Population and Habitat Viability Assessment for Endemic Tortoise Species in Madagascar

Radiated Tortoise (*Geochelone radiata*)
Spider Tortoise (*Pyxis arachnoides*)

Final Report

Ifaty, Madagascar
25-28 August 2005

MINENVEF

CONSERVATION BREEDING SPECIALIST GROUP

WILDLIFE CONSERVATION SOCIETY

SeaWorld ADVENTURE PARK

CONSERVATION INTERNATIONAL

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

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Additional copies of *Population and Habitat Viability Assessment Workshop for Endemic Tortoise Species in Madagascar* Geochelone radiata *(Madagascar radiated tortoise)* Pyxis arachnoides *(spider tortoise)* can be ordered through the IUCN/SSC Conservation Breeding Specialist Group, 12101 Johnny Cake Ridge Road, Apple Valley, MN 55124, USA www.cbsg.org.

Population and Habitat Viability Assessment Workshop for Endemic Tortoise Species in Madagascar

Geochelone radiata (*Madagascar radiated tortoise*)
Pyxis arachnoides (*spider tortoise*)

Ifaty, Madagascar
August 25-28, 2005

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PHVA Workshop on Endemic Tortoise Species in Madagascar
Geochelone radiata (*Madagascar radiated tortoise*)
Pyxis arachnoides (*spider tortoise*)

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Section I
Executive Summary

PHVA Workshop on Endemic Tortoise Species in Madagascar

Executive Summary

Introduction

A Population and Habitat Viability Assessment (PHVA) workshop was conducted for two Madagascar tortoise species in Ifaty, Madagascar on 25-28 August 2005. These endemic tortoise species, *Geochelone radiata* and *Pyxis arachnoides*, are found within the dry, spiny forest of southern Madagascar. Tortoise populations have decreased drastically in the wild during the past two decades because of habitat loss and unsustainable illegal harvesting.

Both species are protected by Malagasy law, are listed as vulnerable by the IUCN and are included in the list of CITES Appendix I (not allowed in the wildlife trade). However, law enforcement at every level often fails, due in large part to poverty-induced corruption, and illegal trade. Illegal harvesting is not conducted by the local communities (the Antandroy and Mahafaly tribes) for whom even touching the tortoise is taboo.

The impetus for this workshop was the recognition that the ecological damage caused by the illegal harvesting of tortoises and unsustainable land use could be controlled if the local people were given the chance to understand and to manage their renewable resources in an appropriate way. Therefore, the natural tortoise population should recover by empowering local communities to look after their natural heritage. The PHVA workshop is aimed at promoting the community-based management of natural resources and supporting the already existing taboo to prevent intruders from attempting to collect tortoises.

The PHVA was organized and hosted by Wildlife Conservation Society – Madagascar and generously funded by SeaWorld, Inc. and Conservation International – Madagascar. The workshop involved a wide variety of stakeholders, including local community members, legislators, decision-makers, academic biologists, wildlife managers and other interested parties. The goals of the workshop were to assist local people, biologists, managers and policy makers to: 1) collaboratively formulate priorities for a practical management program for survival and recovery of the tortoises; 2) develop a risk analysis and population simulation model for each of the tortoise species that can be used to guide and evaluate management and research activities; 3) identify specific actions that will mitigate threats; 4) identify needed conservation research projects; and 5) identify and recruit potential collaborators, if needed, from the greater international community.

To ensure full participation by the local community representatives, pre-meetings were held in three rural communes throughout the range of the tortoise. WCS organized, with help from legal authorities, one pre-workshop session each for the major tribes (Antandroy, Mahafaly and Antanosy) directly involved in the tortoise crisis. In total, 80 participants representing 27 rural communes were brought together. For the Antandroy tribe, the session was held in Tsihombe and lasted for three days. For the Mahafaly tribe, Itampolo was chosen as a venue where 8 rural communes worked with 24 conveners. Those that consume tortoises were represented by the Antanosy tribe. Six rural communes from the consumers' region sent 18 participants to discuss, in a special meeting held in Fotadrevo, the issue of tortoise conservation and their local beliefs. Even though the purpose of having pre-meetings was simply to gather information and identify representatives from local communities, there were noteworthy recommendations adopted durning each session (Appendix 1).

The Workshop Process

The PHVA workshop began on the evening of 25 August 2005. Thirty nine participants, including local community representatives, local and provincial government and law enforcement officials, wildlife managers, biologists, field researchers and NGO representatives, gathered for an opening ceremony and reception. The following morning the work began in earnest. Each participant was asked to share with the group their personal goals for the workshop. These goals are listed in Section V of this report. Next, presentations were given to ensure that everyone was familiar with the process and the available scientific information. CBSG introduced the PHVA process and the role of population modeling in the workshop and Thomas Leuteritz gave a report on his published tortoise survey results. Following this, each local community was invited to make a presentation on the status of tortoises in their area, and the law enforcement officials followed with a description of the difficulties they face and the effectiveness of their efforts.

The first task for the stakeholder groups was designed to identify the issues and needs related to the long-term survival of tortoises in Madagascar. Participants were divided into four groups (Local Community Representatives; Park Managers/Wildlife Managers and Government Representatives; Biological Scientists/Researchers; Conservationists/NGOs) and were asked to answer the following two questions:

1. In your group's view, what are the central issues/problems related to recovery of the tortoise populations?
2. What are your needs in relation to solutions to these central issues/problems?

The issues identified in this first task were then grouped together into themes by participants and made into topics for further working group discussions. The list of needs served as criteria for shaping, prioritizing, and selecting among suggested solutions. Each working group prepared a presentation, which was later shared with the entire group. This process of working group sessions, followed by plenary reports and discussion, continued throughout the workshop.

For the remainder of the workshop, participants were divided into issue-based working groups. Each stakeholder group was asked to determine which members of their group should be in each of the four issue-based working groups (harvesting of tortoises and the lack of respect for local customs; habitat destruction and laws; public awareness and collaboration with stakeholders; and lack of capacity and support to act locally for conservation).

Issue-based working groups amplified the issues that were identified and prioritized by the stakeholder groups, and then groups began brainstorming potential recommendations to address these concerns. In addition, as recommendations were formed, the groups were asked to identify those recommendations with the potential to impact any of the population model input parameters such as mortality rate, infant survival rate, and harvest rate. Once the impact of each recommendation was quantified, the information was conveyed to the population modeling group. The modeling group then used this information to develop alternative management scenarios for each tortoise species. Later in the workshop the results from the population modeling group were used to modify the recommendations.

The working groups were next asked to cross check their recommendations with the needs statements each stakeholder group had made on day 1 of the workshop, and to identify which needs their recommendations did not address. This allowed the groups to revise or add to their recommendations in order to fill any significant needs gaps.

Finally, after recommendation presentations were shared with the entire group, lengthy and animated discussions were conducted. The groups resumed work to respond to the concerns heard in plenary session and began developing action plans for implementation of their priority recommendations. Instructions were given for the development of concrete action steps using the SMART criteria. Action steps can be long or short-term, and are small steps that help to implement stated recommendations. Each action was to be made 'SMART': Specific, Measurable, Attainable, Relevant and Timely and include: 1) a timeline (when the action will begin and when it will be completed); 2) responsible party; and 3) resource needs.

Outcomes

For both tortoise species, population models based on the best available data project substantial tortoise population decline in the face of illegal harvesting. All scenarios tested based on current estimated harvest rates project that the radiated tortoise population will continue to decline to extinction, likely within 50 years. Likewise, two of the three spider tortoise populations are projected to disappear in 60-80 years at current estimated harvest rates. If spider tortoise harvesting increases as large radiated tortoises become rarer, population decline could accelerate toward earlier extinction. Although better data on tortoise biology, population size and harvest rates would allow refinement of these projections, they are unlikely to reveal that these populations are viable unless harvesting is greatly reduced.

Tortoise population decline is being driven by over-harvesting, which currently overshadows the effects of habitat loss and fragmentation. Harvest rates for radiated tortoises may need to be reduced by 85% or more to halt this population decline. With the current population and harvest estimates, this translates to a loss of no more than about 9,000 radiated tortoises and 3,000 spider tortoises per year. Conservation actions that serve to significantly reduce the number of tortoises harvested will be necessary to ensure the persistence of viable tortoise populations into the future. Habitat conversion, fragmentation and other threats to the tortoise population should also be addressed, as they also affect population viability, especially if harvesting is not completely eliminated. It is likely that no single conservation action will sufficiently protect tortoises; therefore, multiple effective conservation efforts will be needed to ensure the long-term persistence of this species.

Each working group identified a set of recommendations to address the key issues facing the tortoise populations. All recommendations were listed on flip charts and posted on a large board at the front of the meeting room. A prioritization exercise was then conducted. Each participant was given 5 sticky dots and asked to place a dot on the recommendation they feel most needs to be addressed in order to protect the future of the radiated and spider tortoises in Madagascar. The sticky dots were counted and those recommendations with the greatest number of dots were considered the top priority outcomes of the workshop. This was a very powerful exercise and the voice of the workshop was clearly heard in its prioritization of the role of local community in law enforcement. The top ranking recommendations are listed below in order of priority:

POVERTY

No specific recommendation was made with regard to poverty. It was decided in plenary session that this will be addressed through capacity building for local communities and raising awareness for the general population, also by putting into place micro-credits in rural areas, which are already part of some recommendations.

On domesticated tortoises

Domesticated tortoises are to be returned to the wild:

1. Conduct a census of the domesticated tortoise population;
2. Set a timeline for the returning process;
3. Proceed with the returning of tortoises; persons that do not comply will be subject to law enforcement

   NB: Each step in the procedure should be carefully followed and collaboration among stakeholders is highly recommended.
   As a reminder, according to prevailing regulations, no authorization whatsoever can ever be issued for protected species.

On harvested tortoises

1. Tortoises that are found in the national territory are to be returned to their original areas (Androy, Mahafaly and Tagnalagna), and the *Dina* (locally developed pact) and laws will be imposed on all those involved in tortoise displacement, including those laws and *Dina* applicable in the tortoises region of origin. After tortoises are returned, a scientific monitoring should be conducted under the oversight of qualified entities.
2. Authorities in the original areas, i.e. Androy, Mahafaly and Tagnalagna, are responsible for assigning a place to host these tortoises. The tortoises are to undergo scientific treatment and the report should note the place of return. Places of return are to be alternately designated, so that tortoises are returned in equal numbers to the western region (Mahafaly) and eastern region (Androy). Quarantine should also be conducted in these regions.

HARVESTING

Develop a pact, enforced by all Malagasy, to protect these species against harm, killing, consumption, trade, and export.

INADEQUATE PARTICIPATION OF STAKEHOLDERS

1. Put in place a stakeholder's charter of liabilities (joint steering committee);

2. Establish the Tortoise Foundation;
3. Ensure the financial sustainability of the joint steering committee;
4. Procure equipment: communications equipment (SSB) for communes, allotment of single frequency radios, motorcycles, cars, bonus for agents and informers, fuel

Pact

Development of pacts addressing the conservation of tortoises after approval by the relevant Court (interregional).

Obsolete laws
Update all the laws proven to be obsolete, especially those under Order 60-126 dated 10/03/60.

HUMAN IMPACT:
Put in place a development plan at the level of concerned Communes (to be included in the Communal Development Plan)

Capacity building for the communes
Financial and technical support from relevant institutions
Promotion of income-generating activities
Forest and pastoral management by migrants and stock breeders
Introduction of fodder crops
Promotion of rural micro-credits

RAISING PUBLIC AWARENESS:
Encourage denunciation through a system of rewards.
Informers shall not be involved in the investigations and information provided shall be kept confidential.
Rewards to be defined during the development process of the pacts.
Teachers at primary schools, high schools, and universities, and village elders will be provided some prior training in order to spread awareness of the tortoise crisis.
Conservation education should start at the primary school level.

Three types of training should be designed:

- In school delivery (formal education with the ministry of education),
- Out of school delivery (non-formal education with the ministry of population),
- Media outreach (informal education with the ministry of communication)

Training content:

- Endemic specificity
- Accountability in protection efforts
- Increasing communes' budgets with tourism-generated income
- Informing the people of new laws
- Encouraging stakeholders in community-based participation
- Creation of associations focused on protection of tortoises in their areas (youth, artists, etc.)
- Use of visual messages for illiterate people

Complete reports from each working group, including all recommendations and actions, can be found in Section III of this document.

The PHVA workshop was a valuable tool for local communities and managers in Madagascar, setting directions and priorities for management, and serving as a model for other threatened species living in this unique ecosystem.

PHVA Workshop on Endemic Tortoise Species in Madagascar

Geochelone radiata (*radiated tortoise of Madagascar*)
Pyxis arachnoides (*spider tortoise*)

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Section II
Identification of problems and needs

Group: GOVERNMENT

PROBLEMS

1. Lack of awareness on the part of local authorities as to their role and authority regarding natural resources management and conservation
2. Unclear understanding on the part of the local population of the ecological importance of tortoises
3. Lack of knowledge surrounding the benefits of protecting the species; insufficient information and education
4. Differing levels of knowledge among the institutions that are to make decisions on conservation, i.e. they are unaware of the current situation
5. Not being aware of the laws; laws are also outdated, and no longer effective
6. Poverty leading to the exploitation of the species
7. Poor means of prevention
8. Inadequate civic education and pubic awareness
9. Inadequate control and awareness on the part of local communities
10. Not being aware of prevailing laws in place for the conservation of tortoises
11. Being unaware of the linkages between protecting these two species and local development
12. Law enforcement is not uniform throughout the country
13. Lack of accountability from the relevant authorities
14. All stakeholders do not have the same level of knowledge, or have their own interpretation of regulations
15. Inadequate collaboration between stakeholders
16. Pervading illiteracy
17. Lack of understanding leading to lack of interest
18. Lack of motivation on the part of those knowing how and those willing to protect
19. No tangible impact regarding certain decisions made
20. No support for stakeholders in the field (forestry agents, local population, GN)
21. Disregard for the law
22. Alienation from ancestral taboos and traditions leading to loss in the value of tortoises.
23. Traffickers never get caught, either at national or international level
24. People keeping tortoises at home as pets are not made aware of the negative ecological impact that they are having. Their exact number throughout the country should be known.
25. An international regulatory framework does not exist that would allow for the enforcement of laws beyond borders.

PRIORITIZATION OF PROBLEMS

1. Inadequate collaboration among stakeholders
2. Loss of cultural identity
3. Local communities are not made aware of the problem
4. Mass ignorance of prevailing laws

UNDERLYING CAUSES OF PROBLEMS

1. Inadequate collaboration between stakeholders:
   CORRUPTION: wanting to become rich
   NEGLIGENCE: lack of motivation
   INCOMPETENCE: nepotism + favoritism
   TRADING FAVORS: misuse of power
   FAILURE TO COMMUNICATE: withholding information

2. Poverty:
   - 85% of the population live with less than 1$ a day

3. Local communities are not made aware of the problem:
   Resources available to entities are very inadequate

4. The population is unaware of prevailing laws:
   Laws are not publicized enough.

IMPACT ON TORTOISES

1. Decrease of the tortoise population in its natural habitat
2. Illegal trade and consumption
3. Increase in the trade of tortoises
4. Systematic killing of the tortoises

NEEDS

1. Development of a charter of liabilities:
   - This charter does not currently exist
   - Is needed for good governance

2. Political support for changing the current mindset:
   - For a better understanding of the Mahafaly and Tandroy culture

3. Human and technical resources
   - Increasing formal, informal and non-formal education
   - Securing changes in the current behaviors towards tortoises

4. Large scale campaign to make people aware of the laws already in place:
   - Only a minority of people are aware of the current laws

Group: LOCAL COMMUNITIES

PROBLEMS

1. Destruction of the tortoise's natural habitat (charcoal production, clearing land, house construction, etc.)
2. Lack of responsibility and accountability on the part of local authorities who are supposed to enforce the laws and monitor enforcement for the conservation of the species
3. Lack of respect for local and traditional practices
4. Frequent droughts
5. Hunting of tortoises (for consumption, trade)
6. Farmers who consider tortoises as taboo kill them because they destroy their crops
7. Lack of resources for the relevant authorities
8. Conniving with *ny ziva*, authorities, next of kin.
9. People in the community are not educated to be accountable
10. Not being aware of the benefits derived from tortoise conservation
11. Outdated laws
12. The authorities and experts try to find ways to remove the tortoises from their original areas and shift them to other places.
13. Displacement of seized tortoises
14. Granting of hunting and export permits
15. Differing vision between the authorities and communities
16. Some local communities tend to scorn traditional practices (use of *fandrara faly* or holy water)

PRORITIZATION OF PROBLEMS

1. Hunting of tortoises (5)
2. Destruction of the tortoises' natural habitat (1)
   Lack of respect for local traditions (3)
3. Granting of hunting and export permits (14)
4. Lack of responsibility and accountability on the part of local authorities (2)
   The authorities and experts try to find ways to remove tortoises form their original habitat (12)
   Lack of resources for the relevant authorities (7)
5. People in the community are not educated to be accountable (9)
   Frequent droughts (4)

UNDERLYING CAUSES OF PROBLEMS

Hunting

Reasons:
To be eaten, to be sold, for research, to be used in handicraft to attract tourists, illegal trade
-consumption (20%):

-trade (55%)
-research (15%)
-handicraft (5%)
-as a tourist attraction (5%)
-random hunt,
-illegal trade

Destruction of tortoises' natural habitat (10%)

Reasons:
1. Farming: slash and burn techniques resulting in habitat destruction
2. "Fahi-tonda", a human made hollow around cultivated areas: affects all tortoises
3. Housing construction: affects all tortoises
4. Production of charcoal: affects all tortoises
5. Woodwork, bullock cart making
6. Creation of villages which clears a large space
7. Drought: affects all tortoises

Lack of respect for local and traditional practices

Reasons:
1. Close relationship with and/or fear of the authorities
2. Differing religious beliefs and foreign influences (copying foreign practices)
3. Absence of authority to prohibit consumption and harvesting (lack of awareness and information, accountability, etc.)
4. Lack of accountability on the part of local people for whom tortoises are taboo (tortoises destroy crops)
5. Non observance of taboo by killing the tortoises
    - Lax discipline in the society
    - Disrespect towards Antandroy, Mahafaly, and Tagnalagna customs

NEEDS

1. To change the outdated laws and increase the enforcement of existing laws. Changing the laws will improve tortoise conservation.
2. To develop regional and interregional pacts to establish discipline within the society, restore the value of tortoise conservation, and re-establish the local values and traditions.
3. To return tortoises to their original habitats to improve their health, living, and survival condition; to encourage people to commit themselves to protecting tortoises.
4. To create a "Tortoise Village" (in the Androy and Mahafaly regions; other areas where tortoises are not currently found will not be considered) to foster regional development, attract tourists, and be a place to host confiscated tortoises.
5. To give full powers to OPCI Communes and provide them with the equipment (SSB, motorcycles, launch vessels, computers, audiovisual equipment, generators or solar panels,

documentation, etc.) needed to facilitate collaboration and communication in tortoise conservation, provide the people and authorities with incentives to conserve tortoises, and improve their knowledge enabling them to more easily catch illegal traffickers and hunters.
6. Reforestation: restoration of tortoises' natural habitat, improvement of overall environment (rain…)

Group: NGOs AND CONSERVATION SPECIALISTS IN IFATY

PROBLEMS
1. Deteriorating environment
2. Biology
3. Human impact
4. Weakness of the legal system

Deteriorating environment
- Natural disasters
- Predators
  - Snake: *renimbitika*, wild cat, boar
- Mother nature
  - Drought, flooding, quicksand
- Man's actions/intervention
  - Clearing
  - Bush fire
  - Cattle wandering
  - Extensive goat breeding
- Deterioration of customs and traditions
  - Change in traditional practices with regard to taboo
  - Non-observance by those who disregard taboo

Biology
- Lack of knowledge in tortoise biology
  - Lack of knowledgeable persons
  - No outreach effort for the little information that is currently available
  - Lack of interest and concern
- Disease
- Slow growing species
- Competition with other species

Human impact
- Harvesting
  - Decorative use

- Food
    - Local consumption
    - International consumption

Weakness of the legal system

- Laws not suited to the current situation
- Inadequate and arbitrary enforcement of laws
- People are not aware of the laws
- Arbitrary law enforcement policy
- Community-based groups are not involved in designing the laws

Group: BIOLOGISTS

PROBLEMS

1. Status and future of the current tortoise population: reducing? stable? increasing? No knowledge of the trend and inadequate basic data on tortoises
2. Inaccurate biological data that is based on estimations
3. Destruction of habitat, genetic diversity
4. Crop destruction (littoral) : the animals are considered as harmful
5. Non-observance and non-enforcement of existing laws
6. Attractive nature of the tortoises (domesticated, decorative, beliefs, consumption, medicinal virtues)
7. Illegal harvesting and trade
8. High value in the international market
9. Large species are a valued food item
10. Disrespect of traditional practices -*fady* (by immigrants)
11. *Fady*-related behavior (by immigrants)
12. Effects of road construction (the drainage system makes holes)
13. Natural traps
14. Lack of natural population management tools
15. Roads and communications lead to easier access to tortoises
16. Food competition among tortoises and other species living in the same habitat
17. Predation of young tortoises by dogs, boars, raptors, crows, trampling of their habitat
18. Fire (hunting, fishing), habitat destruction, land clearing
19. Existence of invading plants
20. Effects of population density: high density populations are vulnerable to harvesting and competition among individuals
21. Isolation of populations
22. Inadequate public awareness of the importance of protection

PRIORITIZATION OF PROBLEMS

1. Flourishing illegal harvesting and trade (6+7+8+9)
2. Disrespect for traditional practices -*fady*
3. Destruction and fragmentation of habitat
4. Lack of management tools (1+2+22) (basic knowledge and awareness of tortoise conservation)
5. Non observance of existing laws
6. Road infrastructures (easy access, traps, accidents, fragmentation)

RATIONALE FOR PRIORITIZATION

1. **Flourishing illegal harvesting and trade**
    - Leads to decrease of the population
    - Causes massive harvesting of species of all ages and sexes

    Causes:

- high price
- valued food item
- attractive nature
- increasing international demand

Effects: Massive loss of the species and its genetic diversity are caused by a combination of (1) high infant mortality rate, (2) high harvest rate of species of all ages, and (3) late sexual maturity. There is real concern for the population's survival.

Results: decrease in size, in genetic diversity, decrease of the whole population.

