

**A TRAINING REPORT
ON
MODULE 1: CONSERVATION BIOLOGY**

Unit 1.4: Threat to Biodiversity

**A SHORT COURSE
ON
POPULATION DYNAMICS OF HUNTED WILDLIFE
AND
SPECIES CONSERVATION & MANAGEMENT STRATEGIES IN PNG**

UNDER TAKEN IN COLLABORATION WITH



STRENGTHENING CONSERVATION CAPACITY PROJECT



WILDLIFE CONSERVATION SOCIETY-PNG



UNIVERSITY OF PAPUA NEW GUINEA

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The Strengthening Conservation Capacity Project (SCCP) and the Wildlife Conservation Society – PNG (WCS_PNG) would like to thank everyone who has made this training a success. The organizers of the course would also like to thank all the participants who have made every effort to attend the training program. Thanks to the WCS-Goroka for the use of their training facilities.

On behalf of the SCCP, WCS- PNG, the aspiring biologists or participants, we wish to thank the Darwin Initiative and the John D & Catherine T MacArthur Foundation for their funding in developing and running such trainings.

Above all we would like to thank Dr. Leo Salas who has been instrumental in developing and teaching the course(s).

All the participants who have attended the training course felt that they have learnt a lot over a space of four days and would like to sincerely thank Dr. Leo Salas for his contribution.

Dr. Salas contract has expired and is due to live the country for the United States before the end of this month. The participants who attend the first training on “Inventories and Collections of Biological Specimens and their Use in Conservation and Management” including this training have actually learned alot from him. It is hoped that the remaining units in the module that he helped put together will further enhance the biological diversity conservation incentives in PNG. He has sowed seeds in the hearts and minds of the like minded people, in due course of time he will see the fruits of his work. We wish him all the best of luck in his future endeavors.

Introduction

This course was jointly sponsored by the Strengthening Conservation Capacity Program (SCCP) and the Wildlife Conservation Society – PNG Program (WCS-PNG). It was conducted from the 7th August – 11th of August 2006 in Goroka using WCS facilities.

The Course covered the “unit 1.4: Threat to Biodiversity” for the “Module 1: Biodiversity Conservation” for the “Strengthening Conservation Capacity Project”.

There are many threats to biodiversity conservation in PNG. The threats includes; clearing of bush for gardening or domestic use, natural resources exploitation for commercial use, pollution, hunting, wildlife trade and etc.

Despite these threats to biodiversity conservation, the greatest of all threats is hunting. Hunting is ranked as the number 1 threat to biodiversity conservation due to 85% of the PNG population living in rural communities. Hunting is the only source of protein for those rural communities.

The modeling and methodologies used in the training is more focus on hunting of wildlife and population dynamics however, the conceptual or theoretical approach is applicable to any other sources of threats to biodiversity conservation population modeling and simulations.

After the training, it is envisage that the trainees would understand the dynamics of population in relation to threats from hunting. The trainees would in the end, make better biodiversity conservation management decisions based upon the knowledge and insights gained from such trainings.

Aim of the Course

Introduce basic concepts of population dynamics of wildlife, various models, and software used currently as tools for management strategies.

Course Instructors

The main instructor during the short course was Dr Leonardo Salas. He designed the course syllabus. Dr Andrew Mack also gave a lecture about hunting in Papua New Guinea using data collected from hunting surveys by his team members.

Presentations

The presentations were conduction through slide show on power point presentation, some of which were animated. *If you wish to view the slide shows, than ask the Project Coordinator of SCCP.*

Exercises

All students had access to either a laptop or desk top computers. All the modeling on population dynamics and computer simulation were done on the computers using the given matrix and environmental parameters. Students were also allowed to do a concept paper discussing the importance of what was taught and its applicability in the formulation of strategies for the conservation of biodiversity.

Course Participants

Invitation was sent out to NGOs and Government Department who have personnel dealing with issues relating to conservation legislation and enforcement, wildlife monitoring, and an active involvement with biological research.

