Western Chimpanzee (*Pan troglodytes verus*) Population and Habitat Viability Assessment (PHVA) for Sierra Leone

Freetown, Sierra Leone
24 to 27 May 2011

FINAL REPORT

A contribution of the IUCN/SSC Conservation Breeding Specialist Group (CBSG)
in cooperation with the Tacugama Chimpanzee Sanctuary.
Western Chimpanzee (*Pan troglodytes verus*) Population and Habitat Viability Assessment (PHVA)
for Sierra Leone. Final Report. CBSG Europe and CBSG Headquarters

Torben and Alice Frimodt's Foundation

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Edited by: Carlsen, F.; Leus, K.; Traylor-Holzer, K.; McKenna, A.

Compiled by the workshop participants

A participative workshop in cooperation with:

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Planning committee: Anita McKenna, Frands Carlsen, Kathy Traylor-Holzer, Kristin Leus

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

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Acronyms and Abbreviations

AICU – Agriculture Information and Communications Unit

ARD – Association for Rural Development

CAP – Conservation Action Plan

CCSP – Chimpanzee Conservation and Sensitization Program

CBD – Convention on Biological Diversity

CBSG – Conservation Breeding Specialist Group

CITES – Convention on International Trade in Endangered Species of Wild Fauna and Flora

CLO – Community Liaison Officers

CSO – Civil Society Organisations

CSSL – Conservation Society of Sierra Leone

CUNY – The City University of New York

CWMU – Conservation and Wildlife Management Unit

DICE - Durrell Institute of Conservation and Ecology

EAZA – European Association of Zoos and Aquaria

ENFORAC – Environmental Forum for Action

EPA – Environmental Protection Agency

FD – Forestry Department

GEF – Global Environment Facility

GIS – Geographic Information System

GoSL – Government of Sierra Leone

INGO - International Non-Governmental Organization

IUCN - International Union for Conservation of Nature

JGI – Jane Goodall Institute

MAFFS – The Ministry of Agriculture, Forestry and Food Security

MIALGRD – Ministry of Internal Affairs, Local Government & Rural Development

MLCPE – Ministry of Lands Country Planning and the Environment

MPI – Max Planck Institute

MTA – Ministry of Transport and Aviation

MTCA – Ministry of Tourism and Cultural Affairs

NCCC – National Chimpanzee Conservation Coordinator

NGO – Non Governmental Organisation

NP- National Park

NRM – Natural Resource Management

OKNP – Outamba-Kilimi National Park

ONS – Office of National Security

PA - Protected Area

PAGE – Promoting Agriculture, Governance, and Environment

PASA – Pan African Sanctuary Alliance

PHVA – Population and Habitat Viability Assessment

PSG – Primate Specialist Group

REDD – Reducing Emissions from Deforestation and Forest Degradation

RSPB – The Royal Society for the Protection of Birds

SGA – Section for Great Apes

SLARI – Sierra Leone Agricultural Research Institute

SLCRP – Sierra Leone Chimpanzee Rehabilitation Programme

SLEPA – Sierra Leone Environment Protection Agency

SCS – Species Conservation Strategy

SSC – Species Survival Commission

STEWARD - Sustainable and Thriving Environments for West Africa Regional Development

TCS – Tacugama Chimpanzee Sanctuary

TWS – Tiwai Island Wildlife Sanctuary

UNFCCC – United Nations Framework Convention on Climate Change

UNEP – United Nations Environmental Program

USAID – U.S. Agency for International Development

WAPFoR – Western Area Peninsular Forest Reserve

WB – World Bank

ZSL – Zoological Society of London

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Section 1

Executive summary

INTRODUCTION

All subspecies of the common chimpanzee, *Pan troglodytes*, including the western chimpanzee, *P. t. verus*, are currently categorised as Endangered (A4cd) by the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN), which means that they face a high extinction risk in the wild (Oates *et al*. 2008). In addition, the species is included in CITES Appendix I, which in effect prohibits its international trade (UNEP-WCMC 2011).

Chimpanzee taxonomy remains an active area of research. Four subspecies are presently recognized: the Western Chimpanzee *Pan troglodytes verus*; the Nigeria-Cameroon Chimpanzee *P. t. ellioti*; the Central Chimpanzee *P. t. troglodytes*; and the Eastern Chimpanzee *P. t. schweinfurthii* (Oates *et al*. 2008; Oates 2011). The subspecies found in Sierra Leone is the Western Chimpanzee, which occurs from Senegal in the west to the Dahomey Gap or perhaps the Niger River in the east (Butynski 2003; Gonder *et al.* 2006; Hill 1969; Kormos & Boesch 2003).

With an estimated remaining population of between 21,300 and 55,600, the Western Chimpanzee is among the two most endangered chimpanzee subspecies, suggesting that if no action is taken to halt the decline it is highly likely to face extinction in the near future (Kormos *et al*., 2003). Extinction has already probably occurred in three of its former range countries – Benin, Togo and Burkina Faso – and populations in Senegal, Guinea Bissau and Ghana are extremely threatened (Butynski 2001).

Sierra Leone lies entirely within the natural range of Western Chimpanzees, which were once distributed throughout the country (Hanson-Alp *et al*. 2003). An early estimate from Teleki and Baldwin (1981) put the number of remaining chimpanzees in the country at 1,500 to 2,500 individuals. In the 1970s and into the 1980s, Sierra Leone was a major source for the live chimpanzee trade; most were exported for biomedical research and to the entertainment industry. Estimates on the number of infant chimpanzees exported from Sierra Leone vary widely but from 1957-1968 an estimated 2,574 chimpanzees were exported from Sierra Leone (Robinson 1971). Detailed customs records from 1973-1979 show that a total of 1,582 live chimpanzees were exported from the country, primarily to the United States; Geza Teleki estimates that over 2,000 infants were sold overseas during the 1970s (Teleki & Baldwin, 1981, Teleki 1980). It is possible, therefore, that at least 5,000 chimpanzees from the region were exported via Freetown between 1950 and the mid-1980s. Following reports to the Government of Sierra Leone (GoSL) about the state of chimpanzees in Sierra Leone, a presidential ban was put in place in 1985 banning live trade in chimpanzees and making illegal the killing, sale, capture or keeping of chimpanzees as pets. Nonetheless the pet trade continued, often in the open (Teleki

1985). Law enforcement was largely non-existent and there were limited attempts at making the public aware about the protected status of chimpanzees and other wildlife.

Geza Teleki, who reviewed the capture practices of wildlife traders in the 1970-80s, estimated that for every live captive infant chimpanzee that arrives in a laboratory or sanctuary, 5-10 chimpanzees have been killed (the mother and often other members of the community are killed either for bushmeat or to retrieve the infants and not all infants survive) (Teleki 1989). Previous population sizes will never be known for certain but it is possible to make rough estimates of attrition. Taking export records together with the findings from Tacugama and using a conservative estimate of five mortalities for every one captured, these could represent the estimated loss of at least 25,000 chimpanzees from Sierra Leone (and perhaps neighbouring countries) in the last 60 years.

In 1995, the Sierra Leone Chimpanzee Rehabilitation Programme (SLCRP) was implemented by Bala Amarasekaran working with the GoSL and the Conservation Society of Sierra Leone (CSSL). This resulted in the establishment of Tacugama Chimpanzee Sanctuary (TCS) located south of Freetown in the Western Area Peninsular Forest Reserve (WAPFoR). The existence of the sanctuary significantly enhanced the ability of the GoSL to enforce the Sierra Leone Wildlife Conservation Act of 1972 with respect to chimpanzees. Tacugama finally allowed illegally held chimpanzees to be confiscated, cared for and rehabilitated. Since then Tacugama has confiscated orphan chimpanzees at a rate of approximately ten per year. As of 2010 Tacugama has recorded over 150 orphan chimpanzees, most of which were rescued.

As a result of recommendations from the Pan African Sanctuary Alliance (PASA) meeting held in Sierra Leone in 2008, Tacugama Chimpanzee Sanctuary (TCS) undertook a National Chimpanzee Census Project during 2009 and 2010 (Brncic *et al.* 2010). The results of this census confirm that: an estimated 5,500 wild chimpanzees remain in Sierra Leone; more than one half of these live outside protected areas; they are declining in number; and they are threatened by many factors. The census also indicates that Sierra Leone is probably now home to the second largest population of chimpanzees in West Africa following Guinea. Urgent conservation action is needed to ensure that Sierra Leone can protect its remaining chimpanzees and their habitats – especially in those areas that have no existing conservation status. Information compiled during the census now makes it possible to examine population viability under various conditions and to develop knowledgeable and effective conservation actions.

To address this issue the IUCN/SSC Conservation Breeding Specialist Group was invited by the Sierra Leone Government, Ministry of Agriculture, Forestry and Food Security (MAFFS) to conduct a PHVA (Population and Habitat Viability Assessment) workshop that would bring together people with diverse perspectives and knowledge, creating a scientifically sound basis for the planning, setting of priorities, and initiation of projects to catalyse a positive conservation change for the chimpanzee in Sierra Leone.

SIERRA LEONE GOVERNMENT
Ministry of Agriculture, Forestry and Food Security
Youyi Building
Freetown.

22nd December, 2010.

Frands Carlsen
Head of Zoology Section, Research and Conservation
Copenhagen Zoo
Zoologisk Have
Roskildevej 38, Postboks 7
DK 2000 Frederiksberg
Denmark.

Dear Mr. Carlsen,

INVITATION TO FACILITATE A POPULATION, HABITAT AND VIABILITY ASSESSMENT FOR THE WESTERN CHIMPANZEE IN SIERRA LEONE

On behalf of the Conservation and Wildlife Unit of the Forestry Division, Ministry of Agriculture, Forestry and Food Security (MAFFS), thank you very much for the significant support that you have provided Tacugama Chimpanzee Sanctuary to make the Sierra Leone National Chimpanzee Census Project a reality. The successful conclusion of this project has provided important information on the status of the wild chimpanzee population in our country and built the knowledge and understanding of our key stakeholders.

Following the census we co-hosted a dissemination workshop with Tacugama to ensure that the information generated reached a wider audience.

As a result of this workshop we would like to proceed to the next level and host a PHVA workshop in Sierra Leone.

We understand that the Conservation Breeding Specialist Group that you represent has the experience and capacity to deliver a successful PHVA workshop. We would welcome you to Sierra Leone so that we can build on the data generated through the census and move towards the creation of a National Chimpanzee Conservation Action Plan. This important step would go a long way to ensuring increased protection for chimpanzees in Sierra Leone.

With the momentum generated by the workshop it would be preferable for the workshop to take place at the earliest opportunity.

I look forward to your response.

Kate M. B. Garnett (Mrs.)
Asst. Director of Forestry
Conservation and Wildlife Management Unit
Forestry Division

GOALS

The main goal of the PHVA workshop was to gather and discuss all available information on wild western chimpanzees in Sierra Leone, to use this information to identify the primary issues affecting chimpanzee viability, and to establish conservation priorities, management strategies and effective actions for their conservation that have stakeholder support as input to a future Conservation Action Plan for the subspecies, including the population in Tacugama Chimpanzee Sanctuary.

RESULTS

The official opening of the workshop, additional opening statements and presentations on chimpanzee status and workshop processes were followed by a series of alternating plenary sessions to produce a vision statement as well as a chain of events map of direct and indirect threats to the viability of the chimpanzee population in Sierra Leone.
Workshop participants agreed on the following vision statement for the conservation of chimpanzees in Sierra Leone:

"To ensure a long-term viable chimpanzee population across Sierra Leone in both protected and non-protected areas, maintaining genetic, cultural and ecological diversity, living in harmony with communities, bringing socio-economic benefits and being a source of pride to Sierra Leone."

In an interactive plenary session the workshop participants identified proximate and ultimate threats influencing the viability of the chimpanzees in Sierra Leone and these threats were incorporated into an event chain map that clarified how threats influence others and what are the chains of events leading from each threat to a particular effect on the chimpanzee demography and genetics. This threat map was used to help decide the topics for the different working groups and was referred back to at several times during the workshop to help inform goal and action setting and to make sure that all major threats were addressed in some form in at least one of the working groups or during plenary discussions.

Based on the recognised challenges for the conservation of chimpanzees in Sierra Leone, the participants and workshop facilitators identified five (5) working groups focused on the following topics:

- Population and threat analysis
- Role of government agencies in chimpanzee conservation
- National Parks: effective management and surrounding communities

- Building human/chimpanzee harmony in community forests
- Ensuring the implementation and long-term sustainability of the action plan

In consecutive working group sessions, working groups were asked to describe and prioritise issue statements and develop measurable long- and short-term goals to address these issues, while also taking into consideration the overall conservation vision for the subspecies. Groups were further asked to develop action steps for each of these goals. During plenary sessions all participants had an opportunity to contribute to the work of the other groups through plenary discussions sessions during which each group's issues were carefully reviewed and discussed by all participants. The recommendations developed at the workshop were accepted by all participants, thus representing a form of consensus.

In parallel with this process, a computer population simulation model (Vortex) was developed to assess the viability of chimpanzee populations in Sierra Leone under current conditions, identify those factors that most acutely affect chimpanzee population growth and persistence, and to evaluate the likely impact of alternative management strategies and actions on the long-term viability of chimpanzee populations.

Population and threats

Workshop participants agreed that there is a paucity of data on populations outside protected areas, and on how threats affect the viability of chimpanzee populations in general. It was deemed of high priority to determine whether chimpanzees outside of protected areas have typical community structure and reproduction, and of medium priority to determine the extent of connectivity among chimpanzee populations in Sierra Leone – do they form one meta-population or multiple isolated populations?

Priorities identified for action included getting a better understanding of:

- The status of chimpanzee populations – through camera trapping projects and a genetic study to get more precise population sizes.
- The threats – through GIS mapping of concession and infrastructure project areas, as well as climate change predictions for the country and to inform mitigation and offset plans and promoting REDD process.
- Conservation opportunities such as potential watershed protection schemes, potential carbon offset areas and combining chimpanzee protection with other species – through the creation of GIS information and the gathering of existing information about such locations.

Population modelling

An analysis of population viability for chimpanzee populations in Sierra Leone using the best available data and expert opinion on demographic rates and potential threats suggests that the major factors affecting viability are the continual loss of chimpanzees (especially adult females) from the population and small population size. Both of these factors can be influenced through management and conservation actions. Any activities that reduce reproduction (either directly by loss of adult females or indirectly through the impacts of disturbance) jeopardize the viability of chimpanzee populations. Given an intrinsic growth rate of 1.2%, it is not surprising that populations decline under annual removal rates higher than 1%. Population size is regulated to some extent by habitat quality and quantity as it relates to chimpanzees. Small populations in small habitat patches exhibit poor viability when isolated from other chimpanzee populations. Moderate sized populations are vulnerable to habitat loss and removal that result in smaller carrying capacity, population size and growth, and thus reduced viability. Protection of habitat to preserve or create large connected populations and prevent fragmentation into small isolated populations will promote viability and reduce risk of decline and extinction. Activities that reduce chimpanzee survival or reproduction or reduce the carrying capacity of the habitat for chimpanzees, either directly or indirectly through disturbance, will reduce viability.

Better estimates of demographic rates (particularly female mortality rates), the rates of loss of chimpanzees, the rate and impacts of habitat loss and conversion, and population size and connectivity all will enable more accurate assessment of long-term viability of specific chimpanzee populations in Sierra Leone.

Government agencies

Workshop participants agreed that government agencies could play a role in improving chimpanzee conservation by addressing issues regarding weak policies and regulations, lack of law enforcement, lack of awareness and lack of proper land use planning in Sierra Leone.

Priorities identified for action included:

- Review laws and policies pertaining to conservation by establishing a policy review/reform committee.

- Conducting training to build capacity for improved law enforcement by law enforcement agencies and other stakeholders, improving salary structure and providing incentives to ensure adequate personnel in protected areas.
- Promoting awareness and sensitising local communities, civil societies and government agencies by establishing a national stakeholder platform for sensitisation on conservation policies for chimpanzees and engaging/lobbying the parliamentary committee on environmental issues.

National Parks

Workshop participants agreed that protected areas have limited effectiveness due to a lack of sufficient motivated personnel and adequate funding, a lack of local involvement in decision making and management and a lack of (perceived) economic benefits from protected areas, coupled with a low appreciation for the intangible benefits of conservation leading to a low level of support for conservation and increased exploitation pressure from surrounding communities.

Priorities identified for action included:

- Establishing a network of National Parks and a fully functioning National Park Authority and ensuring funding of core costs of the network through the national budget with outside agencies able to contribute to specific programmes.
- Establishing co-management committees for National Parks and buffer zones with representation from surrounding communities and development of tourism programmes from which revenues are fairly shared with local communities. **Please note:** the issues of co-management of national parks and of buffer zones generated varying opinions and debate during the workshop. Please consult notes in section 7.
- Designing and conducting research into ecological services and disseminating research results to communities through environmental education/awareness programmes.

Building human chimpanzee harmony

Workshop participants agreed on:

- The lack of knowledge on the following issues: lack of knowledge of location of human communities facing issues of conflict and competition with chimpanzees; absence of a central body to assist communities to mitigate and/or prevent conflict and resource competition issues with chimpanzees.

- The lack of understanding of and misperceptions about chimpanzees among local communities.
- The conflict inherent in protecting a species that potentially inflicts harm to local people through crop-raiding, resource competition, aggression and risk of disease transmission.

Priorities identified for action included:

- Compile information of known affected communities, establish reporting mechanism for conflicts, and set up a body that can support, advice and help communities minimise conflicts and resource competition.
- Strengthen environmental education and awareness-raising programmes and create value for local communities to preserve chimpanzees in their locality.
- Improve health/hygiene of local communities and develop a partnership with the Ministry of Health to promote understanding of zoonoses. Increase research into links between human and chimpanzee health in localities and increase access to health workers by local communities

Action Plan implementation

Workshop participants agreed that it is a common occurrence that action plans are not actively implemented but rather viewed as reference or historical documents and that there is no donor confidence without evidence of effective monitoring and evaluation demonstrating successful implementation.

Priorities identified for action included:

Defining an appropriate implementation strategy to ensure the effective delivery of the actions through:

1. Endorsement of the action plan by the Government of Sierra Leone, establishment of a steering committee with oversight, able to guide and drive implementation and dissemination of the action plan to key stakeholder groups.
2. Development of an effective communication strategy to ensure awareness and understanding and establishment of an effective monitoring and evaluation system and a feedback mechanism to improve implementation effectiveness
3. Establish the monitoring of chimpanzee populations to measure the effectiveness of the actions being implemented and to acquire knowledge of large challenges to the success of chimpanzee conservation.

The expected outcome of this workshop is a realistic Conservation Action Plan for the Western Chimpanzee in Sierra Leone, including short- and long-term goals, as well as prioritized action steps for both in-situ and ex-situ conservation efforts.

Institutional information

Tacugama Chimpanzee Sanctuary (TCS)
Working as the Sierra Leone Chimpanzee Rehabilitation Programme, Tacugama cares for around 100 confiscated and abandoned chimpanzees at the sanctuary close to Freetown and supports the enforcement of the laws protecting chimpanzees in Sierra Leone. Founded in 1995, Tacugama operates education, community development, field research, conservation and ecotourism projects to address the root cause issues that threaten the survival of chimpanzees and their habitat in Sierra Leone. www.tacugama.com

The Conservation and Wildlife Management Unit (CWMU), Forestry Division of the Ministry of Agriculture, Forestry and Food Security (MAFFS)
CWMU/MAFFS is the body within the GoSL responsible for the protection of the country's biodiversity. Several protected areas are managed by game wardens and guards located on site. An existing network of 48 forest reserves and conservation areas are managed by foresters assigned by MAFFS through district offices. Each district office is headed by a District Forest Officer, who oversees logging concessions and overall management of forests in the region. Foresters, located near some reserves, are responsible for enforcing laws as stipulated in relevant Acts.

IUCN/SSC/CBSG – Conservation Breeding Specialist Group
With 350 volunteer members, the IUCN/SSC Conservation Breeding Specialist Group (CBSG) is one of the largest Specialist Groups comprising of the Species Survival Commission (SSC). CBSG has over 20 years of experience developing, testing and applying scientifically based tools and processes for risk assessment and decision-making in the context of species management. These tools, based on small population and conservation biology, 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. CBSG's workshop processes provide an objective environment, expert knowledge, and neutral facilitation to support the exchange of information across diverse stakeholder groups in order to reach some agreement on the important issues facing both humans and wildlife. With this understanding, meaningful and practical management recommendations can be made. www.cbsg.org

IUCN/SSC/PSG – Primate Specialist Group

The Primate Specialist Group (PSG) is concerned with more than 670 species and subspecies of monkeys, apes and lemurs, carrying out conservation status assessments and making recommendations on taxonomic decisions, which inform IUCN policy as a whole. The Section on Great Apes (SGA) of the PSG focuses exclusively on issues affecting the 13 taxa of chimpanzees, gorillas and orangutans.

The goal of the SGA is to prevent the extinction of the great apes by informing and supporting sound policy decisions by habitat countries. The SGA advises governments on effective conservation strategies based on current knowledge of the populations and distributions of the great apes and the many pressures that threaten their survival. As an integral aspect of this role, the SGA facilitates the exchange of critical information among primatologists and the professional conservation community.

With more than 100 members- including some of the world's most distinguished and experienced great ape researchers-the combined expertise of the SGA spans the scientific, social and ethical aspects of great ape conservation, providing a comprehensive perspective on the challenges and solutions available. www.primate-sg.org

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Section 2

Workshop format and process

Background to the overall workshop process

The design of this workshop was based on the CBSG Population and Habitat Viability Assessment (PHVA) workshop process with integrated components of the IUCN/SSC handbook for Strategic Planning for Species Conservation (IUCN/SSC 2008).

Population and Habitat Viability Assessment (PHVA) workshop process

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 behaviour that are cross-disciplinary and cross-cultural and that 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 that 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 stakeholders 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 modelling, 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. 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.

Traditional approaches to endangered species problems have tended to emphasize the 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. The CBSG PHVA workshop process recognises 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 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.

During the PHVA process, participants work in small groups. Each working group produces a report on their topic, which is included in the PHVA document resulting from the meeting. A successful workshop depends on determining an outcome where all participants, coming to the workshop with different interests and needs, "win" in developing a management strategy for the species in question. Local solutions take priority – workshop recommendations are developed by, and are the property of, the local participants.

The use of stochastic simulation modelling in the PHVA process

Stochastic simulation modelling is an important tool as part of the process and provides a continuing test of assumptions, data consistency, and of scenarios. A stochastic population simulation model attempts to incorporate the uncertainty, randomness or unpredictability of life history and environmental events into the modelling process. Events that are 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 many reasons why simulation modelling is valuable for the workshop process and development of management tools, including:

- Population modelling promotes 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 modelling allows the simulation of scenarios and the impact of numerous interacting variables on the population dynamics and risk of population extinction.
- Population modelling facilitates explaining and demonstrating population biological issues to non-biologically oriented groups.
- Population modelling 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 modelling results can help provide support for perceived population trends and the need for action. It can help managers to justify resource allocation for a program to their superiors and budgetary agencies, as well as identify areas for intensifying program efforts.

Our most commonly used model for use in the population simulation modelling process is a software program called Vortex. Developed by Robert Lacy (Chicago Zoological Society), Vortex is designed specifically for use in the stochastic simulation of the extinction process in small wildlife populations and was developed in collaboration with the CBSG PHVA process. The model simulates deterministic forces as well as stochastic demographic, environmental, and genetic events in relation to their probabilities. Vortex can incorporate catastrophes, density dependence, meta-population dynamics, and inbreeding effects. Whenever relevant, other simulation models are used instead of, or in conjunction with, the Vortex model.

IUCN/SSC Species Conservation Strategy components incorporated into the PHVA process

In 2008 the Species Survival Commission (SSC) of IUCN published the document *Strategic Planning for Species Conservation: A Handbook* (IUCN/SSC 2008). This document provides guidance to IUCN/SSC Specialist Groups on when and how to prepare and promote Species Conservation Strategies (SCSs). This guidance includes advice on how to conduct a thorough status review; how to develop, through broad consultation with stakeholders, a vision and goals for the conservation of a species or species group; how to set objectives to help achieve the vision and goals; and how to address those objectives through geographically and thematically specific actions. The handbook describes recommended methods for creating successful SCSs, brief case studies or examples of aspects of SCSs, and references to sources of additional help and guidance. These methods are incorporated into the PHVA process whenever possible.

SIERRA LEONE CHIMPANZEE PHVA WORKSHOP PROCESS

The sequence of events during the Sierra Leone Chimpanzee PHVA workshop was as follows:

- In preparation for the workshop, participants were requested to provide briefing materials with information on the status of and threats to chimpanzees in Sierra Leone as well as on general conservation, socio-economic and developmental activities and plans in the country that may be of relevance to chimpanzee viability and conservation. These documents were sent to the participants before the workshop to read in advance and to have accessible during the workshop (see Resource list app. 1).