2. Disrespect for traditional practices -*fady*

- Decline in natural conservation
- High migratory flow, migrants do not observe local taboo
- Degradation of belief system (incitement to tortoise consumption)
- Consumers influences on populations that observe the taboo

Leading to harvesting and consumption of tortoises, decrease of adult population (especially female)

3. Destruction, deterioration and fragmentation of habitat

- Affects species viability
- Decrease in food resources, refuge, egg-laying places
- Decrease in genetic diversity
- Infections (tortoises feed on goat feces). All age groups are affected, leading to bad health and reduced viability of the population

4. Lack of management tools

- Inadequate basic data (population, biological data, monitoring)
- Ineffective management of natural population (rational and sustainable management)
  - lack of research means
  - lack of suppression
  - lack of monitoring
  - continued harmful practices

5. Non-observance of existing laws

- Exploitation and trade are authorized
- All age classes are affected
- Population is decreasing

6. Road infrastructure

- Increasing mortality rate (accidents, trampling, natural traps, lavaka, drainage)
- Furthers harvesting due to easy access, communication
- Decrease in population affects all age groups

NEEDS

1. Flourishing illegal harvesting and trade

- Capacity building of the mixed squad (equipment, training)
  - Motorcycles, cars, SSB, launch vessels, etc.
    - To limit harvesting
    - To control trafficking
- Financial incentive for the mixed squad
- Strict and impartial law enforcement
- Income generating activities
  - To create alternative sources of income
  - To reduce poverty
  - To reduce human pressures on tortoise populations
- Establishment of pacts at local, communal, and inter-communal levels
- Information networking at national and international levels
  - To monitor traffickers
  - To control harvesting and marketing
- Border control
- Information on the origin of seized tortoises
  - To restore the affected populations
  - To reintroduce them into their original populations
  - To ensure genetic conservation of the original populations, i.e. not to reduce genetic diversity

2. Disrespect for traditional practices-*fady* (taboo)

- Education and creating awareness among migrants
  - To reinforce observation of *fady*
  - To protect animals
  - To limit harvesting
  - To respect the Antandroy and the Mahafaly cultures
  - To stop the consumption of tortoises

3. Destruction and fragmentation of habitat

- Monitor and control cattle wandering
  - To avoid food competition
  - To protect nests and egg-laying areas
  - To avoid infections caused by parasites due to goat feces
- Monitor and control bush fire, land clearing
  - To reduce human pressures on habitat
  - To avoid decrease in tortoise populations
- Ecological restoration of degraded areas of tortoise habitat
  - To increase vital space
  - For population recovery
- Tortoise ecological monitoring system, with branding (impacts of pressures)
  - To assess the impact of pressures and conservation strategies used
  - To observe population trend, i.e. an adaptive management of wild populations

4. Lack of management tools (basic knowledge on how to increase public awareness for tortoise conservation)

- Basic data on ecology and biology
- Social and cultural data
- Socio-economic data
- Distribution data
  - To put in place a management and development plan
  - For an effective management suited to the situation
  - To recover the tortoise population

5. Non-observance of existing laws

- Synergy in the actions of involved stakeholders
- Increased coordination among involved stakeholders
  - To enforce the laws in order to improve the management tortoises
  - To put an end to, or at least reduce, harvesting

6. Road infrastructures (easy access, traps, accidents, fragmentation)

- Setting up of check-points
- To control cars, carts, harvesters to reduce trafficking of tortoises
- Capacity building of human resources involved (GN conservation specialists, agents)
  - For immediate and regular action
  - To work with the local community

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Section III
Issue-based Working Group Reports

Group 1: HARVESTING & LACK OF RESPECT FOR LOCAL CUSTOMS

Group members: *Longin (Facilitator), Jean Claude (Rapporteur), Philibert, Zigzag, Hery, Sambimana, Harison, Hasina (student)*

PROBLEMS

A. Harvesting

- Easy to harvest
- Demand exceeds supply
- Lucrative speculation
- Ineffective pacts
- Corruption and misuse of power
- Malagasy do not value their natural resources
- Lack of resources for the prosecution of traffickers
- Lack of a sustainable strategy for the protection of tortoises
- Handicraft is a soaring activity
- Conniving with "ziva" (connections or acquaintances), close relations, authorities
- The authorities and experts try to find the ways to remove the tortoises from their original habitat and shift them to other places
- Existence of exportation permits
- Poverty leading to the consumption of tortoises

Prioritization of Harvesting

1. Easy to harvest (5 points)
2. Malagasy do not value their natural resources (5 points)
3. Lack of a sustainable strategy in tortoise conservation (4 points)
4. Demand exceeds supply (3 points)

Why

1. Tortoises are harmless and easy to catch
2. Lack of awareness and education;
   No awareness of the importance and richness of Madagascar's natural resources
3. Trade generates obvious benefits;
   Pervading corruption from bottom to top;
   Ineffective pacts
4. Many are willing to buy tortoises at an expensive price;
   Valued for handicraft

B. Non-Observance of Local Customs

- Migrants do not observe traditional practices
- High migratory flow
- Migrants do not respect the Tandroy and Mahafaly customs (tortoise taboo)

- Consumers influence local populations
- Effects of western beliefs on traditional practices (disappearance of taboo) and of freedom of education and information

Prioritization of Non-Observance of Local Customs

1. Disrespect for traditional practices by migrants (8 points)
2. High migratory flow (6 points)

Why

1. Ill-acquired cultural value (A few former and old Tandroy FLM preachers: BENALINGA)
2. Migrants do not respect the Tandroy, Mahafaly and Tagnalagna practices (*fady*)

Influence of new lifestyles

=> Flow of consumers
=> Bad idea to adopt marketing by migrants

CONCLUSION

Harvesting and consumption of tortoises leads to a decrease in tortoise populations

RECOMMENDATIONS

A. Harvesting

1. Development of a nation-wide pact to protect these inoffensive species

2. Incorporating into the school curriculum "the sacred nature and overarching importance of tortoises in society, and benefits derived from them for the Tandroy, Mahafaly, and Tagnalagna"

3. Development of a strategy for the protection of tortoises:
   - A charter of liabilities will be established
   - Rules will be enforced without discrimination

4. The *Dina* (pact) and laws will be applicable to everyone to prevent the torturing, killing, consumption, sale or trafficking of tortoises.

B. Non-Observance of Local Customs

1. Educating and raising the awareness of all people about Malagasy culture so that they can better understand and respect tortoises, which are both a national and international heritage.

2. All should know that religion and customs are complementary to each other (particularly among a few religious leaders of “BENALINGA” FLM fahagola) to avoid disrespect of the Malagasy culture and traditions.

3. Migrants and visitors in the Androy, Mahafaly, and Tagnalagna areas should observe the local practices (*Dina*, laws, taboos) for the sake of social peace.

DISCUSSIONS

Questions

What are the positive points for the Tandroy people in having tortoises part of their lives?

- The Tandroy people believe that they get special blessings from tortoises when they come to the village.
- If someone comes across a tortoise they put a branch on the tortoise's shell to seek blessings and success in their undertakings.
- In times of drought, they drink tortoise urine as a substitute for water. They feel that when God sees this, he will feel sorry for them and will open the sky and let the rain fall.

What are the scientific benefits of tortoises? (i.e. What is the ecological role of tortoises?)

- They protect other animals from diseases; e.g. diseases affecting cattle in the forest will decrease when tortoises are around.

FURTHER RECOMMENDATIONS

1. Benefits derived from tortoises are more cultural than material
2. The solution is not a *Dina* for the local Malagasy people but a *Dina* for visiting Malagasy or foreigners that visit the areas where tortoises are taboo and protected. All Malagasy should be aware of the *Dina* regarding the taboo on tortoises (tortoises should be taboo for all Malagasy).

OUTCOMES FOR RECOMMENDATIONS

A. Harvesting

1. If the *Dina* is put in place and immediately enforceable in the 2 regions where tortoises are found, tortoise hunting will be reduced by 60%;
2. If all the people are aware of the sacred nature and overarching importance of tortoises and the benefits derived from them (religious, economic, etc.), tortoise hunting will decrease by 20%;
3. If long term plans and designs are put into place (charter of liabilities, rules applicable to all without any discrimination), tortoise hunting will decrease by 20%;
4. If the *Dina* and laws are applicable to all (migrants and visitors), tortoise hunting will decrease by 20%.

B. Non-Observance of Local Customs

1. If people better understand the richness of the Tandroy, Mahafaly and Tagnalagna cultures, tortoise hunting will decrease by 20%;
2. If customs and other taboos are observed in the Androy, Mahafaly and Tagnalagna areas, 20% of tortoises will be conserved.

SMART

	WHO	WHAT	WHEN	WHERE	WHY
A 1 & 4	-Mayors, Councilors, fokontany committee officials, village elders - Mayor SAMBIMANA (rural commune of Marovato) - Mayor LONGIN Louis Fanantera (rural commune of Tranovaho)	*Dina* (Pact)	06/01	Androy, Mahafaly, and Tagnalagna regions	- Prevent tortoise hunting - Protect tortoises - Increase tortoise species - Protect natural resources and environment
A2	- MENRES - Min Cult	Education on the importance of tortoises and benefits derived from them (religious and economic benefits)	School year 2006/2007	Throughout the country	- Increase the Malagasy people's knowledge of the importance of tortoises and benefits derived from them
A3	- MINENVEF - MDN - MDAF - MINJUS	Well designed plan: charter of liabilities	2006/2007	National level	- Tortoise hunters and consumers will be prosecuted - Laws will be enforced - Law enforcement will be monitored
B 1 & 2	- Idol Custodians - Village elders - Religious leaders - Fokontany leaders	To develop a plan for a smooth coexistence of religion and customs	2006/2007	Throughout the country	- Promote and strengthen the rich Tandroy, Mahafaly, and Tagnalagna cultures - Promote coexistence of Christian faith and ancestral customs within society

MAYORS AND COUNCILLORS

- Provide input for the *Dina*
- Submit them through the line of authority and to the Court for compliance with existing laws
- Enforce the *Dina* in their jurisdiction

MENRES

- Will incorporate into school curriculum "the sacred nature and overarching importance of tortoises, and benefits derived from them"

MINCULT/TOURISME

- Will raise the people's awareness on the sacred nature and overarching importance of tortoises, and the benefits derived from them

MINENVEF
MDN
MDAT
MINJUS

- Develop a plan and put in place a "charter of liabilities"
- Establish a "penal policy" based on existing laws

IDOL CUSTODIANS
VILLAGE ELDERS
RELIGIOUS LEADERS
FOKONTANY LEADERS

- Will raise awareness and work out a plan for the smooth coexistence of religious and ancestral customs

ACTION PLAN

Implementation of *Dina*

Prior to the development of a *Dina* at the regional level, the Ministry of Interior will have to provide a "framework *Dina*" to facilitate the development of a *Dina* based on the existing laws, and to enable the Court to adopt it.

1. Convening of Councilors' meeting by the Mayor (STAFF) ⇒ Oct'05: in each commune and OPCI
2. Convening of fokontany officials and village elders' meeting ⇒ Oct'05 in each commune and OPCI town
3. Working together to provide input and content for the *Dina* ⇒ Oct'05: in each commune and OPCI town
4. Informing the people of the proposed *Dina* ⇒ Nov'05 – Feb'06: at fokontany level
5. Validation of the proposed *Dina* by the commune's council ⇒ March'06: in each commune and OPCI town
6. Submission of the proposed *Dina* to the authorities
   (District, Region, Court) ⇒ March'06: Districts in the Androy and Atsimo Andrefana regions, as well as Ampanihy, Taolagnaro, Toliara, and Betroka
7. Adoption by the Court ⇒ May'06: Androy and Atsimo Andrefana regions, as well as Ampanihy, Taolagnaro, and Betroka
8. Dissemination of the *Dina* to people within the Androy and Atsimo Andrefana regions and in areas adjacent to these regions ⇒ May-Sept'06: throughout FKT, Communes, Districts, the 22 regions, and other countries around the world.

SUPPLEMENTAL REPORT OF GROUP 1

I. The *Dina* (pact)

1. Definition: A *Dina* is an agreed upon document, designed in such a way as to correspond to the current laws and binding to all people, for a smooth functioning of society in a given region. This method of working is a traditional method, inherited from our forefathers.

2. *Dina* on tortoises

a. The reasons for developing a *Dina* are the following:
   - Reassert the sacred nature and overarching importance of tortoises within the Mahafaly, Tandroy and Tagnalagna tribes
   - Remind the population that tortoises are a valuable heritage
   - Prevent disrespect of local traditions
   - Ensure the survival of tortoises

b. A *Dina* is important because:
   - It is an easy-to-understand document
   - It does not discriminate on the basis of age (children or adults)
   - It is easy to enforce
   - It facilitates relationships among neighbors
   - It is agreed upon in the region and has a quick and regular effect

c. Impacts when the *Dina* is enforced:
   - Everybody feels accountable
   - The *Dina* establishes fines for offenders, and those subject to the *Dina* have an interest in upholding the document as any fines that are collected are used for the benefit of the society.

⇒ The impact of *Dina* is a 60% reduction of hunting and consumption of tortoises

d. Objectively Verifiable Indicator (OVI):

Statistical data available from each region, including:
   - Number of people that paid fines during the last 3 months
   - Number of shells collected from recently deceased tortoises during the last 3 months
   - Amount of seized equipment that was used for trafficking tortoises (bicycles, canoes, carts, cars, etc.)

II. Customs and Traditions (Raising Public Awareness)

Idol custodians and village elders are influential people in their society. They hold important and sacred responsibilities and functions and will play influential roles in raising public awareness for the conservation of tortoises and for the local traditions and customs.

GROUP 2: HABITAT DESTRUCTION & LAWS

***Group members**: René R., Lemena R., Victor Rasolonirina, Victor Zanany, Félicien R., Jean Philippe Randrianatoandro, Masimana (facilitator), Edmond R., Manantsoa Andriatahina, Angelo Ramy Mandimbihasina, Domoina Rakotomalala, Achille Raselimanana*

PROBLEMS

I. Destruction of habitat
  - Bush fires
  - Grazing
  - Land clearing
  - Cattle wandering

II. Laws and law enforcement

I. Destruction of Habitat

The four groups of stakeholders raised the following issues regarding habitat destruction:

Local community	Biologists	Government	NGOs
• Land clearing • Charcoal production • Construction • Farming • Fence building • Furniture making • Houses • Cart making • Village rehabilitation • Park • Drought	• Habitat destruction • Habitat fragmentation • Hunting • Trampling • Fires		• Environmental decline • Climate change o drought o flood o quicksand • Human actions • Extensive goat rearing

Review of issues

After the discussions, we grouped together all the problems showing common points:

A. *Human impact*

- Bush fires and land clearing are the primary causes of habitat destruction. Bush fires and land clearing are some of the major pressures that lead to a reduction of tortoise habitat
- Commercial logging (charcoal production, construction, cart production, etc.)
- Selective felling for cooking of limestone rocks (rural communes of Beheloke, Anakao, and Soalary)
- Mining (new)
- Introduction of black olive scales (Decaryi) to destroy Malagasy cactuses
- Grazing and cattle wandering are secondary causes (effect of destruction)

B. *Natural disasters*

- Droughts

- Floods
- Cyclones
- Locust invasions
- Red cactus invasion (invading plants: *Opuntia stricta*)

Prioritization of issues
After setting the priorities using the "sticky dots" method, we have classified all of these issues as priority issues in the above order except grazing and cattle wandering (the latter does not result in large scale habitat destruction).

II. Laws and Law Enforcement

Local community	Biologists	Government	NGOs
	• Non observance of existing laws • Non enforcement of laws	• Masses are not aware of the current laws (poor administration) • Current law is outdated and not adequately strict • Law enforcement is variable in Madagascar • Local authorities are not aware of their duties in natural resources management	• Outdated laws • Penal policy is highly variable • No community-based endorsement of bills

Review of issues

A. *Poor administration*
- No enforcement of the current laws
- Selective or partial enforcement of laws

B. *Non-observance of the existing laws*

C. *Outdated laws*
- Too old
- Do not respond to the current circumstances

D. *Ignorance of the laws (in general and with respect to tortoises)*
- By the masses
- Local authorities (government)
- Framework *Dina*

E. *Bills are not endorsed by local communities*

F. ***Penal policy is highly variable***

Priority setting

After setting the priorities using the "sticky dots" method, we have classified points E and F as non-priority points. The other four have been classified as priority points in the order A-D-B-C

RECOMMENDATIONS

A. Human impact

1. Establishment of a development plan for concerned communes (to be included in the Communal Development Plan)
    - Communes capacity building (including fokontany) to help them understand, act, and communicate in order to put an end to hunting and trafficking; control human migrations; inform the various institutions concerned in the event of an offence or seizure. In turn, communes will take actions at the fokontany level.
    - Financial and technical support from concerned institutions. Implementation of the conservation actions requires equipment, funds, and technical training.
    - Promotion of income generating activities: creating businesses that generate resource alternatives for families may reduce pressures on the habitat and the hunting of tortoises.
    - Forest and pastoral management by migrants and stockbreeders
    - Introducing fodder crops for the production of cattle feed reduces the animals' impact on tortoise habitat
    - Promotion of rural micro-credits will help give locals the funding that they need in order to start up other income generating activities

2. Development and capitalization of FOFIFA research results
    - Removal by hand of *raketamena* (red cactuses): *Raketamena* gradually invades and competes with the natural vegetation, destroying habitat. This will impact the people's viability if invasion continues on a long-term basis.
    - Promotion of other techniques to check the invasion of *raketamena*
    - Study on scale insects, which have been used previously to destroy cactuses. Further studies on the use of scale insects to destroy invading cactus species might be a solution to check the invasion of *raketamena*.

B. Natural disasters

1. Reforestation: For the tortoise population to grow, their habitat must be restored. Reforesting with endemic plant species and forest restoration will help increase tortoise habitat, in part by producing more food for the tortoises and improving their living conditions.

2. Locust control: Locusts destroy the habitat. Means to control them should be found, including:
    - Creating locust control committees at the commune and fokontany levels
    - Material and financial means

C. Laws and *Dina*

1. Poor Administration
    - Impartial and strict enforcement of the laws is necessary. The law should be applicable to everyone, without exception. Everyone should feel obligated to follow the laws, prohibiting them from hunting or trafficking tortoises or resorting to bush fires. This law enforcement will not only have positive effects on habitat destruction (i.e. reduction of areas destroyed by fire), but also on the natural tortoise population (reduced hunting).

2. Ignorance of the laws
    - Raising the awareness of the people and authorities on the current laws and regulations related to protected species (fauna and flora). Not everybody is aware of the laws, particularly the rural people. Most of the local mayors and fokontany leaders are not aware of the conservation laws in place for protected species. It would be useful to educate the population on the current laws and to conduct awareness raising campaigns on the conservation laws in general.
    - Dissemination of laws and regulations currently in place
    - Allow local communities to contribute to the development of new laws

3. Outdated laws
    - The updating of all provisions deemed obsolete, including those of Order No. 60-126 of 10/03/60. The laws in place in Madagascar related to the protection of fauna and flora, including star tortoises, date back to 1960. These laws are outdated and do not address the current situation. The current fines given to those illegally trafficking or hunting tortoises are very small and do not deter people from continuing these illegal practices.

4. Non observance of the laws in force
    - Observance of the rules of law

5. *Dina*
    - Development of *Dina* related to tortoise conservation and enforcement of these *Dina* after approval by the relevant Court (interregional). *Dina* are very strict for residents and their enforcement at the local, communal, and regional levels may constitute a means to penalize tortoise hunters, traffickers and consumers.

Generalities

1. Request the concerned regions to integrate the strategies and actions adopted during this workshop into their respective regional program (i.e. to integrate into the RDP)

2. Free flow of communication in legal proceedings
3. Census of domesticated tortoises across Madagascar (new)

DISCUSSIONS

The following table shows the relationship between our recommendations and needs identified by each group in the first day of the workshop:

GROUP RECOMMENDATION	NEEDS MET
I. Habitat destruction	
A. Human destruction 1. Implementation of a concerned commune development plan (to be included in the Commune Development Plan)	**BIOLOGY** • Flourishing illegal hunting and trading • Habitat destruction and fragmentation • Road infrastructure (easy access, traps, accidents, fragmentation?) **NGO** • Development programs to settle migrants • Land tenure • Education for all • Mutual rural credit promotion • Habitat restoration • Management transfer of areas highly populated by tortoises • Land area zoning according to use (grazing, reforestation, farming, conservation) **LOCAL COMMUNITY** • Establishment of tortoise villages in the Androy and Mahafaly regions. Others areas where tortoises are not currently found will not be considered. • Reforestation: - To restore the tortoises' habitat - To improve overall environment (rainfall…) **GOVERNMENT** Nil
2. Development and capitalization of FOFIFA research results	**BIOLOGY** • Habitat destruction and fragmentation • Missing management tools (Basic knowledge of raising awareness for tortoise preservation) **NGO** Habitat restoration
B. Natural Disasters 1. Reforestation	**BIOLOGY** Habitat destruction and fragmentation **NGO** Habitat restoration **LOCAL COMMUNITY** Reforestation:
2. Locust control	NEW
II. Laws and *Dina*	
A. Poor administration 1. Impartial and strict law enforcement	**BIOLOGY** • Flourishing hunting and trading: road infrastructure (easy access, traps, accidents, fragmentation?) **NGO** Updating and enforcement of laws **LOCAL COMMUNITY** Changing and strengthening of law enforcement

OUTCOMES FOR RECOMMENDATIONS

I. Destruction of Habitat

A. Human impact

1. Implementation of a concerned communes' development plan (to be included in the Commune Development Plan)
   - Building communes capacity
   - Financial and technical support by relevant institutions
   - Promotion of income generating activities
   - Forest and pastoral management by migrants and stockbreeders
   - Introduction of fodder crops
   - Promotion of rural micro-credits

Results: 30% reduction of pressures on the habitat

2. Development and capitalization of FOFIFA research results
   - Removal by hand of red cactuses
   - Promotion of other techniques to check *raketamena* invasion
   - Study on scale insects

Results: 10% reduction of pressures on the habitat

3. Raising awareness and environmental civic education

Results: 20% reduction of pressures on the habitat

B. Natural disasters

1. Reforestation

Results: 5% increase in habitat area

2. Locust control
   - Creating locust control committees at the commune and fokontany level
   - Material and financial means

Results: 3% reduction of pressures on the habitat

II. Laws and *Dina*

A. *Poor administration*

- Impartial and strict enforcement of the laws

Results: 30% reduction of hunting

B. *Lack of knowledge of laws*

- Educating the people and authorities on the laws and regulations currently in place for protected species (fauna and flora)
- Dissemination of the laws and regulations in place
- Partners' contribution to the development of implementation orders

Results: 8% reduction of hunting

C. *Outdated Laws*

- Updating of all provisions deemed obsolete, including those of Order No. 60-126 of 10/03/60

D. *Non Observance of Laws in Place*

- Observance of the rule of law

E. *Dina*

- Development of *Dina* related to tortoise conservation and enforcement of these *Dina* after approval by the relevant Court (interregional)

