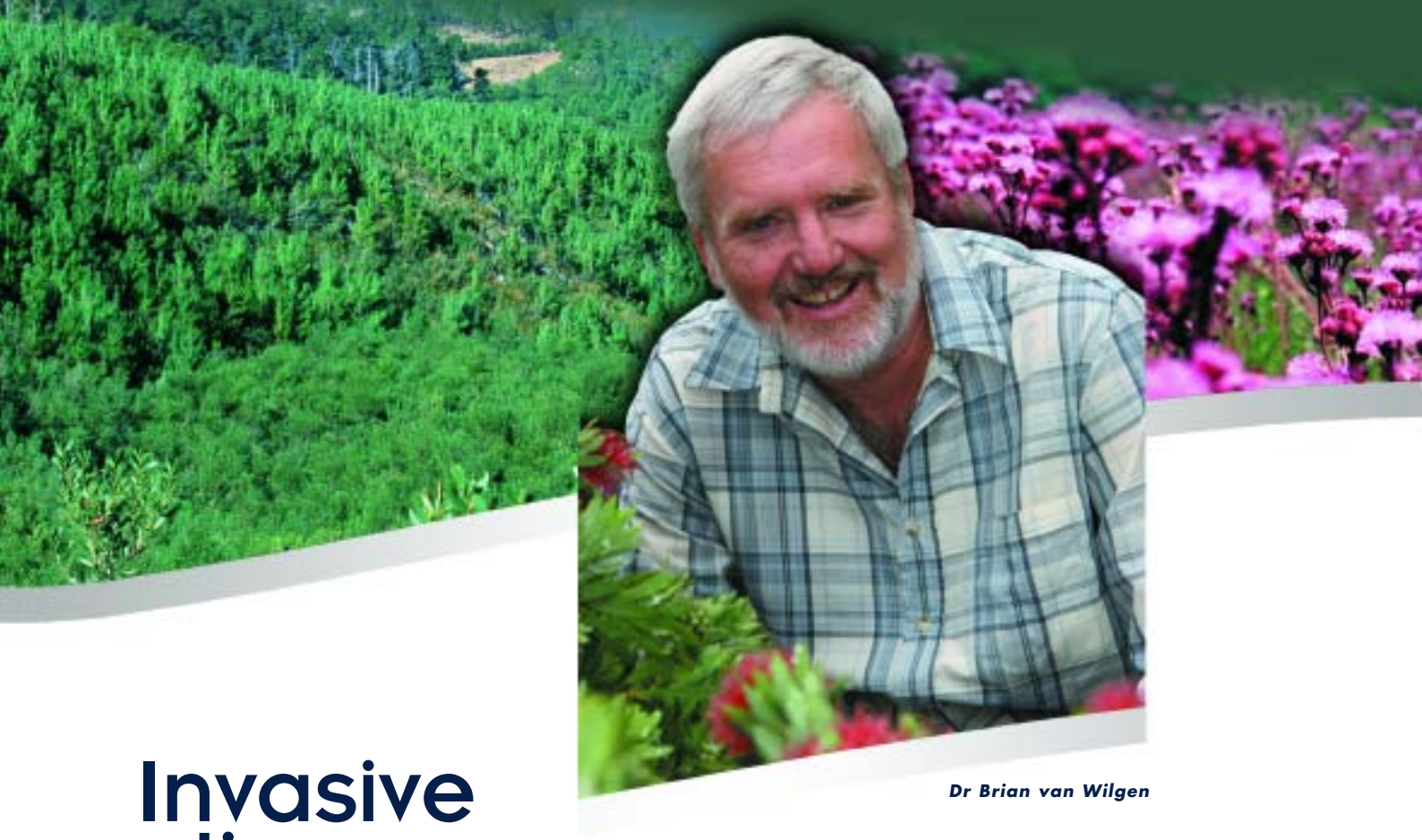

Dr Brian van Wilgen

Invasive alien species – an important aspect of global change

Invasion of ecosystems by alien species is an important and growing aspect of global change. Up until the late 19th century, mountains, large rivers, deserts and oceans provided formidable barriers to the movement and migration of species. As a result, ecosystems evolved in isolation. Early human migration saw the first intentional introductions of alien species as our ancestors attempted to satisfy physical and social needs.

