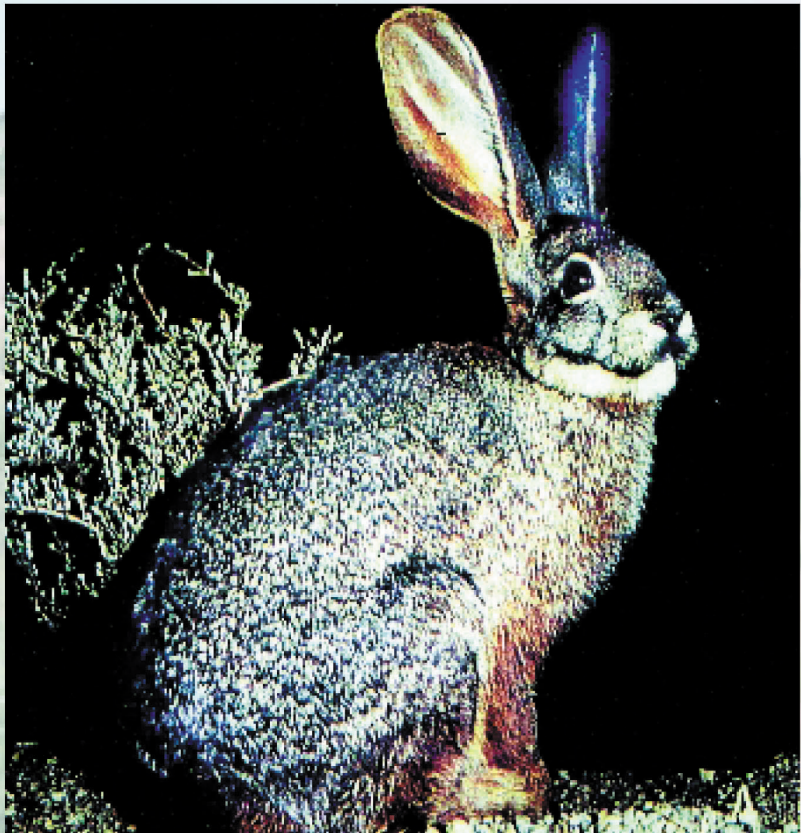
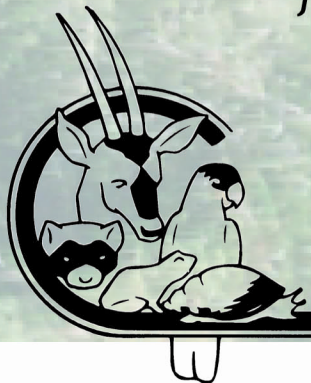


# Riverine Rabbit PHVA



## Workshop Report

*Population & Habitat Viability Assessment  
for the Riverine Rabbit (Bunolagus monticularis)  
Stellenbosch, South Africa  
27 - 29 July 2000*



# **RIVERINE RABBIT**

*(Bunolagus monticularis)*

**Population and Habitat Viability Assessment Workshop**

**27 – 29 July 2000**

**Stellenbosch, South Africa**

**Final Report**



**Sponsored by:**

**Philadelphia Zoo  
Peter Scott IUCN/SSC Action Fund  
Zoological Society for the Conservation of Species and Populations  
Zoological Garden Berlin**

**In Collaboration with:  
Lagomorph Specialist Group IUCN/SSC  
Conservation Breeding Specialist Group IUCN/SSC**

**V. Ahlmann, K. Collins, and U. S. Seal, Editors.** 2000. *Riverine Rabbit (*Bunolagus monticularis*): A Population and Habitat Viability Assessment Workshop. Final Report* CBSG, Apple Valley, MN.

Cover photo courtesy of Andrew Duthie.

A contribution of the IUCN/SSC Conservation Breeding Specialist Group in collaboration with the IUCN/SSC Lagomorph Specialist Group.

Sponsored by the Philadelphia Zoo, the Peter Scott IUCN/SSC Action Fund, Zoological Society for the Conservation of Species and Populations and the Zoological Garden Berlin.

Conservation Breeding Specialist Group (SSC/IUCN). 2000. *Riverine Rabbit (*Bunolagus monticularis*): A Population and Habitat Viability Assessment Workshop. Final Report*. CBSG, Apple Valley, MN.

**RIVERINE RABBIT**  
*(Bunolagus monticularis)*

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# **RIVERINE RABBIT**

*(Bunolagus monticularis)*

**Population and Habitat Viability Assessment Workshop**

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Photo by: Chrizette Kleynhans

**Executive Summary and Recommendations**



# Executive Summary and Recommendations

## Introduction

### Conservation efforts on the endangered Riverine Rabbit (*Bunolagus monticularis*)

The endemic Riverine Rabbit (*Bunolagus monticularis*) (Thomas 1903) is one of South Africa's most threatened terrestrial mammals, (Smithers 1986) and one of twelve globally endangered rabbit species (IUCN 1996). It has been classified as endangered since 1981 and listed as such in both the IUCN (IUCN 1996) and the South African Red Data books (Smithers 1986).

The entire distribution range of the Riverine Rabbit is restricted to the semi-arid Central Karoo region of South Africa. Being a habitat specialist, *Bunolagus* is associated with the dense, discontinuous and highly diverse vegetation fringing the seasonal rivers of the Central Karoo. As the only indigenous burrowing rabbit in Africa, *Bunolagus* is adapted to and dependent on soft and deep alluvial soils along the river courses for constructing stable breeding stops. Riverine Rabbit numbers have decreased considerably with the disappearance of this habitat type over large parts of its former range (Robinson 1981; Duthie and Robinson 1990).

Ten years ago it was suggested that the remaining suitable habitat might, theoretically, support 1435 rabbits. However, *Bunolagus* densities may vary widely among river systems, and the Ongers river which alone supports approximately 21% of the remaining habitat, shows no evidence of the rabbit. Thus the population size may be very much lower (Duthie et al. 1989). The massive decline of two-thirds of its original habitat and, correspondingly, of the *Bunolagus* population, can be attributed to the loss of suitable habitat as a result of agricultural activities on the seasonal river flood plains (Robinson 1981; Duthie et al. 1989; Duthie and Robinson 1990). Today the Riverine Rabbit only occurs on private farmland and this riverine habitat is equally attractive to landowners for both cultivation of crops and extensive livestock grazing. In addition, anthropogenic fragmentation of riverine vegetation through impoundments in river channels, weirs, historic and current cultivated lands also represents a significant threat to the remaining riverine habitat.

At present, none of the Riverine Rabbit habitat is protected within a provincial nature reserve or national park in the Karoo region. During 1987 and 1988 nine Riverine Rabbits were captured on private farmland in the Karoo and brought to the De Wildt Cheetah Research Center near Pretoria to start the first captive breeding programme (Duthie and Robinson 1990). Over a period of 5 years, 17 births were recorded, and by the end of 1993 the captive population stood at 14 animals. In 1994 the Karoo National Park continued the captive breeding programme with six rabbits which were donated from De Wildt. In 5 years time 20 rabbits were born in the breeding enclosure and 16 animals died. Attempts were undertaken in 1996 to introduce Riverine Rabbits in the Sandrivier area of the park. The breeding camp of the Karoo National Park lies below



the escarpment of the Nuweveld Mountains, whereby the remaining distribution area of the Riverine Rabbit is situated above the escarpment. The composition of the riverine vegetation in the Karoo National Park differs obviously from riverine habitat above the escarpment, and this might be one reason why a healthy population has never developed. During annual surveys conducted by rangers of the park, no more than one or two rabbits have been observed outside the enclosures. The longevity of *Bunolagus* in the wild is unknown, however, in captivity longevity was found to be up to 5 years or possibly more (E. Smidt pers. comm.). Of the 20 animals born in the park, 87.5% (n = 14) died under the age of three years. Besides the lack of essential habitat resources, periods of high ambient temperatures as well as inbreeding appeared to be responsible for most of this high mortality rate in the park. At present four Riverine Rabbits are left in the breeding enclosures at the Karoo National Park, and the sex of three of these animals is unknown. Because of the small number of the breeding population, and because these rabbits are all closely related, the captive breeding programme is almost at its end. No data have been collected from the breeding colony in the park.

### **Current Activities**

Since January 1999 the ZOOLOGICAL SOCIETY FOR THE CONSERVATION OF SPECIES AND POPULATIONS (ZSCSP) has been conducting a comprehensive habitat evaluation and mapping exercise in riverine areas combined with the confirmation of *Bunolagus* in surveyed areas by observation. These field surveys are partly undertaken in cooperation with Cape Nature Conservation and are designed to estimate the current population size of the Riverine Rabbit. During investigations conducted in 1999 in the Western and Northern Cape Provinces, optimal riverine habitat has been identified for the most part in the form of isolated pockets or narrow areas respectively within very poor up to sub-optimal areas. Nevertheless, on nine investigated farms Riverine Rabbit specimens were found for the first time. Altogether 43 farms were surveyed in 1999, and a total number of 22 rabbits has been observed on 11 farms.

### **The Workshop**

The PHVA Workshop for the endangered Riverine Rabbit was organized to identify and bring together all groups responsible for the conservation and management of the Riverine Rabbit and its habitat.

A carefully selected and diverse group of participants (private landowners, national and provincial conservation authorities, lagomorph experts, and members of the IUCN/SSC/Lagomorph Specialist Group clarified aims and objectives and established actions needed for the long-term conservation of the Riverine Rabbit and its habitat in the Central Karoo region of South Africa. The workshop also recommended that expertise should be brought together to coordinate work on conservation and management and to establish a database on the species and its habitat.

The workshop was conducted at the Ellerman Resource Center, University of Stellenbosch from Thursday through to Saturday 27<sup>th</sup> to 29<sup>th</sup> July 2000. It was opened by

Prof. Terry Robinson and Dr. Victoria Ahlmann. Presentations were made during the course of the workshop by Robinson, Ahlmann, Muller, Collins, Milton, Kleynhans, and Bell.

Initially four working groups were formed: Habitat, Management, Threats, and Population Modelling with the Threats group later merging with the Management Group. These groups worked together throughout the workshop. Discussions in the plenary sessions provided guidance for the next steps for the working groups.

The workshop was closed at 13h00 on Saturday 29<sup>th</sup> July with comments from Seal and Ahlmann. .

## Group Summaries and Recommendations

### Habitat and Land Use Group

Habitat destruction and alteration of Riverine Rabbit habitat peaked in the 1960's with sporadic clearance, increase in extent and intensity of grazing practices which took place subsequent to that. Ecological events (e.g. climatic changes, flooding), political changes, as well as an uninformed understanding of the Riverine Rabbit and riverine systems by landowners can also be considered problematic factors in overall decline.

The priorities to overcome the present and inherited problems related to the above-mentioned activities are as follows:

1. **Habitat Conservation** with the emphasis on ensuring that enough optimal habitat will be conserved, formally or otherwise, the means to properly identify and survey these areas and manage them.
2. **Sustainable land use** is fundamental for long-term survival of the Riverine Rabbit. This includes both economic and ecological sustainability. Actions to ensure this is identifying land use impacts and the relevant extension work to encourage an upward shift in proportion of land in suitability categories.
3. **Climate change** can be monitored by means of scenario modelling to make estimated predictions relevant to the Riverine Rabbit and its habitat management.
4. **Reclamation of land and economic values** are issues considers dealing with inherited problems of destroyed habitat on viable terms and encouraging financial benefits for the private landowners conserving the Riverine Rabbit at their own cost.  
This would include media exposure, lobbying for tax, political and other incentives, correct ways and means to reclaim habitat.
5. **Metapopulation management** requires extended areas of habitat in order to secure sufficient populations of Riverine Rabbits to ensure for long-term survival. The use, management and development of corridors are being considered to achieve these aims.

## **Management and Strategies Group**

The need for environmental awareness through a coordinated environmental education initiative is essential.

The lack of formal habitat protection requires the expansion of the existing conservancy system to cover a wider range of the Riverine Rabbits distribution, with the ultimate goal being to develop a biosphere reserve system of core and buffer areas.

The lack of a coordinated management strategy requires the expansion of the National Riverine Rabbit Coordinating Committee, and it taking formal responsibility for the implementation of the goals and objectives identified by the Riverine Rabbit PHVA Workshop.

Information collection, processing and distribution was identified as essential for the informed and coordinated implementation of conservation strategies. This process would also identify gaps in knowledge that would serve to identify future research priorities.

## **Threats**

Threats (not addressed by other working groups) :

- 1) The control of dog predation was identified as a major priority to be implemented through the NRRCC, with the cooperation of the existing and future conservancies.
- 2) Potential catastrophic events that were identified included; flooding, climate change, fire, and disease. Elements that can be controlled to some extent through careful land management included flooding and fire. This would require the NRRCC to promote the use of judicious management techniques that favour the survival of the Riverine Rabbit.

The National Riverine Rabbit Coordinating Committee shall include the provincial agencies, South African National Parks, Department of Agriculture, Department of Water Affairs and Forestry, Department of Environmental Affairs and Tourism, landowners, NGOs, academic institutions, and other interested parties. This group shall take the lead role in promoting and facilitating the conservation of the Riverine Rabbit through a cooperative, inclusive process.

## **Census**

Further research is urgently required for the development of a standardized sencing protocol that is both reliable and replicable. Problems associated with sencing are the nocturnal activity and dense, low visibility of the habitat of this species, as well as its high susceptibility to stress upon capture and handling. Current experience favours a

technique using a combination of transect sweep from horseback and on foot through the habitat, counting any individuals flushed from cover.

Research Priorities:

- Standardized and repeatable census techniques for assessing the population numbers of Riverine Rabbits within particular patches of habitat.
- Standardized and quantitative methods of identification of the vegetation and soil characteristics of suitable riverine habitat.

Execution of the above two research topics requires close collaboration between property owners, conservation institutions and research scientists at academic institutions.

### **Captive Population**

It was decided, given the lack of knowledge and resources to initiate a captive breeding programme, the negative factors by far outweigh the benefits and that it would be unwise to initiate a captive breeding programme until more knowledge is obtained.

Concerning the four captive rabbits currently in enclosures in the Karoo National Park, it was unanimously decided that the best solution is to return the rabbits to the original farms where the founders for the initial breeding programme were captured. The rabbits would have to be kept in enclosures on the farms and cannot be released until a genetic analysis is completed in order to establish that no significant genetic difference exists between the captive rabbits and the wild rabbits. If there is no such difference, and if the rabbits have no demonstrable signs of disease, then they can be released into the wild.

Feelings with regards to the issues of reintroductions, supplementations and translocations of rabbits were that, due to a serious lack of knowledge and data, these management actions should be postponed until such a time as more precise data are available. Such management actions could, however, play a very important role in the future.

### **Modelling and Life History Parameters**

**Summary:** The probability of extinction of Riverine Rabbit populations with  $K=20$  is high under all conditions explored in these simulations. Inbreeding depression, if it occurs, greatly increases this risk and remains a problem at higher population sizes. Increase of the  $K$  to 50 provided substantial benefits in reducing the risk of extinction under ideal conditions. The greatest improvements in growth rates or extinction risks occurred with a reduction of juvenile mortality rates.

**Recommendations:** Measurement of first year mortality and its causes and efforts to reduce that rate to 50% or less in combination with a minimal expansion of the carrying capacity of individual population fragments to 50 animals appear to offer the most effective management strategies to improve the prospects for survival of the Riverine Rabbit. It will be important to determine the vulnerability of the species to inbreeding depression as a guide to the possible need for additional management actions.

