MANAGEMENT OF RIPARIAN HABITAT ON FARMLAND

Best Practice Guidelines

Endangered Wildlife Trust

Drylands Conservation Programme

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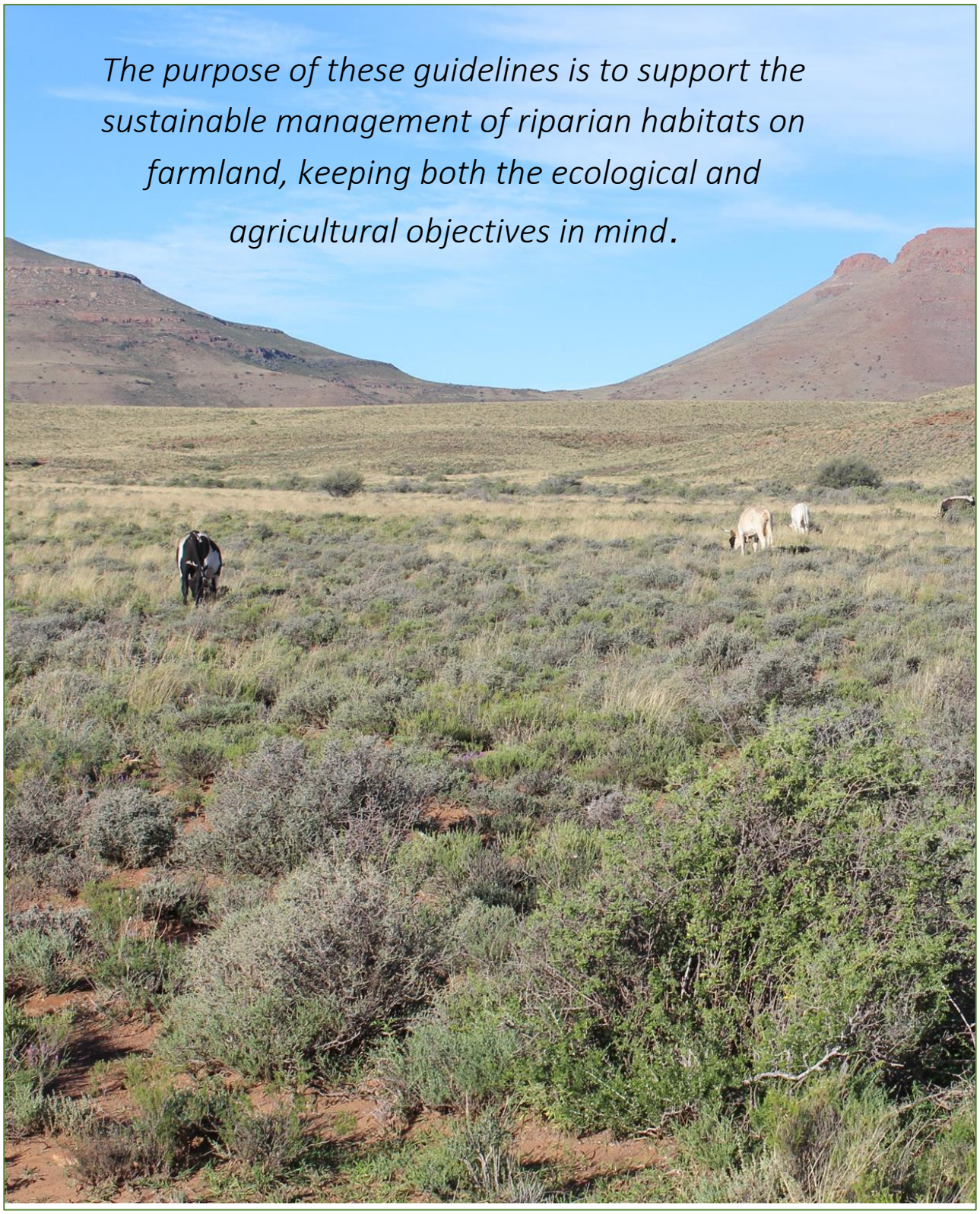

Cover Artwork by **Gina van Zyl de Oliviera**

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Karoo Forever Project Background

The Endangered Wildlife Trust's Drylands Conservation Programme (DCP) partnered with the United Nations Development Programme and the Department of Environmental Affairs to promote sustainable land management (SLM) in the Nama Karoo. The project is funded by the Global Environment Facility (GEF). The project is titled "Securing multiple ecosystems benefits through Sustainable Land Management in the productive but degraded landscapes of South Africa". The project was rolled out in 2017 in three different geographic regions by three partners. The EWT is the project implementer in the Northern Cape's Nama Karoo. Rhodes University is the implementer in the Baviaanskloof (Eastern Cape) and the Council for Scientific and Industrial Research in the Olifants River Catchment (Mpumalanga).

The Endangered Wildlife Trust's Drylands Conservation Programme launched the Karoo Forever Project to promote sustainable land management in the Karoo. Various documents have been produced by the project focussing on sustainable land management across the broader Karoo landscape. The project aims to capture lessons learned, spark future farming innovation, and share this knowledge. Information is accessible to the farming community on the project website.

Over 80% of South Africa's land is used for agriculture, with livestock farming being the dominant rural land use. Approximately 1.5 million hectares of land in South Africa is degraded, resulting in the loss of vital ecosystem services and productive land. The Nama Karoo is characterised by mostly intact diverse natural rangelands utilised primarily for extensive livestock production. Nonetheless, there is a great need to halt and reverse existing degradation and adopt the most effective management practices to counter increased climatic uncertainty.

Water catchment areas are critical natural resource areas. Riparian ecosystems provide ecological goods and services, such as reducing runoff and promoting the recharge of underground water, reducing flooding, reducing erosion, thereby reducing the sediment load in rivers, which in turn reduces siltation of dams. These areas also serve as important corridors for wildlife movement across landscapes. Due to the shallow water table and deep, fertile alluvial soil, these areas are important to agriculture in the Karoo, both as rangeland and for cultivation purposes.

The broad principles pertaining to SLM in this document can be applied to the other biomes where Riverine Rabbits occur, namely the Succulent Karoo- and Fynbos biomes. However, the specifics in this document primarily focus on the Nama Karoo region. Management strategies are addressed to integrate both conservation and agricultural objectives.

1. General

The animal and plant life of the Nama Karoo region is well adapted to extreme conditions, ranging from floods to droughts. The region can be described as arid to semi-arid from west to east. The mean annual potential evaporation is 2692 mm (Mucina *et al.* 2006 & Shearing 1994), and the hot, dry winds, which are a prevalent feature in the region, have adverse effects on plant growth due to drying out (Grace 1977). While plant and animal life are adapted to these extremes, it must be borne in mind that these same conditions are extremely limiting for vegetation growth and subsequent ecosystem recovery following disturbance (Esler *et al.* 2006). All veld types are sensitive to incorrect grazing practices, and good veld management must be practised to ensure the conservation of the veld through sustainable land management.

