definition: Government policy to change a larger scale forest type (the policies of "Forest Improvement' and "Undergrowth Clearing" by Forestry Bureau).

Effects: Habitat change: Effect on pangolins could be positive or negative.

Although not included above, the group recognized that forest fires may also be an important factor affecting pangolin habitat. Most forest fires under 1500 m are caused by humans (e.g., related to grave clearing, agriculture, camping).

The working group used the paired ranking comparison method to prioritize these 10 issues (see Table 1). Due to time limitations the group chose to concentrate on the top three issues (road construction, housing and agricultural abuse) for developing goals and actions.

Table 1. Prioritized list of habitat-related issues.

Issue	**Combined Score**
Road construction	34
Housing	30
Agricultural abuse	24
Stream channelization	23
Golf courses	19
Grave yards	16
Temples	13
Human exercise	11
Forest recreation areas	6
Tree plantations	4

Developing an Action Plan

Many of the issues and goals related to pangolin habitat are interrelated. Four major goals were identified by the working group to address habitat-related concerns:

1. Reduce habitat loss.
2. Reduce habitat fragmentation.
3. Reduce habitat degradation.
4. Increase understanding of pangolins.

The working group developed the following table (Table 2) outlining the relationship between these goals, the three top priority issues and general recommended actions. Specific recommendations are detailed in the action plan below and in Table 3.

Table 2. Recommended actions to address each priority issue and goal.

	GOAL		
ISSUE (activity)	**Reduce habitat loss**	**Reduce habitat fragmentation**	**Reduce habitat degradation**
Road construction	*Promote critical review for new road construction.	*Connect habitat and improve road construction.	*Restrict road use in pangolin habitat.
Housing	*Decrease lowland hill development. *Establish wildlife protected area.		*Enhance conservation awareness of residents through community awareness programs.
Agricultural abuse	*Improve law enforcement for land abuse.	*Encourage habitat restoration.	*Reduce use of pesticides and herbicides.

Issue: Road Construction

Action 1: Promote critical review for new road construction.

The following recommendations should be addressed through legislation: Restrict road density in hilly areas; strengthen Environmental Impact Assessment (EIA); establish an EIA fund to maintain public confidence; improve civil engineering method and quality; restrict road width; design corridors.

1. Establish an NGO [possible names are Pangolin Watch Society (PWS) or Pangolin Watch International (PWI)].
2. Promote the pangolin and its image to induce public interest and concern.
3. Invite international scholars and the public to sign a request for legislation.

Action 2: Connect habitat and improve road construction.

The suggestion of establishing a corridor for pangolins should be made to the Department of Transportation.

1. Hold a freeway corridor workshop. Set up corridors between habitats fragmented by highways based on conclusions from the workshop.

2. Hold a highway corridor design contest to propose highway enhancement alternatives to the Department of Transportation.

Road construction along hillsides should be improved.

1. Improve drainage system of hill roads by limiting the depth and putting covers on sewers. Current drainage systems cause “road traps” and kill pangolins and other animals.
2. Construct underground pathway to assist animals in crossing a highway.
3. Improve fence structure on road sides to prevent animals from being stuck and caught in the fence.

Action 3: Restrict road use in pangolin habitat. Management authority: Local police office, Bureau of public roads

1. Restrict vehicles – reinforce the Law of Public Roads to restrict vehicle size and speed in hilly areas.
2. Restrict vehicle access time – limit traffic time in important habitats.
3. Set up signs to warn drivers to watch out for pangolins.

Issue: Housing

Action 1: Decrease lowland hill development.

- Strengthen EIA – establish a fund for EIA to maintain public confidence. Without independent and neutral financial support, sponsors (typically construction companies) with a particular interest in the outcome can affect the results.
- Restrict construction – legislate restriction of construction by management authorities in watersheds, etc. Improve legislation – limit building area in watersheds.
- Decrease existing human disturbance (PWS, Taipei Zoo, Administration of Education, primary schools).

1. Improve residents’ knowledge of pangolins through family activities and competitions (games).
2. Enhance conservation awareness of residents through community awareness programs.

Action 2: Establish wildlife protected area.

Establish “Important Wildlife Habitat” (IWH) protected area. Management authority: Council of Agriculture (COA), local government.

1. Use the pangolin habitat GIS database and habitat inventory data to ascertain and rank the priority of pangolin habitats.
2. Incorporate local conservation organizations to propose planning to local governments, and persuade the local government to apply for IWH announced by COA.

Issue: Agriculture

Action 1: Improve law enforcement for land abuse.

Supervise local governments, Taiwan Forestry Bureau, etc.

1. Set up a website and encourage the public to notify authorities about threatened habitats.
2. Announce habitat conditions and management efforts in threatened areas to develop public pressure on the government.

Action 2: Encourage habitat restoration – regain lost habitat, establish corridors.

- Set encouragement guidelines (award) to augment habitat restoration.
- Hold educational activities to improve farmer conservation awareness and understanding (Taipei Zoo, PWS, local conservation groups).
- Plan local ecotourism, construct visitor facilities, etc. to promote economic incentives for sustainable management.

Action 3: Reduce use of pesticides and herbicides.

1. Develop local organic agriculture.
2. Request the Environmental Protection Bureau to check pesticide or herbicide levels in hillside soils periodically.

Knowledge Required

The working group identified the following types of knowledge needed regarding pangolins to improve the ability to manage and conserve this species:

- Present and potential habitat distribution analysis using GIS tools
- Dispersal pattern
- Habitat fragmentation effects on gene diversity
- Habitat selection and requirements by pangolins
- Requirements for corridors
- Assessment of edge effect of roads
- Light and noise disturbance effects
- Food resources distribution pattern
- Pesticide and herbicide effects (through food or direct contact）
- Fire disturbance on pangolin populations and habitats

Table 3. Summary of actions and tentative schedule.

Strategy	*Actions or steps*	*Responsible parties*	*Timeline*
ROAD CONSTRUCTION			
Legislation (critical review of new road construction).	Establish an NGO (e.g., Pangolin Watch Society).	PHVA Habitat WG members	As soon as possible
	Promote the image for the pangolin to induce public interest and concern.	PWS, Taipei Zoo Foundation	2005
	Invite international scholars and the public to sign a request for legislation.	PWI, Taiwan scholars	Before 2007 council election
Connect habitat and improve road construction.	Hold a freeway corridor workshop.	PWI, Department of Transportation	2006
	Hold a highway corridor design contest.	PWI, Department of Transportation	2006
	Improve drainage system of hill roads.	Related road maintenance authorities	Ongoing
	Construct underground pathway.	Department of Transportation	Ongoing
	Improve fence structure on roadsides.	Department of Transportation, related road maintenance authorities	Ongoing
Restrict road use in pangolin's habitat.	Restrict vehicles.	Local police office, Bureau of public roads	2008
	Restrict vehicle time.		
	Set up warning signs.	Taipei Zoo Foundation, Bureau of public roads	2006
HOUSING			
Decrease lowland hill development.	Strengthen EIA－establish a neutral fund for EIA.	PWS, EPB	2009
	Restrict construction (total area of limited portion) in a watershed.	PWS, management authorities in watersheds	2008
	Decrease existing human disturbance through education.	Taipei Zoo, Administration of Education, primary schools	2010
Establish wildlife protected area.	Establish "Important Wildlife Habitat" protected area.	Management authority: COA, local government	2015
	Use the pangolin habitat GIS database and habitat inventory data to ascertain and rank the priority of pangolin habitats.	Dr. Lee Pei-Fen, graduate students, local police offices (records), Taipei Zoo (records)	2006
	Incorporate local conservation organizations to propose planning to local governments, and persuade the local government to apply for IWH announced by COA.	Society of Wildness, Animal Protection Society, wild bird societies, PWS, local government, COA	2007
AGRICULTURE			
Improve law enforcement for land abuse.	Set up a website and encourage the public to notify authorities about threatened habitats.	PWS, local governments, Taiwan Forestry Bureau, etc.	2005
	Announce habitat conditions and management efforts in threatened areas to develop public pressure on the government.	PWS, public media.	2008
Encourage habitat restoration.	Set encouragement guidelines to augment habitat restoration.	PWS, local and central councils	2007
	Hold educational activities to improve farmer conservational awareness and understanding.	PWI, Taipei Zoo, primary schools, local conservation groups	2009
	Plan local ecotourism, construct visitor facilities, etc. to promote economic incentives.	PWI, tourism companies, local NGOs, local residents	2008
Reduce use of pesticides and herbicides.	Develop local organic agriculture.	Academic research team, PWI, farmers	2006
	Request the Environmental Protection Bureau to check pesticide or herbicide levels in hillside soils periodically.	EPB, PWS, public media, Consumers Protection Society	2008 and ongoing

COA = Taiwan Council of Agriculture
EBP = Environmental Protection Bureau
PWI = Pangolin Watch International; PWS = Pangolin Watch Society

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SECTION 3

Human-Caused Threats Working Group Report

Human-Caused Threats Working Group Report

Members: Thattyata Bidayabha, Joann C.W. Chang, Ellen C.M. Chin, Jason Shih-Chien Chin, Jun-Cheng Guo, Richard Tenaza, Ci-Wen Yang, Hsiao-Wei Yuan.