Participants who attended were from the Binatang Research Center (BRC), WCS, and SCCP. See Appendix (1).

SCCP funded the trip to Goroka for Mr. Tom Pringle and Dr Leo Salas. The Darwin Initiative sponsored participants from BRC (Mr. Daren Bito and Ms. Leontine Baje). Meals were covered jointly by SCCP-UPNG and the WCS.

All participants who traveled from other parts of the country for the course resided in WCS accommodation within the Pacific Estate.

Syllabus

See Appendix (2)

DAY 1: Monday 7th August 2006

In the morning session of the course, Dr Leo Salas lectured about the basic concepts in population dynamics of wildlife. Population Dynamics as pointed out is the study of the process that cause populations to change within a certain time frame (change at a temporal scale).

In order for change to occur a number of variables (parameters) play a part. Four key features emphasized include reproduction, mortality, immigration and emigration. Fluctuations in the environment affect change of population within time. In short studying population dynamics mean studying the pattern of population (s) (N) given the known parameters.

In order to help understand population (s) patterns over time, mathematical models/or equation can be used. During the course examples used included *logistic, exponential model, Leslie Matrix, and Age /stage structured populations*.

After Lunch Break

In the afternoon the lecture led to more practical approach where models can be used in harvesting wildlife. In this part of the lecture, Dr Salas elaborated about *Maximum Sustainable Yield (MSY)* of wildlife and gave an example of the Barramundi (an article in Science in New Guinea). In MSY, knowing the inflection point ($k/2$) is important and since at this stage it is termed 'unstable equilibrium', monitoring is essential to ensure population recovers.

This lecture clarified some points that students did not understand about MSY and how critical hunting only a certain number was important in maintaining a healthy population or exacerbate population decline.

He pointed out the Tragedy of the Commons, and how a resource that is communally owned can lead to over use of it.

Following this lecture, Dr Andrew Mack gave a presentation on the hunting survey conducted by WCS over 3 years (2003-2005). The study revealed that some species that are endangered such as the echidna, tree kangaroos, and cuscus were being hunted in large numbers by people in very remote areas.

DAY 2: Tuesday 8th August 2006

The start of the lecture given was on reproductive potential and how knowledge of this could be harnessed into management policies or Fauna Act; an idea that came up included harvesting older animals where reproductive potential is declining or juveniles.

In many third world countries, the overexploitation of wildlife has resulted in a reduction in the numbers which could lead to be catastrophe. In this part of the lecture, Dr Salas presented a module on the Robinson and Redford Model (R & R model) for sustainable harvesting. In this model, depending on the longevity of the wildlife under study (three categories: animals living < 5 years =A is 0.6, 5-10 years =A is 0.4, > 10 years =A is 0.6) and knowing the parameters that affect the number of animals is important. Having figures at hand, enables one to calculate the number of animals ($P_{lim} = P_{max} * A$) that can be harvested sustainable and thus recover. This model gives a conservative figure that can be harvested (P_{lim}).

Like most models, this model operates on the assumption that the population studied is a *closed population* (i.e. no immigration and emigration). The R & R model was used at the Crater Mountain Wildlife Management Area (CMWMA) and it was found that animals were over harvested.

Following this, Dr Salas presented a lecture on WMA's and species conservation. He highlighted the importance of *Tambu grauns*¹ in relation to biodiversity conservation in Papua New Guinea; the importance of having a refugium² and how population behaviour if distribution is in a fragmented habitats (i.e metapopulations). He demonstrated the behaviour of populations (N) using Vortex simulations.

¹ No go zone or prohibited areas

² Refugia usually form centres for RELIC species populations or communities. Any area of pedologic, topographic or climatic uniqueness, into which organisms have migrated, either as a result of competition from more adaptable species, or through their ability to adapt to changing habitat conditions of surrounding areas.