> "**sustainable**", in relation to the use of a biological resource, means the use of such resource in a way and at a rate that -
>
> (a) would not lead to its long-term decline;
>
> (b) would not disrupt the ecological integrity of the ecosystem in which it occurs; and
>
> (c) would ensure its continued use to meet the needs and aspirations of present and future generations of people.
>
> *(Northern Cape Nature Conservation Bill 2009)*

In arid areas and particularly in riparian zones, transformation is very risky due to the drought-flood patterns. Flood irrigated lands stand fallow for extended periods during drought. Extreme drought-breaking rains that usually follow extended droughts then cause infrastructure damage. By the same measure, veld restoration in this brittle, arid environment is exceptionally difficult and expensive, with the added risk of flood damage during rainfall periods. The decision to transform riparian areas in arid biomes is thus not only extremely risky but, in many cases, not economically viable in the long run.

Historically game migrated through the Karoo region in high numbers, but due to a lack of surface water, moved off again, allowing a period of veld recovery. The Karoo vegetation is thus adapted to a grazing-rest cycle. Continuous grazing has been shown to result in a gradual reduction of veld productivity due to a loss of palatable species.

The Karoo is famous for its great springbok migrations. The most recent migration took place in 1896, but hunting, roads, fences, urbanisation, farming and other human developments gradually brought an end to these spectacular events. (*Image from Safari.com*)

Vegetation cover and composition decline when vegetation is grazed in such a way that insufficient rest periods do not allow for the regrowth of vegetation. In particular, if the rest periods are too short, plants do not have sufficient time to flower and set seed. During years when the rainfall is sufficient and falls at the right time, not only does germination occur, but seedlings may have the opportunity to establish themselves. During this period, the veld needs to be rested for extended periods so that palatable species, in particular, can recruit. Seedlings require enough time to establish sufficient root and above ground volume before they are grazed, or they will not survive. Many Karoo bushes are very long-lived, but the seed viability is short. As palatable bushes are browsed, their flower and seed volumes are consumed, resulting in no seed input into the soil. When a bush dies, a gap is created. If only unpalatable species have had the chance to seed, it stands to reason that a turnover from palatable to less-palatable species will inevitably happen. This is a slow but insidious process and may not be noticed in a land user's lifetime.

The impact of agricultural activities on riparian areas in the Karoo is best illustrated by the loss of riparian specific habitat along the seasonal rivers. An initiative in the 1940s to turn parts of the Karoo into the

Flood irrigated lands are most often uncultivated, during extended dry periods, leaving the bare soil vulnerable to the loss of topsoil caused by wind erosion. Many of these lands are the legacy of wetter periods when flood irrigation was thought to be viable in the Karoo. (*Images supplied by Bonnie*

"breadbasket" of the Cape resulted in the dramatic loss of up to 60% of riparian habitat along seasonal rivers in the upper Nama Karoo. In some cases, almost all of the riparian habitat on the banks of these rivers was irreparably transformed for wheat planting during the 1940s. Two such examples are found along the Fish- and Renoster Rivers (between Calvinia and Williston), where almost no natural riparian vegetation remains. The floodplains along these rivers were up to 1 km wide, compared to 170 m along rivers such as the Sak- and Krom River. Given the historical extent of the riparian vegetation along the Fish- and Renoster Rivers, it is likely that they supported the majority of Riverine Rabbit (*Bunolagus monticularis*) populations prior to the loss of this habitat. This agricultural development enterprise had failed by 1950, primarily due to a shortage of irrigation water caused by the erratic rainfall patterns typical of the Karoo.

Much of the remaining riparian habitat across the Nama Karoo is degraded to some extent, with a loss of cover and species diversity due to grazing pressure. This trend is typical of riparian areas in general due to their high agricultural production value. As a result, at least one animal species, the Riverine Rabbit, is listed as Critically Endangered. This species is regarded as an indicator species for riparian health in the Karoo. The rabbit is a habitat specialist, occurring along the dense scrub associated with the seasonal rivers. Optimal Riverine Rabbit habitat must be structurally adequate. The structure is composed of tall

(>1m), large (>1m diameter), shrubs such as kriedoring (*Lycium spp*), rivierdraaibos (*Tripteris spinescens*) and gannabos (*Salsola spp*.). The rabbit's absence within much of its range is an indicator of an ecosystem under pressure and that it is not functioning optimally.

2. Riparian vegetation in the Nama Karoo

Riparian vegetation in the Nama Karoo is by no means the same across the landscape. The extent and composition of the vegetation depend on various factors, including altitude, the extent of the flood plain, substrate and location along the catchment (upper, middle, or lower reaches). Vegetation varies considerably even at a local level, ranging from thick, almost impenetrable, and less palatable stands of grootdoringkapokbos (*Eriocephalus* spp.) or kriedoring (*Lycium* spp.) to more open lower scrub consisting of perdebos (*Rosenia* spp.), skaapbos (*Pentzia* spp.), various vygies (mesembs) and grasses. This range of structure and composition within an area is essential for maintaining species such as Riverine Rabbits and Common Duiker, which utilise the shrubby thickets for cover from predators while foraging in the more nutritious mixed-shrub patches.

Management of riparian areas ought to take this into account. Too much grazing pressure results in more uniform open areas, but underutilisation can result in the vegetation becoming woody and unproductive, dominated by less palatable species such as kriedoring (*Lycium* spp.).

The entire flood plain as pictured above has been severely impacted by a loss of vegetation cover and topsoil. Reversing degradation at this scale to recover ecosystem function is almost impossible. (*Images supplied by Bonnie Schumann*)

Veld condition is the condition of the vegetation in relation to certain characteristics such as the species composition, cover, productivity, palatability, and nutritional value. Grazing capacity depends on the condition of a camp or the farm's veld (Saayman 2016).

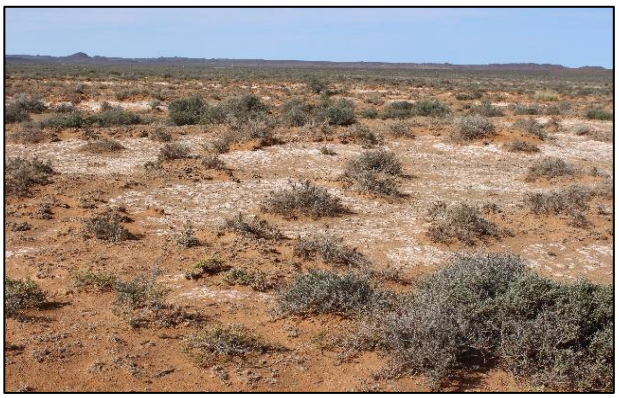
Riparian vegetation is distinctly different from the adjacent areas in species composition and structure (height and density). Typical species include the gannabos (*Salsola* spp.), kriedoring (*Lycium* spp.), rivierdraaibos (*Tripteris spinescence*), grootdoringkapokbos (*Eriocephalus decussatus*), bierbos (*Pteronia erythrocheata*), skaapbos (*Pentzia* spp.), perdebos (*Rosenia* spp.) and inkbos (*Exomis* spp).

