# *Bunolagus monticularis* – Riverine Rabbit


Tony Camacho

| Red List status (2016) | Critically Endangered C2a(i)*† |
|---|---|
| Red List status (2008) | Critically Endangered C2a(i) |
| Reasons for change | No change |
| Global Red List status (2008) | Critically Endangered C2a(i) |
| TOPS listing (NEMBA) (2007) | Critically Endangered |
| CITES listing | None |
| Endemic | Yes |

*Watch-list Data †Watch-list Threat

The Riverine Rabbit ranks amongst the rarest and historically most interesting of our southern African mammals (see history described within Skinner & Chimimba 2005).

## Taxonomy

*Bunolagus monticularis* (Thomas 1903)

ANIMALIA - CHORDATA - MAMMALIA - LAGOMORPHA - LEPORIDAE - *Bunolagus* - *monticularis*

**Synonyms:** *Lepus monticularis* (Thomas 1903)

**Common names:** Riverine Rabbit, Bushman Hare (English), Boshaas, Oewerkonyn, Pondhaas, Vleihaas, Doekvoetjie (Afrikaans)

**Taxonomic status:** Species

**Taxonomic notes:** While not separable from *Lepus* species based on morphometric data (Robinson 1981a; Robinson & Dippenaar 1987), cytogenetic evidence demonstrates that it is a unique species (Robinson 1981a; Robinson & Skinner 1983). No subspecies have been described.

## Assessment Rationale

The Riverine Rabbit is endemic to the semi-arid central Karoo region of South Africa (estimated extent of occurrence, EOO, is 54,227 km$^2$ and area of occupancy, AOO, is 2,943 km$^2$). Recent population estimates of 157–207 mature individuals indicate an alarmingly small species population size, with no subpopulation having > 50 mature individuals. The current assessment suggests that the Riverine Rabbit should, under a precautionary purview, remain listed as Critically Endangered C2a(i) due to its inferred small population size and suspected continuing decline from habitat loss and degradation, including ongoing loss of mature individuals. There are an estimated 12 subpopulations (9 in the northern range and 3 recently discovered south of the historic known range) determined by clusters of > 6 sightings within 10 km of each other. Large numbers of surveys throughout the distribution range have confirmed current subpopulations but failed to detect subpopulations in some areas of the historic range (indicated by museum records). Only current subpopulations are used to estimate population size. No subpopulation is estimated to exceed 50 mature individuals (range: 8–46 mature individuals). Subpopulation size was determined by summing independent sightings (non-repeat sightings) from survey data collected between 1999 and 2013. This estimate thus represents minimum sizes and it is possible that subpopulation size is higher, given that this is a cryptic species and difficult to detect. Monitoring work should be continued to improve subpopulation estimates and trends, and this species should be reassessed once further data have been generated. However, we suspect maximum subpopulation size could not be significantly higher, given that previous studies found low densities of the species on the Klipgat farm, Victoria West (0.06–0.17 individual / ha). Subpopulations are presumably further fragmented and isolated by anthropogenic barriers to dispersal, such as impoundments in river channels and fencing, and are threatened by illegal hunting and predation by domestic animals. Total mature population size (assuming 70% adults) is estimated to be between 157 and 207 individuals.

Additionally, both climate change and fracking are emerging threats to Riverine Rabbits: an initial assessment of climate change indicates that a net reduction of 89% in habitat is likely for the northern population. Fracking of the Karoo region is also likely to further reduce suitable habitat and the two threats may synergise. Thus, although population size in this analysis is likely an underestimate as it is based solely on confirmed current sightings, the Critically Endangered listing is retained (over a possible Endangered listing) as emerging threats are likely to severely threaten the already small population. Systematic monitoring and evidence for conservation interventions are desperately needed. Additionally, as the southern subpopulation may be genetically distinct from the northern animals, genetic work and subsequent taxonomic revision may require a possible reassessment of the two putative subspecies.