- **Opening addresses**
    - Welcome address and opening prayers: Chairman - Acting Director of Forestry - Sheku Mansaray
    - Opening remarks - Director of Livestock, MAFFS Dr Francis Sankoh
    - Introduction of representative institutions - Programme Director, TCS - Bala Amarasekaran
    - Purpose statement - CBSG Europe Programme Officer - Frands Carlsen

- **Opening statements**
    - Environmental Protection Agency - Head, Intersectoral and International Cooperation -Momodu A Bah
    - UN Environmental Programme - Programme Assistant - Fatmata Sarah Turay
    - Ministry for Rural Development & Local Affairs - Michael Samai, Deputy Director (Local Government)
    - Keynote Address- Deputy Minister, MAFFS - Lovell Thomas
    - Vote of Thanks- Conservation and Wildlife MU, Senior Game Warden -Kalie Bangura

- Presentations were given on:
    - IUCN/SSC, CBSG, PHVAs and SCS process and philosophy (Kristin Leus – CBSG Europe)
    - Status of chimpanzees and their conservation in Sierra Leone and results from the nationwide chimpanzee census and dissemination workshop after the census (Anita McKenna - Programme Manager Tacugama Chimpanzee Sanctuary). This presentation gave an overview of the current state of knowledge on the status of chimpanzees in Sierra Leone and gave indications of current knowledge of the main threats in different regions

- Introduction of workshop participants: all participants were asked to introduce themselves by stating their name, institutional affiliation or the group of people they were representing, and how they thought they might be able to contribute to the workshop

- Plenary brainstorm session on all potential values (direct or indirect) of conserving chimpanzees in Sierra Leone. This allowed for discussion of different perspectives and development of an equal understanding of or feeling for the importance of conserving chimpanzees in Sierra Leone (see Section 3).

- Presentation on the relevance of small population biology to species conservation, the stochastic population model Vortex and its use in the PHVA process, and preliminary results of a baseline model for protected chimpanzee populations in good habitat (giving participants an understanding of how the model can be used and of which life history parameters are important determinants for the viability of chimpanzee populations).

- Presentation on the process of developing a vision

- Plenary session: developing a vision for chimpanzees in Sierra Leone (see Section 3)

- Plenary session: mapping of event chains of direct and indirect threats to the viability of the chimpanzee population in Sierra Leone (see Section 3)

- Plenary session: presentation of the first draft of the vision statement and building consensus for the final statement

- Working group sessions: Participants chose to join one of the following working groups:

GROUP 1. Population and threat analysis
GROUP 2. Role of government agencies in chimpanzee conservation
GROUP 3. National Parks: effective management and surrounding communities
GROUP 4. Building human/chimpanzee harmony in community forests
GROUP 5. Ensuring the implementation and long term sustainability of the action plan

  - Each working group was given a first task:

GROUP 1. Define and characterise chimpanzee populations across Sierra Leone based on density, habitat suitability and the level of various threats. Identify priority areas for viable chimpanzee populations and also priority areas for management and conservation action. This information is relevant to the work of the other groups and also feeds into the Vortex model.
GROUP 2. Given the threats identified yesterday, what are the issues/problems/challenges for which the government agencies could play a role in improving chimpanzee conservation?
GROUP 3. List the challenges/problems/issues you face when trying to improve effectiveness of National Park management with respect to chimpanzee conservation, including the impacts of the park on the surrounding communities and the impacts of the communities on the park.
GROUP 4. List the challenges/problems/issues communities face when trying to minimise the negative impact of humans on chimpanzees and of chimpanzees on humans.
GROUP 5. Define what can be done to ensure that the action plan is implemented and that actions and progress can be followed through long term.

All groups except group 5 were asked to:

- Write 2-3 sentences clearly describing each issue/problem/challenge
- Prioritise problem statements
- Consider:
    - What are the facts that you know about this issue?
    - What are our assumptions surrounding this issue?
    - What important data are missing that would better help you address this issue?

- Working groups were then asked to develop long and short term goals: Considering the overall conservation vision for the species as well as the group's issue/problem statements:
    - Develop measurable long-term goals that describe what you would like the situation to eventually look like when this issue/problem is overcome.
    - For each long-term goal, develop measurable shorter term goals (between 1 and 5 years) that describe directions in which to proceed in order to address the stated issue/problem and achieve the long-term goal.

- Subsequently working groups were asked to develop action steps for each goal:
    - The working groups were asked to brainstorm actions to reach each goal and then to evaluate the feasibility and effectiveness of alternative strategies to decide which ones to recommend and which to discard and why. While these evaluative decision-making processes were evident in the working group and plenary discussions, however, the groups generally struggled to address and document this in a structured way. In general, the working group reports document the final recommendations but little of the evaluative discussions leading to these recommendations.
    - For each recommended action, determine:
        - ❖ Responsibility – who in the room is responsible for organizing/doing the action?
        - ❖ Collaborators or Partners – who is essential to get the action accomplished?

- ❖ Time line – beginning and completion of the action (dates).
  - ❖ Measurable outcome or result – a specific product or change in condition.
  - ❖ Consequences – expected impact or outcome or result of the action if accomplished.

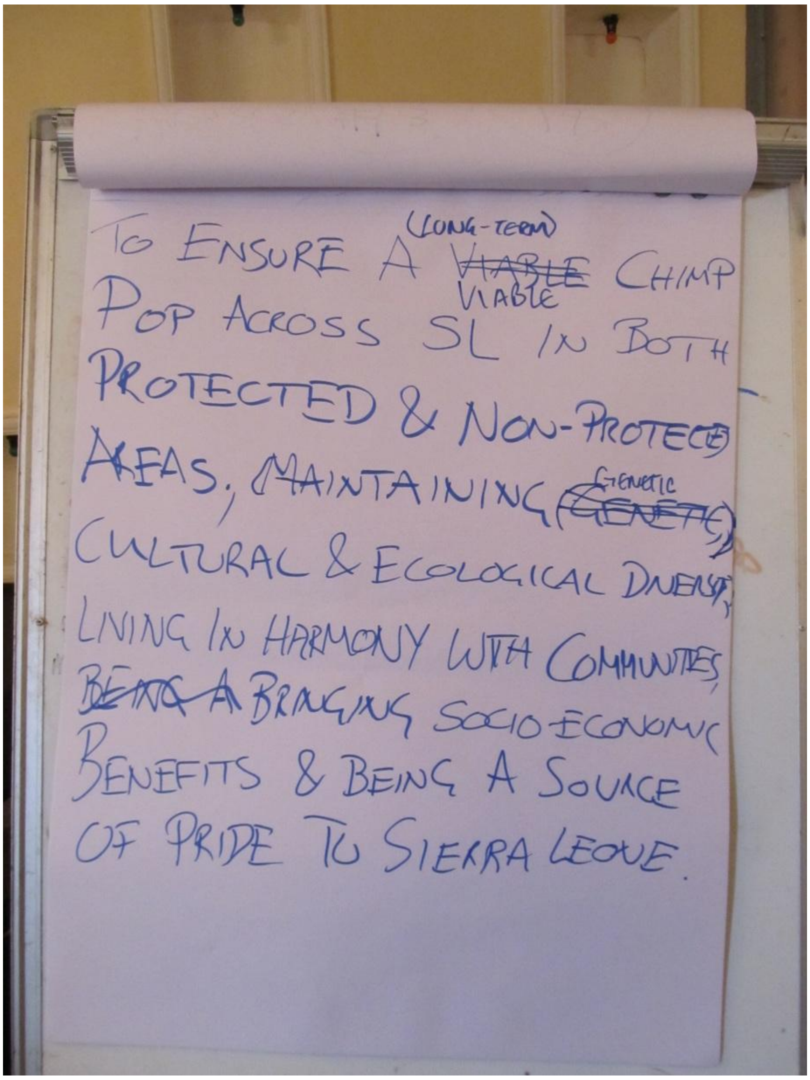
- In parallel with this process, a computer population model (Vortex) was developed to assess the viability of chimpanzee populations in Sierra Leone under current conditions, identify those factors that most acutely affect chimpanzee population growth and persistence, and evaluate the likely impact of alternative management strategies and actions on the long-term viability of chimpanzee populations. This helped to guide participants in making the best informed decisions regarding effective, prioritized conservation actions to achieve their vision for chimpanzee conservation in Sierra Leone.

- Regular plenary sessions were interspersed throughout the process so that all participants had an opportunity to contribute to the work of the other groups and to ensure that issues were carefully reviewed and discussed by the full plenary group. The recommendations coming from the workshop were accepted by all participants, thus representing a form of consensus.

- More details on the workshop process as well as the working group reports can be found in Sections 4 – 9 of this document.

Western Chimpanzee (*Pan troglodytes verus*)
Population and Habitat Viability Assessment (PHVA)
for Sierra Leone

Freetown, Sierra Leone
24 to 27 May 2011



Section 3

Vision, Value and Threat Mapping

VALUE OF CONSERVING CHIMPANZEES IN SIERRA LEONE

At the start of the workshop, all participants were asked to introduce themselves by stating their name, institutional affiliation or the group of people they were representing, and how they thought they might be able to contribute to the workshop. From this it became clear that not everyone had an equal understanding of, or feeling for, the importance of conserving chimpanzees in Sierra Leone. For this reason, a brainstorming session was organised in which participants were asked to list the potential benefits (direct or indirect) of conserving chimpanzees in Sierra Leone. An added benefit of the introduction session and this brainstorming session was that it provided an opportunity for participants to voice their concerns about possible management strategies for the conservation of chimpanzees or about consequences of continued presence of chimpanzees in terms of conflicts with socio-economic well-being of the people living in the area. Because both the concerns and the benefits of chimpanzee conservation could be voiced to neutral facilitators, participants were exposed to each other's viewpoints and reasoning, without one group trying to actively and directly persuade the other group of "being right". By the second half of the brainstorming session, all stakeholders were contributing equally to the listing of benefits of chimpanzee conservation and the concerns about human welfare were spontaneously included in the vision statement (see below).

The workshop participants identified the following values of/reasons for conserving chimpanzees:

- All species have a right to exist (intrinsic right).
- Protecting chimpanzees leads to protection of additional species, their habitat and their ecological functions.
- Chimpanzees and their habitat provide environmental services.
- Chimpanzees are important for the dispersal of some seeds and play a role in plant and forest regeneration.
- By protecting forests we protect water supply.
- Protecting and regenerating forests contributes to carbon sequestration.
- By protecting chimpanzee habitat we help combat erosion.
- By protecting chimpanzees and their habitat we will also protect ourselves.
- It is important to maintain species richness (including chimpanzees) as this represents the biodiversity of the country.
- Losing one species leads to a slippery slope of losing more and more biodiversity.
- Chimpanzees are part of Africa's history and culture.
- Chimpanzees reflect part of our human evolutionary process.

- Protecting chimpanzees helps to protect cultural links between humans and chimpanzees (e.g. tool use).
- Chimpanzees resemble humans and are useful for learning more about ourselves (including medical discoveries).
- Chimpanzees are similar to humans and is ethical for us to protect them.
- The presence of chimpanzees is important to attract tourists and for ecotourism activities.
- The presence of chimpanzees can lead to increased revenue for the country.
- There is name confusion between chimpanzees and baboons in local languages in Sierra Leone – the presence of chimpanzees is important to be able to demonstrate differences between primates (more particularly chimpanzees vs. baboons).

VISION

By means of a presentation the facilitators explained to the participants that:

- A vision statement is a short statement that outlines the desired future state of the species (i.e. describes what it means to "save the species") and is long term and ambitious.
- There may be several different components to a vision statement that they might want to consider:
    1. Representation: e.g. think about whether to conserve one population in one place or different populations in different places, e.g. because they represent:
        – major ecological settings
        – genetic differences across the range
        – culturally transmitted chimpanzee behaviour that differs between populations
        – different country regions/districts/chiefdoms (as iconic species)

        or, because they help

        – Minimise extinction due to catastrophes

    2. Functionality: e.g. think about how functional individual populations should be, and/or how "natural" should they be? E.g.
        – sustainable for long term?
        – sustainable for the long term without intensive management?

- conserve ecological roles of chimpanzees? (seed dispersal, prey/ predators, etc.)?
- conserve "typical" social group structure/social dynamics?

3. Human needs/desires: e.g. think about issues such as:
    - does conservation of chimpanzees need to take into account any human socio-economic or cultural needs/desires/concerns?

The facilitators also presented some examples of vision statements from other workshops for other species/taxa and then facilitated a brainstorming session during which the participants identified issues in terms of representation, functionality and human needs/desires that they felt should be mentioned in a vision statement for the conservation of chimpanzees in Sierra Leone:

1. Representation
    - Throughout Sierra Leone (in suitable habitat)
    - Ensure viability in both protected areas and also outside of protected areas when numbers are currently of sufficient size (aligns with national policy)
    - Maintain current geographic distribution

2. Functionality
    - Maintain genetic diversity of chimpanzees
    - Maintain cultural diversity of chimpanzees
    - Maintain ecological diversity of chimpanzees
    - Long-term persistence (into perpetuity)

3. Human needs/desires
    - For the well-being of humans
    - Socio-economic benefit to local communities
    - Humans and chimps to live in harmony (harmonious co-habitation / reactivate past relationship)
    - Mass communication to increase awareness of benefits of chimpanzees
    - Livelihood developed of local communities
    - Eliminate the negative perception of chimpanzees
    - Source of pride for Sierra Leone (national emblem)

A small working group then worked on a first draft of a vision statement that was brought back to plenary at the end of the first day. After a plenary discussion of the first draft and some wordsmithing, the following final vision statement for the conservation of chimpanzees in Sierra Leone had consensus agreement:

"To ensure a long-term viable chimpanzee population across Sierra Leone in both protected and non-protected areas, maintaining genetic, cultural and ecological diversity, living in harmony with communities, bringing socio-economic benefits and being a source of pride to Sierra Leone."

The added benefit of this visioning process was that at the end of it, the wide field of stakeholders all felt comfortable that their concerns/issues would be taken into account during the workshop – it created mutual understanding and good will among the participants.

STATUS REVIEW

The status review for the chimpanzees of Sierra Leone was conducted in four separate stages:

1. Resulting from the Pan African Sanctuary Alliance (PASA) meeting held in Sierra Leone in 2008, and with the endorsement of the Government of Sierra Leone, Tacugama Chimpanzee Sanctuary (TCS) undertook a National Chimpanzee Census Project during 2009 and 2010 (Brncic *et al*. 2010). Objectives of the census were to determine the abundance and distribution of chimpanzees, to collect data in preparation for the PHVA and conservation planning, to build capacity of Sierra Leone nationals, to identify potential release sites for rehabilitated chimpanzees from TCS, and to contribute to the subspecies data set within the Ape Populations, Environments and Surveys (APES) database. The innovative methodology developed made use of a combination of interview and transect surveys to gather both qualitative and quantitative information on the abundance and distribution chimpanzees (and other mammals), the degree of crop raiding by chimpanzees, vegetation types, signs of human activities (such as power-saw logging, hunting, trails and farms), attitudes towards chimpanzees and knowledge about chimpanzees and laws for their protection. For the survey of non-protected areas the country was divided into 9x9 km² blocks of which every 9^{th} block was studied resulting in 100 blocks being surveyed across the country (Figure 1). In addition, seven Forest Reserves (Gola (including community forests), Kambui, Kangari, Loma, Nimini, Tingi and WAPFR (Western Area Peninsular Forest Reserve)) and one

National Park (the Outamba-Kilimi) were studied in more detail (Figure 1). The results of the census show that an estimated 5,500 wild chimpanzees (with a lower and upper confidence interval of 3052 and 10446 respectively) remain in Sierra Leone (Table 1), making the country home to the second largest population of chimpanzees in West Africa following Guinea. More than half of these chimpanzees live outside protected areas (Table 1, Figure 2), they are declining in number (e.g. Figure 3), and they are threatened by many factors (e.g. Figures 4 and 5)

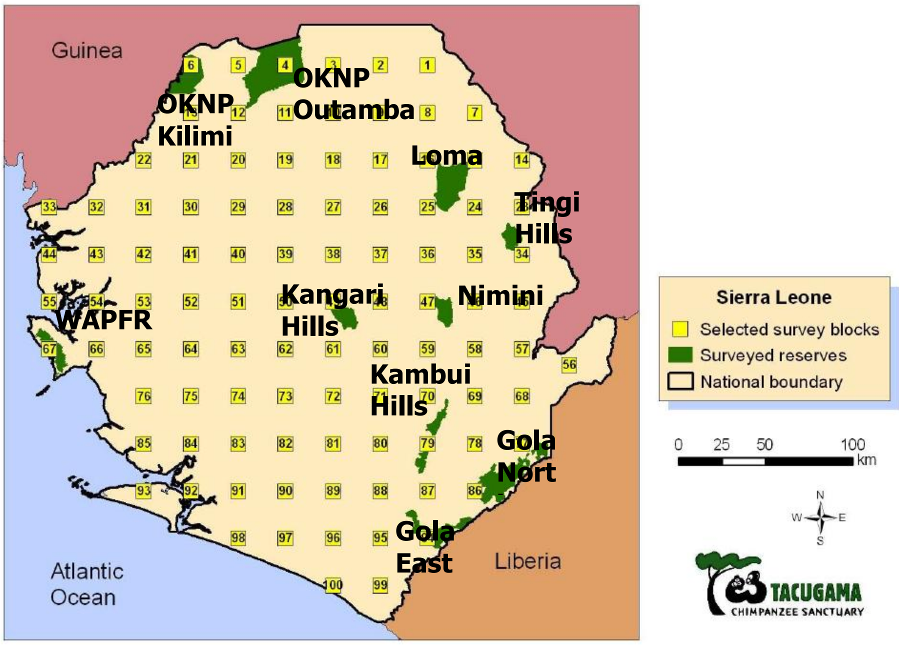


Figure 1: Map of Sierra Leone showing the 9x9 km² grid blocks that were selected to be surveyed by a combination of interview and transect methods (in yellow), as well as the protected areas that were surveyed separately using systematic line transects with a random start point (in green). From Brncic *et al.* 2010.

Table 1: Total chimpanzee population in Sierra Leone with associated lower and upper confidence intervals. From Brncic *et al.* 2010.

Habitat	No. of chimps	Lower CI	Upper CI
Non-protected area	3100	1540	6341
Forest reserves	1460	854	2509
Outamba-Kilimi National Park	1020	658	1596
Sierra Leone Total	**5580**	**3052**	**10446**

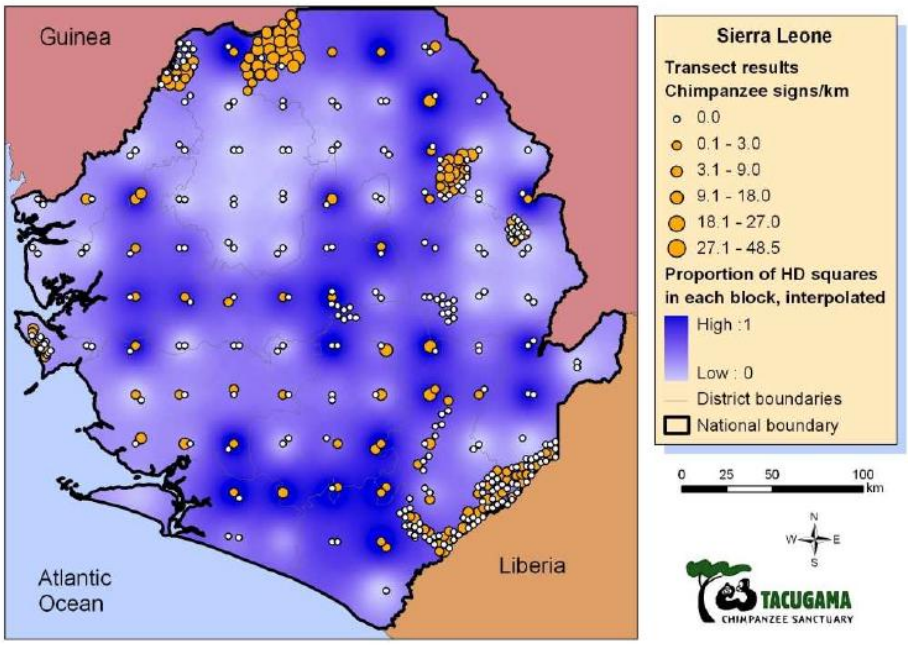


Figure 2: Comparison of chimpanzee sign encounter rates on transects (orange circles) with predicted chimpanzee occurrence from block interviews (blue shading). From Brncic *et al*. 2010.

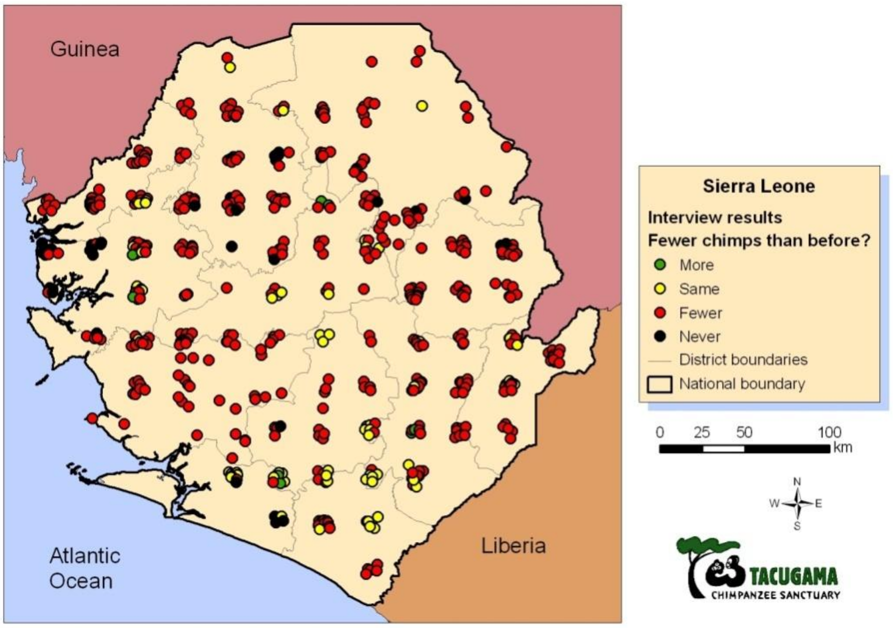


Figure 3: Summary of interview data regarding community perceptions on chimpanzee populations trends. From Brncic *et al*. 2010.

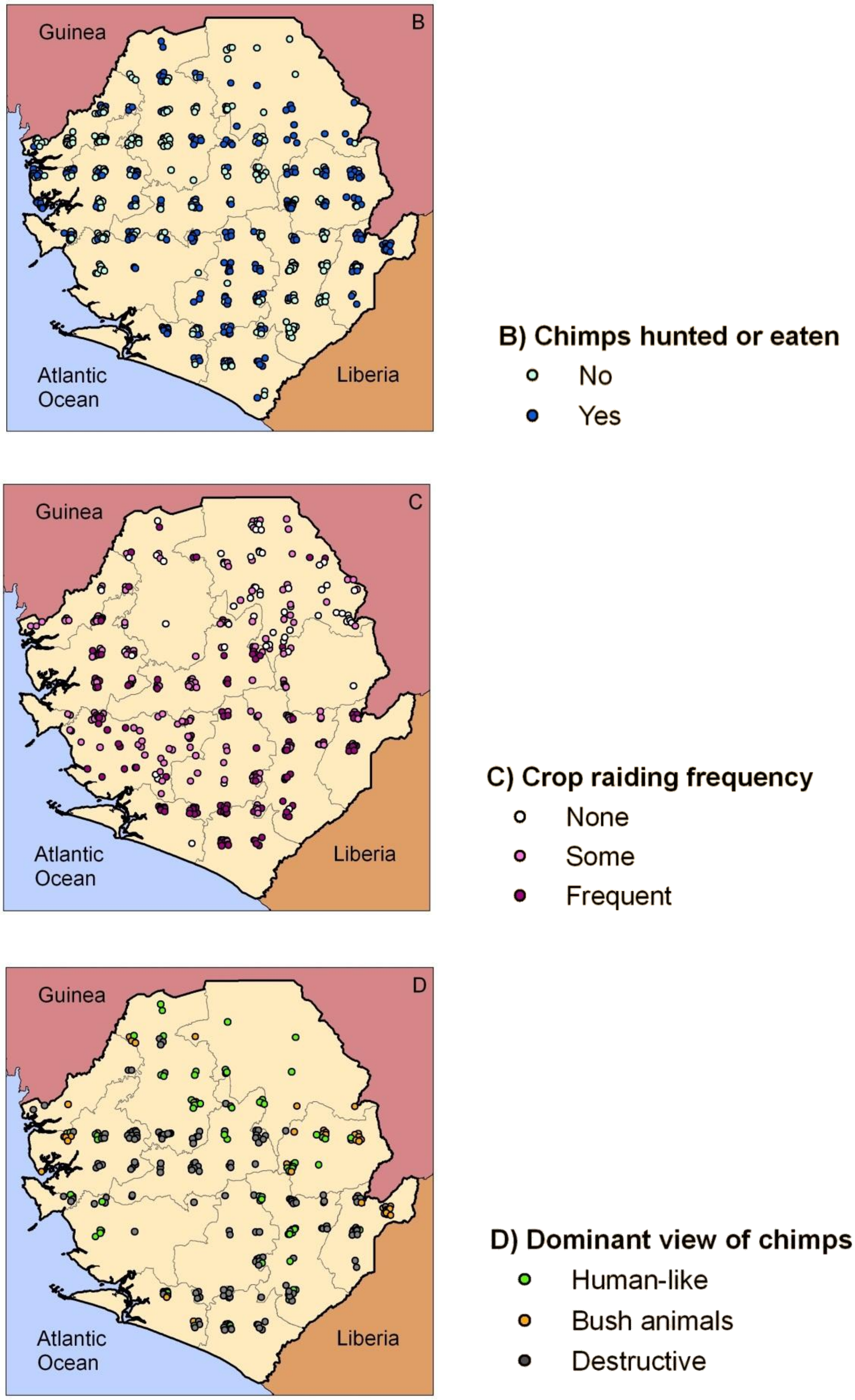


Figure 4: Summary of supplementary interview data regarding B) hunting or eating of chimpanzees, C) crop raiding frequency and D) the predominant attitude of communities towards chimpanzees. From Brncic *et al*. 2010.