Results: 60% reduction of hunting

GENERALITIES

1. Request the concerned regions to integrate strategies and actions adopted during this workshop into their respective regional program (i.e. integrate into the RDP)
2. Free flow of communication in legal proceedings
   Results: 2% reduction of hunting (1+2)
3. Census of domesticated tortoises throughout Madagascar (new)
   Results: very small reduction of hunting

ACTIONS – SMART – GROUP 2
HABITAT DESTRUCTION

Recommendations	What	Who	When	Where	Why	OVI
1. Creation of concerned communes' development plan • Communes capacity building • Financial and technical support by relevant institutions • Promotion of income generating activities • Forest and pastoral management by migrants and stockbreeders • Introduction of fodder crops • Promotion of rural micro credits	• Material and financial support to Communes • Training in sustainable management of natural resources, legal base • Promotion of income generating activities • Forest and pastoral management and fodder crops	WCS – CI – MIARO SAGE-ANGAP-MINENVEF-CUSTOMS (targets) COMMUNE PSDR PAICAL ACORDS BIODIVERSITY FOUNDATION MINENVEF UNDP MINAGRI NGO development WWF-KFW	Nov'05 Oct'05 Nov'05 Nov'05	SW region Androy Anosy do – do – do –	• Increase effectiveness • Control to reduce hunting (30% reduction)	• Funds and equipment provided • Number of trainings conducted • Number of beneficiaries • Number of sites identified and created under forest and pastoral management
2. Development and application of FOFIFA research results	• Physical elimination • Promotion of other techniques to check *raketamena* invasion • Study on scale insects	WFP, FID FOFIFA University Researchers FOFIFA	Sept'05 Sept'05 Sept'05	do – do – do –	10% reduction of pressures of the habitat	• Eliminated and developed area
3. Raising awareness and environmental civic education		MENRS, ANGAP, NGO MINENVEF MINPOP MININFO Security Forces	Jan'06	do –	20% reduction of pressures	• Number of training conducted • Number of BCC performed • Training aids distributed

LAWS AND *DINA*

Recommendations	What	Who	When	Where	Why	OVI
1. BCC (Behavior Change Communication) and mainstreaming of laws and regulations in place	• Updating of the law, dissemination • Law enforcement and observance • Awareness raising	Ministry Government Assembly MENRS MIRA (MinInter and Admin Reform)	Sept'05 (permanent)	Madagascar Mainly in SW region Androy Anosy	38% reduction of pressures	• Number of sensitized villages • Number of reports made • Number of laws updated and promulgated
2. Development of *Dina*	• Dissemination of law 2001/004 related to framework *Dina* in areas concerned by tortoises to develop a pact on tortoise conservation • *Dina* enforcement	MIRA COMMUNES COURT COMMUNE FOKONTANY FOKONOLONA	Sept'05 Oct'05 Nov'05 Dec'05	do –	60% reduction of pressures	• Developed *Dina* • *Dina* enforced and effective

COMMENTS:

- Study of the possibility of using scale insects in response to the invasion of red cactus (*raketamena*)
- Collaboration with CAN (locust control committee)
- Locust control activities started late and crops already suffered significant damages
- Communities should be given certain responsibilities for locust control in their area

Group 3: INSUFFICIENT COLLABORATION AMONG STAKEHOLDERS

***Group members** : Félicité Rejo-Fienena – Venance Ravelosoa – Flavien Rebara – Beby Fabienne Ralavarisoa – Avimare – Capitaine Théodule Ranaivoarison – Sahondra Rabesihanaka – Eholongony – Martel Alexis – Berthine Hotovoe (student)*

The threats for endemic tortoises of Madagascar (*Geochelone radiata* and *Pyxis arachnoides*) take on various forms that require an increased and quick public awareness and action. Currently, the inadequate collaboration among stakeholders is a hurdle for effective conservation actions. To address this, the following recommendations have been made for an improved coordination of all actions to be undertaken in tortoise conservation:

- Establishment of a joint steering committee
- Creation of a mixed squad
- Creation of a Tortoise Foundation

The joint steering committee

This committee comprises the following entities: GN-JUDICIARY-NGI-REGION-COMMUNE-MINENVEF-DIREEF. Its major assignment is to make field visits and conduct an awareness raising campaign to ensure accountability at the level of local communities in the concerned areas (villages of hunters and hunting places), including Androka, Itampolo, Fontadrevo, Marolita, Ampanihy, Beloha, Tsihombe, Marovato, Nikoly, Tranovaho, and Ikopoky. A vigilance committee will be established in every village, and intelligence agents designated and tasked to inform the vigilance committee and nearest police station of any infractions.

In addition, the joint steering committee will also be assigned to survey field situations in order to better understand and control the action strategies of traffickers and hunters to facilitate their apprehension.

Through a quarterly newsletter, the joint steering committee will inform those involved on recent actions taken and actions needing to be taken for the conservation of the tortoises.. This newsletter will be available for distribution in Betioky for the South West region, and in Ambovombe for the Androy region.

The mixed squad

The mixed squad is the joint steering committee's emergency body. It is composed of members of the National Gendarmerie, Water, Forest, & Environment Agency, intelligence agents and/or informers. This squad is assigned with the task of intervening in case of alert, and automatically during normal verification missions.

Creation of a Tortoise Foundation

The success of the joint steering committee and mixed squad is limited by the inadequate means available to them. In addition, many public departments can allocate only a very small part (if any) of their annual budget to the establishment and maintenance of such a committee.

The idea to establish a special Tortoise Foundation was born to ensure the effective establishment of these committees. Along with partners, the committees will submit a viable project proposal to donors. An account will be opened in late November in each main town of the Betioky and Ambovombe-Androy regions for each regional committee to operate according to its annual working program (PTA).

Money for this fund will be raised through gifts and donations, government contributions, and sponsorships. Committees can also embark on profit making activities of their own.
The establishment of this Tortoise Foundation will ensure financial sustainability for the functioning of regional committees and mixed squads. It will contribute to the procurement of various pieces of communications equipment, including single side band radio, and rolling stock including cars, motorcycles, launches vessels, etc.

Additionally, the allowances of agents on assignment, transportation charges, and bonuses for reporting offences will be met by this fund. Bonuses should be paid to agents that arrest traffickers, to informers, and to people and villages that contribute to the recovery of trafficked tortoises.

The creation of the Tortoise Foundation will increase the joint steering committee's effectiveness, and bring tortoise trafficking down by 75%.

The issue of poverty has not been addressed in these studies as we believe it is not a hurdle for the protection of the four species of protected terrestrial tortoises, and does not therefore hamper collaboration among stakeholders. Poverty is not measurable and cannot be taken as a determining component for the success or failure of the model. It can be overcome, hence it was set aside.

The particular case of the Antandroy, Mahafaly, and Tagnalagna areas, where protected tortoises are mainly found in the southern Madagascar, shows that in spite of poverty (drought, famine, illiteracy), the locals keep their *fady* (taboo). The question is, then, what should be done to impose this *fady* (i.e. not to touch these species), on strangers in their area. A thought is local collaboration at the community level.

This leads us to work out a charter of liabilities that is binding to each and everyone and defines the tasks, liabilities, and duties of all for a sound collaboration and an optimum result (e.g. zero percent of pressure on these species in the five years to come). We firmly believe that the best method is prevention and that suppression is the exception.

A- Performance Indicators (55% reduction of tortoise trafficking)

1- Mixed visit
Participating communes establish vigilance committees
Creating awareness and support for tortoise conservation that will deter hunters, traffickers, and other ill-intentioned people

2- Intervention

Exemplary arrest of offenders

B- Performance Indicators (75% reduction of tortoise trafficking)

- Quick intervention (SSB, motorcycles, cars, fuel)
- Frequency of visits maintained

OFFENCES COMMITTED OUTSIDE OF CIRCUMSCRIPTION

From	Number of animals	Year	Comments
Fianarantsoa Ambalavao	70 tortoises caught	12/15/2003	Transferred to tortoise village, in Mangily
Fianarantsoa Traffic police	372 Pyxis 6 Radiata	05/14/2004	Transferred to tortoise village, in Mangily
Diego	256 Pyxis and Radiata	12/24/2004	Transferred to tortoise village, in Mangily
Reunion Island	83 Radiata 103 Pyxis	2005	Transferred to tortoise village, in Mangily
Comoros	3,000 star tortoises 3,000 Pyxis	December 2001	Transferred to tortoise village, in Mangily
Reunion Island	1,045 star tortoises	06/18/2002	7 offenders

Group 4: INADEQUATE PUBLIC AWARENESS, EQUIPMENT, TOOLS, ROAD INFRASTRUCTURE

Group members: *Anne Marie – Jean Odon Randrianarivelo – Colonel Herman Maka – Fiadana Fabrice – Maminirina Dutel – Jacquot Tahindro – Daniel Ramampiherika – Georges Ibramdjee – Rijasoa Fanazava – Lima (student)*

PROBLEMS

1. Raising awareness

Group Government:

Need for a campaign to raise public awareness of the current laws in place for protecting tortoises

Group Community:

The people being unaware of the benefits derived from protecting tortoises

Group Biology:

Lack of education and awareness of migrants

Group NGOs:

Need to raise the awareness of and educate the people on the importance of tortoises as a Malagasy heritage

Group Government:

Need to improve both formal and non-formal education

2. Equipment and tools

Group Government:

Material and personal means lacking

Group Community:

Need to empower communes and provide them with equipment (SSB, motorcycles, launch vessels, computers, audio-visual equipment, generator, solar panels, documents)

Group Biology:

Lack of management tools
Absence of funding for research
Inadequate basic data

Group NGOs:

Need for funding for key actors
Inadequate number of people and equipment, pushing people to burn and exploit the forest

Development of a procedural manual

Group Biology:
Need to establish of check points

Group NGOs:
Need for controls and monitoring structures at various levels (commune, fokontany, village)

Ideas of the Group
Inadequate public awareness taught in schools in both urban and rural areas
There is a need for equipment and tools, tortoise location map, data bank, laboratory

Priority Setting

1. Raising awareness

2. Equipment and tools:
   - Increase the number of emergency responders
   - Providing communications equipment
   - Establishment of mixed squads and providing them with equipment (portable computers, cars, motorcycles, launch vessels, office space, etc.)

3. Road infrastructure: reconstruction of barriers

RECOMMENDATIONS

1. Raising awareness
- Provide incentives for people to turn in tortoise hunters to the authorities
- Informers will not be involved in investigations; information to be kept confidential
- Incentives: to be determined in *Dina*

Training should be provided to elementary school, middle school, and university teachers, and village elders (idol custodians, *lonaka, roandria*) so that they can pass on information about laws and protecting tortoises.

There are three types of training, including:
- formal education: conducted at school (MENRS)
- non formal education: conducted by the Ministry of Population (elimination of illiteracy)
- informal education: conducted by the Ministry of Communication (media)

Subject matters:
- Endemic species: these tortoises are found only in Madagascar
- Each and everyone is responsible for protecting tortoises
- How to increase communal budgets with tourism earnings
- Inform people of the new laws
- Encourage stakeholders to collaborate with the community

- Establishment of tortoise protection clubs (for youth, artists, etc.) in areas where tortoises are found
- Use of visual messages (e.g. posters) for the illiterate

2. Equipment and tools

It is important to have adequate equipment in order to raise awareness for the protection of tortoises. This equipment includes:

a. Communications equipment: SSB radio for quick decision making; audiovisual equipment to raise awareness and disseminate information

b. Means of transportation (including cars, bicycles, motorcycles, and launch vessels) for the apprehension of tortoise hunters and to monitor tortoise habitats

c. Provision of office equipment, including portable computers and typewriters

d. Increase the strength of monitoring forces (security forces, water and forest monitoring staff) and number of prevention agents (non governmental entities) through reinforcement and enrollment

e. Establishment of mixed squads and providing them with equipment (office space, barriers, portable computers, etc.). These mixed squads will have headquarters or outposts that will be provided with equipment for the collection of all information on tortoises. There should be 2-3 outposts per district, depending on the circumscription

f. Tortoise location map

g. Use of caps, logos, posters, T-shirts, drama with a message, mobile theaters and audio visual aids (e.g. posters) for the illiterate.

h. Creation of a research laboratory

i. Creation of a procedural manual

j. Improvement of *Dina*

3. Road infrastructure

Barriers should be put in place where vehicle searches can be conducted, thereby reducing illegal trade, hunting, and trafficking. Communes are responsible for designating persons in their region to undertake this task. It should be noted that this has nothing to do with RP (traffic police), but both entities can work together.

Fences around protected areas, if they already exist, should be repaired to avoid traffic accidents that may harm tortoises and reduce their numbers.

OUTCOMES FOR RECOMMENDATIONS

Effectiveness of recommendations (out of 90% success)

1- Raising awareness: 26.6%
2- Provision of equipment and tools: 46.6%
3- Road infrastructure: 16.8%

Assessments according to recommended activities:

THEMES	ACTIVITIES	PERCENTAGE	
Raising awareness	Incentive	5.6%	
	Training and education	17%	

	Visual aids	4%	26.6%
Equipment and tools	Communication and transportation	20%	
	Human resources, creation of mixed squads	10%	
	Lab and data bank	3%	46.6%
	Dina	13.6%	
Road infrastructure	Creation of barrier		16.8%
		Total	90%

RECOMMENDATIONS AND ACTION PLAN

Recommendations	Who	What	When	Where	Why
Encourage the people by providing them with incentives to denounce tortoise hunters	Stakeholders	Fine	Early 2006	Fokontany where they are caught	To enforce the laws and empower the people
Training of outreach workers	Experts	Benefits derived from tortoises	Late 2005	Concerned regions	To provide experience to outreach workers
Education 1) formal 2) non formal 3) informal	Primary school teachers and other teachers	Importance of tortoises for the environment	1) beginning of school year 2006/2007 2) from Nov'05 3) 2006	1) all schools 2) national level 3) fokontany	Inadequate knowledge of tortoises
To establish a club for the protection of tortoises	Stakeholders	Increase outreach activities	2006	Concerned regions	To increase and facilitate protection, field activities, existing systems
Transportation and communication	Mixed squad (all actors)	Rolling stock and communication equipment	2006	Concerned regions	Quick intervention
Human resources	Gendarmes, water and forest agents, local communities	Emergency responders	2006	Concerned regions	Quick intervention
Research (Lab)	Researchers	Tortoise bio-ecological studies	2006	Toliara University	Store and analyze basic data

SUMMARY

- Primary school teachers, middle school teachers, University teachers, and local authorities should be provided some initial training allowing them to pass on information concerning the protection of tortoises.
- Awareness and education concerning the protection of tortoises should be taught starting at the primary school level.
- Empowerment of officials is also necessary.

- Educate and spread awareness with the help of manuals, notices, visual aids, posters with different slogans, and dissemination of all the latest information on tortoises.
- To raise public awareness and educate people, mixed squads should be put into place and provided with communications equipment (SSB, radio sets, mobile phones, walkie-talkies), means of transportation (cycles, motorcycles, launch vessels, helicopters), and electronic and computer equipment.
- For research, create a laboratory at Toliara University where basic tortoise data, of which there is not enough today, will be collected, stored, and analyzed.
- Due to lack of field emergency responders, it is advisable to begin using the National Gendarmerie and water and forest agents.
- Local communities play a primary role in the establishment of road barriers that would be different from those of traffic police.

CONCLUSION

It is possible to put an end to destructive tortoise exploitation by 90% if public awareness programs are effective, there are adequate means available, and communities take on the responsibility of protecting the tortoises in their region.

MISCELLANEOUS

Regarding domesticated tortoises in residences, hotels, parks, etc., all irregular cases (absence of authorization or legal documents) should be referred to the government, even cases that involve tortoises taken outside of the country (700,000) and cases covered by immunity (Diplomats, Senators, Deputies. etc.).

PHVA Workshop on Endemic Tortoise Species in Madagascar

Geochelone radiata (*Madagascar radiated tortoise*)
Pyxis arachnoides (*spider tortoise*)

Ifaty, Madagascar
25-28 August 2005

Final Report

Section IV
Population Modeling Report

Madagascar Tortoise Population Model

Modeling Group Members: Kathy Traylor-Holzer (CBSG), Kristin Leus (CBSG Europe), Kerryn Morrison (CBSG Southern Africa), Thomas Leuteritz (University of Redlands)

Introduction to PVA and the Tortoise Model

Wildlife populations can be negatively affected by a variety of threats, which may have changing impacts over time. All populations are susceptible to deterministic threats – those that act in a predictable manner. Common threats include habitat loss and fragmentation, over-harvesting and the effects of invasive species. Many deterministic threats result from human actions and can be mitigated through changes in human activities and management of the species and habitat.

Deterministic threats can lead to population decline. As populations become smaller and more fragmented, they become vulnerable to additional stochastic processes – those threats that are probabilistic in nature and more difficult to predict and control. Such processes include random variation in fecundity and mortality rates (demographic stochasticity), annual environmental variation, and inbreeding depression. Large populations are buffered against these processes, but once they become small, stochastic threats may drive the population to extinction even if the original cause of population decline, such as over-harvesting, is removed. It is therefore critical to halt population decline before populations become too small for long-term viability.

Computer modeling is a valuable and versatile tool for assessing the risk of decline and extinction of wildlife populations. 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).

For many species at risk, populations have already declined to a point where stochastic processes are a contributing factor, requiring the use of a simulation software program such as *Vortex* for PVA. *Vortex* models population dynamics as discrete sequential events that occur according to defined probabilities. The program creates individuals to form the starting population and steps through life events (e.g., births, deaths, dispersal, catastrophic events) annually based upon designated probabilities. Such models are designed for modeling small populations, in which stochastic processes operate, and cannot easily handle populations over several thousand individuals.

Given the relatively large estimated population sizes for the radiated tortoise (*Geochelone radiata*) and spider tortoise (*Pyxis arachnoides*) in Madagascar, stochastic processes are of little immediate concern; furthermore, the large number of individuals make the use of *Vortex* problematic. Therefore, a simpler, deterministic population model was initially developed for evaluation of these species. This demographic model incorporated the life history of each species as fixed demographic rates with no year-to-year environmental variation. No genetic effects such as inbreeding depression were included. This model has the capability to incorporate harvest of individuals and to model habitat loss or expansion as changes in carrying capacity over time.

The deterministic model was used to explore potential demographic rates under consideration in order to identify model input values that produce a representative model of these tortoise populations. The inability of this model, however, to accommodate age-biased harvest rates led to the decision to use *Vortex* for all radiated tortoise population analyses. This necessitated modeling a smaller population of 30,000 tortoises and scaling carrying capacity and harvest rates accordingly (see section on *Age Structure of Harvested Tortoises*).

Demographic input values used in the model were taken from discussions with workshop participants and from review of the literature. Much of the revision of demographic rates was based on field observations by Thomas Leuteritz in 1999-2000, who worked with the modelers at the PHVA workshop to develop plausible models representative of the life history for each of the tortoise species. Presented here are the model input values and results for the radiated tortoise; see the following section for discussion of the input values and results for the spider tortoise.

Radiated Tortoise Baseline Model

The input parameters and values used for the radiated tortoise baseline model are presented in Table 1. Below is a description of how these values were determined.

Demographic Rates

Annual age-specific mortality: *50%, 25.1%, 9.9%, 2.9%*

There were no age-specific mortality data available for radiated tortoises. Mark-recapture data from ploughshare tortoises (*Geochelone yniphora*), another Madagascar tortoise species of comparable size, supplied age-specific mortality rates that were adopted for the radiated tortoise model (O'Brien pers. comm.).

Table 1. Model input values for radiated and spider tortoise baseline models.

Parameter	Radiated Baseline	Spider Baseline
Mortality (annual):		
Hatchling (first year)	50.0%	45.0%
Juvenile	25.1% (1 - 4 yrs)	25.1% (1 - 4 yrs)
Sub-adult	9.9% (5 -19 yrs)	9.9% (5 - 11 yrs)
Adult	2.9% (20+ yrs)	2.9% (12+ yrs)
Reproduction:		
Maximum age	100 years	70 years
Age of first reproduction (females)	20 years	12 years
% females breeding each year	82%	82%
Sex ratio at hatching	1:1	1:1
No. hatchlings produced per year	4	1.79
Catastrophes:		
Probability of occurrence	5% (1 every 20 years)	5% (1 every 20 years)
Effect on reproduction (multiplier)	0.5	0.5
Effect on survival (multiplier)	0.9	0.9
Initial population size	4.5 million	94,000/subspecies
Carrying capacity:		
Current	4.5 million	94,000/subspecies
Years of change	5 years	5 years
% annual change	- 2% (x 5 years)	- 2% (x 5 years)
Annual harvest	60,560	*P.a. arachnoides:* 2200 *P.a. brygooi:* 1800 *P.a. oblonga.:* 1000

Maximum age: *100 years*
Accurate longevity estimates for wild radiated tortoise populations are not available. Coulson (2005) and Leuteritz suggest that radiated tortoises can live well over 100 years, while many workshop participants were more conservative in their estimates. Radiated tortoises are larger than, and therefore are expected to mature later and live longer than, spider tortoises. Discussion at the workshop led to 100 years being chosen as a reasonable estimate for maximum age. Given the mortality rates used above, few tortoises (about 1% of hatchlings) live beyond 50 years in the model.

Age of first reproduction (females): *20 years*
Sexual maturity in tortoises is typically a function of size rather than age, making it difficult to obtain and use age class to define sexual maturity. The slightly smaller gopher tortoise (*Gopherus polyphemus*) of Florida matures at 10-20 years of age, depending upon the latitude and length of the growing season (Iverson 1980; Miller *et al*. 2001). Coulson (2005) reports that radiated tortoises reach sexual maturity at 15-20 years of age. Twenty years was chosen as the best estimate of mean age of first reproduction for females (i.e., age at which eggs hatch).

Percent of females breeding: *82%*
Estimated by Leuteritz based on field observations.

Sex ratio of hatchlings: *1:1*
Leuteritz *et al*. (2005) report an observed sex ratio of 1:0.98. In the absence of other data to the contrary, an equal sex ratio at birth was adopted.

Mean number of hatchlings/female/year: *4*
Workshop participants reported that a maximum of six eggs have been reported in one clutch. Leuteritz (2002) observed a maximum of five eggs and an average of 2.53 eggs per clutch. Participants decided that three eggs per clutch is a reasonable average. Leuteritz observed a maximum of three clutches per female during the study period of December to April, with a mean of 1.67 clutches. Radiated tortoises are known to lay eggs later than April, although they are generally inactive during the dry season. Two clutches per female per year was taken as a reasonable average. Leuteritz observed that about 67% of eggs successfully hatched, which was accepted by workshop participants. In total, this led to an estimate of four hatchlings produced per breeding female per year on average.