**Recommended citation:** Collins K, Bragg C, Birss C, Child MF. 2016. A conservation assessment of *Bunolagus monticularis*. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

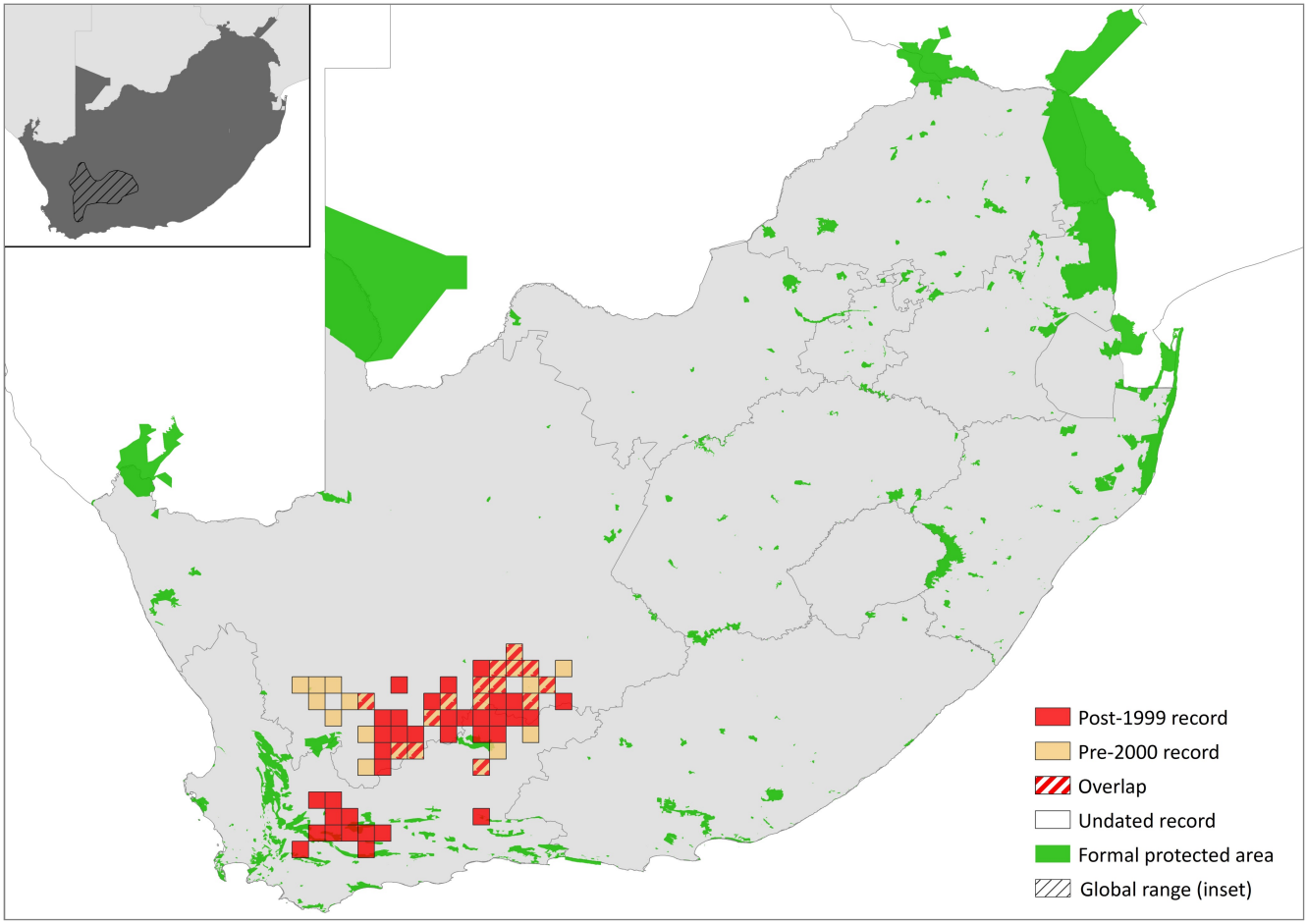


**Figure 1. Distribution records for Riverine Rabbit (*Bunolagus monticularis*) within the assessment region**

**Table 1. Countries of occurrence within southern Africa**

| Country | Presence | Origin |
|---|---|---|
| Botswana | Absent | - |
| Lesotho | Absent | - |
| Mozambique | Absent | - |
| Namibia | Absent | - |
| South Africa | Extant | Native |
| Swaziland | Absent | - |
| Zimbabwe | Absent | - |

