

# Recent developments in the science and management of invasive alien plants: connecting the dots of research knowledge, and linking disciplinary boxes

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OVER 700 DELEGATES FROM 21 COUNTRIES converged on Fort Lauderdale, Florida, U.S.A., in November 2003 for an historic four-day summit on 'Invasive plants in natural and managed systems: Linking science and management'. Participants were mainly researchers working in weed science and plant invasion ecology, and managers and policy-makers with wide-ranging interests in alien species and biological invasions. The meeting, jointly sponsored by the Ecological Society of America and the Weed Science Society of America, was held in conjunction with the 7th International Conference on the Ecology and Management of Alien Plant Invasions. Catalysts for the joint gathering were the discovery that the two societies were planning separate meetings in the same area in the same year, and the realization that escalating problems with invasive alien species demand better integration between weed scientists (working mainly in agricultural settings) and ecologists focusing on invasions in natural systems. The conference was unique in bringing together so many of the world's top researchers engaged in all aspects of alien plant invasions. We provide a commentary on this conference because:

- of its direct relevance to the subject matter covered in this review issue of the *South African Journal of Science*, namely, the role of the Working for Water programme in the management of invasive alien plants in South Africa;
- in many respects, it represents cutting-edge thinking in the ecology and management of invasive plants; and
- it provides some measure of how South African scientists and managers are shaping up in this highly competitive and burgeoning field.

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In this report, we record our subjective impressions of the conference. Given the size of the meeting (more than 250 oral presentations, mostly run in several concurrent sessions, and a display of over 200 posters) we make no claim to be comprehensive. Our summary comments are an eclectic view of the conference, with special reference to our own experiences, current work, and our perceptions of the relevance of the proceedings to South Africa.

## The extent and impact of plant invasions

Alien plant invasions are getting more widespread and serious at an alarming rate around the world. Many more species are becoming invasive, more processes are being disrupted, more ecosystems damaged, and more costs are being incurred. Many images of devastating invasions were presented, including entire landscapes dominated by single invasive alien species. Some of the most damaging invaders discussed at the meeting were virtually unknown even a few decades ago. Notable in this category is the Old World climbing fern (*Lygodium microphyllum*), which has invaded southern Florida at astonishing speed.

Many new or less well-known aspects of plant invasions were discussed. For example: (i) The complexity of real-life systems was highlighted using quantitative food-web models. These show that changes in species composition caused by plant invasions could have serious consequences for higher trophic levels, and may greatly affect organisms at levels that have no direct connection with the invasive plant species in question. (ii) Evidence was presented of what was dubbed 'invasional meltdown', meaning synergistic interactions between invasive species that promote further invasions and exacerbate their detrimental effects. (iii) Particularly alarming was the revelation that various elements of global change (global warming, elevated atmospheric CO<sub>2</sub>, nitrogen deposition, habitat fragmentation) are already interacting to worsen the impacts of plant invasions.

Some experimental results suggest that elevated CO<sub>2</sub> levels have already had a marked effect on traits of some key invasive species in North America: increased biomass production, expanded leaf area and spininess, and enhanced pollen loads.<sup>1</sup> All of these traits, alone or in combination, affect how these plants influence native species, and the invasibility of the ecosystems they occupy.

## Advances in invasion ecology

### Attributes of invaders

Considerable strides have been made in the new domain of plant invasion ecology. Each session at the conference provided examples of the bewildering array of questions that are being asked and methods applied to unravelling the intricacies of alien plant invasions. The three key questions that were explored in the SCOPE (Scientific Committee on Problems in the Environment) programme on the ecology and management of biological invasions in the 1980s<sup>2</sup> still largely define the field: (i) what makes some species more invasive than others?; (ii) what makes ecosystems resistant or susceptible to invasions?; and (iii) How can we use insights from the previous questions to manage invasions?

Scientists continue to rely heavily on the track record of various species as aliens in order to predict their *invasiveness* (explaining why some species are more invasive than others), rather than on mechanistic understanding of invasions. Problems with this approach include the fact that only a small proportion of the world's flora has been widely planted as aliens, and for long enough, to gauge their invasiveness. Fewer than half of the currently invasive plant species have a track record of being invasive elsewhere. Species known to have invaded many parts of the world are obviously more likely to invade in other areas, but no prediction can be made for species that have no history of widespread introduction over long periods, or evidence of their invasiveness. Nonetheless, it seems that risk assessments based largely on the experience of other invasive species are still the most pragmatic approach in predicting invasibility worldwide. In any event, continuing global changes will complicate any predictions.

Several speakers reported on progress towards a more mechanistic understanding of invasiveness, contributing to the debate on whether it is feasible or desirable to aim for standardized criteria for all weed lists, given that such lists serve different purposes in different parts of the world. Formal protocols for assessing the risk of invasiveness are not widely applied. Australia and New Zealand are

the only countries using risk assessment models in day-to-day decision-making when evaluating applications for permission to introduce new species.