After Lunch Break

Participants were allowed to use the afternoon to work on exercise based on lectures and the models introduced in lectures (see APPENDIX 3).

DAY 3: Wednesday 9th August 2006

The morning lecture was about better representation of data based on good sampling design and data collection. The lecture covered basic statistical principals of sampling, sampling methods, importance of sample size (N) which was followed using examples with quadrates size. The two common sampling strategies include quadrates and distance sampling.

Adequate sample size (increased N) leads to more confidence in data being analyzed i.e. close to representing what is out there in nature or sampling universe.

The exercise which followed this was using quadrates on excel file. Here participants were required to change number of samples (N), quadrate size, and the density of the sampling universe on excel which Dr Salas had designed. From the outcome of the results, participant were required to submit 1-2 page report about how sampling size, and quadrate size affect the data being collected i.e. whether it is a good representation of the sampling universe.



Dr. Leo Salas listens tentatively during a group discussion. Photo: Miriam Supuma

After Lunch Break

This content of the lecture was more difficult than the previous lectures. Here the focus was on distance sampling. Topics covered during lecture included basic principles of estimated transect width, maximum likelihood estimations and curve fitting, limits to distance, and assumption of 100 % detectability.

With estimation of transect width, the importance lies in having data at hand (data with a number of parameters relating to the wildlife species being studied); the more parameters that one has when entered into the distance software may mean, the better the fit of the estimates. However, there are trade offs therefore distance software incorporates *Akaike coefficient* which is a mathematical function that weighs the trade off between more parameters and goodness-of-fit.

It is important that one understands the software program well before one interprets the results being produced by the software. This takes practice.

Again, to demonstrate his points, Dr Salas used real data collected from Indonesia on Orangutan nest density and produced simulations using Distance software.



Dr. Leo Salas answering questions asked, by the trainees. Photo: T. Pringel

DAY 4: Thursday 10th August 2006

The day mostly included simulations of distance sampling which Dr Salas took us through.

Following that was a summary of the lectures over the past couple of days.

After Lunch Break

Participants continue working on their two reports (1) Analysis exercise and (2) Quadrature sampling exercise.

DAY 5: Thursday 11th August 2006

Review of the entering and retrieving data into an excel spread sheet file, converting an excel file into an Access spread sheet file and visa versa.

Participants hand in their work and those that flew in prepare to depart the next day.

DAY 5: Friday 12th August 2006

Participants started Departing



Title Picture of the Power Point Slid of the 2nd SCCP-UPNG & WCS Conservation Biological Training held in Goroka from the 7th-11th of August 2006. Photo: T.Pringel

Discussion³

The management plans for Hunted Wildlife Species in Papua New Guinea depends very much on demographic locations as well as culture or traditional values and beliefs. There are other common anomalies/variance that needs to be fully understood for the species management plans from a scientific point of view. This would include distribution and migratory patterns, sexual behaviours, breeding or mating seasons, mortality and birth rates, roosting and breeding habitat, and etc.

Moreover, the social, cultural and economical value of the species needs to be fully explored. A very good cultural, economical, ecological and biological baseline data of the species needs to be collected to substantiate the management plan as well as for the purpose of monitoring and evaluating the management plan for the species conservation plan(s). Without much of this, it would be unrealistic to draw up a management plan or seeing what is really being conserved, how much is conserved or how it's conserved.

As seen in the sort course on population dynamic of hunted wildlife and species conservation in PNG; the variance can be to some extent eliminated leaving with the most probable and possible scenario from which management plans can be made to take stoke for the conservation of specie(s).

In Papua New Guinea, hunting is the most common treat to specie(s). There is no way in which an outsider would stop the local resources owners from hunting which is part of their life style. Despite the fact, there are management alternatives available to ensure hunting rates are sustained in any village in PNG. Here in the brief discussion, the most possible management alternatives are explored and discussed. It should be noted that most of the possibilities are based on the postulation of the PNG society. How realistically, the options are/is subjected to questioning depending on the parameters the assumption is based on.