# Distribution

This species is endemic to the central Karoo region of South Africa. It is associated with the dense, discontinuous vegetation fringing the seasonal rivers. It is the only indigenous burrowing rabbit in Africa, and is dependent on soft and deep alluvial soils along the river courses for constructing stable breeding stops. Approximately 40–60% of habitat was lost or fragmented during the 1930s to 1970s due to agricultural expansion on the seasonal river flood plains across its distribution range (Robinson 1981b; Duthie et al. 1989; Duthie & Robinson 1990). Historically, this species was known to occur in five localities towards the northwestern portion of its range, along the Vis and Renoster Rivers, as well as their tributaries near Calvinia (Duthie 1989). The lack of sightings data during the last 30 years, suggests that *B. monticularis* is now locally extinct in these regions (Collins & Toit 2016). This is likely to be a direct consequence of the extensive agricultural expansion along riverine floodplains (Duthie et al. 1989).

A large number of surveys from 1999–2013 throughout the distribution range has improved our estimates of location and sizes of the various subpopulations, and identified a new southern population in 2004, which now consists of three known subpopulations. The southern population is distributed within three catchments: the Breede, Gouritz and Olifant river systems.

Subpopulations are defined as being made up groups of confirmed sightings along first-, second- or third-order rivers that are within a maximum of 10 km of each other. If the groups of sightings are more than 10 km from each other, they are not taken as being from the same subpopulation. Due to limited information about dispersal ability of this species and the fact that known densities, where home range studies were carried out, showed approximately one Riverine Rabbit for every 400 m of river length, 10 km between confirmed sightings was estimated as a reasonable distance to separate subpopulations. A minimum of six sightings was taken to represent a subpopulation (potentially representing up to three breeding pairs). Where less than six sightings occurred in isolation from survey data, these were assumed to be part of the nearest subpopulation based on connectivity along the rivers.

The approximate ranges of both the northern and southern populations was calculated using Kernel Density home range estimation (buffered by 5 km) and combined to give a total extent of occurrence, estimated as 54,227 km$^2$. To calculate area of occupancy, all rivers inside the EOO were buffered by 1 km on either side. Similarly, all

sightings points were buffered by a 1 km radius and were used to clip the river buffer providing a total estimate of AOO. A buffer of 1 km was chosen as most of the larger patches of riverine vegetation do not occur more than 1 km from rivers, and by buffering all rivers by 1 km, all known sightings were located within these buffered areas. AOO was thus calculated as 2,943 km$^2$.

# Population

Riverine Rabbits have a critically low population size. For example, Duthie et al. (1989) found low densities of the species on the Klipgat farm, Victoria West (0.06–0.17 individual / ha). However, this sample represented too few home ranges to extrapolate to population level. Duthie et al. (1989) speculated that remaining habitat might potentially support around 1,435 individuals. However, densities may vary widely among river systems. For example, there is remaining natural habitat on the Ongers River but there is no evidence of Riverine Rabbit occupancy (Ahlmann et al. 2000). Thus the population size may be very much lower (Duthie et al. 1989).

There are an estimated 12 subpopulations, three in the southern population and nine in the northern population. Subpopulations are isolated from each other by jackal-proof fencing and severe land transformation through agricultural practices. All these subpopulations are estimated to contain less than 50 mature individuals (8–46 mature individuals, based on independent sightings in each river system). There are also an additional five possible historic subpopulations that are represented by five separate museum specimens collected in the past, but no surveys in the past 30 years have confirmed any sightings in those localities, so those five subpopulations are assumed to be locally extinct. To estimate total population size, we used survey data representing confirmed sightings along rivers to indicate size of individual subpopulations along river systems. For population size estimates, the total number of sightings across all 12 subpopulations was 380 individuals, yielding a total population estimate of 207 mature individuals (assuming 70% adults). The alternative estimate, derived from the average density of sightings per 1 km river buffer for all subpopulations multiplied by the total area (AOO), was 224 individuals in total, or 157 mature individuals (Collins & Toit 2016).