HOWEVER, THE MAGNITUDE AND frequency of these introductions were minor compared to those associated with today's global agriculture and vast volumes of trade and passenger movements. The ongoing and increasing human redistribution of species to support agriculture, forestry, mariculture, horticulture and recreation supplies a continuous pool of species from which invasive aliens are recruited. Invasive alien species are also a by-product of accidental introductions, and include disease organisms, agricultural weeds and insect pests.

The problem is growing in severity and geographic extent as global trade and travel accelerate, and as human-mediated disturbance, global changes in climate and biogeochemical cycling make ecosystems more susceptible to invasion by alien species. As a result, human communities and natural ecosystems worldwide are under siege from a growing number of destructive invasive alien species that erode natural capital, compromise ecosystem stability and threaten economic productivity.

Pom-pom weed (Campuloclinium macrocephalum) from South America, which is rapidly becoming a problem in Gauteng.

What are invasive alien species?

Alien species are those species that have been relocated outside of their normal distribution ranges. Some alien species become invasive – that is, they display the ability to reproduce and spread in their new environment, often dominating vegetation and water bodies or displacing native species. It is important to recognise that not all alien species are invasive, and that some are highly beneficial.

Most of our food, fibre and building materials are provided by alien species. Many alien species that are not useful can also be benign, surviving without becoming a problem. It is the relatively small subset of alien species that become invasive, which are a problem – although this "relatively small" subset amounts to hundreds of species!

Why are they a problem?

Invasive alien species can out-compete native species, and they often eventually dominate the ecosystems they invade. This often leads to the extinction of native species, and they change the way in which ecosystems function. Global reviews of the impacts of plant invasions, for example, suggest that the most damaging species transform ecosystems by using excessive amounts of resources (notably water, light and oxygen), adding resources (notably nitrogen), promoting or suppressing fire, stabilising sand movement and/or promoting erosion, or by accumulating litter. Such changes potentially alter the flow, availability or quality of nutrient resources in biogeochemical cycles; they alter complex food webs on which many species rely; and they alter physical resources such as living space or habitat, sediment, light or water. Some invaders have been likened to "ecosystem engineers" for some of the dramatic effects they can have on ecosystem dynamics.These impacts come at a significant cost to the economy.

A recent overview of seven different countries estimates the global costs of control programmes plus the total costs of damage caused by invaders to be in the order of US$314 billion per year. Invaders also cost South Africans tens of billions of rand per year in lost agricultural productivity and resources spent on weed control. For example, a recent assessment of the economic impact of black wattle gave an estimated net cost of R8.4 billion, although this cost is largely offset by the substantial social and economic benefits derived from the wattle industry. Many other invading species do not have any commercial value or use to offset their cost to society and their impact on the environment.

In total, over 200 plants species have been identified as serious or potentially serious invaders in South Africa – and more are added to the list regularly.

The role of science and research

South Africa is a global leader in the field of invasive species ecology and control, partly because of the investments that have been made in research. The understanding derived from this research has allowed South Africans to tackle the many invasive alien plant problems that it faces with confidence. This understanding has provided guidance and solutions to ecosystem managers, such as the ability to demonstrate the potential impacts of invasive species on water resources, and provide a range of solutions based on biological control.

Impact on water resources: Research in the field of forest hydrology led to the prediction that invasive alien trees currently use 7% of South Africa's surface water resources, and that this number was set to grow if action was not taken. Research at the CSIR focuses on the development of biophysical models to assess the impacts of vegetation on water resources.