The Human-Caused Threats Working Group identified and ranked human-caused threats to the Formosan pangolin as shown in Table 1 below. For each of these threats the working group established: 1) a set of goals to deal with the threat, and 2) actions – or activities – to accomplish these goals. The goals, actions, timelines, and parties proposed to be responsible for the actions are summarized in Table 3 at the end of this section. A category-by-category explanation of the threats follows. Veterinary requirements for treating rescued pangolins were also considered.

Feral Dogs

Feral dogs are domestic dogs that have gone wild, or dogs descended from such strays. They live as wild predators, attacking many kinds of wildlife, including pangolins. Pangolins assaulted by dogs are stressed, injured, or killed. Dr. Jason Chin estimates that 20 - 30% of rescued pangolins brought to Taipei Zoo in the last 15 years had been injured by dogs.

Formosan pangolins mainly live in habitats below 1000 m in elevation (some also live between 1000 – 2000 m). During the past decade humans have exploited this altitudinal zone intensively for housing, industry, and agriculture. Pet dogs accompanying humans settling in these recently developed areas harass pangolins, and some become full-time feral predators.

Goal: *Control feral dog populations in pangolin habitat and in all national parks and other conservation areas.*

Table 1. Conservation threats to the Formosan pangolin. Priority Rating A-1 signifies the highest degree of threat, A-2 the next highest, etc. The ratings represent the combined educated estimates of members of the working group.

Threat	**Priority Rating**	**Explanation**
Feral dogs	A-1	Feral dogs attack pangolins, causing them stress, injury, and death.
Poaching	A-1	Poachers capture pangolins for meat, scales, and skins.
Development	A-2	Development is destroying, degrading, and fragmenting pangolin habitat.
Other human disturbances	A-2	Collection of plants, logging, recreational activities, garbage dumps, pesticides, and road traffic are other human threats to pangolins.
Pesticides	B	The extent to which pesticides in their food and water may threaten pangolins in unknown.
Hybridization	B	In the 1970s large numbers of Malayan pangolins were imported into Taiwan to supply the scale and leather market. If any became feral, they and their descendents may pose a human-caused hybridization problem to the Formosan pangolin.

Taiwan law requires that all dog owners register their dogs with the government. The working group suggests that every dog be marked with a microchip at the time of registration, and that a computerized record-keeping system be established. This would make it possible to recognize any dog that has been registered, and trace it to its owner. This would facilitate enforcement of dog control laws. Stray dogs should be removed from pangolin habitat.

Garbage in conservation areas as well as in residential areas provides food for feral dogs, which may result in higher dog populations than could otherwise exist. An analogous example occurred in parts of North America, where garbage dumps increased gull populations, which in turn increased predation pressure by gulls on other seabirds. As feral dog populations are increased by garbage, the predation pressure on pangolins and other wildlife susceptible to dogs also increases. Thus garbage control becomes an aspect of wildlife protection. The working group recommends several measures to control garbage.

Poaching

Taiwan banned hunting of pangolins and trade in pangolin products in 1989. Before that pangolins were hunted for their meat, which is eaten; for their scales, which are used in Chinese medicine; and for their skin, which is made into leather. Records on numbers of pangolins legally traded in Taiwan by three companies between 1934 and the 1980s are presented in Table 2.

Although Taiwan now prohibits hunting of pangolins, poachers still hunt them. Poachers drive pangolins from their burrows with smoke, catch them by hand at night when pangolins are active, or dig them from their burrows following heavy rains, when the soil is soft. Pangolin hunters in Thailand frequently use the digging method during the rainy season. In addition, hunters that set traps to catch other animals may capture pangolins unintentionally.

Smuggling of pangolins and pangolin products continues. For example, in August 2004 the Taiwan government confiscated a 2000 kg shipment of pangolin scales that was being smuggled into Taiwan. Pangolin smuggling affects conservation of the Formosan pangolin in two ways: First, exotic pangolins that are released or that escape in Taiwan might hybridize with Formosan pangolins, or they might develop feral populations that compete with the native species. Second, importation of pangolin products into Taiwan stimulates illegal trade, putting poaching pressure on the native pangolin.

Goal: *Reduce or stop poaching of pangolins.*
Goal: *Reduce demand for pangolins and pangolin products.*

Table 2. Trade statistics for three companies that were involved in trading pangolin products in Taiwan before the trade was banned in 1989.

Company	Year Entered Trade	Peak Trade in Formosan Pangolins	Statistics on Imported Pangolins	Year Trade in Pangolins Ceased
A	1934 1000 skins/mo.	1959-1979 >1000 skins/mo.	1967-1980 >3000 skins/mo.	1980
B	1940	1950-1972 >1000 skins/mo.	1972-1983 >4000-5000 skins/mo.	1983
C	1959	1968-1972 >1500 skins/mo.	1973-1981	1981

Human Disturbances

One set of human-caused disturbances to pangolins is activities related to industrial, residential, agricultural, recreational, and transportation development. These activities can remove, diminish, and fragment natural habitats. A second set of disturbances occurs through use of natural environments for recreation, for collecting medicinal and other plants, and for releasing unwanted pets, which may become predators on pangolins. Visitors in protected areas may disturb wildlife by bringing dogs that disturb wildlife or by leaving garbage behind that attracts and nourishes feral dogs.

Goal: *Minimize human disturbance to pangolin populations.*

People often do not know what pangolins are, and do not understand how development or other human-related activities and factors (e.g., dogs, garbage, pesticides, plantations) affect pangolins. Public awareness could be increased by educating teachers, students, parents and the general public about the conservation of native species and why they should not use medicines derived from wildlife. Similar education efforts could be targeted toward government officials. One component of a public awareness program would be to increase media attention on native species.

Goal: *Increase public awareness of pangolins*

Biocides

Chemicals used to control crop pests and diseases of domestic animals can contaminate invertebrate prey and concentrate in food chains, ultimately poisoning wildlife. By killing invertebrates they also reduce the food supplies of pangolins and other wildlife dependent on invertebrates for food.

Goal: *Stop or reduce the use of highly toxic pesticides.*
Goal: *Promote the idea of coexistence between humans and pangolins.*

Hybridization/Competition with Malayan Pangolins

Before Taiwan prohibited trade of pangolins in 1989, tens of thousands of Malayan pangolins *(Manis javanicus)* were imported into Taiwan from Southeast Asian countries. With so many thousands of Malayan pangolins imported, it seems likely that some would have escaped or been released into the wild and become feral in Taiwan. Three possible scenarios are as follows:

1. Malayan pangolins are unable to survive wild in Taiwan, so all escaped or released individuals died and no problem exists.

2. If some survived and hybridized with Formosan pangolins, then it threatens the genetic integrity of the Formosan pangolin.

3. If feral Malayan pangolins cannot hybridize with Formosan pangolins but formed populations of their own, then they may have become competitors with the native species.

Field, systematic, and genetic research are required to determine which of these three scenarios occurred.

Goal: *Clarify the taxonomic status of the Formosan pangolin.*
Goal: *Reduce the possibility of hybridization between Formosan pangolins and feral Malayan pangolins.*

Veterinary Care for Injured/Weakened Pangolins

Pangolins rescued after being injured or displaced by human activities require shelter, feeding, and medical treatment. The most common ailments of rescued pangolins arriving at the Taipei Zoo have been dog bites, injuries from traps, gastric ulcers, and pneumonia.