3 eggs/clutch x 2 clutches x 67% success rate = 4 hatchlings/breeding female/year

Catastrophes
One catastrophe was included in the model to represent a severe drought, and was defined as:
- probability of occurrence in a given year of 5% (i.e., mean occurrence of once every 20 years);
- 50% reduction in reproduction (percent females breeding) during the year in which the catastrophe occurs; and
- 10% reduction in survival (all age classes) during the year of occurrence

Population-Specific Parameters

Preliminary estimates of current population size, carrying capacity and harvest rates were made by the modeling working group based primarily on data from Leuteritz and from O'Brien (2003). These values were then discussed in detail with each of the four working groups and refined. Estimates were compared across groups to determine the most accurate values for each portion of the radiated tortoise's range to derive a final input value for the entire population (Table 2).

Each group was asked to address the following issues:

- Current population estimates (for radiated tortoises)
- Current range of tortoises (indicate on map)
- Expected range of tortoises 5 years from now (indicate on map)
- Is harvesting expected to continue as tortoise populations become more remote, or is there a point at which tortoises are safe from harvesting?
- Tortoise harvest estimates (annual) per region
- Are small tortoises (<15cm) also harvested? If so, are they harvested less or more than large tortoises? For what reason are small tortoises harvested?

Tortoises are sometimes harvested for local consumption, but often are transported to larger cities with residents who do not hold the taboo against touching or eating tortoises. Tortoise is a popular food for special occasions such as weddings or holidays. Larger tortoises are preferred, as they provide a larger source of protein. Smaller tortoises may be taken as pets, as food if larger tortoises are not available, or by collectors targeting spider tortoises.

Through workshop discussions it became apparent that most people did not differentiate between the two tortoise species and that people may mistake spider tortoises for young radiated tortoises. The harvest of "small tortoises" therefore may represent the loss of both spider tortoises and juvenile radiated tortoises. This practice may be becoming more common as the preferred large radiated tortoises are harvested unsustainably, reducing their availability and shifting the population to a younger age structure.

A large map of southern Madagascar was provided at the workshop that indicated the past and current estimated range of the radiated tortoise. Each working group used this map to draw their best estimates of current tortoise range based on their local knowledge. They also indicated their projection of where tortoises might exist five years from now, extrapolating from their experience of where tortoises are being harvested, the rate of harvest, and how quickly tortoises are being lost from the peripheral areas of the range (Fig. 1). The perception is that people are having to go farther and farther into the habitat to collect the same number of tortoises, indicating that the range is shrinking. Essentially these peripheral areas are being lost as tortoise habitat, either due to actual habitat loss or to over-harvesting, because even if the environment is able to sustain tortoises, any tortoises that recolonize these areas are immediately harvested. The consensus of all working groups was that people will continue to go as far as necessary into the habitat to collect tortoises, and that there are no remote core areas that could be considered natural refugia due to their distance from developed areas and roads.

Following is a summary of each working group's discussion of these issues.

Resources Working Group Estimates

Population estimate

The current estimate of 12 million tortoises is too high; a better estimate is 5 to 7.5 million.

Current and projected range

The working group concurred in general with the current range indicated on the map, adding an additional area in the northeast portion of the range between Ebelo and Ifotaka and removing the extreme eastern tip approximately at the Mandrare River. The group did not have enough information to estimate future trends in habitat loss.

Harvest estimates

People will go anywhere to get tortoises and will continue to harvest tortoises until they are gone. Tortoises are collected by individuals who are hired by dealers in exchange for cash, and also are collected by family groups for their own consumption. People also collect small tortoises, however, these tend to be outsiders, not local people.

One shipment of tortoises that was intercepted in Antanosy last year contained approximately 4,000 tortoises (based upon about 27 tortoises per sack x 150 sacks). Group members adjusted the harvest rates as follows:

Collection area	Prelim. Est.	Est. from Group	Justification
Toliara	46,500	139,500	Questionnaire underestimates harvest (3x higher due to 3 main holidays)
Fort Dauphin	40,000	46,500 Toliara	in taboo region; consumption is 1/3 of
Antanosy	20,000	40,000	Used to collect Nov. to Feb., but now collect longer (to July)
Mahafaly/Androy (5 areas)	10,000 (5 x 2,000)	5,000 (5 x 1,000)	Consume less tortoise in this area
Ambovombe	1,000	2,000	Consume more tortoise in this area
Misc. villages	20,000	8,000	
Total population	137,500	241,000	

Collaboration Working Group

Population estimate
Estimated population size is 4 to 5 million tortoises. This estimate is based on data on tortoises in the Tsihombe area gathered before the workshop, and then extrapolated across the range.

Current and projected range
The working group concurred with most of the current range indicated on the map, but revised the eastern portion of the range. An additional area was added to the northeast, from Ankiliboba north to Imanombo, east to Andranofotsy, south past Ifotaka, and southwest to Amborekahaka, and eliminating the most eastern tip of the suggested range. The working group projected that within the next five years tortoises may be lost from Tsimanampetsotsa National Park south of Toliara, as this area may lose its protected status. This was roughly estimated to represent 10% of the current range; loss of this habitat would fragment the population, with about 20% of the current range remaining to the north and 70% to the south and east.

Harvest estimates
People will continue to harvest tortoises until they are gone. Small tortoises are harvested but to a lesser degree than large tortoises. There have been concerted efforts to reduce trade in tortoises in Fort Dauphin (which is about 1/5 of the size of Toliara).

Group members quote a known instance in which 50 carts, carrying 50 tortoises each, were observed in one trip, and used this figure in considering some of their harvest estimates.

Collection area	Prelim. Est.	Est. from Group	Justification
Toliara	46,500	2,400	50 tortoises x 6 boats x 4 holidays x 2 trips
Fort Dauphin	40,000	5,760	10 tortoises x 6 cars x 4 holidays x 24 trips
Antanosy (outside range)	20,000	5,600 collectors)	50 tortoises x 50 carts x 2 trips 50 tortoises x 6 carts x 2 trips (new
Mahafaly/Androy (5 areas)	10,000 (5 x 2,000)	6,800 (3 x 2,000) (2 x 400)	 Tsihombe, Narohilo, Ampamily Androka, Itampolo
Ambovombe	1,000	1,000	
Misc. villages	20,000	0	
Amboasary - Atsimo	0	600	Ifotaka-Tranomaro-Ebelo
Total population	137,500	22,160	

Collection Working Group

Population estimate

The estimated current population of radiated tortoises is 2.5 million. This was calculated by dividing the range into three areas (north, central, and east), estimating the area of each, and applying different tortoise density estimates to these areas, as follows:

North: From Onilahy River south to the northern border of Tsimanampetsotsa National Park
Central: From north border of Tsimanampetsotsa NP to the Manambovo River east of Faux Cap
East: From the Manambovo River east to the Mandrare River

North: 100km coastline x 50km inland = 5,000km^2 x 50 tortoises/ km^2 = 250,000 tortoises
Central: 200km coastline x 50km inland = 10,000km^2 x 200 tortoises/ km^2 = 2,000,000 tortoises
East: 100km coastline x 50km inland = 5,000km^2 x 50 tortoises/ km^2 = 250,000 tortoises
Total: 2,500,000 tortoises

Current and projected range

The working group agreed with most of the current range indicated on the map, extending the north boundary to Ankazomanga and slightly further east north of the Linta River, adding the area around Tranoroa, and revising the eastern tip to include the mountainous area north of Ifotaka and ending at the Mandrare River. The addition of these areas increased the current estimated range by about 15%.

The group projected that tortoises would be extirpated from large areas of their current range within the next five years (estimated loss of 70%). Tortoises are predicted to be lost from the inland areas, with animals remaining only within areas about 30-40 km from the coast in the north and central areas, and about 20 km from the coast in the south.

Harvest estimates

People will continue to harvest tortoises and will go anywhere to collect them until they are all gone. They prefer large tortoises, but now are starting to collect small tortoises. The group predicts that as numbers of large tortoises decline, people will harvest smaller and smaller tortoises and possibly for different purposes (small tortoises are not necessarily eaten but are kept alive for the pet trade). It is not clear if the harvesters differentiate between tortoise species.

The group referred to one instance in which 500 tortoises were traded in one week in Antanosy and extrapolated that rate to year-round. Regarding the miscellaneous villages, there was information indicating that out of 30 villages, there was only one person in one village who collected tortoises. Group members adjusted the harvest rates as follows:

Collection area	Prelim. Est.	Est. from Group	Justification
Toliara	46,500	24,800	180 tortoises x 15 boats x 4 holidays x 2 trips 200 tortoises x 4 trucks x 4 holidays
Fort Dauphin	40,000	20,000	Similar reduction of O'Brien estimates as seen for Toliara
Antanosy	20,000	26,000	500 tortoises x 52 weeks
Mahafaly/Androy (5 areas)	10,000 (5 x 2,000)	12,000	Beloha: 1600 tortoises Tsihombe: 2000 tortoises Betioky: 8 tortoises/day x 365 days = 2920 Ampanihy: 15 tortoises/day x 365 = 5475
Ambovombe	1,000	1,000	
Misc. villages	20,000	350	200 villages / 30 x 1 tortoise x 52 weeks
Amboasary – Atsimo	0	3,650	10 tortoises/day x 365
Total population	137,500	87,800	

Habitat Working Group

Population estimate

The working group participants discussed past and recent tortoise density estimates for the eastern part of the species' range. They decided to divide the range (approx. 600km long by 50km wide) into four sections, each with differing density estimates, as follows:

North: North of Toliara, extending south to Beheloka, approx. 100km long
North central: Beheloke south to Androka, approx. 150km long
South central: Androka, south to Henarandra/FTU, approx. 50km long
East: East of FTU (just west of Menarandra River), approx. 300km long

North: 100km coastline x 50km inland = 5,000km^2 x 20 tortoises/ km^2 = 100,000 tortoises
North central: 150km x 50km inland = 7,500km^2 x 50 tortoises/ km^2 = 375,000 tortoises
South central: 50km x 50km inland = 2,500km^2 x 100 tortoises/ km^2 = 250,000 tortoises
East: 300km x 50km = 15,000km^2 x 200-250 tortoises/ km^2 = 3,000,000-3,750,000 tortoises
Total: 3.725 to 4.475 million tortoises

Current and projected range

The working group generally concurred with the current range indicated on the map, but added areas to the north and east. The northern range border was extended to north of the Fiherenana River, while areas were added in the northeast portion of the range from north of Marotsiraka south to Ifotaka. This increased the current estimated range by about 15%. Areas in the eastern tip of the range may be somewhat fragmented.

Tortoises are predicted to be lost over the next five years from three areas: 1) the northern tip of the range (north of the Onilahy River); 2) coastal areas between Beheloka and Androka; and 3) the eastern tip of the range, east of the Mandrare River. This represents an estimated loss of 13% of the current range.

Harvest estimates

People will continue to harvest tortoises as long as any tortoises remain. Harvesting is organized, with trucks going by every 24 hours. Harvesters adapt to new conditions and challenges. For instance, as tortoises are extirpated from nearby areas, trucks are brought in so that they can go farther to collect tortoises. If enforcement is strengthened, then harvesters switch to transporting dried meat instead of live tortoises, which is more difficult to detect. People collect all sizes of tortoises, but there is less trade in small tortoises, and they are mostly sent out of the region. The group felt that this trend may change in the future, as smaller tortoises are easier to hide and can be sold.

Tortoise prices have increased in recent years as tortoises have become harder to find. The following prices are in Madagascar francs:

1998: 1,000 – 1,500 FMG/tortoise
2000: 2,000 – 2,500 FMG/tortoise
2005: 2,500 – 3,000 FMG/tortoise

As law enforcement has increased, harvesting activities have become more secretive, with poachers only selling to people who they trust. Because tortoise numbers are lower and they are harder to find, and because selling tortoises has become more difficult, harvest and trade in tortoises has decreased. In 2002, an estimated 60,000 tortoises were harvested from one area, while only 10,000 were harvested in 2005.

Group members adjusted the estimated harvest rates as follows:

Collection area	Prelim. Est.	Est. from Group	Justification
Toliara	46,500	10,000	6 holidays + 2 family events (more collecting groups than those interviwed)
Fort Dauphin	40,000	20,000	50% of estimate (lower because taboo to some, and others eat more lobster than tortoise
Antanosy	20,000	60,000	Hunting over larger range; most harvest is from July-March, but some harvest year-round (Dried meat, not live tortoises anymore)
Mahafaly/Androy	10,000	3,000	Estimate too high (from local participant); exchange tortoises for money or food
Ambovombe	1,000	1,000	Ambondro is providing tortoises to Ambovombe (specialty dish)
Misc. villages	20,000	0	
Total population	137,500	94,000	

Table 2. Estimated harvest rates, total population size, and predicted future trends in carrying capacity by working groups.

	Preliminary Estimates	**Resources Group**	**Collaboration Group**	**Collection Group**	**Habitat Group**	**Best Guess**
Harvest (annual)	137,500	241,000	22,160	87,800	94,000	60,560
Tulear	46,500	139,500	2,400	24,800	10,000	24,800
Fort Dauphin	40,000	46,500	5,760	20,000	20,000	5,760
Antanosy	20,000	40,000	5,600	26,000	60,000	13,000
Mahafaly/Antandroy	10,000	5,000	6,800	12,000	3,000	12,000
Ambohombe	1,000	2,000	1,000	1,000	1,000	1,000
Misc. villages	20,000	8,000	0	350	0	350
Amboasary/Atsimo	0	0	600	3,650	0	3,650
Population size (in millions)	11.4	5 – 7.5	4 – 5	2.5	3.725 – 4.475	4.5
Future trend in K (over next 5 years)	None	No opinion	Loss of 10%; fragment into 2 populations	70% reduction	13% reduction	10% reduction

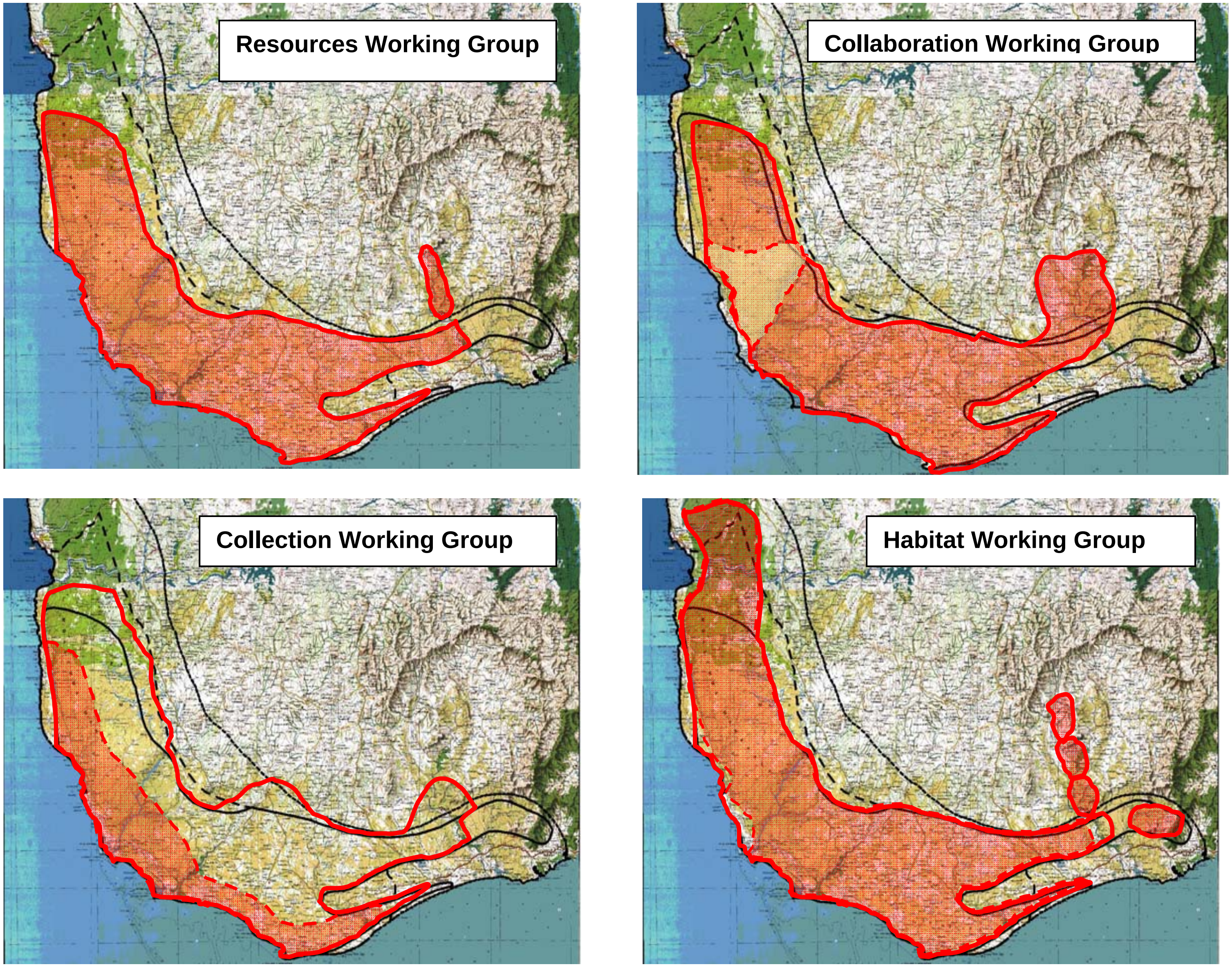


Figure 1. Current (solid red line) and projected future (shaded) range in five years of radiated tortoises in Madagascar estimated by each working group. Black lines represent estimates of historical range (small dashed) and ranges in 1975 (large dashed) and 2000 (solid).

Model Scenarios

Estimates made by the four working groups were considered by the modeling group and workshop organizers and evaluated in terms of the geographic expertise and other knowledge present within each working group. The best estimates in terms of population size and harvest rates were selected to develop a baseline (best estimate) model, which includes the minimum estimated loss of carrying capacity. Estimates for total population number varied from 2.5 to 7.5 million, all of which were significantly below the estimate of 12 to 54 million made by Leuteritz in 2000 based on extrapolation of transect data. The best estimate for annual harvest of radiated tortoises is about 60,560, which is somewhat higher than O'Brien *et al*.'s estimate of 45,000. Additional scenarios based on the range of estimates were also modeled to address the range of projected futures based upon participant information. These include using the numbers provided by each working group as well as a worst case scenario (see Table 3 for input values).

Additional scenarios were run using the baseline model and exploring the effect of reduction in harvest rates that may be achieved through increased law enforcement, reduced demand, education, and other management strategies.

Table 3. Input values for annual harvest, population size, and predicted future trends in carrying capacity for model scenarios.

	Baseline Model	**Worst Case**	**Resources Group**	**Collaboration Group**	**Collection Group**	**Habitat Group**
Harvest (annual)	60,560	241,000	241,000	22,160	87,800	94,000
Population size (in millions)	4.5	2.5	6.25	4 – 5	2.5	4.1
Future trend in K (over next 5 years)	2% annual loss x 5 yrs	14% annual loss x 5 yrs	None	2% annual loss x 5 yrs; two pops.	14% annual loss x 5 yrs	2.6% annual loss x 5 yrs

Model Validation

The final values used for the demographic rates describe a population that reasonably represents a relatively large, long-lived and slow reproducing tortoise species. Generation time (i.e., mean age of reproduction) is about 42 years, with a deterministic growth rate (r) of 0.007 and an annual growth rate of 0.7% in the absence of harvest. In one generation the population has the capacity to increase by 32%. Of those tortoises that reach at least one year of age, about 79% are immature (ages 1 – 19 years) and 21% are of breeding age ($\geq$ 20 years of age).

The demographic characteristics of this model population were examined to help validate the utility of this model in describing the radiated tortoise population. Leuteritz noted that adults represented 29.8% of tortoises captured during his study. He estimated that tortoises under 3 years of age were too small to be detected and captured. If only tortoises' ages 3 years and older are considered, the tortoise model represents a population with 28.2% of the population comprised of adults. This suggests that demographic rates used in the model produce a similar age structure as that observed by Leuteritz.

This species is slow to mature and reproduce, leading to a low population growth rate that is compensated for by a long life span. Although the growth rate is quite low (r = 0.007), the resulting net replacement rate R0 (per generation change) of 1.32 is comparable to that estimated for the gopher tortoise (*Gopherus polyphemus*) of R0 = 1.29, which has a higher growth rate (r = 0.011) but shorter generation time (23 years) (Miller *et al*. 2001). This slow growth rate means that population persistence and growth will be dependent upon relatively low adult mortality.

Age Structure of Harvested Tortoises

In discussions with the workshop participants it became clear that tortoises are not harvested randomly across age classes, but that large tortoises are preferentially harvested as a larger source of protein. Unfortunately, the simple demographic model initially used in this analysis harvested proportionately across a stable age distribution, resulting in adults accounting for only 21% of the harvest. To adequately incorporate the preferential harvest of adult tortoises, further analyses were accomplished using the *Vortex* simulation program (v9.57). No environmental variation was added to the model and no genetic effects (i.e., inbreeding depression) were included. Demographic stochasticity (probabilistic variation in birth and death rates) is inherent in the program, but is unlikely to have significant effects with these relatively large populations. *Vortex* is not able to model populations over 30,000; therefore all models were run with an initial population size and carrying capacity of 30,000 (which is $1/150^{th}$ of 4.5 million) and an annual harvest of 404 ($1/150^{th}$ of 60,560), and resulting population sizes in the output were multiplied by 150. Deterministic outputs of this model for generation time and population growth rate match those from the simple deterministic model.

Workshop participants estimated that harvested tortoises consisted of 5% juveniles (ages 1-8 years), 15% sub-adults (ages 9-19 years), and 80% adults (20+ years). Adults were harvested randomly across adult age classes, so older (i.e., larger) adults were not preferentially harvested over younger (smaller) adults but in proportion to their availability. If larger, older tortoises are more fecund and are harvested preferentially (O'Brien pers. comm.), the negative effects of harvest may be underestimated in the model.

Radiated Tortoise Model Results

Results of the baseline (best guess) model indicate a strong and constant decline in the radiated tortoise population driven by over-harvesting. Although the population declines, there is little risk of total extinction for the first 35-40 years. After that, however, extinction risk is high, with the probability of extinction reaching 100% by Year 50. Median time to extinction is 45 years.

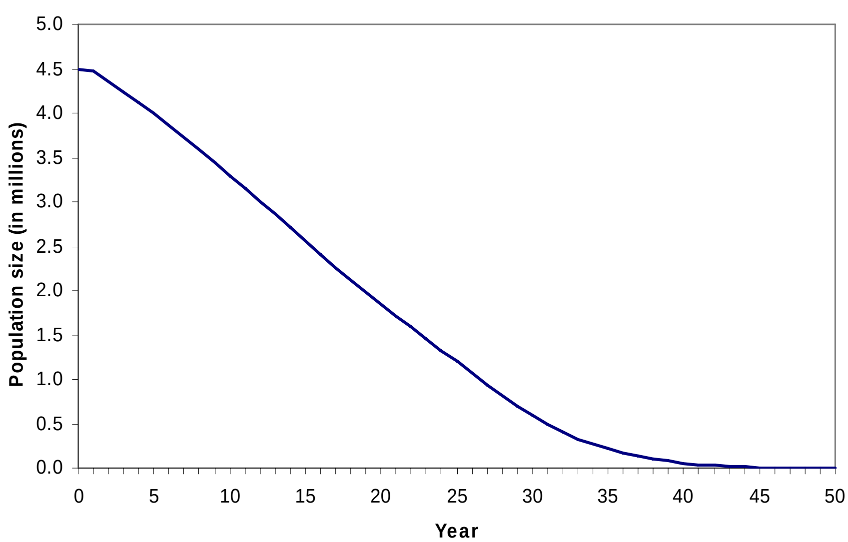


Figure 2. Projected number of radiated tortoises over the next 50 years assuming current estimated harvest rates.