Left: Typical riparian vegetation along the Sak River, showing the structural diversity of the riparian vegetation with a taller shrub layer composed of vaalbrak (*Atriplex vestita*), kriedoring (*Lycium pumilum*) and kerriebos (*Helichrysum pentzioides*) and a ground layer of pan dropseed (*Sporobolus ioclados*), couch grass (*Cynodon dactylon*) and doublaarvygie (*Drosanthemum lique*). Right: Riparian vegetation protects the banks and floodplains from erosion and promotes infiltration, replenishing ground water supplies. (*Images supplied by EWT*)

The alluvial sediment of the Sak River, one of the most important in terms of Riverine Rabbit populations, and typical of the main seasonal rivers of the region, hosts the vegetation classified as azonal (AZi 5), Bushmanland Vloere (Mucina *et al.* 2006). Bushmanland Vloere is an azonal vegetation type typically located in pans and along the intermittent riverbeds within the Eastern Upper Karoo vegetation unit mentioned above and in other vegetation units within the Bushmanland basin (Mucina *et al.* 2006). Bushmanland Vloere is characterized by patchy vegetation assemblages dominated by assorted species of the genera *Salsola* (gannabos) and *Lycium* (kriedoring), interspersed with various microphyllous (single un-branched leaf-veins) shrubs, some of which are halophytic (salt tolerant). Bushmanland Vloere remains one of the least studied vegetation types in South Africa (Mucina *et al.* 2006). It is likely that the riparian vegetation should be reclassified as a distinct type at some point as it is not typical of the general area.

The tall, dense riparian vegetation maintains a shady environment, increases organic matter, and creates favourable safe micro-sites for seeds to germinate. Where vegetation has been lost, salt tends to accumulate in the soil surface through the evaporation of rainwater (Esler et al. 2006). This is a problem, particularly in the lowlands where the water table is often shallow. Seeds do not typically germinate in saline soils. Salinisation, therefore severely hampers the natural and induced re-vegetation (rehabilitation efforts) of degraded areas. In addition, exposed soil is also vulnerable to water and wind erosion, whereby the precious topsoil is lost, and trampling by livestock that leads to an accelerated rate of degradation. Soil salinisation is a major process of land degradation that decreases soil fertility and is a significant component of desertification processes in the world's (Vengosh 2003).

Besides the ecological value of riparian areas, the riparian zone provides valuable forage and refuge for wildlife and livestock during the dry season and droughts and plays a vital role in boosting livestock production, which has significant economic value. Riparian areas also allow the movement of wildlife through agricultural areas, functioning as "corridors" through an often-transformed landscape. Livestock that is lambing are routinely camped in these areas as the ewes' condition, and their ability to feed lambs is supported by the good forage. Lambing occurs in specific seasons each year; this often results in riparian areas being grazed during the same months each year.



Left: Healthy riparian habitat, with the palatable draaibos (*Tripteris spinescens*) in flower, visible in the foreground on the right. **Right**: A loss of vegetation cover has contributed to the salinization of topsoil, which will prevent the germination of seeds and severely hamper any restoration efforts. (*Images supplied by Bonnie Schumann*)

Different plant species flower and germinate at different times, so if an area is grazed at the same time every year, certain species will eventually be lost as they are prohibited from reproducing. Beesgannabos (Salsola aphylla) flowers in December, whereas bierbos (Pteronia erythrocheata) flowers in September. Skaapbos (Pentzia spp) tend to flower opportunistically following rain. Many annuals and geophytes will be absent unless sufficient rain has fallen, making it essential to rest following good rains to allow these species to persist. Management regimes for riparian areas must therefore also adhere to a rotational grazing system, whereby the riparian areas are allowed to rest at different times over a number of years.

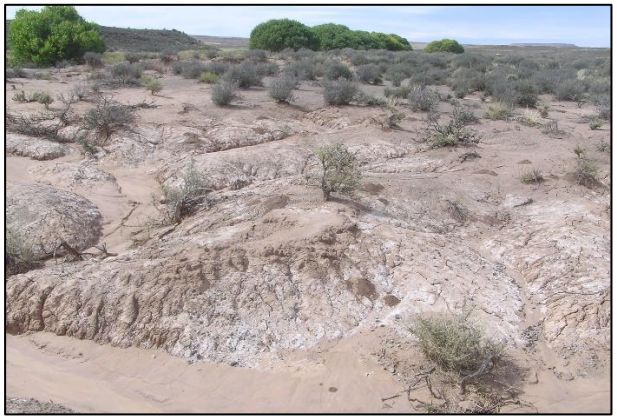
Peak reproductive periods for Karoo shrubs are Spring and (more so) Autumn, with growth and germination favouring the wetter, cooler, late Summer to Autumn season, whereas the grass component favours the warm wet growing conditions (Spring & Summer).

In order for riparian vegetation to be considered in an optimal condition, both in terms of ecological and agricultural needs, certain criteria need to be met with regards to density, structure, species composition and diversity. One of the factors identified by farmers that can have a negative impact on structure is the collection of wood from riparian areas by farmworkers as a source of fuel. The tall woody shrubs, such as gannabos, are typically collected. As the large woody shrubs are slow-growing, this can have a negative impact on the structural integrity of the riparian vegetation over time. As such, no collecting of wood should be allowed within the riparian zone. Alternative fuel sources should be provided by the farmer.


Left: Typical dense healthy riparian vegetation (Krom River). **Right:** Riparian vegetation near Loxton in the Northern Cape that has been subjected to continuous grazing at high stocking rates, with the subsequent loss of vegetation cover, species diversity and topsoil. This system is no longer fully functional. (*Images*

3. Riparian soils

The soils of the region are derived predominantly from Mudstones of the Beaufort Group, with many of the alluvial deposits being silty, clayey, and highly sodic (containing a higher proportion of sodium than usual) (Mucina *et al.* 2006). The alluvial nature of the soils contributes to the variability of the soil structure and composition (Naiman and Décamps 1997). The high clay content, fine texture, and low organic material content of these soils limit water infiltration and retention, particularly where topsoil has been removed and the soil structure has been changed by erosion. The nature of the soil makes them vulnerable to trampling and erosion once exposed. Spontaneous recovery after degradation is thus very unlikely, making restoration interventions necessary. However, these interventions are extremely costly and often have low success rates due to the erratic rainfall patterns. Maintaining optimal soil cover through judicious veld management is thus the best approach to prevent degradation through salinisation and erosion.



Left: Loss of vegetation cover has led to a loss of topsoil and gulley erosion, seen here along the Sak River. The accumulation of minerals, the result of increased evaporation, is visible on the soil surface. **Right:** Exposed soils are vulnerable to capping, which prevents moisture infiltration and increased run off. Seeds will struggle to germinate, and recruitment is very poor under these conditions. (*Images supplied by EWT*)

4. Karoo fauna

The last two centuries have seen the occurrence of major habitat modifications such as land degradation (including erosion, loss of cover and changes in species diversity), overhunting of wildlife and the erection of fences (Milton *et al.* 1994). Fences restrict the movement of wildlife and concentrate domestic stock into an area for extended periods of time. The herbivores of the region tended to be migratory due to the aridity and general unpredictability of favourable conditions and food supply (Skead *et al.* 2011). Species present in the area would have included African Buffalo (*Syncerus caffer*), the now extinct Quagga (*Equus quagga*), Red Hartebeest (*Alcelaphus buselaphus caama*), Springbok (*Antidorcas marsupialus*), Eland (*Taurotragus oryx*) and Black Wildebeest (*Connochaetes gnou*). This would have been complemented by populations of the large African predators such as Lion (*Panthera leo*), Spotted Hyaena (*Crocuta crocuta*) and Leopard (*Panthera pardus*) (Skead *et al.* 2011). Local rock art painted by Late Stone Age people indicates that mega-herbivores such as African Elephant (*Loxodonta africana*) were transient inhabitants on the Karoo plains within the last 10,000 years (Shearing 1994; Deacon 1997).