Care of rescued pangolins falls to wildlife veterinarians, but few know pangolin nutritional requirements or how to diagnosis their medical problems. Few know, for example, that to remain healthy, captive pangolins require plenty of chitin in their diets and must be housed at ambient temperatures above 22^{o} C (this is based on unpublished studies at Taipei Zoo).

Goal: *Improve veterinary care for rescued pangolins.*
Goal: *Increase knowledge of pangolin biology and medicine.*

In addition to caring for rescued pangolins, veterinarians should join field research to monitor the health situation of pangolins in the wild.

Several studies have been conducted by the Taipei Zoo on the veterinary care, diet, husbandry, anatomy, reproduction, and behavior of Formosan pangolins in captivity; the results of these studies are presented in Appendix I.

Table 3. Goals for conservation of the Formosan pangolin, actions proposed to accomplish the goals, parties responsible for accomplishing them, and timelines for accomplishment.

Goal	Recommended Actions	Responsible Party	Timeline
Control feral dogs.	1. Mark pet dogs with microchips during registration and keep computerized records. Remove stray dogs from pangolin habitat.	BAPHIQ (identity records), EPB (stray dog removal).	30 June 2005, ongoing
	2. Control garbage (food source for feral dogs). Improve garbage container insulation to keep out dogs.	EPB	31 Dec. 2005, ongoing
	3. Anti-littering campaign to increase public awareness about littering.	National Parks, Media, Government Information Office, Taipei Zoo	31 Dec. 2005, ongoing
Stop poaching.	1. Enforce wildlife conservation laws.	COA, Police	Ongoing
	2. Encourage visitors to remove traps and report them to police.	National Parks, Local Government, Ag. Bureau, Forestry Bureau., Police	Ongoing
	3. Organize volunteer watch team to prevent poaching.	Local Govt., National Parks, Conservation Organizations	ASAP
Reduce demand for pangolins and pangolin products.	1. Enforce the conservation laws.	COA, Police	Ongoing
	2. Encourage the substitution of pig hoof for pangolin scales in Chinese medicine.	Chinese Medicine Association	ASAP
	3. Prevent smuggling of pangolins into and out of Taiwan.	Conservation Police, Customs, Coast Guard Administration	Ongoing
Minimize human disturbance to habitats and wildlife.	1. Conduct basic research on pangolin biology and populations and establish a data center.	Taipei Zoo, TFRI, COA, National Science Council	ASAP
	2. Establish EIA requirement before construction; encourage ecological engineering.	Central and Local Governments	Ongoing
	3. Prepare "Rules of Conduct" for park visitors.	TFRI, COA, Local Government, Inspection Police Office	30 June 2005
	4. Encourage Eco-Farming.	Local Government, COA, Farmers	Ongoing
	5. Enforce National Park laws and construction-related laws.	Local Police, Forestry Bureau., COA, Nat. Parks	Ongoing
Increase public awareness of pangolins.	1. Add study of native fauna and flora to basic school curricula.	Ministry of Education	ASAP
Stop or reduce use of highly toxic pesticides.	1. Restrict use of highly toxic pesticides and promote organic farming.	TACTSRI, COA	Ongoing

Goal	Recommended Actions	Responsible Party	Timeline
Promote the idea of coexistence between humans and pangolins.	1. Promote organic farming.	TACTSRI, COA	Ongoing
Clarify the taxonomic status of the Formosan pangolin.	1. Conduct comparative genetic studies of the Chinese and Formosan pangolins to determine whether the latter is a subspecies of the former, as currently believed, or a distinct species.	Taipei Zoo, University Researchers, Investigation Bureau	Ongoing 31 December 2005
Reduce the possibility of hybridization between Formosan and feral Malayan pangolins.	1. Prevent wildlife smuggling.	Conservation Police, Customs, Patrol Agency, Investigation Bureau	Ongoing
Improve veterinary care for rescued pangolins.	1. Establish diets and protocols for quarantine and basic physical exam procedures.	Taipei Zoo	Ongoing
Increase knowledge of pangolin biology and medicine.	1. Research in anatomy, physiology, nutrition, and medical care of pangolins.	Taipei Zoo, University Researchers	Ongoing

BAPHIQ = Bureau of Animal and Plant Health Inspection and Quarantine
COA = Taiwan Council of Agriculture
EPB = Environmental Protection Bureau
TACTSRI = Taiwan Agricultural Chemicals & Toxic Substance Research Institute
TFRI = Taiwan Forestry Research Institute

At the first meetings of the members of the research teams Jung-Tai Chao will add to the agenda a discussion of how to best influence/inform the different government bodies and institutions mentioned above. Jason S.C. Chin will coordinate actions related to pangolin husbandry and veterinary care.

Formosan Pangolin PHVA

Taipei, Taiwan
23-26 October 2004

FINAL REPORT

SECTION 4

Population Biology/Modeling Working Group Report

Population Biology/Modeling Working Group Report

Members: Ke-Yang Chang, Hsuan-Fen Chen, Shu-Mei Chen, Yi-Hsiu Chen, Chung-Chi Hsu, Sofia Jeng, Cho-Yen Lai, Ling-Ling Lee, Kristin Leus, Chen-Yeh Lien, David Reed.

This working group was tasked with further developing input parameters for the *Vortex* model of the Formosan pangolin. A preliminary baseline model was already available from plenary discussions at the beginning of the PHVA workshop.

Input Parameters for Baseline Model in Vortex

Parameter values used for the baseline model were a result of the plenary and working group discussions and are given below.

Model Conditions: **1,000 iterations for 100 years**
The simulation scenarios were run 1,000 times for 100 time-steps (years). Suggestions were made to forecast 20, 50 or 100 years into the future. Twenty and 50 years were decided to be too short in relation to the generation length of the pangolin.

Extinction: **Only one sex remaining**

Number of populations: **4**
Four populations were modeled. There were no genetic studies available with information on the population structure of pangolins on Taiwan. However, studies on other organisms have suggested different populations existing on the east and west coasts, due to the mountain ranges that bisect the island. The two sides of the island are linked in the north, but there is a highway bisecting this area. It is known that pangolins do try to cross roads as they are sometimes found dead along roadsides after being struck by motor vehicles. It is assumed that some pangolins cross the highway and, therefore, the road is not an absolute barrier. However, gene flow is thought to be small and localized to that area. It was the consensus of the experts that the pangolins cannot cross the mountains. It was also brought out that the Yangmingshan National Park area (YMS) is geographically isolated from other pangolin populations because of human activity (the park lies within Taipei city); about 200 pangolins are thought to live there. Finally, there is also a coastal range population that is believed to be isolated from other populations.

Inbreeding Depression: **LE = 3.14**
Inbreeding depression was included in the model. We used the median value, for 40 mammalian species in captivity, of 3.14 lethal equivalents. *Vortex* models inbreeding depression for juvenile survival only. We assumed that 50% of the lethal equivalents were due to completely recessive lethal alleles and the other 50% was due to recessive alleles of smaller effect.

Environmental Concordance of Reproduction and Survival: **Yes**
There were no data available on this, and the group was unable to reach consensus on the major types of environmental variation affecting pangolin populations or the extent of the concordance. Thus, it was decided to use the most conservative choice and make the two concordant.

***Correlation among Populations in Environmental Variation:* 0.75**
This correlation was set at 0.75. It was generally agreed that, despite being a subtropical island, different geographical regions have their own microclimate and that these regional differences could affect food availability and other factors for pangolins. However, the island is not very large and climate differences in the different geographic regions are not great. The lack of migration among populations might help shelter the populations against a disease epidemic.

***Catastrophes:* 1 (severe cold)**
A severe cold front with heavy rain was felt to be the single catastrophe facing pangolin populations on Taiwan. Typhoons were also mentioned as a possible catastrophe, but were then discarded.

***Dispersal:* see below**
It is thought that there is small amount of dispersal among populations. Dispersers are believed to be from 1-4 years of age. Both males and females disperse. Pangolins picked up away from their habitat tend to be about 50% males and 50% females. It is felt that mortality among dispersing individuals is very high because they often die from collisions with motor vehicles, are killed by dogs, or collected by people. Thus, we entered 80% mortality for dispersing individuals.

There are no data regarding the percent of pangolins that disperse from one population to another per year. Discussion among the working group members lead to the following estimates of dispersal among populations (proportion of 1-4 year olds dispersing each year):

	To:			
From:	Coast	East	West	YMS
Coast	0.95	0.05	--	--
East	0.02	0.93	0.05	--
West	--	0.05	0.94	0.01
YMS	--	--	0.05	0.95

***Breeding System:* Polygynous**

***Age of First Reproduction:* 3 years**
Expert opinion was that the average age of first reproduction is three years for both females and males.