#### Attributes of ecosystems

Regarding *invasibility* (factors that determine the susceptibility of an ecosystem to invasion), evidence from many studies, including palaeoecology, modern observational studies and experimental work at different scales (mainly small plots) shows that susceptibility/resistance of systems to invasion fluctuates markedly over time and space due to changing climatic conditions, disturbance, nutrients, availability of mutualists, and the availability and abundance of propagules to initiate and sustain invasions. Invasibility must thus be considered probabilistically rather than deterministically. A strong realization emerged at the meeting that even areas currently thought to be resistant to invasion will probably be invaded as increased propagule pressure and elements of global change alter key processes in the system. A related debate, discussed in several presentations, was the link between native species richness in a system and its capacity to accept new invaders.

Below-ground biodiversity and its role in maintaining ecosystem functioning and integrity, is a new field of research. There is growing evidence that invading plant species alter this diversity and may affect ecosystem functioning and resource pools in ways that are not well understood.

Lastly, two sessions were dedicated to the use of mathematical models and geographic information systems (GIS) in understanding the effects of biological invasions on ecosystems and as tools to enhance the design of appropriate management strategies.

#### What is being done to manage plant invasions?

Although biological invasions have rapidly become prominent environmental concerns in almost every part of the world, only a handful of countries are giving serious attention to the problem. It was difficult to draw firm conclusions on levels of awareness and commitment to managing invasions in different regions from the presentations at the meeting, but clearly the most focused research, planning, policy formation, and implementation of counter-measures is taking place in Australia, Europe (with marked variations between countries and regions), New Zealand, South Africa and the United States. At least there, perspectives have changed radically in the last few decades, from the consideration of

single-species problems to the incorporation of invasive species as a complex component of global change requiring substantial investment at multiple scales of time and space. Yet, most developing countries lack the capacity even to deal with dramatic single-species problems, let alone to respond holistically to the escalating problems associated with invasions that demand expensive, multi-pronged, international efforts.

In this respect, several international initiatives were mentioned, including the Global Invasive Species Programme (GISP), the International Plant Protection Convention (IPPC), the Convention on Biological Diversity (CBD), and the South Pacific Regional Environment Programme (SPREP). Although the list of acronyms is long and daunting, we cannot, unfortunately, report that there has been substantial progress. On the contrary, much effort is wasted through a lack of cooperation, collaboration and integration, and in many cases, open rivalry exists between different agencies and groups involved nationally and internationally. There are at least some notable exceptions to this gloomy picture, which include the Nature Conservancy (a U.S.-based non-governmental organization), which leads in acquiring land, and supporting multidisciplinary research and control operations in conservation areas, in the United States, and elsewhere. South Africa's Working for Water programme, with its strong emphasis on multi-departmental involvement and international cooperation, and the Australian Cooperative Research Centre for Weed Management are others.

Many presentations by top-tier ecologists attested to the flurry of activity in the wake of former U.S. president Bill Clinton's Executive Order (#13112 of 1997) which led to the establishment of the National Invasive Species Council. One of the main functions of this body is to oversee the production, every two years, of a National Invasive Species Management Plan, and a massive effort is now under way at every level in the United States (including work on prediction/prevention, early detection, eradication, containment, management, restoration and education).

There was a particular emphasis in the management of plant invasions on prevention, early detection and/or eradication. In the area of prevention, that is, the anticipation and interception of invasions, Australia, New Zealand and the U.S.A. are the only countries devoting even remotely appropriate resources to research, policy development and implementation.

Given the exponential increase of

invasive species, it makes sense to focus effort on preventing the entry of known invasive species and to maintain early warning systems to detect nascent invasions of species that do gain entry. Much was made at the meeting of a few cases where very small populations of potentially invasive plants have been eradicated (that is, totally eliminated). While eradication may be a sound goal for new and small invasions, it could be an illusory and costly objective for well-established mainland populations of invasive plants.

#### Linking ecological and socio-economic impacts

Linking the effects of invasive species to ecosystem services is critical and remains one of the least developed areas in invasion ecology. Fewer than ten papers assessed the economic consequences of invading species, even superficially. This may be due, in part, to the absence of key researchers in the field from the meeting. The work on costing impacts of alien plant invasions on water resources in South Africa<sup>3</sup> remains the most cited example in the field. Also, the detailed assessment of costs and benefits of the commercially important but invasive tree *Acacia mearnsii* in South Africa<sup>4</sup> is unique. Several studies were presented on the costs and benefits of biological control and these yielded cost:benefit ratios similar to those estimated for South African species,<sup>5</sup> confirming the cost-effectiveness of this type of control for extensive invasions and for tackling emerging species. Such information is crucial in strategies to influence the media, and hence politicians and decision-makers.