Other complimentary recommendations include:

- Determine the distances and rates of migration and dispersal of Riverine Rabbits and the degree of between-population movements.
- Determine the degree of genetic differentiation between different populations of Riverine Rabbits.
- Undertake the study of population dynamics (including reproductive rates and mortality) of natural populations of Riverine Rabbits.

The execution of the above three projects requires collaboration between research institutions and property owners.

# **RIVERINE RABBIT**

*(Bunolagus monticularis)*

**Population and Habitat Viability Assessment Workshop**

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**Participants Personal Goals**



### **Question 1: The participants' goals for this workshop**

- 1) Broad, collaborative, achievable strategy for the maintenance of the riverine rabbit and its habitat.
- 2) A clear, concise conservation action and management plan that can be applied through the process of adaptive management.
- 3) Synthesis of latest findings and initiatives on species so as to provide a framework for a species action plan (with specific reference to South African National Parks.)
- 4) Synthesis of knowledge and thinking, and learn about PHVA / CBSG workshop process.
- 5) Synthesis of available information. Clearly defined problems and range of realistic management applications.
- 6) A synthesis of available data and more concrete direction to move forward.
- 7) Long term conservation strategy plan and to start a serious funding / public awareness programme.
- 8) To get more information about the rabbit to help to save the rabbit on our farm and in my area.
- 9) Long term management plan – research / conservation – priorities to species and habitat.
- 10) Gain more knowledge of the Riverine Rabbit and how effectively to establish a conservancy for the benefit of the rabbit and myself.
- 11) To at least synthesise all current information on the rabbit and use this to ensure the conservation and effective management of the rabbit and especially its habitat, encompassing all the other associated biota in this environment.
- 12) To help the Riverine Rabbit to survive, a lot of people and organisations have to give their support. Support must be co-ordinate.
- 13) Viable breeding programme.
- 14) Meaningful strategy for the implementation of a conservation programme for the Riverine Rabbit.
- 15) A workable management plan for the overall conservation of the Riverine Rabbit.
- 16) Development of a co-ordinated strategy that engages all stakeholders in meeting the priority need of the Riverine Rabbit.



**Question 2: The major problem, according to the participants, in terms of the long term survival of the Riverine Rabbit.**

- 1) Habitat degradation (on going) – through modification – with little prospect of rehabilitation.
- 2) Lack of capacity of the responsible organizations, provincial, national, research, etc.
- 3) The low fecundity rate that appears to be due to inbreeding, some subpopulations may still have high fecundity – mix genes.
- 4) Inappropriate land use in Karoo.
- 5) Lack of information regarding population numbers and historical connectivity. Dearth of life history / ecological / genetic data to work with in making realistic management plans.
- 6) Habitat degradation.
- 7) Traditional hunting by farm workers with hunting dogs and other predators like the black backed jackal, foxes and lynx.
- 8) Money, staff for investigation, monitoring and habitat rehabilitation.
- 9) Habitat fragmentation and population genetic diversity.
- 10) Habitat degradation, ignorance and natural evolution.
- 11) Not enough knowledge of this small animal and its needs. Because we do not know, we yet cannot help. People easily jump to theoretical conclusions, but over a time of 20 years the contrary was shown to me on the farm. I walk a lot, during rain and dry seasons, and I experience the realities. We saw many enthusiasts come and go, but we and our remaining rabbits stay, and they, the rabbits, look into our eyes.
- 12) More trust and openness between all concerned.
- 13) Knowledge of how individuals uses their home range and how / if they distribute into vacant areas, also a lack of national conservation strategy / consensus.
- 14) Lack of cooperation and coordination between all parties concerned and funding for conservation efforts.
- 15) Preservation and restoration of suitable habitat.
- 16) The continuing loss of its natural habitat resulting in fragmentation of habitats and populations with genetic implications and the ignorance concerning the animal.

# **RIVERINE RABBIT**

*(Bunolagus monticularis)*

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Photo by: Kai Collins

**Habitat and Land Use**



## Habitat Group

### Problems

1. Intensive Riverine Rabbit habitat destruction and alteration during the 1960's.
2. Continues sporadic clearance of habitat.
3. Manipulation of run-off (agricultural soil conservation works)
4. Fragmentation by artificial and natural barriers.
5. Catchment degradation (poor floodplain and catchment area management resulting in degraded riverine systems. Past overgrazing impacted, changing quality of grazing in floodplain.
6. Competition for alluvial soils and habitat by landowners and game (including the Riverine Rabbit)
7. Grazing by single species constantly (only sheep)
8. Climatic changes & human involvement pronounce effects of normal flooding.
9. Climatic changes influencing land uses. (grain to grazing to game)
10. Flooding due to impoundments. Build up water and increased flooding when wall breaks.
11. Source – sink supplementation of populations from headwaters to lower down is not possible due to development, disturbances and fragmentation.
12. Political change: due to changes there is greater pressure on landowners to perform economically with less government support.
13. Management inertia – reclamation costs not viable

**Priorities:**    **Habitat conservation**  
                  **Sustainable land use**  
                  **Climate change**  
                  **Reclamation / Economics**  
                  **Metapopulation management**

### GOALS:

**1. Adequate habitat conserved**  
National Park? / formally conserved area  
Conservancies - where  
Contractual Park  
Comprehensive habitat evaluation.

MINIMUM

2x 200ha patches of optimal habitat with 50

MAXIMUM

1000 rabbits within a conserved

animals each with possibility to connect

framework / 4000ha not necessarily connected

## **2. Sustainable land use**

management of grazing, dogs, impacts, developments

MINIMUM

Sustainable land-use practice on min area

MAXIMUM

Sustainable land-use practices on max area

## **3. Scenario Modelling / Prediction / Monitoring**

Climate change and its possible effect should be compared with existing ecological data

MINIMUM

Karoo climate model with indicators

MAXIMUM

Use of global predictions

## **4. Real incentives and methods for reclamation**

MINIMUM

Costs of conservation are affordable to landowner

MAXIMUM

RR to pay their way

## **5. Connectivity / corridors: encourage extensive areas.**

MINIMUM

To recognize the importance of corridors

MAXIMUM

Corridors connecting 4000ha of optimal habitat

## **ACTIONS TO ACCOMPLISH OUR GOALS:**

### **1. ADEQUATE HABITAT CONSERVED**

#### **1.1 Habitat mapping**

Integrated GIS mapping programme functional

- CNC Scientific Services
- Five years before completion and before processed is data available as a digitised map

#### **1.2 Standard format for collecting field data concerning (Grading of habitats)**

- CNC
- September 2000
- Having comparable data, database accessible

#### **1.3 Development and implementation of conservation strategies**

To develop overseeing authority and working group under an existing organization with research capacity. Participatory workshops involving all parties.

- NRRCC

- Five years
- Implemented by enough landowners beyond minimum expectations (400ha)

1.4 Identify core areas and management  
Ground truthing of habitats to identify Incorporated with mapping process

## **2 SUSTAINABLE LAND USE**

2.1- Categorizing of land use practices / systems and allocation of sustainability indices. (goats, cattle, cropping etc.)  
Provincial responsibility (Conservation and agricultural agencies )  
-continues  
-reduction in habitat degradation and improvement of habitat (upward shift in proportion of land in suitability categories)

2.2 -Collation of knowledge on present land use and ecological responses in RR habitat  
RR Conservation Biologist  
One year  
Presentation and relevant document.

2.3 Co-ordination and integration of extension effort on continuing basis from all authorities (municipal, conservation, agriculture) to community.  
- NRRCC  
- One year  
- All landowners and labourers on land with confirmed RR sightings are aware of RR conservation needs.  
- Five years - General awareness throughout the whole distribution range of RR.

2.4 Economic sustainability analysis  
- Cost-benefit analysis to determine viability of conserving RR habitat (includes financial incentives and management costs)  
- Student project (agricultural economics student)  
- Five years  
- Cost benefit analysis report

## **3 SCENARIO MODELLING OF CLIMATE CHANGES**

3.1 Networking with spatial / climate modelling groups (already existing)  
- RR conservation biologist  
- Ongoing  
- Sequential production of ten year scenarios for RR distribution

## **4 INCENTIVES & MANAGEMENT FOR RECLAMATION**

4.1 More national and international media exposure (Web page)  
- EWT and Conservation agencies

- Ongoing - Starting within a year. Discussion with Botanical Society of South Africa in their incentives programmes (contact: Mark Botha).
  - Website
- 4.2 Lobbying & Networking for tax, political and other incentives for privately conserved land.
- Conservation agency (combine efforts with Botanical Society of South Africa)
  - Ongoing starting within a year
  - Landowners realizing incentives for RR conservation
- 4.3 Ecotourism
- Delegated to management and strategy working group
- 4.4 EE incentives - competitions, schools adopting species
- EE officer
  - Two years
  - Awareness of all local schools
- 4.5 Reclamation: implement known methods to reclaim areas and research new methods and identify farms for experiments
- Restoration ecology group (University) coordinated by conservation biology
  - Ongoing
  - Restored habitat
- 4.6 State support to rehabilitate habitat, erosion control involving RDP (Poverty Relief)
- Relevant agricultural extension officer and conservation biologist and landowner
  - Five years
  - Application procedure in place for restoration assistance from State
- 5. METAPOPOPULATION MANAGEMENT (CONNECTIVITY /CORRIDORS)**
- 5.1 Use of habitat mapping to identify existing and required corridors
- Conservation biologist
  - Five years
  - Corridors mapped
- 5.2 Monitoring whether corridors are effective and (feasibility) used.
- Student project
  - Three years
  - Thesis
- 5.3 Research into requirements of corridor configuration & structure, as well as the feasibility of creating new corridors where needed. Minimum vegetation structure for the corridor to be effective See 5.2

- 5.4 Identification of bottleneck(physical barrier to RR dispersal e.g.: dams, rocky gorges) points where no corridors are possible and development of possible solutions
- Conservation biologist (as in 5.1)
  - Five years
  - Corridors mapped and artificial dispersal systems identified (egg: rabbit in a box)
- 5.5 Metapopulation: demographic and modelling issues dealt with by modelling group.

## **ACTION PRIORITIES**

### **DISCREET ACTIONS**

Habitat Mapping (1.1)

Identify existing and required corridors (5.1)

Identify core areas (1.4)

National & International media exposure (4.1)

Economic sustainability analysis (2.4)

Standardization of collecting field data (1.2)

Monitoring corridor use by RR (5.2)

Identification of bottlenecks (5.4)

Initial co-ordination and integration of extension effort (2.3)

Collation of knowledge on present land use (2.2)

Categorizing of land use systems (2.1)

### **ONGOING ACTIONS**

Co-ordination and integration of extension efforts (2.3)

National and international media exposure (4.1)

Lobbying & networking for incentives to landowners (4.2)

Participatory workshops involving all parties (1.3)

Research into corridor configuration & structure (5.3)

Reclamation methods / research (4.5)

Environmental education incentives (4.4)

Networking with spatial / climate modelling groups (3.1)

State support rehabilitation (4.5)