This model incorporates a constant number of tortoises harvested each year for each age class. As the population declines, however, at some point there are fewer tortoises in a particular age class than are targeted to be harvested. The model does not compensate by removing tortoises from other age or sex classes; therefore, fewer tortoises are actually removed from the population than the designated harvest quota. In the *Vortex* model, the tortoise population reaches this point after about 25 years (Fig. 3).

Adult tortoises are particularly affected by harvest. Although adults make up about 20% of the harvested population (age 1 year or older), they are more desirable and are estimated to account for 80% of the harvest. As the population declines, a larger proportion of the adults are removed, leading to a skewed age structure with proportionately fewer and fewer adults (Fig. 4). After 30 years, there are fewer adults left in the population than are targeted to be harvested. In the model, this means that after this point: 1) all adult tortoises are harvested each year before they are able to breed; 2) there is no further successful reproduction; and 3) the total number of tortoises harvested declines significantly, since few adults remain. This may represent what might actually occur in the future – that at some point, if adult tortoises are no longer available, harvest rates may decline substantially but that some smaller tortoises will continue to be taken until tortoises disappear entirely. If the number of small tortoises harvested increases with the loss of adults, then the population would decline faster to extinction after 30 years than shown in Figure 2.

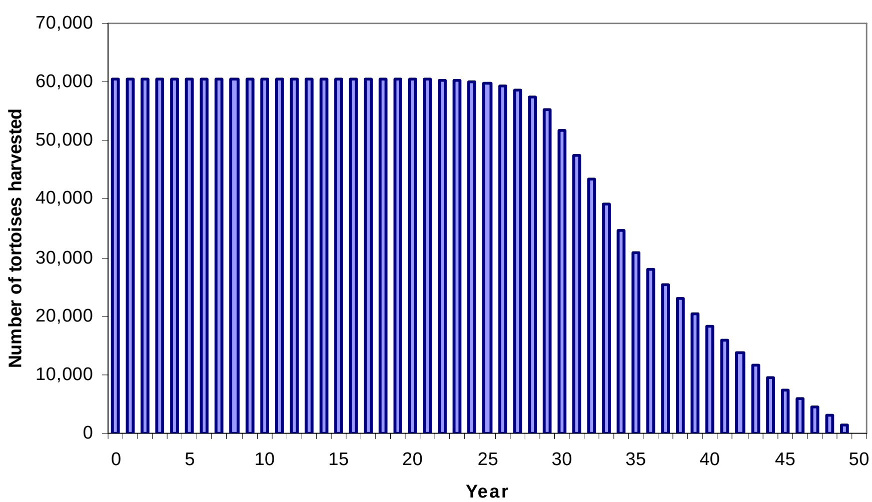


Figure 3. Number of radiated tortoises harvested over the next 50 years in the *Vortex* model, assuming current estimated harvest rates and age class preferences.

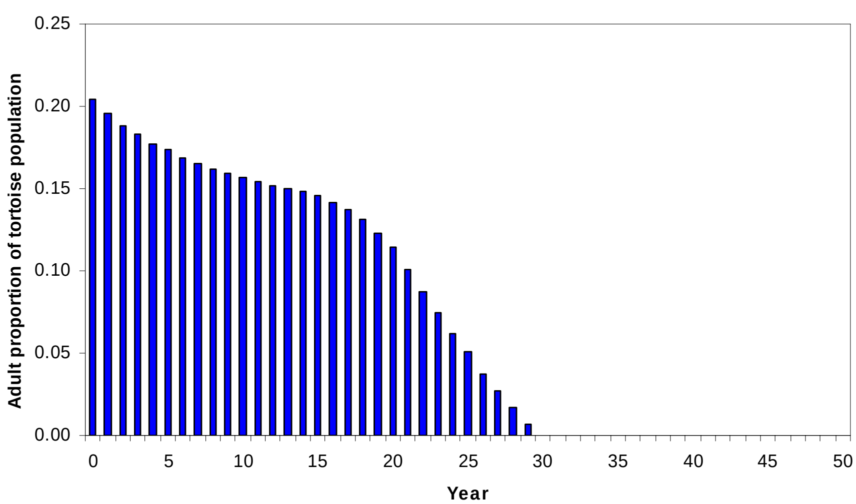


Figure 4. Proportion of tortoise population consisting of adult tortoises over the next 50 years assuming current estimated harvest rates.

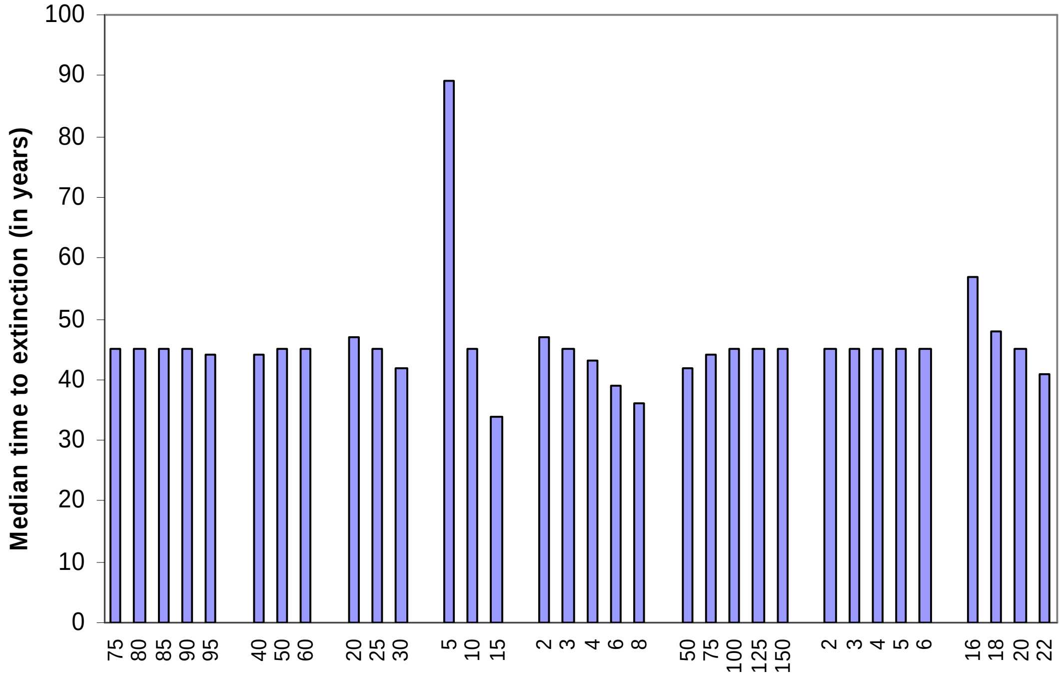
Sensitivity Testing of Demographic Rates

Many of the input values for demographic rates (reproduction and survival) are not accurately known for radiated tortoises and were based upon limited data, sometimes from closely related species. A sensitivity analysis was conducted that explored plausible values for these parameters to determine the effect of these uncertainties on the model results. Parameters tested were:

- Percent of females breeding (% Breed): 75, 80, 85, 90, 95
- First-year mortality (Hat Mort): 40, 50, 60%
- Juvenile mortality (Juv Mort): 20, 25, 30%
- Subadult mortality (Sub Mort): 5, 10, 15%
- Adult mortality (Adult Mort): 2, 3, 4, 6, 8%
- Maximum age (Max Age): 50, 75, 100, 125, 150 years
- Number of hatchlings produced per year (# Hatch): 2, 3, 4, 5, 6
- Age of first reproduction (First Repro): 16, 18, 20, 22 years

Almost all of the input values considered had no effect on the viability of the tortoise population. With one exception, the probability of extinction (PE) is 100% within 100 years for the values tested. Lower mortality and/or higher reproduction in some cases slowed population decline, slightly increasing the number of years before population extinction (Fig. 5). Decreasing subadult annual mortality from 10% to 5% did reduce PE over 100 years to 68%, as this means that more tortoises reach adulthood to augment the heavily harvested adult population. However, the projected population still declines and ultimately goes extinct under baseline conditions (median time to extinction = 89 years). Adult mortality in the baseline model is already low, and reduction from 3% to 2% has little effect in the presence of heavy adult harvest. Therefore, although there is some degree of uncertainty surrounding the demographic values used in this model, this uncertainty does not affect long-term population viability projections in the presence of harvest at the current estimated level.

Figure 5. Median time to extinction under various demographic rates assuming current estimated harvest rates.



irst Repro

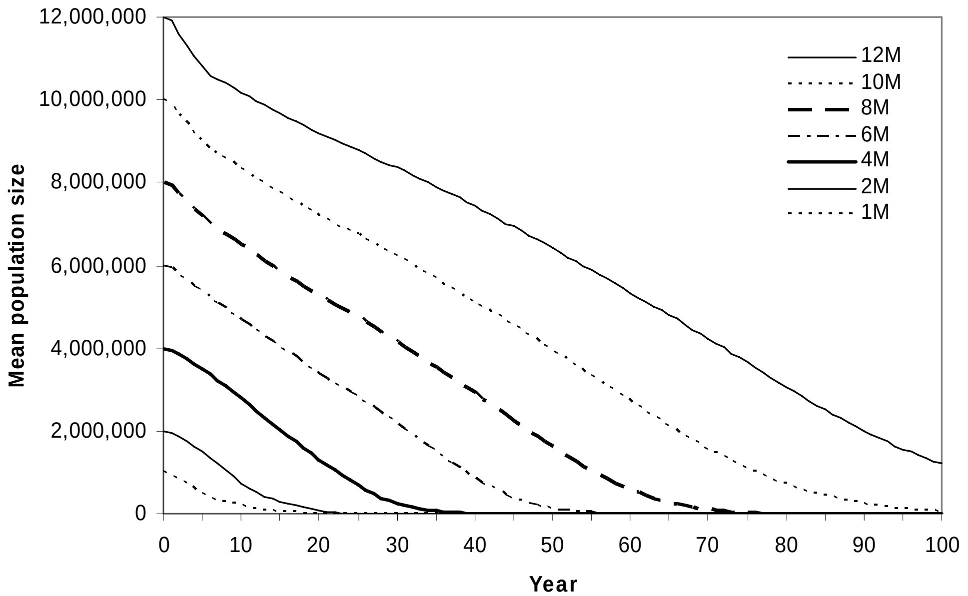


Figure 6. Mean population size over time for various initial population sizes of radiated tortoises assuming current estimated harvest rates.

Effect of Initial Population Size

Another source of uncertainty in model projections is the current size of the t Recent population estimates range from 1.6-4 million in 1995 (Lewis 1995) 2000 (Leuteritz 2005), and 2.5-7.5 million in 2005 by the PHVA workshop pa of initial population sizes (with corresponding carrying capacities) was analyz effect of population estimates on population viability.

All population sizes tested of 8 million or fewer tortoises resulted in 100% chance of extinction in 100 years. A population of 10 million is still at high risk (79%), while 12 million tortoises have a noticeably lower risk of extinction (27%) in 100 years (Table 4). The number of years until extinction was predictably longer for larger populations. However, all populations evaluated showed a negative growth rate indicating population decline; even a population of 12 million is projected to decline by about 90% over 100 years (Fig. 6). Therefore, even if the current number of tortoises is 12 million vs. the best estimate of 4.5 million, this population cannot sustain the current estimated level of harvest of about 60,000 tortoises annually.

Table 4. Model results (stochastic growth rate, probability of extinction, mean population size, and median years to extinction) over 100 years for various initial population sizes.

Population Size	Stoch r	PE	Mean N	Median TE
12 million	-0.044	0.27	1,202,796	---
10 million	-0.082	0.79	54,165	90
8 million	-0.111	1.00	0	72
6 million	-0.140	1.00	0	57
4 million	-0.193	1.00	0	41
2 million	-0.278	1.00	0	26
1 million	-0.315	1.00	0	21

Effect of Reduction in Range

There is evidence that the geographic range of the radiated tortoise in Madagascar has declined substantially in the past 150 years. Recent data suggest that the species' range contracted by 20% over a 25-year period (1975-2000), a rate of approximately 0.8% per year (O'Brien *et al*. 2003). Overgrazing, agriculture, charcoal production and over-harvesting are contributing factors.

Workshop participants believed that harvesting pressures concentrate on the more accessible portions of the tortoise range, and that tortoises have been and continue to be extirpated from some of these peripheral areas. Even if the habitat still may be able to support tortoises, human harvest pressures essentially reduce the carrying capacity of these areas for tortoises to zero, because all tortoises that may colonize these areas are removed. This process can be viewed as a loss of habitat and of carrying capacity for the tortoise population.

The baseline model includes a conservative estimate of 2% annual loss of carrying capacity (K) over the next 5 years (total of 10% reduction in K). Higher rates of loss and longer periods of time were explored to discern the effects on population viability. Annual loss of 2, 4, 6, 10, and 14% for 5, 10, 20, and 50 years were modeled; in some cases, these values lead to a complete loss of tortoise habitat. These effects were modeled as a constant linear loss of K; because tortoises may not be distributed uniformly over their range, this may not translate directly into a constant loss of area (habitat).

All models of range reduction resulted in 100% probability of extinction in 100 years given the current estimated annual harvest rate of 60,560 tortoises. Extending the annual 2% loss of K for longer than 5 years had no effect, suggesting that the estimated harvest rate is higher than that accounted for simply by range reduction. Higher rates of loss (≥4%) reduce the median time to extinction; this effect increases with continued loss of K for longer periods of time. This suggests that an annual loss of K of at least 4% represents a greater level of harvest than currently estimated. If such trends go unchecked, all habitats will be lost and all tortoises extirpated in as little as 18, 11 or even 9 years for rates of loss of 6%, 10% or 14% respectively (Fig. 7).

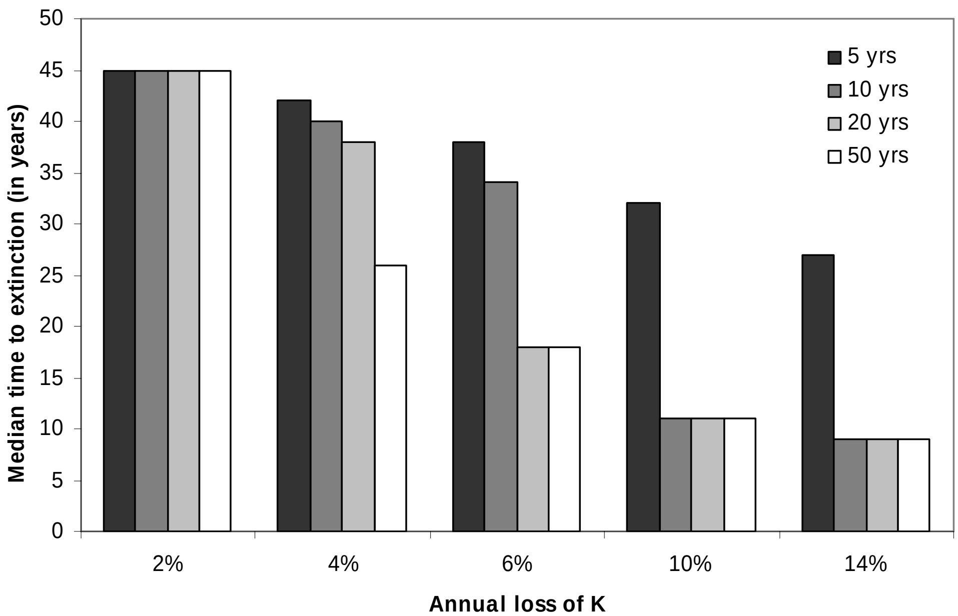


Figure 7. Median time to extinction for various annual rates of decline in K over 5, 10, 20 or 50 years assuming current estimated harvest rates.

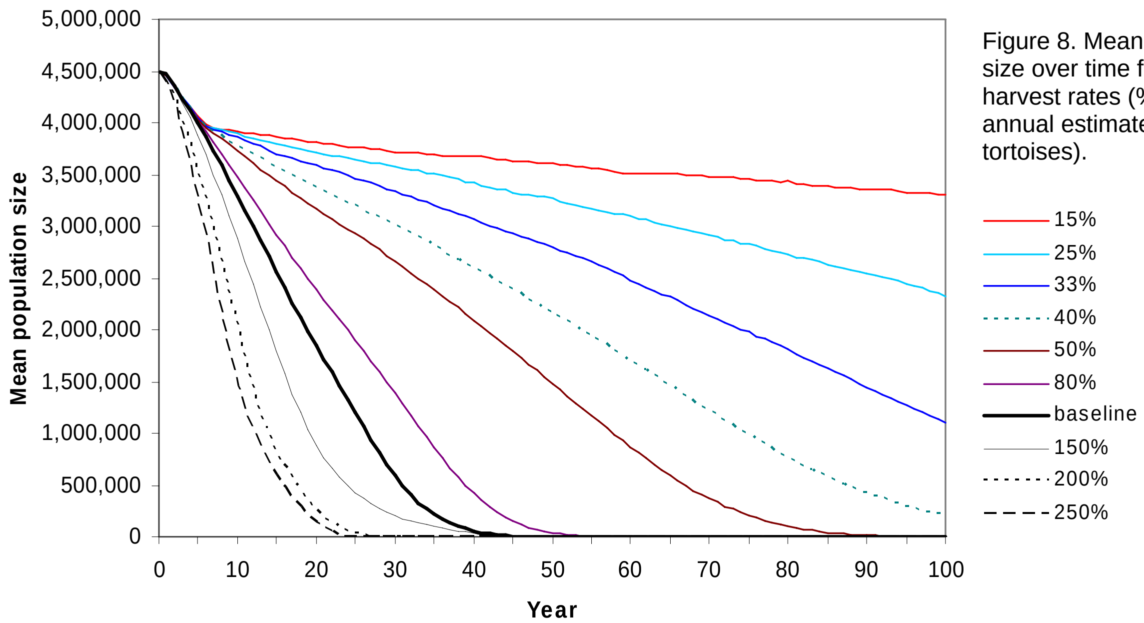


Figure 8. Mean population size over time for various harvest rates (% of current annual estimate of 60,560 tortoises).

Effect of Harvest Rates

Harvest is the driving factor in this model for the radiated tortoise population. As with other parameters, the number of tortoises harvested and the distribution of harvest across age classes has been estimated as accurately as possible by workshop participants, but the actual values are not known. Model results suggest that the radiated tortoise population cannot sustain the estimated rate of harvest. It is therefore valuable to explore alternative harvest rates to identify the importance of accurate harvest estimates, the level of harvest if any that the population can withstand, and the importance of targeting management strategies that reduce harvest rates.

Higher and lower annual harvest rates from 250% to 15% of the current estimate were evaluated for their impact on tortoise population viability. Higher harvest rates lead to faster population decline and shorter times to extinction (Fig. 8); for example, if the harvest rate is twice the current estimate, the median time to extinction is 28 years (Table 5). Extinction within about 100 years is essentially certain even with harvest rates only one-half of the current estimates. The risk of extinction begins to decline with a 60% reduction in harvest rates, and a 75% reduction in harvest leads to a PE = 0 and a mean population size of 2.3 million. Further reduction in harvest (<15% of current estimate, or about 9,000 tortoises) eliminates population decline and may approach sustainability in the absence of other significant factors or events.

Reducing the proportion of harvest that targets adult tortoises (from 80% to 50%) has little effect on population viability. In both cases, PE = 100%, while median time to extinction increases slightly from 45 to 49 years. Therefore, the model is less sensitive to the adult: immature harvest ratio (down to 50:50) than to the actual number of tortoises harvested. This factor may in fact have a greater impact than indicated in the model results if larger tortoises have greater reproductive success. In addition, the size of tortoises harvested may impact the spider tortoise population if these two species are indistinguishable to harvesters.

Table 5. Model results (stochastic growth rate, probability of extinction, mean population size, and median years to extinction) over 100 years for various harvest rates (in relation to current annual harvest estimate of 60,560 tortoises).

Harvest rate	Stoch r	PE	Mean N	Median TE
250%	-0.288	1.00	0	25
200%	-0.268	1.00	0	28
150%	-0.106	1.00	0	33
Baseline (100%)	-0.175	1.00	0	45
80%	-0.148	1.00	0	53
50%	-0.096	0.96	563	82
40%	-0.061	0.51	197,973	100
33%	-0.023	0	1,107,273	---
25%	-0.006	0	2,328,230	---
15%	-0.000	0	3,300,300	---

Effect of Recommended Management Actions

The working groups identified several management strategies designed to increase tortoise conservation and viability. Many of these recommended actions serve to reduce harvest levels, which the model suggests is a primary factor affecting tortoise populations in Madagascar. The estimated impact of individual actions varied from a 2% to 60% reduction in harvest. Model results suggest that less than 60% reduction in harvest will not significantly increase tortoise long-term viability. However, the cumulative effects of multiple conservation actions that together reduce harvest by 70% or more can dramatically change the future of tortoises in Madagascar, in this model from certain extinction in 50 years to over one million tortoises living 100 years from now. Likewise, without a significant reduction in harvest, actions to reduce the loss of carrying capacity or even to expand habitat and carrying capacity are unlikely to improve population long-term viability. When coupled with control of over-harvesting, however, these actions may make the difference between population decline and persistence.

Although the exact impact of recommended conservation actions can only be estimated by the working groups, the results suggest that no one action will sufficiently protect tortoises and that multiple effective conservation efforts will be needed to ensure the long-term persistence of this species. To prevent species extinction, it is vital to implement numerous potential strategies to reduce harvest and habitat loss to maximize their cumulative effects.

Range of Realities

Each working group developed their own estimates of population size, trends in carrying capacity, and harvest rates for radiated tortoises. Some groups were more optimistic, others more pessimistic regarding the status of tortoises. All of the analyses described to this point were based upon a baseline model using the best estimates across these groups and represent the best projections by the PHVA workshop participants on the future of the tortoise population. Additional projections were also made based on collective estimates of each individual working groups, and a worst case model was included using the most pessimistic estimates for each parameter (see Tables 1 & 3 for model input values).