***Maximum Age of Reproduction:* 15 years**
Considerable variation existed among the experts' estimates of the maximum age of reproduction for female pangolins. We chose 15 years for the baseline model.

***Proportion of Females Breeding:* 20-80% (density dependent)**
We assumed that reproduction was density dependent. No data are available on the proportion of females breeding. Using the interbirth interval reported from the Taipei Zoo, we estimated that 80% of females were breeding at low density and only 20% at carrying capacity.

***EV in % of females breeding (in SD):* 10%**
The working group decided that 10% was an appropriate value.

***Maximum Number of Offspring:* 2**
Twins occur very rarely. We set the values so that 99% of pangolin births consisted of one offspring and 1% of births were twins.

***Mortality Rates:* see below**
No data on mortality rates were available for any age class of pangolins. The working group based the following mortality estimates on experience with other mammals of similar size or life history.

Age class	Age (yrs)	% Mortality	SD (%)
Juvenile	0 – 1	40	10
Sub-Adult	1 – 2	22.5	5
Adult	> 2	10	2

***Rate and Severity of Catastrophes:* Survival = 0.8; occurs every 20 – 200 years**
Cold fronts are not thought to affect reproductive rate (percent of females breeding) but to affect survival by reducing it by 20%. Catastrophes are typically events that happen very rarely and have major consequences for reproduction and/or survival. The first estimated annual probabilities for catastrophes established in plenary were quite high and were reduced by the working group to 5%, 2%, 2%, and 0.5% (for the YMS, East, West, and Coast populations, respectively). This seems much more reasonable in light of the literature (Reed *et al.* 2003) and what is actually known about pangolin population dynamics.

***Mate Monopolization:* 50% males breed**
An estimated 50% of adult males are in the breeding pool.

***Carrying Capacity:* 30,000**
Records show that 60,000 pangolins were legally harvested (primarily for traditional Chinese medicines) annually, for 12 years, ending in the early 1980s. At this point the industry became financially untenable due to the scarcity of pangolins. This implies that the carrying capacity of the habitat for pangolins was hundreds of thousands of individuals. There has been a loss of pangolin habitat since that time. The working group decided that a conservative estimate of total carrying capacity of the remaining habitat would be 30,000 individuals (see Table 1).

***Initial population size:* 10,200**
There are some rough estimates of pangolin density for the whole island. We estimated the total starting population size at 10,200 individuals (see Table 1).

Table 1. Estimates of population size and carrying capacity for each of four pangolin populations.

Population	Carrying capacity	Initial population size
Coast	3,000	1,200
East	11,500	3,800
West	15,000	5,000
YMS	500	200
Total	30,000	10,200

Results of Simulation Modeling

The modeling results suggest a population that is in a very slow but steady decline. The deterministic growth rate is slightly positive (r_{det} = 0.014). However, the stochastic growth rate is negative (r_{stoch} = -0.024). Thus the population appears as though it is in a shallow deterministic decline. The baseline model suggests that the Formosan pangolin metapopulation has a very low probability of extinction over the next 100 years given a stable situation described by the estimated parameter values used in the baseline model. In fact, even the YMS population alone has only an estimated 3.6% chance of going extinct over 100 years (the other populations had no extinctions in 1000 simulations). However, it must be noted that the mean size of the entire metapopulation is projected to decline from 10,000 individuals to ~ 1,000 individuals after 100 years (Fig. 1). This suggests that the population is headed for extinction if steps are not taken to reverse this trend.

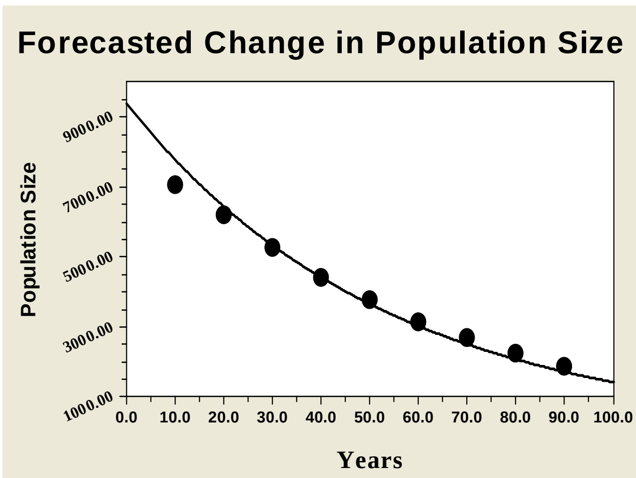

Figure 1. Projected trend in population size for Formosan pangolins over the next 100 years.

Shortly after the pangolin became scarce in the 1980s and large-scale slaughter stopped, the species became protected and illegal trade now appears to be largely under control. According to the best estimates of the experts, the pangolin population in Taiwan is currently thought to be either only slightly decreasing or remaining steady. The populations in the north might even be slightly increasing based on the number of pangolins brought in by people (found on the roads, etc.) and the evidence of many new burrows. However, there are other possible explanations for both the increase in pangolins brought to shelters and the increase in burrows. In summary, despite the very small amount of actual data, the model appears to describe the present and possible future state of the Formosan pangolin reasonably well, assuming that everything pertinent to the model remains constant.

Table 2 shows the results of sensitivity testing on a number of parameters included in the model. The baseline model provided an estimated zero probability of extinction in 100 years. Increasing first-year mortality to the highest rate the working group felt possible (50%) increased the probability of extinction to 5%. Increasing juvenile mortality to 30% had a much larger effect, increasing the estimated probability of extinction to 23%. Increasing adult mortality to 12% increased the estimated probability of extinction to 6%, similar to that of changing juvenile mortality. Removing the catastrophe regime did not alter the baseline model's estimated probability of extinction (0%). Further, it had very little effect overall, as the final population size after 100 years changed only from N = 1082 with catastrophes to N = 1582 without catastrophes. There was considerable debate about the maximum reproductive age of female pangolins. Thus we altered the baseline model (15 years of age) to include a maximum age of 20 and a maximum age of 10. As can be seen in Table 2, lowering the maximum reproductive age of female pangolins to 10 has a dramatic effect on the estimated probability of extinction – increasing it to 68%. Best and worst case scenarios combine the most optimistic and most pessimistic variable estimates for each parameter, respectively. Only under the "best case scenario" does the population grow.

Table 2. Probability of extinction (PE) and mean population size (N) in 100 years for pangolin metapopulation under each scenario.

Scenario	PE	N (extant)
Baseline	0.00	1,082
Best Case Scenario	0.00	25,858
Worst Case Scenario	1.00	--
Maximum Age (20 yrs)	0.00	2,715
Maximum Age (10 yrs)	0.68	11
No Catastrophes	0.00	1,582
Adult Mortality, High	0.06	51
Adult Mortality, Low	0.00	5,490
Sub-Adult Mortality, High	0.23	20
Sub-Adult Mortality, Low	0.00	3,260
Juvenile Mortality, High	0.05	51
Juvenile Mortality, Low	0.00	2,160

Research Needs

The working group first brainstormed to create the following list of research needs based in part upon the lack of data available for the *Vortex* model:

- Determine possible correlation in demographic parameters due to environmental variation among the different populations.
- Conduct long-term studies of the different populations to get information on the types, frequencies and severity of catastrophes.
- Determine the number of populations and the degree of genetic isolation among them.
- Determine life history parameters for the Formosan pangolin, including:
    - age of first and last reproduction of both sexes
    - sex ratio
    - litter size
    - interbirth interval
    - possibly seasonality in births
    - mating system, including quantification of mate monopolization
- Estimate the amount of density dependence in reproduction for each population.
- Determine the percent of adult females breeding in each population.
- Determine mortality rates for juveniles, sub-adults and adults for each population.
- Determine the current size of each population.
- Determine the carrying capacity for the different habitats (requires habitat knowledge and pangolin density for different habitats).

Prioritizing Research Needs

Sensitivity testing of the following parameters was carried out in *Vortex*:

- Adult mortality
- Juvenile mortality
- Catastrophes (*i.e.*, with or without the one catastrophe identified)
- Maximum age of reproduction (longevity)

The baseline model proved to be most sensitive to changes in mortality and longevity. Thus, priority should be given to projects that will provide estimates of these parameters.