Ensuring Sustainable Rate for Hunting in PNG

Without fully exploring the parameters for the baseline data for the management plan, there are several management plans that can be executed at a national and community level to sustain hunting rates in PNG.

Reviewing and Amending the Fauna (Protection & Control Act) 1966

Baseline Data & Management Plans

The Fauna (Protection & Control Act) could be amended so that the biological and ecological aspect or parameters are covered in the act to ensure that the management plans for a WMA is inline with the ecological and biological parameters for the area. Before an area can be declared as a WMA, a conservation area or any other types of Protected Area, some or if not all of the parameters identified in the introduction should be included in the matrix for the site data sheet. Along with the site data sheet, a management plan should be requested. The management plan should cover for the allowable sustainable harvest, when, where, how much, and how to hunt. There should be a clause put in the Act (s) stipulating biological monitoring mechanisms and tools. Furthermore, a time frame for review of the plans should be included so that the authorities would assess whether or not the Protected Area mechanisms are reaching the targeted objectives.

³ Please note that the discussion in this section is the view of the Report Writer(s) of the training report. The rest of the participants would obviously conclude that scientific instruments should be inserted into the PA Acts or legislations as seen in this training to substantiate and enhance conservation capacity in PNG.

The roles and responsibilities of Agents and Rangers should explicitly cover as much as possible the social, economical, cultural, ecological and biological aspects of the Protected Area. This should include consistency in the data collection of all parameters using standard procedures including any other information that can be used to make informative management decisions to better improve the management of the PA or assess whether or not the goals and objectives of the PA has been.

Delegation of Enforcement Powers for WMA or Protected Area

The WMA should allow for police and other law enforcement bodies to intervene if the WMA committee who's vested with the mandate does not perform. In order for this to happen a clause in the Fauna (Protection & Control) Act 1966 need to be inserted, specifying that when all stakeholders sign and agree to have a area declared as a WMA, they will be subjected to prosecuted in a criminal court of law in the event that the WMA committees are unable to perform. *(If this would be deterrence for the landowners than it should be so in the first place than to cover up and go through hell later when it not the objective/interest of the local landowners in declare an area and yet rules will not be enforceable. That would also include the WMA advertising in the National News Papers the purpose of the WMA's intents so that anyone who has an objection can object to the proposal.)*

No go zone for major developers

Apart from the sustainable hunting discussion, the Fauna Act 1966 should have a clause that would allow for consultation at national and provincial level with the NGOs at National and community level with the WMA committee on any major developments that is to take place specifically with the extraction of natural resources in a declared Protected Area. Without, proper protocol of entry to PA, a developer should be liable for prosecution.

Providing Alternative Protein Sources

Most rural Papua New Guineans diets consists mostly of starch (90%) and 10 % protein. Most of the protein is supplemented through hunting while domestication and production of other sources of protein comprises of less than 10% of the total protein consumed each year. In comparison, the amount of starch consumed each year maybe more the amount of protein. However, hunting forms a major component of the protein supplement consumption by an individual on an annual base. Collectively, there is a high turnover of wildlife being hunted annual to supplement the diet of the rural and mostly isolated communities in PNG. Furthermore, the protein content by weight and size would vary therefore the number hunted could be far more than may be postulated on speciation.

Other sources and ways to supplement protein in the rural community(s) diets; is to explore other ways and means of substituting wildlife protein with locally produced proteins. That would include providing trainings in animal husbandry such as chicken/poultry farming, fish farming, duck farming, rabbit farming, piggery and any other viable form of activities that would allow for the substitution of domesticated animal protein as against wildlife protein. In collaboration with the Provincial Government, the department of agriculture and life stoke and other stakeholders this could be addressed.