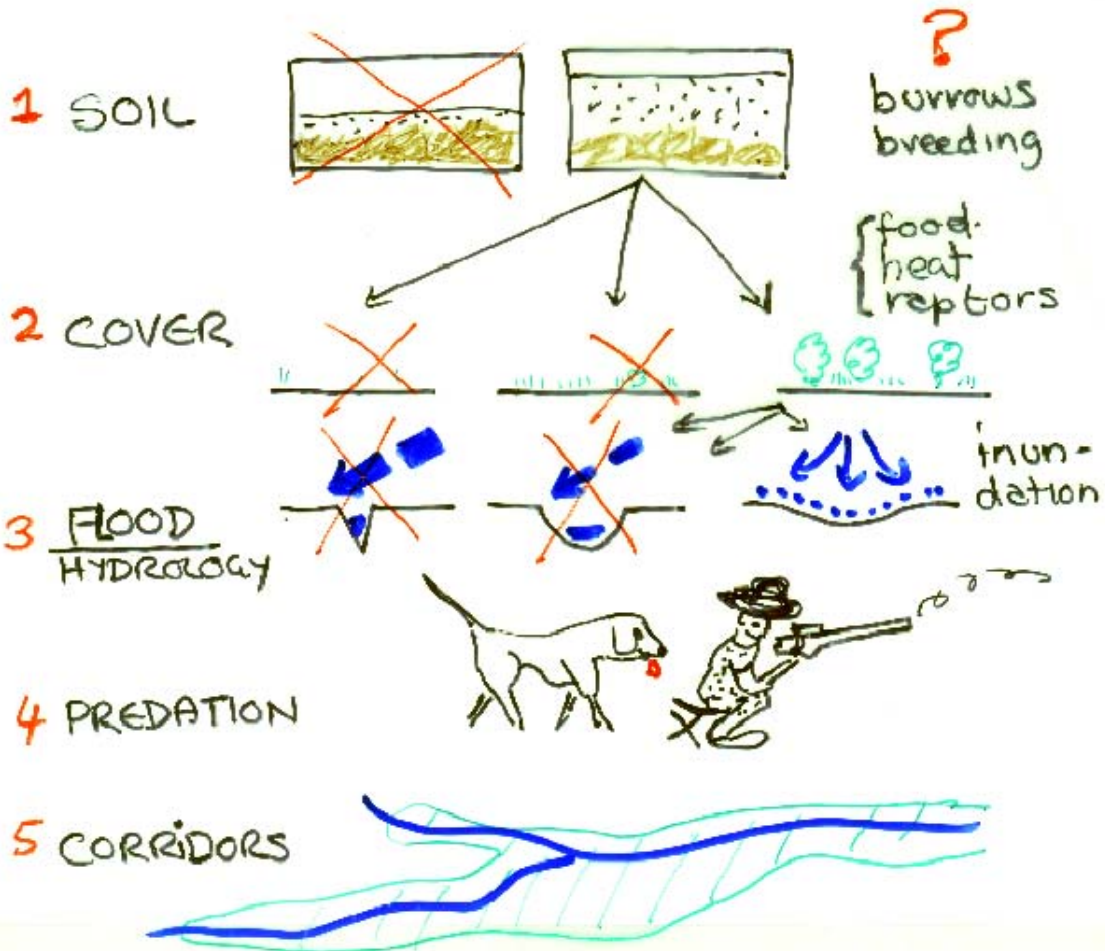
# A KAROO ENVIRONMENT

Sue Milton, U Stellenbosch  
Richard Dean, UCT

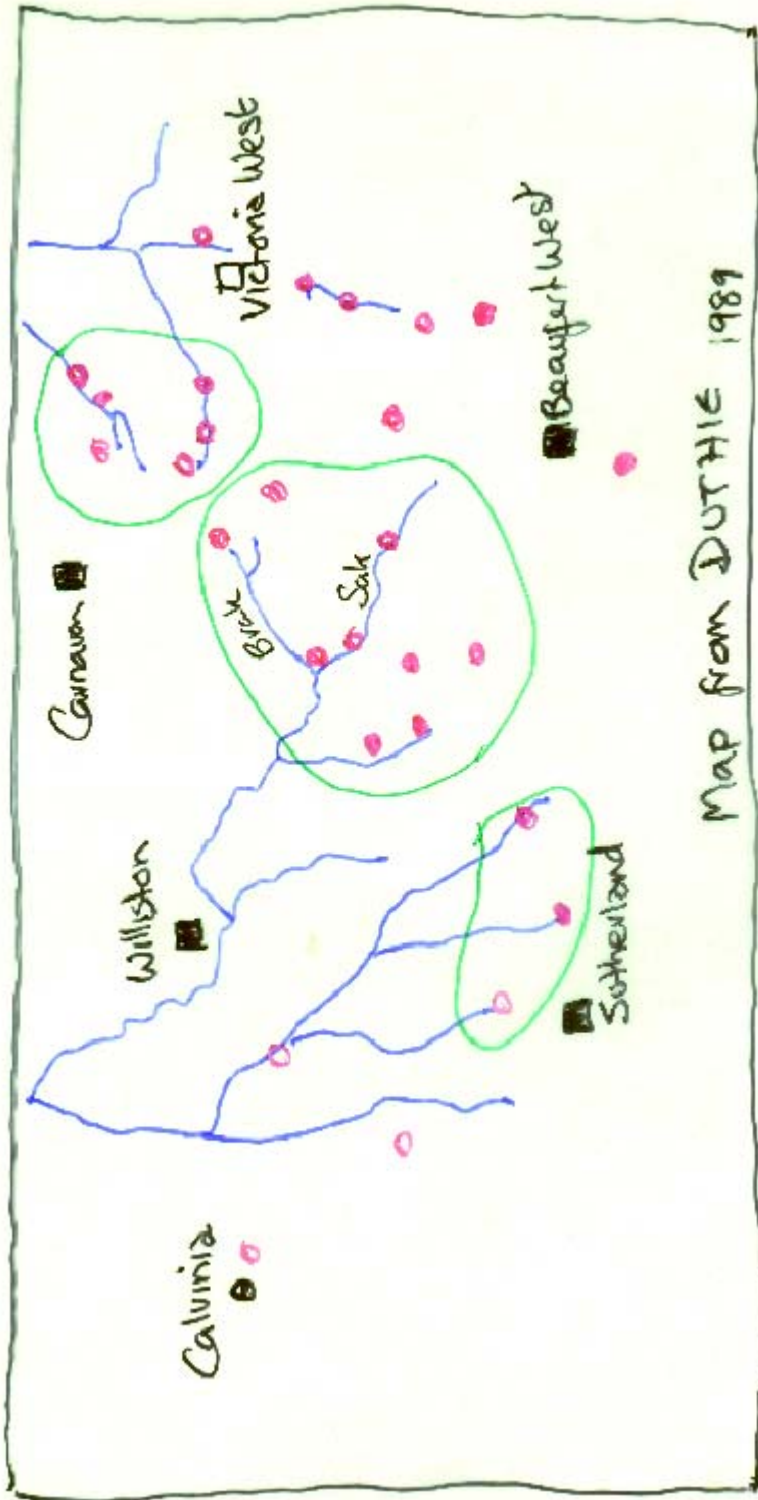


- Vegetation
- Habitat destruction
- Rehabilitation

# C FRAMEWORK for R



Richard Dean's comment: Headwaters mainly: Why?



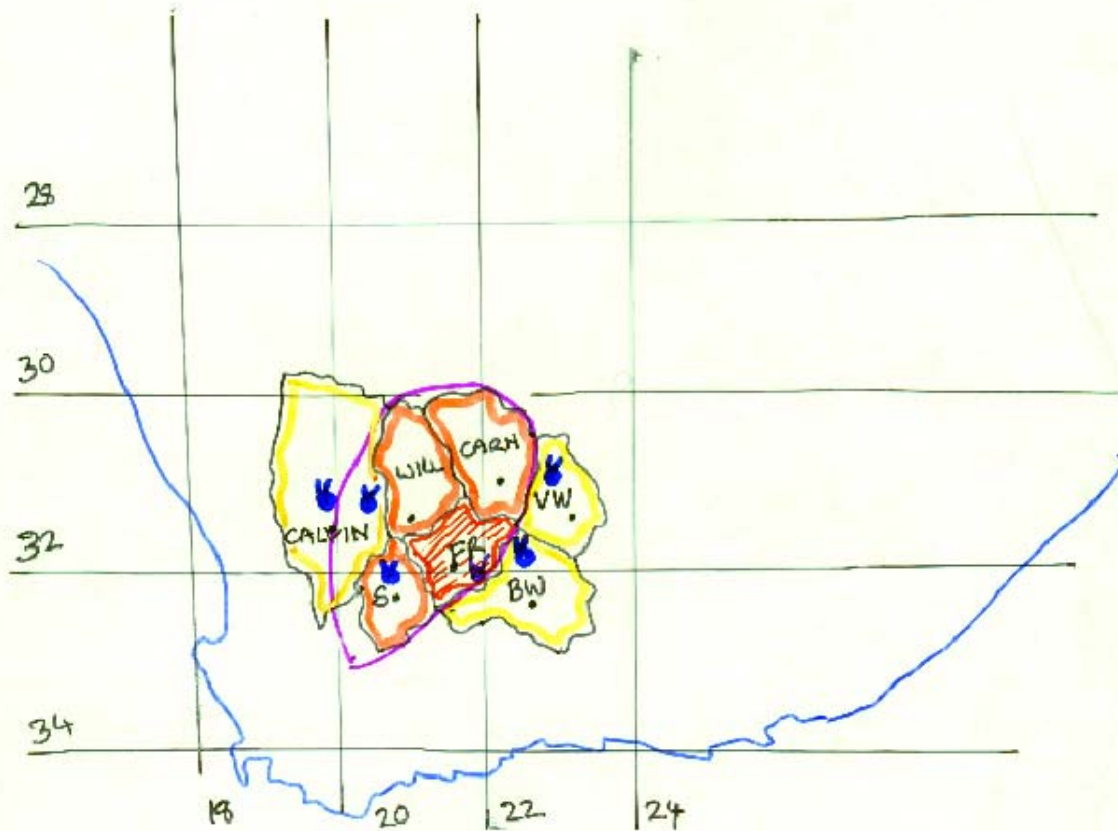
B COMBINED INDEX of LAND DEGRADATION  
(SOIL + vegetation)

Hoffman et al (1999)

□ MOST > AVG < AVG

○ LYCIUM thickening

♣ Rabbits



# **RIVERINE RABBIT**

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Photo by: Chrizette Kleynhans

**Management and Strategies**



## Management and Strategies Working Group

Participants: Vicky Ahlmann, Leon Muller, Tony Marshall, Reg Hoyt, Guy Palmer, Monty Truter, Joe van Wyk, Jan Human, and Wilma Truter

### Problems:

1. Lack of a coordinated management strategy.
2. Past inter-provincial territorialism
3. Fragmentation of conservation authorities and legislation, and other environmental legislation authorities
4. Public lack of knowledge, awareness and involvement in conservation Issues and conservation organizations/functions
5. Lack of commitment to conservation issues by public (state & private) enterprises (funds, personnel, logistics)
6. Lack of agreed upon conservation priorities within conservation bodies
7. Management activities (priorities=survival) re-active and not pro-active
8. Low public interest profile of Riverine Rabbit
9. No formally protected habitat (conservation organizations manage indirectly and must get public involvement)

### Priority Problems:

#### 1) Lack of coordinated management strategy

**Minimum Goal:** Formal adoption of PHVA recommendations by all role players

**Maximum Goal:** Coordinated management of Riverine Rabbit

#### 2) Information deficiency

**Minimum Goal:** Consolidation of available information, and the identification of information gaps/research priorities

**Maximum Goal:** National/international specialist involvement

Scientific  
Managerial  
Funding

#### 3) Environmental education

**Low public interest profile of Riverine Rabbit**

**Public lack of knowledge, awareness and involvement in conservation issues and conservation organizations/functions**

**Minimum Goal:** Environmentally aware community within Riverine Rabbit distributional range

**Maximum Goal:** Nation-wide awareness of riverine rabbit/Karoo/riverine system/ functions/ threats/ potentials

**4) No formally protected habitat  
Conservation organizations manage indirectly and must get public involvement.**

Lack of a coordinated management strategy

Past inter-provincial territorialism

Fragmentation of conservation authorities and legislation, and other environmental legislation authorities

Lack of commitment to conservation issues by public (state & private) enterprises (funds, personnel, logistics)

Lack of agreed upon conservation priorities within conservation bodies

Management activities (priorities=survival) re-active and not pro-Active

**Minimum Goal:** Scattered conservancies

**Maximum Goal:** Biosphere Core areas-open space III

## **Actions**

### **Priority: 3. Environmental Education**

#### **A. Minimum Goal: Environmentally Aware Community in Riverine Rabbit Distribution Range**

1. Standardized education programme for different ages and target audiences to be developed by a working group elected by the NRRCC (September 2000). Draft programme to be completed by December 2000. A final draft to be completed by March 2001. Budget: R20,000 (NC/WCNCB application has been made to WWF-SA for funding already). Collaborators: Teachers  
End product: Informed schools and community within the Riverine Rabbit distribution range.
2. Develop informational materials concerning the Karoo and the Riverine Rabbit. NRRCC working group elect, identify Environmental Education Working Group. Working Group will be responsible for development, production and distribution. Working group to evaluate and refine, as needed, existing materials and identify additional materials required by March 2001. Create additional materials by December 2001. Budget: R60,000

(NCNCS/WCNCB application submitted to WWF-SA for funding).

Collaborators: SABC

- 2.1 Brochure
- 2.2 Poster
- 2.3 Slide presentation
- 2.4 Video
- 2.5 Webpage

3. Develop network to disseminate/present information, setting target groups, via the NRRCC education working group by December 2000. Collaborators: tourism information centers, museums, agricultural extension officers, schools, municipalities, volunteers, land-owners, and guest farms, farmers unions, clubs.
4. Develop effective and applicable evaluation process and set goals. September 2000. Collaborators: teachers.  
Responsible person: Environmental Education Working Group.  
Product: Constant standard throughout Riverine Rabbit distribution of environmental education drive.
5. Establish regional media connections (radio, newspapers, trade publications). Dec. 2000 by Environmental Education Working Group. Product: Effective regional media coverage (all media organizations).

**B. Maximum Goal: National and International awareness of Riverine Rabbit/Karoo/riverine system/ functions/ threats/ potentials**

1. Expansion of the network nationally and internationally.
2. Widen media connections on national and international level, include TV and internet website.

**Priority: 4. Formalize the protection of habitat**

**A. Minimum Goal: Establish Riverine Rabbit conservancies.**

1. Responsible parties: NRRCC (CNC/NCS, conservancies, Zoological Society for the Conservation of Species and Populations-ZSCSP). Collaborators: Conservation Committee (Agriculture). Establish 3-4 conservancies (J. Human-Brak River, M. Truter-Krom River, J.P. van der Merwe-Sak River) Forms and information of initial preparation work to proposed conservancies by January 2001. The investigation of the development of potential additional conservancies will be an on-going process.
2. Promotion of the conservancy concept within the Riverine Rabbit distributional range. Responsibility NRRCC, Ongoing. Product: Additional conservancies in Riverine distribution range.



3. Develop specific guidelines for habitat selection and possible corridors in conservancies in Riverine Rabbit distribution range (in cooperation with all collaborators)  
Suggested topics: Resource utilization (stock, eco-tourism)  
Predation (dogs, hunting)  
Interference (rehabilitation, stabilization)  
Also see “Habitat” section
4. Develop support structure for conservancies  
(NRRCC will be the main support structure that provides forums, statutory agency connections, legal advice, and inclusion of researchers from academic institutions) Ongoing process. Product: Network to equip conservancies.
5. Develop a list of benefits of being a conservancy member. NRRCC for September NRRCC meeting. Product – list.
6. Establish conservancies. NRRCC. Ongoing. Product: Establishing new conservancies.
7. Implement success evaluation system (monitoring) for conservancies.  
Responsible person: Registration agencies. Ongoing process. Product: High standard of conservancies.

**B. Maximum Goal: biosphere (core areas-open space III)-NRRCC will identify these areas within five years**

NOTE: Conclusion should be reached for independent management for biosphere reserve or whether NRRCC should become that body and resign as present NRRCC.

- 1) Set goals (e.g. 90% known distributional area in biosphere, 60% in core area, independent management plan, size of biosphere reserve)  
NRRCC, ongoing, Product: get vision for biosphere.
- 2) Identify core areas and buffer zones.  
NRRCC appoint Biosphere Reserve Working Group. Subsequent to completion of habitat map (see habitat section)
- 3) Promote biosphere reserve concept  
NRRCC, ongoing. Product: establishment of biosphere.
- 4) Establish biosphere reserve —rezone core areas  
Biosphere Reserve Working Group, within 10 years will have established, self sufficient biosphere reserve management by community.
- 5) Expand support and evaluation systems

NRRCC, ongoing. Will have developed systems at inception of biosphere reserve.

**Priority: 1. Develop coordinated management strategy**

**A. Minimum Goal: Formal adoption of PHVA recommendations by all role players, with the members of the NRRCC taking responsibility for furthering the adoption amongst their own constituencies (December 2000).**

- 1) Pro-active effort to encourage all applicable role players to commit to NRRCC. September 2000. Product: Improve representation/effectiveness of the NRRCC.

**B. Maximum Goal: Coordinated management of the Riverine Rabbit**

- 1.)NRRCC facilitate the PHVA plan implementation

**Priority: 2. Information deficiency**

**A. Minimum Goal: Consolidation of available information, identify gaps in knowledge and research priorities.**

1. The Zoological Society for the Conservation of Species and Populations will take the lead on the collation of existing relevant literature and data (e.g. scientific, Riverine Rabbit specific, land management, vegetation surveys, plus data collation needed by habitat group.) August 2001. Product: Available database and bibliography.
2. The NRRCC determining the final repository and method of dissemination of this information. September 2000, CNC. Present area and control persons for above mentioned.
3. The NRRCC will also take the lead role in identifying gaps in knowledge and research priorities. After 2001, NRRCC. Continue updated version of data base.

**B. Maximum Goal: National/international specialist involvement (scientific, managerial, funding)**

- 1) Identify projects and potential researchers/funders NRRCC, PHVA product. Ongoing. Continued involvement of Riverine Rabbit related activities.
- 2) Facilitate and implement projects NRRCC, Ongoing. More information available from outside sources.

- 3) Integrate and implement findings. NRRCC and applicable land owners. Ongoing, improved standards of management.

**CODE OF CONDUCT:**

Future research initiatives shall require the approval of the NRRCC.

Applications for research, possession or transport of Riverine Rabbits must meet legal requirements as stipulated in the respective ordinances.

**EXECUTIVE SUMMARY: Management and Strategies**

**Management and Strategies:**

The need for environmental awareness through a coordinated environmental education initiative is essential.

The lack of formal habitat protection requires the expansion of the existing conservancy system to cover a wider range of the Riverine Rabbits distribution, with the ultimate goal being to develop a biosphere reserve system of core and buffer areas.

The lack of a coordinated management strategy requires the expansion of the National Riverine Rabbit Coordinating Committee, and it taking formal responsibility for the implementation of the goals and objectives identified by the Riverine Rabbit PHVA Workshop.

Information collection, processing and distribution were identified as essential for the informed and coordinated implementation of conservation strategies. This process would also identify gaps in knowledge that would serve to identify future research priorities.

