Understanding how water resources shape our flora

Changes in ground water resources – either as a result of abstraction or climate change – have important implications for fynbos

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Within this plot on New Years Peak in the Limietberg Nature Reserve you can see species segregating along a 'hydrological gradient' from top to bottom. Visible vegetation bands include the restios *Ceratocaryum fimbriatum* (1) and *Elegia filacea* (2), *Erica fastigata* (3) and *Anthochortus crinalis* (4). **Photo:** Mike Dodd.

Water is one of the most important resources for plants. It controls and influences their diversity and distribution. Water availability in soil influences plants directly as a limiting resource, or indirectly by filling soil pore spaces and reducing oxygen supply, which limits plant root growth. Water regimes dictate different vegetation types and ecosystems. Global examples are the major world biomes, such as tropical rainforest, deserts or tundra. At this level, precipitation differences as a result of latitude and incoming solar radiation define which species prevail. At a regional level, plant communities are determined by precipitation differences associated with topographic features such as elevation.

More locally, within a small plot, species distribution is often determined by the seasonal variation in availability and behaviour of water. Fine-scale differences in water regime results in a gradient of water stresses where different plants respond to varying levels of stress in different ways, and therefore their competitive ability changes along this hydrological gradient. The zone they occupy is known as their **niche.** It is where they can outcompete their rivals. This division into niches can be a particularly important feature in species-rich ecosystems. (See accompanying photograph.)

In a diverse community structured along a hydrological gradient, co-existing species' dependence on the soil-water regime is finely balanced. Any change in water level that destabilizes the system is often serious. Species response is either shifting from their local range to more suitable habitat around them or failing that disappearing from the particularly locality. This change can happen at plot scale, regionally and often within short time.

The Cape Floristic Region

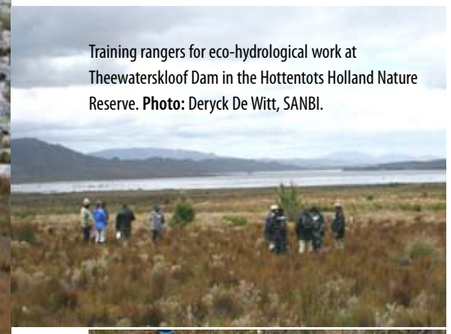
The Cape Floristic Region (CFR) contains nearly 9 000 plant species, the majority of which are found nowhere else on Earth. One of the most important habitats of the CFR is the fynbos, most of which is currently protected by a network of nature reserves managed by CapeNature or the South African National Parks. The value of this hotspot of biodiversity is recognized by the United Nations, which has awarded the region World Heritage status. Conservation of such a global heritage calls not only concerted local but also international effort.

Currently, rapid population growth and economic development in the Western Cape region are placing increasing demands upon water resources. Increased abstraction from the sandstone aquifers underlying important fynbos habitats is one of the options under consideration to meet the urban demand for water. At present, little is known about how such abstraction might affect the Cape flora and there is almost no information at all about the eco-hydrology of Cape plants.

What about changing climate?

The uncharted waters of changing climate are another impending threat for CFR. Climate comprises a complex relationship between temperature, precipitation, evaporation, wind and cloud. It is very likely that human activities through the increased emission of carbon dioxide and other greenhouse gases will raise the surface temperature of the earth. A change in climate will have major impacts on hydrological systems and will influence the hydrological cycle through increasing surface temperatures and changing rates of precipitation. An increase in surface air temperature would increase plant transpiration and evaporation from both the soil and water bodies. The magnitude of any such increase will depend on changes in sunlight, humidity, wind speed, rainfall and vegetation characteristics. We don't know how individual catchment areas will respond to changing precipitation patterns and evapo-transpiration rates. However, it is expected that drier areas will be more sensitive to changes in climate.