Generation length for this species is two years (Collins et al. 2004). This species has a single litter per year with 1–2 young per litter in a fur- and grass-lined subterranean chamber excavated in stable soils (Duthie 1989). Reproductive periodicity occurs from August through May (Duthie & Robinson 1990). Gestation time is 35–36 days (Duthie 1989). Longevity in captivity is five years (K. Collins unpubl. data).

**Current population trend:** Unknown, but is possibly declining based on ongoing and future habitat loss and degradation.

**Continuing decline in mature individuals:** Possibly, due to human disturbances such as hunting, predation by domestic pets and road collisions.

**Number of mature individuals in population:** 157–207

**Number of mature individuals in largest subpopulation:** 8–46

**Number of subpopulations:** 12

**Severely fragmented:** Yes. Large areas of habitat have been fragmented by fences, agricultural development, water impoundments as well as overgrazing resulting in large areas of habitat becoming unsuitable.

# Habitats and Ecology

The Riverine Rabbit inhabits dense riparian growth along the seasonal rivers in the central Karoo (Nama-Karoo shrubland). Specifically, it occurs in riverine vegetation on alluvial soils adjacent to seasonal rivers. The habitat is highly fragmented and transformed. Studies show the habitat to be 61% fragmented in certain areas (Duthie 1989). Observations from the more recently discovered southern Cape population include new records spread over thirteen sites (within three subpopulations), of which nine sites are managed as game reserves/nature reserves. The majority of Riverine Rabbit occupancy lies in the Upper Karoo Bioregion (approximately 80%), with about 12% in the Rainshadow Valley Karoo Bioregion, 4% in the Trans-Escarpment Succulent Karoo Bioregion, 3% in the Western Fynbos-Renosterveld Bioregion and 1% in the Lower Karoo Bioregion (Mucina & Rutherford 2006). For the southern population found within the Little Karoo, the presence occurs within the habitat types as described by Vlok and Schutte-Vlok (2010) including Transitional Shrublands Vegetation Type, Arid Renosterveld Habitat Type, Succulent Karoo Vegetation Type, Apronveld Habitat Type and the Randteveld Habitat Type. However, they are not restricted to the alluvial floodplains in the southern Cape (C. Bragg pers. obs. 2014) and can also occur in old lands not associated with riverine vegetation. Further habitat studies are required.

It should be noted that these are broad habitat types, whereas subpopulations in the northern part of the distribution are always associated with alluvial floodplains and narrow belts of riverine vegetation adjacent to seasonal rivers on a scale that is unlikely to fit within these broader habitat types. They are thus highly reliant on the critical resource areas of Karoo riparian ecosystems. These descriptions do, however, give an indication of the general vegetation structure and composition within various parts of its range. Home range has been estimated as 12 ha (Duthie 1989). This species is elusive and nocturnal, spending daylight hours in a scrape beneath riparian vegetation. They are solitary, and will only be found in breeding pairs for short periods, or in female-juvenile pairs for rearing purposes (Duthie 1989).

This species is predominantly a browser, but is known to occasionally feed on grasses during the early wet rainy season when short, green grasses become available (Duthie 1989). When browsing, they have been found to show a particular selection for *Pteronia erythrochaetha*, *Kochia pubescens*, *Salsola glabrescens* and Mesembryanthemaceae. They are unable to survive on heavily overgrazed or agriculturally transformed habitats, but have been found feeding on lucerne fields at night.

**Ecosystem and cultural services:** It is both a flagship species for the Karoo, as well as an indicator species of riparian habitat fringing the rivers of the Nama (Upper and Central Karoo) and the Succulent Karoo where its presence is associated with ecosystem integrity (healthy ecosystem services, such as water infiltration, vegetation cover, and soil health). Its unique habitat is of economic importance to landowners in terms of cultivation and small-stock grazing. Threats to the river ecosystems include overgrazing and anthropogenic land and river

transformation, which leads to the degradation and fragmentation of Riverine Rabbit habitat.

# Use and Trade

The Riverine Rabbit is suspected to be opportunistically hunted for sport and for bushmeat by farm workers (Duthie & Robinson 1990; Coetzee 1994).