# **RIVERINE RABBIT**

*(Bunolagus monticularis)*

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Photo by: Kai Collins

**Threats**



## **Threats and Impacts .**

1. Habitat degradation and loss-this was covered by the habitat group
  - Fragmentation – Habitat / Genetic
  - Bush encroachment
  - Alien plant invaders
  
2. Predators
  - Natural
  - Jackal
  - Lynx
  - Black & Marshall Eagle
  - African wildcat
  - Introduced
    - Dogs
    - Cats
  
3. Capacity-this was covered by the Management & Strategies Group
  - Institutional
  - Research
  - Landowner collaboration
  
4. Lack of environmental awareness-this was covered by the Management & Strategies Group
  - Lack of co-operation and knowledge between farmers
  - Inappropriate land use.
  
- 5.Catastrophic events
  - floods
  - climate change
  - fire
  - disease

## **Goals**

1. Increase area of suitable habitat
2. Predators: eradicate predation by dogs

Conservancies should be established covering the entire range of the Riverine Rabbit. These conservancies must have as one of the mutually decided and occupied rules that no hunting with the use of dogs in the veld be tolerated.

3. Increase capacity and collaboration

Create a body that consists of all relevant role-players that can co-ordinate the effects and facilitate collaborations. Institutional capacity: dedicated staff need to be appointed that can facilitate the establishment of conservancies and collaboration. Research funding should be sought for specific projects from local and international funding agencies.

4. Increase environmental awareness.

Responsibility of Cape Nature Conservation (Western Cape province) and Northern Cape Nature Conservation Services.

5. Minimise the effect of catastrophic events

Flooding: Promote the stabilization of water courses using Phragmites and naturally occurring grasses such as Cynodon. Water courses should also be protected from excessive grazing through the judicious use of fencing and low weirs.

### **Tasks Remaining to be Completed after the Workshop:**

- 1) Fully integrate the Threats Working Group materials into a consolidated report.**
- 2) Clarify any elements that may not be understandable to others who did not attend the workshop.**
- 3) Set responsibilities and time frames for the remainder of the tasks.**
- 4) Identify resources required to complete all tasks.**

**Working group members agree to complete these tasks following the workshop (see Appendix).**

## **Executive Summary:**

### **Threats (not addressed by other working groups) :**

- 3) The control of dog predation was identified as a major priority to be implemented through the NRRCC, with the cooperation of the existing and future conservancies.**
- 4) Potential catastrophic events that were identified included; flooding, climate change, fire, and disease. Elements that can be controlled to some extent through careful land management included flooding and fire. It will be the NRRCC to promote the use of judicious management techniques that favour the survival of the Riverine Rabbit.**

**The National Riverine Rabbit Coordinating Committee shall include the provincial agencies, South African National Parks, Department of Agriculture, Department of Water Affairs and Forestry, Department of Environmental Affairs and Tourism, landowners, NGOs, academic institutions, and other interested parties. This group shall take the lead role in promoting and facilitating the conservation of the Riverine Rabbit through a cooperative, inclusive process.**





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Photo by: Kai Collins

**Census Needs**



## Census Needs

### Census techniques – Review

A range of possible techniques which may be of value in the censusing of Riverine Rabbit populations were listed as worthy of future examination by the group. This may be divided into two broad groups in terms of requiring handling and catching of individuals and are therefore listed below as invasive and non-invasive techniques.

#### A. Non-invasive

1. Use of indirect signs:  
Counts of fecal pellets  
Counts of Riverine Rabbit breeding burrows  
Counts of forms

Counts of breeding burrows and forms could potentially be performed by means of drive counts (line of operators moving through habitat) who collect hairs from burrows and forms for microscopic identification of species.

Collection of faecal pellets requires tracker expertise in identification of faecal material and other sign (e.g. ability to distinguish that of Riverine Rabbit from that of the *Lepus* species present) and additionally some experience in determining the age of these signs (e.g. are the forms in current use)

2. Use of auto-trap cameras  
These would be set up in potential habitat areas and activated by any animal passing in front of the camera.  
This is an expensive approach to the problem and has the additional disadvantage that distinguishing individual animals may be impossible.

3. Transect counts of animals from horseback or vehicle.  
These techniques are already in use within these areas so there has been a certain refinement of these particular methods.  
MORE DETAILS REQUIRED FROM EXPERTS HERE

Comments:

1) & 2) above may be useful in determining a rank index of animals in an area but would require further research if these methods were to be used to try to ascertain NUMBERS of animals in areas.

Horseback counts involve some disturbance of animals/habitat as areas of assessed.

#### 4. Genetic techniques

The possibility of sencing through genetic identification may be possible. This would require collection of hair/faeces or other products for DNA extraction and might permit identification of numbers of individuals within areas. This could be an expensive process requiring expertise in appropriate genetic technology.

#### **B. Invasive techniques**

IT IS EMPHASIZED AT THE OUTSET THAT RABBITS/HARES ARE HIGHLY SUSCEPTIBLE TO CAPTURE STRESS AND THAT TRAINING OF OPERATORS IS ESSENTIAL AND PROTOCOL DURATION MINIMISED TO DECREASE RISKS TO CAPTURED ANIMALS.

*Capture of animals in long-nets and/or cage-traps.*

Long-nets are hung from short sticks and a line of people walk through habitat towards the net.

People stationed at the net quickly remove animals captured into holding bag/box for marking/collection of biological data. The description of a successful technique using this approach is given in the thesis of Duthie (1989).

Dual entrance cage-traps would be positioned along rabbit tracks (probably in areas of dense habitat) and would be set (and checked after suitable time intervals) after the rabbits had become habituated to passing through these. Again any rabbits caught would be removed by a trained operator into bag/box for subsequent tagging/data collection.

Once captured the animals can be marked with coloured/numbered ear tags, radio-collars or satellite tags for individual recognition/tracking. This marking would assist the sencing process in that the fate of individuals may be tracked over time and space.

#### **Conclusions**

Further research is urgently required into the development of a standardised sencing protocol which can be repeated by successive researchers across the species range. The particular problems associated with sencing this species include its nocturnal activity within dense, low visibility habitat and its high susceptibility to stress on capture. Research should focus on identifying a technique yielding reliable replicability in results with minimal negative impact on the target species.

Current experience favours a technique using a combination transect sweep from horseback and on foot through the habitat counting any individuals displaced en route.

**Recommendations: Research Priorities:**

- Standardised and repeatable census techniques for assessing the population numbers of Riverine Rabbits within particular patches of habitat.
- Standardised and quantitative identifiability of the vegetation and soil characteristics of suitable riverine habitat.

Execution of the above two research topics needs require close collaboration between property owners, conservation institutions and research scientists at academic institutions.

- The distances of migration and dispersal of Riverine Rabbits and the degree of between-population movements.
- The degree of genetic differentiation between different populations of Riverine Rabbits.
- The population dynamics (including reproductive rates and mortality) of natural populations of Riverine Rabbits.

The execution of the above three projects require collaboration between research institutions and property owners.



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Photo by: Chrizette Kleynhans

**Captive Population**





## Captive Population

### Captive breeding as a tool in the conservation of the Riverine Rabbit

Captive breeding would have several benefits for the conservation of Riverine Rabbits. These include:

- It would provide a reserve of live animals which could be reintroduced into areas of suitable habitat.
- It would result in a repository of genetic variation in the species for augmenting genetic variation in genetically depleted populations.
- It would allow the gathering of demographic data (fecundity, mortality, life span) of Riverine Rabbits. These are very difficult to obtain in the wild.
- It could be a valuable source of sperm and tissue for use in tissue banking.

However, captive breeding also has several negative attributes:

- The release of captive-bred individuals into the wild has very little value if the fundamental causes of threat to the existing population are not understood. Reintroduction would constitute a short-term bolstering of existing populations, but the longer-term threats to existing populations would most likely also apply to released rabbits.
- A captive breeding programme would draw resources and attention away from the fundamental conservation efforts required to remove the threats to which wild populations are subject to.
- An absence of knowledge about the genetic structure within the extant Riverine Rabbit populations would make it impossible to predict the genetic consequences of reintroduction of captive-bred rabbits. Reintroductions could compromise geographic genetic structuring in this species.
- Captive-bred rabbits could introduce infectious diseases into wild populations.
- Captive-bred rabbits would not necessarily have the behavioural attributes in feeding and predator avoidance, as well as digestive microfauna found in wild rabbits.
- The costly infrastructure required for captive breeding (husbandry experience in combination with suitable holding facilities) is not available at present.
- Experience with Riverine Rabbits in captivity has shown that it is technically very difficult to implement a planned captive breeding programme for these animals.
- There is no compelling evidence that sufficiently large populations exist in the wild so that a sample of 16-32 rabbits could be captured to initiate a captive breeding programme.

### Recommendation 1

**It was decided that, given the lack of knowledge and resources to initiate a captive breeding programme, the negative factors (disadvantages of using wild stock; putting source populations at risk; potentially inbreeding perhaps) by far outweigh the benefits and that it would be unwise to initiate a captive breeding programme.**

### **The captive rabbits currently in the Karoo National Park:**

The reintroduction of Riverine Rabbits into the Karoo National Park (KNP) started with tentative explorations by the park manager, Harold Braack in the mid-80's. This coincided with ecological and genetic studies and the initiation of a captive breeding programme at De Wildt near Pretoria. Investigation showed that Riverine Rabbits did occur historically at Lombardskraal near the KNP. This was deemed sufficient to infer that the animals did occur within the park. Possible sites were investigated. After vegetation surveys and discussion with experts the Sand River section in the park was considered most suitable. This was in line with the policy of S. A. National Parks to reintroduce species that historically occurred in the park. During 1994 six animals (3 male, 3 female) were donated to the KNP.

For several reasons, including sex ratios, inbreeding and the recognition that the Sand River section comprises suboptimal habitat, it was decided during 1998 that captive breeding of rabbits in the KNP should be terminated. The question thus arose about the fate of the animals in the KNP. Six possible release sites were considered:

- Return of animals to the farms where the founder individuals were captured, i.e. Sandgat (Victoria West district) and Lapfontein (Beaufort West district).
- Release into available habitat in the KNP.
- Release into suitable, vacant habitat elsewhere.
- Donation of animals to a zoological garden.
- Keeping the rabbits in the present enclosures at the KNP.

Four criteria were used to determine a ranking of these possibilities:

- Possibility of introduction of diseases to natural populations.
- Possibility of genetic incompatibilities between captive and wild rabbits.
- Availability of suitable habitat.
- The longstanding relationship between property owners and biologists.

### **Recommendation 2**

**By far the largest benefit would be obtained if rabbits were returned to the original farms where the founder rabbits were captured.** These farms have suitable habitat and the goodwill between biologists and property owners would be significantly increased by this action. The farmers will decide among themselves about the allocation of the four rabbits.

The physical capture of the four rabbits will be done using capture nets under the supervision of a veterinarian with interest in lagomorphs. Tissue and hair samples of each animal will be collected and forwarded to Prof. Robinson at Stellenbosch University who will sex the animals by karyotype. The handling of animals needs to be minimised and suitable tranquilisers will be used during the handling of the rabbits. The animals will be

transported in separate boxes with bedding. The animals would need to be kept in quarantine facilities on the destination farms. The KNP offered to make the fencing material of the present holding facilities available to the farmers. The quarantine camp needs to be situated outside core areas that may have high densities of Riverine Rabbits in order not to disrupt the social organisation of the wild rabbits.

### **Recommendation 3**

**The four captive rabbits will not be released until a genetic analysis has been performed by Prof. Robinson at the University of Stellenbosch in order to infer the degree of genetic difference between the captive animals and the wild rabbits at the release site.** Given that no such differences exist, and if the rabbits have no demonstrable signs of disease, the lifting of the quarantine fencing will be performed.

### **Reintroductions, supplementations and translocations:**

#### **Recommendation 4**

**In principle the recommendation from this group would be not to consider any of these as possible management techniques at this point in time.**

These actions would be premature due to the lack of fundamental life history, demographic, ecological and genetic data. The criteria for these management actions would include information on the causes of decline, reasons for the absence of animals in areas of optimal habitat, genetic compatibility amongst populations in different areas, potential disease introduction, behavioural constraints and other well-established principles.

In reference to the geographic population genetic structure we recommend the a broad-scale genetic survey be undertaken including DNA samples collected from extant populations as well as museum specimens collected approximately sixty years ago. Extant populations could be sampled either by non-invasive techniques such as anonymously-collected hairs or faecal samples, or by tissue collected from captured animals. The collection of samples from these extant population will be the limiting factor in terms of setting time frames for completion.

In respect of the above principles the specific recommendations for the four captive animals (that we know were derived from two geographically distinct localities) are as follows. These animals are to be confined within enclosures pending the outcome of genetic studies. At a minimum these genetic studies would involve comparisons between the four captive animals and existing museum material including several samples from the species range. However, the optimum genetic studies would include baseline population genetic information from selected study sites throughout the species current distribution. If the genetic studies show that the species exhibits geographical genetic

structuring then these animals must not be introduced into areas where they are not genetically compatible.

# RIVERINE RABBIT

*(Bunolagus monticularis)*

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**Population Biology and Modelling  
with an  
Introduction to Population Modelling**



# Population Biology and Modelling

## Riverine Rabbit Computer Simulation Modelling Working Group

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Terry Robinson  
Emile Smidt  
Willem Ferguson  
Kai Collins  
Rod Randall  
Deryn Alpers  
Diana Bell

### Main Problems:

**Inadequate knowledge and data, there is a need to investigate to following parameters:**

#### A) Demographic parameters

1. Mortality rates (of both young and adults).
2. Lifespan
3. Litter sizes
4. Breeding frequency
5. Fecundity and fertility
6. Frequency and severity of inbreeding
7. Presence of genetic drift
8. Migration and dispersal of subpopulations within a metapopulation framework.
9. Social system
10. Territoriality

#### B) Environmental variation

**C) Main threats to population in relation to mortality and possible population decline.**

### **VORTEX parameters investigated**

Many of the parameters whose data was not available were estimated in combination with, where possible, expertise from specialists in the relevant fields. The parameter values for the base scenario are shown in bold italics.

One population was modelled with a starting size of 20.



Inbreeding depression was included in half of the simulations at the default value of 3.14 lethal equivalents per diploid genome with 50% as lethal alleles. .

<b>Parameters</b>	<b>Variations tested</b>
1. Initial population size (N):	<b>20</b>
2. Carrying Capacity (K)	<b>20, 50, 100</b>
3. Maximum breeding age (life expectancy)	2, 3, 4 & <b>5</b> years.
4. Sex ratio at birth?	1:1
5. .Max number of young/year? This is based on the maximum seen in captivity, i.e. the potential maximum, of two litters of twins per year.	<b>4</b>
6. Mortality rates: (made up of a combination of natural mortality, natural predation and hunting).	
Adult mortality: Males	20%, <b>25%</b>
Females	15%, <b>20%</b>
Juvenile mortality: Males	<b>70</b>
Females	<b>60, 50, 40%</b>
7. Is reproduction density dependent?	No
8. % adult females breeding each year?	Use 100% for now
9. % of breeding females producing (at birth, per year):	
1 offspring	<b>20,</b> 40, 60
2 offspring	<b>60,</b> 40, 40
3 offspring	<b>15,</b> 20, 0
4 offspring	<b>5,</b> 0, 0
10. Catastrophes	
a) Floods - occurrence; every 20 years i.e. 5% probability)	
• effect on repro?	0.5
• (important to do a sensitivity analysis for this) effect on adult survival?	0.8
b) Severe Drought - once every 11 years, i.e. 9% (from work done by Tyson)	
• effect on repro?	0.2
• (important to do a sensitivity analysis for this) effect on adult survival?	0.75

11.	All males in breeding pool?	Yes
12.	Stable age distribution?	Yes
13.	Carrying capacity?	<b>20</b> , 50, 100
14.	Harvest population?	No for now
15.	Supplement?	No for now

### **Results of the Simulations:**

The simulations were run for 100 years with 500 repetitions for each scenario. Inbreeding was not included in the BASE scenario and no catastrophes were included. The BASE scenario, Table 1 Line 1, indicates a high probability of extinction ( $P_e$ ) under these conditions with a 73% probability of populations extinct in 100 years with a mean time to extinction ( $T_e$ -yr) of 42 years. This is in spite of positive deterministic ( $r_{det}$ ) and stochastic growth rates ( $r_{stoc}$ ). A deterministic model would have indicated that the population is growing under these conditions. In addition the population has lost about 89% of the starting heterozygosity ( $Het$ ) and is experiencing a high level of inbreeding. The generation time was estimated at 2.4 years (Table 4). With these adult mortalities, the stable age distribution indicates the proportion of adult males to females in the population is reduced to 0.69/1.00.