According to future climate scenarios from most of the global climate models, the annual rainfall in the Western Cape is likely to decrease. The rate of re-charge of groundwater supplies will be greatly impacted by changes in surface water availability and run-off. In the longer term, this will also affect the re-charge of aquifers. Changes in rainfall patterns (timing and amount) will also influence water quality.



Training rangers for eco-hydrological work at Theewaterskloof Dam in the Hottentots Holland Nature Reserve. **Photo:** Deryck De Witt, SANBI.

Hydrological monitoring in action. A 'buzzing stick' is used to monitor water table depth. **Photo:** Deryck De Witt, SANBI.

These modifications to the climate and the resulting change in soil water availability for plants will mean that the fynbos biome will be seriously affected by climate change over the next 50-100 years.

The demand for water in the Western Cape will increase over the next few decades, especially for municipal water supplies in rapidly urbanizing areas, for the production of energy and for irrigation. Therefore, water resource management will need to focus on demand management and the implementation of regulatory controls to minimize stresses resulting from the increased demand. According to a specialist group from the International Water Association, it will become increasingly difficult to combine the maintenance of biodiversity and groundwater extraction in drought-sensitive areas. The fynbos biome has a high proportion of endemic species, therefore, a permanent lowering of the water table, whether due to climate change or from abstraction, could lead to extinctions.

What is being done?

South Africa's National Biodiversity Strategy and Action Plan (NBSAP, 2005) identifies the Cape Floristic Region as a priority area and calls for research and monitoring programmes to support integrated management of ecosystems. A better understanding of the pattern and processes of the Fynbos Biome, including threatening processes, will enhance the way in which this biodiversity hotspot is managed.

A consortium of researchers from the Open University of England and the South African National Biodiversity Institute (SANBI) at Kirstenbosch are working in co-operation with CapeNature and SANParks to establish a network of sites on which hydrology and botany will be monitored. This will help to address the lack of suitable field data available for analysis. The group has established ten sites across the Western Cape. (See accompanying text box for a description of what is involved in monitoring). The work of the group will also ensure future sustainability of monitoring by training local reserve personnel in 'eco-hydrological' techniques. Twenty-one rangers from CapeNature and SANParks have been trained and are now monitoring the sites, and further training is planned to include other sites and conservation bodies to expand the project.

As the data is being processed, useful information on the ecohydrological requirements of fynbos species and the potential impact of environmental change will come to light. This information will then be disseminated among nature-conservation managers and other stakeholders, such as water abstractors, involved in the management of the unique fynbos habitat. Hopefully this knowledge will help not only in understanding the current vegetation patterns and the likelihood of future changes, but it will also help in the development of adaptive strategies for future scenarios.

ECO-HYDROLOGICAL MONITORING TECHNIQUES

Plots 50x50 m are set up with nine dipwell locations for hydrological monitoring. At the time of dipwell installation, soil samples are taken for characterization. The site is surveyed using a total station device for topography. At the same time 200 quadrats (1x1 m) are surveyed for the presence of species. Hydrological monitoring is conducted fortnightly for at least three years. Eco-hydrological monitoring involves the collection of data on the flow and soil storage of water at the site. This enables us to understand the behaviour of water during the plants' growth period. Two types of measurements are conducted. Firstly, the water-table depth and secondly, the amount of water stored in the soil.

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Project website: *www.open.ac.uk/fynbos*

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WHAT DOES THAT MEAN?

Niche A niches is the range of environmental conditions in which a species can survive (fundamental niche) or sustain itself even when competing with neighbouring species (realised niche).
Fynbos 'Fine bush' in Afrikaans, this is the natural shrubland/heathland vegetation occurring mainly in winter rainfall areas of the Western Cape.
Eco-hydrology The science of the relationship of living things and the water component (or hydrology) of their environment.
Dipwell A buried PVC tube (about 1 m long) with holes that let water enter and equilibrate with the surrounding soil. An array of dipwells are used to monitor water-table depth across a site over the course of time.