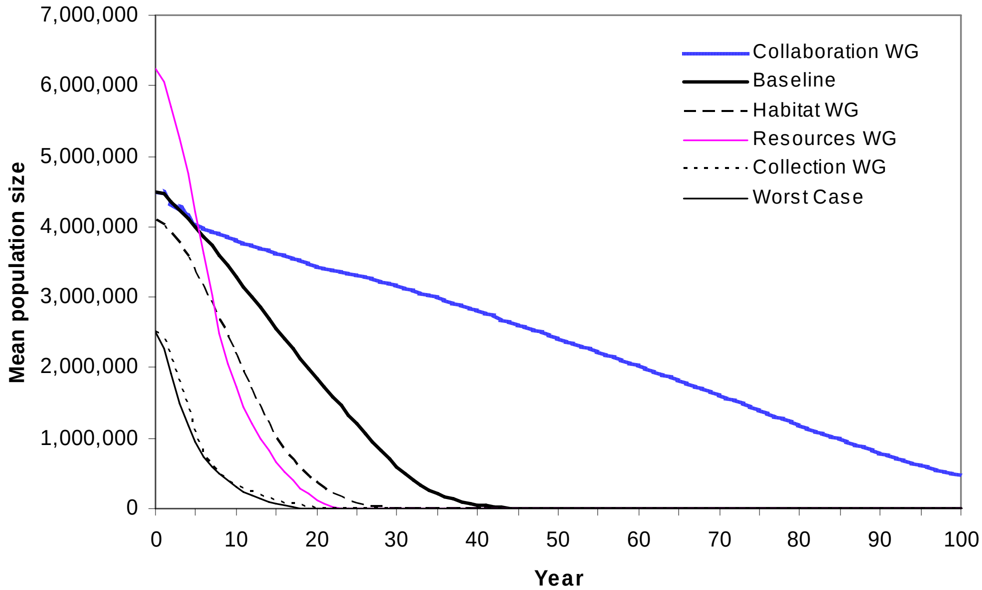


Figure 9. Mean population size over time based on estimates from each working group as well as the best (baseline) and worst case estimates.

Estimates made by three of the four working groups projected more rapid decline of tortoises than the baseline model and resulted in 100% probability of extinction (Table 6). Only estimates by the Collaboration Working Group led to the likelihood of population persistence (PE = 22% over 100 years), but still resulted in a population decline of over 90% (Fig. 9). The slower decline in this scenario is attributable to the relatively low harvest rate used by this group, which is only 37% of the best harvest estimate at the PHVA and about 50% of that estimated for Toliara by O'Brien in 2000. As expected, the worst case scenario leads to more rapid population decline, with a median time to extinction of only 20 years. These results suggest that the baseline model is not too pessimistic, but might even underestimate the decline and time to extinction of tortoise populations.

Table 6. Model results (stochastic growth rate, probability of extinction, mean population size, and median years to extinction) over 100 years based on the estimates of each working group compared to the best estimate (baseline) model and worst case scenario.

Scenario	Stoch r	PE	Mean N	Median TE
Baseline	-0.175	1.00	0	45
Worst case	-0.356	1.00	0	20
Resources WG	-0.294	1.00	0	24
Collaboration WG	-0.041	0.22	467,648	---
Collection WG	-0.300	1.00	0	22
Habitat WG	-0.254	1.00	0	30

Summary of Results for Radiated Tortoises

Field observations demonstrate declines in tortoise densities and a reduction in tortoise range that have continued over recent years. These observations match the baseline model results that project substantial tortoise population decline in the face of illegal harvest. All scenarios tested based on current estimated harvest rates project that the radiated tortoise population will continue to decline to extinction, likely within 50 years. Although better data on tortoise biology, population size and harvest rates would allow refinement of these projections, they are unlikely to reveal that this population is viable unless harvest is greatly reduced.

Tortoise population decline is being driven by over-harvesting, which currently overshadows the effects of habitat loss and fragmentation. Harvest rates may need to be reduced by 85% or more to halt this population decline. With the current population and harvest estimates, this translates to a loss of no more than about 9,000 tortoises per year, or only 0.2% of the population annually. Conservation actions that serve to significantly reduce the harvest of tortoises will be necessary to ensure the persistence of a viable radiated tortoise population into the future. Habitat conversion, fragmentation and other threats to the tortoise population should not be ignored, as they also affect population viability, especially if harvesting is not completely eliminated. It is likely that no single conservation action will sufficiently protect tortoises; therefore, multiple effective conservation efforts will be needed to ensure the long-term persistence of this species. To prevent species extinction, it is vital to implement all potential strategies to reduce harvest and habitat loss to maximize their cumulative beneficial effects.

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Spider Tortoise Baseline Model

The input parameters and values used for the spider tortoise baseline model are presented in Table 1. Below is a description of how these values were determined.

Demographic Rates

Annual age-specific mortality: *45% (0-1 yrs), 25.1% (1-4 yrs), 9.9% (5-11 yrs), 2.9% (12+ yrs)*
As was the case for radiated tortoises, there were no age-specific mortality data available for spider tortoises. The age-specific mortality rates based on mark-recapture data from ploughshare tortoises (*Geochelone yniphora*) (O'Brien pers. comm.) were also adopted for the spider tortoise model – with the following adaptations. The modeling group members considered it likely that hatchlings of spider tortoises have a slightly higher survival rate than those of radiated (or ploughshare) tortoises. Spider tortoises only lay one egg per clutch and this egg is relatively large in comparison to the adult animal. In turtles, egg size is an important factor determining hatchling size and larger hatchlings have higher survival rates (Janzen 1993). One might therefore assume that hatching rate and first year survival for spider tortoises are slightly higher than for radiated tortoises. The 50% first year mortality for ploughshare tortoises was adapted to 45% first year mortality for spider tortoises. First year mortality is taken to be from hatching onwards. This has as a consequence that the mean number of offspring per female per year will need to be translated into the mean number of hatchlings per female per year (i.e. taking into account the hatching rate of the eggs) (see below).

Young spider tortoises remain very vulnerable to predation until the age of about 5 years (because they are small and still relatively soft). Therefore, the age-specific mortality rate of 25.1% was maintained for age classes 1-5 (as for the radiated tortoises). The ploughshare tortoise had an Ox of 9.9% until the age of first reproduction. For spider tortoises the age of first reproduction was set at 12 years, and Ox from 5-12 years was therefore taken to be 9.9%.

Maximum age: *70 years*
Accurate longevity estimates for wild spider tortoises are not available. One hundred years was chosen as a reasonable estimate for maximum age for the radiated tortoise. Radiated tortoises are larger than, and therefore are expected to mature later and live longer than, spider tortoises. Gopher tortoises (*Gopherus polyphemus*) (smaller than radiated tortoises but larger than spider tortoises) were estimated to have a longevity of 60 years (Miller et al. 2001). Discussions at the workshop led to 70 years being chosen as the estimate for maximum age for the spider tortoise.

Age of first reproduction (females): *12 years*
The information in literature sources available to us at the time of the workshop is summarized in the table below. The information appears to be largely based on estimates, or assumed relationships between carapace length, growth rings on second costal scute, and age.

Reference	Age of (sexual) maturity
Jesu and Schimmenti 1995	Males 7 years; females 11 years
CBSG 2002	12
Glaw and Vences 1994	12-14
Madagascar CITES Scientific Authority and CITES Management Authority 2004	12
Species Survival Network 2004	12
Zwartepoorte and Behler (2005, pers. comm...)	14

Based on the table above, the working group participants decided to assume a mean age of first reproduction (i.e., age at which eggs hatch) for females of 12 years.

Percent of females breeding: *82%*
Due to lack of information for the spider tortoise, the percentage estimated by Leuteritz for radiated tortoises (based on field observations), was maintained for the spider tortoise, i.e. 82% of females breeding.

Sex ratio of hatchlings: *1:1*
During a one-week census of a population of *P. a. arachnoides* inhabiting the coastal dunes south of Onilahy river, Jesu and Giovanni (1995) found 52% males, 46% females and 2% juveniles among the 54 animals measured. This translates in a male to female ratio of 1:0.86. Keeping in mind the short term and small sample size of the study and in the absence of other data to the contrary, an equal sex ratio at birth was adopted for the model.

Mean number of hatchlings/female/year: *1.79*

Clutch size: 1
Female spider tortoises' lay one, relatively large (25-30 x 33-35 mm; ~17 gram) egg, per clutch (Bour 1981; Durrell *et al*. 1989; Castellano and Behler 2003).

Number of clutches (and therefore eggs) per year: 2.38
It still remains unknown how many clutches female spider tortoises produce per year in the wild. No information was found in the literature and the workshop participants could not help with personal experience. In fact, many workshop participants were not aware of there being two species of tortoise in the area, indicating that adult spider tortoises are likely often confused for young radiated tortoises. Spider tortoises estivate during the dry period (April/May to November/ December) and are active during the wetter season (Durrell *et al*. 1989). However, depending on the circumstances, they, like the radiated tortoises, may well remain active for some time past April. In any case, there is time for more than one clutch to be produced.

Zwartepoorte (2003) reports a series of clutches for two captive female *P. a. arachnoides* – each clutch counting one egg (Table 7). Based on these data, an average of 2.63 clutches per year can be calculated. One female *P. a. brygooi* produced 2 clutches per year for five years (one egg/ clutch). This gives an average of 2 clutches per year. Because data are still too fragmentary to prove true differences between subspecies, an average value for the two subspecies of 2.38 clutches per year was used.

Number of hatchlings per year: 1.79

No data are available on the hatching rate of spider tortoises in the wild. Rather than taking hatching rates from captivity, where incubation is usually artificial and relatively unsuccessful, it was decided to base hatching rates on those for wild radiated tortoises.

Table 7. Eggs laid by *P. a. arachnoides* females 1 & 2 between February 1998 and July 2001 (from Zwartepoorte, 2003) (* = assumption made by Leus during the PHVA workshop, largely based on the fact that it is unlikely that one female will produce two clutches only a few days apart)

Egg Lay Date	Female #
2/14/1998	1
7/14/1998	2
8/24/1998	? (assumed 2)*
2/20/1999	1
3/19/1999	2
5/4/1999	1
6/29/1999	1
6/30/1999	2
7/21/1999	2
9/9/1999	? (assumed 1)*
9/28/1999	? (assumed 2)*
8/6/2000	2
8/28/2000	? (assumed 2)*
8/30/2000	? (assumed 1)*
9/15/2000	? (assumed 2)*
9/18/2000	1
11/5/2000	2
11/5/2000	1
1/16/2001	1
2/1/2001	2
7/2/2001	1

Leuteritz (2002) found that in 1999 65.6% of radiated tortoise eggs hatched and in 2000 66.7%. This results in an average hatching rate of about 67%. Leuteritz saw no natural nest predation during his study on radiated tortoises at Cap Sainte Marie. Nest disturbance was anthropogenic, mostly unintentional and unnoticed by the people (carts driving over them, fishermen building fires on them, etc). We therefore assumed that the same natural environmental and unintentional anthropogenic factors are playing on the eggs of the spider tortoise, as are on those of the radiated tortoise, and that hatching rates are similar.

With one egg per clutch, 2.38 clutches per year times and a hatching rate of 0.67: 1 x 2.38 x 0.67 = 1.59 hatchlings per female per year.

However, spider tortoises only lay one egg at a time and this egg is relatively large in comparison to the adult animal. Larger eggs may produce larger hatchlings with higher survival rates (Janzen 1993). One might therefore assume that hatching rate and first year survival for spider tortoises are slightly higher than for radiated tortoises. It was decided to assume a hatch rate of 0.75 instead of 0.67.

One egg per clutch, times 2.38 clutches per year, times a hatch rate of 0.75 (instead of 0.67) results in: 1 x 2.38 x 0.75 = 1.79 hatchlings per female per year.

As the first year mortality is taken to be from hatching onwards, it is the mean number of hatchlings per female per year that is entered into the model, rather than the mean number of eggs per female per year.

Catastrophes

As for the radiated tortoises, one catastrophe was included in the model to represent a severe drought, and was defined as:

- probability of occurrence in a given year of 5% (i.e., mean occurrence of once every 20 years);
- 50% reduction in reproduction (percent females breeding) during the year in which the catastrophe occurs; and
- 10% reduction in survival (all age classes) during the year of occurrence

Population-Specific Parameters

Total population size: *94,000 / subspecies*

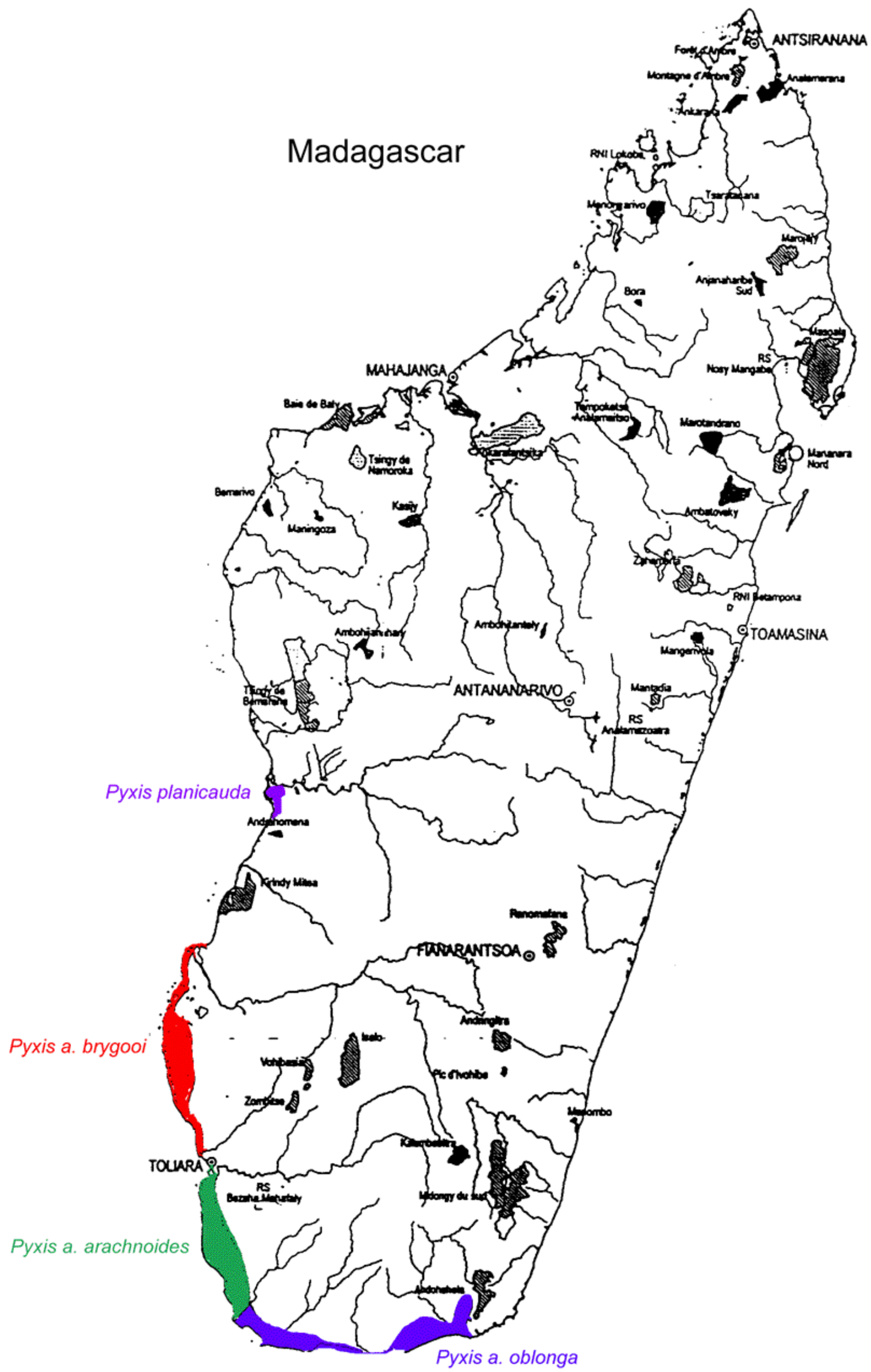
No significant quantitative survey of the spider tortoise has ever been carried out. There is therefore no scientific estimate of the current population size. Because a large proportion of the workshop participants were not aware of the existence of the spider tortoise, no estimates could be obtained through interviews (as were conducted for the radiated tortoise). It was therefore decided to base the baseline model on the relative proportion of spider tortoises to radiated tortoises captured during the study by Leuteritz *et al*. at Cap Sainte Marie: 1438 radiated tortoises were captured and 90 spider tortoises (Leuteritz *et al*., 2005; Leuteritz, pers. comm.). Based on these results, the density of spider tortoises at Cap Sainte Marie is 6.26% of the density of radiated tortoises, assuming that both species have the same capture probability. Whether this assumption is valid still remains a matter of investigation. Spider tortoises are smaller than radiated tortoises and there is a possibility that the former are somewhat less “detectable”.
The baseline model for the radiated tortoise takes an initial population size for this species of 4.5 million. If we assume the same relative density of spider tortoises to radiated tortoises across the range (again an assumption that remains to be tested), this results in an initial population size of 281,700 spider tortoises.

However, currently three subspecies of the spider tortoise are recognized (Bour 1978, 1981; Castellano and Behler 2003.) (see Fig. 10 for distribution):

- *P. a. brygooi*: Most northern subspecies. No blotches on plastron and no, or imperfect, hinge.
- *P. a. arachnoides*: Southwestern subspecies. No blotches on plastron and hinged forelobe.
- *P. a. oblonga*: Southern subspecies. Black blotches on plastron and highly flexible hinge allowing forelobe of plastron to be moved up to close off the front of the shell.

Because the three distribution areas appear of similar size, and due to a lack of census/density data, it was decided to split the estimated total population size evenly across the three subspecies. Each subspecies was therefore considered to have population size of 281.700 / 3 = ~94,000 tortoises.

Figure 10. Distribution of the three subspecies of *Pyxis arachnoides* (CBSG, 2002; Castellano and Behler 2003)



<u>Harvest rates:</u> *P.a.a. 2200 /yr, P.a.b. 1800/yr, P.a.o 1000/yr.*
Very little information is available on the rate of harvesting of spider tortoises.
The majority of the harvest appears to be for the international pet market (Walker *et al.* 2004).

The pet trade appears to have increased from about the year 2000. From 1980 – 1999, a total of 218 *P. arachnoides* were reported as exported from Madagascar, whereas in the years 2000 and 2001, the total was 3096 individuals, of which 2634 were exported in 2000 alone (Walker *et al.* 2004). 99.2% of all spider tortoises recorded in global movements were recorded as wild caught or not specifically recorded as captive born. Of the wild caught specimens directly exported from Madagascar, 98.6% were declared to be exported for trade purposes. Apart from the legal trade, confiscations attest that there is also an as yet unidentified level of illegal trade (for example, 218 *P. arachnoides* were seized on La Réunion in 2002 (Walker *et al.* 2004; UNEP WCMC)). Participants at the workshop also confirmed that international traders attempt to export live animals illegally, for example by boat. The reported legal exports from Madagascar decreased significantly after a peak in 2001, and the species was moved from Appendix II to Appendix I of CITES in 2004.

A large proportion of workshop participants, and therefore likely a large proportion of the inhabitants of the distribution area, are not aware of the existence of two tortoise species in the region. Furthermore, anecdotal evidence (Jesu and Schimmenti 1995; Behler 2000) and workshop participants' experience (see interviews of working groups in radiated tortoise modelling report) indicate that sometimes smaller tortoises are harvested once the majority of the adult radiated tortoises have been removed from an area. It is therefore not unlikely that, to a certain extent, adult spider tortoises are harvested for food in those areas where the larger adult radiated tortoises have become rare.

Considering the continuing demand for the species in the exotic pet business, the experience with illegal trade, and the likelihood of the species also being captured for food once adult radiated tortoises have become rare in an area, the workshop participants thought it realistic that a total of 5000 spider tortoises per year were harvested. Because both export and seizure data often do not record the subspecies involved, no information is available on the proportional catch of the different subspecies. Workshop participants felt that *P.a.a.* was probably harvested most (2200 individuals/year), closely followed by *P.a.b.* (1800/year), with a lower harvest for *P.a.o* (1000/year).

<u>Habitat loss:</u> *-2% for 5 years*
No scientific data are available on the loss of spider tortoise habitat over time. Workshop participants indicated that habitat loss for the spider tortoise is mainly in the form of human settlement and disturbance, and to only a lesser degree in the form of clear cutting. This due to the fact that the spider tortoises live in a relatively narrow strip along the beach with a very sandy soil, that is less suitable for agriculture.

For the related species *Pyxis planicauda,* with a distribution area to the north of *P.a.b.*, a decline in habitat loss of 32% between 1960 and 1993 has been estimated (Tidd *et al.* 2001). For the radiated tortoise, a species that shares at least part of its distribution area with the spider tortoise, a habitat loss of 20.9% from 1975 to 2000 is reported in O'Brien et al. (2003) and a loss of

2%/year for the next 5 years was taken for the baseline model during the PHVA workshop, based on the interviews with the workshop working groups (see model report for radiated tortoise).

For the baseline model for the spider tortoise a habitat loss of 2% for 5 years was modeled, as was chosen for the radiated tortoise.

Model Validation

In the absence of harvest or habitat loss, the final values used for the demographic rates describe a population with a deterministic growth rate (r) of 0.012, a generation time (i.e., mean age of reproduction) of about 32 years and a generation growth rate of 44%. Of those tortoises at least one year of age, about 62% are immature (ages 1-11) and 38% are of breeding age (12+ years).

No reliable field data are available to validate this model specifically for the spider tortoise. During a very brief (one week) survey Jesu and Schimmenti (1995) found that only 3.7% of individuals (2 out of 74) had an age ranging between 0 and 7 years. This would be unsustainable and therefore reflects lower detection rates of these age classes with the methods used and/or harvesting of the lower age classes. Jesu and Schimmenti detected ample evidence of bushpig (*Potamochoerus larvatus*) tracks in the area, which they presumed may have been responsible for the low recruitment of the spider tortoises, possibly combined with collection of young individuals for the pet trade. Leuteritz (pers. comm.) on the other hand found no evidence of natural egg predation in the bushpig-free study area at Cap Sainte Marie. Because predation by bushpigs may not be a problem in all regions of the distribution area of the spider tortoise, it was decided to model possible effects of this, and the harvest for pet trade and food, in the harvesting scenarios of the model.

In comparison with the radiated tortoise baseline model results, the spider tortoises have a somewhat higher growth rate (r= 0.012 compared to 0.007), which may be expected for a species with a shorter life span (70 compared to 100 years) and generation time (32 compared to 42 years). Spider tortoises only lay one egg per clutch, but this was partly compensated by a higher hatch rate and first year survival rate.