The rural communities' attention can be diverted from hunting if social and economical incentives/activities can be provided and promoted. That includes vanilla production, coffee production, spice production, bee farming, mushroom farming, Okare nut production and etc. This might prove to be a hand full but proper markets should be identified and ways to transport them to the markets. This could be a collaborative effort between the community, NGO(s) and the government entities.

Biological survey & Baseline Data a Must in any Protected Area Act

A biological survey and other baseline data should be collected by specialists/biologist before any kind of management plans could be drafted. Without these, one would assume that we are protecting or conserving an area but what if one asks WHAT IS ACTUALLY BEING CONSERVED OR PROTECTED IN THAT PROTECTED AREA, WHILE EXTENSIVE CLEARING AND HUNTING IS TAKING PLACE IN A DECLARED PA⁴? How would one answer that, certainly this would bring a conservationist back to the drawing board to try and define or draw a fine line between conservation on what is being conserved, how its conserved, how much is conserved and etc; substantiated answers with facts and figures. Without facts and figures, who care on what one say's.

Therefore, if hunting or clearing is a treat to the PNG wildlife than lets face it. We need scientific baseline data as well as resources use maps to better understand the scenario in order to plan and manage the Protected Area. Again only a clause in an act of parliament would allow for that to happen as a mandatory requirement before any area can be declared as a wildlife management area.

Creating Refugia in a WMA or Conservation Area

The onus of having refugia in a meta-population within a WMA & Conservation Area should not be an option for the local landowners but a must for every WMA or Conservation Areas. The current legislations on WMA & Conservation Area's Act do not clearly outline for refugia or it is not a mandatory requirement to have refugia in WMAs or CAs.

As we have seen in our short course, a meta-population without refugia is more likely to crash thus extinction of species. It is therefore important that a clause is inserted in the existing legislation to allow for every WMA or Conservation Areas to have at least a number of refugia in hotspots within the PA as seen fit by the local landowners as well as on ecological and biological surveys or data. It should be a mandatory requirement that in every proposed Protected Area plan, specific locations should be identified and designated as refugia. Heavy penalties should be included in the clause for the violation of entering and hunting in refugia. Again the enforcement powers should also be decentralized to other component of the community as well.

Public Awareness

Public Awareness should be done continuously, highlighting the importance of conservation. This should be substantiated with facts, figures, pictures and dramas to empower the knowledge of the local community on the states (endemism/endemics) of the species.

On way to do that is through educational institutions, church groups, woman or youth groups, aid posts or clinics and etc. These are strategic point of information disseminations.

"For example: Posters Such as "Numba belong Kumul I go dawn pinis. I Tambu long Kilim Kumul. Sapos yu kilim Kumul ol tumbuna blong yu bai nonap lukim dispela kumul moa bekos yu kilim laspela kumul" Have a picture also of the species on the poster".

It would also be good to erect sign post along hunting tracks in habitats where endangered species are. Sure hunters would be wary of the message that is being put across.

⁴ *Strong pela quston tasol mepela noken watim time, giamen nating na wokim planti maus wara.*

DEC to Keeping Data Base on Distribution and Status of Endangered Species in PNG

The DEC or Conservation NGOs could make data sheets available for local community in PAs or other areas of ecological or biological importance to collect basic data that would allow for informative decision and policy making.

Again the data sheets should be distributed to teachers in schools, church workers, youth leaders, nurses and aid post orderlies in clinics, village councillors and magistrate or any educated person in the villages etc to collect data on weekly bases. The authorities could collect the data from the groups and individuals on quarterly or annually bases, and data entered into the data base. The trends in the distribution and status should be monitored.

For example, a data sheet is left with a community school. The children in each class would be required to bring bones or samples of hunt, type of species, where it was hunted, method of hunting, location, number of people who ate the wildlife and etc. Collectively and over a period of time, the trends in hunting can be established and addressed adequately.

The DEC actually involving the local community in data collection would also help the local community to take stoke of their own action and the consequences or impact it has in sustaining the wildlife population.