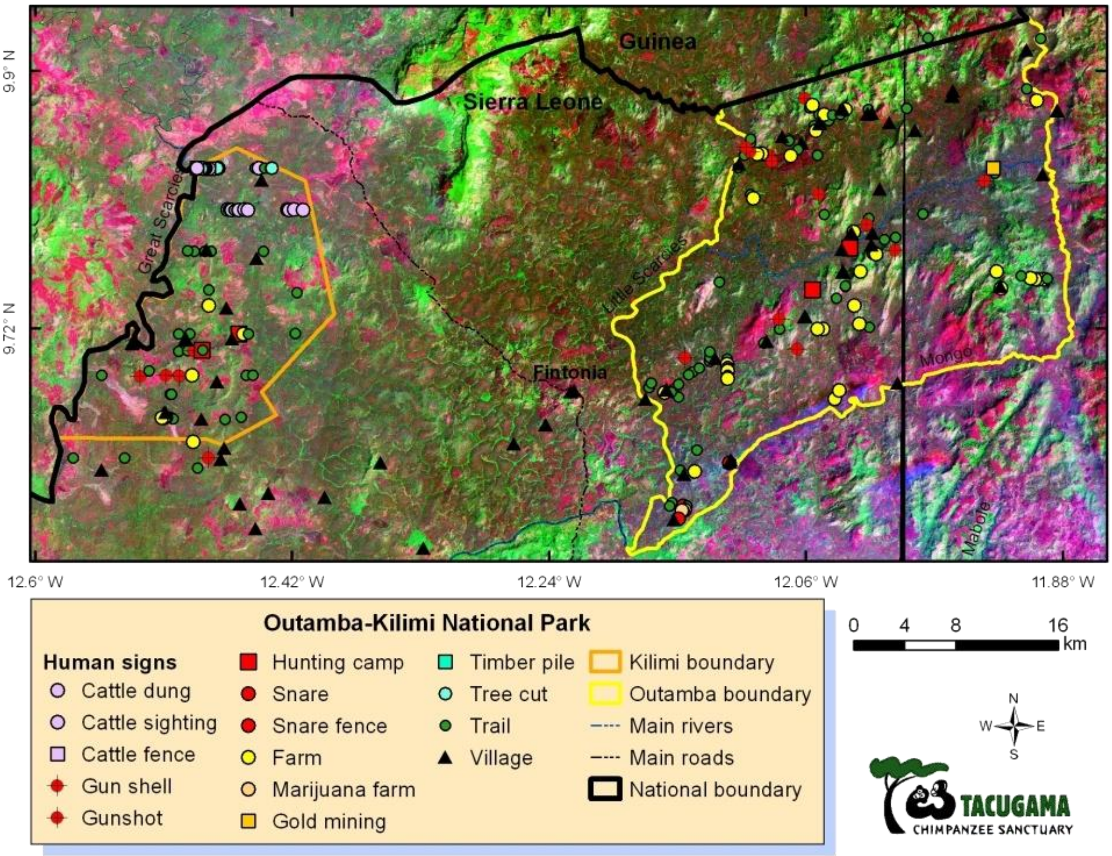


Figure 5: Distribution of human signs found on transects and recces in the Outamba-Kilimi National Park (not all villages outside the park boundaries are shown). From Brncic *et al*. 2010.

2. The census gathered a wealth of new data important for the development of conservation and land use strategies. In order to ensure that awareness of the census information exists within key stakeholder groups, the Conservation and Wildlife Management Unit of the Forestry Division of the Ministry of Agriculture, Forestry and Food Security in collaboration with the Tacugama Chimpanzee Sanctuary organized a Dissemination Workshop in September 2010 with as objectives to embed the knowledge generated by the census, to generate understanding as to the importance of chimpanzees both for Sierra and internationally and to create a viable pathway from the census to the delivery of an endorsed and functioning chimpanzee conservation action plan (TCS 2010). A number of the PHVA participants had also participated in this dissemination workshop.

3. In preparation for the PHVA workshop, participants were requested to provide briefing materials with information on the status of, and threats to, chimpanzees in Sierra Leone, as well as on general conservation, socio-economic and developmental activities in the country that may be of relevance to chimpanzee viability and conservation. These documents (which included the reports of the census and the dissemination workshop) were sent to the participants in advance of the PHVA so they could be consulted before and during the PHVA workshop. For a full list of briefing materials see Appendix I – Resource List.

4. At the start of the PHVA workshop Anita McKenna of the TCS gave the Presentation: "Status of chimpanzee conservation," which:

   - Framed the importance of the conservation of the Sierra Leone chimpanzees in the larger context of the IUCN/SSC Regional Action Plan for the Conservation of Chimpanzees in West Africa (Kormos *et al.* 2003) and West African Chimpanzees: Status Survey and Action Plan (Kormos & Boesch. 2003), of Sierra Leone's importance as western end of the Upper Guinea Forest Block (one of the 25 global biodiversity hotspots and one of the two highest priorities for primate conservation in the world) and of Sierra Leone's National Biodiversity Strategy and Action Plan for the Convention on Biodiversity.
   - Reviewed the results of the national chimpanzee census and the dissemination workshop.
   - Presented already ongoing conservation, research and aid and development activities with relevance to the conservation of chimpanzees and habitat.

5. All PHVA participants were therefore well informed regarding the current state of knowledge about the status of chimpanzees and their habitat in Sierra Leone and used this information in the course of their work. In addition, the Population Analysis working group further developed knowledge about the status of chimpanzees in Sierra Leone based on information and experience added by all of the PHVA participants. More specifically, this working group carefully examined the distribution of chimpanzees across Sierra Leone and the mosaic of habitat types and threats experienced by chimpanzees across the country, and then divided chimpanzees into 11 core populations in Sierra Leone. They then estimated current population size and carrying capacity for each, identified the threats impacting each population, and translated these into estimated future projected rates of habitat loss and loss of chimpanzees through hunting or other human persecution. This information, as well as information generated by other working groups, was used to

develop the Vortex model in order to examine population viability under various conditions and to help inform conservation actions.

THREAT ANALYSIS

The nationwide census work already provided much information on what kinds of threats are influencing the viability of chimpanzee populations in different reasons. However, it was not always clear exactly how these threats affected chimpanzees, and what activities led to and resulted from these threats. Therefore, because it was felt to be important that:

1. All of the various stakeholders contributed their own life experiences in terms of chains of events and activities that affect chimpanzees;
2. Participants learned to understand that a particular threat can be influenced at different steps of the chain of events (which can be important for goal and action setting); and
3. All participants had an equally good understanding of the intricate nature of the threats to chimpanzees;

an interactive plenary session was organised whereby the participants were asked to think about all proximate and ultimate threats influencing the viability of the chimpanzees in Sierra Leone, to write each threat on a large post-it note, and to map this note on the wall so that it becomes clear which threats influence each other in which way and how the chains of events lead to a particular effect on the chimpanzee demography (i.e. increased mortality, reduced reproduction, smaller population size, and/or isolated populations), all of which in turn affect viability (see Figure 6).

This exercise did not bring much surprisingly new information, but it did generate a common level of understanding, and it allowed all participants to express their own knowledge and experiences (rather than having to "accept" findings of a previous study), and to become comfortable with each other and with an interactive workshop process. It also explicitly linked human activities to chimpanzee demography, which could provide important insights for the development of Vortex model scenarios.

This threat map was used to help decide the topics for the different working groups and was referred back to at several times during the workshop to help inform goal and action setting and to help make sure that all major threats were addressed in some form in at least one of the working groups, or during plenary discussions.

Figure 6: Map created by the workshop participants of the chain of events of proximate and ultimate threats to the viability of the chimpanzee population in Sierra Leone with explicit linking of the threats to chimpanzee demography and genetics.

Figure 7 is a reconstruction of this diagram, reorganized such that chimpanzee viability (in green) and demographic effects (in tan) are in the centre and are surrounded by chains of events and activities that impact them. Arrows indicate the direction of estimated causal relationships. Large-scale primary root causes are in blue (i.e. those with arrows only leading away from them). The participants also recognized that 'lack of law enforcement' and 'weak policies and regulations' (and also 'lack of understanding or knowledge') were relevant issues that allowed many of these relationships to occur. In many cases, effective law enforcement, stronger policies and regulations, and/or better knowledge and understanding may be able to sever some of the causal chains diagrammed.

Major issues that did not get tackled by the working groups of this PHVA but should be addressed for the development of the National Action Plan for the Chimpanzee of Sierra Leone are large and small scale mining (and the associated chains of events), increasing human population size and orphan chimpanzees.

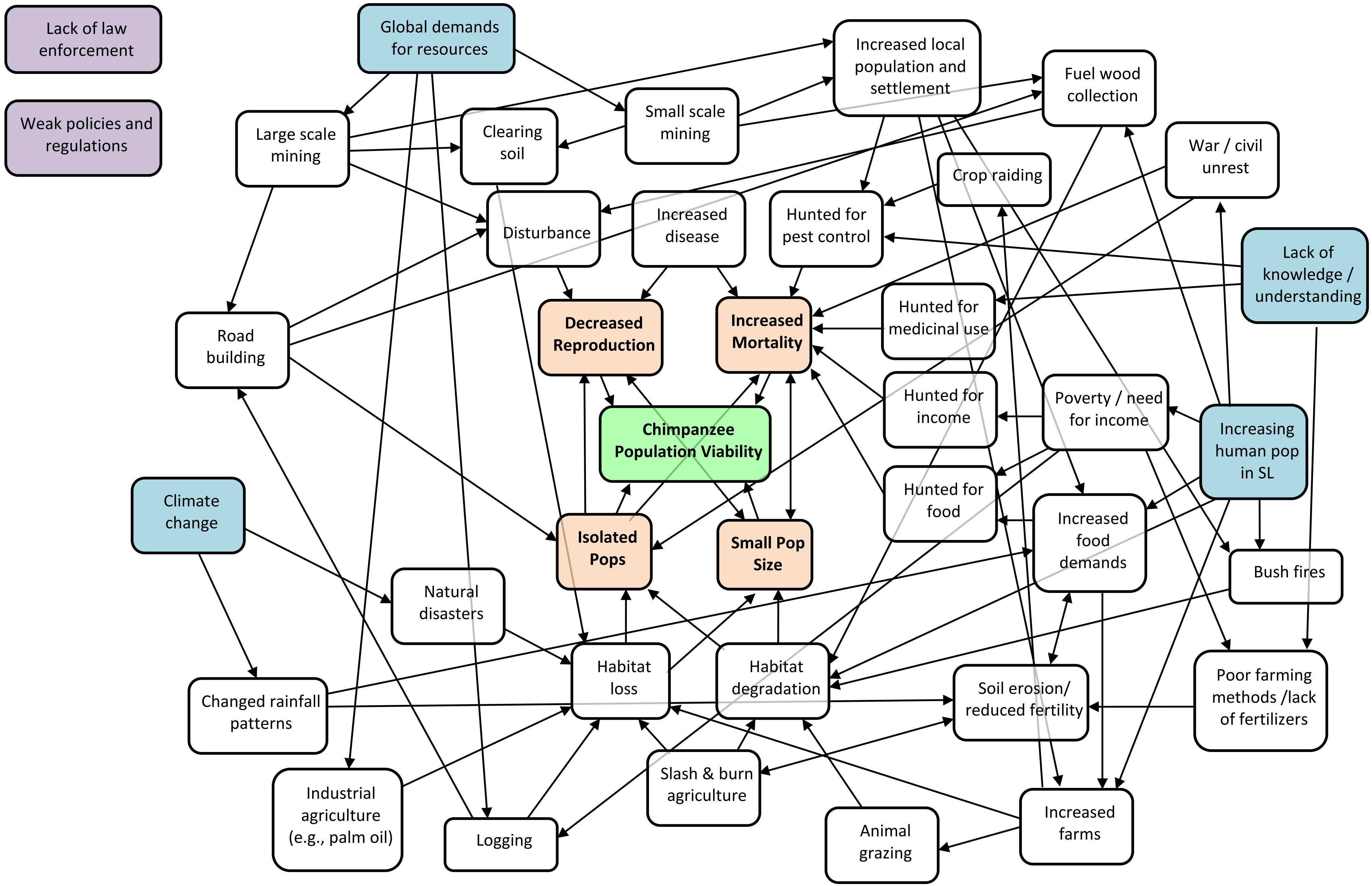


Figure 7. Diagram of threat map (reorganized around chimpanzee population viability.

Western Chimpanzee (*Pan troglodytes verus*) Population and Habitat Viability Assessment (PHVA) for Sierra Leone

Freetown, Sierra Leone
24 to 27 May 2011

Section 4

Population and threats analysis

Population and Threats Analysis Working Group

Participants

Papanie Bai-Sesay, Tacugama Chimpanzee Sanctuary
Alhajie Siaka, Gola Forest Programme
Terry Brncic, Specialist advisor
Hjalmar Kuehl, Max Planck Institute

TASK: Define and characterise chimpanzee populations across Sierra Leone based on density, habitat suitability and the level of various threats. Identify priority areas for viable chimpanzee populations and also priority areas for management and conservation action. This information is relevant to the work of the other groups and also feeds into the Vortex model.

PROBLEM: Data gaps for chimpanzee populations, threats and priority areas

In order to assess the status of chimpanzees in Sierra Leone and develop effective conservation actions, the following information on chimpanzee populations in Sierra Leone needs to be considered:

- What is the current knowledge of chimpanzee distribution and abundance in Sierra Leone?
- What criteria should be used to determine priority areas?
- What are the priority areas that are most important for maintaining viable populations of chimpanzees?
- What are the priority threats and where do they overlap with priority chimpanzee populations?
- What are the different kinds of management actions needed for each area?
- What are the proposed protected areas/national parks and how would their establishment affect chimpanzee populations?

More information is needed on chimpanzee populations across Sierra Leone:

1. We know that there are threats in different parts in Sierra Leone, but we do not know exactly how these threats affect the viability of chimpanzee populations.
2. More data are needed on chimpanzee populations outside of government protected areas (e.g. group size, reproductive rate, connectivity/isolation, diet).
3. We need to test the assumption that hunting pressure is greater outside of vs. inside of the reserves.

Goal 1: Better understanding of the status of chimpanzee populations.

1. Do chimpanzees outside of protected areas still have normal community structure and reproduction? Are chimpanzees reproducing better, or are they old remnant, non-reproducing populations? (high priority)

2. Are chimpanzee populations in Sierra Leone connected genetically as one meta-population, or are there isolated populations, or likely to be isolated populations? This can be summarized from distribution and threat data. (medium priority)

3. What is the chimpanzee carrying capacity for protected areas and agricultural lands? (low priority because carrying capacity is unlikely to be reached)

Action 1.1: Select certain locations for camera trapping projects.
Action 1.2: Conduct genetics study to get more precise population sizes.

Goal 2: Better understanding of the threats to chimpanzees.

1. Understand the actual threats of mining. If each of the 85 mining concessions in the country were active, what would be the impacts?
    1. Bauxite – upper layers of terrain removed over a wide area, therefore chimpanzees will die, need offset.
    2. Gold – Spot exploitation with less habitat destruction, but more hunting. Can be controlled.
    3. Diamonds – Rivers polluted, pit mining, hunting a threat, could be controlled.
    4. Rutile – Clearance of large areas, chimps killed - need offset.
    5. Iron Ore – Clearance of large sites, chimps killed - need offset. Roads and rails, can be controlled - government effort.
2. If logging concessions were reactivated what would be the impact on chimpanzees?
3. Are there any other infrastructure projects planned for the future that will impact chimpanzee populations? e.g. Kono (Big Congo) dam project.

4. What is the potential threat of commercial agriculture (palm oil, cacao, rubber, sugarcane plantations?). It increases demand on the rest of the land.
5. What are the climate change predictions for Sierra Leone, and how might that affect habitat in the future?

Other data gaps with respect to threats were identified in plenary discussions, including increased slash and burn/farming and the increasing human population. The impact of the arms embargo was also mentioned.

Action 2.1: Get a GIS map of mining/logging concessions and infrastructure projects; contact responsible agencies (UNEP, Ministry of Mines, Mining companies, Ministry of Energy, Power, and Water Resources).
Action 2.2: Inform the mitigation or offset plans.
Action 2.3: Get climate change predictions for Sierra Leone (UNCCC).

Goal 3: Better understanding of the opportunities.

1. Where is watershed protection a potential benefit to chimpanzee populations?
2. What are the potential carbon offset areas in Sierra Leone that would benefit chimpanzees (UNEP-WCMC 2010)
3. What are the opportunities to combine chimpanzee conservation with conservation efforts for other species?

Action 3.1: Create GIS information or identify existing information about these locations.
Action 3.2: Promote REDD process in Sierra Leone (conservation coordinator to identify links).

Goal 4: Identification of priority areas for, and threats to, viable chimpanzee populations.

Criteria for assigning priority:
- Larger chimpanzee population size
- Habitat quality
- Surface area
- Threats (high and low)
- Other criteria (e.g., isolation, legal status, potential for ecotourism, etc.)

The working group spent considerable time discussing the distribution and density of chimpanzee populations in Sierra Leone and considered several alternatives in terms of how subpopulations might be designated for modelling based on density, management, threats and connectivity. Based on census data and their collective expertise the group designated a series of 11 core areas (populations) for discussion and modelling purposes. They then developed a matrix of these core areas and types of threats to provide a rough assessment of the primary threats currently affecting each area (see Table 2).

Table 2. Eleven core chimpanzee areas, with estimated approximate chimpanzee population size (N) and types of threats to chimpanzees for each area.

		THREATS (HL = habitat loss; M = increased mortality)								
Population	**Est. N**	Mining	Logging	Farming	Fires	Plantation	City develop	Cattle ranch	Bushmeat hunting	Retaliation killing
Outamba	1000	HL		HL	HL			HL/M	**M**	
N Koinadugu	800				HL			HL/M	M	
Loma	1065			HL					**M**	
Tingi	70			HL					**M**	
Gola	270	HL							**M**	
Kenema	500	HL	HL	HL		**HL**				M
Kangari*	400									
South Bo*	500									
Moyamba	600	HL	HL	**HL**						M
WAPF	55			HL			HL		**M**	
Port Loko	200			**HL**	HL	HL		HL/M		

** threats not recorded for these areas*

Priority Areas (high priority / low vulnerability):

- Loma
- Outamba
- Gola
- Koinadugu

<u>Summary</u>:

1. a) Low vulnerability areas tend to be the protected areas.
   b) High vulnerability areas tend to be agricultural landscapes.
2. a) In low vulnerability areas chimpanzees are threatened by direct mortality through hunting.
   b) In high vulnerability areas chimpanzees are threatened by habitat loss.

Western Chimpanzee (*Pan troglodytes verus*) Population and Habitat Viability Assessment (PHVA) for Sierra Leone

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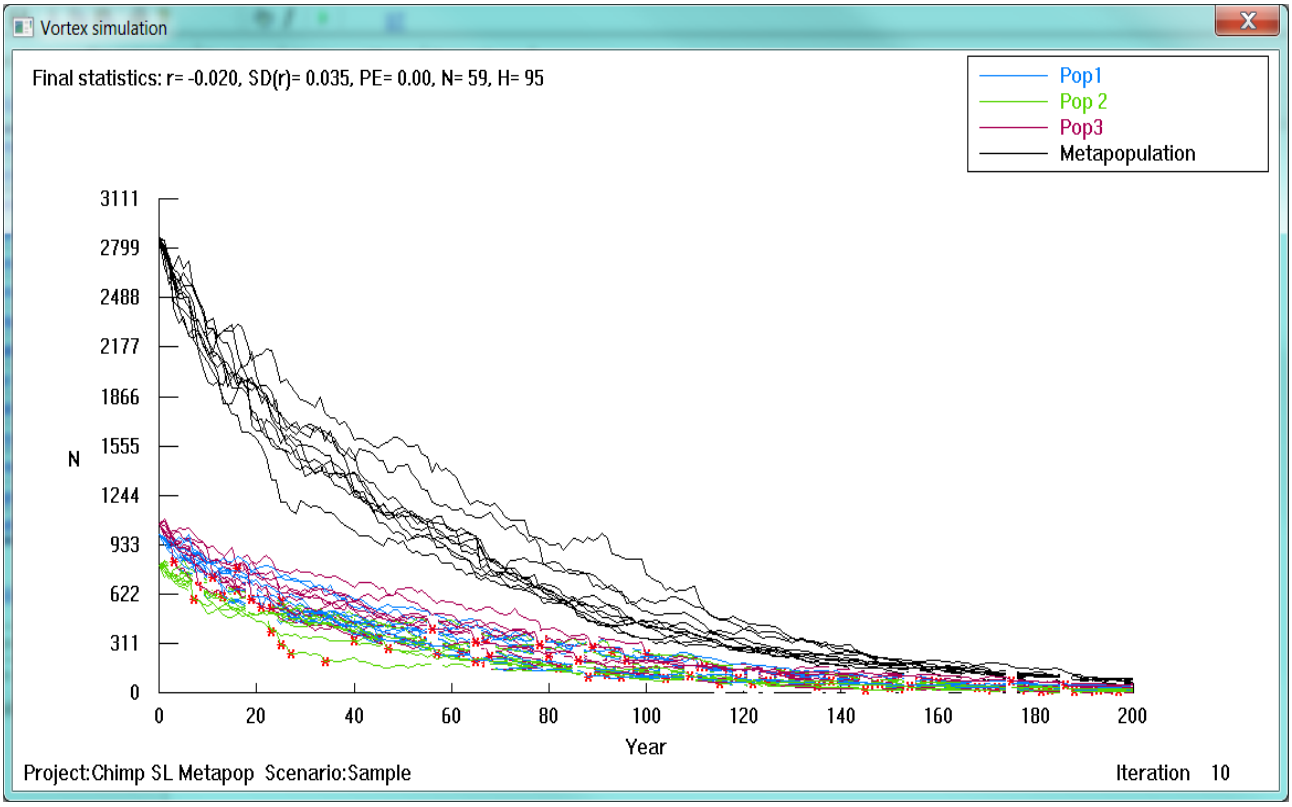


Section 5

Population modelling

Population Modelling Report

Modeller

Kathy Traylor-Holzer, IUCN/SSC Conservation Breeding Specialist Group

With input from the Population and Threats Analysis Working Group:
Papanie Bai-Sesay, Tacugama Chimpanzee Sanctuary
Alhajie Siaka, Gola Forest Programme
Terry Brncic, Specialist advisor
Hjalmar Kuehl, Max Planck Institute

Introduction

The purpose of this Population Viability Analysis (PVA) is to provide an assessment of the relative viability of chimpanzee populations living throughout Sierra Leone through the development of a population simulation model, and to make this modelling tool available during the Sierra Leone Chimpanzee Population and Habitat Viability Assessment (PHVA) Workshop to aid workshop participants in developing a conservation plan for chimpanzees in Sierra Leone. The modelling strategy used can be divided into these components:

1. Baseline chimpanzee model and sensitivity analysis to determine those factors that most influence chimpanzee population viability;

2. Model scenarios that explore the relative viability of chimpanzee populations across a range of population sizes and levels of removal (‘additional’ mortality);

3. Best guess model scenario for core chimpanzee populations in Sierra Leone given estimated projected threats and their impacts; and

4. Alternative scenarios for Sierra Leone chimpanzee populations that represent alternative management or future conditions to assess their relative impact on viability.

The combination of these modelling exercises will assist in assessing the general long-term viability of chimpanzees in Sierra Leone, determine which factors are most likely to affect viability, and guide future management and research actions to better predict, monitor and manage for viability.