The migratory herds of herbivores have largely been replaced by sedentary livestock. Over time rotational grazing systems (including variations of stocking densities) have been developed, and more conservative stocking rates have been applied. These are the result of both the declining ability of the natural resource base to support these unsustainably high livestock numbers, as well as improved veld management knowledge. Understanding the requirements to maintain the integrity of the veld (resource base) or even improve veld condition has contributed to lower stocking rates.

The riparian areas offer refuge to wildlife in terms of forage and vegetation cover, and as is the case with livestock, form an important resource area during dry periods. Animals such as the Riverine Rabbit are habitat specialists and cannot survive outside of the riparian habitat. A range of other species have been recorded in these areas but are not necessarily restricted to them.

5. Sustainable Management of Riparian Areas

5.1. Veld management

Maintaining riparian vegetation can be achieved by using sheep as a tool to prevent veld from becoming moribund and to prevent soil-capping. However, utilisation of the riparian habitat must be carried out in such a way that optimal cover, structure, and plant diversity are promoted. When considering plant species diversity, composition is important in that the range of species should include palatable as well as non-palatable species. The grazing system should allow for the persistence, and where possible, increase of palatable species, including perennial bushes, forbs, and grasses. In order to achieve this, riparian areas need to be utilised on a rotational basis and not during the same months year after year.

Research has shown that on farms where rest periods of longer than six months are applied, camps are in a better condition than those with shorter or no rest periods (Saayman 2017). In addition, these camps have better cover of palatable species, the soil is more stable, and the risk of erosion is less. Inappropriate management of riparian areas goes hand-in-hand with the loss of soil, water resources and biodiversity as the catchment area no longer functions optimally.

Vegetation cover in the Central Karoo increases from 15% to 40% from west to east because of the increasing average rainfall. As a rule of thumb, the more arid an area, the more rest it will need in order to maintain veld condition and productivity.

<150mm Rainfall	>150mm Rainfall
Graze according to a planned rotational grazing system	Graze according to a planned rotational grazing system
Rest camps for longer than six months to allow for adequate regrowth, seed formation, germination, and recruitment.	Rest camps for four* months or longer to allow for regrowth, seed formation, germination, and recruitment.
Stock at recommended rates or less to allow for the build-up of fodder reserves.	Stock at recommended rates or less to allow for the build-up of fodder reserves.
(Saayman 2017) ** Many practitioners recommend a minimum of 6 months rest period in the Karoo.	

Many different grazing systems exist and are applied with varying levels of success. Success is not determined by the system applied but by how it is applied. Ultimately veld condition and soil health will indicate whether the grazing regime is yielding the desired results. Only one system is discussed here. Additional information on other systems can be obtained in the EWT's *Best Practice Grazing Guidelines*[1].

[1] http://karooforever.org.za/index.php/en/resources/#publications

A farm with multiple camps can divide the camps into four groups, where the camps of each group represent the different types of veld on the farm, for example, mountainous veld, randteveld, plains and water lanes (rivers). Veld types must be fenced as when given the option, livestock will concentrate on the more productive and easily accessible areas such as the riparian areas, resulting in over-utilisation. The surface and grazing capacity of each group should more or less be equal in size and therefore be able to carry the same number of animals.

Each year a different group gets the opportunity to rest for the whole year. The same group is never used for grazing in the same season over a four-year period. Therefore, the group of camps gets sufficient opportunity to allow plants to build reserves through regrowth, but critically, also to flower, set seed, *and* seedlings get a chance to establish themselves.

An example of a four-camp grazing system (Saayman 2016):

	Dec/Jan/Feb	Mar/Apr/May	Jun/Jul/Aug	Sep/Oct/Nov	Rest
Year 1	Camp A	Camp B	Camp C	Camp A	Camp D
Year 2	Camp B	Camp C	Camp D	Camp B	Camp A
Year 3	Camp C	Camp D	Camp A	Camp C	Camp B
Year 4	Camp D	Camp A	Camp B	Camp D	Camp C

Only three groups are used annually, while the fourth group of camps is rested for the whole year and only used again for grazing in the third grazing season. Therefore, this group is rested for 18 months in total, after which it is rested intermittently for six to nine months over a four-year period. The 18-month rest period follows after the group has been used for grazing twice in the previous calendar year, with only six months of rest between the grazing periods.

A farm with few camps can follow a four-camp system on the same basis as the four-group camp system.

The impact of management on veld condition needs to be monitored. One indicator that can be monitored is whether or not the palatable species are being given the opportunity to reproduce and recruit (seedlings survive and establish new plants). If only unpalatable plants are flowering and setting seed, the veld management approach needs to be revised. It is also important to monitor changes in the percentage of bare ground over time, looking at the cover provided by existing plants and changes in the size of bare patches. Where plants are grazed too regularly over time and start to become stunted, the amount of cover provided by them decreases, increasing the risk of erosion (and the depletion of energy reserves). Healthy veld produces organic matter (leaves, twigs etc.), which is essential for healthy soil. Where organic matter is lacking, it is a possible indication of overgrazing.

6. Development in riparian zones

Ideally, development in riparian zones with intact riparian habitat should not occur, given the limited intact riparian vegetation remaining in the Nama Karoo. There are, however, various mitigation measures that can be put in place where developments exist or where new developments, such as renewable energy developments, are planned.

6.1. Biodiversity corridors

Biodiversity corridors are sections of intact habitat that allow for species movement through areas that have been transformed by, e.g., agriculture. This allows for the dispersal of genetic material so that populations do not become isolated and inbred. Waterways are particularly important to the movement of animals in a landscape. As such, maintaining intact riparian habitat is critical to maintaining biodiversity across broad landscapes. Riparian corridors are also particularly important for habitat specialists and restricted to the riparian specific vegetation. Where fragmentation occurs along the riparian zone, these habitat specialists become isolated and may be driven to extinction if corridors are not maintained. The loss of habitat and the resulting fragmentation of remaining habitat is one of the primary drivers in the decline of the Riverine Rabbit and impacts other biodiversity in the same way.

According to the National Environmental Management Act, 1998 (Act No. 107 of 1998), the following buffers apply in relation to wetlands:

- A 32-metre buffer zone is required from the edge of the riparian zone for rivers or streams; and
- A 30-metre buffer zone is required from the outer edge of the wetland temporary zone.

No development is allowed between the one-in-ten-year flood line of the river or stream or within 32 m of the bank of the river or stream where the flood line is unknown without an environmental authorisation from the competent authority (National Water Act: 36 of 1998).