Age Structure of Harvested Tortoises

In contrast to the radiated tortoises, it is likely that for the spider tortoises relatively more juveniles than adults are being harvested. Young spider tortoises are preferred for the pet trade, predators (e.g. bushpigs) prefer young individuals as these are still “soft”, and the harvest of adult spider tortoises appears to be a relatively limited phenomenon for the time being. In the simple demographic model used, harvest is applied randomly over age classes. This means that for any given harvest rate, more juveniles than adults will be harvested (because there are more individuals in these lower age classes). This appears to be in line with what happens to the spider tortoises in Madagascar.

Spider Tortoise Model Results

The results in Figure 11 indicate that the harvest rate is the predominant factor determining the fate of the spider tortoise populations. A reduction in habitat of 2% for five years (translated as a reduction in carrying capacity K) does not cause extinction as long as the harvest rate stays within limits. With a harvest rate of 1000 individuals per year, as was thought to be the case for

P. a. oblonga, the population will sustain itself at carrying capacity (with or without habitat loss). A harvest of 1800 individuals per year, as presumed for *P. a. brygooi*, causes the population to go extinct after 82 years (or slightly earlier, at 73 years, if habitat loss is added). Naturally, a harvest of 2200 individuals per year for *P. a. arachnoides* causes extinction even sooner, at around 60 years.

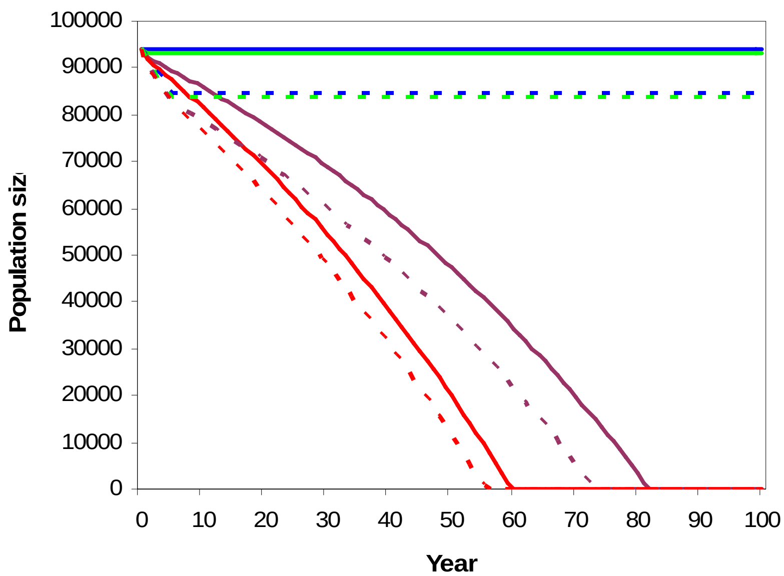


Figure 11. Population size over time based on estimates for harvest rates for the different subspecies: *P.a.o.* (1000/yr); *P.a.b.* (1800/yr), *P.a.a.* (2200/yr), with and without habitat loss of -2% for 5 years.

Effect of Harvest Rates

For the different subspecies, all parameters of the baseline model are the same, except for the harvest level. The analyses for the different subspecies therefore effectively function as a kind of sensitivity analysis for the parameter "harvest rate".

Judging by Figure 11, a harvest rate of 1000 individuals/year would still be sustainable, but not a rate of 1800. An interesting and also useful question with regard to sustainable population management is what harvest level causes a negative population growth (and therefore eventually extinction of the population if that harvest level persists).

Table 8. Year of extinction and, where relevant, population size after 1000 years for different harvest rates (assuming a habitat loss of -2% for 5 years).

Harvest rate (individuals/year)	Year of extinction	N after 100 years.
1000	No extinction	83600
1050	295	78000
1100	220	68974
1200	161	50923
1300	131	32873
1400	112	14822
1500	98	0
1600	88	0
1800	73	0

With the current demographic parameters, the "tipping point" at which harvest causes a negative growth rate, appears to lie at around 1050 individuals per year (although this only causes extinction of the population after 295 years) (Table 8). The lowest harvest rate that causes extinction within 100 years is about 1500 individuals per year (extinction after 98 years).

In reality, one could expect the harvest rate to slow down once fewer tortoises remain because they become absent from the more accessible areas and/or they become harder to find. This might delay the time of extinction. However, this simple deterministic model does not take into account the fact that when populations become smaller and more fragmented, stochastic effects such as genetic drift, inbreeding and demographic stochasticity may put the population into an extinction vortex, thereby quickening the time of extinction. The times to extinction generated by the deterministic model therefore have to be taken as approximations. It is nevertheless useful to know that with the current demographic parameters and a loss of habitat of -2% for 5 years, a harvest of about 1050 individuals per year or higher causes a negative growth rate and extinction at some point in the future if that rate continues.

Sensitivity Testing of Demographic Rates

The majority of the demographic rates are not accurately known for spider tortoises. A sensitivity analysis was conducted that explored plausible values for these rates in order to test the sensitivity of the model to these uncertainties. Parameters tested were:

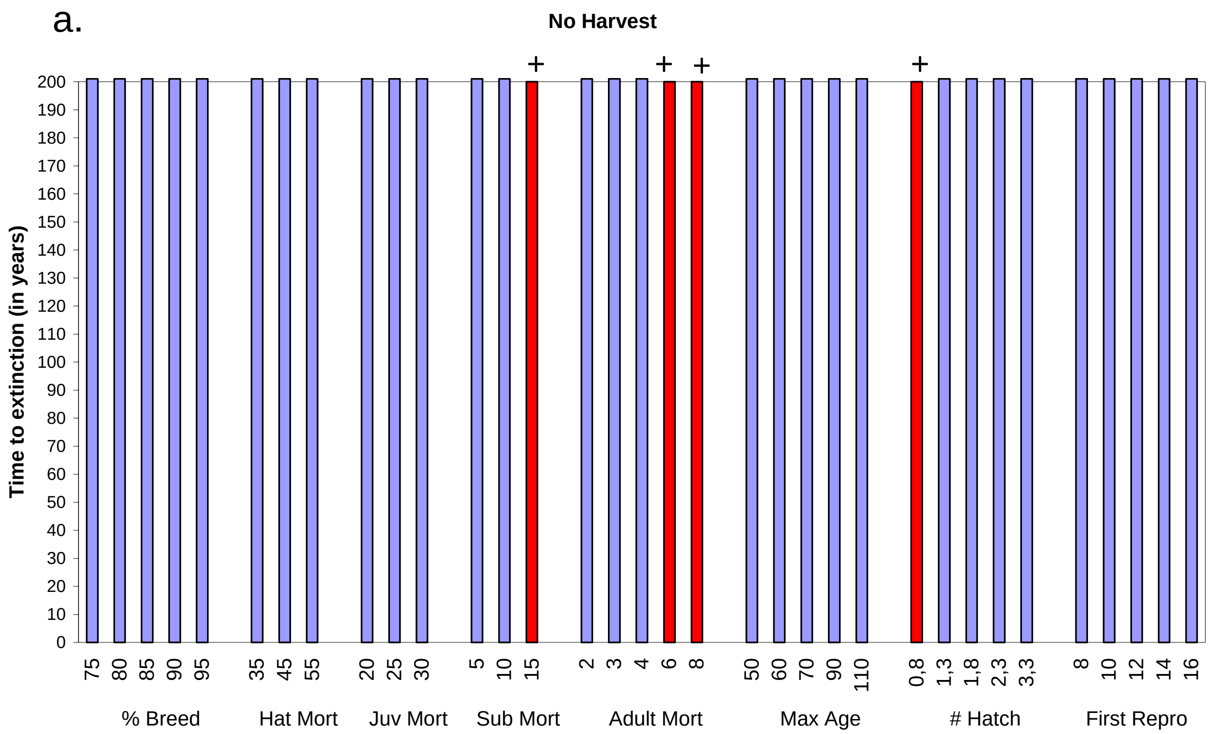
- Percent of females breeding (% Breed): 75, 80, 85, 90, 95
- First-year mortality (Hat Mort): 35, 45, 55
- Juvenile mortality (Juv Mort): 20, 25, 30
- Subadult mortality (Sub Mort): 5, 10, 15
- Adult mortality (Adult Mort): 2, 3, 4, 6, 8
- Maximum age (Max Age): 50, 60, 70, 90, 110
- Number of hatchlings produced per year (# Hatch): 0.8, 1.3, 1.8, 2.3, 3.3
- Age of first reproduction (First Repro): 8, 10, 12, 14, 16

In the absence of harvest, varying the input values had little effect on the viability of the tortoise populations. Only four populations went extinct (Sub Mort 15, Adult Mort 6 & 8, and # Hatch 0.8), in each case after more than 200 years (Fig 12a). With a harvest rate of 1000 individuals/year as was modeled for *P. a. oblonga*., the model appeared to be most sensitive to adult mortality. All adult mortality levels higher than 2% led to extinction at some time in the future (Fig 12b). For the other demographic parameters, even moving only one category away from the baseline value in the "negative direction" (i.e., increased mortality, fewer females breeding, lower longevity, fewer hatchlings, higher age of first reproduction) resulted in extinction. With increased levels of harvest, as was modeled for *P. a. brygooi* (1800 individuals/year) (Fig 12c) and *P. a. arachnoides* (2200 individuals/year) (Fig 12d), harvest becomes the overriding factor determining the fate of the population, and variations in the demographic rates cause relatively little difference in the outcome (extinction within 100 years in almost all cases).

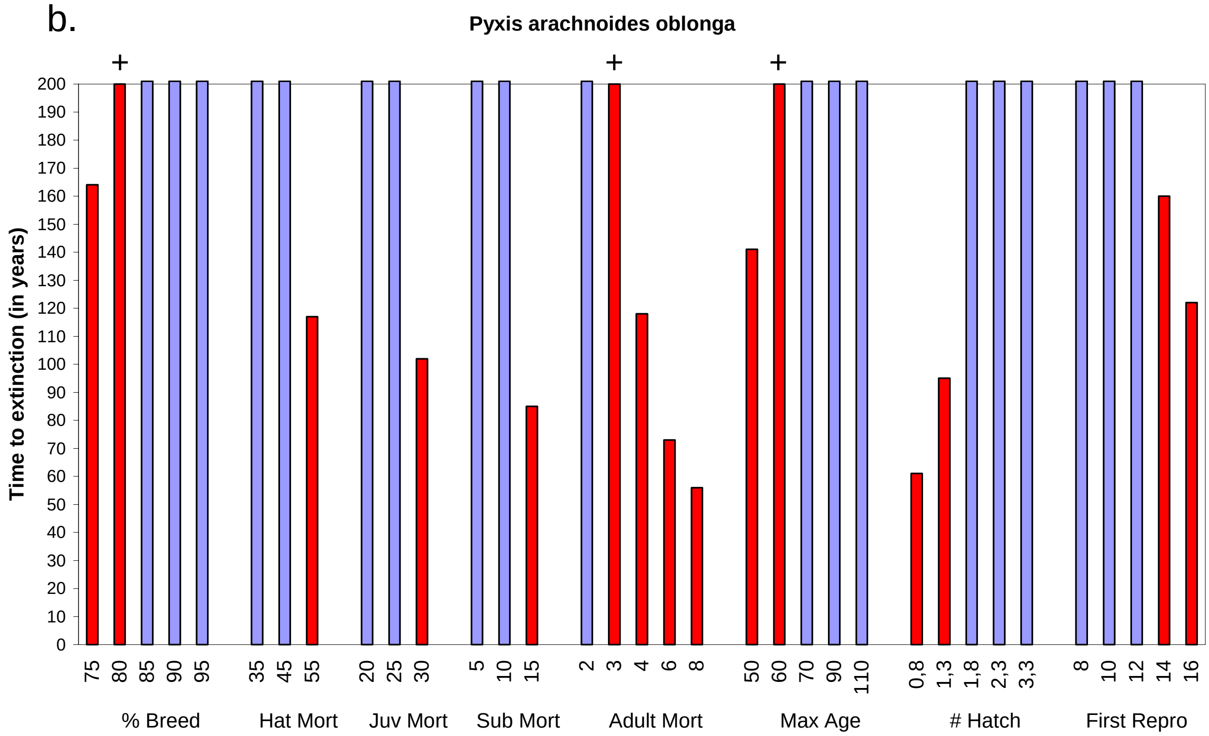
This long lived species with low reproductive potential (one egg per clutch and few clutches per year) can only sustain a relatively low amount of harvesting. For a more secure determination of this sustainable harvest level, it would be advisable to invest in research into the demographic parameters for this species.

Figure 12, a-d. Time to extinction under various demographic rates assuming a) no harvest; b) a harvest of 1000 individuals/year (*Pyxis arachnoides oblonga*); c) a harvest of 1800 individuals/year (*P. a. brygooi*); and d) a harvest of 2200 individuals/year (*P. a. arachnoides*). Blue bar = no extinction. Red bar = extinction. Red bar + = extinction after more than 200 years.

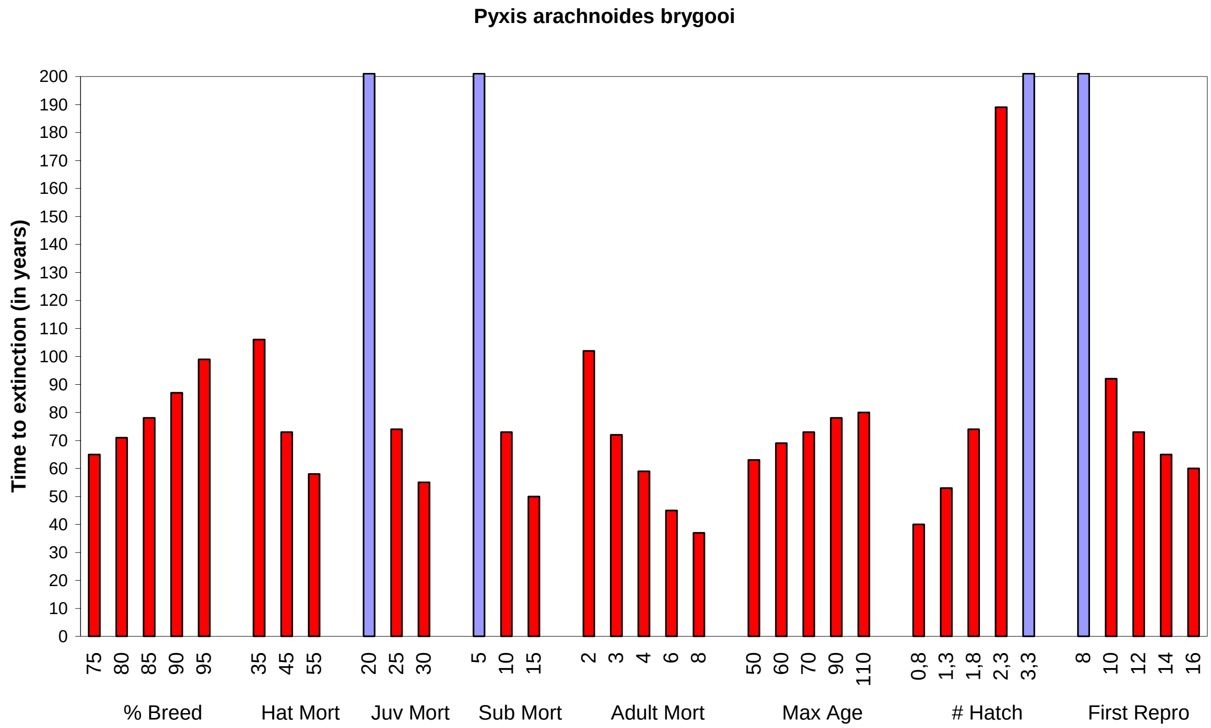
a.



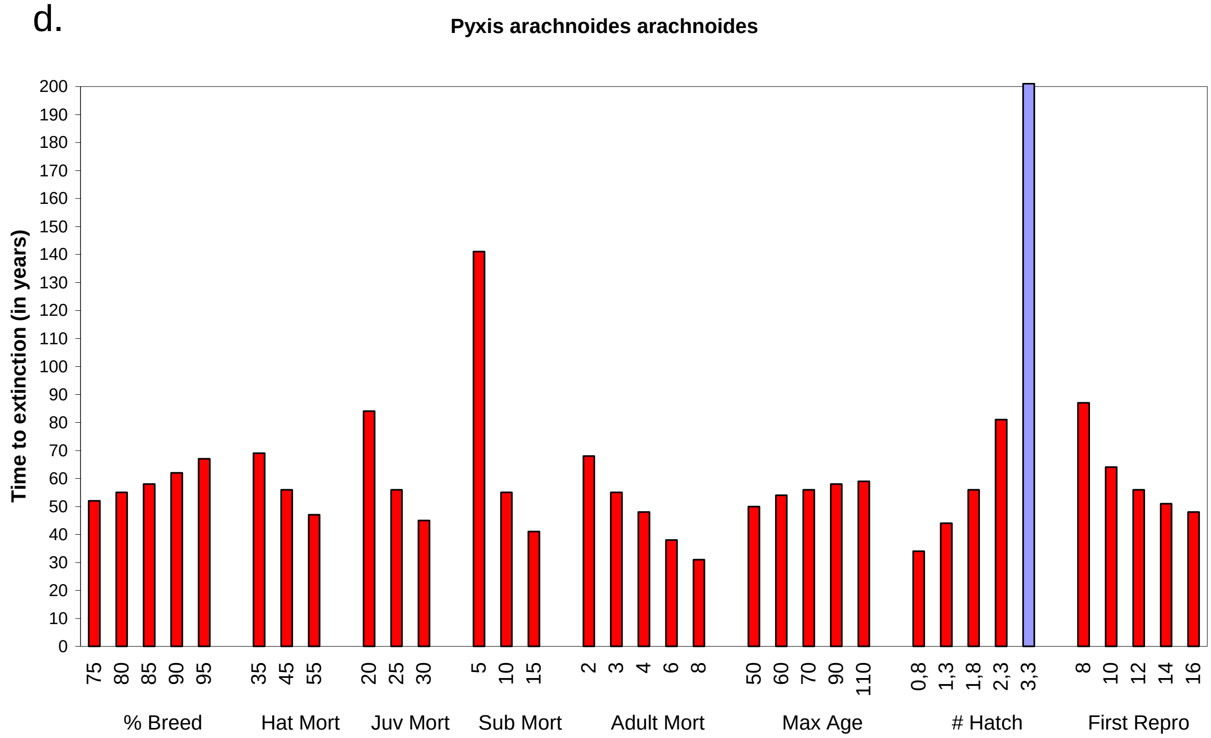
b.



c.


Pyxis arachnoides brygooi
Time to extinction (in years)
% Breed
Hat Mort
Juv Mort
Sub Mort
Adult Mort
Max Age
Hatch
First Repro

d.

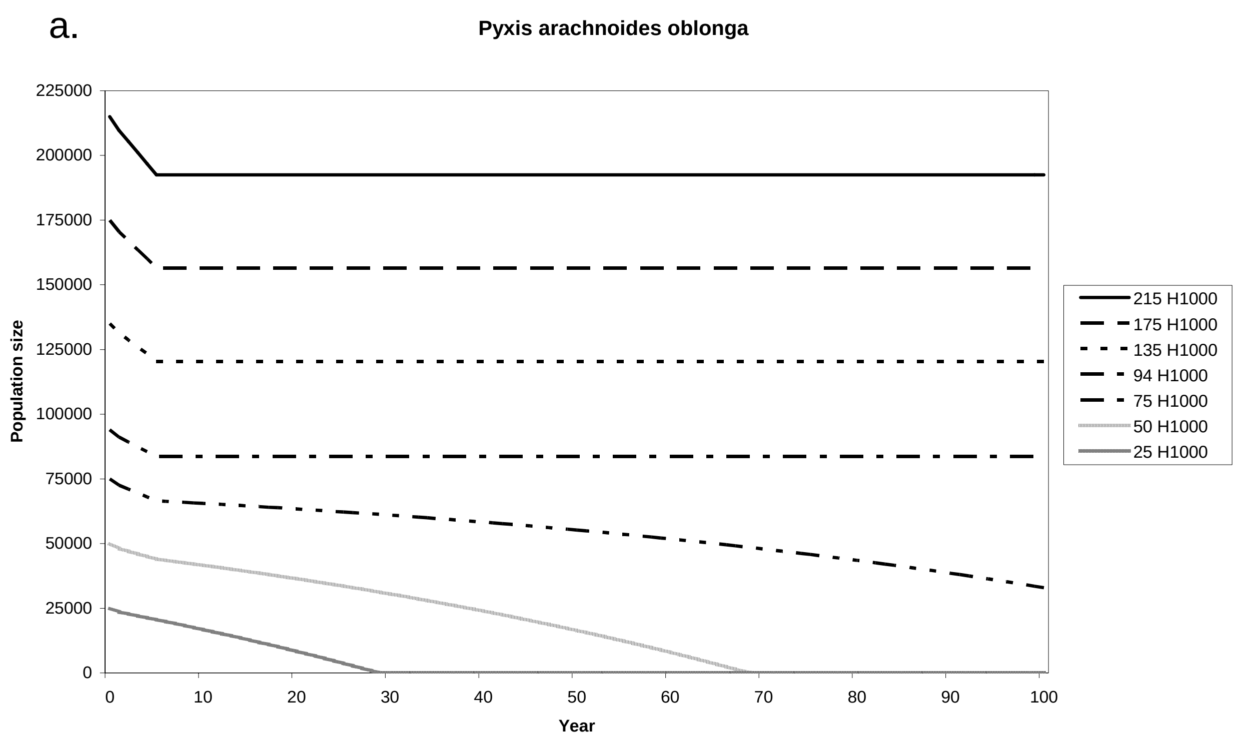

Pyxis arachnoides arachnoides
Time to extinction (in years)
% Breed
Hat Mort
Juv Mort
Sub Mort
Adult Mort
Max Age
Hatch
First Repro

Effect of Initial Population Size

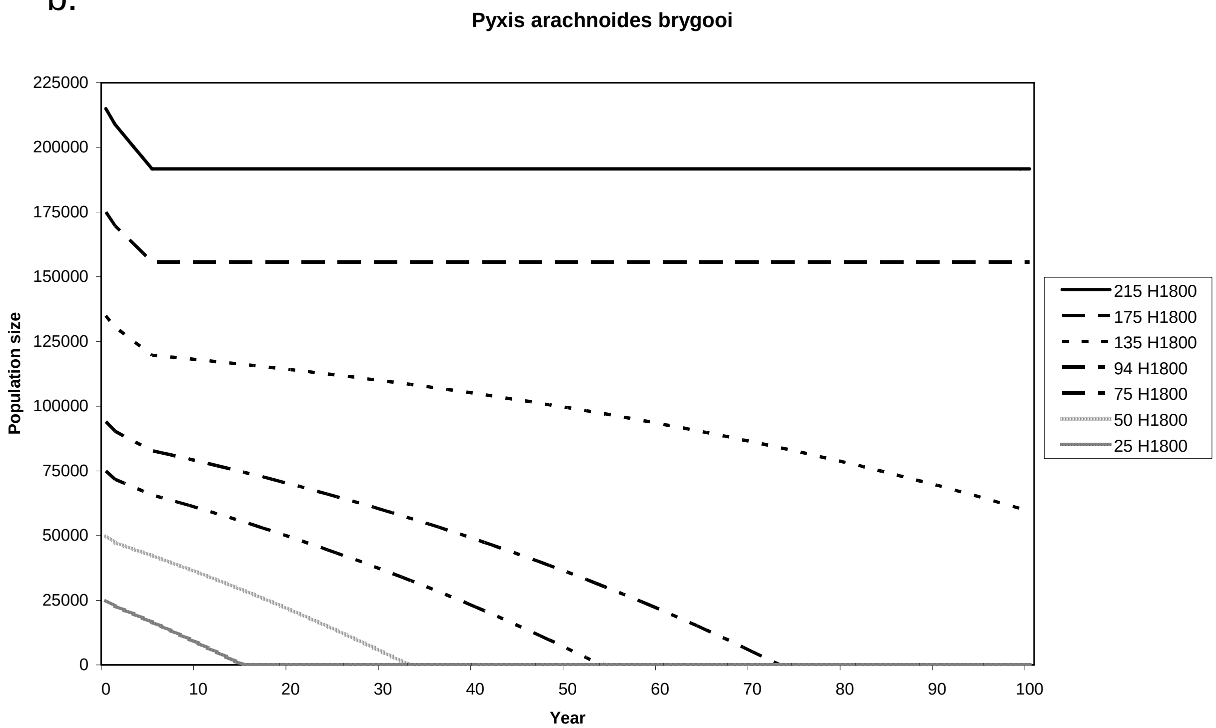
No scientific estimate of the current population size of the spider tortoise was available. Instead, the initial population size for the spider tortoise was based on the initial population size in the baseline model for the radiated tortoise and the proportion of spider tortoises to radiated tortoises captured during the study by Leuteritz *et al.* (2005, pers. comm.). Therefore, a range of initial population sizes were analyzed (with corresponding carrying capacities) to determine the effects on population viability. Taking into account a density of spider tortoises equal to 6.26% of that for radiated tortoises, the maximum population size tested for spider tortoises (215,000) would correspond with about 10.3 million radiated tortoises. This falls within the range of possibilities tested for radiated tortoises and is not too far from the lower estimate for numbers of radiated tortoises by Leuteritz *et al*. (2005) (12 million).