Goals and Actions

The following goals and actions were assigned for these research needs in order of priority:

Priority 1: Determine maximum age of reproduction and mortality rates.

(Note: By determining an age-specific mortality schedule it is possible to make good estimates of the maximum age of reproduction.)

Goals:

1. Determine mortality in the wild and its causes (natural and anthropogenic).

2. Define the maximum age of reproduction.

Actions:

1. Conduct radio-transmitter studies on adult females and their offspring.

Suggest to Dr. Ling-Ling Lee, Mr. Yi-Ming Chen, Dr. Jung-Tai Chao, Dr. Hsiao-Wei Yuan, and Dr. Chin to concentrate on radio-tracking females (priority over males) as much as possible.

The research team members will meet every three months to discuss progress, data collected and experiences. First meeting will be called by Dr. Chao and take place late November/early December 2004.

2. Develop methods to capture pangolins.

Using data only from pangolins that have been found (e.g., along roads) may produce a bias in sex and age (e.g., dispersing individuals) and may be less efficient.

Get information and suggestions on methods from indigenous people and/or hunters through interviews. Thattaya Bidayabha will gather information in Thailand, and Hsiao-Wei Yuan and Yi-Ming Chen will gather information in Taiwan.

Ask researchers that work with other pangolin species if and how they capture pangolins alive for radio tracking. Hsiao-Wei Yuan and Dr. Chao will make contact with researchers in India. Dr. Chao will try to get information through the Pangolin Specialist Group. Thattaya will provide information from her research project in Thailand.

3. Spread the news that this research is urgent and important (see General Actions).

4. Define method to age pangolins.

This would be a good project for Taipei Zoo to work on. Jason Chin and staff at Taipei Zoo will explore the possibilities for this.

Long-term research projects aimed toward these goals will result in gathering data relevant to the parameters listed below:

- Frequency and severity of catastrophes
- Age of first reproduction
- Age of last reproduction
- Sex ratio of adults
- Litter size
- Interbirth interval
- Seasonality of births
- Proportion of females breeding during a year and the variation in this parameter across years
- Age-specific mortality rates

The remaining research needs were prioritized as follows:

Priority projects:

1. Determine the current size of each population, trend in population size, and carrying capacity (requires habitat knowledge and knowledge of densities in different habitats).
2. Determine the number of populations and the degree of genetic isolation/dispersal among the populations (requires development of molecular markers such as microsatellites, AFLPs, or RFLPs for Formosan pangolins).

Other projects:

3. Investigate possible density dependence of reproduction for each population.
4. Determine mating system, including quantification of mate monopolization.
5. Determine possible correlation of EV (environmental variation) in demographic parameter variation among the different populations (follows from the other research, over time).
6. Explore the possible use of pheromone analyses for individual recognition of pangolins (as a methodology).

Priority 2: Determine the current size of each population, trend in population size, and carrying capacity.

Goals:

1. *Determine current size of each population, trend in population size, and carrying capacity.*

Actions:

1. *Validate the burrow counting method for estimating pangolin numbers.*
2. *Explore other possible methods for estimating population size for pangolins.*
3. *Determine pangolin density in different habitat types.*
4. *Determine the habitat types and total amount of habitat available to pangolins..*

Encourage Chung-Yen Fang and Yi-Ming Chen to continue with their research projects, which are addressing these issues. Spread the news that this research is urgent and important (see General Actions).

Priority 3: Determine the number of populations and the degree of genetic isolation/dispersal among populations.

Goals:

1. *Determine the number of populations and the degree of genetic isolation/dispersal among populations.*

Actions:

1. *Find out what genetic research is already under way, and by whom (e.g., ask the IUCN/SSC Pangolin Specialist Group).*
2. *Develop and/or locate appropriate genetic markers, assuming that such markers are not already available (follows from first action).*

All participants should pass their information on to Dr. Chao at the first meeting of the research team members.

3. *Determine the best way to obtain sufficient samples from different regions.*
   Dr. Ling-Ling Lee will ask Taiwan Forestry Bureau to send a letter to the main institutions that receive pangolins (confiscated or brought in by the public) asking them to collect and store a sample (tissue and storage method to be specified) from each pangolin and record the location where each pangolin was found. This should be done prior to the first meeting of the pangolin research team.

4. *Spread the news that this research is urgent and important (see General Actions).*

GENERAL ACTIONS: Encourage pangolin research and researchers.

Actions:

1. *Spread the message that it is important for this research to be done.*
   - Students participating in the PHVA can talk to their classmates and spread the word through student organizations, etc.

   - Post these research priorities on relevant websites such as those for the Taipei Zoo, university departments, Endemic Species Research Institute, the Pangolin Specialist Group website (http://protect.tfri.gov.tw/animal/pangolin/iucn_006_01.asp), etc. Ask Dr. Chao to coordinate this.

   - Ask Dr. Chao to make sure that the research priorities are included in the National Action Plan for Pangolins.

   - Promote general awareness about the pangolin through:
     - education activities in zoos (Taipei Zoo to encourage the other Taiwanese zoos to do this, through the Taiwan Zoo Association)
     - education activities in colleges and universities (Taipei Zoo can help with this)

   - Pangolins are very charismatic, which should be used to motivate people to take conservation action.
     - Taipei Zoo should contact the press (television and newspapers) to talk about the threats the pangolin is facing.

- Once validation process has been completed, promote the use of the database of pangolin sightings/findings by the public on the website of the Endemic Species Research Institute.

Eric Tsao will coordinate the production of an education material pack (including slides, films, instructions on how to handle pangolins, etc.) to be used by workshop participants for raising general awareness about pangolins. Eric will also coordinate spreading this information over the websites.

Formosan Pangolin PHVA

Taipei, Taiwan
23-26 October 2004

FINAL REPORT

APPENDIX I

Taipei Zoo Studies of Formosan Pangolins

Formosan Pangolin PHVA

Taipei, Taiwan
23-26 October 2004

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APPENDIX II

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Participant Introductions

At the beginning of the PHVA workshop, the participants were asked to respond to the following two questions. Their responses are listed below.

1. What do you hope to contribute to the workshop?

- Contribute experience with bird species and habitat that may be useful
- Contribute expertise in population biology and fragmentation
- Share medical expertise on pangolins
- Share knowledge on habitat selection and learn from the others in the workshop
- Share experience on quarantine and physiology of pangolins/rescued pangolins
- Attended orangutan PHVA in Indonesia years ago; would like to update knowledge on Vortex and PHVAs and then help other people understand the process.
- Share knowledge on conservation and ecology of pangolins and identify knowledge gaps related to pangolin conservation
- Share information on pangolin field research data that I gathered
- Learn from other field biologists and educators so that zoo can design enclosure that is most suitable for pangolins
- Share knowledge on captive management of pangolins
- Share knowledge on behavioral observation of pangolins in captivity
- Share experience on field data on both Malayan and Chinese pangolins that both occur in study site
- Hope to learn about issues of endemic species, including the pangolin
- Contribute knowledge on pangolin behavior and activity patterns
- Learn about conservation management issues and pangolins
- Hope to learn more about pangolins and how to care for rescued pangolins
- Learn more about wildlife conservation and pangolins
- Learn how to use Vortex
- Learn about pangolins
- Learn about pangolins and Vortex
- Learn how to manage and assess a population using Vortex
- Interested in pangolins
- Contribute my knowledge on burrow and habitat selection
- Learn more about pangolins
- Share my experience with pangolins in the field
- Interested in wildlife conservation and want to learn about Vortex
- Learn about wildlife management and conservation
- Offer my help with field survey
- Want to help to protect the pangolin
- Interested in Vortex and the PHVA process and group work
- Learn more about pangolins
- Learn more about pangolin medical issues
- Offer my expertise in captive husbandry and nutrition

2. What is the primary issue/threat to Formosan pangolin viability?

- Trade for scales (medicinal) and skin (ornamental)
- Habitat loss (including fragmentation, conversion) ********
- Availability of food resources**
- Low fecundity**
- High juvenile mortality
- Estimating age (lack of information on aging)
- Hunting (including for food)*****
- Lack of information/uncertainty on population size**
- Pesticides
- Human disturbance (including tourism)
- Veterinary care, especially related to gastric disorders
- Feral dogs (as predators)
- Lack of data on population density
- Lack of data on habitat requirements**
- Potential hybridization with Malayan pangolins
- Potential competition with Malayan pangolins
- Lack of awareness (by general public)

* indicates threat was identified by an additional workshop participant

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APPENDIX III

Introduction to CBSG Processes

Conservation Breeding Specialist Group

Species Survival Commission
IUCN -- The World Conservation Union

CBSG Workshop and Training Processes

Information on capabilities of the IUCN/SSC Conservation Breeding Specialist Group

Introduction

There is a lack of generally accepted tools to evaluate and integrate the interaction of biological, physical, and social factors on the population dynamics of threatened species and populations. There is an urgent need for tools and processes to characterize the risk of species and habitat extinction, on the possible impacts of future events, on the effects of management interventions, and on how to develop and sustain learning-based cross-institutional management programs.