It is, therefore, imperative that biodiversity corridors through disturbed or transformed areas are maintained when further transformation takes place. Where this was not done previously, corridors need to be developed retroactively. Where possible, attempts need to be made to restore degraded sections between intact habitat, including old lands, to promote corridors.

Confluences of rivers are possibly important three-way dispersal corridors for species such as Riverine Rabbits, and therefore management in these areas needs to be directed at maintaining the ecological integrity of these areas.

6.2. Weirs and dams

Weirs and dams reduce the available habitat for riparian habitat-specific species and cause fragmentation, particularly where large dams are constructed. The canal systems and agricultural lands are often

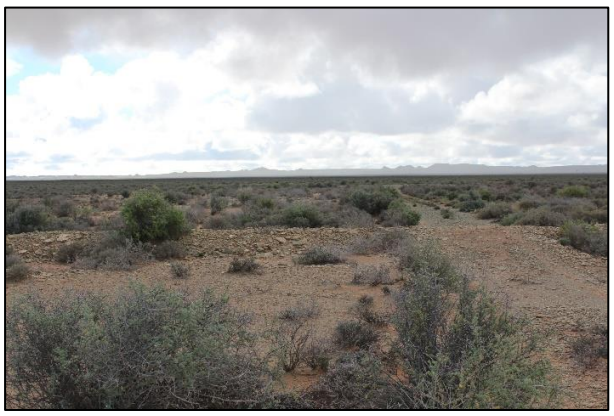
associated with dams that may also negatively impact the integrity of the surrounding vegetation. However, weirs play a crucial role in restoring eroded areas by damming up silt and backfilling the gullies upstream. These degraded areas would not, in any case, support much biodiversity. Where dams and weirs are constructed, every effort must be made to maintain shoreline vegetation to allow the movement of species around water bodies.

Dams have positive and negative impacts. Dams control stream regimes, preventing floods, providing domestic and irrigation water from the stored water, and generating energy. However, as dams change the way rivers function, natural stream flow patterns are disrupted, sediment is trapped and effectively serves as a barrier to species' movement along waterways. Species such as fish are prevented from reaching critical habitat units, such as spawning or nursery areas. The cumulative impact of several smaller impoundments must not be underestimated and can have serious impacts on water availability for downstream water users (WWF 1996).

6.3. Roads

Roads through riparian areas are particularly high-risk areas for certain species, such as Riverine Rabbits, due to mortality caused by vehicles. In addition, besides the hectares of habitat lost, poorly planned roads and poorly designed culverts also negatively impact water flow, changing vegetation growth patterns and resulting in erosion where water runoff is poorly diverted. Roads through riparian areas are subject to erosion, so where possible, these should be placed higher up in the landscape, running parallel with riparian areas, with as few crossings as possible. Where roads transect riparian areas, great care must be taken when crossing through, particularly at night. Ideally, a speed limit of 40km/hr or less should be adhered to to avoid hitting wildlife in these areas.

Erosion of unpaved roads and their drainage systems is the single most significant factor affecting maintenance needs and costs involved with these roadway systems. Most of the eroded soil ultimately ends up in streams and dams. Well-placed runoff diverters/berms redirect runoff onto the surrounding veld at strategic places and minimise water volume and velocity on the roadway. The catchment area for water entering the road space needs to be carefully assessed to ensure that structures to divert water from roads are not too far apart and are high enough so that the water does not merely overrun them.



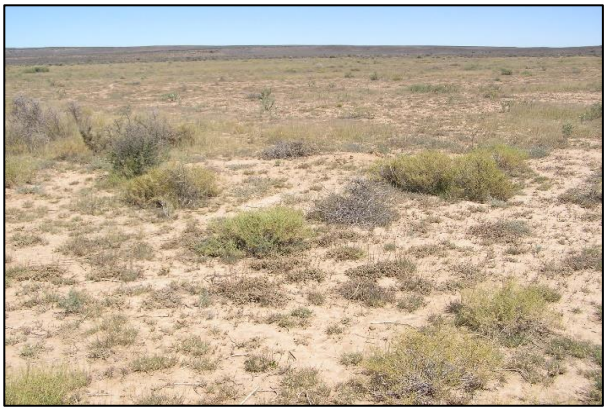
Left: A poorly maintained road, with severe erosion caused by excessive runoff resulting in it becoming unusable. A new road has then been made alongside it. **Right:** A well maintained road. The well-constructed berm diverting water is visible, and the centre line is mostly vegetated. (*Images supplied by Bonnie Schumann*)

Where this happens, erosion will result in ruts forming in the roadway. Where water is correctly diverted, veld effectively receives a "second shower" in the water that would have been lost in a gulley but is redirected back onto veld, supplementing rainfall.

When scraping dirt roads, the centre of the road should be crowned so that the centre of the roadbed is higher than its sides. Retaining the centre vegetation on smaller tracks will create this effect over time. This reduces the risk of erosion by limiting the bare area. However, the converse can be true in that narrow tracks channel the water, increasing the risk of erosion. Regardless of the type of road, the careful placement and maintenance of berms along roads and tracks is critical to curbing erosion. The best way to determine where to control water flow is by observing water flow during a rainstorm and inspecting newly installed structures for effectiveness immediately following downpours.

6.4. Cultivated lands

Cultivated lands fragment riparian habitat, acting as a barrier to movement along the river corridors. It is possible that while crops are standing, movement of, e.g., Riverine Rabbits occurs through cultivated lands, however, this has never been verified. Therefore, mitigating the fragmentation effect of cultivated lands must include maintaining permanent natural vegetation strips between cultivated lands, and between lands and roads to create connectivity between intact patches of habitat. These strips should be a minimum of 2 m wide, and where possible, closer to 5 m to create a more viable strip of natural vegetation in the long term. A wider strip will also provide more effective cover to species, such as Riverine Rabbits that are vulnerable to predation and rely heavily on cover from vegetation to avoid detection.



Left: Erosion of an old land, topsoil is washing into the Sak River as the land borders on the river. The exposed soil is particularly vulnerable to erosion. **Right:** An old land gradually re-vegetating. Although cover is returning, species diversity has been lost. These areas often end up being dominated by unpalatable species such as kriedoring (*Lycium* spp.) or kraalbos (*Galenia africana*). (*Images supplied by EWT)*

Left: An aerial photo illustrating the impact of cultivated lands along the Krom River. Old lands are visible in the foreground, with lands that are still under cultivation behind these, showing the extent of the loss of available habitat. The homestead in the distance and the weir further fragments this section of river. In this case a possible corridor still exists on the left of the river as the vegetation here still appears intact. (*Image supplied by EWT*)

Where possible, every effort should be made to rehabilitate old lands, even if only to establish strips of cover to act as corridors and help manage wind and water erosion. In some cases, old lands will gradually re-vegetate, often mostly with pioneer species and occasionally with kriedoring (*Lycium* spp), providing some cover. However, active restoration is required to restore a measure of species diversity[2][3]. Soil disturbance (ploughing) to break the hard cap, together with brush packing and where possible distribution seed collected from healthy veld are good starting points.