# Threats

Both populations face significant threats from ongoing habitat degradation and fragmentation due to detrimental land-use practices and new emerging habitat-transforming threats, such as climate change and energy development (Ahlmann et al. 2000). Over the last century, *c*. 40–60% of the fertile alluvial floodplains and riparian habitat has been lost as a result of cultivation (for example, winter wheat production, mostly in the past) and livestock farming (ongoing) (Duthie 1989; Duthie et al. 1989; Duthie & Robinson 1990; Coetzee 1994; Ahlmann et al. 2000). Other threats to the species include hunting (hunted for sport and for bushmeat by farm workers), and accidental mortality in traps set for 'pest' animals on farmlands. There is also the potential that the dominance of sheep farming and emerging wildlife ranching for economically valuable species may increase the frequency of both overgrazing (and thus reduction in vital vegetation cover) and predation rates (for example, by higher Black-backed Jackal (*Canis mesomelas*) densities). Similarly, habitat degradation through fuel-wood collecting and overgrazing may have led to an increase in predation (Ahlmann et al. 2000).

There are also several emerging threats that could threaten this species. An initial assessment of climate change indicates that a net reduction of 89% in habitat is likely for the northern population (Hughes et al. 2008). Hence further study is urgently required as to potential effects of projected climate change over the entire distribution.

Fracking of the Karoo region is also a major emerging threat to Riverine Rabbit habitat due to ancillary activities associated with fracking, which could lead to increased road mortalities, habitat fragmentation and altered hydrology of Karoo river systems, which in turn impacts on the species' habitat. Similarly, wind farms are also likely to have a significant impact on the species.

**Current habitat trend:** Habitat quantity and quality is declining through overgrazing by livestock, resulting in reduced cover from predators and lack of sufficient forage. Reduction in streamflow owing to the construction of dams upstream has presumably also reduced habitat quality (Ahlmann et al. 2000). High livestock and, in some cases, wildlife, stocking rates have resulted in large areas of the Karoo having reduced vegetation cover and becoming dominated by unpalatable species, which have

**Table 2. Threats to the Riverine Rabbit (*Bunolagus monticularis*) ranked in order of severity with corresponding evidence (based on IUCN threat categories, with regional context)**

| Rank | Threat description | Evidence in the scientific literature | Data quality | Scale of study | Current trend |
|---|---|---|---|---|---|
| 1 | *2.1.3 Agro-industry Farming*: habitat loss from cultivation, especially wheat. Current stress *1.3 Indirect Ecosystem Effects*: fragmentation of remaining habitats. | Duthie et al. 1989 | Indirect | Regional | Stable |
| 2 | *2.3.2 Small-holder Grazing, Ranching or Farming*: habitat loss from livestock (including wildlife ranching) expansion. Current stress *2.3.2 Competition*: potentially increased predation rates from higher jackal abundance. | - | Anecdotal | - | Unknown |
| 3 | *1.1 Housing & Urban Areas*: rural settlement expansion increasing rates of species mortality. Current stress *2.1 Species Mortality*: poaching and predation from domestic animals. | GeoTerraImage 2015 | Indirect (remote sensing) | National | Rural settlements expanded by 9% in Northern Cape Province from 2000–2013. |
| 4 | *11.2 Droughts*: increased probability of drought conditions reducing suitable habitat. | Hughes et al. 2008 | Simulation | Regional | Projected net habitat loss of 89% by 2050. |
| 5 | *5.1.1 Hunting & Collecting Terrestrial Animals*: bushmeat poaching from farm workers on farmlands. | - | Anecdotal | - | - |
| 6 | *5.1.2 Hunting & Collecting Terrestrial Animals*: accidental mortality from traps intended for 'pest' species. | - | Anecdotal | - | - |
| 7 | *8.1.2 Invasive Non-Native/Alien Species/Diseases*: predation from dogs associated with farmlands. | - | Anecdotal | - | - |
| 8 | *3.1 Oil & Gas Drilling*: habitat loss and degradation from shale gas development. Future stresses *1.3 Indirect Ecosystem Effects* and *2.1 Species Mortality*: further habitat fragmentation and direct mortality from increased road collisions and poaching. | - | Anecdotal | - | - |
| 9 | *3.3 Renewable Energy*: habitat loss and degradation from wind and solar farm development. Future stresses *1.3 Indirect Ecosystem Effects* and *2.1 Species Mortality*: further habitat fragmentation and direct mortality from increased road collisions and poaching. | - | Anecdotal | - | - |