Exploratory scenarios indicated that the outcomes, under these conditions are sensitive to the carrying capacity and to the expected maximum longevity. Increasing the carrying capacity to 50 or 100 reduced the  $P_e$  from 0.730 to 0.112 or 0.076 respectively indicating a substantial benefit (Table 1, Lines 2 & 3). There also was 3 to 5 fold increase in the retention of genetic heterozygosity. Reduction of the expected maximum longevity or maximum age of reproduction to 4 years reduced the stochastic growth rate to 0 and increased the  $P_e$  to 0.940 with a mean  $T_e$  of 34 years Table 1, Lines 4-6).

Addition of the two catastrophe scenarios, one for floods and the other for drought, to the BASE model (Table 1, Lines 7 & 8) although still yielding positive growth rate values resulted in near 100% risk of extinction with mean times of extinction around 25 years. As might be expected, the additional mortality or decreased reproduction imposed on the baseline conditions hastened and increased the risk of extinction. Similar results were obtained with the addition of inbreeding depression to the BASE scenario (Table 1, Line 9) with 100% probability of extinction and a mean time to extinction of 26 years. . Decreasing the average annual reproductive output from an average of 2 per adult female to 1.6 or 1.4 resulted in negative stochastic growth rates and near 100% risk of extinction.

Decreasing juvenile mortality (Table 1, Lines 10 & 11) or adult female mortality (Table 1, Line 12) resulting in a doubling or tripling of 'r' also decreased the  $P_e$  but the values still ranged from 30 to 50% in 1200 years.

The sum of these simulations indicates that if the carrying capacity of the habitat of these population fragments is near 20 then there is little hope for the persistence of the species. It may be expected that individual populations will disappear with a mean time to extinction of 20-40 years and if they cannot be recolonized by either natural migration or releases then there will be a continuing decline in the total population.  $P_e$  must be increased to reduce the risk of extinction. The situation is further complicated by the potential hazards of inbreeding depression which could significantly increase the rate of loss.

Increasing the carrying capacity and by inference the potential population size to 50 animals (Table 2) reduces the risk of extinction but does not provide substantial protection against the hazards of catastrophes or inbreeding depression. Reduction in juvenile mortality by a modest amount from 60% to either 50 or 40% provided large benefits in terms of an increase in 'r' from 0.101 to 0.208 or 0.301 respectively and a decrease in ' $P_e$ '. Reduction of adult female mortality from 20% to 15% also yielded a small increase in stochastic population growth rate from 0.101 to 0.139 and reduced the  $P_e$  from 0.112 to 0.036. Neither improvement is as great as the doubling or tripling in growth rate observed with a decrease in juvenile mortality.

### **Summary and Recommendations:**

**Summary:** The probability of extinction of Riverine Rabbit populations with  $K=20$  is high under all conditions explored in these simulations. Inbreeding depression, if it occurs, greatly increases this risk and remains a problem at higher population sizes. Increase of the  $K$  to 50 provided substantial benefits in reducing the risk of extinction under ideal conditions. The greatest improvements in growth rates or extinction risks occurred with a reduction of juvenile mortality rates.

**Recommendations:** Measurement of first year mortality and its causes and efforts to reduce that rate to 50% or less in combination with a minimal expansion of the carrying capacity of individual population fragments to 50 animals appear to offer the most effective management strategies to improve the prospects for survival of the Riverine Rabbit. It will be important to determine the vulnerability of the species to inbreeding depression as a guide to the possible need for additional management actions.

Table 1. Effects of increases in carrying capacity (K) and decreases in longevity (Long.) on outcomes of simulations of Riverine Rabbit populations. The separate effects on the base scenario, with K=20, of inclusion of catastrophes, adding inbreeding, decreases in juvenile and adult mortality, and decreased reproduction to the base scenario are tabulated. The simulations were run for 100 years with 500 repetitions. The parameter values for the base scenario, suggested during the workshop, are shown in Table 3 and the full output for those values is shown in Table 4. .

File#	K	Long.		r(det)	r(stoc)	Pe	Te-yr	N	Het
RIVEN002	20	5	BASE	.131	.085	.730	42	16	.106
RI50N002	50	5	Base	.131	.101	.112	39	38	.380
R100N002	100	5	Base	.131	.108	.076	18	82	.588
RIVEN020	20	4	Base	.088	.042	.940	34	14	.047
RIVEN038	20	3	Base	.000	-.048	1.00	9	0	0
RIVEN056	20	2	Base	-.207	-.216	1.00	7	0	0
RIVEN006	20	5	Catas. 1	.056	.011	.990	25	15	.011
RIVEN004	20	5	Catas. 2	.077	.028	.966	28	12	.143
RIVEY001	20	5	+Inbr	.131	-.012	1.00	26	0	0
CIVEN002	20	5	50%JM	.231	.194	.344	50	19	.087
EIVEN002	20		40%JM	.386	.356	.328	47	19	.075
DIVEN002	20	5	15%AM	.166	.124	.498	47	17	.107
RIVEN008	20	5	1.6Repr	.029	-.008	.982	29	14	.114
RIVEN014	20	5	1.4Repr	-.023	-.049	1.00	22	0	0

Table 2. Effects of increasing carrying capacity to 50 (K) on outcomes of simulations of Riverine Rabbit populations. The separate effects on the base scenario, with K=50, of inclusion of catastrophes, adding inbreeding, decreases in juvenile and adult mortality, and decreased reproduction to the base scenario are tabulated. The simulations were run for 100 years with 500 repetitions. The parameter values for the base scenario, suggested during the workshop, are shown in Table 3. All conditions except for the increase in carrying capacity are the same as for Table 1.

File#	K	Long.		r(det)	r(stoc)	Pe	Te-yr	N	Het
RIVEN002	20	5	BASE	.131	.085	.730	42	16	.106
RI50N002	50	5	Base-50	.131	.101	.112	39	38	.380
R100N002	100	5	Base100	.131	.108	.076	18	82	.588
RI50N020	50	4	Base-50	.088	.049	.526	41	38	.290
RI50N038	50	3	Base-50	.000	-.042	.980	26	13	.044
RI50N056	50	2	Base-50	-.207	-.226	1.00	8	0	0
RI50N006	50	5	Catas. 1	.056	.014	.844	37	31	.257
RI50N004	50	5	Catas. 2	.077	.036	.712	41	33	.279
RI50Y001	50	5	+Inbr	.131	-.003	.968	51	19	.380
CI50N002	50	5	50%JM	.231	.208	.014	46	48	.403
EI50N002	50	5	40%JM	.318	.301	.018	64	49	.383
DI50N002	50	5	15%AM	.166	.139	.036	25	46	.403
RI50N008	50	5	1.6Repr	.029	-.004	.790	37	31	.236
RI50N014	50	5	1.4Repr	-.023	-.056	.986	26	17	.193

Table 3. Parameter value VORTEX input file for the base scenario.

```

RIVEN002.out      ***Output Filename***
Y      ***Graphing Files?***
N      ***Details each Iteration?***
500    ***Simulations***
100    ***Years***
10     ***Reporting Interval***
0      ***Definition of Extinction***
1      ***Populations***
N      ***Inbreeding Depression?***
Y      ***EV concordance between repro and surv?***
2      ***Types Of Catastrophes***
P      ***Monogamous, Polygynous, or Hermaphroditic***
1      ***Female Breeding Age***
1      ***Male Breeding Age***
5      ***Maximum Breeding Age***
50.000000 ***Sex Ratio (percent males)***
4      ***Maximum Litter Size (0 = normal distribution) *****
N      ***Density Dependent Breeding?***
Pop1
100.00 **breeding
0.00  **EV-breeding
20.000000 ***Pop1: Percent Litter Size 1***
60.000000 ***Pop1: Percent Litter Size 2***
15.000000 ***Pop1: Percent Litter Size 3***
60.000000 *FMort age 0
15.000000 ***EV
20.000000 *Adult FMort
5.000000 ***EV
70.000000 *MMort age 0
18.000000 ***EV
25.000000 *Adult MMort
6.000000 ***EV
5.000000 ***Probability Of Catastrophe 1***
1.000000 ***Severity--Reproduction***
1.000000 ***Severity--Survival***
9.000000 ***Probability Of Catastrophe 2***
1.000000 ***Severity--Reproduction***
1.000000 ***Severity--Survival***
Y      ***All Males Breeders?***
Y      ***Start At Stable Age Distribution?***
20     ***Initial Population Size***
20     ***K***
0.000000 ***EV--K***
N      ***Trend In K?***
N      ***Harvest?***
N      ***Supplement?***
Y      ***AnotherSimulation?***

```

Table 4. Output file for the base scenario with K=20 and Longevity =5 years. The parameter values for the simulation are included.

VORTEX 8.40 -- simulation of genetic and demographic stochasticity

RIVEN002.out

Fri Jul 28 22:59:23 2000

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

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

No inbreeding depression

First age of reproduction for females: 1 for males: 1

Maximum breeding age (senescence): 5

Sex ratio at birth (percent males): 50.000000

Population: Pop1

Polygynous mating; all adult males in the breeding pool.

100.00 percent of adult females produce litters.

EV in % adult females breeding = 0.00 SD

Of those females producing litters, ...

20.00 percent of females produce litters of size 1

60.00 percent of females produce litters of size 2

15.00 percent of females produce litters of size 3

5.00 percent of females produce litters of size 4

60.00 percent mortality of females between ages 0 and 1

EV in % mortality = 15.000000 SD

20.00 percent mortality of adult females (1<=age<=5)

EV in % mortality = 5.000000 SD

70.00 percent mortality of males between ages 0 and 1

EV in % mortality = 18.000000 SD

25.00 percent mortality of adult males (1<=age<=5)

EV in % mortality = 6.000000 SD

EVs may be adjusted to closest values possible for binomial distribution.

EV in reproduction and mortality will be concordant.

Frequency of type 1 catastrophes: 5.000 percent

multiplicative effect on reproduction = 1.000000

multiplicative effect on survival = 1.000000

Frequency of type 2 catastrophes: 9.000 percent

multiplicative effect on reproduction = 1.000000

multiplicative effect on survival = 1.000000

Initial size of Pop1: 20  
 (set to reflect stable age distribution)

Age	1	2	3	4	5	Total	
3	2	2	2	1	0	8	Males
4	3	2	2	2	1	12	Females

Carrying capacity = 20  
 EV in Carrying capacity = 0.00 SD

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

r = 0.131      lambda = 1.140      R0 = 1.378  
 Generation time for: females = 2.44      males = 2.33

Stable age distribution:

Age class	females	males
0	0.274	0.274
1	0.096	0.072
2	0.067	0.047
3	0.047	0.031
4	0.033	0.021
5	0.023	0.013

Ratio of adult (>= 1) males to adult (>= 1) females: 0.691

Population 1: Pop1

Year 10

N[Extinct] = 33, P[E] = 0.066  
 N[Surviving] = 467, P[S] = 0.934  
 Mean size (all populations) = 15.13 ( 0.26 SE, 5.86 SD)  
 Means across extant populations only:  
 Population size = 16.06 ( 0.22 SE, 4.81 SD)  
 Expected heterozygosity = 0.782 ( 0.004 SE, 0.086 SD)  
 Observed heterozygosity = 0.856 ( 0.005 SE, 0.116 SD)  
 Number of extant alleles = 7.62 ( 0.09 SE, 1.95 SD)

Year 20

N[Extinct] = 79, P[E] = 0.158  
 N[Surviving] = 421, P[S] = 0.842  
 Mean size (all populations) = 13.59 ( 0.32 SE, 7.21 SD)  
 Means across extant populations only:  
 Population size = 16.10 ( 0.23 SE, 4.67 SD)  
 Expected heterozygosity = 0.616 ( 0.008 SE, 0.155 SD)  
 Observed heterozygosity = 0.678 ( 0.010 SE, 0.195 SD)  
 Number of extant alleles = 4.30 ( 0.07 SE, 1.37 SD)

Year 30

N[Extinct] = 147, P[E] = 0.294  
 N[Surviving] = 353, P[S] = 0.706  
 Mean size (all populations) = 11.70 ( 0.37 SE, 8.34 SD)  
 Means across extant populations only:  
 Population size = 16.35 ( 0.26 SE, 4.92 SD)  
 Expected heterozygosity = 0.485 ( 0.011 SE, 0.200 SD)



Observed heterozygosity = 0.526 ( 0.013 SE, 0.241 SD)  
 Number of extant alleles = 3.00 ( 0.06 SE, 1.06 SD)

Year 40  
 N[Extinct] = 191, P[E] = 0.382  
 N[Surviving] = 309, P[S] = 0.618  
 Mean size (all populations) = 9.86 ( 0.39 SE, 8.70 SD)  
 Means across extant populations only:  
 Population size = 15.90 ( 0.29 SE, 5.15 SD)  
 Expected heterozygosity = 0.374 ( 0.012 SE, 0.216 SD)  
 Observed heterozygosity = 0.407 ( 0.014 SE, 0.253 SD)  
 Number of extant alleles = 2.34 ( 0.05 SE, 0.86 SD)

Year 50  
 N[Extinct] = 240, P[E] = 0.480  
 N[Surviving] = 260, P[S] = 0.520  
 Mean size (all populations) = 8.63 ( 0.40 SE, 8.91 SD)  
 Means across extant populations only:  
 Population size = 16.40 ( 0.32 SE, 5.11 SD)  
 Expected heterozygosity = 0.297 ( 0.013 SE, 0.216 SD)  
 Observed heterozygosity = 0.330 ( 0.016 SE, 0.254 SD)  
 Number of extant alleles = 1.96 ( 0.04 SE, 0.70 SD)

Year 60  
 N[Extinct] = 277, P[E] = 0.554  
 N[Surviving] = 223, P[S] = 0.446  
 Mean size (all populations) = 7.40 ( 0.39 SE, 8.67 SD)  
 Means across extant populations only:  
 Population size = 16.46 ( 0.30 SE, 4.43 SD)  
 Expected heterozygosity = 0.236 ( 0.015 SE, 0.219 SD)  
 Observed heterozygosity = 0.251 ( 0.016 SE, 0.244 SD)  
 Number of extant alleles = 1.74 ( 0.04 SE, 0.67 SD)