Vortex Simulation Model

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

The simulation software program Vortex (v9.99) was used to examine the viability of chimpanzee populations under a variety of conditions. Vortex is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild or captive small populations. Vortex models population dynamics as discrete sequential events that occur according to defined probabilities. The program begins by creating individuals to form the starting population and then stepping through life cycle events (e.g. births, deaths, dispersal, catastrophic events) on an annual basis. Events such as breeding success, litter size, sex at birth, and survival are determined based upon designated probabilities that incorporate both demographic stochasticity and annual environmental variation. Consequently, each run (iteration) of the model gives a different result. By running the model hundreds of times, it is possible to examine the probable outcome and range of possibilities. For a more detailed explanation of Vortex and its use in population viability analysis, see Lacy (1993, 2000) and Miller and Lacy (2005). PVA using Vortex predicts the future fate of populations without bias for well-studied populations (Brook *et al*. 2000).

Model Development and Data Sources

A Vortex basic model for wild chimpanzee populations living in good quality, protected forest habitat was developed from data from field studies conducted primarily in Gombe (particularly the Kasekela community) and Mahale National Park, the two long-term, extensively studied wild chimpanzee populations. Gombe historical data provided courtesy of Anne Pusey (University of Minnesota) were analysed to obtain some of the demographic rates. Additional demographic information was gleaned from previous chimpanzee PVAs using Vortex, one by Earnhardt *et al*. in 2005 for the Gombe population and one for the Uganda chimpanzee population (Edroma *et al*. 1997). These analyses along with published information and expert opinion were used to develop a reasonable base demographic model for chimpanzee populations living in core protected forest areas.

Information from the following sources was used in model development:

Kano 1972; Hiraiwa-Hawegawa *et al*. 1984; Moore 1992; Ogawa *et al.* 1997; Hill *et al*. 2001; Quiatt *et al.* 2002; Nishida *et al*. 2003; Ogawa *et al.* 2004; Williams *et al.* 2004; Nakamura 2005; Hernandez-Aguilar *et al*. 2006; Lonsdorf *et al.* 2006; Ogawa *et al.* 2006a, b; Emery Thompson *et al.* 2007a, b; Ogawa *et al*. 2007; Pusey *et al*. 2007; Hanamura *et al.* 2008; Kaur *et al*. 2008; Pusey *et al*. 2008; Williams *et al.* 2008; Yoshikawa *et al*. 2008.

This model and sensitivity analysis was initially developed for chimpanzee populations in Tanzania in 2010 as part of the development of a Chimpanzee Conservation Action Plan (JGI *et al*. 2010) and is based on the best available life history data for wild chimpanzees. Given the paucity of similar data for western chimpanzees, this model is believed to be a sound base model for chimpanzee populations in Sierra Leone.

Base Model Parameters

Reproductive parameters

The model used a polygynous mating system, with all adult males in the potential breeding pool and reassignment of mates each year. All births were single (no twins), with an even sex ratio at birth.

Age of first reproduction: Set to 13 years (females); 15 years (males)

This parameter represents the *average* age of first reproduction, not the age of sexual maturity or earliest reproductive age observed. Input values were based on multiple data sources, including published and unpublished data and expert opinion.

Percent adult females breeding per year: Set to 22% (ages 13-30 yrs) and 13.5% for females over 30 yrs

These values were calculated from Gombe population data (all communities) bases on observations of 118 breeding age females from 1963 through December 2008. Environmental variation was partitioned out of the total observed variation by removing the expected demographic variation based on sample size. Reproductive rates were calculated separately for females over 30 years of age, as there is evidence of reduced fertility in some females as they age, perhaps due to health issues (Nishida *et al*. 2003; Emery Thompson *et al.* 2007a). When combined with the expected stable age distribution, these values result in an average interbirth interval (IBI) of 5.33 years. No reproductive senescence and no density dependence were included in the model.

It should be noted that the Gombe data include only births in which a living infant was observed; therefore, the reproductive rates and neonatal mortality rates used in the model do not include stillbirths, abortions or deaths immediately after birth. Inclusion of such information would increase neonatal mortality rates and shorten the average interbirth interval, increasing reproductive rates. Exclusion of these data does not affect the model results presented here (as the lower reproductive rates are compensated for by lower neonatal mortality), but these factors should be kept in mind in comparisons with other reproductive and mortality datasets that might include such early birth events.

Mortality rates

The maximum age was set at 43 years for males and 53 years for females based on the Gombe dataset of 280 individuals. Few individuals survive to maximum age in the model (about 1%) with the mortality rates used. Mortality rates were derived based on a variety of sources, including Earnhardt *et al.* 2005 (based on Kasekela data) and Hill *et al.* 2001 (five chimpanzee populations) as well as the Gombe dataset, and were developed to produce survivorship curves and age- and sex-ratios similar to those reported in the literature (Hiraiwa-Hawegawa *et al.* 1984; Nishida *et al.* 2003). The following age- and sex-specific mortality rates were used in the base model:

Annual rates (%):	Males	Females
0-1 yr:	19	15
1-2 yr:	5.3	5
2-10 yr:	3	2
10-13 yr:	5	2
13-15 yr:	10	2
15-27 yr:	3	2
27-35 yr:	8	7
35-40 yr:	10	7
40-43 yr:	50	12
43-48 yr:	--	12
48-50 yr:	--	25
50-53 yr:		50

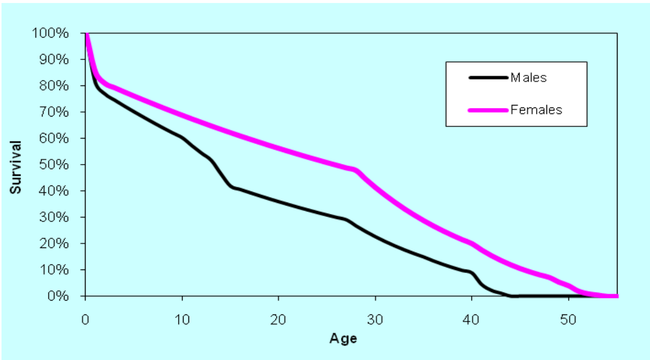


Figure 8. Sex-specific survivorship curves based on mortality rates used in the base model.

Environmental variation (EV)

Environmental variation represents the variation in demographic rates (reproduction and survival) due to variation in environmental conditions between "good" and "bad" years. EV for reproduction and survival are correlated in the model, so that good years are associated with both higher reproduction and survival, and bad years have both lower reproduction and survival. EV was set relatively low for survival (SD = 20% of the mean) and at a moderate level for reproduction (SD = 36% of the mean, based on analysis of Gombe data). Additional variation in demographic rates (demographic stochasticity) is built in as an inherent property of the stochastic modelling process.

Epidemic disease

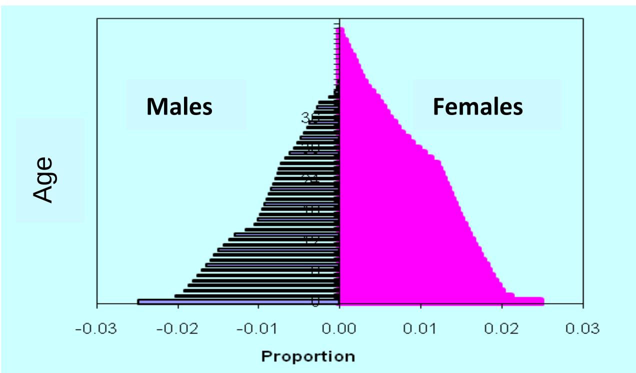
Disease is recognized as a primary cause of mortality in chimpanzees (Nishida *et al*. 2003; Williams *et al.* 2008); as such, the base model mortality rates include deaths due to normal levels of disease. The base model incorporated a 2% risk of a major epidemic (i.e. occurring on average once every 50 years) that results in the death of 20% of those chimpanzees that would normally survive that year based on observed epidemics in Gombe, Mahale and Tai National Parks (Formenty *et al*. 1999a,b; Formenty *et al*. 2003; Lonsdorf *et al*. 2006; Hanamura *et al*. 2008; Kaur *et al.* 2008; Pusey *et al*. 2008; Williams *et al*. 2008). More severe and/or long-lasting disease effects, such as SIV, were not included in the model and would be expected to affect viability (Keele *et al*. 2009). Spatial or population substructure was not incorporated into the model to simulate spread of disease within and among communities, which could have consequences on the extent and impact of disease in chimp populations.

Inbreeding depression

Vortex models inbreeding depression as reduced first-year survival of inbred infants. A value of 6 lethal equivalents (LE) was used in the chimpanzee model, 50% of which were assigned to lethal alleles and subject to purging. This default value is taken as a conservative estimate of inbreeding depression based on O'Grady *et al.* (2006), which found an average of 12.3 lethal equivalents spread across survival and reproduction for wild populations, of which 6.3 LE affected recruitment to one year of age. Other potential effects of inbreeding (e.g., reduced fertility, poor health) were not included in the model.

Population structure and growth rate

The above demographic rates produce a population with the following deterministic characteristics:



Generation time (T) = 24 yrs
Intrinsic growth rate (r) = 0.012 (slightly positive)
% adults: 50%
Adult sex ratio (male:female): 1:2

Figure 9. Age pyramid for a stable age distribution in base model.

Sensitivity Testing of Demographic Rates

Parameter values tested

Sensitivity analyses were performed on the primary demographic rates used in the base model (using a population of 100 chimpanzees) to determine which parameters most affect population viability and therefore to what degree data uncertainty may affect this and subsequent chimpanzee models. These analyses also suggest those parameters that might be targeted for further research to improve the ability to accurately assess population status and for management actions that are likely to promote population viability. The following parameters and input values were tested:

Mortality rates (mean and EV varied by ±10%, ±20%) for:

- Juvenile mortality (0-1 yr) (males)
- Sub-adult mortality (1-15 yr) (males)
- Adult annual mortality (15+ yr) (males)
- Juvenile mortality (0-1 yr) (females)
- Sub-adult mortality (1-13 yr) (females)
- Adult annual mortality (13+ yr) (females)

Reproductive parameters (base value in boldface):

- Maximum age (females): 50, **53**, 56 yrs
- First reproduction (males): 14, **15**, 16 yrs
- First reproduction (females): 12, **13**, 14 yrs
- % females breeding (prime/>30yrs old): 19.8/12.15; **22/13.5**; 24.2/14.85 (represents ±10%)
- Lethal equivalents (inbreeding impact on juvenile mortality): 3, **6**, 9

All scenarios were run for 1000 iterations over a period of 100 years. Each scenario began with a stable age-sex distribution of unrelated individuals at carrying capacity (K). Each scenario represents a single interbreeding population with no internal substructure (e.g. communities) and no connectivity to other populations (no immigration or emigration).

Sensitivity testing results

Mortality rates are perhaps the most uncertain input values in the base model. Scenarios that varied juvenile, subadult, or adult mortality rates by sex by 10% and 20% suggest that such variation in male mortality rates has little impact on the growth rate of the population. Variation in female mortality rates does demonstrate an impact, although growth remains slightly positive in all cases modelled. Adult female mortality is the most sensitive, suggesting that the loss of breeding age females from the population is more likely to affect viability relative to the loss of other age-sex classes (Figure 10).

The intensity of inbreeding depression shows a slight effect as modelled (increased juvenile mortality in inbred individuals of both sexes). Actual inbreeding impacts may be greater if inbreeding affects other traits, such as female fertility and overall health.

Model results are not sensitive to the maximum age of reproduction in females (since few females survive to age 50) or to the average first age of reproduction in males (since male breeders generally are not a limiting factor in polygynous species). Breeding females are more critical to population growth and therefore viability, as evidenced by the relative greater sensitivity of the model to the average age of first reproduction in females and to the percent of adult females breeding each year. There is some evidence that dispersing females that transfer to non-natal communities show a delay in first reproduction (Nishida *et al*. 2003) and lower short-term reproductive success, a factor to keep in mind in situations in which dispersal is likely to be frequent. Factors that improve female fecundity such as high quality core habitat (Emery Thompson *et al.* 2007b) and large community home range (Williams *et al*. 2004) are likely to improve population viability.

While this sensitivity analysis suggests those parameters to which the model results are most sensitive, it should be noted that the observed differences in stochastic r are relatively small over the range of values tested and all result in a slightly positive growth rate. The age- and reproduction-related values used encompass the range of realistic values based on field data; there is greater uncertainty regarding mortality rates, and actual values may lie outside of the range tested here.

Summary

Breeding females are a limiting factor on the growth potential of a chimpanzee population and its ability to sustain the loss of chimpanzees through hunting or other activities and to buffer against the impacts of stochastic processes. Factors that limit the number of breeding age females or female reproduction (i.e. adult female mortality, percent of adult females breeding, delayed onset of first reproduction, longer interbirth intervals) may have serious consequences for the viability of chimpanzee populations. Some threats are obvious, such as the hunting of adult females; other threats may be less clear or difficult to evaluate, such as reduced reproduction due to social stress caused by disturbance, loss of other community members, frequent transfers between chimpanzee communities, or increased disease. Management actions that protect adult females and/or promote successful reproduction will promote population viability.

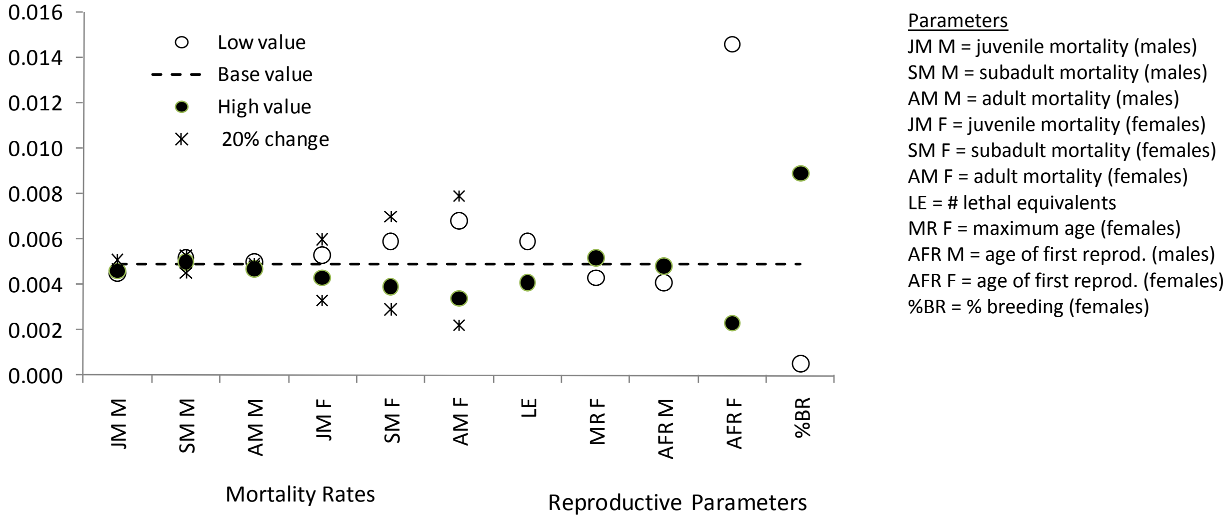


Figure 10. Stochastic growth rate (r) for sensitivity testing of various demographic rates in the base model. Dashed line represents base model stochastic r. Circles represent results for ±10% where applicable; * represent ±20%.

Impacts of Population Size and Removal of Chimpanzees

Actual population size and rate of hunting and habitat loss are not precisely known for chimpanzee populations in Sierra Leone. Models for alternate population conditions were created by varying population size (affected by carrying capacity and loss of habitat) and the rate of direct loss of individuals (e.g. through hunting or snaring). Population size and loss of individuals (above normal mortality rates) were modelled for the following values:

Population size/K:	25, 50, 75, 100, 250, 500, 1000
Annual additional mortality:	0%, 1%, 2%, 3%

All scenarios were run for 1000 iterations over a period of 100 years. Each scenario began with a stable age-sex distribution of unrelated individuals at carrying capacity (K). Each scenario represents a single interbreeding population with no internal substructure (e.g. communities) and no connectivity to other populations (no immigration or emigration).

<u>Population size</u>

Small populations are highly vulnerable to stochastic (chance) processes – for example, an unusually high number of male births within a few years due to chance. Thus, population size is recognized as a major factor affecting the long-term viability of a population (Shaffer 1987). Several population sizes were modelled for each combination of factors above, ranging from quite small (N = 25) to relatively large (N =1000). These population sizes were selected to represent the range of estimated chimpanzee sub-populations in

Sierra Leone. Although chimpanzees are distributed throughout the country, it is probable that these communities and populations are clumped into core areas and may act as multiple sub-populations (which may or may not be connected) rather than as one large panmictic (interbreeding) population.

Vortex models each population as one inbreeding unit isolated from other chimpanzee populations. This should be kept in mind when comparing the model results to actual chimpanzee populations. Substructure within the population or connectivity with other populations may affect viability.

Removal rates

Many chimpanzee populations are subject to the loss of individuals due to human-related causes, including direct killing and incidental snaring (Quiatt *et al*. 2002; Ogawa *et al*. 2004; Ogawa *et al*. 2006a, b). Scenarios were developed to examine the impact of various rates of removal of chimpanzees due to these combined factors. Removal rates ranged from 0% (no removal) to 3% annual loss, designed to represent various levels of human persecution in Sierra Leone. Removals were modelled as annual rates based on the *total* population size, but in this analysis were implemented as the removal of adults (equal number of males and females). In addition, one infant was removed for every 2 adult females removed.

Measuring viability

Several quantitative measures can be used to assess the viability of a population over a given time period. Model outputs provided in this report are:

1) Probability of Extinction (PE) in 100 years
2) Median Time to Extinction (MTE), reported only for scenarios with PE $\geq$ 0.50
3) Stochastic (observed) growth rate (r_s), prior to any truncation due to N exceeding K
4) Gene Diversity (GD) at Year 100 (for populations that did not go extinct)
5) Mean N (N_{ext}) at Year 100 (for those populations that did not go extinct)

The definition of a "viable" population and classification of population viability into categories are in part socio-political decisions. Generally speaking, viability implies a high probability of persistence with good retention of genetic diversity over a long period of time. Biological principles can provide some guidance; for example, a common population management goal is to maintain at least 90% of the gene diversity of the founding population for 100-200 years, which represents an estimate of a tolerable amount of loss of heterozygosity before inbreeding is likely to become a significant concern and a reasonable management time period for population projections (e.g., Soule *et al*. 1986; Foose *et al.* 1995). Viability may also imply sustainability and a positive potential growth rate that allows a population to maintain a size near carrying capacity of its habitat and resources and to rebound from sporadic population decline.

The definitions of viability in Table 3 were used to classify the model results across a matrix of population size and removal rates; however, alternative definitions and classifications of viability can be equally applied to the results.

Table 3. Viability categories used to classify scenario results.

Rating	PE	Stochastic growth rate (r)	N_{ext} /K (%)	GD
Very Good	0%	Stable to positive (≥ 0)	≥ 90%	≥ 95%
Good	≤ 2%	Stable to mild negative (≥ -0.01)	≥ 50%	≥ 90%
Fair	≤ 11%	Stable to moderately negative (≥ -0.03)	≥ 20%	≥ 84%
Poor	All other populations (high PE and/or rapid population decline)			

<u>Model scenario results</u>

Results for all 28 scenarios are presented in Table 4. Each scenario (cell) is color-coded to match the viability categories in Table 3. Reported results include probability of extinction over 100 years (PE); median time to extinction (MTE) when PE ≥ 0.50; stochastic growth rate (r_s); gene diversity after 100 years (GD); and mean population size (N_{ext}) for those populations (iterations) that did not go extinct.

Table 4. Model results for the 28 base scenarios (population size vs. additional annual mortality).

	Initial population size						
Annual loss	**25**	**50**	**75**	**100**	**250**	**500**	**1000**
None	**PE = 0.22 r_s = - 0.005 GD = 0.77 N_{ext} = 14**	**PE = 0.01 r_s = 0.003 GD = 0.89 N_{ext} = 35**	**PE = 0.00 r_s = 0.003 GD = 0.93 N_{ext} = 59**	**PE = 0.00 r_s = 0.005 GD = 0.95 N_{ext} = 83**	**PE = 0.00 r_s = 0.007 GD = 0.98 N_{ext} = 227**	**PE = 0.00 r_s = 0.007 GD = 0.99 N_{ext} = 459**	**PE = 0.00 r_s = 0.007 GD = 0.99 N_{ext} = 934**
1%	**PE = 0.55 r_s = - 0.016 MTE = 96yr**	**PE = 0.11 r_s = - 0.010 GD = 0.84 N_{ext} = 21**	**PE = 0.03 r_s = - 0.009 GD = 0.89 N_{ext} = 34**	**PE = 0.01 r_s = - 0.006 GD = 0.93 N_{ext} = 53**	**PE = 0.00 r_s = - 0.005 GD = 0.97 N_{ext} = 147**	**PE = 0.00 r_s = - 0.004 GD = 0.99 N_{ext} = 319**	**PE = 0.00 r_s = - 0.004 GD = 0.99 N_{ext} = 653**
2%	**PE = 0.88 r_s = - 0.027 MTE = 69yr**	**PE = 0.45 r_s = - 0.022 GD = 0.77 N_{ext} = 11**	**PE = 0.22 r_s = - 0.021 GD = 0.82 N_{ext} = 15**	**PE = 0.09 r_s = - 0.019 GD = 0.86 N_{ext} = 21**	**PE = 0.00 r_s = - 0.016 GD = 0.95 N_{ext} = 60**	**PE = 0.00 r_s = - 0.014 GD = 0.98 N_{ext} = 129**	**PE = 0.00 r_s = - 0.014 GD = 0.99 N_{ext} = 260**
3%	**PE = 0.98 r_s = - 0.037 MTE = 52yr**	**PE = 0.83 r_s = - 0.033 MTE = 78yr**	**PE = 0.66 r_s = - 0.034 MTE = 91yr**	**PE = 0.45 r_s = - 0.031 GD = 0.78 N_{ext} = 9**	**PE = 0.06 r_s = - 0.028 GD = 0.89 N_{ext} = 20**	**PE = 0.00 r_s = - 0.026 GD = 0.94 N_{ext} = 44**	**PE = 0.00 r_s = - 0.026 GD = 0.97 N_{ext} = 87**

Impact of population size

Population size shows a strong influence on population viability over 100 years, particularly with 0-2% additional mortality. In the absence of additional removals, interbreeding populations of 250 or more chimpanzee persist at relatively stable numbers near carrying capacity (>90% K) with good retention of gene diversity. Moderate-sized populations of 75-100 chimpanzees also fare well over a 100-year period with no additional mortality, but may be more vulnerable to increased removal rates and inbreeding (Figure 11). Isolated small populations of around 50 chimps or fewer are subject to inbreeding depression and other stochastic processes, resulting in generally poor viability without intervention or connectivity to other populations.

Impact of loss of chimpanzees (removal)

The continual loss of adult chimpanzees, whether due to hunting, snaring or other sources of removal or death, has a dramatic effect on population viability due to the loss of breeders at rates greater than can be replaced through reproduction. All populations decline at an annual removal rate of 2%, which is not surprising given the relatively slow intrinsic rate of growth. Small to moderate sized populations have a significant risk of extinction, and those populations that do persist are small and declining with moderate loss of gene diversity. Although relatively large populations (250-1000 chimpanzees) still persist with good gene diversity after 100 years, the remaining population is small and will continue to decline to eventual extinction unless removal is reduced or eliminated. Figure 12 illustrates the rapid decline in population size under various removal rates for even a large population of 1000 chimpanzees.

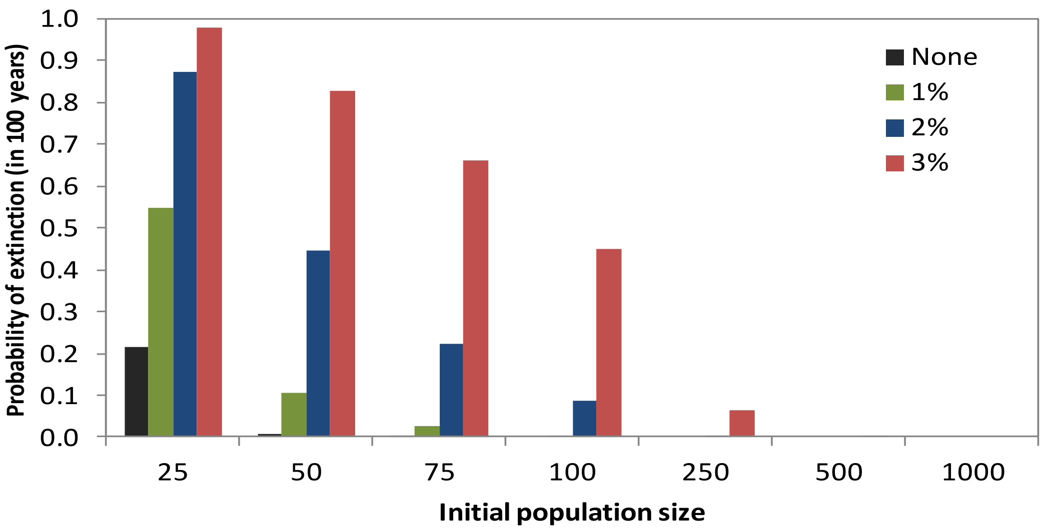


Figure 11. Impact of population size on the probability of extinction over 100 years under different annual rates of removal (0%, 1%, 2%, 3%).