further reduced vegetation biodiversity and stocking potential for livestock and game. Additionally, continued rural settlement expansion in the Northern Cape Province, estimated to be 9% from 2000 to 2013 (GeoTerraImage 2015), will presumably increase rates of poaching and predation by dogs. However, stewardship schemes for this species in the Karoo have also been initiated and cover 350,000 ha in the Greater Karoo. Anecdotal evidence suggests improved biodiversity and Riverine Rabbit populations on these farms, as well as greater landowner awareness of the requirements to protect Riverine Rabbits (C. Bragg unpubl. data). Continued biodiversity stewardship expansion will help to mitigate habitat loss and deterioration.

# Conservation

This species occurs mainly outside of formally protected areas. However, it was recently discovered (2013) on the formally protected Anysberg Nature Reserve (C. Birss unpubl. data), and there is a healthy subpopulation based in the private Sanbona Wildlife Reserve (both sites in the Western Cape Province), which is in the process of achieving formal protected status through the CapeNature biodiversity stewardship programme. There is also a substantial proportion of the species' habitat from the northern population informally protected within the Riverine Rabbit conservancies. The primary conservation interventions involve further protected area expansion, especially through stewardship programmes, and active habitat restoration.

The Drylands Conservation Programme of the Endangered Wildlife Trust (EWT-DCP) was established in August 2003 and coordinates all conservation efforts on the Riverine Rabbit and its habitat. The programme aims to conserve the biodiversity of the Karoo region, to encourage private landowners to participate in conservation stewardship and to promote integrated land management practices that can sustain the Riverine Rabbit, its habitat and many other species while providing employment for communities and facilitating ecosystem restoration on landowners' farms. The current projects are:

- **Riparian habitat restoration**: Initiated in 2007, the Riparian Habitat Rehabilitation Project develops and implements strategies to regenerate degraded riparian habitat in order to re-connect remaining riverine habitat fragments. Riparian zones perform a variety of functions including storing water, reducing floods, stabilizing river banks, improving water quality by trapping sediment and nutrients, and providing shelter and food for animals. They provide corridors for movement and migration of different species, including Riverine Rabbits, and act as a buffer between aquatic ecosystems and adjacent land uses. Additionally, maintaining the integrity of riparian areas will help mitigate the effects of climate change, which could potentially heavily impact this semi-arid region. To date, the programme has undertaken restoration interventions, including soil and water erosion control, re-vegetating, grazing reduction, and soil health technologies, of 350 ha of

**Table 3. Conservation interventions for the Riverine Rabbit (*Bunolagus monticularis*) ranked in order of effectiveness with corresponding evidence (based on IUCN action categories, with regional context)**

| Rank | Intervention description | Evidence in the scientific literature | Data quality | Scale of evidence | Demonstrated impact | Current conservation projects |
|---|---|---|---|---|---|---|
| 1 | *1.2 Resource & Habitat Protection*: expand suitable habitat through conservancies and biodiversity stewardship schemes that manage land according to planned criteria. | - | Anecdotal | - | Four conservancies have been established, protecting *c*. 350,000 ha of habitat. | Drylands Conservation Programme, Endangered Wildlife Trust (EWT-DCP) |
| 2 | *5.3 Private Sector Standards & Codes*: provide compliant private landowners with certification and recognition of Riverine Rabbit conservation when compliant with management criteria. | - | Anecdotal | - | - | EWT-DCP |
| 3 | *3.2 Species Recovery*: restore critical areas of habitat to enhance key resource areas for Riverine Rabbits. | - | Anecdotal | - | 350 ha of habitat restored. | EWT-DCP |
| 4 | *2.1 Site/Area Management*: encourage farmers and ranchers to retain vegetation cover by leaving buffer habitats or reducing stocking rates. | - | Anecdotal | - | - | EWT-DCP |
| 5 | *6.1 Linked Enterprises & Livelihood Alternatives*: provide livelihoods for community members based on habitat restoration and maintenance to decrease poaching rates and ecosystem degradation. | - | Anecdotal | - | - | EWT-DCP; Working for Water, Department of Environmental Affairs |
| 6 | *1.1 Site/Area Protection*: acquire land for formal conservation of key subpopulations. | - | Anecdotal | - | - | EWT-DCP |
| 7 | *4.3 Awareness & Communications*: education of key stakeholders to increase support for Riverine Rabbit conservation and disseminate opportunities for involvement. | - | Anecdotal | - | - | EWT-DCP |

*Bunolagus* habitat, and is monitoring the recovery of the species in these areas, as well as the subsequent improvement of ecosystem services.