Year 70  
 N[Extinct] = 300, P[E] = 0.600  
 N[Surviving] = 200, P[S] = 0.400  
 Mean size (all populations) = 6.59 ( 0.38 SE, 8.55 SD)  
 Means across extant populations only:  
 Population size = 16.32 ( 0.35 SE, 4.89 SD)  
 Expected heterozygosity = 0.194 ( 0.015 SE, 0.211 SD)  
 Observed heterozygosity = 0.209 ( 0.017 SE, 0.239 SD)  
 Number of extant alleles = 1.57 ( 0.04 SE, 0.60 SD)

Year 80  
 N[Extinct] = 327, P[E] = 0.654  
 N[Surviving] = 173, P[S] = 0.346  
 Mean size (all populations) = 5.67 ( 0.36 SE, 8.15 SD)  
 Means across extant populations only:  
 Population size = 16.26 ( 0.34 SE, 4.46 SD)  
 Expected heterozygosity = 0.163 ( 0.016 SE, 0.205 SD)  
 Observed heterozygosity = 0.169 ( 0.017 SE, 0.224 SD)  
 Number of extant alleles = 1.46 ( 0.04 SE, 0.54 SD)

Year 90  
 N[Extinct] = 345, P[E] = 0.690  
 N[Surviving] = 155, P[S] = 0.310  
 Mean size (all populations) = 4.92 ( 0.36 SE, 7.96 SD)

Means across extant populations only:  
 Population size = 15.77 ( 0.46 SE, 5.74 SD)  
 Expected heterozygosity = 0.136 ( 0.015 SE, 0.193 SD)  
 Observed heterozygosity = 0.160 ( 0.019 SE, 0.239 SD)  
 Number of extant alleles = 1.36 ( 0.04 SE, 0.48 SD)

Year 100

N[Extinct] = 365, P[E] = 0.730  
 N[Surviving] = 135, P[S] = 0.270  
 Mean size (all populations) = 4.33 ( 0.33 SE, 7.49 SD)

Means across extant populations only:  
 Population size = 15.96 ( 0.40 SE, 4.69 SD)  
 Expected heterozygosity = 0.106 ( 0.016 SE, 0.183 SD)  
 Observed heterozygosity = 0.119 ( 0.018 SE, 0.214 SD)  
 Number of extant alleles = 1.29 ( 0.04 SE, 0.45 SD)

In 500 simulations of Pop1 for 100 years:  
 365 went extinct and 135 survived.

This gives a probability of extinction of 0.7300 (0.0199 SE),  
 or a probability of success of 0.2700 (0.0199 SE).

365 simulations went extinct at least once.  
 Median time to first extinction was 53 years.  
 Of those going extinct,  
 mean time to first extinction was 42.37 years (1.33 SE, 25.49 SD).

Means across all populations (extant and extinct) ...  
 Mean final population was 4.33 (0.33 SE, 7.49 SD)

1.79 Males  
 2.54 Females

Means across extant populations only ...  
 Mean final population for successful cases was 15.96 (0.40 SE, 4.69 SD)

6.63 Males  
 9.41 Females

Across all years, prior to carrying capacity truncation,  
 mean growth rate (r) was 0.0848 (0.0017 SE, 0.2911 SD)

Final expected heterozygosity was 0.1058 ( 0.0157 SE, 0.1829 SD)  
 Final observed heterozygosity was 0.1186 ( 0.0184 SE, 0.2136 SD)  
 Final number of alleles was 1.29 ( 0.04 SE, 0.45 SD)  
 \*\*\*\*\*

\*



## **An Introduction to Simulation Modelling and Population Viability Analysis**

A model is any simplified representation of a real system. We use models in all aspects of our lives, in order to: (1) extract the important trends from complex processes, (2) permit comparison among systems, (3) facilitate analysis of causes of processes acting on the system, and (4) make predictions about the future. A complete description of a natural system, if it were possible, would often decrease our understanding relative to that provided by a good model, because there is "noise" in the system that is extraneous to the processes we wish to understand. For example, the typical representation of the growth of a wildlife population by an annual percent growth rate is a simplified mathematical model of the much more complex changes in population size. Representing population growth as an annual percent change assumes constant exponential growth, ignoring the irregular fluctuations as individuals are born or immigrate, and die or emigrate. For many purposes, such a simplified model of population growth is very useful, because it captures the essential information we might need regarding the average change in population size, and it allows us to make predictions about the future size of the population. A detailed description of the exact changes in numbers of individuals, while a true description of the population, would often be of much less value because the essential pattern would be obscured, and it would be difficult or impossible to make predictions about the future population size.

In considerations of the vulnerability of a population to extinction, as is so often required for conservation planning and management, the simple model of population growth as a constant annual rate of change is inadequate for our needs. The fluctuations in population size that are omitted from the standard ecological models of population change can cause population extinction, and therefore are often the primary focus of concern. In order to understand and predict the vulnerability of a wildlife population to extinction, we need to use a model which incorporates the processes which cause fluctuations in the population, as well as those which control the long-term trends in population size (Shaffer 1981). Many processes can cause fluctuations in population size: variation in the environment (such as weather, food supplies, and predation), genetic changes in the population (such as genetic drift, inbreeding, and response to natural selection), catastrophic effects (such as disease epidemics, floods, and droughts), decimation of the population or its habitats by humans, the chance results of the probabilistic events in the lives of individuals (sex determination, location of mates, breeding success, survival), and interactions among these factors (Gilpin and Soulé 1986).

Models of population dynamics which incorporate causes of fluctuations in population size in order to predict probabilities of extinction, and to help identify the processes which contribute to a population's vulnerability, are used in "Population Viability Analysis" (PVA) (Lacy 1993/4). For the purpose of predicting vulnerability to extinction, any and all population processes that impact population dynamics can be important. Much analysis of conservation issues is conducted by largely intuitive assessments by biologists with experience with the system. Assessments by experts can be quite valuable, and are often contrasted with "models" used to evaluate population vulnerability to extinction. Such a contrast is not valid, however, as *any* synthesis of facts and

understanding of processes constitutes a model, even if it is a mental model within the mind of the expert and perhaps only vaguely specified to others (or even to the expert himself or herself).

A number of properties of the problem of assessing vulnerability of a population to extinction make it difficult to rely on mental or intuitive models. Numerous processes impact population dynamics, and many of the factors interact in complex ways. For example, increased fragmentation of habitat can make it more difficult to locate mates, can lead to greater mortality as individuals disperse greater distances across unsuitable habitat, and can lead to increased inbreeding which in turn can further reduce ability to attract mates and to survive. In addition, many of the processes impacting population dynamics are intrinsically probabilistic, with a random component. Sex determination, disease, predation, mate acquisition -- indeed, almost all events in the life of an individual -- are stochastic events, occurring with certain probabilities rather than with absolute certainty at any given time. The consequences of factors influencing population dynamics are often delayed for years or even generations. With a long-lived species, a population might persist for 20 to 40 years beyond the emergence of factors that ultimately cause extinction. Humans can synthesize mentally only a few factors at a time, most people have difficulty assessing probabilities intuitively, and it is difficult to consider delayed effects. Moreover, the data needed for models of population dynamics are often very uncertain. Optimal decision-making when data are uncertain is difficult, as it involves correct assessment of probabilities that the true values fall within certain ranges, adding yet another probabilistic or chance component to the evaluation of the situation.

The difficulty of incorporating multiple, interacting, probabilistic processes into a model that can utilize uncertain data has prevented (to date) development of analytical models (mathematical equations developed from theory) which encompass more than a small subset of the processes known to affect wildlife population dynamics. It is possible that the mental models of some biologists are sufficiently complex to predict accurately population vulnerabilities to extinction under a range of conditions, but it is not possible to assess objectively the precision of such intuitive assessments, and it is difficult to transfer that knowledge to others who need also to evaluate the situation. Computer simulation models have increasingly been used to assist in PVA. Although rarely as elegant as models framed in analytical equations, computer simulation models can be well suited for the complex task of evaluating risks of extinction. Simulation models can include as many factors that influence population dynamics as the modeler and the user of the model want to assess. Interactions between processes can be modeled, if the nature of those interactions can be specified. Probabilistic events can be easily simulated by computer programmes, providing output that gives both the mean expected result and the range or distribution of possible outcomes. In theory, simulation programmes can be used to build models of population dynamics that include all the knowledge of the system which is available to experts. In practice, the models will be simpler, because some factors are judged unlikely to be important, and because the persons who developed the model did not have access to the full array of expert knowledge.

Although computer simulation models can be complex and confusing, they are precisely defined and all the assumptions and algorithms can be examined. Therefore, the models

are objective, testable, and open to challenge and improvement. PVA models allow use of all available data on the biology of the taxon, facilitate testing of the effects of unknown or uncertain data, and expedite the comparison of the likely results of various possible management options.

PVA models also have weaknesses and limitations. A model of the population dynamics does not define the goals for conservation planning. Goals, in terms of population growth, probability of persistence, number of extant populations, genetic diversity, or other measures of population performance must be defined by the management authorities before the results of population modelling can be used. Because the models incorporate many factors, the number of possibilities to test can seem endless, and it can be difficult to determine which of the factors that were analyzed are most important to the population dynamics. PVA models are necessarily incomplete. We can model only those factors which we understand and for which we can specify the parameters. Therefore, it is important to realize that the models probably underestimate the threats facing the population. Finally, the models are used to predict the long-term effects of the processes presently acting on the population. Many aspects of the situation could change radically within the time span that is modeled. Therefore, it is important to reassess the data and model results periodically, with changes made to the conservation programmes as needed.

### **The *VORTEX* Population Viability Analysis Model**

For the analyses presented here, the *VORTEX* computer software package (Lacy 1993a, Miller and Lacy 1999) for population viability analysis was used. *VORTEX* models demographic stochasticity (the randomness of reproduction and deaths among individuals in a population), environmental variation in the annual birth and death rates, the impacts of sporadic catastrophes, and the effects of inbreeding in small populations. *VORTEX* also allows analysis of the effects of losses or gains in habitat, harvest or supplementation of populations, and movement of individuals among local populations.

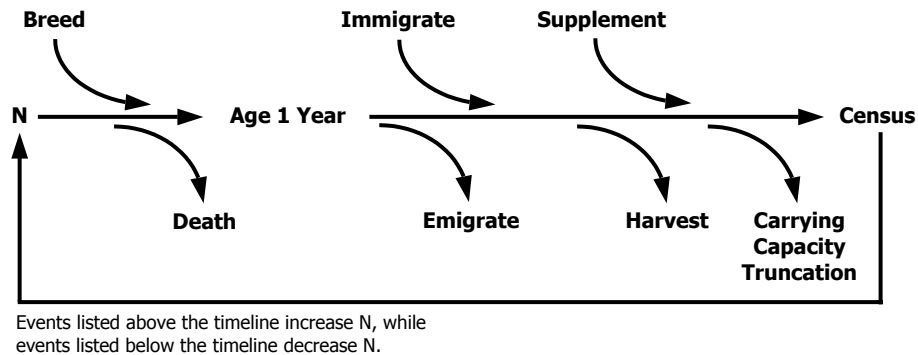
Density dependence in mortality is modeled by specifying a carrying capacity of the habitat. When the population size exceeds the carrying capacity, additional mortality is imposed across all age classes to bring the population back down to the carrying capacity. The carrying capacity can be specified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

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

depression.

*VORTEX* is an *individual-based* model. That is, *VORTEX* creates a representation of each

### **VORTEX Simulation Model Timeline**



animal in its memory and follows the fate of the animal through each year of its lifetime. *VORTEX* keeps track of the sex, age, and parentage of each animal. Demographic events (birth, sex determination, mating, dispersal, and death) are modeled by determining for each animal in each year of the simulation whether any of the events occur. (See figure below.) Events occur according to the specified age and sex-specific probabilities. Demographic stochasticity is therefore a consequence of the uncertainty regarding whether each demographic event occurs for any given animal.

*VORTEX* requires a lot of population-specific data. For example, the user must specify the amount of annual variation in each demographic rate caused by fluctuations in the environment. In addition, the frequency of each type of catastrophe (drought, flood, epidemic disease) and the effects of the catastrophes on survival and reproduction must be specified. Rates of migration (dispersal) between each pair of local populations must be specified. Because *VORTEX* requires specification of many biological parameters, it is not necessarily a good model for the examination of population dynamics that would result from some generalized life history. It is most usefully applied to the analysis of a specific population in a specific environment.

Further information on *VORTEX* is available in Lacy (1993a) and Miller and Lacy (1999).

### **Dealing with Uncertainty**

It is important to recognize that uncertainty regarding the biological parameters of a population and its consequent fate occurs at several levels and for independent reasons. Uncertainty can occur because the parameters have never been measured on the population; limited field data have yielded estimates with potentially large sampling error; independent studies have generated discordant estimates; environmental conditions or population status have been changing over time, and field surveys were conducted during periods which may not be representative of long-term averages; and the environment will change in the future, so that measurements made in the past may not accurately predict future conditions.

Sensitivity testing is necessary to determine the extent to which uncertainty in input parameters results in uncertainty regarding the future fate of the desert bighorn sheep population in New Mexico. If alternative plausible parameter values result in divergent predictions for the population, then it is important to try to resolve the uncertainty with better data. Sensitivity of population dynamics to certain parameters also indicates that those parameters describe factors that could be critical determinants of population viability. Such factors are therefore good candidates for efficient management actions designed to ensure the persistence of the population.

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

## **Results**

Results reported for each scenario include:

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

The deterministic growth rate is the average population growth expected if the population is so large as to be unaffected by stochastic, random processes. The deterministic growth rate will correctly predict future population growth if: the population is presently at a stable age distribution; birth and death rates remain constant over time and space (i.e., not only do the probabilities remain constant, but the actual number of births and deaths each year match the expected values); there is no inbreeding depression; there is never a limitation of mates preventing some females from breeding;



and there is no density dependence in birth or death rates, such as a Allee effects or a habitat “carrying capacity” limiting population growth. Because some or all of these assumptions are usually violated, the average population growth of real populations (and stochastically simulated ones) will usually be less than the deterministic growth rate.