6.5. Water Extraction

All water extraction must be in accordance with the relevant legislation, notably the National Water Act (No. 36 of 1998) (NWA) designed to achieve equity, sustainability and efficiency in the use and protection of South Africa's water resources. Of particular relevance to rivers and their associated riparian areas in the NWA is the concept of the Ecological Reserve, which refers to "the quantity and quality of water required to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource" (NWA, Ch 1, para. 1.(xviii)). The ecological Reserve recognises the vital role played by ecologically functional rivers and their riparian areas.

Extraction of groundwater in the semi-arid Karoo environment requires more caution than the limits set by the NWA, however. These limits are based on the average annual recharge flow into an aquifer, yet the actual recharge rate in any given year may be much lower than the average in drought conditions (Seward 2010). Furthermore, it is important to consider the impacts of extraction at the local scale, rather than solely at the basin scale at which water licenses are granted. Local wetlands, springs and riparian zones that are vital to the ecology of arid and semi-arid areas can dry out as a result of pumping from a single borehole (Levy and Xu 2011).

Underground aquifers are linked to the water table in riparian areas, and the water can flow in either direction. When too much water is extracted from the aquifer (called overdraft), the water flows from riparian zones towards the aquifers, thus providing less water for riparian plant species (Tularam and Krishna 2009). Other long-term consequences of aquifer overdraft include declining water quality, land subsidence, and higher costs for pumping water as the water table recedes. All of these impacts can

[2] http://www.karooforever.org.za/images/1_Best_Practice_Sustainability_Rehabilitation_Final_13Sep2019.pdf

[3] https://www.renu-karoo.co.za/

negatively impact other water users downstream from the extraction point. Furthermore, aquifers that are severely depleted may never fully recharge or produce much lower quality water, thus affecting water use by future generations.

Left: The introduction of windmills into the Karoo around 1874 made the establishment of permanent farm and towns possible. Right: Irresponsible water extraction in a landscape virtually entirely dependent on ground water can have dire consequences both locally and downstream. (*Images supplied by Bonnie Schumann*)

6.6. Renewable Energy Developments

Where renewable energy developments are proposed, various mechanisms are in place to minimise the environmental impact. Power generating infrastructure may typically not be placed in ecologically sensitive areas. However, the extensive road network and power distribution infrastructure (powerlines) invariably impact the entire landscape. Wind farms, in particular, due to the extensive nature of the developments, often require an extensive road network. The increased traffic, especially through riparian areas, can have a heavy impact if care is not taken to avoid wildlife collisions. As discussed in 6.3, guidelines need to be adhered to, especially with regard to reducing speed in sensitive areas.

Left: A riverine Rabbit photographed using a road during a camera trap survey by the EWT. Below: The extensive footprint of wind farms, including the turbines and roads are clearly visible. The additional footprint of the powerline infrastructure is not visible here. Photo source:
(*Image supplied by EWT)*
Below:
https://www.renewableenergyworld.com/2019/11/05/enel-green-power-starts-construction-of-280-mw-wind-farms-in-south-africa/#gref

6.7. Invasive plant control

Of the estimated 9,000 plants introduced to this country, 198 are currently classified as being invasive. It is estimated that these plants cover about 10% of the country, and the problem is growing at an exponential rate[4].

[4] https://www.environment.gov.za/projectsprogrammes/wfw

Several exotic plant species pose a severe threat to riparian vegetation when they invade. The loss of natural riparian vegetation and its associated biodiversity results in a dysfunctional ecosystem. While many invasive alien species may provide canopy cover (e.g., *Prosopis* spp.), they result in a loss of ground cover as shrubs and grasses are outcompeted. Soils are thus exposed to erosion, particularly during floods. In addition, many of these species, such as *Prosopis* spp., poplar trees (*Populus* spp.) and gum trees (*Eucalyptus* spp.), utilise large volumes of water, lowering water tables. Natural vegetation with shallower root systems is negatively impacted by the loss of available moisture and shading.

The effective control of invasive species requires a multi-pronged approach and must be done with care not to make the situation worse. Control measures need to address the cause of the increase in undesirable species. For instance, where unsuitable grazing practices are the cause, practices need to be adjusted to allow natural vegetation to reproduce and maintain cover, giving them a competitive edge.

Above: A typical example of a mixture of alien species invading a river course. In this case mostly Gum trees (*Eucalyptus* spp) and Oleander (*Nerium oleander*). (*Images supplied by*

Ideally, alien vegetation must be removed. The approach chosen will depend on the species concerned and the resources available, as it can be a very expensive process. In addition, it is critical that a long-term plan, which must include regular follow up, is put in place *prior* to initiating removal, particularly for highly invasive species such as *Prosopis* spp. Clearing large established stands of invasive species often results in an "ecological release" of seedbanks. The established trees prevent seedlings from germinating; seeds accumulate in the soil and germinate *en masse* when the adult trees are removed. Where a long-term follow-up plan is not in place, established stands should not be removed, as the resulting situation will often be several times worse than the initial infestation. Where control is applied, a plan must be in place to remove the resulting biomass so that this material is not carried downstream by floodwaters, where it may cause damage to flood-irrigation infrastructure. It is also critical that *prior* to removing invasive species, a plan must be in place to aid restoration of the bare area following removal. In arid areas such as the Karoo, natural vegetation seldom spontaneously recovers without active interventions. When floods occur, areas exposed by clearing operations are extremely vulnerable to sudden and often irreparably severe erosion caused by floods.

Where chemical control is chosen, great care must be taken in this highly sensitive ecosystem, as chemicals will be washed into the river system when it rains and the river flows. They, therefore, not only pose a threat at the site of application but also downstream. It is critical that the chemical used is recommended explicitly for riparian zones due to the high risk to this aquatic ecosystem. It is not advisable to use products such as diesel to create adhesion of chemicals, as these will leach into the soil and/or end up in the water during floods.

Gum trees growing in riparian areas must, according to the current legislation, be removed. However, it is worth noting that research by the SA National Biodiversity Institute (SANBI) has found that gum trees provide nectar and pollen for swarms of commercial bees – and bees, in turn, pollinate about 50 food crops in the country. Because of this, the Department of Environmental Affairs' legislation on alien and invasive species does not require all of them to come under the axe or chainsaw. There are six species the legislation defines as invasive, which have to be controlled even outside these areas. Discretion must be exercised when deciding whether to remove or leave the other species to ensure that water sources are not impacted, but crop pollination benefits can be realised[5].

The relevant legislation – the Alien and Invasive Species Regulations – promulgated under the National Environmental Management: Biodiversity Act, 2004 (NEMBA), was published in the Government Gazette on 1 August 2014 and became law on 1 October 2014.

The Working for Water (WfW) programme, established in 1995, aims to reduce the density of established, terrestrial, invasive alien plants, through labour intensive, mechanical and chemical control, by 22% per annum. The programme is administered through the Department of Environment, Forestry, and fisheries and helps landowners remove alien plants from their properties (contact your provincial DEA office for more information).[6]

7. Managing livestock predation

All management actions must be undertaken within the confines of the law. Effectively addressing problems caused by damaging causing animals requires a well thought out Predation Management Plan for the farm. The plan should incorporate a holistic approach to solving problems with predators. An excellent example is the one advocated by Niel Viljoen[7] and supported by the National Wool Growers Association. This approach addresses not just the risk from predators but takes a balanced approach, which incorporates a range of aspects, including livestock management, adequate infrastructure development, and a thorough understanding of the predator and its ecology.