- **Establishing alternative livelihoods**: Labour for the rehabilitation project is sourced locally, thereby creating employment and developing skills in poor rural communities with few other social upliftment opportunities. Through this approach a strong component of the Riparian Habitat Rehabilitation Project lies in the conservation of water resources and regional biodiversity through community involvement. The EWT-DCP established the Indigenous Karoo Plant Nursery in Loxton (Northern Cape) to support the plant needs of the Riparian Habitat Rehabilitation Project. Community members employed by the nursery are trained to propagate indigenous plants needed for the re-vegetation of Riverine Rabbit habitat within riparian zones in the Karoo. Seed is produced on the production plot within the nursery grounds and are supplemented with seeds harvested in the veld by community members.
- **Expanding Riverine Rabbit conservancies and stewardship**: Little of the Riverine Rabbit's remaining habitat is protected within nature reserves or national parks; the survival of the Riverine Rabbit is in the hands of private landowners, consisting mostly of farmers. Therefore the EWT-DCP works in partnership with provincial conservation departments to involve private landowners in biodiversity conservation through the process of 'stewardship'. Stewardship refers to the wise use, management and protection of that which has been entrusted to the landowner. Within the context of conservation, stewardship means protecting important ecosystems by effectively managing aspects such as invasive alien species, fires, and grazing and cultivation practices. The EWT-DCP works closely with the four Riverine Rabbit conservancies, encompassing an area of approximately 350,000 ha in the Northern and Western Cape provinces. The long-term goal of the EWT-DCP is to use these existing conservancies as a stepping stone to upgrade and declare specific and key properties as Protected Areas in terms of South Africa's National Environmental Management: Protected Areas Act (No. 57 of 2003). A critical component of the work is to promote and encourage sustainable land-use practices amongst landowners and land managers in the Karoo through developing partnerships with the relevant stakeholders. Thus the EWT-DCP strives to mainstream sustainable land management principles into agricultural practices in the Karoo and into decisions made by policymakers.
- **Environmental Education and Awareness**: The EWT-DCP creates awareness about Riverine Rabbit conservation efforts with farmers, farm workers and their families, school learners, teachers, and the general public. It aims to establish custodianship by cultivating a sense of ownership for the Riverine Rabbit, its habitat and the river ecosystems of the Karoo.

**Recommendations for land managers and practitioners:**

- Further surveys are needed to identify Riverine Rabbit habitat and occupancy. Hughes et al. (2008) developed a habitat model that showed potential suitable habitat east of Victoria West that might contain isolated subpopulations or offer re-introduction opportunities. The results of such surveys should feed into conservation planning. For example, the work of the Drylands Conservation Programme has succeeded in mitigating impacts of high-risk wind farms through dedicated interventions, particularly in regards to stopping development within suitable habitat. These data would also be used to develop a broad habitat map of the entire distribution range.


**Photo 1. Riverine Rabbit (*Bunolagus monticularis*) caught on a camera trap (Christy Bragg)**

- Develop public recognition schemes to encourage private landowners to form conservancies and protect the Riverine Rabbit. Presence on private land should lead to the exclusion of ranching activities in key habitat areas. This should include developing riparian grazing guidelines to inform sustainable management of riparian areas, and a user-friendly manual of cost-effective sustainable land management technologies to encourage farmers to adopt restoration and sustainable farming practices. Finally, incentives should be identified to encourage landowners to adopt such practices that benefit the species (*sensu* Pasquini et al. 2010).
- Develop a Riverine Rabbit monitoring tool to facilitate improved conservation outcomes, such as monitoring the impacts of conservation interventions (for example, restoration) on the density of subpopulations and prioritising resources to subpopulations that are declining.
- Development of a legal tool to address Riverine Rabbit conservation: a Biodiversity Management Plan for the species in terms of the National Environmental Management: Biodiversity Act (No. 10 of 2004). This includes investigating the genetic and ecological differences between the southern and northern populations and the development of separate conservation strategies for both.
- Although captive breeding was recommended by Collins et al. (2004), captive breeding trials in the 1990s were largely unsuccessful (Dippenaar & Ferguson 1994; Ahlmann et al. 2000). Thus, the current conservation strategy for the species does not include captive breeding as an option due to the difficulty of breeding this sensitive species in captivity and the higher chance of improving