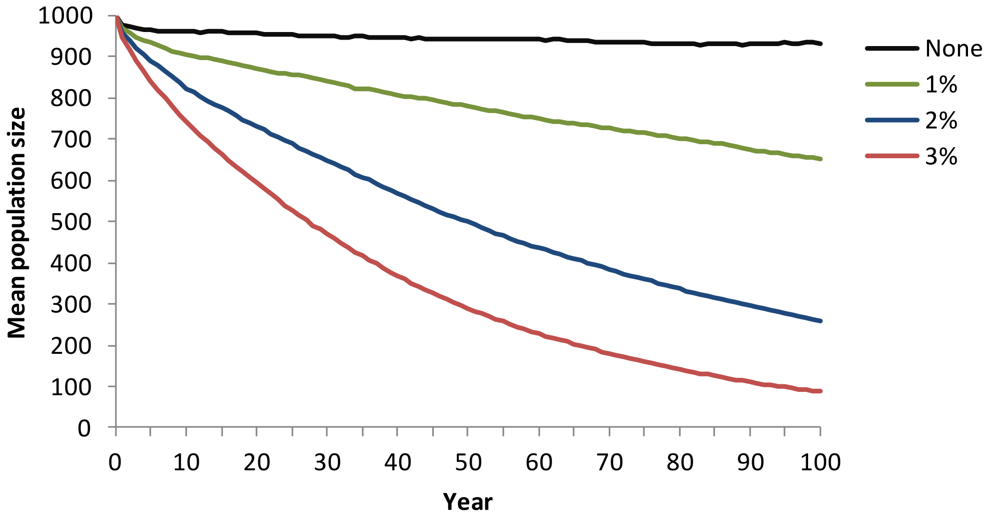


Figure 12. Mean population size (all iterations) for a population of 1000 chimpanzees over 100 years under different annual rates of removal (0%, 1%, 2%, 3%).

Assessing Viability of Chimpanzees in Sierra Leone

Population substructure

In order to estimate the viability of chimpanzees in Sierra Leone, it was first necessary to determine how best to substructure the population in the model. Although chimpanzees are found throughout much of the country, densities and available habitat vary. Treating chimpanzees as one large panmictic (interbreeding) population of over 5000 individuals would ignore the stochastic risks of the actual matrix of chimpanzee densities and make it difficult to accurately model the impacts of different types and severity of threats in different areas. After much discussion and data analysis the Population and Threats Analysis Working Group designated 11 core areas for chimpanzee populations based on chimpanzee density, regional threats and protected area status (Figure 13). Current population size was estimated based on extrapolation of recent census data.

Connectivity between these core populations was modelled as low levels of movement (0.1 to 1.2% annually) of young females (ages 10-16 years) between populations, with the restriction that the recipient population contained at least one adult male. Connectivity was modelled between the following populations:

- Between Outamba and N Koinadugu
- Between N Koinadugu and Loma
- Between Loma and Tingi
- Between Kenema and Kangari
- From Kenema to S Bo
- Between So Bo and Moyamba

Outamba and N Koinadugu populations are believed to be connected to chimpanzee populations in Guinea, while the Gola population is likely connected to chimpanzee populations in Liberia. The impacts of these transboundary connections were modelled by simulating the exchange of one 11-year-old female once every two years between each of these three SL populations and their adjacent international population.

Port Loko and WAPF populations were modelled as isolated populations.

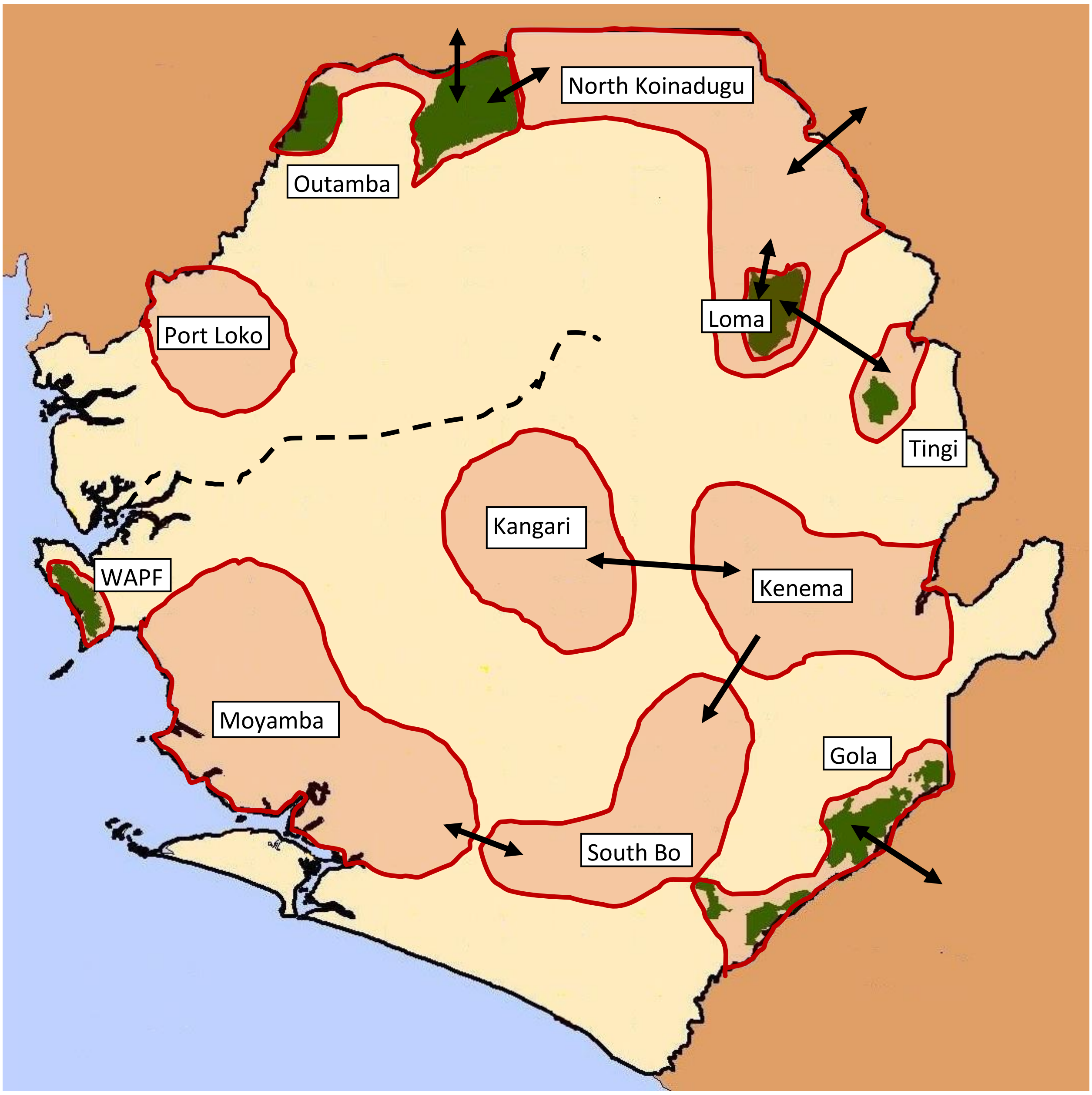


Figure 13. Map of Sierra Leone approximately indicating the 11 populations used in the Vortex model. Green areas indicate protected areas. Black arrows indicate connectivity between populations. Red boundary lines are very approximate for general illustrative purposes only and are not intended to indicate hard boundaries or precise placement within Sierra Leone.

Regional threats to populations

Once these core populations were designated, the working group members then considered the various threats to each chimpanzee population (see Table 1 in Section 4, Population and Threats Analysis Working Group). These threats fell into two categories:

1) Threats that impact chimpanzees by affecting their habitat (either by habitat loss or degradation), resulting in reduced carrying capacity for chimpanzees and reducing population size. These include: mining, logging, farming, plantations, fires, urban expansion, and cattle ranching.

2) Threats that impact chimpanzees through the direct removal of chimpanzees (increased mortality). These include: hunting for bushmeat and retaliation killing.

The working group developed estimates of hunting intensity and projected habitat loss (rate and time period) for each population as outlined in Table 5. Hunting intensity was modelled in terms of either 1.5% (moderate) or 2.5% (high) additional mortality for all age-sex classes). For example, if base mortality rates for particular age-sex classes were 2%, 7%, and 12%, these rates would be 4.5%, 9.5% and 14.5% under high hunting intensity, and so forth. To provide a benchmark, moderate hunting pressure would result on average in the loss of one chimpanzee annually for every 67 chimpanzees due to direct killing; high hunting intensity removes about one chimpanzee per 40 chimpanzees annually. Looking at this in another way, TCS has reported that arrivals at the sanctuary represent the loss of ~ 1500 chimpanzees over the past 15 years – about 100 per year would represent about 1.5% of a total national population of about 6700 chimpanzees.

Projected habitat loss was modelled as a reduction in carrying capacity at an annual rate of 0.5% to 2% for 5 to 15 years, depending on the area, resulting in a total loss of about 17% of the current total carrying capacity for chimpanzees in Sierra Leone. These estimates were used to construct a 'best guess' population model to project the relative viability of chimpanzee populations in Sierra Leone over the next 200 years.

Estimated viability under current projected conditions

Results of the 'best guess' population viability model given the current estimated level of hunting/removal and projected loss of habitat over the next 15 years are in Table 6. Overall projected viability of chimpanzees in Sierra Leone over the next 200 years is poor. Nine of the 11 populations rank as 'poor' using the viability criteria in Table 3, due to the relatively small size of the remaining populations (only 2-15% of final K) along with, in many cases, high extinction risk and low gene diversity (Figures 14 and 15).

Table 5. Parameter values used to model threats (removal through hunting and reduction in carrying capacity through habitat loss) for each of the 11 populations.

Population	Initial N and (K)	Hunting intensity	Habitat loss (reduction in K)	% K lost	Final K
Outamba	1000 (1100)	High (2.5%)	Low (0.5%/yr for 10 yrs)	5%	1045
North Koinadugu	800 (840)	High (2.5%)	Moderate (1%/yr for 10 yrs)	10%	756
Loma	1065 (1171)	High (2.5%)	Moderate (1%/yr for 10 yrs)	10%	1054
Tingi	70 (77)	High (2.5%)	Low (0.75%/yr for 10 yrs)	7.5%	71
Gola	270 (297)	High (2.5%)	Low (0.5%/yr for 10 yrs)	5%	282
Kenema	500 (525)	Moderate (1.5%)	High (2%/yr for 15 yrs)	30%	368
Kangari	400 (440)	Moderate (1.5%)	High (2%/yr for 15 yrs)	30%	308
South Bo	500 (525)	Moderate (1.5%)	High (2%/yr for 15 yrs)	30%	368
Moyamba	600 (630)	Moderate (1.5%)	High (2%/yr for 15 yrs)	30%	441
WAPF	55 (58)	Moderate (1.5%)	Moderate (2%/yr for 5 yrs)	10%	52
Port Loko	200 (210)	Moderate (1.5%)	High (2%/yr for 15 yrs)	30%	147
Metapopulation	**5460 (5873)**		**Total projected future K**	**17%**	**4892**

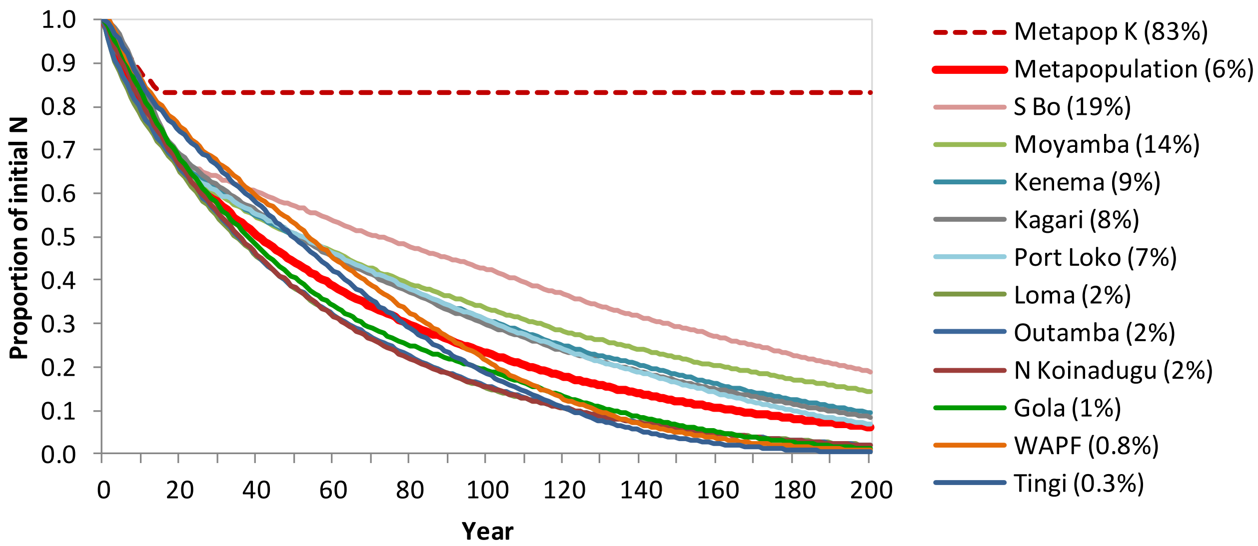


Figure 14. Mean population size (all iterations) for each population over time, plotted as the proportion of the initial population size (N) so that the relative declines of all populations are presented on the same scale. Proportional decline in the total Sierra Leone metapopulation is given in red. Numbers in () indicate % of initial N remaining after 200 years. The dashed line indicates the total metapopulation carrying capacity (K) modelled with projected habitat loss.

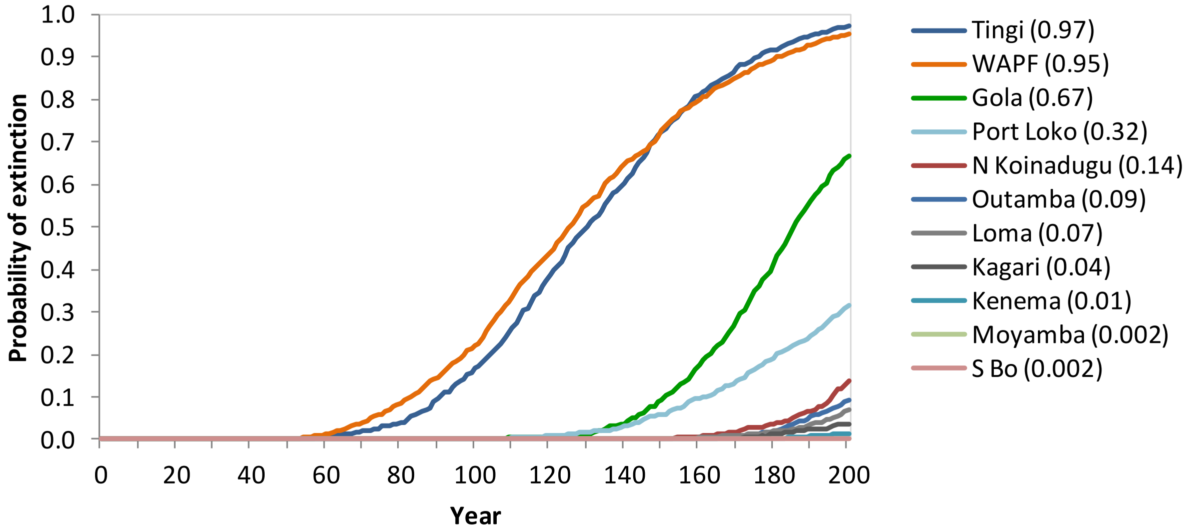


Figure 15. Probability of extinction (PE) for each population over time (PE for total Sierra Leone metapopulation is zero over 200 years). Numbers in () indicate PE for each population.

The northern populations (Outamba, N Koinadugu, Loma, Tingi) and Gola show the most dramatic declines (up to 98% of the current estimated population size). These are primarily protected areas that are believed by some participants to be currently vulnerable to, and perhaps targeted for, bushmeat hunting due to the relatively high concentration of chimpanzees. The isolated populations (WAPF, Port Loko) show major decline and risk of extinction.

The chimpanzee population in farmlands in central Sierra Leone fair a bit better under the conditions modelled, with relatively low risk of extinction in 200 years and good gene diversity due to the lower rate of removal and some connectivity among these populations. However, long-term viable is still 'fair' to 'poor' using the viability criteria in Table 3 – these populations still decline significantly and are all projected to contain fewer than 100 chimpanzees 200 years from now. In addition, the model assumes that each core population remains intact after habitat loss; however, if the habitat loss in these areas serves to fragment chimpanzees into multiple smaller populations, population decline and the risk of extinction may be much higher than modelled.

While the metapopulation of chimpanzees in Sierra Leone maintains good genetic diversity and has little to no risk of extinction as modelled, the projected total population in 200 years is about 334 chimpanzees – thus, despite the projected loss of only 17% of the current habitat carrying capacity, the population is projected to decline by 94% (Fig. 7). Under the conditions modelled, habitat loss (loss of K) alone does not appear to be driving the decline and extinction of chimpanzee populations – rather the removal of chimpanzees and/or small population size are greater risks to long-term viability.

Table 6. Model results for each population and metapopulation for the 'best guess' estimates of future rates of hunting and habitat loss. Stoch r = stochastic growth rate; PE_{200} = probability of extinction within 200 years; N_{200} = mean population size after 200 years (all iterations); N_{200}/N_0 = %N remaining after 200 years (compared to initial N); N_{200}/K_{200} = %N remaining after 200 years (compared to available K); GD_{200} = gene diversity after 200 years; Mean TE = mean time to extinction.

Population	Stoch r	PE_{200}	N_{200}	N_{200}/N_0	N_{200}/K_{200}	GD_{200}	Mean TE
Outamba	-0.021	0.094	19	2%	2%	0.88	188 yrs
North Koinadugu	-0.021	0.136	15	2%	2%	0.88	187 yrs
Loma	-0.021	0.068	21	2%	2%	0.89	186 yrs
Tingi	-0.022	0.972	<1	<1%	<1%	0.64	130 yrs
Gola	-0.023	0.666	3	1%	1%	0.74	172 yrs
Kenema	-0.012	0.013	47	9%	13%	0.92	189 yrs
Kangari	-0.013	0.035	34	8%	11%	0.90	184 yrs
South Bo	-0.007	0.002	95	19%	26%	0.96	180 yrs
Moyamba	-0.010	0.002	86	14%	19%	0.95	190 yrs
WAPF	-0.020	0.954	<1	<1%	1%	0.62	125 yrs
Port Loko	-0.015	0.316	14	7%	9%	0.80	171 yrs
Metapopulation	**-0.014**	**0**	**334**	**6%**	**7%**	**0.99**	**--**

Alternative Scenarios and Impacts on Viability

Results from the 'best guess' model suggest the relative importance of the various factors that affect chimpanzee population viability and may be subject to alteration under different future management strategies. Four additional scenarios were developed to better assess the impact of these factors:

<u>Hunting (Removal)</u>

A 'No Hunting' scenario was developed in which all projected removal (hunting, snaring, etc.) was removed from the model. That is, the model included baseline mortality that simulated a stable chimpanzee population in good habitat, but no additional mortality was included to simulate additional levels of removal due to human or other causes. This simulates the immediate halting of all hunting, snaring and poisoning of chimpanzees in Sierra Leone. All other aspects of the model were identical with the 'Current Status' best guess projection.

Habitat Loss

A 'No Habitat Loss' scenario was developed in which all future projected habitat loss was removed from the model, such that the carrying capacity remained stable for all 11 populations over the projected 200 years. This simulates no future habitat loss, degradation or fragmentation in Sierra Leone. All other aspects of the model were identical with the 'Current Status' best guess projection.

Population Connectivity

An 'Isolated Populations' scenario was developed in which all 11 chimpanzee populations were treated as isolated populations. That is, there was no movement of chimpanzees among Sierra Leone populations and no transboundary exchanges with Guinea and Liberia were included in the model. All other aspects of the model were identical with the 'Current Status' best guess projection.

Protected Areas

A 'Protected Areas Only' scenario was developed in which all habitat in non-protected areas was lost over the next 10 years. That is, the scenario modelled a linear reduction of carrying capacity to zero in 10 years for the North Koinadugu, Kenema, Kangari, South Bo, Moyamba, and Port Loko populations, leaving chimpanzee populations in the protected areas only (Outamba, Loma, Tingi, Gola and WAPF) with the same projected rate of hunting and habitat loss as in the 'Current Status' scenario. All other aspects of the model were identical with the 'Current Status' best guess projection.

Relative Impacts on Viability

Model results for these four alternative scenarios and the best guess projection of the current situation ('Current Status') are given for the metapopulation in Table 7 and Figure 16. The factor with the greatest impact on population numbers and viability is the removal of chimpanzees (hunting and related activities). If all sources of additional mortality to chimpanzees such as hunting for bushmeat or killing for retaliation could be halted immediately, chimpanzee populations would have a much greater chance of maintaining their numbers rather than declining dramatically, even with some low levels of habitat loss.

Removal of habitat loss from the model does little to improve population viability as long as hunting continues at the projected rate. Loss of connectivity between large core chimpanzee populations only slightly decreases viability (provided that there is no further fragmentation within these areas). In both cases, significant population decline is driven primarily by hunting and other direct mortality.

The loss of chimpanzees in farmlands and other non-protected areas (about half of the estimated current capacity for chimpanzees) significantly reduces chimpanzee numbers and viability compared to all other scenarios, provided that hunting rates continue as projected. If hunting/removal could be eliminated within protected areas, however, viable chimpanzee populations might be contained within the protected areas matrix of populations.

Table 8 gives the results and relative viability of each of the 11 populations under the five scenarios tested. All populations show good long-term viability in the absence of additional mortality with the exception of WAPF – this small, isolated population will likely require periodic demographic and genetic supplementation to remain viable.

Table 7. Model results for the metapopulation for all five scenarios.

Population	**Stoch r**	**PE_{200}**	**N_{200}**	**N_{200}/N_0**	**N_{200}/K_{200}**	**GD_{200}**
Current Status	**-0.014**	**0**	**334**	**6%**	**7%**	**0.99**
No Hunting	0.007	0	4361	80%	89%	1.00
No Habitat Loss	-0.013	0	417	8%	7%	0.99
Isolated Populations	-0.014	0	307	6%	6%	0.99
Protected Areas Only	-0.021	0.02	38	0.7%	2%	0.92

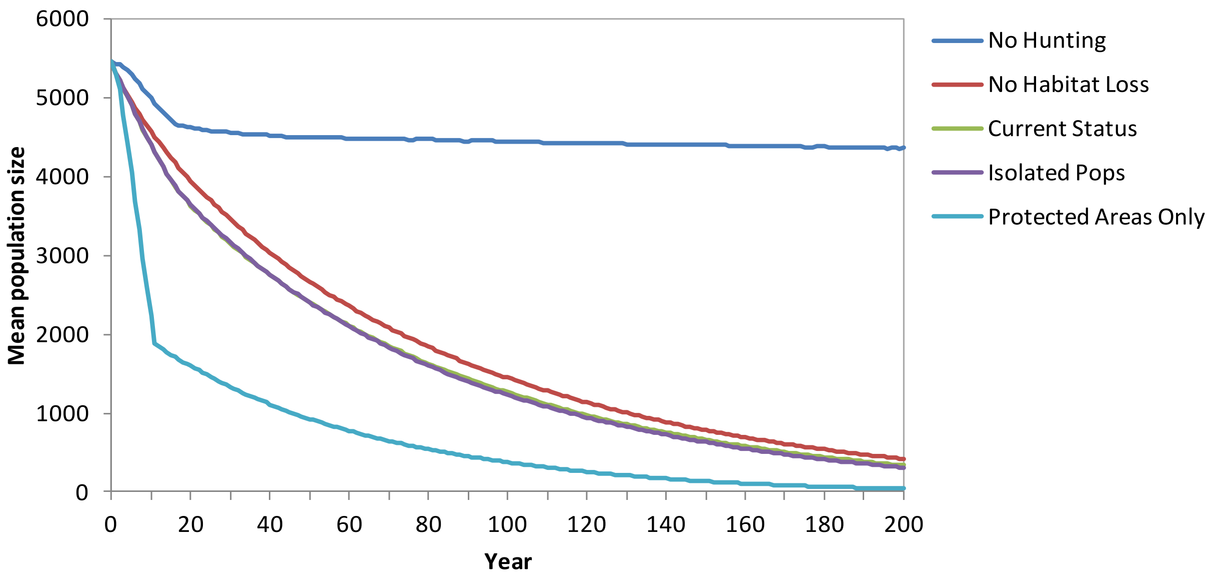


Figure 16. Mean population size (all iterations) for the metapopulation of chimpanzees in Sierra Leone over 200 years under each of five alternative scenarios.