Captive Breeding Programs

The local community should also be given the task to do captive breeding program with some sort of training in captive breeding. Better still, network and collaborate with established organizations that have the skills and resources to do captive breeding program to undertake breeding programs.

Participatory Management Planning

All the stakeholders at all level of the community should be involved in the discussion and planning process so that they would feel part of and take charge of any conservation program. That would include planning on minimizing hunting of endangered species.

Above all, no hunters can be banned from hunting, however hunting can be regulated through legal mechanisms, proper data collection and planning, public awareness and consistency in monitoring and enforcement mechanisms.

Some of the management alternatives highlighted here also have some implications in terms of willingness, financial constraints, human resources, infrastructures and etc. Despite those assumed implications, it is the purgatives of conservationists to explore the alternatives before the assumption can be verified. A lot of time people simply take a negative approach to issues when all seem too complicated but yet there are many better and simple ways around it.

Closing Remarks

All in all, the short training course was a success. It was made clear from the beginning of the course by Dr. Leo Salas that in reality, *Population Dynamics* is an aspect of biology that involves more mathematical calculations and modeling. Usually it takes weeks to teach the course which was however, simplified and taught within a week. The course was to introduce participants to the basics and to give an insight into the subject. Most of what was taught was kept as simple as possible.

Invitations were sent to the Department of Environment and Conservation (DEC) as well as other NGOs and line agencies. However, not many organizations were able to send their participants except 3 organizations (See Appendix 1: List of Participants).

Part of this course involve how models can be used to predict populations of wildlife which in turn would equip policy makers with tools to make better decisions regarding wildlife management. Perhaps, even to revise the Fauna Act and make some amendments. Thus, it would have been great to have participants from various organizations such as the biological scientific community involved in the policy, planning, management and decision making process.

APPENDIX 1: List of Participants

No.	First Name	Surname	Institution		Contact Details	Comments
1	Leontine	BAJE	BRC	Student	853 3258	participant
2	Darren	BITO	BRC	Staff Biologist	853 3258	participant
3	Mellie	SAMSON JR	WCS	Student	732 3836	participant
4	Michael	KIGL	WCS	Staff	732 3836	participant
5	Eunice	DUS	WCS	Student	732 3836	participant
6	Leo	LEGRA	WCS	Staff	732 3836	participant
7	Enock	KALEDIMIMO	WCS	Student	732 3836	participant
8	Miriam	SUPUMA	WCS	Staff	732 3836	participant
9	Kenneth	YHUANJE	WCS	Student	732 3836	participant
10	Junior	NOVERA	WCS	Student	732 3836	participant
11	Kore	TAU	WCS	Student	732 3836	participant
12	Susan	TOMDA	WCS	Student	732 3836	participant
13	Tom	PRINGLE	SCCP/UPNG	SCCP Co-ordinator	326 7225	Sit-in
14	Dr Debra	WRIGHT	WCS	WCS Co-Director	732 3836	Sit-in
15	Dr Andrew	MACK	WCS	WCS Co-Director	732 3836	Instructor/sit-in
16	Dr Leo	SALAS	WCS/CI	Conservation Biologist	732 3836	Instructor

APPENDIX 2: SYLLABLE----Course Outline

Title: **Population dynamics of hunted wildlife and species conservation in PNG**

1. The basic principles of population growth (3 hrs)
 - 1.1. Exponential growth and natural limits
 - 1.2. Logistic growth
 - 1.3. Leslie matrix
 - 1.4. Demographic stochasticity and relevant parameters
 - 1.5. Exercise: Vortex simulation

2. Hunting wildlife (3 hrs)
 - 2.1. Overview of hunting impact on PNG wildlife
 - 2.2. Maximum sustained yield
 - 2.3. Reproductive potential and hunting/fishing laws
 - 2.4. Sustainable hunting: Robinson & Redford's model
 - 2.5. Refugia and other spatial factors
 - 2.6. The "tragedy of the commons"
 - 2.7. Exercise: Vortex simulation