Global examples of invasive alien species	Invasive alien species in South Africa
The brown tree snake, accidentally introduced to the Pacific islands from Australia, resulted in the near-complete extermination of native forest birds on Guam and elsewhere.	The famous Cape Floral Kingdom is seriously threatened by Australian hakeas, wattles and myrtles, and northern-hemisphere pines. These displace the native species, reduce water yields and increase fire intensities and erosion.
The deliberate introduction of the Nile perch into Africa's Lake Victoria precipitated the extinction of over 200 species of native fishes, disrupted traditional fishing practices, polluted the lake, increased erosion and caused insect outbreaks.	Large infestations of Argentine ants in the fynbos are displacing native ants, and disrupting the seed dispersal of native plants – widespread plant extinctions have been predicted as a result.
The introduction of African grasses to northern Australia, in an attempt to supplement the poor natural grazing, has led to invasions of surrounding woodlands, huge increases in grass fuel loads, and subsequent intense fires that wreak havoc with trees adapted to less intense fires. In time, northern Australia's trees will be eliminated from the landscape.	Mesquite trees, introduced from North America to provide fodder for livestock, are forming impenetrable thickets in the dry Karoo and Kalahari, displacing valuable grazing, depleting groundwater resources and eliminating many bird species by changing the habitat for the worse.
Caulerpa seaweed, accidentally introduced into the Mediterranean from the Monaco Aquarium in France, is smothering the nursery habitats of many marine species.	Alien fish such as bass and carp, introduced for recreational fishing and as a source of cheap protein, are eliminating native fish and causing water quality problems. Invasive water hyacinth (from South America) causes the erosion of aquatic biodiversity and changes to water chemistry and oxygen levels, completely disrupting whole communities dependent on these freshwater ecosystems.

Other efforts focus on the estimation of runoff at a catchment level, and are aimed largely at water resource planning. The interest generated by these estimations provided a stimulus that brought ecologists, forest hydrologists and engineers together in attempts to combine these approaches, and to understand the role of invasive alien plants in changing the hydrological characteristics of catchments.

Biological control: This is the practice of importing plant-feeding insects and plant pathogens (the plants' "natural enemies") from their country of origin and then releasing them into the new environment where the plants have become a problem. In a successful operation, the natural enemies damage or kill the target plants. Before releasing any natural enemies (also called "biological control agents"), rigorous scientific safety tests are conducted under strict quarantine protocols. The tests – which can take as long as several years for a single agent species – are designed to make sure that the intended agent is sufficiently host specific, that is, that it can feed and live on only one or a very limited number of closely-related species of host plants. With the death of the host plant(s), the agent cannot feed on any other plant species, and the agent population dies out with its food supply.

For nearly 150 years, biological control has been a key weapon around the world in suppressing alien, invasive problem plants successfully. Without it, weed management would be beyond the capabilities and resources of most countries. It is a particularly attractive option because it is cost-effective and safe, compared with the expense and risks of herbicide development and deployment; it can be integrated with other management practices; and, most compelling of all, it is self-sustaining.

The first biological control project against invasive alien plants in South Africa was in 1913. Initially, invasive cactus species were the only plants in South Africa targeted for biological control. By the early 1960s, the emphasis expanded to include many other invasive plant species; to date, over 80 biological control agents have been released against almost 50 invasive plant species; of these almost 30 have been brought under substantial or complete control by biological control alone.

Biological control has to be one of the country's best investments, if we compare the benefits of controlling alien plants with the costs of biological control research. Research at the CSIR has shown that the annual economic benefits of prevent-

ing invasion ranged from R300 per hectare for jointed cactus, to R3 600 per hectare for golden wattle. Historical analyses of the benefit cost ratios from the time the biocontrol agent was released to the year 2000 ranged from 8:1 for lantana to an astonishing 709:1 for jointed cactus. In other words, for every R1 invested in biocontrol research for jointed cactus, R709 worth of benefits was generated.

Ecosystem management

South Africa's Working for Water programme was established to address the problem of invasive alien plants. Its name captures the programme's focus on job creation in support of an important ecosystem service (the protection of water supplies threatened by invasive alien plants). The programme contended that controlling invasions of alien plants would protect water yields, and that employing people to deal with the problem could at the same time provide upliftment in poor rural communities.