Table 8. Model results and viability for each population for 5 alternative scenarios (dark green = very good; green = good; yellow = fair; red = poor viability; grey = population lost).

Population	No Hunting or removal	No Habitat Loss	Current Status	Isolated Populations	Protected Areas Only
Outamba (protected area)	PE = 0 r_s = 0.006 GD = 0.99 N_{ext} = 954	PE = 0.083 r_s = - 0.021 GD = 0.88 N_{ext} = 20	PE = 0.094 r_s = - 0.021 GD = 0.88 N_{ext} = 21	PE = 0.173 r_s = - 0.023 GD = 0.85 N_{ext} = 21	PE = 0.195 r_s = - 0.022 GD = 0.86 N_{ext} = 21
North Koinadugu	PE = 0 r_s = 0.007 GD = 0.99 N_{ext} = 699	PE = 0.108 r_s = - 0.021 GD = 0.88 N_{ext} = 16	PE = 0.136 r_s = - 0.021 GD = 0.88 N_{ext} = 17	PE = 0.234 r_s = - 0.023 GD = 0.83 N_{ext} = 17	All Habitat Lost
Loma (protected area)	PE = 0 r_s = 0.007 GD = 0.99 N_{ext} = 958	PE = 0.072 r_s = - 0.021 GD = 0.89 N_{ext} = 23	PE = 0.068 r_s = - 0.021 GD = 0.89 N_{ext} = 23	PE = 0.171 r_s = - 0.022 GD = 0.86 N_{ext} = 22	PE = 0.184 r_s = - 0.023 GD = 0.85 N_{ext} = 21
Tingi (protected area)	PE = 0 r_s = 0.011 GD = 0.93 N_{ext} = 64	PE = 0.971 r_s = - 0.022 GD = 0.61 N_{ext} = 6	PE = 0.972 r_s = - 0.022 GD = 0.64 N_{ext} = 5	PE = 0.994 r_s = - 0.029 GD = 0.62 N_{ext} = 9	PE = 0.979 r_s = - 0.023 GD = 0.68 N_{ext} = 7
Gola (protected area)	PE = 0 r_s = 0.006 GD = 0.97 N_{ext} = 241	PE = 0.657 r_s = - 0.023 GD = 0.74 N_{ext} = 8	PE = 0.666 r_s = - 0.023 GD = 0.74 N_{ext} = 8	PE = 0.817 r_s = - 0.026 GD = 0.72 N_{ext} = 8	PE = 0.670 r_s = - 0.023 GD = 0.73 N_{ext} = 9
Kenema	PE = 0 r_s = 0.005 GD = 0.98 N_{ext} = 321	PE = 0.008 r_s = - 0.012 GD = 0.94 N_{ext} = 61	PE = 0.013 r_s = - 0.012 GD = 0.92 N_{ext} = 48	PE = 0.012 r_s = - 0.011 GD = 0.92 N_{ext} = 60	All Habitat Lost
Kangari	PE = 0 r_s = 0.004 GD = 0.98 N_{ext} = 257	PE = 0.020 r_s = - 0.013 GD = 0.91 N_{ext} = 42	PE = 0.035 r_s = - 0.013 GD = 0.90 N_{ext} = 35	PE = 0.045 r_s = - 0.012 GD = 0.89 N_{ext} = 49	All Habitat Lost
South Bo	PE = 0 r_s = 0.010 GD = 0.99 N_{ext} = 343	PE = 0 r_s = - 0.007 GD = 0.97 N_{ext} = 127	PE = 0.002 r_s = - 0.007 GD = 0.96 N_{ext} = 95	PE = 0.020 r_s = - 0.011 GD = 0.91 N_{ext} = 61	All Habitat Lost
Moyamba	PE = 0 r_s = 0.005 GD = 0.98 N_{ext} = 392	PE = 0 r_s = - 0.009 GD = 0.96 N_{ext} = 109	PE = 0.002 r_s = - 0.010 GD = 0.95 N_{ext} = 86	PE = 0.012 r_s = - 0.011 GD = 0.93 N_{ext} = 77	All Habitat Lost
WAPF (protected area)	PE = 0.184 r_s = - 0.002 GD = 0.76 N_{ext} = 27	PE = 0.914 r_s = - 0.019 GD = 0.62 N_{ext} = 9	PE = 0.954 r_s = - 0.020 GD = 0.62 N_{ext} = 8	PE = 0.933 r_s = - 0.019 GD = 0.65 N_{ext} = 12	PE = 0.929 r_s = - 0.019 GD = 0.60 N_{ext} = 9
Port Loko	PE = 0 r_s = 0.004 GD = 0.93 N_{ext} = 111	PE = 0.224 r_s = - 0.014 GD = 0.83 N_{ext} = 26	PE = 0.316 r_s = - 0.015 GD = 0.80 N_{ext} = 20	PE = 0.344 r_s = - 0.015 GD = 0.80 N_{ext} = 20	All Habitat Lost
Metapopulation	PE = 0 r_s = 0.007 GD = 1.00 N_{ext} = 4361	PE = 0 r_s = - 0.013 GD = 0.99 N_{ext} = 417	PE = 0 r_s = - 0.014 GD = 0.99 N_{ext} = 334	PE = 0 r_s = - 0.014 GD = 0.99 N_{ext} = 307	PE = 0.020 r_s = - 0.021 GD = 0.92 N_{ext} = 39

Assumptions, Limitations and Cautions for Data Interpretation

All of these projections and model results should not be considered as accurate, precise predictions of the future of chimpanzee populations in Sierra Leone, as the results depend heavily on the biological traits of chimpanzees, current population size and degree of substructuring and connectivity, and particularly on the impact of human activities, all of which have been estimated in this model. Specifically, the rate of removal of chimpanzees (due to hunting, snaring, etc.), the loss and fragmentation of chimpanzee habitat, and the impact of disturbance and other activities on chimpanzee survival and reproduction all can greatly affect population viability. However, the results presented here do indicate the vulnerability of chimpanzee populations to hunting, isolation (through habitat fragmentation), and habitat loss, all of which lead to small population size.

Demographic rates

The results presented in this report provide viability projections for chimpanzee populations given the demographic rates and characteristics used in the model. The best available information from field databases, published literature, and expert opinion was incorporated into the model. Sensitivity analysis of demographic rates indicates that parameters affecting adult females and the breeding (growth) potential of the population (i.e. % females breeding, age of first reproduction, adult female mortality) are the most sensitive parameters in the model. Of these, mortality are the least known from field data and the one that is most affected by human activities.

Mortality rates may vary from population to population, due to factors such as differences in levels of intraspecific aggression. The mortality rates used in the model most closely describe a population such as Kasekela in Gombe National Park in Tanzania; populations with higher natural mortality rates would be expected to have lower viability than that projected in the model results. Differences in the actual mortality rates, particularly of adult females, will likely affect the viability of a population and its ability to persist under various adult removal rates.

Population structure and connectivity

A simplifying assumption made in these models is that each population represents an isolated, panmictic (interbreeding) population. For many chimpanzee populations, this assumption does not hold true. The substructuring of chimpanzee populations into communities with occasional exchange of individuals has the potential to affect viability, depending upon the nature of dispersal and threats affecting each community. For this analysis it may be appropriate to interpret "population" as a series of one or more well connected communities. Dispersal among adjacent communities is likely to be sufficient to treat them as one interbreeding population. Peripheral communities within such populations may be subject to greater threat of removal and even local extinction, but may be replaced by dispersers from adjacent communities if habitat remains available and if removal rates are sufficiently low.

On a larger scale, some chimpanzee populations may not be completely isolated, but may be connected by occasional migration of individuals through habitat corridors between populations. Such connectivity has the potential to demographically and genetically rescue populations with low viability if survival and reproductive success is high for dispersers. Metapopulation dynamics can be complex, in some cases with some populations serving as suppliers of chimpanzees ("sources") and others as "sinks" that undergo substantial losses (e.g. through hunting). Assumptions about the connectivity of chimpanzee populations in Sierra Leone were made in the development of these models but may or may not reflect the true situation.

<u>Impact of habitat loss</u>

An important assumption in this PVA model is that the only impact of all projected future habitat loss is to reduce the carrying capacity of the area. This might be due to actual loss of habitat, but also includes habitat conversion or changes in land use or human activities that reduce the quality of the habitat for sustaining chimpanzees – thereby reducing the carrying capacity for chimpanzees. The model assumes no effects of fragmentation, isolation, disturbance or increased mortality due to hunting or other activities. In reality, the effects of habitat loss may be greater, depending upon location of habitat loss and the nature of associated human activities. Thus, the model projections for the viability of chimpanzee populations in the central farmlands of Sierra Leone, which are believed to be vulnerable to potentially significant habitat loss or conversion, may be overly optimistic since they do not incorporate these potential effects.

<u>Loss of chimpanzees through removal</u>

This model assumes that removal occurs annually and at a constant rate (in proportion to the number of individuals). Chimpanzees were removed in proportion to each age and sex class in the models; if a greater proportion of adult females or juveniles are removed in actuality, the impact on population viability will be worse.

A significant assumption in the PVA presented here is that the rate of hunting in protected areas (primarily for bushmeat) is greater than in non-protected farmlands due to the larger concentration of chimpanzees found in the protected areas. Thus, perhaps counter intuitively, the large chimpanzee populations in the protected areas of northern

Sierra Leone are projected to have lower viability than some populations in non-protected areas. This assumption has not been tested (a data gap identified by the Population and Threats Analysis Working Group). The actual rate of removal of chimpanzees in protected areas vs. farmlands may determine the true viability of chimpanzee populations in these areas relative to each other.

Specific chimpanzee populations in Sierra Leone

The 11 chimpanzee "populations" modelled here and roughly delineated in Figure 13 are only approximate and should not be taken as separate populations with discrete and well-defined boundaries and buffer zones. Given this, it therefore was not feasible to model the effects of buffer zones of various sizes around protected areas. However, this model can be used for such analyses in the future if specific areas (core and buffer zones) are defined and detailed spatial information is provided on population numbers, carrying capacity, threats, and probable movement of chimpanzees and humans within and across these areas.

Uncertainty regarding the level and impact of threats on chimpanzees across different habitat types, regions and protected status of Sierra Leone make it difficult to project even relative viability estimates for different chimpanzee "populations". The model results presented in this report are based on a particular set of assumptions as outlined above; different assumptions may lead to different viability projections for different populations. For example, there are differing views on whether the rate of hunting is higher or lower in protected areas vs. farmlands; thus, it is difficult to assess the impact of establishing new protected areas unless particular assumptions are made regarding the level of protection against hunting that will be realized in those areas.

Despite the cautions above, the model results do provide some useful and overarching guidelines. For example, the PVA suggests that the removal of chimpanzees, and/or activities that cause lower reproduction and/or higher adult female mortality, can cause significant decline in chimpanzee populations and put them at high risk of extinction, even if these populations are relatively large and live in good quality, protected habitat. Thus, habitat protection alone is insufficient if removal is not controlled. Also, activities that reduce and/or fragment populations make populations even more vulnerable to decline and possible future extinction. Any additional mortality to these populations (e.g. through hunting) may greatly reduce their long-term viability.

Summary
An analysis of population viability for chimpanzee populations in Sierra Leone using the best available data and expert opinion on demographic rates and potential threats suggests that the major factors affecting viability are the continual loss of chimpanzees (especially adult females) from the population and population size. Both of these factors can be influenced through management and conservation actions.

The loss of chimpanzees from populations may occur through a variety of mechanisms, including hunting, poisoning and snaring, as well as other sources (e.g. continual emigration without reciprocal immigration, long persisting disease). Given an intrinsic growth rate of 1.2%, it is not surprising that populations decline under annual removal rates higher than 1%. All populations decline with removal rates that exceed growth rate – the smaller the population, the more quickly it is likely to go extinct.

Efforts to reduce or eliminate sources of mortality may be critical for the long-term viability of all chimpanzee populations, regardless of the current rate of loss. The loss of chimpanzees through periodic disease epidemics can also reduce viability if such events are frequent, particularly for smaller populations with less potential to rebound before declining to extinction. The long-term viability of moderate to large size populations may be substantially improved by reducing and/or halting existing removals at some point in the future. The more quickly removals can be reduced or stopped, the larger and more genetically diverse these populations will remain, resulting in better long-term viability.

Population size is regulated to some extent by habitat quality and quantity as it relates to chimpanzees. Small populations in small habitat patches exhibit poor viability when isolated from other chimpanzee populations. Moderate sized populations are vulnerable to habitat loss and removal that result in smaller carrying capacity, population size and growth, and thus reduced viability. Protection of habitat to preserve or create large connected populations and prevent fragmentation into small isolated populations will promote viability and reduce risk of decline and extinction. Activities that reduce chimpanzee survival or reproduction or reduce the carrying capacity of the habitat for chimpanzees, either directly or indirectly through disturbance, will reduce viability.
While the results of this PVA are informative in guiding future management action and research activities, better estimates of demographic rates (particularly female mortality rates), the rates of loss of chimpanzees due to hunting, snaring, epidemic disease or other threats, the rate and impacts of habitat loss and conversion, and population size and connectivity all will enable more accurate assessment of long-term viability of specific chimpanzee populations in Sierra Leone.

Western Chimpanzee (*Pan troglodytes verus*) Population and Habitat Viability Assessment (PHVA) for Sierra Leone

Freetown, Sierra Leone
24 to 27 May 2011

Section 6

Role of government agencies in chimpanzee conservation

Government Agencies Working Group

PARTICIPANTS

Arthur Chinsman-Williams, SLARI
Edmund Konneh, Makpele Chiefdom representative
Samuel Koroma, Yoni Chiefdom representative
Sandra Koroma, Gaura Chiefdom representative
Foday Kanu, Kholifa-Rowala Chiefdom representative
Fatmata Turay, UNEP
Mohamed Dabo, Office of National Security, Disaster Management Division
Kalie Bangura, Wildlife and Conservation Unit, Forestry Division, MAFFS
Eugene Cole, PAGE (USAID)
Boisinnah Kanneh, Baoma Koya Chiefdom representative

TASK: Given the threats identified yesterday, what are the issues/problems/ challenges for which the government agencies could play a role in improving chimpanzee conservation?

Table 9. Government Agencies – challenges and goals.

CHALLENGES/PROBLEMS		GOALS
1 Weak policies and regulations	Legal framework in place, penalties are weak Outdated policies, Acts do not address current situation Limited national parks	**Long Term** To review legislations/policies pertaining to conservation **Short term** Strengthen the laws with penalties that are deterrents to crimes Seek consultation of stakeholders Create local by-laws by chiefdom authorities Promote awareness and sensitise local communities, civil societies and government agencies
2 No law enforcement	Inadequate personnel to ensure law and order in national parks/ reserved forest Illegal use of firearms (e.g. shotguns)	**Long term** Employ more personnel Government to determine the use of firearms by game rangers and forest guards **Short term** Conduct training to build capacity Provide logistics Improve salary structure and provide incentives Undertake survey of all community forests Introduce the concept of co-forest management within communities Forestry division to lobby the government on the use of firearms

3 Lack of knowledge and understanding	3 Lack of knowledge and understanding Inadequate awareness on chimpanzee conservation policies Inadequate knowledge to protect additional species, habitat and their ecological functions Little understanding to demonstrate differences between primates (e.g. chimpanzees and baboons)	**Long term** Establish national stakeholders platform for sensitisation on conservation policies **Short term** Engage/lobby the parliamentary committee on environmental issues Collaborate with relevant stakeholders on information sharing Undertake research for the discovery of more species and habitat improvement (SLARI) Provide identification materials for species (IEC)
4 No proper land use planning (mining, road construction, agriculture and forest conservation)	4 No proper land use planning (mining, road construction, agriculture and forest conservation) No/little coordination between line ministries (agriculture, lands, mineral resources and local government) Conflict of interest between line ministries Conflict of interest between local communities and conservationists	**Long term** Government to review land tenure systems **Short term** MLCPE and other stakeholders to enforce land use planning system in the country Strengthen the cooperation and understanding between ministries Sustainable livelihood opportunities for communities

<u>OBJECTIVES & ACTIONS</u>

Objective 1.0 **To review legislation/policies pertaining to chimpanzee conservation**

Action 1.1

Establish a policy review/reform committee
Responsibility: MAFFS EPA/SL
Partners: INGO, NGO, CSO, ONS, TCS, Gola Forest Programme IUCN, UNEP, WWF
Timeframe: 2 years
Expected Outcome: Enhance a platform for policy review
Challenges: Little/no political will
Resources needed: Personnel, time, finance

Action 1.2

Seek consultation of stakeholders.
Responsibility: Forestry Division, MAFFS, MLCPE, EPASL, MLGRD,
Partners: Law reform commission, conservation NGOs, CSO, CSSL, Green Scenery, SLARI, Law officers
Timeframe: 2 years
Expected Outcome: Establishment of law reform committee
Challenges: Lack of commitment
Resources needed: Personnel and finances

Action 1.3	Encourage local district council to formulate chiefdom by-law regarding chimpanzee conservation Responsibility: Councillors and Paramount Chiefs Partners: Forestry division, CSO, NGO, EPASL, CLO Timeframe: 3 years Expected Outcome: Chiefdom bylaw established with penalties that are deterrent to wildlife crime Challenges: Poor coordination amongst stakeholders Resources needed: Personnel and finances
Action 1.4	Lobby parliament enactment of the reviewed wildlife law and lobby cabinet for adoption of the wildlife policy Responsibility: PAGE, ENFORAC, FD,-MAFFS Partners: EPA, MTCA, CSO, MLGRD Timeframe: 6 months Expected Outcome: Adopted policies and act Challenges: Competing mandates amongst government sectors. Pressures from development partners seeming incompatible Resources needed: Legal expert, finances
Action 1.5	Review of the wildlife regulation Responsibility: PAGE, ENFORAC Partners: EPA, MTA, CSO, MLGRD Timeframe: 1 year Expected Outcome: Reviewed regulation including chimpanzee acts Challenges: Incumbent upon the enactment of the law Resources needed: Legal expert, finances
Objective 2.0	**Strengthen law enforcement**
Action 2.1	Undertake survey of all community forests Responsibility: FD MAFFS, Survey lands Partners: local communities, MLGRD Timeframe: 1-2 years Expected Outcome: Community forest maps produced Challenges: Difficult terrains Adverse weather conditions Resources needed: Surveying equipment, finance, time, personnel
Action 2.2	Recruitment of forest guards and rangers Responsibility: FD MAFFS Partners: TCS, Timeframe: 1-2 years Expected Outcome: Personnel recruited

Challenges: Time, political connection
Resources needed: Personnel and finances

Action 2.3 Building capacity of law enforcement agencies and other stakeholders
Responsibility: FD MAFFS
Partners: Judiciary, police, customs, ONS
Timeframe: 1-5 years
Expected Outcome: Reduction in occurrence of wildlife crimes, especially involving chimpanzees
Challenges: Lack of training resources
Resources needed: Stationery, logistics

Objective 3.0 Lack of knowledge and understanding

Action 3.1 Establish national stakeholder platform for sensitisation on conservation policies for chimpanzees.
Responsibility: MAFFS, EPA
Partners: ENFORAC, NGOS MLGRD
Timeframe: 3 months
Expected Outcome: National stakeholder forum established
Challenges: Coordination;
ownership of initiatives;
problem to generate buy-in from stakeholders
Resources needed: Personnel

Action 3.2 Engage / lobby parliamentary committee on environmental issues
Responsibility: National stakeholder platforms
Partners: CSO
Timeframe: 1-2 years
Expected Outcome: Keeping chimpanzees on the national agenda

Objective 4.0 Improve land use planning

With the limited time available and the extensive discussion that took place it was not possible for the group to address the objectives and actions for the issue of land use planning.

It was acknowledged during plenary discussions that there is a danger of involving everyone and then no one taking responsibility to lead actions. However, it was believed to be important that all relevant stakeholders and ministries be involved to secure input and commitment from everyone. A ministry council and plan coordinator were identified as potential solutions to promoting action and implementation.

Western Chimpanzee (*Pan troglodytes verus*) Population and Habitat Viability Assessment (PHVA) for Sierra Leone

Freetown, Sierra Leone
24 to 27 May 2011

Section 7

National Parks: Effective management and surrounding communities

National Parks Working Group

PARTICIPANTS

John Oates, PSG/SGA
Paramount Chief Foday Jalloh, Nieni chiefdom (Loma non-hunting forest reserve area)
Muctarr Kamara, Tambaka chiefdom, brother of Paramount Chief, - OKNP area
Oli Brown, UNEP, building capacity of GoSL for national resource management
Chris Ransom ZSL
Bangalie Mansarey, representing speaker for Naya chiefdom
Paramount Chief Abdulai Turay, Neya chiefdom
Woody Umaru, National Tourist Board
Gabe Tucker, STEWARD
Thomas Winnebah, Dean, School of Environmental Sciences, Njala University.

TASK: List challenges/problems/issues you face when trying to improve effectiveness of national park management with respect to chimpanzee conservation, including the impacts of the park on the surrounding communities and the impacts of communities on the park.

Brainstorm of challenges/problems/issue/opportunities

The group has experience from people who have been involved in OKNP and Loma reserve.

- Concerns from OKNP are habitat encroachment of farmers into park land due to economic needs – poor people needing land to farm.
- There is a need to provide sustainable livelihoods outside of the national park area. Compensation was paid to land holders but now there are lots of restrictions on resource use – mining, fishing, hunting, etc. even though they are still living on the land. 'Compensation in kind' – provision of development projects – wells, water systems etc. as well as token financial compensation.
- In Loma the current approach from The World Bank (WB) is going well – ensuring that future conflicts are avoided by consulting communities in advance.
- Process framework is looking into how to 'compensate' communities for losses in farmland, hunting etc. – proposing alternative livelihoods so they do not need to encroach on Loma Mountain. Voiced concerns from people as to how they will survive without access to the national park and its resources.

- In Neya chiefdom they have suggested to the consultant what they need: Farming, education, health, roads, water and sanitation, fish ponds. Since 60% of Loma lies within boundaries of the Neya chiefdom, they need to benefit.
- There are hunters coming from outside to both Loma and OKNP.
- In OKNP logging is being carried out by people coming from Guinea.
- There is a need to incorporate landowners/communities in decision making processes. OKNP – tourists coming in and out but no benefits to local communities.
- Need adequate security around parks to prevent outsiders from entering the park.
- Loma will not have sufficient ranger stations in order to patrol all the entry points into the park.
- Local chiefs should also be involved – need to involve communities in management of the protected areas.
- Sensitisation over local radio to explain benefits of chimpanzees and national parks in general.
- Economic pressures affect the national parks.
- People need to understand the benefits of protected areas – lack of adequate knowledge undermines conservation.
- Lack of other protein sources makes people enter the parks to hunt.
- Existing taboos on eating chimpanzees but all the same hunters may still kill them for selling the meat to make money. Make possible because they are easily visible and enter the farm lands.
- Concern over bushfires.
- Health – lack of health facilities means people use chimp parts in traditional medical treatments. Therefore development projects need to include health facilities.
- Attitudes to law enforcement.
- There is a lack of law enforcement in the parks due to a lack of rangers, equipment, roads to move about, vehicles/motorbikes, ranger stations etc. which prevents adequate patrolling, prevention.
- Law enforcement by authorities could be supported by the communities where chiefs would assist but in order to do this the communities must be involved in protected area management.
- Local NGOs can be empowered to collect information and pass on to the authorities e.g. Conservation Society of OKNP, who have in the past found people doing illegal activities and reported them to the chiefs.
- Local people still depend on resources in protected areas for their livelihoods so they continue to enter parks and exploit. Chimpanzees may be hunted for food, or traditional medicine, or to sell the meat.
- Chimpanzees may be killed if they are destroying crops – even by people who will not eat the meat.

<u>INITIAL PROBLEM STATEMENTS</u>

- **A lack of sufficient personnel, the right equipment, adequate infrastructure coupled with attitudes to law enforcement and a lack of local involvement in monitoring can lead to limited enforcement of park laws.**
- **A lack of perceived economic benefits from protected areas, coupled with a low appreciation for the intangible benefits of conservation can lead to a low level of support for conservation.**

- **<u>Questions/comments</u>**
    - The issue of insufficient staff could be addressed by recruitment of people from communities. This will have the additional benefits of providing alternative jobs for hunters and income to local communities. However one issue that may not make this possible is that government policy requires certain qualifications for a role, which may prevent these people being recruited. Therefore, we need to look at government recruitment policy.
    - It is not just a question of numbers of staff; it is also about their ability and motivation so it is important that incentives are provided, for example, sufficient salaries and equipment.
    - An associated issue is that the government authority responsible for all this – the Wildlife and Conservation Unit – is massively under-funded and under-staffed. This raises the question of whether changes are needed in how this department is structured and funded, and where it should sit within the government, for example, should it be made into a National Park service?