3. WMAs⁵ and species conservation (3 hrs)
 - 3.1. WMAs and species conservation
 - 3.2. The size and importance of tumbuna grounds
 - 3.3. Meta-populations
 - 3.4. Other alternatives to species conservation in PNG
 - 3.5. Exercise: Vortex simulation

4. Estimating density/abundance through samples (3 hrs)
 - 4.1. Basic statistical principles of sampling: the three R's of Leslie Kish
 - 4.2. Methods – a quick overview
 - 4.3. The importance of sample size (shown with simulation)
 - 4.4. Exercise: quadrat sampling

5. Distance sampling (3 hrs)
 - 5.1. Understanding the principle of ETW
 - 5.2. Understanding the principles of MLEs and curve fitting
 - 5.3. Limits to Distance and the assumption of 100% detectability
 - 5.4. Exercise: estimating Orangutan nest densities

In addition

- Repeat of database design course with in-depth explanation of table linking and query building (3 hrs)
- Exercise on database building (Leo provides the data and you design and build your own db) (2 hrs)

⁵ Wildlife Management Areas

APPENDIX 3: Analysis Exercise

A SHORT COURSE ON: POPULATION DYNAMICS OF HUNTED WILDLIFE AND SPECIES CONSERVATION IN PNG

The University of Papua New Guinea & The Wildlife Conservation Society
Strengthening Conservation Capacity Program
August 7 – 11, 2006

Analysis paper

In this workshop you have learned the basic principles of population dynamics: exponential growth, logistic growth, natural limits to growth and carrying capacity, age/stage structured populations and Leslie matrices, survivorship schedules and reproductive potential, and demographic stochasticity.

In this course you have also learned about Maximum Sustained Yield, its use and problems associated with it. You have also learned about the Robinson and Redford limit for sustainable hunting, and spatial factors that may affect this limit.

In this workshop we also learned about the possible magnitude of wildlife take by subsistence hunters in PNG, the widespread nature of the problem and how the most sensitive species to extinction (the larger ones) represented the majority of the take (in grams of weight). We discussed the potential role of refugia and meta-populations in conserving hunted wildlife.

Last, we also discussed the main species conservation law of PNG, to show that:

- I. it states all kinds of kills of endangered species are illegal
- II. enforcing this is perhaps impossible
- III. there is no provision for the conservation of the habitats and resources used by the endangered species
- IV. management plans are to be drafted by resource-owners (the same people that created the problem) and enforced by resource owners
- V. there is no provision for monitoring the populations of endangered species
- VI. there is no provision for stating and ensuring a desirable length for population survival of endangered species
- VII. there are no provisions for management planning to include potential effects of catastrophes

Given what you have learned, please write a brief report with recommendations for the design and management of protected areas for the

conservation of endangered species of PNG. Please make sure to address the following:

- what management alternatives may be useful for ensuring that hunting rates are sustainable in any village of PNG?
- how realistically enforceable are these alternatives, given the fact that resource owners are responsible for enforcing them
- which of the above problems would be solved with your management options (be specific to explain how your options address each of these problems)

BONUS: You know that on average a rural inhabitant of PNG consumes 23 grams of animal protein per day; there are 365 days in a year, roughly indicating that this person eats 7.5 Kg of bush meat a year. Assuming that tree kangaroos represent 20% of that intake, and that this person belongs to a village with 500 people, this means 750 Kg of kangaroo meat/year consumed in the village. Because kangaroos weigh about 5 Kg, this represents a take of 150 animals. If kangaroos use a home range of 40 hectares, what size of population of tree kangaroos (in numbers of animals and area) should the villagers have to ensure this take is barely sustainable? What size of a population they should have to ensure they hunt under the R&R limit? Show your calculations....