The Conservation Breeding Specialist Group (CBSG) of IUCN's Species Survival Commission (SSC) has more than 15 years of experience in developing, testing and applying a series of scientifically based tools and processes to assist risk characterization and species management decision making. These tools, based on small population and conservation biology (biological and physical factors), human demography, and the dynamics of social learning are used in intensive, problem-solving workshops to produce realistic and achievable recommendations for both *in situ* and *ex situ* population management.

Our workshop processes provide an objective environment, expert knowledge, and a neutral facilitation process that supports sharing of available information across institutions and stakeholder groups, reaching agreement on the issues and available information, and then making useful and practical management recommendations for the taxon and habitat system under consideration. The process has been remarkably successful in unearthing and integrating previously unpublished information for the decision-making process. Their proven heuristic value and constant refinement and expansion have made CBSG workshop processes one of the most imaginative and productive organizing forces for species conservation today (Conway 1995; Byers and Seal 2003; Westley and Miller 2003).

Integration of Science, Management, and Stakeholders

The CBSG PHVA Workshop process is based upon biological and sociological science. Effective conservation action is best built upon a synthesis of available biological information, but is dependent on actions of humans living within the range of the threatened species as well as established national and international interests. There are characteristic patterns of human behavior that are cross-disciplinary and cross-cultural which affect the processes of communication, problem-solving, and collaboration: 1) in the acquisition, sharing, and analysis of information; 2) in the perception and characterization of risk; 3) in the development of trust among individuals; and 4) in 'territoriality' (personal, institutional, local, national). Each of these has strong emotional components that shape our interactions. Recognition of these patterns has been essential in the development of processes to assist people in working groups to reach agreement on needed conservation actions, collaboration needed, and to establish new working relationships.

Frequently, local management agencies, external consultants, and local experts have identified management actions. However, an isolated narrow professional approach which focuses primarily on the perceived biological problems seems to have little effect on the needed political and social changes (social learning) for collaboration, effective management and conservation of habitat fragments or protected areas and their species components. CBSG workshops are organized to bring together the full range of groups with a strong interest in conserving and managing the species in its habitat or the consequences of such management. One goal in all workshops is to reach a common understanding of the state of scientific knowledge available and its possible application to the decision-making process and to needed management actions. We have found that the decision-making driven workshop process with risk characterization tools, stochastic simulation modeling, scenario testing, and deliberation among stakeholders is a powerful tool for extracting, assembling, and exploring information. This process encourages developing a shared understanding across wide boundaries of training and expertise. These tools also support building of working agreements and instilling local ownership of the problems, the decisions required, and their management during the workshop process. As participants appreciate the complexity of the problems as a group, they take more ownership of the process as well as the ultimate recommendations made to achieve workable solutions. This is essential if the management recommendations generated by the workshops are to succeed.

Participants have learned a host of lessons in more than 120 CBSG Workshop experiences in nearly 50 countries. Traditional approaches to endangered species problems have tended to emphasize our lack of information and the need for additional research. This has been coupled with a hesitancy to make explicit risk assessments of species status and a reluctance to make immediate or non-traditional management recommendations. The result has been long delays in preparing action plans, loss of momentum, and dependency on crisis-driven actions or broad recommendations that do not provide useful guidance to the managers.

CBSG's interactive and participatory workshop approach produces positive effects on management decision-making and in generating political and social support for conservation actions by local people. Modeling is an important tool as part of the process and provides a continuing test of assumptions, data consistency, and of scenarios. CBSG participants recognize that the present science is imperfect and that management policies and actions need to be designed as part of a biological and social learning process. The workshop process essentially provides a means for designing management decisions and programs on the basis of sound science while allowing new information and unexpected events to be used for learning and to adjust management practices.

Workshop Processes and Multiple Stakeholders

Experience: The Chairman and Program Staff of CBSG have conducted and facilitated more than 120 species and ecosystem workshops in 50 countries including the USA during the past 6 years. *Reports from these workshops are available from the CBSG Office*. We have worked on a continuing basis with agencies on specific taxa (e.g., Florida panther, Atlantic Forest primates in Brazil, Sumatran tiger) and have assisted in the development of national conservation strategies for other taxa (e.g., Sumatran elephant, Sumatran tiger, Mexican wolf).

Facilitator's Training and Manual: A manual has been prepared to assist CBSG workshop conveners, collaborators, and facilitators in the process of organizing, conducting, and completing a CBSG workshop. It was developed with the assistance of two management science professionals and 30 people from 11 countries with experience in CBSG workshops. These facilitator's training workshops have proven very popular with 2 per year planned through 2000 in several countries including the USA. *Copies of the Facilitator's Manual are available from the CBSG Office.*

Scientific Studies of Workshop Process: The effectiveness of these workshops as tools for eliciting information, assisting the development of sustained networking among stakeholders, impact on attitudes of participants, and in achieving consensus on needed management actions and research has been extensively debated. We initiated a scientific study of the process and its long term aftermath four years ago in collaboration with an independent team of researchers (Westley and Vredenburg, 2003). A survey questionnaire is administered at the beginning and end of each workshop. They have also conducted extensive interviews with participants in workshops held in five countries. A book detailing our experiences with this expanded approach to Population and Habitat Viability Assessment workshops (Westley and Miller, 2003) will provide practical guidance to scientists and managers on quantitative approaches to threatened species conservation. The study also is undertaking follow up at one and two years after each workshop to assess longer-term effects. To the best of our knowledge there is no comparable systematic scientific study of conservation and management processes. *We would apply the same scientific study tools to the workshops in this program and provide an analysis of the results after the workshop.*

CBSG Workshop Toolkit

Our basic set of tools for workshops include: small group dynamic skills; explicit use in small groups of problem restatement; divergent thinking sessions; identification of the history and chronology of the problem; causal flow diagramming (elementary systems analysis); matrix methods for qualitative data and expert judgments; paired and weighted ranking for making comparisons between sites, criteria, and options; utility analysis; stochastic simulation modeling for single populations and metapopulations; and deterministic and stochastic modeling of local human populations. Several computer packages are used to assist collection and analysis of information with these tools. We provide training in several of these tools in each workshop as well as intensive special training workshops for people wishing to organize their own workshops.

Stochastic Simulation Modeling

Integration of Biological, Physical and Social Factors: The workshop process, as developed by CBSG, generates population and habitat viability assessments based upon in-depth analysis of information on the life history, population dynamics, ecology, and history of the populations. Information on demography, genetics, and environmental factors pertinent to assessing population status and risk of extinction under current management scenarios and perceived threats are assembled in preparation for and during the workshops. Modeling and simulations provide a neutral externalization focus for assembly of information, identifying assumptions, projecting possible outcomes (risks), and examining for internal consistency. Timely reports from the workshop are necessary to have impact on stakeholders and decision makers. Draft reports are distributed within 3-4 weeks of the workshop and final reports within about 3 months.

Human Dimension: We have collaborated with human demographers in 5 CBSG workshops on endangered species and habitats. They have utilized computer models incorporating human population characteristics and events at the local level in order to provide projections of the likely course of population growth and the utilization of local resources. This information was then incorporated into projections of the likely viability of the habitat of the threatened species and used as part of the population projections and risk assessments. We are preparing a series of papers on the human dimension of population and habitat viability assessment. It is our intention to further develop these tools and to utilize them as part of the scenario assessment process.