<u>REVISED PROBLEM STATEMENTS</u>

- **Protected areas have limited effectiveness due to:**
    - **A lack of sufficient motivated personnel and adequate funding to provide the right equipment, and infrastructure coupled with attitudes to law enforcement. (resulting in limited law enforcement)**
    - **A lack of local involvement in decision making and management.**
    - **A lack of (perceived) economic benefits from protected areas, coupled with a low appreciation for the intangible benefits of**

conservation leading to a low level of support for conservation and increased exploitation pressure from surrounding communities.

GOALS, OBJECTIVES, ACTIONS

Long Term Goal: **A network of effective National Parks that protects large chimpanzee populations in a diversity of habitats, with support from surrounding communities within functioning and sustainable agro-ecosystems.**

NB 1 *At the time of the workshop only one national park existed in Sierra Leone (OKNP); the Gola Forest has since been gazetted as a National Park. Additional parks have been proposed and two more (Kangari Hills and Loma Mountain) are in the process of establishment through the current GEF project and Bumbuna offset funded by the WB. Therefore, there is a long term hope for a network of NPs but presently there is only a network of forest reserves, non-hunting reserves etc. In addition, 'National Parks' could be replaced with 'Protected Areas' and instead of a NP authority one could consider strengthening the Wildlife and Conservation Unit of the Forestry Commission – this may include moving this unit to outside the Forestry Commission and establishing it as its own body, probably still within the Ministry of Agriculture, but perhaps outside. There may be a need to have complementary goals and objectives referring specifically to forest reserves, non-hunting reserves. Currently there are only two areas specifically managed for wildlife conservation – OKNP and Tiwai Island Wildlife Sanctuary (TWS).*

NB 2 *The group did not have full representation of stakeholders, especially government, and consequently struggled to deal with some of the issues identified. There were differences of opinion amongst members of the group and the final objectives and actions below reflect acceptable compromises reached.*

PROBLEM 1	**Protected areas have limited effectiveness due to a lack of sufficient motivated personnel and adequate funding to provide the right equipment, and infrastructure coupled with attitudes to law enforcement.**

Objective 1.0	**Establish a network of National Parks.**
Action 1.0.1	Review existing and proposed protected areas and other important sites for chimpanzees, and make recommendations for upgrading to National Park status. Ensure these include the core/most important chimp populations.
Objective 1.1	A fully functioning National Park Authority established by 2016.
Action 1.1.1	Identify relative stakeholders, including civil society (ensuring adequate consultation of chiefdoms), relevant ministries (Ministry of Tourism, MAFFS, Ministry of Lands, SLEPA, Ministry of Local Government) and Office of the President, and establish a consultative group to produce recommendations leading to appropriate legislation.
Action 1.1.2	Produce recommendations for appropriate legislation.
Action 1.1.2	Develop legislative framework (if necessary and agreed on).
Objective 1.2	**Core costs of National Park network funded through the national budget with outside agencies able to contribute to specific programmes.** (Outside agencies were included because one group member felt that international donors should fund the parks but after discussion it was agreed that the government should commit to fund the park but there was a need to keep the option open for securing additional funding from donors).
Action 1.2.1	Full operational budget produced and presented to appropriate government body.

Objective 1.3	**Collaboration between all relevant government ministries (education, agriculture etc.), National Park Service, Forestry Department cannot be expected to provide roads, schools, health services etc. so involvement of other ministries will be needed to provide these services (assuming these are seen as services that should be provided alongside the national park).**
Action 1.3.1	Ensure regular communication and collaboration between ministries.
Objective 1.4	**Build the capacity of staff operating in protected areas and wildlife management to develop and deliver effective programmes**
Action 1.4.1	Establish a curriculum of continuing education for park staff.
Action 1.4.2	Provide staff with opportunities to attend training courses.
PROBLEM 2	**Protected areas have limited effectiveness due to a lack of local involvement in decision making and management**
Objective 2.1	**'Co-management committee' established and functioning for each National Park and its buffer zone with representation from surrounding communities.** **Please note:** the issue of co-management and the role of governments in park management generated differing opinions during the workshop and action 2.1.0, together with reviews of management approaches of National Parks in other areas of Africa and abroad, will need to be important elements in identifying the most effective approaches for National Park management Sierra Leone.
Action 2.1.0	Conduct a review of other 'co-management' schemes identifying strengths, weaknesses etc. and produce an appropriate structure

Action 2.1.1	Participatory Rural Appraisals in surrounding communities, include identifying existing structures in communities which can be utilised.
Action 2.1.2	Organise communities into 'NP management organising committees'.
Problem 3	**Protected areas have limited effectiveness due to a lack of (perceived) economic benefits from protected areas, coupled with a low appreciation for the intangible benefits of conservation, leading to a low level of support for conservation and increased exploitation pressure from surrounding communities.**
Objective 3.1	Develop a tourism programme from which revenues are fairly shared with local communities.
Action 3.1.1	Assessment of tourism potential for each park and develop a tourism plan.
Action 3.1.2	Within framework of NP legislation, agreement on revenue sharing and mechanism for dispersing of revenues *(i.e. there needs to be a set policy across all National Parks that ensures the same approach is taken across the country. This should be incorporated into the policies establishing the parks)*
Action 3.1.3	National Park Management Committees ensure transparent and accountable management of revenues.
Objective 3.2	**Evaluate and explain economic benefits that accrue to local people as a result of ecological services provided by parks (e.g. water supplies, local climate, medicinal plants in buffer zone etc.).**
Action 3.2.1	Design and conduct research into ecological services.
Action 3.2.2	Disseminate research results to communities through environmental education/awareness programmes.

Action 3.2.3 Investigate potential for carbon revenues from national parks and buffer zones.

Action 3.2.4 Establish carbon revenue forestry projects (Please note: There were varying opinions on this issue during the workshop. It was suggested that these projects only take place in community forest areas, and not to include credits from the park, but this was debated. There was also debate over whether revenues should be shared between communities and government or just go to communities. It was suggested that if there is co-management and revenue sharing for the protected area and its buffer zone, it would be likely that government would expect a share of carbon revenues from the buffer zone in the same way that communities would get a share of revenues from activities like tourism in the park. It was also noted that carbon projects are in their early stages of evolution and only voluntary market credits are available).

Objective 3.3 **Nurture/develop awareness of aesthetic, natural heritage and recreational benefits of healthy wildlife populations.**

Action 3.3.1 Incorporate the use of parks as part of environmental education for schools in surrounding communities

Action 3.3.2 Develop materials and carry out awareness activities in local communities, schools, etc.

Objective 3.4 **Establish buffer zones around each national park**

Action 3.4.1 Identify buffer zones for each park that can be managed compatibly with chimpanzees.

Action 3.4.2 Develop trials and demonstrations for chimpanzee compatible agroforestry systems for the buffers, e.g. using upland rice

Action 3.4.3 Work with local communities to gain acceptance of the chimpanzee compatible agroforestry

NB *This last objective and actions were suggested by one individual who was concerned that management of land outside the parks be incorporated into this section of the action plan. Initially very* *specific actions were made which the rest of the group were uncomfortable with, such as planting Asian bamboo (which could be invasive) around the boundary of the parks as a fence to stop animals moving out and people moving into the park – others in the group felt that it wasn't desirable to fence the animals into the park if we are trying to maintain a national population rather than isolated ones, and that chimps would be able to climb over or through bamboo any way, as well as people cutting their way through. Bamboo would also demarcate the boundary of parks which everyone agreed is necessary but probably not with this bamboo – suggested that it should be with something else beneficial to the communities. It was felt by others that more research into options would be necessary rather than putting the use of bamboo into the action plan. Another suggestion which was not incorporated into the final actions was the need for active management inside the parks to ensure a diversity of habitats for chimps. The wording of the Long-term Goal states the desire to 'protect large chimpanzee populations in a diversity of habitats', which was intended to mean that the protected area network should have a diversity of habitats not necessarily each individual park. The need for management plans was also suggested whilst we were writing the objectives/short-term goals and it was agreed that these were necessary but that the development of these might be more of an action than an objective so it was suggested these be included in the actions; however this was not raised again so it was not included. However the group agree that management plans are necessary and can be included as this is an essential part of the process of establishing a PA and its success.*

There was some disagreement over what should be included in this management plan – whether a park management plan should include all the details of agroforestry management in buffer zone and neighbouring community areas, or whether a park management plan should focus on park management, and a land use planning exercise with other relevant ministries responsible for things like agriculture taking part rather than this becoming the role of the park authority.

In plenary discussions concern was expressed that current buffer zones are shrinking and support given to expanding buffer zones and protected areas. It was also recognized, however, that more research is needed on the current effectiveness of buffer areas and corridors and on how to design them to be more effective. Similarly, there is a data gap with respect to the current level of threat (hunting) in the current protected areas. While it is thought that expanding protected areas and buffer areas will benefit chimpanzees, the resulting impact on chimpanzees will depend upon how chimpanzees and humans use these areas and the ability to reduce threats such as hunting in these areas.

Western Chimpanzee (*Pan troglodytes verus*)
Population and Habitat Viability Assessment (PHVA)
for Sierra Leone

Freetown, Sierra Leone
24 to 27 May 2011

Section 8

Building human/chimpanzee harmony

Building Harmony Working Group

PARTICIPANTS:

Fatmata Gitta Koroma, Barri Chiefdom representative
Bala Amarasekaram, TCS
Tatyana Humle; PSG/SGA
Joseph S. Mansaray, Bafodia Chiefdom representative
Edward Fatoma, Green Scenery
Michael Samai, Deputy Director (Local Government), MIALGRD
Olufemi Omiyalwe, Dean, School of Forestry and Horticulture

TASK	List the challenges/problems/issues communities face when trying to minimise the negative impact of humans on chimpanzees and chimpanzees on humans.

PROBLEM 1	**Gaps in knowledge of location of human communities facing issues of conflict and/or competition with chimpanzees and absence of a central body to assist communities to mitigate and/or prevent conflict and/or resource competition issues with chimpanzees:**
	National and international laws protect chimpanzees so issue with law enforcement is problematic; people cannot injure/kill problematic chimpanzee individuals (e.g. ones that are particularly aggressive towards humans)? How are the local communities to deal with this? How do we know which ones are affected or are viewing co-existence as a conflict? Who can help them mitigate and/or prevent issues?
Goal 1a	**Identify localities or human communities affected by issues of conflict with chimpanzees and resource competition with chimpanzees.**
Action 1.1	Based on national survey data, compile information of known affected communities.

Action 1.2 Set up Free Hotline as a reporting mechanism for cases of conflict and encounter of dead/sick chimpanzees (evaluated for expansion).

- Responsibility: Task Force (Ministry of agriculture, forestry and food security (wildlife and agriculture divisions/Police)/Tacugama sanctuary)
- Collaborators or partners: Chiefdom authorities (filtering of info & checking; formation of standing committee), AirTel (Hotline-for reporting), other communications company etc.
- Timeline: Start: End 2011
- Measurable: Hotline in place, Reporting and filtering system in place (Chiefdom standing committee w/in chiefdom to filter and check information/reports of problem, prior to hotline reporting)
- Consequences: Communities are identified so that assistance, advice etc. can be delivered to them via task force (below)
- Resources required: Transport/ lodging/expenses for Task force to visit chiefdoms to inform them of system in place, issues of concern to report and not report, not to raise expectations of affected people etc.

The establishment of a Hotline was discussed and evaluated within the working group and during plenary discussions. Currently whenever the police are contacted regarding a chimpanzee situation they in turn contact Tacugama Chimpanzee Sanctuary; establishing a hotline would avoid a potentially unnecessary step and also ensure that the information is always passed on to TCS. A potential disadvantage is the police may be left out and should be informed on all legal matters. Good communication with the police on chimpanzee matters is important.

Goal 1b **Set up a body (Task Force) that can support, advise and help communities to select, implement and evaluate mitigation and prevention schemes aimed at minimizing conflict and resource competition.**

Action 1b.1 Approach MAFFS to select representatives from the Agriculture Division and the Conservation and Wildlife Management Unit (CWMU) to partake in task force coordinated by TCS.

Action 1b.2 Develop revisable operational manual on how to deal with certain issues, approach communities and also providing info on possible mitigation and prevention strategies, how they could be implemented, etc.

Action 1b.3 Training of members of task force.

Action 1b.4 Inform Chiefdoms of the existence of task force

- Responsibility: Task Force (Ministry of agriculture, forestry and food security (CWMU and Agriculture Division)/TCS)
- Collaborators or partners: Chiefdom authorities (filtering of info & checking), AirTel (Hotline-for reporting) etc.
- Timeline: Start: End 2011
- Measurable: Task force set up with representation from relevant divisions
- Consequences: Body in place to respond to issues.
- Resources required: Transport/ lodging/expenses for Task force to visit chiefdoms to inform them of system in place, issues of concern to report and not report, not to raise expectations of affected people, etc.

Goal 1c **Set up database and promote more research into human-chimpanzee conflict and resource competition issues.**

Action 1c.1 Compile relevant data from national surveys-TCS

Action 1c.2 Set up database-what elements need to be in it and how it should be organized (geo-referenced community, pbs, etc.)

Action 1c.3 Train one or more members of Task force to maintain database

- Responsibility: Task Force (CWMU/TCS).
- Collaborators or partners: Chiefdom authorities (filtering of info & checking), Research experts on conflict issue from national and international universities (initial contact group-Tatyana Humle/SGA)
- Timeline: End of 2011
- Measurable: Increased knowledge about causes of pb

- Consequences: Baseline info to work with communities to develop mitigation schemes; improve effectiveness of task force
- Resources required:

PROBLEM 2	**Lack of understanding and misperceptions about chimpanzees among local communities**
	Poor general awareness/perceptions related to the behaviour of chimpanzees and their true impact on local economic loss and 'physical' injury; medicinal value. Some people believe that chimpanzees rape women, that chimpanzee products can give them strength. Many people lack an understanding of how to behave when they see chimpanzees (what to do and not to do).
Goal 2a	**Increase tolerance toward chimpanzees (convince people that humans and chimpanzees, and other wildlife, need to share natural resources) and respect of the law pertaining to chimpanzee**
Goal 2b	**Ensure that local people no longer hold unfounded beliefs about chimpanzee behaviour or the value of the chimpanzees for medicinal purposes.**
Goal 2c	**Improve understanding of zoonoses.**
Action 2	Strengthen environmental education and awareness-raising programme.
Sub-Action 2.1	Develop old and new ideas (e.g. local language song writing, youth clubs) and materials targeted at schools and local communities (leaflets, books, films).
Sub-Action 2.2	Develop partnerships with community radios and theatre groups to target communities and NGOs.
Sub-Action 2.3	Develop partnership with Ministry of Health to promote understanding of zoonoses.

- Responsibility: TCS

- Collaborators or partners: USAID, PAGE, UNEP? Community radios, theatre troops, Health Ministry
- Timeline: on-going, needs to expanded and developed nationwide
- Measurable: Increased knowledge (target communities evaluation will be carried out), task force database (no more reports of aggressions); Reduce no. of people holding these unfounded beliefs (target communities evaluation will be carried out)
- Consequences: Increased tolerance, reduced reported incidences of aggression; Change in beliefs, better awareness of hygiene and zoonoses
- Resources required: Finances for developing materials, radio spots, generators, projector, computer, development of short education films, theatre troop etc.

PROBLEM 3	**Why should people protect chimpanzees, especially if human communities are impacted by conflict with chimpanzees and protected species**

Why should people care to protect chimpanzees, when they are struggling with their basic needs? This directly compromises chances of any harmony between humans and chimpanzees. Any revenue generating activity should benefit the local people, especially those impacted by crop-raiding. (Side note: eco-tourism not recommended as revenue generating activity-Requires habituation of chimpanzees, which will yield loss of fear and escalation of crop-raiding and aggression events).

Goal 3 **Creating value for the local people to preserve chimpanzees in their locality**

Action 3.1 Identify target/pilot communities (initially).

Action 3.2 Identify activities that communities are interested in developing (e.g. production of marketable items, agricultural techniques, skill training for youth).

Action 3.3 Identify markets or organizations that can assist in improving technical aspects of the above.

- Responsibility: Government and NGOs
- Collaborators or partners: Chiefdoms, NGOs Partners and Government agencies with expertise in this domain, facilitated by Tacugama, etc.
- Timeline: Start with target/pilot communities
- Measurable: Increase income of villagers
- Consequences: Create less dependence on wild resource extraction
- Resources required: Pending on proposed activities

Action 3.4 Encourage more use of fuel efficient cooking methods to reduce incursions into forest in target communities with conflict issues-if need identified.

(NOTE: there is an on-going PAGE programme looking at usage of various fuel sources, results of this programme will inform this action)

- Responsibility for identifying potential partners: TCS/Green scenery/Conservation society/WAPFoR
- Measurable: Increased usage of energy efficient stove (not charcoal)
- Consequences: Less harvesting of wood in forest for fuel, reduce encounter rate between humans -chimpanzees
- Resources required: Finances for stoves, need to be thought through with partners

PROBLEM 4 **Crop-raiding, resource competition and aggression:**

Chimpanzees raid crops in farms, orchards, plantations; this has for economic consequence and causes loss of time (children guarding crops); people sometimes tease or threaten the chimpanzees. This can fuel anger/intolerance on both sides. Threats towards chimpanzees, generates higher probability of aggressive behaviour by chimpanzees toward humans. Chimpanzees can be vengeful and have a good memory of people that have behaved badly towards them. Women and children are more vulnerable, since they are typically more fearful. Both chimpanzees and humans compete for same natural resources, e.g. oil palm, which again leads to economic loss for families and may also increase risk of encounter between humans and chimpanzees, especially in forest, which could increase risk of *aggression. This could also compel chimpanzees to crop raid if they lack natural resources.*

Goal 4a	**Reduce crop raiding/improve land-use management.**
Goal 4b	**No more reports of chimpanzee aggression on humans (and vice versa).**
Action 4.1	Ensure that communities most affected are visited by Task force (via current knowledge and hotline database/info).
Action 4.2	Engagement of participatory process between Task Force and community in identifying and implement possible mitigation scheme and identify affected families to ensure that they benefit.
Action 4.3	Evaluation of effectiveness of schemes and revision if necessary.
Action 4.4	Input info/data into Database and eventual revision of operational manual.

- Responsibility: Task Force
- Collaborators or partners: NGOs, Governmental organizations, Research Institutions

Action 4.5 — **Increase research into habitat restoration to improve chimpanzee habitat in cleared areas in/outside protected areas/buffer zones/potential corridors.**

- Measurable: Increased suitable natural habitat for chimpanzees and increased connectivity between chimpanzee communities
- Consequences: Reduction in conflict issues reported in these areas and increased gene flow-minimise risks of inbreeding in chimpanzees
- Resources required: Pending on areas identified and partners

PROBLEM 5	**Health issues, risk of disease transmission and family planning**

E.g. water points for clean access; human waste.

Goal 5.1 **Improve health/hygiene of local communities**

Action 5.1 Develop and promote construction of wells, latrines or related facilities aimed at improving health and/or hygiene of local communities.

- Responsibility: Task Force
- Collaborators or partners: NGOs, Governmental organizations, Research Institutions
- Timeline: 2012-ongoing
- Measurable: Increased health of villagers (and chimpanzees) (Health evaluations in target communities will be carried out, also possibility for research linking community health with chimpanzee population health)
- Consequences: Healthy populations of both humans and chimpanzees. Improve economic situation of local communities (reduce expenditure on medical expenses)
- Resources required: Pending on needs and partners

Action 5.2 **Increase research into links between human and chimpanzee health in localities (e.g. intestinal parasites, respiratory disease).**

- Responsibility: Tacugama and Ministry of Health
- Collaborators or partners: Universities/Research Institutions
- Timeline: 2012-ongoing
- Measurable: Increased knowledge of health links, issues.
- Consequences: Research can serve to better educate and convince communities of the link between human and chimpanzee health and promote good hygiene habits etc., evaluate effectiveness of health program on improving chimpanzee survival.
- Resources required: Pending on needs and partners

Goal 5.2 **Improve community access to family planning.**

Action 5.3 Increase access to health workers by local communities, including information on family planning.

- Responsibility: TCS and Ministry of Health
- Collaborators or partners: NGOs, Governmental organizations, Research Institutions
- Timeline: 2012-ongoing
- Measurable: Increased health of villagers (and chimpanzees) (Health evaluations in target communities will be carried out, also possibility for research linking community health with chimpanzee population health); Have more health workers reach remote village communities
- Consequences: Healthy populations of both humans and chimpanzees. Improve economic situation of local communities (reduce expenditure on medical expenses)
- Resources required: Pending on needs and partners

There was some discussion in plenary whether the issue of increasing human population in Sierra Leone should be addressed more explicitly in this report. The group acknowledged that this is a sensitive issue and that other ministries are addressing this. It was decided that this report should focus on activities that affect chimpanzees more directly.

Western Chimpanzee (*Pan troglodytes verus*) Population and Habitat Viability Assessment (PHVA) for Sierra Leone

Freetown, Sierra Leone
24 to 27 May 2011

Section 9

Ensuring the implementation and long-term sustainability of the action plan

Action Plan Implementation Working Group

PARTICIPANTS

Eddie Aruna, Manager Marine Turtle Conservation Project, CSSL
Paramount Chief Sheku Fasuluku, Sandor Chiefdom
Hjalmar Kuehl, MPI
Anita (Frankie) McKenna, TCS
Frands Carlsen, Copenhagen Zoo/CBSG Europe
Liz Williamson PSG/SGA

TASK	Define what can be done to ensure that the action plan is implemented and that actions and progress can be followed through the long-term.

PROBLEM STATEMENT:

What has been the failure of some other action plans?

1. Some action plans have not been actively implemented but rather viewed as reference or historical documents. To avoid this being the case for the Sierra Leone chimpanzee Action Plan, we will define an appropriate implementation strategy, which ensures effective delivery of the actions prescribed in the action plan.
2. There is no donor confidence without evidence of effective monitoring and evaluation demonstrating successful implementation.

GOALS

Long-Term Goal

The successful adoption and implementation of the Action Plan.

Short-Term Goals

1. To gain endorsement of the Action Plan by Government of Sierra Leone.
2. To disseminate the Action Plan to key stakeholder groups.

3. To develop an effective communication strategy that will ensure awareness and understanding of the conservation plan and its recommendations. .
4. To have an effective monitoring and evaluation system in place for the Action Plan.
5. Stimulate national and international engagement and new partnerships.
6. Establish a feedback mechanism to improve implementation effectiveness.
7. Establish a steering committee (general oversight) to guide and drive implementation of the Action Plan.
8. Monitoring of chimpanzee populations established to measure effectiveness of the actions being implemented.
9. Acquire knowledge of large-scale challenges/obstacles to successful chimpanzee conservation.

