

Restoration in South Africa

James Blignaut and colleagues explain the importance of ecological restoration in the changing South African landscape.



Restoration of dunes after strip mining. Image: Marco Pauw

This is interesting

Restoration can provide a wide range of direct and indirect benefits to society. However, there are very few projects that have attempted to properly quantify those benefits and present them in such a way that society is motivated to invest in restoration. Describing and quantifying these benefits requires people who understand ecosystems and their restoration, as well as people who know how to assess benefits. However, it is not a matter of simply combining knowledge. We need to understand how differently our sciences view the world and organise their knowledge of it. For example, ecologists are concerned about how ecosystems function and how their restoration may be affected by their history, location and context. Economists are more interested in flows of goods and services to and through society and less so in where things are. Developing the shared understanding needed to provide a thorough and sound assessment of the benefits requires us to find (a) ways of linking the information that ecologists provide to the benefits that economists can value and (b) ways of sharing these benefits with society.

Restoration is one example of the very complex problems faced by society. There are many such problems that will require co-operation between disciplines and the active participation of society in the search for the solutions.

There is a clear message in this: the era when single disciplines and scientists alone found solutions is rapidly passing. Scientists, government, industry and society need to work together to find and implement solutions. Together we can do much better than we can do individually!

What is restoration?

Our human population continues to grow at an unprecedented rate, demanding ever-increasing amounts of goods and services from the natural ecosystems upon which we depend. No part of the planet has been left untouched, and many areas are degraded. We have scarred (or transformed) landscapes by removing natural vegetation to plant crops, dam rivers, mine minerals and to gain access to previously inaccessible areas. In the process, we have tampered with the very fabric of the ecosystems that we need for our survival.

But all is not lost. *Ecological restoration* is the process of repairing these affected ecosystems, with the main goal of bringing them back to some level of health, integrity and self-sustainability. If the size of the impact is small and manageable, all that may be needed is a gentle prod to shift the ecosystem back (*passive restoration*) towards its natural state. If this does not happen within a reasonable time frame, active measures might need to be put in place (*active restoration*), such as the re-introduction of important species or the removal of alien species.

If the level of transformation is too large or severe for restoration, *ecological rehabilitation* may be a better option. This is where some of the important functions of the system (e.g. grazing capacity) are recovered, but not to the same natural state as before. Rehabilitation typically occurs on post-mining sites and sites heavily affected by overgrazing.

If ecosystems are so badly damaged that they can no longer recover, even with the best of efforts, they are usually reassigned to a different function (*reallocation*). So, for example old croplands with soils that have been ploughed and fertilised for years may be best used for housing developments, thereby leaving more intact ecosystems untouched. It is obviously best to avoid the need for restoration altogether by balancing wise management with sustainable growth, but sadly this has not always been the case, and the science of restoration is needed to develop the appropriate technologies for ecosystem repair.

Natural capital

A recent development is the concept of restoring natural capital (RNC – see also www.rncalliance.org). RNC is a somewhat larger or broader concept than ecological restoration as defined above. It refers to all investments in renewable and cultivated natural capital stocks and their maintenance in ways that will improve the functions of both natural and human-managed ecosystems. At the same time these investments contribute to the socio-economic wellbeing of people through holistic restoration of ecosystems, ecologically sound improvements to lands managed as production systems for useful purposes, improvements in the utilisation of biological resources, and the establishment or enhancement of socio-economic systems that facilitate the incorporation of knowledge and awareness of the value of natural capital into daily activities.

Investing in renewable and cultivated natural capital is like putting money in the bank, generating interest in terms of ecological goods and services (EGS) indefinitely. However, the 'banks' (ecosystems) require effective management to protect or augment capital and to prevent its dissipation for short-term profit.

Why is restoration necessary?

Overgrazing, surface mining, ploughing and abandonment of fields all remove the natural vegetation cover. Bare soil, exposed to sun and beating rain, often becomes smooth and baked like a tennis court. Rainwater cannot penetrate the hard ground but runs off, carrying away leaves and seeds. Dry top-soil, without living roots to hold it together, turns to rivers of mud that silt up dams and pollute streams. Wind further scours the bare surface and the remaining topsoil spirals away as dust devils.

Such damaged land can heal itself – but this may take hundreds or even thousands of years. The growing human population needs productive land for food and large tracts of natural vegetation to absorb carbon dioxide and stimulate the imagination, uplift the spirit and soothe weary urban eyes. We cannot wait centuries for nature to heal the damage we cause through our daily activities. This is why restoration must be proactive.