For all three subspecies, a population size of 50,000 or less led to extinction within 100 years (Fig. 13a-c). A population size of 75,000 always led to extinction, but in the case of *P. a. oblonga* (harvest 1000 ind./yr) after more than 100 years. Predictably, higher harvest levels caused negative growth rates even in the larger populations – only a population of 215,000 individuals was able to sustain the highest harvest rate tested (2200 ind./yr for *P. a. arachnoides*).

Figure 13. a-c. Population size over time for various initial population sizes of spider tortoises assuming reduction in habitat of 2%/year during 5 years and assuming a) a harvest of 1000 individuals/year (*Pyxis arachnoides oblonga*); b) a harvest of 1800 individuals/year (*P. a. brygooi*); and c) a harvest of 2200 individuals/year (*P. a. arachnoides*).

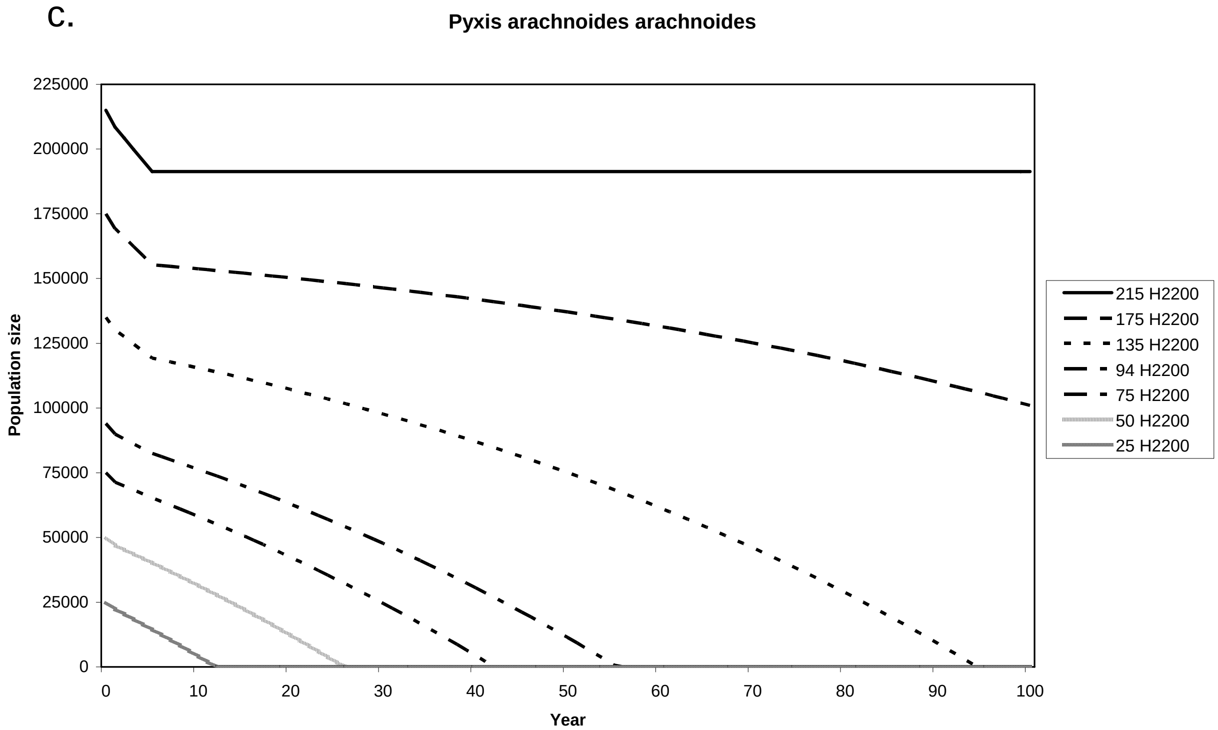


b.



Pyxis arachnoides brygooi
Population size
225000
200000
175000
150000
125000
100000
75000
50000
25000
0
0
10
20
30
40
50
60
70
80
90
100
Year
215 H1800
175 H1800
135 H1800
94 H1800
75 H1800
50 H1800
25 H1800

c.



Pyxis arachnoides arachnoides
Population size
225000
200000
175000
150000
125000
100000
75000
50000
25000
0
0
10
20
30
40
50
60
70
80
90
100
Year
215 H2200
175 H2200
135 H2200
94 H2200
75 H2200
50 H2200
25 H2200

Effect of Habitat Loss

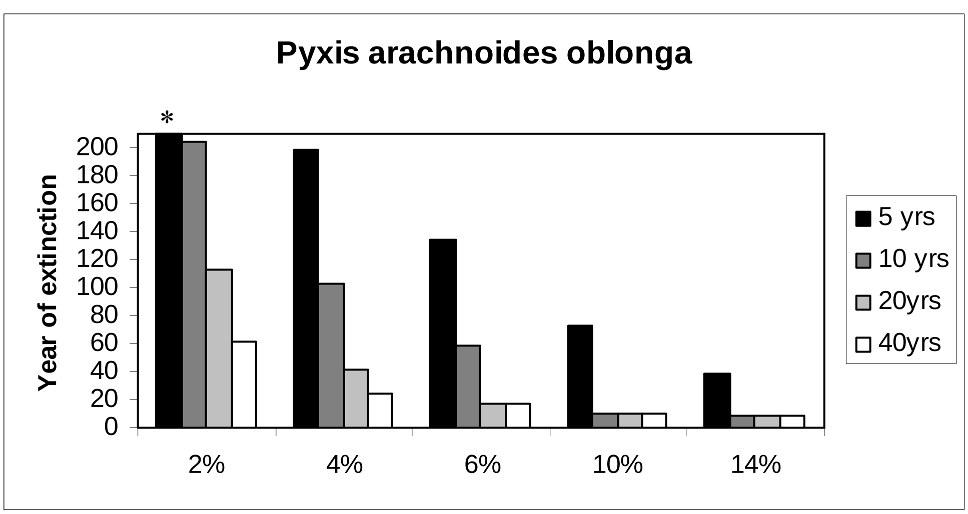
The extent of habitat loss for the spider tortoise, either due to overgrazing, agriculture and charcoal production, or to tortoises continuously being cleared out of the most accessible areas (thereby effectively turning these into "no go" areas), is entirely unclear. Therefore a range of both severity and duration of habitat loss was tested for each of the three subspecies. Annual loss of 2, 4, 6, 10 and 14% for 5, 10, 20 and 40 years were modeled. In the case of 4% for 40 years; 6% for 20 or 40 years; and 10 or 14 % for 10, 20, or 40 years, this led to a complete loss of K. In these cases the year of extinction coincides with the year that no habitat for tortoises is left at all. This happens in as little as 25, 17, 10 or even 8 years (Fig. 14a-c).

In the case of *P. a. oblonga* (with the lowest harvest level of 1000 ind. /yr) the only rate and duration of habitat loss not causing extinction, was the one used for the baseline model: -2% for 5 years. In contrast to a similar test in the radiated tortoise model, applying a 2% loss per year for longer than 5 years did decrease the time to extinction, suggesting that this level of harvest for the spider tortoise is lower than that accounted for by range reduction, i.e. the loss of tortoises due to loss of K is additional to the loss caused by harvesting. Similarly, higher rates of habitat loss ($\geq$ 4%) reduce the time to extinction, again suggesting that loss of K represents a greater level of removal of tortoises than the "real harvest" tested in the model.

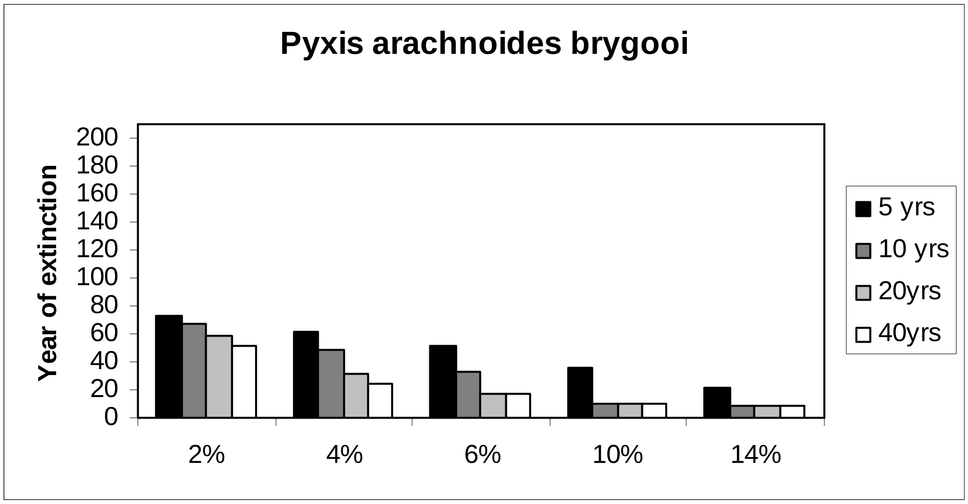
For the two other subspecies, *P. a. brygooi* and *P. a. arachnoides*, the effects of applying a certain loss of K for longer, or applying a higher loss of K, have a much smaller effect on the year of extinction in comparison to the results obtained for *P. a. oblonga*. This suggests that for these subspecies, the harvest rates are getting close to being equal or larger than those accounted for by range reduction, i.e. harvest rather than range reduction becomes the main driving force of the model.

Figure 14, a-c. Time to extinction for various annual rates of decline in K over 5, 10, 20 or 40 years assuming current estimated harvest rates: a) *Pyxis arachnoides oblonga* (1000 individuals/year); b) *P. a. brygooi* (1800 individuals/year); and c) *P. a. arachnoides* (2200 individuals/year). * = no extinction.

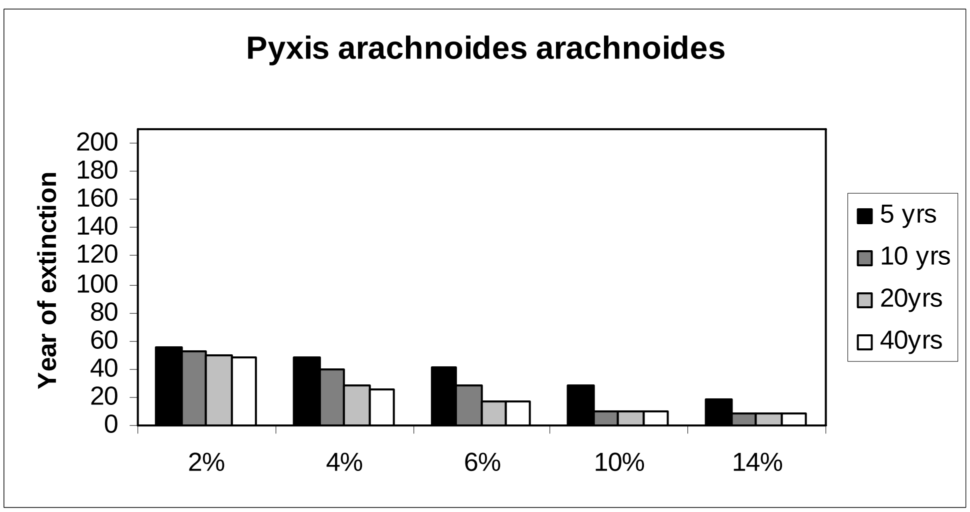
a.



b.



c.



Summary of Results for Spider Tortoises

This long lived species with low reproductive potential (one egg per clutch) can, certainly in comparison with the radiated tortoise, only sustain a relatively low harvest rate. With the demographic parameters used in the baseline model, only a harvest rate of about 1000 individuals per year, or lower, is sustainable. However, in order to obtain a more reliable estimate of what level of harvest will still ensure the persistence of a viable population, it would be advisable to invest in research into the basic demographic parameters of reproduction, mortality and initial population size. At present, almost no scientific data are available for the

majority of demographic parameters for the species, and it is not know if there is significant variation in these parameters among the three different subspecies.
The fact that many Malagasy people are not aware of there being two tortoise species in the area, and do not distinguish young radiated tortoises from adult spider tortoises, may well link the fate of both species. If smaller radiated tortoises are being caught once large adult radiated tortoises have been removed from an area, this could lead to a concurrent higher harvest of adult spider tortoises that would go undetected, unless an active interest is taken in the fate of the latter species.

The rate of harvest of spider tortoises for the exotic pet trade is very small in comparison to the harvest of radiated tortoises for food. However, for the spider tortoise, even these relatively low levels of harvest can drive the species to extinction. Now that the spider tortoise is included on Appendix I of CITES, attention will need to be focused on the enforcement of this law on international trade, the detection and prevention of illegal trade and the determination of harvest rates (per subspecies) within Madagascar for food or as family pets.

Even if harvest rates can be reduced and maintained at a low level, further action will be necessary to prevent (further) habitat destruction. On a positive note, the management actions recommended for the radiated tortoise during the workshop, both to counteract habitat loss and over-harvesting, will at the same time have a positive effect on the status of the spider tortoise. Nevertheless, the preference of the spider tortoise for a narrow area along the coast may require attention to be paid to subtle difference in the causes for habitat destruction, when compared to the situation of the radiated tortoise.

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PHVA Workshop on Endemic Tortoise Species in Madagascar
Geochelone radiata (*tortue étoilée de Madagascar*)
Pyxis arachnoides (*pyxide arachnoïde*)

Ifaty, Madagascar
25-28 August 2005

Final Report

Section V
Participant List and Participant Goals

Participant List

Nº	Names of participants	Institutions	Locality
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11	Zigzag RANDRIA	Chef Cantonnement de l'Environnement et des Eaux et Forêts	Betioky Sud
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26	Venance RAVELOSOA	Maire, Représentant de la Communauté de la région Tanosy consommateur de tortue	Soaserana
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31	SAMBIMANA	Maire, Représentant de la Communauté de la région Androy, zone de départ de la collecte de tortue	Marovato
32	Justin GOLY	Maire, Représentant de la Communauté de la région Androy, zone de départ de la collecte de tortue	Tsihombe
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38	Angelo RAMY	Biologiste Chercheur, DWCT	Antananarivo
39	Thomas LEUTERITZ	Chercheur Biologiste,	USA
40	Anne Marie RAZANADRAIBE	Biologiste, Chef de département de la Biologie Animale, Université de Toliara	Toliara
41	Jean Claude LIMBERAZA	Agent de Parc du PNM-ANGAP	Cap Sainte Marie

GOALS

1. These protected species should be taken back to their original habitat and protected as their area is taboo
2. To provide input for tortoise conservation activities
3. Tortoises will be brought back to their original area and conserved so that they do not disappear from the Androy region
4. Better scientific understanding for the purposes of tortoise conservation
5. Overhaul of prevention and suppression laws
6. An effective way to reduce or eliminate illegal trading of tortoises
7. Coordination of relevant departments actions to increase preventive and suppressive measures
8. To conserve the protected species, and make people aware of how to conserve endangered species such as tortoises
9. The Vezo will protect tortoises' life
10. Sharing of experiences in management, conservation and protection of tortoises; looking for sustainable solutions for conservation
11. To make the people accountable for tortoise conservation
12. Individual responsibility for sustainable management
13. Improve knowledge of both species, and increase responsibility for conserving them in the areas where they are found
14. To achieve consensus over tortoise conservation and habitat
15. Coordination for the purpose of working out basic strategies of the conservation program (education, raising awareness, and mobilization)
16. Sharing of experiences in tortoise conservation in a sound environment
17. Deepening the understanding of tortoise biodiversity in order to improve environmental education, and achieve sustainable development
18. To conserve tortoises and their habitat
19. To enforce the laws for the conservation of protected species
20. To review law 60-126 and update it for tortoise conservation
21. To eliminate at the community level the trafficking and consumption of tortoises through education and suppression and providing equipment to the authorities
22. To achieve a consensus
23. Malagasy tortoises will be conserved to bring about development
24. Sustainable conservation of radiata and pyxis arachnoid tortoises so that they do not disappear from Madagascar
25. To put an end to trafficking by the impartial enforcement of the laws in force
26. To be ready to implement conservation programs
27. To make a good plan available for tortoise conservation

28. Tortoises should be taboo for visitors and residents in the region where tortoises live
29. To find a consensus with partners for a rational management of both species
30. To put an end to hunting and trafficking of Malagasy tortoises; to look for the ways and means to increase the number of natural populations
31. Together, let's protect tortoises
32. To determine the roles of government services (MINENVEF, Judiciary, Force) ⇒ AGREEMENT
33. To learn from participants more about the biology of the tortoises and about what is happening to them and to use that information in computer models to help set conservation goals
34. To work with the workshop participants to develop a model for Madagascar tortoises that helps them understand the biology and threats of these species and to develop effective management strategies for their conservation
35. To work with the modeling group and assist with the development of a model for a better understanding of the conservation option for these 2 tortoises in Madagascar

PHVA Workshop on Endemic Tortoise Species in Madagascar

Geochelone radiata (*tortue radiée de Madagascar*)
Pyxis arachnoides (*pyxide arachnoïde*)

Ifaty, Madagascar
25-28 August 2005

Final Report

Appendix 1
Recommendations

RECOMMENDATIONS:

Tortoises as pets:

A list of the tortoises kept in households should be drawn up and these species should be sent back to the office in charge of them

Captured tortoises:

1. The captured tortoises should be sent back to their original habitat. A scientific monitoring should be carried out.
2. The Androy, Mahafaly and Tagnalagna regions are the ones that can receive the captured tortoises

Harvesting:

1. To draw up a kind of collective pact called "DINA" to preserve the tortoises. This pact is to be applied to protect these animals from torture, slaughter and trade
2. To integrate into school curriculum information that teaches about the value of tortoises and the respect for them
3. To set up a conservation strategy for tortoises

The ways and customs:

4. To ensure a good communication on the Malagasy customs which promote respect for the value of the tortoises – they are part of our patrimony.
5. All visitors in the southern region have to respect all the existing customs ("Dina" or pact, law, "fady" or taboo)

Disasters caused by human activities:

6. To set up a development plan for the concerned regions
7. To consider the research results carried out by FOFIFA (removal of 'raketa mena')
8. Raising consciousness through civic and environmental education

Natural disasters:

9. Reforestation
10. Fight against locusts :

Law and 'dina' (pact):

11. Strict enforcement of laws

Lack of knowledge of the laws*:*

12. Public awareness campaign about the laws and regulations governing the protected species;
13. To spread knowledge of the existing laws and rules ;
14. To involve the concerned parties and partners in writing new laws

Outdated laws

15. To update the outdated clauses, especially those of the order n° *60-126 dated 3/10/60 ;*

Non respect for the laws in force

16. To have respect for a legally constituted State

'Dina'

17. To set up 'Dina' (conventions) related to tortoises and apply them once they have the concerned interregional authorities' approval.

Generalities

18. To ask the concerned regional authorities to integrate the strategies adopted during the workshop into their action plan.
19. To facilitate communication in terms of judicial proceedings
20. To make an inventory of the tortoises kept in households all over the country.

Poor collaboration between the concerned parties in terms of tortoises' conservation:

21. To set up a joint committee (in charge of tortoises) that will help determine everyone's duties
22. To set up a Tortoise Foundation

Raising awareness:

23. To incite the population to advise the authorities of tortoises' illegal harvesting while rewarding them for doing so

    It is essential to train teachers and local notables methods for raising public awareness so that they can more effectively teach others about tortoise conservation

    Types of education:

    - *Formal education*: by Ministry of National Education)
    - *Non formal education*: by Ministry of population (literacy tuition)
    - *Informal education*: by Ministry of communication (*media*)

    Education topics:

    - Endemic nature of the tortoises in Madagascar
    - Everybody's role in tortoise conservation
    - Fund raising for the "Communes" through tourism
    - Spreading information about the modification of the laws governing the tortoise conservation
    - Inciting the concerned parties to work with local people
    - Setting up clubs devoted to the tortoises' conservation
    - Use of visual aid for the illiterate

Tools :

24. Communications tools (advertising medium)
25. Means of transport for pursuing poachers and for visiting tortoise habitats
26. Logistical tools (laptop, typewriter)
27. Increase in the number of law enforcement and prevention officials
28. Brigade in charge of the tortoises
29. Map showing the tortoises' distribution area
30. Advertising medium (hats, logo, posters, and tee shirt) and visual aids for illiterate people.
31. Research laboratory
32. Laws and regulations manual

33. Strengthening of the ‘dina’ (local convention)

Road infrastructure:

34. Roadblocks for controls, thus reducing illegal trades and traffics

35. Fences for protected tortoise areas to prevent accidents