Any method used must not negatively impact other species (by-catch) or have negative ecological impacts. Any method that can have negative ecological impacts, even though it is legal, must be used as a last resort and with extreme caution. All reasonable precautions must be undertaken to prevent losses

[5] https://www.sanbi.org/wp-content/uploads/2018/05/gumsbees-web-version-hyperlinks.pdf

[6] https://www.environment.gov.za/projectsprogrammes/wfw

[7] http://nielviljoen.co.za/

caused by damage-causing animals. All non-lethal methods must be considered first. Lethal options should be a last resort and applied with extreme caution to reduce impacts on non-target species and individuals.

7.1. Managing damage-causing animals

There is a wide range of options for managing the impact caused by predators[8]. It is a fact that predators cause severe damage to the livestock industry every year. While large predators such as lion, leopard, cheetah, wild dogs and hyaena have been eradicated over much of their natural range, the smaller caracal (*Felis caracal*) and jackal (*Canis mesomelas*) persist despite an all-out effort over centuries to eradicate them.

It can, therefore, probably safely be assumed they will be around for some time to come. Any management approach should take this fact into account. While they may be temporarily eradicated on a particular property, neighbouring areas will invariably serve as a source of new animals. From an ecological perspective, it is not desirable to eradicate predators on farms in extensive rangeland, as they fill a valuable ecological role. As such, farmers need to adapt their livestock management and approaches to managing problems caused by individuals of the various species instead of aiming for eradication.

Veld that is in good condition will support a range of species from invertebrates to birds and small game. The value of these alternative food resources for predators is often underestimated. Where a well-balanced ecosystem is maintained, with healthy populations of small game and other species, the overall incidence of predation on livestock may be reduced. Attempts at eradication in the absence of a holistic approach to solving problems have repeatedly been proven inefficient, either from a cost-effectiveness or reduction in livestock loss point of view.

Black-backed Jackals can best be described as opportunistic omnivores. They have a wide-ranging diet that includes invertebrates, such as beetles, grasshoppers, crickets, termites, millipedes, spiders, and scorpions. They also feed on mammals, such as rodents, hares, and young antelope. They also feed on carrion, lizards, birds and snakes, as well as berries and fruits.

7.2. Controlling of domestic dogs and cats

Dogs pose a significant risk to wildlife, including Riverine Rabbits. Dogs must be under strict supervision at all times to prevent them from hunting. Dogs should never be allowed to roam freely in the veld, let alone riparian areas. The exception is working dogs such as Border Collies, provided they are under strict supervision by trustworthy staff. Hunting dogs should be strictly forbidden in riparian zones. The risk of accidental by-catch of Riverine Rabbits is too great, together with the disturbance posed by hunting activities.

[8] https://www.ewt.org.za/wp-content/uploads/2019/02/Predators-and-Farmers-2018_small.pdf

All farm dogs must be secured at night, either on run wires, in kennels or adequately fenced yards. During the day, pets must not be allowed off the homestead unless under strict supervision. Workers' yards should be adequately fenced so that dogs are effectively contained. Keeping dogs on short chains for extended periods is inhumane and often results in overly aggressive dogs.

Both male and female dogs should be sterilised to prevent them from wandering off or producing unwanted litters of puppies. In addition, the number of pets owned by staff should ideally be limited to one pet dog per family to reduce the risk of dogs roaming onto the farm. While small-sized dogs are preferable, the damage they can cause to wildlife (and livestock) should not be underestimated.

a) The use of gin-traps (leg-holds) must comply with the legal requirements (these may differ between provinces). The person setting the trap must have a permit from the Provincial authority and the trap must meet the provincial specifications. A register must be maintained where gin traps are in use wherein all kills are documented.

b) However:
   - Gin traps are indiscrimminate and inhumane, and result in the death of a host of non-target species.
   - As such the EWT does not condone their use.

c) The use of poison to control damage causing animals is not legal, with the exception of the use of poison collars and then only with a permit issued by the Provincial authority.

d) It is illegal to use snares under any circumstances.

A jackal hunter with a pack of 11 dogs heads into rabbit habitat in search of jackals. While this practice is common on farms, packs are seldom trained well enough to ignore non-target species, resulting in a negative impact on small game numbers. This in turn increases the risk of predation on livestock in the absence of natural prey. (*Image supplied by EWT*)

Domestic cats pose a threat to wildlife by capturing a range of animals from invertebrates to reptiles, birds, and small mammals. They also pose a threat to the African wild cat (*Felis lybica*) as they will readily breed with this indigenous species, producing fertile hybrids. This poses a threat to the genetic integrity of this species. Domestic cats, especially the so-called "barn cats", should all be sterilised to prevent numbers spiralling out of control.

8. Biodiversity Stewardship

River catchments in the Nama Karoo and the associated riparian specific habitat are under great pressure from agriculture. River catchments are critical water source areas and serve as biodiversity corridors and important resource areas for biodiversity. Given the extent of the loss of riparian habitat in the Nama Karoo, specific conservation measures are warranted to ensure the remaining intact riparian vegetation is protected. The protection of these habitats would not necessarily exclude utilisation by extensive livestock farming. Instead, the management of these areas should be specifically formulated to ensure that ecosystem functionality improves over time. Formal conservation measures put checks and balances in place to ensure that this happens.

Critically Endangered Riverine Rabbit **(left)**, and **(right)** livestock photographed at the same location, at different times, during an EWT camera trap survey on a commercial sheep farm. Biodiversity conservation and agriculture are not mutually exclusive in the Karoo's extensive rangelands. Priorities need to be integrated to ensure the ecosystem remains functional in the long-term, particularly in light of the potential impacts of climate change. (*Image supplied by EWT*)