— a case study

Government, businesses, NGOs and individuals need to invest and engage in active restoration to hasten the recovery processes. Major steps in restoration include the development of structures and soil works that trap water and improve infiltration, 'bandages' such as mulch, textile or branches to hold the soil, and sowing or replanting plants that will bring life back to the land and attract the pollinating birds and insects necessary to make the vegetation self sustaining.

The importance of restoration is highlighted and discussed, complete with international case studies, in Chapter 9 of the Economics of Ecosystems and Biodiversity project (TEEB) and can be downloaded at <http://www.teebweb.org/LinkClick.aspx?fileticket=9NUqtjb3bo%3d&tabid=1019&language=en-US>.

An example of restoration research in South Africa

Currently ASSET Research (www.assetresearch.org.za), a section 21 Public Benefit Organisation that endeavours to develop capacity and advance the ecology/economic/scientific knowledge frontier, is engaged, under contract from the Water Research Commission (www.wrc.org.za), with significant co-funding from the Working for Water programme, to assess and quantify the impact of restoration. ASSET awarded a total of 13 scholarships to 12 Masters' and one PhD candidate attached to six universities to conduct an in-depth analysis of the ecological, hydrological and economic impacts of restoration at eight sites across South Africa. The sites, four of which are discussed in the accompanying boxes, have been carefully selected to be representative of South Africa's rich biodiversity. Another selection criterion was the need for historic data and a restoration history. In each of the cases the ASSET Research team collaborates with partners, that include the Working for Water programme, Flower Valley, the Ostrich Business Chamber, Exxaro and AWARD, to a) benefit from these organisations' experiences, and b) to add value to the ongoing initiatives. In practice this implies that for each of the research sites a combination, or team, of hydrology, ecology and economic students assess the impact of restoration in collaboration with the resident research/organisation and his/

her university supervisor.

Student colloquiums are organised approximately every three to four months to provide feedback to the broader stakeholder community, and to enhance multi- and interdisciplinary research. Student colloquiums provide a non-threatening environment where research progress, as well as difficult conceptual and methodological issues, is discussed. Students are provided with an opportunity to engage with researchers and students from other institutions and organisations and disciplines while having the opportunity to communicate their research findings. These student colloquiums are invaluable in offering students the necessary practice in public speaking and science communication.

The flagship of the project is the multi-disciplinary PhD study that seeks to learn from and distil the information from the various Masters' studies into one systems model that could be used in policy and strategic decision-making through scenario planning. This systems model could be used, through and in interaction with various role-players and stakeholders, to develop scenarios that show what the impact of restoration under various circumstances and conditions is likely to be, based on the outcomes and the results from the eight reference sites.

It is expected that this research will demonstrate the importance of restored ecosystems to human wellbeing in the context of developing countries. In one way it is no different from other kinds of restoration work. For example, if roads are not well maintained, transport becomes more costly and economic development suffers. The only difference is that investment is now needed in the ecological infrastructure supporting those ecosystem services that are often taken for granted.

It is further expected that restored ecological services such as grazing and assured water flows are necessary, but certainly not sufficient, for an improvement in socio-economic activities such as agriculture. Despite this realisation, restoration of natural capital is one important way to address the increasingly important biophysical limits of socio-economic development. In developing countries with high numbers of rural poor relying on agriculture for their survival, this may be one of the few remaining viable options left.



This project is commissioned and funded by the Water Research Commission (Key Strategic Area 4: Water Utilisation in Agriculture)

The students

Name: Douglas Crookes

Thesis title (degree): *A meta-analysis of the ecological, hydrological and socio-economic impacts of restoring natural capital in South Africa* (PhD, Stellenbosch University)

What it means to be part of an inter-disciplinary team: It is an invaluable experience to be part of this inter-disciplinary team.



Name: Petra de Abreu

Thesis title (degree): *Restoration in the semi-arid Little Karoo, South Africa: Testing methods for re-establishing indigenous vegetation on degraded ostrich farmland and the impact of restoration on ecosystem services on degraded ostrich farmland* (MSc Conservation Biology, UCT)

What it means to be part of an inter-disciplinary team: Being a part of the Asset Research inter-disciplinary team allows me to place my research into a bigger picture between the diverse fields of natural and social sciences and economics.