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

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

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

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

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

# **RIVERINE RABBIT**

*(Bunolagus monticularis)*

**Population and Habitat Viability Assessment Workshop**

**27 – 29 July 2000**

**Final Report**

**Participants**



**PARTICIPANT LIST**

<b><u>Name</u></b>	<b><u>Affiliation/ Dept and address</u></b>	<b><u>Tel</u></b>	<b><u>Fax</u></b>	<b><u>e-mail</u></b>
<b>Joan Human</b>	Landowner Box 63, Victoria West, 7070	053 6121104		
<b>Ian Human</b>	Landowner Box 63, Victoria West, 7070	053 6121104		
<b>J.F. van Wyk</b>	Landowner Box 47, Loxton, 6985	0202 121802		
<b>L. S. Muller *</b>	Northern Cape Nature Cons. Box 476, Calvinia, 8190	027 3411779	027 3411718	leon@natuur.ncape.gov.za
<b>Reg Hoyt *</b>	Philadelphia Zoo 3400 W. Girard Ave, Philadelphia, PA 19104	215 2435309	215 2225263	hoyt.reg@phillyzoo.org
<b>A.H. Marshall</b>	Cape Nature Cons. Private Bag X6546, George	044 8742160	044 8741567	kkarea@mweb.co.za
<b>Guy Palmer *</b>	Cape Nature Cons. Private Bag X5014, Stellenbosch	021 8891560	021 8891523	palmerg@cncjnk.wcape.gov.za
<b>R.L.M. Truter</b>	Landowner Box 54, Beaufort West, 6970	023 4181624		
<b>R.Steven-Jennings</b>	Landowner Box 160, Beaufort West, 6970	023 4161714		hillandale@intekom.co.za
<b>P.H. Lloyd *</b>	Cape Nature Cons. Private Bag 5014, Stellenbosch	021 8891560	021 8891523	lloydp@cncjnk.wcape.gov.za
<b>C.D. Kleynhans *</b>	Cape Nature Cons. Private Bag X658, Oudshoorn,	044 2791739 0827717785	044 2728110	kknatser@mweb.co.za

<b>Diana Bell *</b>	School of Biological Sciences UEA, Norwich, Norfolk, United Kingdom NR4 7TJ	1603 592177		d.bell@uea.ac.uk
<b>Deryn Alpers</b>	Department of Zoology University of Stellenbosch Private Bag X1, Matieland, 7602	021 8083229		da2@akad.sun.ac.za
<b>Terry * Robinson</b>	Department of Zoology University of Stellenbosch	021 8083955		tjr@akad.sun.ac.za
<b>Rod Randall</b>	S.A. National Parks Box 176, Sedgefield, 6573	044 3431302	044 3432331	rodr@parks-sa.co.za
<b>Emile Smidt</b>	Karoo National Park P.O.Box 316, Beaufort West 6970	083 988 4540		normanj@parks-sa.co.za
<b>Willem * Ferguson</b>	Dept. Zoology & Entomology University of Pretoria, Pretoria 0002	012 4202016	012 3625242	jwhferguson@zoology.up.ac.za
<b>Johan Du Toit</b>	Mammal Research Institute University of Pretoria, Pretoria 0002	012 4203776	012 4202534	jtdutoit@zoology.up.ac.za
<b>Kai Collins</b>	108 Greenbriar, 71 Dorset Rd. Parkwood, 2193, Johannesburg South Africa	082 780 9929		kaicollins@crosswinds.net kcollins@onebox.com
<b>Vicky Ahlmann</b>	Zoological Society for the Conservation of Species and Populations P.O.Box 172, Loxton, 6985	020212-13	020212-46	ahlmann@yebo.co.za
<b>J.P. Van Der Merwe</b>	Lapfontein Conservancy Landowner Box 1102, Beaufort West, 6970	023 4181611 083 5141544	023 4181617	

# **RIVERINE RABBIT**

*(Bunolagus monticularis)*

**Population and Habitat Viability Assessment Workshop**

**27 – 29 July 2000**

**Final Report**

**Appendix**



**RIVERINE RABBIT**  
*(Bunolagus monticularis)*

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## **Riverine Rabbit Co-ordinators Committee Meeting**

### **PHVA - workshop report back and discussion**

#### **1. ADOPTION OF PHVA**

It was decided that this functional document must be accepted by all relevant parties. The final copy will be forwarded to the listed parties to adopt in writing. The definition of adopting would be:

1. The support of the PHVA report and strategies as highlighted there in.
2. To comply with the principles and ethics when going into any Riverine Rabbit distribution area.
3. The organization will adopt, sponsor and promote the PHVA report in their terms of reference.

Adoption of the PHVA - workshop report will be forwarded to the following institutions:

- Department of Agriculture - Provincial
- Department of Agriculture - Nationally
- Zoological Society for the Conservation of Species and Populations
- Western Cape Nature Conservation Board
- Northern Cape Nature Conservation
- South African National Parks
- National Department of Environmental Affairs and Tourism
- Lagormorph Specialist Group
- Landowners forum: Riverine Rabbit Conservancy Association
- Conservancies
- World Wildlife Fund for Nature
- Endangered Wildlife Trust
- Mammal Research Institute
- All relevant Universities and other relevant educational institutions

## 2. THREATS (as attachment of PHVA)

### **Habitat Fragmentation** (as copied from habitat and landuse - no. 5)

Minimum Goal: Recognize the importance of connectivity / corridors

Maximum Goal: Have corridors / connected habitat of 4000ha in size.

#### **Actions:**

1. Use of habitat mapping to identify existing and required corridors  
Resp. person: Conservation biologist  
Time: Five years  
Outcome: All corridors mapped.
2. Monitoring whether corridors are effective and used.(feasibility)  
Resp. person: Student project  
Time: Three years  
Outcome: Thesis
3. Research into requirements of corridor configuration & structure, as well as the feasibility of creating new corridors where needed.
4. Identification of bottlenecks (physical barriers to RR dispersal e.g.: dams, rocky gorges) points where no corridors are possible and development of possible solutions.  
Resp. person: Conservation Biologist  
Time: Five years  
Outcome: Corridors mapped and artificial dispersal systems identified.
5. Metapopulation: demographic and modeling issues dealt with by modeling group.

### **Genetic Fragmentation**

Minimum Goal: Determine mitochondrial DNA status

Resp. person: Prof. T. Robinson / Other Universities, institutes

Time: end of 2001

Outcome: Results of tests.

Maximum Goal: Micro-satellite of nuclear DNA.

Resp. person: NRRCC to identify and notify person/s to do sufficient tests

Time: Advert to identify persons by December 2000

Outcome: Sufficient data to help make informed management decision

### **Bush encroachment and Alien invaders**

Minimum Goal: Map area and extent of alien invaders / bush encroachment

Resp. person: NRRCC

Time: Five years

Outcome: Habitat map: distribution and status

Maximum Goal: Implementation of remedial action.  
Resp. person: Conservancies / WFW (Work for Water Project)  
Time: Ongoing  
Outcome: Optimum habitat management

### **Natural Predators**

Problem animal control will not be implemented on behalf of the Riverine Rabbit, but if it is it must be done in a way not threatening the Riverine Rabbit. Ensure natural prey base.

Resp. person: Landowners / Agriculture / NRRCC  
Time: All the time  
Outcome: A stable natural predator/prey relationship on relevant farms

### **Introduced Predators**

Minimum Goal: Promote exclusion of introduced / domestic predators from natural habitats, especially Riverine Rabbit habitats.  
Resp. person: NRRCC - Environmental education workgroup  
Time: ongoing  
Outcome: Conservation conscience community regarding their pets and the natural veld

Maximum Goal: Total exclusion of introduced predators / pets from natural Riverine Rabbit habitat. No hunting of other prey species of potential Riverine Rabbit predators.  
Resp. person: Conservancies: Constitutions  
Time: ongoing  
Outcome: No introduced pets or predators in Riverine Rabbit habitat.

## **3. ENVIRONMENTAL EDUCATION WORKING GROUP**

This working group has the responsibility to collate and organize / prioritize all Environmental Education activities as dictated in the PHVA report and WWF application.

The following persons are in this working group:

Nico Laubscher Northern Cape Nature Conservation  
Vicky Ahlmann Zoological Society for Conservation of Species Populations  
Chrizette Kleynhans Cape Nature Conservation (Convener)

The first meeting of this group is scheduled for 5th October 2000.

#### **4. DATA CAPTURE AND INFO STORAGE/DISSEMINATION**

It was decided that Scientific Services of Cape Nature Conservation is best equipped to deal with the storage / dissemination of data.

The following immediate actions will be undertaken to solve the problem expressed during the PHVA and during this meeting:

1. Geological data that could be relevant will be provided by Mr. Human to Northern Cape Nature Conservation.
2. The problem expressed by Mr. Human and Mr. P. Lloyd of sufficient tests being done on the captive rabbits by Dr. T. Robinson will be investigated by Vicky Ahlmann and the relevant information forwarded to Scientific Services. (A research report by Prof. T. J. Robinson has been added to the PHVA Workshop Final Report Appendix.)
3. Data that is unknown to this committee from the Transvaal Museum will be obtained / researched by Mr. L. Muller.
4. The processing of live, dead and other material of significance must be done in a way to preserve the specimens for later use. No set standard is presently in use by the NRRCC. Mr. P. Lloyd will collate the methods to process specimens by scientist and general public alike. This information will be presented to the NRRCC. Then it will be made available to landowners and institutes.

#### **5. STANDARDIZATION OF HABITAT EVALUATION**

This discussion was not completed during this meeting and will be dealt with at the EE-group meeting with the relevant computer technician. (copy of the results of this meeting attached).

#### **6. IDENTIFY STUDENT PROJECTS**

Projects listed in the PHVA will be prioritized by Mr. A. Marshall and forwarded to the relevant institutions. No new projects were identified.

ALL PRESENT COMMITTEE MEMBERS ARE TO LIST THEIR PRIORITIES OF THE PHVA GOALS AND ACTIONS TO COMPILE A COMPREHENSIVE LIST. THIS WILL BE FORWARDED TO VICKY BEFORE 15th OF OCTOBER. THE EDITED LIST WILL THEN BE SENT BACK FOR COMMENTS BEFORE END OF OCTOBER.

## **Research Priorities - Summary**

- Standardised and repeatable census techniques for assessing the population numbers of riverine rabbits within particular patches of habitat.
- Standardised and quantitative identifiability of the vegetation and soil characteristics of suitable riverine habitat.

Execution of the above two research topics needs require close collaboration between property owners, conservation institutions and research scientists at academic institutions.

- The distances of migration and dispersal of riverine rabbits and the degree of between-population movements.
- The degree of genetic differentiation between different populations of riverine rabbits.
- The population dynamics (including reproductive rates and mortality) of natural populations of riverine rabbits.

The execution of the above three projects require collaboration between research institutions and property owners.

## **Essential/Potential Student Projects**

- Collation of knowledge on present land use and ecological responses in Riverine Rabbit habitat (2001).
- Economic sustainability analysis – cost-benefit analysis to determine viability of conserving Riverine Rabbit habitat (includes financial incentives and management costs) (2005).
- Scenario modeling of climate changes – networking with spatial/climate modeling groups (ongoing).
- Use of habitat mapping to identify existing and required corridors (2005).
- Monitoring whether corridors are effective and used. Research into requirements of corridors configuration and structure, as well as the feasibility of creating new corridors where needed. (2003).
- Identification of bottleneck points where no corridors are possible and development of possible solutions (2005).

## **Provincial Responsibilities**

- Categorizing of land use practices/systems and allocation of sustainability indices (goats, cattle, cropping)
- State support to rehabilitate habitat, erosion control involving RPD (Poverty Relief)

## LIST OF DEFINITIONS

Biosphere Reserve	<p>→ Area of terrestrial (and coastal/marine) ecosystems recognised internationally under UNESCO's Man and the Biosphere Programme. The area must fulfil 3 complementary functions :-</p> <ul style="list-style-type: none"><li>• Conservation function – to preserve genetic resources, species, ecosystems and landscapes</li><li>• Development function – to foster sustainable economic and human development</li><li>• Logistical support function – projects, EE, training, research and monitoring (local, national and global issues)</li></ul> <p>A Biosphere Reserve is made up of three elements – Core, Buffer and Transition zones.</p>
Biosphere core areas	→ Securely protected area – conserving bio-diversity, monitoring, non-destructive research, EE.
Biosphere Buffer area (zone)	→ area around or adjacent to core area – co-operative activities compatible with sound ecological practices – EE, recreation, ecotourism, research.
Biosphere Transition area (zone)	→ or area of co-operation around or adjacent to core and buffer areas – agricultural activities, settlements where the areas resources are managed and developed.
EE	→ Environmental Education.
RDP (Poverty Relief)	→ Reconstruction & Development Project – State funded projects for the alleviation of Poverty.
Riverine Rabbit Conservancy	→ A commitment by an individual landowner to actively conserve a population of Riverine Rabbits ( <i>Bunolagus monticularis</i> ) and the associated habitat that occurs on that particular property.
Sustainable land use	→ Utilisation of an area in a manner that will not have a detrimental impact on the continued functioning of the ecological ecosystem and its associated processes.
Conservancy (national)	→ A voluntary constituted agreement between two or more landowners to manage the environment of their respective properties by means of co-operation and commitment to the conservation of that environment. Recognised nationally and

### Open Space III

internationally as a protected area. These Conservancies are constituted and then registered by the relevant Provincial Nature Conservation authority.

→ Nature Reserve (primary use) - "...means a national park or some other nature park which is in the ownership of a public authority or has been declared as such in terms of legislation and remains in private ownership; it consists of an area which is utilised as a game park or reserve for fauna and flora in their natural habitat and includes accommodation facilities for tourists and holidaymakers."

**RIVERINE RABBIT CO-ORDINATING COMMITTEE MEETING**  
**Minutes of Meeting held at Fraserburg, 28 September 2000**

**1. OPENING**

1.1 T. Marshall welcomes and thanks everybody for coming

1.2 Present: T. Marshall                      CNC (chairman)  
                    L. Muller                                      NCNC  
                    N. Loubscher                                      NCNC  
                    C. Kleynhans                                      CNC  
                    V. Ahlmann                                      ZSCSP  
                    G. Palmer                                      CNC  
                    P. Lloyd                                      CNC  
                    J. Human                                      Landowner  
                    G. Visser                                      Landowner

1.3 Apologies:                      J. Coen                                      R. Randell  
    N. Badenhorst                                      J. Bekkersmith  
    M. Scholtz                                      G. Visser (Sen)  
    N. Jacobs                                      J. du Toit  
    D. Alpers                                      T. Robinson  
    K. Collins                                      J. Espling

**2. MINUTES OF PREVIOUS MEETING**

2.1 Corrections:

2.1.1 The breeding of rabbits in Mexico was only used as an example by V. Ahlmann, not suggested for future breeding of the Riverine Rabbit.

2.1.2 The conservation idea to be forwarded by the two chairmen will be submitted to DEAT and by informing all relevant parties.

2.1.3 Domestic dogs are still a problem in Riverine habitat.

Acceptance of Minutes:                      Minutes accepted by N. Laubscher & C. Kleynhans

**3. POINTS ARISING FROM PREVIOUS AGENDA**

3.1. The captive breeding programme report, as promised by National Parks (E. Smidt) is still outstanding, with present information deficiency.

A letter will go forward from the chairmen to obtain either processed (as promised) or unprocessed data from National Parks before the next NRRCC.



## **4. FIXED AGENDA POINTS**

### 4.1. Monitoring: Projects status

NCNC did RR surveys during May 2000 as well as presentations to Williston Farmers Union and another Farmers Association. The habitat looked at in the Ceres Karoo was investigated with results of relatively suitable habitat.

Mr. Human also mentioned rumours of RR released historically in the Ceres Karoo.

Five farms with conservancy boards were also discovered for which no records are available.

Me. Kleynhans will investigate this issue further with Mr. Martin who would possibly know about this. The relevant farms are: Roodekruis / Saaifontein / Maanhaarskraal / Vastrap / Bakovenskraal.

ZSCSP checked the Ongeriver/ Groenriver and Pampoenpoort and confirms Duthie's report of optimal habitat. No rabbits were found however. Kalkfontein and Klein Brakriver was also done with two people. Two newspaper articles were also placed and released.

CNC gave training to National Parks educational training staff. Radio interviews were also done. Habitat evaluation of 13 farms took place as well as a survey during June 2000. Conservancy starters meeting was also held.

#### 4.1.1 Monitoring: Projects - Future:

##### **NCNC**

Future projects of NCNC include a survey of the Sakriver from Western Cape border to Williston during December.

##### **CNC**

Future projects include the Carnavon and Victoria-west area.