Risk Assessment and Scenario Evaluation: A stochastic population simulation model is a kind of model that attempts to incorporate the uncertainty, randomness or unpredictability of life history and environmental events into the modeling process. Events whose occurrence is uncertain, unpredictable, and random are called stochastic. Most events in an animal's life have some level of uncertainty. Similarly, environmental factors, and their effect on the population process, are stochastic - they are not completely random, but their effects are predictable within certain limits. Simulation solutions are usually needed for complex models including several stochastic parameters.

There are a host of reasons why simulation modeling is valuable for the workshop process and development of management tools. The primary advantage, of course, is to simulate scenarios and the impact of numerous variables on the population dynamics and potential for population extinction. Interestingly, not all advantages are related to generating useful management recommendations. The side-benefits are substantial.

- Population modeling supports consensus and instills ownership and pride during the workshop process. As groups begin to appreciate the complexity of the problems, they have a tendency to take more ownership of the process and the ultimate recommendations to achieve workable solutions.
- Population modeling forces discussion on biological and physical aspects and specification of assumptions, data, and goals. The lack of sufficient data of useable quality rapidly becomes apparent and identifies critical factors for further study (driving research and decision making), management, and monitoring. This not only influences assumptions, but also the group's goals.
- Population modeling generates credibility by using technology that non-biologically oriented groups can use to relate to population biology and the "real" problems. The acceptance of the computer as a tool for performing repetitive tasks has led to a common ground for persons of diverse backgrounds.
- Population modeling explicitly incorporates what we know about dynamics by allowing the simultaneous examination of multiple factors and interactions - more than can be considered in analytical models. The ability to alter these parameters in a systematic fashion allows testing a multitude of scenarios that can guide adaptive management strategies.
- Population modeling can be a neutral computer "game" that focuses attention while providing persons of diverse agendas the opportunity to reach consensus on difficult issues.
- Population modeling results can be of political value for people in governmental agencies by providing support for perceived population trends and the need for action. It helps managers to justify resource allocation for a program to their superiors and budgetary agencies as well as identify areas for intensifying program efforts.

Modeling Tools: At the present time, our preferred model for use in the population simulation modeling process is called *VORTEX*. This model, developed by Bob Lacy (Chicago Zoological Society), is designed specifically for use in the stochastic simulation of the extinction process in small wildlife populations. It has been developed in collaboration and cooperation with the CBSG PHVA process. The model simulates deterministic forces as well as demographic, environmental, and genetic events in relation to their probabilities. It includes modules for catastrophes, density dependence, metapopulation dynamics, and inbreeding effects. The *VORTEX* model analyzes a population in a stochastic and probabilistic fashion. It also makes predictions that are testable in a scientific manner, lending more credibility to the process of using population-modeling tools.

There are other commercial models, but presently they have some limitations such as failing to measure genetic effects, being difficult to use, or failing to model individuals. *VORTEX* has been successfully used in more than 90 PHVA workshops in guiding management decisions. *VORTEX* is general enough for use when dealing with a broad range of species, but specific enough to incorporate most of the important processes. It is continually evolving in conjunction with the PHVA process. *VORTEX* has, as do all models, its limitations, which may restrict its utility. The model analyzes a population in a stochastic and probabilistic fashion. It is now at Version 9.45 through the cooperative contributions of dozens of biologists. It has been the subject of a series of both published and in-press validation studies and comparisons with other modeling tools. More than 2000 copies of *VORTEX* are in circulation and it is being used as a teaching tool in university courses.

We use this model and the experience we have with it as a central tool for the population dynamic aspects of the workshop process. Additional modules, building on other simulation modeling tools for human population dynamics (which we have used in 3 countries) with potential impacts on water usage, harvesting effects, and physical factors such as hydrology and water diversion will be developed to provide input into the population and habitat models which can then be used to evaluate possible effects of different management scenarios. No such composite models are available.

CBSG Resources as a Unique Asset

Expertise and Costs: The problems and threats to endangered species everywhere are complex and interactive with a need for information from diverse specialists. No agency or country encompasses all of the useful expert knowledge. Thus, there is a need to include a wide range of people as resources and analysts. It is important that the invited experts have reputations for expertise, objectivity, initial lack of local stake, and for active transfer of wanted skills. CBSG has a volunteer network of more than 800 experts with about 250 in the USA. More than 3,000 people from 400 organizations have assisted CBSG on projects and participated in workshops on a volunteer basis contributing tens of thousands of hours of time. We will call upon individual experts to assist in all phases of this project.

Indirect cost contributions to support: Use of CBSG resources and the contribution of participating experts provide a matching contribution more than equaling the proposed budget request for projects.

Manuals and Reports: We have manuals available that provide guidance on the goals, objectives, and preparations needed for CBSG workshops. These help to reduce startup time and costs and allow us to begin work on organizing the project immediately with proposed participants and stockholders. We have a process manual for use by local organizers, which goes into detail on all aspects of organizing, conducting, and preparing reports from the workshops. Draft reports are prepared during the workshop so that there is agreement by participants on its content and recommendations. Reports are also prepared on the mini-workshops (working groups) that will be conducted in information gathering exercises with small groups of experts and stakeholders. We can print reports within 24-48 hours of preparation of final copy. We also have CD-ROM preparation facilities, software and experience.

References

Byers, O., and U.S. Seal. 2003. The Conservation Breeding Specialist Group (CBSG): Activities, core competencies and vision for the future. *International Zoo Yearbook* 38:43-52.

Conway, W. 1995. Wild and zoo animal interactive management and habitat conservation. *Biodiversity and Conservation* 4: 573-594.

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

Westley, F., and H. Vredenburg. 2003. Logic models for building knowledge and networks: Early evaluations of the PHVA approach. In Westley, F. and P.S. Miller (eds.) *Experiments in Consilience: Integrating Social and Scientific Responses to Save Endangered Species*. Washington, DC: Island Press.

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APPENDIX IV

Simulation Modeling and PVA

Simulation Modeling and Population Viability Analysis

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Bob Lacy – Chicago Zoological Society / Conservation Breeding Specialist Group
Phil Miller – Conservation Breeding Specialist Group (IUCN)

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 (see Lacy and Miller (2002), Nyhus et al. (2002) and Westley and Miller (2003) for more details).

The *VORTEX* Population Viability Analysis Model

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

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

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

VORTEX 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 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 Miller and Lacy (1999) and Lacy (2000).

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. Uncertainty can occur because limited field data have yielded estimates with potentially large sampling error. Uncertainty can occur because independent studies have generated discordant estimates. Uncertainty can occur because 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. Uncertainty can occur because 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 pronghorn population. If alternative plausible parameter values result in divergent predictions for the population, then it is important to try to resolve the uncertainty with better data. Sensitivity of population dynamics to certain parameters also indicates that those parameters describe factors that could be critical determinants of population viability. Such factors are therefore good candidates for efficient management actions designed to ensure the persistence of the population.

The above kinds of uncertainty should be distinguished from several more sources of uncertainty about the future of the population. Even if long-term average demographic rates are known with precision, variation over time caused by fluctuating environmental conditions will cause uncertainty in the fate of the population at any given time in the future. Such environmental variation should be incorporated into the model used to assess population dynamics, and will generate a range of possible outcomes (perhaps represented as a mean and standard deviation) from the model. In addition, most biological processes are inherently stochastic, having a random component. The stochastic or probabilistic nature of survival, sex determination, transmission of genes, acquisition of mates, reproduction, and other processes preclude exact determination of the future state of a population. Such demographic stochasticity should also be incorporated into a population model, because such variability both increases our uncertainty about the future and can also change the expected or mean outcome relative to that which would result if there were no such variation. Finally, there is "uncertainty" which represents the alternative actions or interventions which might be pursued as a management strategy. The likely effectiveness of such management options can be explored by testing alternative scenarios in the model of population dynamics, in much the same way that sensitivity testing is used to explore the effects of uncertain biological parameters.

Results
Results reported for each scenario include:

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

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

Stochastic r -- The mean rate of stochastic population growth or decline demonstrated by the simulated populations, averaged across years and iterations, for all those simulated populations that are not extinct. This population growth rate is calculated each year of the simulation, prior to any truncation of the population size due to the population exceeding the carrying capacity. Usually, this stochastic r will be less than the deterministic r predicted from birth and death rates. The stochastic r from the simulations will be close to the deterministic r if the population growth is steady and robust. The stochastic r will be notably less than the deterministic r if the population is subjected to large fluctuations due to environmental variation, catastrophes, or the genetic and demographic instabilities inherent in small populations.