Name: Thabisani Ndhlovu

Thesis title (degree): *Prosopis clearing in the Karoo: Assessing the value of restoring Nama Karoo rangeland through the recovery of ecosystem structure, function and agricultural productivity* (MSc Conservation Ecology, Stellenbosch University)

What it means to be part of an inter-disciplinary team: I have found that looking at a problem from other points of view gives me a greater understanding of the issues being researched. >>





Name: Marco Pauw
Thesis title (degree): *The ecological effects of restoration on a coastal mineral sands mine in the arid Namaqualand, South Africa* (MSc Conservation Ecology, Stellenbosch University)

What it means to be part of an inter-disciplinary team: Being part of an inter-disciplinary team teaches me to better communicate my work to people without ecological training and to appreciate that people from different disciplines value things differently.



Name: Helanya Vlok
Thesis title (degree): *Restoring natural capital: estimating the value of changes in ecosystem functions in the Nama Karoo and the Agulhas plain* (MSc Economics, Stellenbosch University)

What it means to be part of an inter-disciplinary team: Being part of a transdisciplinary team has contributed greatly to my understanding of the interrelatedness of economic, ecological and hydrological functions. I have also realised how important it is to be able to communicate discipline-specific concepts in terms that a person from any study background should be able to understand.



Name: Worship Mugido
Thesis title (degree): *A financial and cost benefit analysis of veld restoration after ostrich farming and sand dune mining* (MSc Economics, Stellenbosch University)

What it means to be part of an inter-disciplinary team: Working with colleagues from different disciplines with different skills, knowledge and personal attributes has given me new ideas and perspectives on my subject.



Name: Musiwa Makumbe
Thesis title (degree): *The Impacts of Prosopis species on Groundwater Resources in Beaufort West/Britstown area, South Africa.* (MSc Environmental Science, UWC)

What it means to be part of an inter-disciplinary team: This type of study facilitates the exchange of knowledge and brings new ideas in the area of research.



Name: Megan Nowell
Thesis title (degree): *Determining the net benefits of clearing invasive alien vegetation on the Agulhas Plains* (MSc Conservation Ecology, Stellenbosch University)

What it means to be part of an inter-disciplinary team: Working with economists not only teaches us ecologists and hydrologists how to communicate outside of our realm, but also helps us to make a bigger impact with our findings.

SITE 1: Restoration of the natural veld in the Little Karoo

Research site

The study area lies between Oudtshoorn and Calitzdorp in the Little Karoo, within the Succulent Karoo Biodiversity Hotspot.



Monitoring restoration at the study site in January 2010. Image: Sue Milton

Description of the problem at the site

High densities of ostriches cause severe damage to the veld. The main problem is trampling, but overgrazing is also important. Both have destroyed the vegetation, exposing the top soil to erosion by wind and rain. The bare soil surface becomes so compacted that rain does not soak into the soil and dongas form along the old paths. The result is that seeds are not able to germinate under these conditions and natural recovery is likely to take a very long time, certainly longer than a person's lifetime.



The effects of trampling and overgrazing on the study site. Image: Sue Milton

The hypothesis being investigated at this site is that restoration will revive biodiversity and regenerate the ecosystem services on which people rely. Work at this site will evaluate the success of various methods in restoring the natural veld and the ecosystem services that it can deliver. The work will also evaluate the benefits received by the farmer and surrounding community from the restored veld against the costs incurred in the restoration of the veld.

Description of the restoration and outcomes

Two methods were employed in the restoration. The first method consisted of hand-dug holes (0.25 m deep and 1 m across) 1 m apart. The soil was loosened and sculpted in such a way that each would retain rainfall runoff. The second method was to break the soil surface using a tractor-drawn ripper. Breaking the hard caked soil surface allows both rainwater to infiltrate into the soil and plant roots to penetrate so that the plants can establish.



Bushman grass. Image: Jose Hernandez © USDA-NRCS PLANTS Database

Naturally occurring Karoo shrub and grass seeds and seedlings (bushman grass (*Fingerhuthia africana*) and anchor karoo shrub (*Pentzia incana*) were then planted by hand into the loosened soil and a wood-chip mulch was scattered over the planted areas to improve the capacity of the soil to hold water.



Rehabilitation planting at Greylands. Image: Sue Milton



Rehabilitation planting at Morester, Oudtshoorn. Image: Sue Milton

The initial findings of the research are that these restoration methods have been successful in the short term. Restoration can be costly but farmers can reduce costs by doing the work themselves. The value of the restored and sustainably managed veld needs to be set against the restoration costs.

Who are the collaborators?

Students working on this site are Petra de Abreu (ecologist) and Worship Mugido (economist).

Collaborators in the project include ASSET Research (Prof. James Bignaut), Renu-Karoo (Prof. Sue Milton and Prof. Richard Dean), South African Ostrich Business Chamber (Susan Botha and Yvette Uys), Conservation Management Services (Ken Coetzee and Wallie Stroebel) and landowners (Joey Potgieter, Hein Jonker and Jan Ernst).