populations in the wild through concerted conservation interventions such as stewardship and habitat restoration.

**Research priorities:** This cryptic species' small size, and solitary and nocturnal behaviour, coupled with the fact that it occurs in dense vegetation with low visibility, presents challenges to biologists studying them. The current Riverine Rabbit distribution range is based on the results of surveys carried out on foot in cooperation with the relevant provincial conservation authorities. The distribution data also includes *ad hoc* sightings data on farms and from the general public. Determining population densities and trends, however, requires a different approach. In March 2012, the DCP initiated a study into the application of camera traps to determine Riverine Rabbit densities. Camera traps have been used extensively on other species, primarily patterned carnivores, but not extensively on Lagomorphs. Currently (2016), a student is engaged in developing a methodology to monitor Riverine Rabbit population trends using camera trap grids and GPS collars. These methods and data will be used to estimate population size and trend.

There is also a genetic study of the species underway (2016), investigating the phylogeographic structure and evolutionary history of the species. Preliminary results suggest that at least two genetically distinct lineages exist and these are correlated to geographic regions. One lineage occurs predominantly in the central Karoo while the other lineage seems to be restricted to lower altitudes in the southern part of the distribution.

Further research priorities include:

- Quantifying the potential effects of shale gas mining and wind or solar farm developments on Riverine Rabbits.
- Quantifying recent land-use change in the region and its effects on Riverine Rabbits.
- Assessing the degree of fragmentation by farm fences, dispersal ability, home range size and habitat preferences of the two populations.
- Develop a remote sensing habitat signature in order to produce a habitat map.
- Quantifying the predation rate of Black-backed Jackals on Riverine Rabbits and relating this to land-use change.
- Research into its breeding biology and behaviour.
- Quantifying best practice for livestock grazing to sustain Riverine Rabbit subpopulations and identify cost-effective restoration technologies/techniques.

**Encouraged citizen actions:**

- Landowners can create or join conservancies to protect this species and its habitat.
- Landowners can lower stocking levels to improve riparian ecosystem grazing systems; reduce the number of dogs on farms; and restore riparian habitats through Working for Water and/or the EWT-DCP.
- Landowners and the public can report sightings of individuals on virtual museum platforms (for example, iSpot and MammalMAP) or provincial conservation authorities to enhance the distribution map. For example, new sightings recorded by the public and landowners are recorded in the CapeNature database.

# Data Sources and Quality

**Table 4. Information and interpretation qualifiers for the Riverine Rabbit (*Bunolagus monticularis*) assessment**

| | |
|---|---|
| Data sources | Field study (literature), indirect information (literature, expert knowledge) |
| Data quality (max) | Estimated |
| Data quality (min) | Suspected |
| Uncertainty resolution | Best estimate |
| Risk tolerance | Precautionary |

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## Assessors and Reviewers

**Kai Collins[1†], Christy Bragg[2†], Coral Birss[3], Matthew F. Child[2]**

*[1]University of Pretoria, [2]Endangered Wildlife Trust, [3]CapeNature*

*[†]IUCN SSC Lagomorph Specialist Group*

## Contributors

**Conrad Matthee[1], Vicky Nel[2], Mike Hoffmann[3], Andrew Smith[4], Lizanne Roxburgh[5]**

*[1]University of Stellenbosch, [2]Private, [3]International Union for the Conservation of Nature, [4†]Arizona State University, [5]Endangered Wildlife Trust*

*[†]IUCN SSC Lagomorph Specialist Group*

Details of the methods used to make this assessment can be found in *Mammal Red List 2016: Introduction and Methodology.*