P(E) -- the probability of population extinction, determined by the proportion of, for example, 500 iterations within that given scenario that have gone extinct in the simulations. "Extinction" is defined in the VORTEX model as the lack of either sex.

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

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

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

Literature Cited

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

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

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

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

Lacy, R.C. 1993/1994. What is Population (and Habitat) Viability Analysis? *Primate Conservation* 14/15:27-33.

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

Miller, P.S., and R.C. Lacy. 1999. *VORTEX: A Stochastic Simulation of the Extinction Process. Version 8 User's Manual*. Apple Valley, MN: Conservation Breeding Specialist Group (SSC/IUCN).

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

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

Shaffer, M.L. 1981. Minimum population sizes for species conservation. *BioScience* 1:131-134.

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

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

Formosan Pangolin PHVA

Taipei, Taiwan
23-26 October 2004

FINAL REPORT

APPENDIX V

IUCN Guidelines

IUCN Technical Guidelines on the Management of *Ex-situ* Populations for Conservation

Approved at the 14th Meeting of the Programme Committee of Council, Gland Switzerland, 10 December 2002

PREAMBLE

IUCN affirms that a goal of conservation is the maintenance of existing genetic diversity and viable populations of all taxa in the wild in order to maintain biological interactions, ecological processes and function. Conservation managers and decision-makers should adopt a realistic and integrated approach to conservation implementation. The threats to biodiversity in situ continue to expand, and taxa have to survive in increasingly human-modified environments. Threats, which include habitat loss, climate change, unsustainable use, and invasive and pathogenic organisms, can be difficult to control. The reality of the current situation is that it will not be possible to ensure the survival of an increasing number of threatened taxa without effectively using a diverse range of complementary conservation approaches and techniques including, for some taxa, increasing the role and practical use of ex situ techniques.

If the decision to bring a taxon under ex situ management is left until extinction is imminent, it is frequently too late to effectively implement, thus risking permanent loss of the taxon. Moreover, ex situ conservation should be considered as a tool to ensure the survival of the wild population. Ex situ management should be considered only as an alternative to the imperative of in situ management in exceptional circumstances, and effective integration between in situ and ex situ approaches should be sought wherever possible.

The decision to implement an ex situ conservation programme as part of a formalised conservation management or recovery plan and the specific design of and prescription for such an ex situ programme will depend on the taxon's circumstances and conservation needs. A taxon-specific conservation plan may involve a range of ex situ objectives, including short-, medium- and long-term maintenance of ex situ stocks. This can utilise a variety of techniques including reproduction propagation, germplasm banking, applied research, reinforcement of existing populations and re-introduction into the wild or controlled environments. The objectives and overall purpose should be clearly stated and agreed among organisations participating in the programme, and other relevant stakeholders including landowners and users of the taxon involved. In order to maximise their full potential in conservation, ex situ facilities and their co-operative networks should adopt the guidelines defined by the Convention on Biological Diversity (CBD), the International Agenda for Botanic Gardens in Conservation, Center for Plant Conservation and the World Zoo Conservation Strategy, along with other guidelines, strategies, and relevant legislative requirements at national and regional levels. IUCN recognizes the considerable set of resources committed worldwide to ex situ conservation by the world's zoological and botanical gardens, gene banks and other ex situ facilities. The effective utilisation of these resources represents an essential component of conservation strategies at all levels.

VISION

To maintain present biodiversity levels through all available and effective means including, where appropriate, ex situ propagation, translocation and other ex situ methodologies.

GOAL

Those responsible for managing ex situ plant and animal populations and facilities will use all resources and means at their disposal to maximise the conservation and utilitarian values of these populations, including:
1) increasing public and political awareness and understanding of important conservation issues and the significance of extinction;
2) co-ordinated genetic and demographic population management of threatened taxa;
3) re-introduction and support to wild populations;
4) habitat restoration and management;
5) long-term gene and biomaterial banking;
6) institutional strengthening and professional capacity building;
7) appropriate benefit sharing;
8) research on biological and ecological questions relevant to in situ conservation; and
9) fundraising to support all of the above.

Ex situ agencies and institutions must follow national and international obligations with regard to access and benefit sharing (as outlined in the CBD) and other legally binding instruments such as CITES, to ensure full collaboration with all range States. Priority should be given to the ex situ management of threatened taxa (according to the latest IUCN Red List Categories) and threatened populations of economic or social/cultural importance. Ex situ programmes are often best situated close to or within the ecogeographic range of the target taxa and where possible within the range State. Nevertheless a role for international and extra regional support for ex situ conservation is also recognised. The option of locating the ex situ programme outside the taxa's natural range should be considered if the taxa is threatened by natural catastrophes, political and social disruptions, or if further germplasm banking, propagation, research, isolation or reintroduction facilities are required and cannot be feasibly established. In all cases, ex situ populations should be managed in ways that minimize the loss of capacity for expression of natural behaviours and loss of ability to later again thrive in natural habitats.

TECHNICAL GUIDELINES

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

- The primary objective of maintaining ex situ populations is to help support the conservation of a threatened taxon, its genetic diversity, and its habitat. Ex situ programmes should give added value to other complementary programmes for conservation.

  Although there will be taxa-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 taxa/population is prone to effects of human activities or stochastic events or

2. When the taxa/population is likely to become Critically Endangered, Extinct in the Wild, or Extinct in a very short time. Additional criteria may need to be considered in some cases where taxa or populations of cultural importance, and significant economic or scientific importance, are threatened. All Critically Endangered and Extinct in the Wild taxa should be subject to ex situ management to ensure recovery of wild populations.

- Ex situ conservation should be initiated only when an understanding of the target taxon's biology and ex situ management and storage needs are at a level where there is a reasonable probability that successful enhancement of species conservation can be achieved; or where the development of such protocols could be achieved within the time frame of the taxon's required conservation management, ideally before the taxa becomes threatened in the wild. Ex situ institutions are strongly urged to develop ex situ protocols prior to any forthcoming ex situ management. Consideration must be given to institutional viability before embarking on a long term ex situ project.
- For those threatened taxa for which husbandry and/or cultivation protocols do not exist, surrogates of closely related taxa can serve important functions, for example in research and the development of protocols, conservation biology research, staff training, public education and fundraising.
- While some ex situ populations may have been established prior to the ratification of the CBD, all ex situ and in situ populations should be managed in an integrated, multidisciplinary manner, and where possible, in accordance with the principles and provisions of the CBD.
- Extreme and desperate situations, where taxa/populations are in imminent risk of extinction, must be dealt with on an emergency basis. This action must be implemented with the full consent and support of the range State.
- All ex situ populations must be managed so as to reduce risk of loss through natural catastrophe, disease or political upheaval. Safeguards include effective quarantine procedures, disease and pathogen monitoring, and duplication of stored germplasm samples in different locations and provision of emergency power supplies to support collection needs (e.g. climate control for long term germplasm repositories).
- All ex situ populations should be managed so as to reduce the risk of invasive escape from propagation, display and research facilities. Taxa should be assessed as to their invasive potential and appropriate controls taken to avoid escape and subsequent naturalisation.
- The management of ex situ populations must minimise any deleterious effects of ex situ management, such as loss of genetic diversity, artificial selection, pathogen transfer and hybridisation, in the interest of maintaining the genetic integrity and viability of such material. Particular attention should be paid to initial sampling techniques, which should be designed to capture as much wild genetic variability as practicable. Ex situ practitioners should adhere to, and further develop, any taxon- or region-specific record keeping and genetic management guidelines produced by ex situ management agencies.
- Those responsible for managing ex situ populations and facilities should seek both to increase public awareness, concern and support for biodiversity, and to support the implementation of conservation management, through education, fundraising and professional capacity building programmes, and by supporting direct action in situ.

- Where appropriate, data and the results of research derived from ex situ collections and ex situ methodologies should be made freely available to ongoing in-country management programmes concerned with supporting conservation of in situ populations, their habitats, and the ecosystems and landscapes in which they occur .

NB. Ex situ conservation is defined here, as in the CBD, as "the conservation of components of biological diversity outside their natural habitats". Ex situ collections include whole plant or animal collections, zoological parks and botanic gardens, wildlife research facilities, and germplasm collections of wild and domesticated taxa (zygotes, gametes and somatic tissue).

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.

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.

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 nataional 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.

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.

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.

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 (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.

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