Supervisors are Prof. Sue Milton (Percy FitzPatrick Institute of African Ornithology – Department of Zoology – University of Cape Town), Prof. Timm Hoffman (Plant Conservation Unit – Department of Botany - University of Cape Town), Dr David Le Maitre (Council for Scientific and Industrial Research (CSIR)) and Prof. Theo Kleynhans (Stellenbosch University).

SITE 2: Restoration of the veld and hydrogeology in the Nama Karoo, Beaufort West

Research site

The research site is located in the heavily grazed and degraded Nama Karoo rangeland on two adjacent farms (Brandwagt and De Hoop) about 30 kilometres north of Beaufort West in the Western Cape.



The study site at Brandwagt farm.

Image: Thabisisani Ndlovu

Description of the problem at the site

Invasion by alien plants is a major environmental and economic problem in the Nama Karoo. The worst of these is the mesquite (*Prosopis* species).

The concentration of mesquite around water points, combined with their deep root system, is thought to have reduced the availability of groundwater through both the interception of water in the upper soil levels as well as the deep roots tapping into the

groundwater. This groundwater contributes to the water supply for the Karoo town of Beaufort West and so it is important to protect this resource. The sustainability of the meat- and wool-based small-stock industry of the area relies entirely on natural pasture and this industry is threatened by the erosion of natural capital base by mesquite infestations.



An alien plant stump after clearing.

Image: Thabisisani Ndlovu

The hypothesis being investigated is that clearing the mesquite will raise the level of the groundwater and result in the unaided regeneration of natural rangeland vegetation cover and grazing capacity. The resultant restoration of rangeland natural capital is expected to increase the assurance of water supply to Beaufort West and lead to financial and economic gains for the farmer and the surrounding area.

Description of the restoration and outcomes

Clearing of *Prosopis* sp. by a Working for Water team on a farm in the arid Central Karoo has not yet shown positive benefits. Although the vegetation has changed following clearing to resemble un-invaded vegetation, its grazing value has not improved significantly as palatable plant species have not yet recolonised the cleared areas. It is recommended that, following *Prosopis* clearing, the area be reseeded with palatable plants and livestock and game be excluded from the treated site for a period of time to allow the palatable plants to establish. The effect of *Prosopis* removal on the water table is being investigated.

Who are the collaborators?

Students working on this site are Mr Thabisisani Ndlovu (ecologist), Ms Helenya Vlok (economist) and Mr Musiwa Makumbe (hydrologist)

Collaborators are Brandwagt farm on which restoration was done in the Nama Karoo.

Supervisors of the students working on this site are Prof. Karen Esler (Department of Conservation Ecology & Entomology, Stellenbosch University), Prof. Martin de Wit (School of Public Management and Planning, Stellenbosch University ASSET Research) and Dr David Le Maitre (CSIR).

SITE 3: Rehabilitation after strip-mining: Exxaro Namakwa Sands mine

Area of research site

Exxaro Namakwa Sands mine, Brand-se-Baai.

Description of the problem at the site

Strip-mining completely disrupts natural ecosystems through the destruction of natural vegetation, resulting in large-scale changes in the natural topography, soil structure and chemistry. South African legislation requires mining companies to restore mined areas but the restoration process is complicated by abovementioned changes to the original environment which determined the structure and composition of floral and faunal communities. The harsh environment (extreme heat, strong winds and low rainfall) at Brand-se-Baai further hinders the restoration process.

This research aims to monitor the effectiveness of the restoration process. It will also determine if private (financial) benefits will exceed restoration costs. This will be gauged in the light of social benefits realised and the economic value of the quantifiable social benefits. The research will also investigate the possibility of establishing a market for the payment of ecosystem services.

Description of the restoration and outcomes

ENS's restoration goal is to 'rehabilitate and re-vegetate disturbed areas and establish a self-sustaining Strandveld vegetation cover in order to control dust

generation, control wind and water erosion, as well as restore land capability'. In this way the grazing capacity of the restored land should be as close as possible to that prior to mining operations. Before the mining process starts, the topsoil is removed and either directly transported to an area that is currently being restored, or stockpiled until it can be used. The subsoil is then removed and undergoes various treatments in order to separate and concentrate the mineral content. The portion of the subsoil left after treatment, known as tailings, is transported to mined-out areas and bulldozed to recreate pre-mining contours. The topsoil is then replaced and spread, and rows of shade cloth are erected perpendicular to the prevailing wind direction to act as wind-breaks.