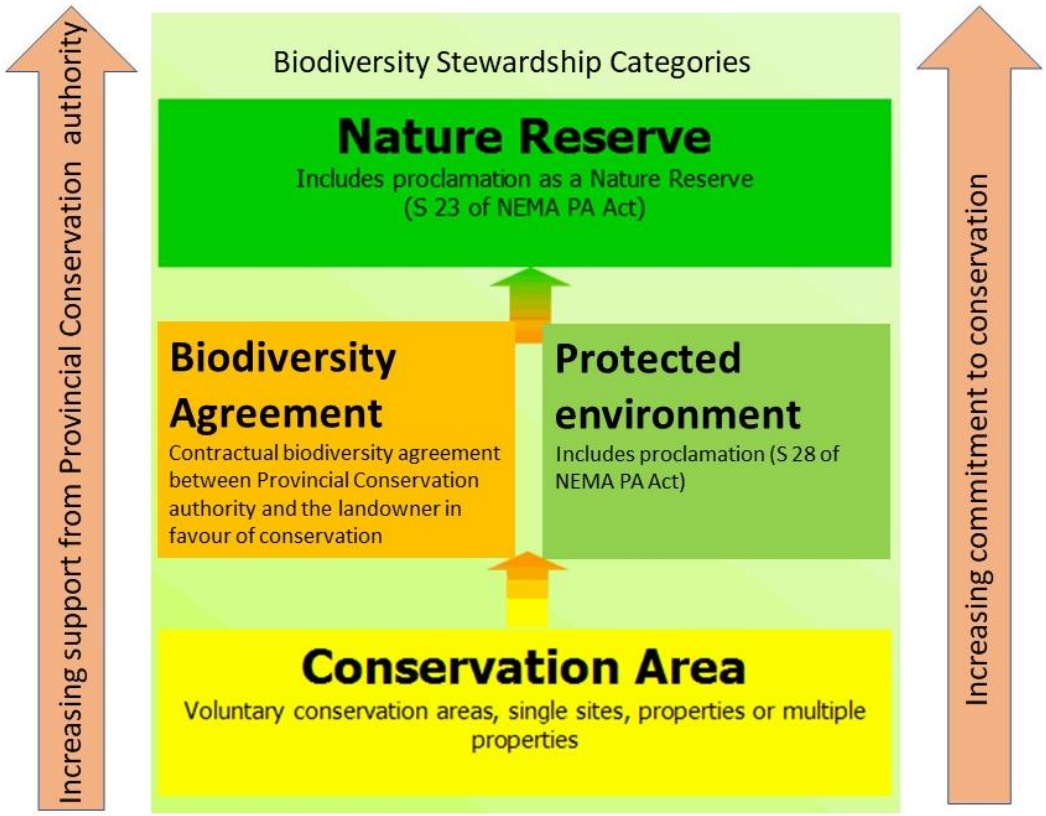
8.1. Stewardship options

Biodiversity stewardship is an approach to securing land in biodiversity priority areas through the conservation authorities entering into agreements with private and communal landowners. In South Africa, certain mechanisms to declare privately protected areas have been incorporated into national legislation, and currently, five different types of biodiversity stewardship agreements exist. These range from non-binding agreements to long-term formally declared protected areas. Agreements formally declared (National Environmental Management: Protected Areas Act: Act 57 of 2003) form part of South Africa's protected area network and contribute towards meeting national protected area targets. The

focus is on ensuring that contract protected areas are declared on areas of high biodiversity importance, such as Critical Biodiversity Areas and threatened ecosystems. A flexible range of biodiversity stewardship agreements is available, making biodiversity stewardship appropriate for a wide variety of landscapes, including agricultural and communal areas.

Each agreement requires a different level of commitment. Each successive level of agreement provides more protection for biodiversity and involves more land-use restrictions, with increased support to the landowner at the higher levels of commitment. The relative importance of biodiversity is considered for eligibility at each level, with higher levels requiring the property to have sufficiently important biodiversity features.

Biodiversity stewardship programmes are implemented through a collaborative approach involving private and communal landowners and partnerships with various government and non-government organisations. Key role-players within the programmes are landowners and conservation authorities[9], with support from the national government. In many provinces, conservation NGOs also play a critical role in supporting the stewardship programme.



[9] https://www.ewt.org.za/wp-content/uploads/2019/02/Farmer-guidelines.pdf

8.1.1. Formal Protected Areas

In South Africa, protected areas are defined as geographic areas that are gazetted and formally protected in terms of the Protected Areas Act and managed mainly for biodiversity conservation. They constitute the protected areas estate and contribute to meeting protected area targets.

8.1.1.1. Nature Reserves

Nature Reserves are only declared on properties of high biodiversity importance. A title deed restriction is placed on the property, creating two protection layers, the Nature Reserve declaration and the title deed restriction. A signed contract between the landowner and conservation authority has a duration of at least 30 to 99 years or in perpetuity. This ensures the property is secured, regardless of future ownership changes, and binds the landowner to specific activities. Management plans are developed by the conservation authority or NGO and the landowner. These are reviewed every five years.

8.1.1.2. Protected Environments

Protected Environments can be declared on a single property or multiple properties. A title deed restriction can also be placed on the property, thereby creating two layers of protection, the declaration and the title deed restriction. A contract is signed between the landowner and conservation authority and typically has a duration of 30 to 99 years or in perpetuity. Protected Environments allow for a broader range of compatible land uses on the property than a Nature Reserve would. The management of the Protected Environment must be guided by a management plan developed by the conservation authority and the landowner, sometimes with NGO support.

8.1.1.3. Conservation Areas

Conservation areas are not formally protected in terms of the PAA but are nevertheless managed at least partly for biodiversity conservation. They may have an agreement in place.

8.1.1.4. Biodiversity Management Agreements

This agreement is entered into under the National Environmental Management: Biodiversity Act (Act 10 of 2004) and should have a minimum duration of 5 years and be reviewed every five years, in line with the Biodiversity Act. A Biodiversity Management Plan needs to be developed for the property.

8.1.1.5. Biodiversity Agreements

These agreements are entered into in terms of contract law and are five to 15 years in duration but can be signed in perpetuity. These agreements are more flexible than the higher levels of biodiversity stewardship.

8.1.1.6. Biodiversity Partnership Areas

These agreements are considered informal agreements between the landowner and conservation authority and do not legally bind either party to any obligations. It usually takes the form of a Memorandum of Understanding.

8.1.2. Servitudes

Conservation servitudes are an acceptable, efficient and legally recognised method of securing habitat in South Africa. Provincial conservation authorities and the Deeds Offices in the Northern and Western Cape provinces support the use of servitudes. Conservation servitudes have already been registered in the Western Cape for Fauna and Flora International and the Overberg Conservation Trust.

The riparian specific vegetation in the Nama Karoo is linearly distributed and extends across multiple properties. As such, servitudes are a practical option for implementing formal conservation of this habitat within the broader landscape, as the focal conservation areas only occur on parts of several properties. Where habitat conservation, with a view to supporting a viable population of Riverine Rabbits is the objective, an area encompassing at least 750 ha (in good condition) would need to be incorporated. Incorporating a large enough area will necessitate servitude agreements with several landowners in most cases. In cases where the biodiversity value of the broader landscape warrants formal protection, servitudes can be registered over larger untransformed parts of the farm.

Management objectives would include a set of generic and specific conditions outlined in a management plan, included in the legal document, and bound to the title deed restriction. Generic objectives would be aimed at veld management and improvement of riparian areas in which structure and composition of vegetation would be promoted along with regular rest intervals. Specific conditions would include items that need to be managed or prohibited, such as not allowing dogs to roam in riparian areas.

The Public Benefit servitude type is best suited for the conservation of habitat. Beneficiaries can be the public in general and/or specifically mentioned entities such as the Endangered Wildlife Trust. The servitude, as described above, can be designed to have a legal effect for a significant period (up to 99 years) and can be engineered to survive the transfer of ownership or changes in land tenure.

The Endangered Wildlife Trust is dedicated to conserving threatened species and ecosystems in Southern Africa for the benefit of all people. For more information please visit: www.ewt.org.za

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Recommended Websites

Conservation focus: https://www.ewt.org.za/

Agriculture and Sustainable Land Management focus: http://www.karooforever.org.za/

Veld Restoration focus: https://www.renu-karoo.co.za/

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