##### **ZSCSP**

Future projects are presently waiting for funding from WWF before any actions can be taken.

#### 4.1.2 Monitoring: Research

Presently research is being done by K. Collins and T. Robinson. These two projects, for reference sake will have to go through the application process. This application will be added as addendum in the PHVA document as an example.

V. Ahlmann is to approach these institutes, and the research project proposals will to be presented to the NRRCC of the next meeting.

The fact that projects must be approved by the NRRCC should be spread by all NRRCC members especially to inform the landowners of this as well.

### 4.2 Environmental Education

The chosen EE working group will address all the needs of the PHVA as listed in the document in this regard.

Mr. Muller did the research to open a website for the RR with quotes from Gateway, who will supply us with free development / plates / links / Registration. Only running costs will be paid to this company.

From all members of the committee Mr. Muller requires the following before end Nov. 2000:

Name of Website

Pictures in digital form

Content in digital form

links information: internet address

20 key words to search

Home page / contents / research / Sponsors / projects to put in site.

#### 4.3 Conservancies - Existing:

NCNC has records of ten single landowner "conservancies" known to them, and records of five new ones, with no information about them. NCNC also has fourteen new conservancy boards for landowners.

CNC has one single landowner "conservancy" no existing registered conservancies, but two conservancies starting. The Kromriver conservancy has already had their initial meeting.

Discussions were conflicting in ideas concerning conservancies and present management thereof. The following was concluded:

NCNC gives landowners recognition by conservancy member boards to single landowners and recognizes them as provincial conservancies.

Me. C. Kleynhans only, feels that the landowner deserves recognition for their efforts with the RR, but must not be recognized as a conservancy member until they are registered as a nationally accepted conservancy.

A flyer for specifically RR conservancies will have to be compiled. C. Kleynhans will compile the draft as soon as possible.

4.4 The captive rabbits are presently in temporary cages on Mr. Human's farm. It was suggested that these rabbits may be used for environmental education purposes if the tests shows that they will not be able to be released; otherwise they will be released. If a project proposal to breed is to be presented prior to the release of the rabbits, it will be considered by the NRRCC, otherwise it presently stands on the decisions made during the PHVA.

Definitions and regulations regarding captivity will be forwarded to Mr. Human by Miss Kleynhans at his request.

## 5. NEW POINTS

5.1. Adoption of PHVA workshop was dealt with in PHVA meeting.

5.2. Conservation Association:

Mr. Human is the motivation for this Association. The principle of the association is to get all landowners together from the whole distribution area.

The Association already has an account and funds raised will be used for logistics. This Association will have conservancy committee members on board.

Mr. Marshall expressed the need for an independent facilitator on the Association, with reference to the already functional Conservancy Forum in Outeniqua area. His request for a seat on this Association was

accepted. Conservation will be invited as a body, the specific representative will be delegated within the organization itself.

5.3 NRRCC: It was decided to forward letters to all present members that are listed, but that do not attend meetings. This is to inquire who wants minutes and who will still be actively represented at the meetings.

A suggestion came forward to have one chairman, it was however decided that the present situation is functional and effective as it is.

It was decided that the NRRCC will have three meetings a year, instead of two. One of these will be an Annual General Meeting.

6. Next meeting will be held 02 February 2001. The schedule for meetings for the rest of 2001 is as follows:  
10 July 2001  
21-22 November 2001 (AGM)

## 7. **Closing**

**ENVIRONMENTAL EDUCATION GROUP MEETING**  
**George / 06 October 2000**

**WELCOME**

**PRESENT:** V. Ahlmann  
N. Laubscher  
C. Kleynhans

**POINTS OF DISCUSSION:**

Environmental education priorities as listed in the PHVA were discussed and relevant actions delegated.

**1. STANDARDIZING OF EDUCATION PROGRAM**

Target groups were established for environmental education. It was decided to compile one comprehensive slide presentation to serve for all the listed target groups. Only exhibitions for public (e.g. during Expo's / shows) will have different material.

The target groups are:

- Farm labourers
- Farmers / farmers unions and associations
- Conservancies
- Schools
- General public - exhibitions

One copy of the slides for this presentation will be made for each EEG member with funding from WWF. All parties must collect as many good quality slides as possible of the topics listed for the next meeting. A list of the topics for slides is attached.

**1.1** The present presentation will be forwarded by C. Kleynhans for editing and comments.

**1.2** It was decided to wait until the opportunity to have an exhibition presents itself before compiling the material for this.

**2. EE., MEDIA MATERIALS AND, DISTRIBUTION**

**2.1** Brochure will be discussed with communication section of CNC during January.

**2.2** Poster will be discussed with communication section of CNC during January.

**2.3** Video: copies will be made for all EEG members of the two 50/50 videos.

**2.4** Conservation games were also discussed for schools. A Riverine Rabbit puzzle will be discussed in the future.

**2.5** Website: Mr. Muller is working on this, information from the slide presentation can be used in the webpage as well.

**2.6** Newspapers/Radio: a list of NCNC to be forwarded to C. Kleynhans for media releases.

**2.7** SABC / TV: V. Ahlmann to investigate

**2.8** Magazines: V. Ahlmann to investigate

Drafting of media releases to be done by Communication section, CNC.

It was suggested to use one person from the RR project be responsible for communications. After discussing this with CNC it seems that Miss Kleynhans will be this person as communication section may not receive requests from the other parties not working in CNC.

### **3. NETWORKING TO DISSEMINATE/PRESENT INFORMATION**

Schools and communities will be approached by sending them an invitation open for one year from the EEG with the required notice if they accept of one month.

This letter will be compiled and sent out by Mr. N. Laubscher.

Provincial lists will also be compiled for the next meeting of:

Schools

Municipalities

Tourism offices

Guest farms

Farmers unions

Farmers associations

Museums

Agricultural extension officers.

Volunteers: this will be handled by V. Ahlmann.

### **4. EVALUATION PROCESS FOR EE.**

The problem of effective evaluation will be presented to the NRRCC, but the WWF proposal will be used as reference.

### **5. CAPACITY**

It was mentioned by Mr. Laubscher that capacity and commitment for certain deadlines might be a problem for him.

It was decided that all three members of the EEG will compile a schedule within their present capacity to do Environmental Education.

## **SLIDES FOR E.E. PRESENTATION:**

**Lagomorph species:** Riverine Rabbit  
Shrub Hare / Ribbok haas  
Cape Hare / Vlakhaas  
Smith's Rock Rabbit

**Rodentia species:** Spring Hare

**Habitat:** Optimal  
Poor  
Distroyed  
+ old aerial photos x 3

**Soil:** Good  
Poor

**Predators:** Black backed jackal  
Caracal  
Eagle  
Owl  
Wildcat  
Domestic dogs & cats

**Threats:** Wood collecting  
Hunting  
Domestic dogs & cats  
Cultivation  
Overgrazing  
Dams  
Weirs  
Natural isolation

**Conservation efforts:** Environmental education  
Research  
Captive rabbits (capture / present status)  
Conservancies  
Surveys  
Extension – exhibitions  
Media

**Conservation efforts of farmers & laborers:** Sustainable landuse  
Keeping pets from habitat / no (hunting) dogs

**General:** Distribution area  
Other endangered species: Wild dog / Roan Antelope  
Home ranges (slide from A. Duthie)

The **standardization of habitat evaluation and Riverine Rabbit record sightings** was completed 06 October 2000 at George with the following results:

PRESENT: G. Palmer: CNC-Scientific Services  
A. Turner CNC-Scientific Services  
V. Ahlmann ZSCSP  
N. Laubscher NCNC  
C. Kleynhans CNC-co-ordinator

It was decided to have two forms: One for habitat evaluation / One for sightings.  
It was also realized that cyber-trackers will have to be used to make this effective and practical.

The following information will be put on for recording:

## **HABITAT EVALUATION**

Observer no.:  
Date:  
Time:  
Starting Longitude:  
Latitude:  
Finish Longitude:  
Latitude:  
District:  
Farm name/locality:  
River:  
Landowner:  
Alluvial soil: extend (map attached of every patch)  
depth: >1m <1m <0.5m  
Vegetation: Average height: >0.5m <0.5m >1m <1m  
Density: Dense Not Dense  
Diversity: tick relevant species  
Dominance: tick relevant species  
Threats in habitat: Cultivated lands  
Excessive grazing  
Wood collecting  
Dogs / Cats  
Dam  
Weir  
Others  
Flood in the last twelve months  
Habitat: Optimal  
Sub-optimal  
Poor  
Not habitat  
Trashed  
Notes:

The presence of other animals in the habitat should be recorded, but separately.

## OBSERVATION RECORD

Observation no.:

Longitude:

Latitude:

No. of animals:

Form:

Burrow:

Hair found:

Pellets found:

Photo no.:

Date:

Time:

Sightings:      First observation  
                    Confirmation of siting  
                    Repeat siting

Notes:

Vegetation evaluation will be done for five (5)m diameter around siting according to the habitat evaluation form.

Alluvial soil:    extend (map attached of every patch)  
                    depth: >1m   <1m   <0.5m

Vegetation:    Average height: >0.5m <0.5m                      >1m                      <1m  
                    Density:            Dense                      Not Dense

Diversity:      tick relevant species

Dominance:    tick relevant species

Habitat:        Optimal  
                    Sub-optimal  
                    Poor  
                    Not habitat  
                    Trashed



**(Genetics of small populations: population connectivity and temporal genetic variation in the Riverine rabbit (responsible P.I. T.J. Robinson):**

A species for which there is significant concern both from a demographic as well as genetic perspective is the Riverine rabbit, *Bunolagus monticularis*. This endemic Red Data Book leporid survives in the dense discontinuous karoid vegetation in the central Karoo of South Africa, an area though to be approximately 86km<sup>2</sup> in size which is linearly distributed along the seasonal rivers in this region. Censuses conducted in 1989 in two discrete sections of typical habitat yielded densities of 0.064 and 0.166 riverine rabbits per hectare (Duthie et al 1989). Extrapolation of these values to remaining habitat indicates that this vegetation could possibly support a total population of approximately 1500 rabbits. In historic times its range was known to be far larger but habitat surveys suggest that it has disappeared from large tracts of its historic range due to the impact of agricultural development in the region (Robinson 1981). In spite of sporadic attempts at captive breeding (see Dippenaar and Ferguson 1994), conservation efforts have had limited success in placing the species on a more secure footing and increasingly conservationists are looking to in situ measures to ensure its long term survival.

Pivotal in this approach will be the need to determine the levels of genetic variation within and among remnant populations of the species. Moreover, it is now possible to quantify the genetic variability of historical populations (represented by museum specimens) and their living descendants and thus assess the rate at which genetic variation is being lost in fragmented populations. Consequently, when determining heterozygosity levels in endangered populations we will make use of museum specimens (~N=30) collected in the early part of the last century. This temporal view will allow us to compare levels of heterozygosity present in the extant population with that contained in the historically much larger control population. These and other data from the study will provide management guidelines for the identification of source populations in restocking programmes (once the causes for declines have been unequivocally identified), estimates of current population size, the distances of migration and dispersal of riverine rabbits, and connectivity and/or discreteness of populations along water courses. Approach: Genetic factors which affect small populations can involve the loss of overall diversity due to reduced allelic diversity and heterozygosity. Small populations can also experience inbreeding and the possibly associated inbreeding depression. In small populations random genetic drift will cause the reduction of allelic diversity and heterozygosity (immigration and mutation will tend to increase genetic variation) with allelic diversity expected to reduce faster than heterozygosity. While at the individual level, the levels of heterozygosity and the degree of inbreeding may affect fitness and survivability, at the population level, however, reduced genetic variation lowers the potential adaptability to novel selective forces (Lande and Barrowclough 1987; Sherwin and Murray 1990).

We intend to use both mitochondrial and nuclear markers in this investigation since population structure within a species can vary over time (or between sexes) and different patterns may be observed when different genetic systems are examined. The phylogeny of mitochondrial haplotypes can be used to infer long-term gene flow, while nuclear DNA patterns of local differentiation can indicate more recent population subdivision (Moritz and Lavery 1996). Differences in mitochondrial and nuclear DNA patterns may also indicate gender-specific dispersal due to the maternal inheritance of mitochondrial DNA. We will use PCR based analysis in both instances. The intention is to amplify and sequence the 5' portion of the variable control region (d-loop) using conserved primers. Since we anticipate that the bottleneck associated with the current census numbers will have a significant impact on haplotype diversity we will initially screen PCR products using SSCP; distinct haplotypes will subsequently be sequenced. Microsatellite markers, initially developed for use in the European rabbit (Bell, University of East Anglia, unpublished) will be tested for usefulness in *B. monticularis* and used for estimating levels of genetic heterogeneity and gene flow between isolates as well as for assessing patterns of population structure. Since we will of necessity have to rely (at least in most instances) on hairs collected remotely in the field and museum specimens as our source of DNA, PCR-based methods are essential.

Given the species' endangered status we will need to rely on non-invasive sampling techniques for assessing genetic variation in extant populations. The utility of hairs as samples for population genetic studies was investigated by Alpers (1998) in her study of the hairy nosed wombat *Lasiorchinus latifrons* and we will

follow her approach by using hair-collection tapes positioned at the mouths of Riverine rabbit breeding burrows. Alpers reported that hairs collected from hair-collection tapes would probably be more reliable than shed hairs and would not be subject to the problems of allele dropout and false allele amplification that have been observed with the limited quantity of DNA obtained from shed hairs and faeces (Taberlet et al. 1996, Gagneux et al. 1997). In the case of museum specimen we will extract DNA from teeth/skin following Hagelberg (1994), a protocol with which we have had good success in previous studies (Robinson et al. 1996; Robinson and Matthee 1999). Given the risk of contamination when working with degraded museum specimens (Austin et al 1997), we will adopt procedures routinely used in our laboratory for this type of DNA. Among others these include DNA extractions in a separate DNA-free laboratory, multiple extractions, the temporal separation of the amplification and sequencing of museum specimens from taxa represented by fresh tissue and, finally, we will check to ensure that the data make phylogenetic sense. Allele frequencies will be determined by direct counting. Observed heterozygosity and unbiased estimates of expected heterozygosity will be computed for all locus/population combinations (Nei 1987). Deviations from Hardy-Weinberg expectations and linkage disequilibrium will be tested using GENEPOP version 3 (Raymond & Rousset 1995). To condense the genetic variation revealed, principal component analysis will be used as described by Carvalli-Sforza et al (1994). Population genetic partitioning will be measured by tests for allele frequency differences among populations,  $F_{ST}$  (Weir & Cockerham 1984) and  $R_{ST}$  estimates (Goodman 1997).  $F_{ST}$  will be estimated in GENEPOP while  $R_{ST}$  will be computed using the program RSTCALC. Gene flow estimates will be obtained in terms of  $N_m$  (effective number of migrants per generation). Genetic distances ( $D$ ) will be inferred using Nei et al (1983).

## Comments of PHVA Workshop participants on the Appendix

**Diana Bell, 21. November 2000:**

Comment on section **2. THREATS - Habitat Fragmentation** (see appendix)

*The first priority must be accurate mapping of suitable habitat (and the knowledge of what constitutes suitable habitat ) plus information on home-range size and dispersal behaviour of this species before corridor analysis can be attempted.*

Comment on **Natural Predators**

*I disagree with the notion of "problem" natural predators. I think that this habitat should be managed to increase biodiversity as a whole not simply single species. Natural predators should not be portrayed as the enemy!*