ENS implements four restoration techniques varying the topsoil replacement, seeding and plant translocation. Cuttings of various indigenous plant species are made from natural vegetation on nearby farms and allowed to grow in an on-site nursery. The seedlings are transplanted with the first winter rains. After five to six years the vegetation cover has established sufficiently for the wind-breaks to be removed.

Who are the collaborators?

Students involved in this research are Mr Worship Mugido (economist) and Mr



The Namakwa Sands mine research area.

Image: Marco Pauw

Marco Pauw (ecologist).

The collaborator is Exxaro Namakwa Sands.

Supervisors of the students working on this site are Prof. Karen Esler (Department of Conservation Ecology and Entomology, Stellenbosch University), Prof. Theo Kleynhans (Department of Agricultural Economics, Stellenbosch University), and Dr David Le Maitre (CSIR). >>

SITE 4: The Agulhas Plain

Table Mountain in the centre of the city of Cape Town. Image: Wikimedia commons



Table Mountain sandstone is a quartzitic sandstone, formed in the Ordovician (488-443 million years ago) era. This type of rock is highly resistant to erosion and forms the characteristic steep grey crags, seen particularly around Table Mountain in Cape Town.

Benefits associated with restoring invaded areas to indigenous wild fynbos include the sustainable harvest of fynbos flowers, the creation of employment through the use of marginal land, positive externalities such as beekeeping, thatching and Honeybush tea, and increases in water supply for agricultural and domestic use. The impact of restoration on carbon sequestration is being investigated.

Seed collecting at Bergplaas on the Agulhas Plain. Image: Mirjam Gaertner



of the area. This natural capital, such as fynbos flowers for export, is the source of ecosystem goods and services on which people depend. Land owners are reluctant to clear invasive vegetation for two reasons. One is the high costs incurred by such projects. The other is that if all land owners do not put equal effort into clearing then there will be reinvasion from uncleared areas.

The aim of the research at this site is to assess the change in the availability of water and the benefit of the restoration of natural capital after the removal of alien vegetation.

Description of the restoration and outcomes

Restoration on the Agulhas Plain was undertaken by removing different species of invasive vegetation and sowing indigenous fynbos seeds on plots on Table Mountain sandstone. Cost-benefit analyses are used to compare the present values of costs and benefits associated with natural capital restoration over a number of years. Financial analyses are undertaken to assess the impact of restoration on a farmer's production decision, while economic analyses are done to include costs and benefits external to a farmer. The outcome of this restoration is then extrapolated across invaded areas of Table Mountain sandstone for the whole of the plain.

Carbon sequestration is a technique for the long-term storage of carbon dioxide or other forms of carbon, for the mitigation of climate change. Planting vegetation that absorbs carbon dioxide is one approach.

The impact of restoration on ecotourism is expected to be small but positive. Other than the direct expenditure on restoration, costs include the opportunity cost incurred by the rural population who depend on invasive vegetation as a source of fuel for heating and cooking, and who derive income from firewood sales.

Who are the collaborators?

Students involved in this research site are Ms Helanya Vlok (economist) and Ms Megan Nowell (ecologist).

Collaborators in this research site are Flower Valley farm on which restoration was done on the Agulhas Plain and Flower Valley Conservation Trust and CIB (University of Stellenbosch).

Supervisors of the students working on this site are Prof. Martin de Wit (School of Public Management and Planning, University of Stellenbosch ASSET Research), Dr David Le Maitre (CSIR) and Prof. Karen Esler (Department of Conservation Ecology & Entomology, Stellenbosch University)

Area of research site:

The area of the Agulhas Plain covered by this research is fynbos, which is growing on Table Mountain sandstone. The fynbos has been encroached by invasive alien plants, reducing the natural capital of the area.

Description of the problem at the site

Invasive vegetation has transformed much of the indigenous fynbos on the Agulhas Plain. Non-indigenous plants were originally planted with objectives such as dune stabilisation and shade provision. Some of these have become invasive and their rapid and persistent spread has led to the reduction in the natural capital

Conclusion

With an increasing scarcity of nature's services, it is expected that active restoration will play an increasingly important role in the future. Although the costs of active restoration are

prohibitive in the context of abundant resources, it is expected that this situation is changing rapidly. Cheap land, water and biomass suitable for socio-economic development are becoming scarcer. The logical alternative

is to restore what has been lost. □

Prof. James Bignaut, Dr Martin de Wit, Prof. Karen Esler, Dr David Le Maitre, Prof. Sue Milton, Dr Steve Mitchell and Ms Leandri van der Elst together with each of the students mentioned.