Endorsement (different levels of government responsibility in parentheses)

By government - submit Action Plan to Forestry Division (Conservation and Wildlife Management Unit), in Ministry of Agriculture, Forestry and Food Security, following a hearing in parliament
a) MAFFS Director CWMU (Conservation and Wildlife Management Unit)
b) Parliament – Minister of MAFFS

Dissemination to various levels of government:

- PROVINCE LEVEL (4) Provincial Secretary receives from Ministry; shares with District Councils.
- DISTRICT LEVEL (14) District Councils share with Paramount Chiefs
- CHIEFDOM LEVEL (149) Paramount Chiefs present to Chiefdom committee
- SECTION LEVEL

Communication Strategy – National (responsibility in parentheses)

a) Media (CWMU and TCS)
Press release
Press conference to present to NGOs, national and international journalists
Radio interviews
Newspapers
TV SLBC

b) Public Meetings/Hearings at District Levels

c) Hard copies of Action Plan to be publicly available for reference at Chiefdom Level

d) Diffusion to international media

Communication Strategy -- International

a) Donors
Arcus and USFWS (IUCN)

b) International Conservation NGOs & Agencies
IUCN, UNEP, WWF, WCS
Encourage new partnerships –- engagement in Sierra Leone needed to start new projects and to implement them. Action Plan must present opportunities

c) A.P.E.S. Portal (http://apes.eva.mpg.de/eng/index.php)
UNIVERSITIES AND RESEARCH ORGANISATIONS

Table 10. Action Plan implementation

ST Goal	Action	Responsibility	Partners	Timeline	Measurable	Outcome	Resources
1. Presentation to SL government	Briefing about draft AP to MAFFS (WCMU)	TCS	Grasp	June 2012 – July 2012	Letter of acknowledgement	Awareness at govt. level	CBSG & TCS for draft AP
2. Dissemination	Print Action Plan	CBSG & TCS		August 2012	300 copies printed	Document readily availability	Printing costs CBSG & TCS
	International donors and conservation agencies	WCMU & TCS		August 2012	Copies received	Awareness of Action Plan	
3. Steering Committee	Develop ToR for SC	MAFFS & TCS	CSSL	June 2012	ToR established	Clear scope of operations	
	Nominate members to SC	MAFFS & TCS		July 2012	Members appointed	Functioning committee	
	Seek formalization from MAFFS	CBSG & TCS		July 2012	SC mandated	Ability to convene meeting	
	Organise inaugural meeting	SC		August 2012	Meeting has taken place	Acceptance of ownership of AP	
	Formal communication of existence of SC	SC		August 2012	Awareness of SC	Transparency of process	
	Appoint a National Chimpanzee Conservation Coordinator	SC		September 2012	CCC hired	Clear responsibility for driving implementation of AP	Copenhagen Zoo to seek funding for National Coordinator
4. Communication Strategy	National and international media: press release, press conference, interviews with radio, SLBC, newspapers	WCMU & TCS		August 2012	XX number of interviews/articles	Increased awareness of AP	Venue, refreshments
	Public meetings at District Level	NCCC	WCMU & TCS	Within 1 year, prioritised strategically	Meetings held in 14 Districts	Increased awareness of AP	Transportation, lodging, venue, refreshments

ST Goal	Action	Responsibility	Partners	Timeline	Measurable	Outcome	Resources
	Distribute to Provincial Secretaries, District Councils, Paramount Chiefs, Chiefdom committee	NCCC during public meetings	TCS, WCMU & TCS MLGRD	One year	Hard copies of AP publicly available for reference in 149 Chiefdoms	Awareness of Action Plan	
5. Stimulate engagement & involvement	Present opportunities for new projects to INGO forum	NCCC	WCMU & TCS	October 2012	New projects/ partnerships with INGOs established	Greater consideration of chimp conservation needs	
	Assess opportunities for collaborative implementation with other species plans	NCCC	INGOs and local NGOs				
	Contact national universities	NCCC			Research projects developed		
	Identify international research institutions	NCCC	WCMU & TCS				
	Partnerships in Guinea and Liberia	NCCC			Links with Mano River Union	Regional awareness of hunting, disease	
6. Project M&E system	Design M&E methodology	NCCC					
	Compile and analyse info on measurable outcomes of projects	NCCC					
7. Feedback mechanism	Results of M&E presented to SC	NCCC					
	Results of M&E provided to projects	NCCC					
	Recommend project modifications if needed	NCCC, SC					
8. Chimp population monitoring	Repeat interviews from 2008 survey	NCCC, TCS					
	Select locations for periodic camera trap and/or transect surveys	NCCC, TCS		5 years			

ST Goal	Action	Responsibility	Partners	Timeline	Measurable	Outcome	Resources
	Compare survey results with 2008 baselines	NCCC	Max Planck Institute	5 years	Partnership established with A.P.E.S.		
	Monitor verified reports of orphaned chimpanzees			Ongoing			
9. Acquire knowledge of large-scale challenges/obstacles to success of chimp conservation	Identify and stay updated on key large-scale threats (bushmeat, poaching, extractive industries, biofuels, climate change, human population growth)	NCCC	Ministries CSOs, NGOs, UN orgs	Baselines 2012; info gathering ongoing and continuous			
	Seek opportunities to mitigate obstacles	NCCC					
	Lobbying government	NCCC	TCS	Ongoing		Increase awareness of chimpanzees conservation issues in key ministries	
10. Endorsement by government				2013		Ownership at govt. level	

Western Chimpanzee (*Pan troglodytes verus*) Population and Habitat Viability Assessment (PHVA) for Sierra Leone

Freetown, Sierra Leone
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Section 10

List of participants

Name	Organisation	Role	Email	Tel No
Abu Bakarr S Kamara	Kambia District	Masungbala Chiefdom representative	NA	088 608155
Alden Whitaker	STEWARD (USAID)	Head of Party	alden.whittaker@yahoo.com	076 856079
Alhaji A Turay	Neya Chiefdom (Loma Mountains)	Neya Chiefdom Representative	NA	077 263684
Alhaji Malikie Siaka	RSPB/Gola Forest Programme	Research Biologist	alhajisiaka@yahoo.com	076 767291 / 033 350470
Anita McKenna (Frankie)	Tacugama Chimpanzee Sanctuary	Programme Manager	info@tacugama.com	076 740100 / 033 960830
Ansumana Swaray	ENFORAC	National Coordinator	enforac@yahoo.com	076 465603
Arthur Chinsman-Williams	Sierra Leone Agricultural Research Institute (SLARI)	Research Officer, Land and Water	chinswise_williams@yahoo.com	033 317645
Bala Amarasekaran	Tacugama Chimpanzee Sanctuary	Programme Director	bala@tacugama.com	076 611211 / 033 611211
Boisinnah Kanneh	Pujehun District	Baoma Koya Chiefdom representative	bosinkann@hotmail.com	076 298581
Chris Ransom	West and North Africa Conservation Programme, Zoological Society of London	Programme Manager	chrisransom@zsl.org	+44 (0)207 4496442
Christo Johnson	Reuters	Correspondent	christo1941@yahoo.com	076 628813
Dr Olufemi Omiyale	Njala University	Dean, School of Forestry and Horticulture	femiyale@yahoo.co.uk	033 564379
Edward Aruna	Conservation Society of SL	Acting Director	ewardaruna@yahoo.com	033 3470043 / 076 645130
Edmund Mustapha Konneh	Moyamba District	Makpele Chiefdom representative		078 625890
Edward Bendu	Environmental Protection Agency Sierra Leone	Head, Dept. of Information, Education and Communications	edwardpbendu@yahoo.co.uk	076 749024
Edward T Fatoma	Green Scenery	Asst. Programme Coordinator	gscenery@yahoo.co.uk	076 524202 / 033 524202
Eugene Cole	PAGE (USAID)	Governance and Natural Resource Policy Specialist	eugchris@yahoo.com	076 630451
Fatmata G Koroma	Barri Chiefdom	Barri Chiefdom representative	gitta.koroma1@yahoo.com	076 333479
Fatmata Sarah Turay	UNEP	Programme Assistant	fsturay1@yahoo.co.uk	076 758078 / 033 310311
Foday K Kanu	Mamunto Mayoso, Tonkolili District	Kholifa-Rowala Chiefdom Treasury Clerk	NA	076 734074
Frands Carlsen	IUCN/SSC Conservation Breeding Specialist Group (CSBG) Europe	EAZA Species Coordinator Chimpanzees	fc@zoo.dk	+45 72200223
Gabe Tucker	STEWARD (USAID)	Natural Resource Programme Manager	g.tuckercf@gmail.com	076 678838
Hjalmar Kuehl	Max Planck Institute	Primatologist -Project Manager, A.P.E.S. Database	kuehl@eva.mpg.de	
John Oates	Hunter College CUNY, Primate Specialist Group IUCN	Professor Emeritus	johnoates1@aol.com	076 415392
Joseph S Mansaray	Wara Wara Hills, Koinadugu District	Bafodia Chiefdom representative	NA	076 618326
Kalie I Bangura	Wildlife and Conservation Unit, Forestry Division, MAFFS	Senior Game Superintendent	kibangura785@yahoo.com	076 680362
Kathy Traylor-Holzer	IUCN/SSC Conservation Breeding Specialist Group (CSBG) HQ	Modeller	Kathy@cbsg.org	+1 9529979800

Kristin Leus	IUCN/SSC Conservation Breeding Specialist Group (CSBG) Europe	Facilitator	kristin@cbsgeurope.eu	+32 36455894
Liz Williamson	Primate Specialist Group IUCN/SSC	Primatologist - University of Stirling, UK	eaw1@str.ac.uk	
Lovell Thomas	MAFFS	Deputy Minister		
Michael Samai	MIALGRD (Min of Internal Affairs, Local Gov. & Rural Development)	Acting Director of Rural Development	michaelasamai@hotmail.com	076 607437
Mohamed Kamara-Kolleh	Tambaka Chiefdom	Chiefdom representative	mikamarakolleh@yahoo.co.uk	076 641681
Mohamed M Koroma	MAFFS AICU	Communications	koromamm@yahoo.com	076 323 184
Mohamed S Dabo	Office of National Security, Disaster Management Division	Assistant Desk Officer	gboyama@hotmail.com	033 862767 / 078 862767
Momodu A Bah	Environmental Protection Agency Sierra Leone	Head, Intersectoral and International Cooperation	modbah@yahoo.com	078 350627
Muctarr Kamara	OKNP Conservation Society	Chairman	muctarr.kamara@yahoo.com	076 811198
Musa Kamara	MAFFS AICU	Communications		076 604975
Oli Brown	UNEP	Country Coordinator	oli.brown@unep.org	078 853187
Papani Bai-Sesay	Tacugama Chimpanzee Sanctuary	Field Officer	papani.baisesay@gmail.com	077 636802 / 078 233255
PC Abdulai Turay	Neya Chiefdom (Loma Mountains)	Paramount Chief		077 452106
PC Foday Alimamy Umaru Jalloh III	Nieni Chiefdom (Loma Mountains)	Paramount Chief	chieffoday_nieni@yahoo.com	076 740817/033 801308
PC Sheku Fasuluku III	Sandor Chiefdom (Tingi Hills, Kono)	Paramount Chief	pcfasol@yahoo.com	076/33 630673
Prof Abdul Karim	Fourah Bay College (University of SL)	Head of Biological Sciences	adeshafe@yahoo.co.uk	076 623795
Rod Mac-Johnson	French Press Agency	Correspondent	kudeyami@yahoo.co.uk	076 613894
Samuel Yamba Koroma	Kangari Hills Non-hunting Forest Reserve	Yoni Chiefdom Treasury Clerk	NA	076 792220
Sandra M Koroma	Gola Forest	Gaura Chiefdom representative	NA	076 967766
Scott Bode	ARD / PAGE (USAID)	NRM Programme Manager	scott.bode@yahoo.com	076 918700
Sheku Mansaray	Forestry Division, MAFFS	Acting Director	mansasheka@yahoo.com	076 640429
Tatyana Humle	School of Anthropology and Conservation, University of Kent	Primatologist - DICE	t.humle@kent.ac.uk	+ 44 (0)7941 139791
Terry Brncic	Independent	Specialist advisor	terry.brncic@linacre.oxon.org	077 900 657
Thomas Winnebah	Njala University	Dean, School of Environmental Sciences	twinnebah@yahoo.com	076 615229
Umaru Woody	National Tourist Board (NTB)	Senior Planning and Product Development Manager	donwood2000@yahoo.com	033 375037

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SECTION 11

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Appendix I

Resource List

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Appendix II:

Simulation Modeling and Population Viability Analysis

Jon Ballou – Smithsonian Institution / National Zoological Park
Bob Lacy – Chicago Zoological Society
Phil Miller – Conservation Breeding Specialist Group (IUCN / SSC)

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.

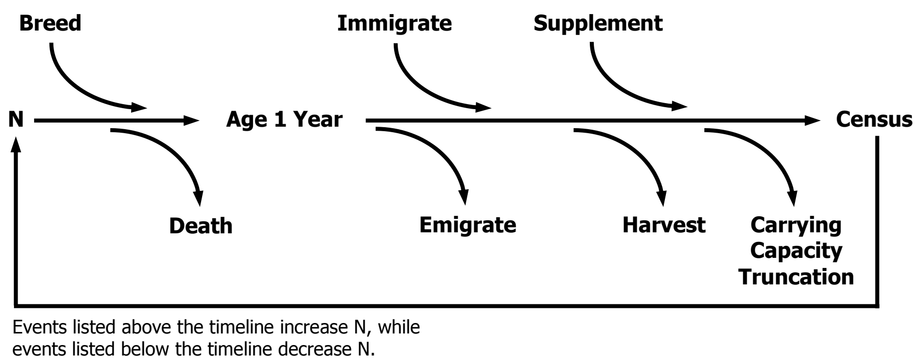
In considerations of the vulnerability of a population to extinction, as is so often required for conservation planning and management, the simple model of population growth as a constant annual rate of change is inadequate for our needs. The fluctuations in population size that are omitted from the 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.

VORTEX Simulation Model Timeline



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 (in press) 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:

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

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

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

genetic and demographic instabilities inherent in small populations.

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

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

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

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

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Appendix III

"What types of models should I run in my PVA?"

Some thoughts on data availability, analysis objectives, and scenario construction in population viability analysis

Phil Miller
Senior Program Officer, CBSG

Introduction

To be most effective, any population viability analysis (PVA) should begin by presenting a clear list of questions that are to be addressed in the quantitative analysis to follow. The structure and characteristics of the scenarios that are then constructed should be tightly linked to these questions; in this way, answers to these questions can be obtained in the most direct fashion and, where appropriate, research and/or management recommendations can then be presented in the most logical and understandable voice based on the insights gained from the analysis. Failure to begin a PVA project in this way can lead to unclear analysis objectives, a lack of organization in the analysis and, more importantly, a similar lack of organization in the presentation of the analysis – frequently leading to reduced credibility of the PVA effort itself and the recommendations that result from it.

As an example of the types of questions one might ask in a PVA analysis, shown below is a list of specific questions identified by wildlife managers in Colorado when developing a PVA for the state's population of Greater Sage Grouse:

- Can we build a series of simulation models with sufficient detail and precision that can accurately describe the dynamics of Greater Sage Grouse populations distributed across Colorado?
- What are the primary demographic factors that drive growth of Greater Sage Grouse populations in Colorado?
- How vulnerable are small, fragmented populations of Greater Sage Grouse in Colorado to extinction under current management conditions? How small must a population become to increase its risk of extinction to an unacceptable level?
- What are the predicted impacts of current and potential future levels of hunting on selected Greater Sage Grouse populations in Colorado?
- What are the predicted impacts of current and potential future levels of housing development on selected Greater Sage Grouse populations in Colorado?
- What are the predicted impacts of current and potential future levels of

petroleum and natural gas development on selected Greater Sage Grouse populations in Colorado?

- What are the predicted impacts of current and potential future levels of surface mining on selected Greater Sage Grouse populations in Colorado?
- Can predator mitigation improve the viability of Greater Sage Grouse populations in Colorado in the face of other anthropogenic processes?

With this list of questions in hand, the PVA practitioner can immediately begin to plan an outline of my analytical approach: Can I build a high-quality, retrospective model of species demography that will form the basis of subsequent models? Is a demographic sensitivity analysis going to be desirable? What kinds of risk assessment models can I build? This "mental organization" of the PVA is a critical early step in the overall process.

The types of scenarios that can be constructed – and, more importantly, the conclusions that can be drawn from them – is vitally dependent on the extent of data you have. This is true for both the species / population of concern, as well as for the different natural and anthropogenic threats that have been identified as having a potential impact. It is important for the PVA practitioner to recognize this interaction between the goals of the PVA, the data that are (or are not) available, and the nature of the appropriate scenarios to construct in the analysis. Interestingly, this interaction can be easily overlooked when designing an analysis in the context of decision-making for species conservation.

Analysing the Situation

The flow chart below is an attempt to graphically portray the types of situations one will face in organizing a PVA, and attempts to give some guidance on the kinds of scenarios considered to be the most appropriate for each situation. In addition, the chart identifies the types of conclusions one can most logically draw from these scenarios, and therefore points out situations where specific conclusions, thought to be important for management planning, may be misguided given the nature of the analyses.

For example, if detailed data on both the biology/demography of the species and on the threats to that species are absent, it then becomes effectively impossible to make precise predictions about the viability of that species at any point in the future (i.e., a given scenario), with or without the inclusion of information on addition or removal of anthropogenic threats. This lack of precision in model outcome is a direct result of the lack of precision in the model input. Under these conditions, detailed and accurate answers to questions like those posed for the Greater Sage Grouse above are unrealistic. Instead, the PVA practitioner must use appropriate sources of general species information, liberally sprinkled with expert intuition on both the species and the PVA process itself, to generate a baseline scenario that portrays the demographic performance of the focal species / population to a degree that is deemed reasonable to those species experts supplying the data. More specifically, a scenario could be constructed that gives a particular deterministic or stochastic population growth rate that seems reasonable for the species / population in question. With this reasonable baseline scenario in hand, the practitioner is then largely restricted to conducting a detailed **demographic sensitivity analysis**. This process is designed to identify specific demographic variables which, when perturbed around their baseline estimates, produce the greatest change in overall population growth. Demographic sensitivity analysis is quite appropriate when specific data are lacking, and is very useful in providing insight into the demography of the species under study. Through this insight, wildlife managers can make meaningful priorities for further research into the biology of the species, and can also make more general recommendations about those aspects of species demography that could be given higher priority for active population management (e.g., Santos del Prado-Gasca 2005). However, given the lack of accurate data on the underlying rates of fecundity and mortality in these scenarios, it is not appropriate to make specific recommendations about, for example, reducing anthropogenic mortality of juveniles from *x*% to *y*% over a period of *z* years.

When only part of the picture is in clear focus – in other words, when one set of data on species demography or threats is available in quality and quantity but is absent in the other – the accuracy of the resulting risk assessment is somewhat less than the ideal. Consequently, the portrayal of that accuracy must also be carefully considered when describing the results of what I have called either **generalized** or **modified risk analysis** scenarios. The interpretation of the results of these two types of scenarios can become rather tricky. For example, in the PVA of tree kangaroos of Papua New Guinea (Bonaccorso et al. 1999) we were able to obtain fairly accurate estimates of the total number of animals removed from the forest each year by hunters living in villages near suitable tree kangaroo habitat. With knowledge of these data, we could have asked a very detailed question of great utility to wild tree kangaroo population managers: "What is the maximum harvest level of tree kangaroos that can maintain population stability (e.g., positive population growth) over the next 25 years?" Unfortunately, because we had precious little data on the underlying mortality rates of wild tree kangaroo populations in these areas, not to mention the absence of data on current population sizes, the more detailed threat data could not be used to its fullest potential. As a result, we were unable to provide a more accurate answer to this important question. Instead, we were forced to be more general in our recommendations regarding the impact of harvesting on tree kangaroo populations; if a specific assumption is made regarding the underlying growth rate of the population, we could perhaps recommend that hunting-based mortality be maintained at a level below *x*% so that overall tree kangaroo populations can continue to increase in size. However, we had little information to determine the current rate of hunting observed in the population, so it became very difficult to ascertain the level of management intensity required to go below this threshold.

On the other hand, absence of threat data in the presence of detailed species biology data presents the PVA practitioner with different challenges and opportunities. During our PVA of the mountain gorilla (Werikhe et al. 1998) we were presented with an interesting situation: More than 25 years of data on wild population demography were available, thanks to the work of Dian Fossey and her colleagues at Rwanda's Karisoke Research Centre. However, very little data existed for one of the primary threats to the future survival of the species: the intense human social instability in the region, exemplified by the Rwandan crisis of 1994. We were able to therefore construct highly detailed and accurate models of mountain gorilla demography during a time *before* the Rwandan crisis erupted, but we had a much greater degree of difficulty accurately simulating the long-term impact of such a threat on the future viability of the species. Despite some observational data on the negative impacts of the crisis, specific data available only through directed research on these particular issues were not available. A question similar to that posed for the tree kangaroo example discussed above seemed equally difficult to resolve. In this case, however, the apparent difficulties in fact created an interesting opportunity to use PVA as a tool for hypothesis-testing – to make *a posteriori* predictions about how a specific threat might impact wildlife populations, and to then analyse the appropriate threat scenarios as a means of prioritizing detailed plans for collecting threat data.

In both of these cases of risk analysis, detailed and accurate projections of the future performance of wildlife populations in the face of human-generated threats remain elusive. Nevertheless, meaningful and practical recommendations for population management are possible, but only if the PVA practitioner emphasizes the importance of relative predictions over absolute predictions throughout the analysis. Explanation of this often-subtle difference is crucial to effective use of PVA methodologies in a conservation planning workshop process such as the PHVA.

To many practitioners of PVA, the ideal situation presents itself when detailed data are available for both population demography and anthropogenic threats. In this case, detailed baseline models can be constructed using accurate field data; retrospective analyses can be developed to ensure model validity; sensitivity tests can identify remaining gaps in our knowledge of the species or its habitat (and human impacts therein); and highly detailed risk analyses can be designed to predict the response of a threatened population to one or more threats and, more importantly for management, one or more mitigation efforts. Sadly, this ideal is rather uncommon. A suitable example can be found in Miller (2006), which included the questions first described earlier in this document. While not as complete as those for the mountain gorilla, detailed field data on Greater Sage Grouse in Colorado were available, therefore making it possible to build detailed baseline scenarios and accurate population retrospective analyses to confirm the models' integrity. Once this was done, we were able to discuss newly-released field data on the observed impact of oil and natural gas development on nearby Sage Grouse populations. These data were used to construct detailed scenarios that predicted the longer-term impact of this activity on the viability of local Sage

Grouse populations. More importantly, this risk analysis stimulated the subsequent discussion of methods by which these impacts could be mitigated. This discussion then led to the construction of another whole suite of complex management scenarios that simulated specific alternative actions that the oil and natural gas community could initiate to minimize disturbance to birds while maintaining acceptable levels of natural gas production at each well pad. This type of detailed analysis, when participation from all interested parties can be secured, can be extremely important in setting specific management targets for successful population conservation.

But even in this so-called "ideal" situation, the PVA practitioner needs to remain mindful of the fact that no population data set is fully complete; as a result, we must also remember to avoid putting too much emphasis on the quantitative output from any one modelling scenario and to instead focus on the value of relative prediction in the practical application of PVA to wildlife conservation planning.

Conclusion

It's important to always remember the value of good planning in a PVA. Don't forget to establish the goals of an analysis. What are you and your colleagues trying to achieve? Are your datasets suitable for the goals you have identified? Are the scenarios you intend to create those that are most appropriate for answering the questions which form the basis of the analysis? And are you prepared to present the results of the analyses in the most effective way? Careful attention to these issues will help you create a truly valuable population viability analysis.

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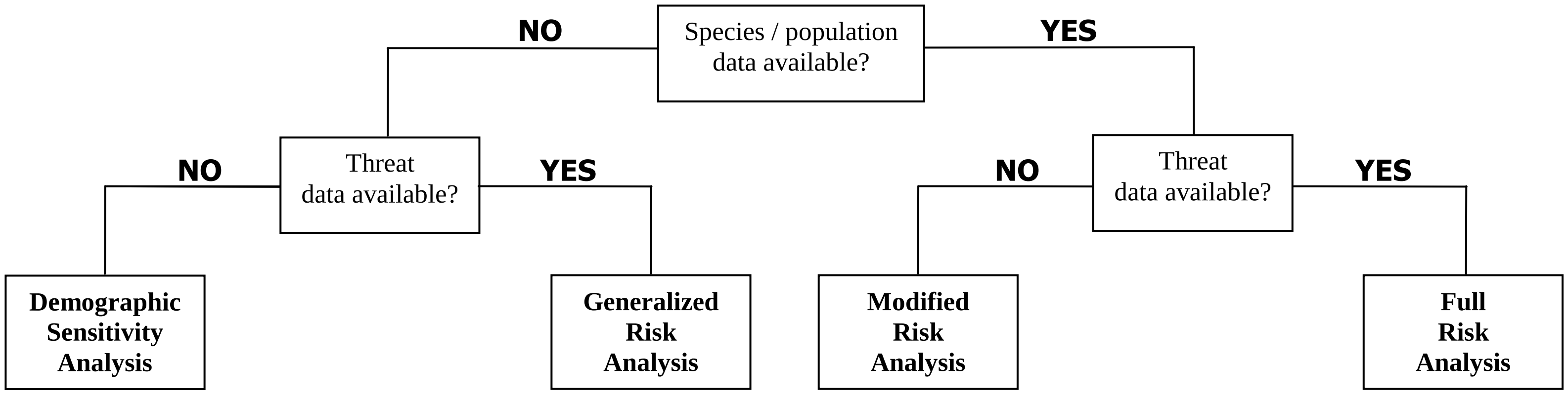

Characteristics: • Greater insight into species demography, population trends • Unable to realistically portray underlying causes of demography, population trends • Can identify only general population management, research priorities	**Characteristics:** • Unable to accurately predict quantitative impact of threat on underlying population demography • Can more accurately prioritize threat impacts, but cannot set specific management targets based on threat remediation (e.g., reduce hunting intensity from x% to y%)	**Characteristics:** • Can set management thresholds for threat impacts that improve viability, without specific data on the extent of the threat in the field • Valuable opportunity for hypothesis testing in threat assessment (i.e., prioritize data collection on threats)	**Characteristics:** • Opportunity to accurately predict quantitative impact of threat on underlying population demography • Can set specific management targets and / or thresholds based on threat remediation • Ideal analytical tool for management-based decision-making
Examples: • Whale sharks of Mexico • Guizhou Snub-nosed Monkey	**Examples:** • Tree kangaroos of Papua New Guinea • Malay tapir	**Examples:** • Mountain gorilla	**Examples:** • Greater Sage Grouse of Colorado
Appropriate scenarios: • Baseline model using best-guess parameters • General sensitivity testing with comparative analysis using arbitrary demographic data where necessary	**Appropriate scenarios:** • Baseline model using best-guess parameters, generating a reasonable population growth rate • Simple risk analysis focusing on relative changes in demographic performance in the face of alternative threats	**Appropriate scenarios:** • Baseline model using accurate parameters, generating a population growth rate that describes actual conditions • Exploratory risk analysis models with guesstimates of threat parameters	**Appropriate scenarios:** • Baseline model using accurate parameters, generating a population growth rate that describes actual conditions • Detailed suite of risk analysis models with direct numerical comparison of population response across different threats