#### Dealing with the human dimensions of the problem

The human dimensions of invasions were addressed in a number of sessions. There were talks on education and outreach, and pre-conference workshops looking specifically at materials for different audiences such as school children. Important contributions came from Australia, New Zealand and the United States. One of the plenary speakers questioned why, even in the United States, there is little general public engagement on the issue of invasives, despite almost daily news coverage. He stressed the importance of 'connecting the dots' — that is, presenting research results appropriately for different audiences — and 'linking the boxes' — meaning fostering of cooperative and mutually beneficial interactions between scientists and managers in different disciplines and in different organizations. In another influential

plenary address the speaker emphasized the need for management interventions to be strategic, tackling invasions at key points and devising incentives as well as punitive measures to enhance results.

The constructive engagement between the nursery trade in the U.S.A. and ecologists and authorities was encouraging.<sup>6</sup> The nursery industry has adopted voluntary codes of conduct to reduce the dissemination of invasive species and is funding research on, among other things, breeding sterile varieties of popular but invasive species, and improving our ability to screen species. A similar initiative in South Africa, the Working for Water Nurseries Partnership Programme, has also made good progress.

The notion that alien plants are acceptable for short-term use in restoration programmes where no suitable native candidate species are available seems to be gaining currency and was advocated by several speakers. There was general consensus that special measures were needed to prevent the unwanted spread of alien plants. The matter remains highly controversial but there is recognition that invasion and restoration ecologists need to engage in dialogue and to seek 'win-win' medium- to long-term solutions to this difficult problem, which will yield the desired benefits while minimizing the risks.

### Where does South Africa stand?

South Africa's major investment and faith in biological control of invasive plants as an integral part of its overall management strategy, and the many recent success stories were widely lauded. However, some countries with serious invasive plant problems (such as Portugal) have not yet initiated this practice or have doubts because of concerns about the possible effects of biological control agents on some non-target plant species.<sup>7,8</sup>

South Africa is leading the field when it comes to assessing the hydrological consequences of invading species, especially in using a range of methods to compile a comprehensive picture. Surprisingly, Australia and New Zealand seem to have paid little attention to hydrological impacts. In much of North America, water shortages are not an important issue but in the semi-arid regions of the southwestern United States water shortages are approaching critical levels. Yet the effects of changes in plant-species composition, for example when grasslands replace shrublands, have not been quantified, or the data are fragmentary and site specific. The opportunities to paint the big picture ('connect the dots') have not been taken and the message that invaders are using

excessive amounts of water is, by and large, not reaching the decision makers and the wider public.

A lesson for South African research is the emphasis on scientific rigour and proper experimental design in studies of the dynamics and impacts of invasions. A recent review of the mechanisms of invasion<sup>9</sup> highlighted the paucity of studies aimed at identifying the various factors and processes involved in invasions and how ecosystems are affected. South Africa is no exception to this problem. Our ecosystems provide an excellent natural laboratory for careful experimental studies, and we need to capitalize on this.

There were numerous references in many sessions to South Africa's substantial and innovative contributions in the field. There is no doubt that the small scientific community in South Africa has made its mark.<sup>10</sup> South Africa's Working for Water programme was hailed as a model approach for addressing invasive species while simultaneously satisfying socio-political goals. The momentum created by the serendipitous events leading to the establishment of the programme is encouraging, but the pillars upon which it rests need to be strengthened. Working for Water must be informed by advances in invasion ecology in order to ensure maximum efficiency in terms of prediction and priority. The programme must be supported by partner initiatives addressing other facets of global change, and much more attention should be directed towards preventing invasions and to the early detection and management of emerging problems.

Because invasions are driven by the needs of society, invasion pathways have to be clearly defined, and innovative solutions should address the root causes of invasions — the societal needs that lead to the demand for alien species. All role players and stakeholders must be engaged. Enhanced education at all levels is pivotal. There is an urgent need for a South African 'National Strategy on Alien Species'. This country has invested heavily in research and management of biological invasions in recent decades. This investment will be eroded unless we 'connect the dots'. We have the scientific capacity, infrastructure and enlightened political leadership to make rapid advances in this area. Such allocation of effort is certain to yield significant dividends ecologically, socially and economically.

### Conclusions

The Fort Lauderdale conference was timely, well conceived, impressively organized, and in all respects ran smoothly

and efficiently. The meeting presented a feast of information and discussion for anyone interested in the biology and management of invasive alien plants. The excitement generated as a consequence of several hundred people talking together about invasive plants, was palpable. The conference was in many ways unique, a first and, as such, represented a significant step forward in achieving its objectives, namely, forging links between research scientists, managers and politicians. There was a session entitled 'Management and the Research Interface'. Inevitably, researchers, managers and politicians interacting for four days in a single venue must have expanded all their horizons. Whether the conference will have succeeded in forging sufficient mutual understanding and sustained cooperation between busy people who are all more or less entrenched in their own disciplines, is moot. However, that is what is needed, a concerted effort from practitioners in all specialities — we need to connect the dots in our research endeavours, and to link the disciplinary boxes in science and management — if the global threat of invasive plants is to be effectively countered.

The conference proceedings, comprising most of the invited talks and some contributed papers, will be published in the journal *Weed Technology* in 2004.

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