The programme has grown in strength over the years, with an annual budget exceeding R400 million by 2002. By 2004, the programme had invested R2.42 billion in clearing programmes during its first nine years of existence, making it arguably the largest environmental programme on the African continent. Regulations to govern the introduction, management and trade in alien species are shortly to be promulgated in terms of South Africa's new Biodiversity Act. These are likely to have far-reaching effects on many aspects of human endeavour, and are based on novel approaches developed in collaboration with many researchers in this field.

Future challenges

The most obvious and direct solution to the problem of invasive alien species is to implement nationwide control operations (like the Working for Water programme), but this action only addresses one aspect of this multi-faceted and complex problem. Other actions that are needed include preventing invaders entering the country or escaping from cultivation; early detection before the invader becomes a major problem; flexible responses to disasters that trigger invasions and rehabilitation of the cleared areas. However, it will not be possible to find effective solutions until inappropriate actions and behaviours are identified, and the ways to intervene to change them are found. Research is needed to guide interventions, such as:

- The development of the means to identify species that pose serious threats at an early stage, given that new species are entering the country continuously
- The development of an understanding of the potential effects of global climate change, and changes in biogeochemical cycling, on the ability of alien species to become invasive, or to expand their ranges and impacts
- The development of approaches to quantify and demonstrate the likely impacts of invasive alien species; and the definition of plausible management approaches, based on sound ecological understanding
- The means to deal with the significant conflicts of interest that arise when invasive alien species also provide important benefits in some areas.

Perhaps the most crucial challenge is to develop the research capacity to underpin this work. South Africans are well placed to do this, given the history of research and the important and exciting challenges that exist in this field.

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Planning a climatic future for Durban

Climate change is defined as the serious disruption of the world's weather and climate patterns with impacts such as extreme weather events, significant rainfall variability and the potential rise in sea level. The phenomenon of climate change presents possibly the greatest global environmental challenge to be addressed in this and future centuries.

AT A NATIONAL LEVEL, the anticipated detrimental impacts associated with climate change will ultimately modify South Africa's economy, as well as the health, livelihood and social structure of its populations, infrastructure and natural systems. The effects of climate change are likely to be most extreme in coastal cities such as Durban, where communities and infrastructure will be affected by changes in sea level and extreme weather events. These consequences have the potential to inhibit progress towards sustainable development.

In response to these challenges, the South African government released a National Climate Change Response Strategy in 2004 with the aim of integrating climate programmes across national and regional boundaries. Given the likely impacts of climate change and in order to align with national priorities, the eThekwini Municipality, in collaboration with the CSIR, embarked on a project to understand the implications of climate change for the city.

The purpose of this project, known as "Climatic Future for Durban", is to understand the implications of climate change for the eThekwini Municipality. The objectives of the project included:

- Synthesising the science of climate change such that it is clear and understandable
- Facilitating improved awareness and knowledge dissemination by providing information in a user-friendly format
- Providing a forum for scientific debate to seek clarity on the issue of climate change and its impacts amongst local key stakeholders – the involvement of key stakeholders in the climate change discourse is considered critical, as they play an important role in adopting climate change strategies and policies
- Engaging the public in the climate change discourse by conducting a survey aimed at assessing public perceptions of the risks to their living conditions associated with climate change as well as the likely solutions
- Preparing a range of potential images and scenarios that depict the implications of climate change for the city
- Assessing the current Integrated Development Plan (IDP) of the municipality in terms of its responsiveness to the challenge of climate change
- Understanding how the city can maximise opportunities presented through climate change adaptation and mitigation
- Developing elements of a response strategy, which the eThekwini Municipality could adopt to address the challenges associated with climate change.

It is not possible to predict with absolute certainty what will happen in Durban as a result of climate change. However, experts can assist in developing an understanding of the types of impacts that can be expected, and how severe these impacts could be.