



South African programme for the SCOPE project on the ecology of biological invasions

A description and research framework produced by
the Task Group for Invasive Biota of the
National Programme for Environmental Sciences

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ABSTRACT

A description of the aims of the international SCOPE programme on biological invasions is provided, together with a proposed four year time table of international activities. This is followed by a brief account of the history, organization and current aims and approaches for research on invasives in South Africa. A motivation for increased research is included in the form of a set of key questions and a list of current and future research priorities for the South African component of the international SCOPE programme. The list of current research projects together with the list of institutions conducting research in this field (appendix) is intended as a comprehensive future directory of South Africa's research activity in this field.

SAMEVATTING

'n Beskrywing van die doelstellings van die internasionale SCOPE-program oor biologiese indringings word voorsien, tesame met 'n voorgestelde vierjaar tabel van internasionale aktiwiteite. Hierdie word gevolg deur 'n kort verslag van die geskiedenis, organisasie en huidige doelstellings en benaderings vir navorsing oor indringers in Suid-Afrika. 'n Motivering vir verhoogde navorsing word ingesluit in die vorm van 'n stel sleutelvrae en 'n lys van huidige en toekomstige navorsingsprioriteite vir die Suid-Afrikaanse komponent van die internasionale SCOPE-program. Die lys van huidige navorsingsprojekte tesame met 'n lys van instellings wat bydrae tot navorsing in die veld (aanhangel) is bedoel as 'n omvattende toekomstige voorskrif vir Suid-Afrika se navorsingsaktiwiteit in hierdie veld.

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THE INTERNATIONAL SCOPE PROJECT

BACKGROUND

The role of SCOPE

SCOPE (Scientific Committee on Problems of the Environment) is a component of the International Council of Scientific Unions. It was established in 1969 as an international, non-governmental, non-profit organization set up to help identify problems of global concern, particularly in the field of human/environmental interactions. SCOPE's role is particularly suited to multi-disciplinary topics with an emphasis on short-term synthesis and appraisal activities. Its products (more than twenty major publications to date) are intended as a source of advice, of benefit to governments and non-governmental bodies where there is some promise of responsive action. SCOPE has been active in such fields as environmental monitoring, impact assessment, biogeochemical cycling and ecotoxicology. More specifically it has undertaken a detailed analysis of the ecological effects of fire and is currently involved in projects on the dynamics of continental wetlands and water bodies, land transformation and climatic impact assessment.

The global problem of biological invasions

The invasive spread of plants, animals and microorganisms into regions remote from their centres of origin, is a process of increasing global significance.

Several of these species are of considerable economic importance in agriculture, forestry, fisheries and other forms of rural activity. They constitute the main plants and animals used by man as well as many of their associated pests, weeds and diseases. Such species, when they are restricted to agricultural systems and other intensively managed areas, are usually the subject of attention by appropriate national research and management agencies, and do not warrant attention by SCOPE.

Many other species have entered man-modified ecosystems, often as horticultural plants, as pets, captive game animals or aquarium species. Most of these have not invaded native ecosystems. However the impact of those that have done so has frequently been serious. In such cases indigenous species have been displaced. In some instances, particularly when invading plants have become dominant, the entire character of the biota and even soil and landscape characteristics have been changed. These phenomena are now evident on all continents.

A particular problem is posed where alien invasions threaten areas of low economic productivity. In such cases the cost of chemical or mechanical control is too high compared to the potential benefits, resulting in the control option being impractical under current circumstances. These areas include a wide variety of grazing lands, protected areas and other non-agricultural land, including indigenous forests, riverine systems, wetlands and water bodies. Because of the low economic productivity of such areas it is most important to devise low cost procedures that will limit the extent of future invasions and provide management strategies for those already established.

Value of theoretical research on biological invasions

The subject of biological invasions raises interesting and important ecological questions. In the first place it is evident that most introduced species do not become invaders, but those that do are likely to share specific common features. There is already on-going research on this subject but it has not, until now, been focused on the fundamental questions involved. Yet it is obvious that identification of the critical invasive attributes of species could provide a basis for control measures as well as for screening prospective introductions.

Secondly, the degree to which natural ecosystems are susceptible to invasion by introduced species varies considerably. It is evident that the world's mediterranean environments tend to have a high incidence of alien invasion, as do island ecosystems. Apart from the historical influence of man, there are various, often conflicting hypotheses proposed to explain the apparent susceptibility of ecosystems to invasion. On the one hand seasonal moisture stress is identified as the causative factor, and on the other, it is ecosystems that have no seasonal water shortage that are suggested to be most at risk. Sites that have been subject to disturbance, regardless of the ecological system in which they are located, also tend to be prone to invasion. There is a considerable body of ecological theory on the degree to which ecosystems are "open" or "closed" to alien species, but it is not comprehensive and requires validation. There appears to be an opportunity to produce much more effective management strategies, by linking together work on the characteristics of invasive species with that on the characteristics of susceptible ecosystems.

THE INTERNATIONAL COOPERATIVE PROJECT

The project has its origins in mediterranean ecology, having first been proposed at the Third International Workshop on Mediterranean Ecosystems held in South Africa in 1980. Subsequent discussions and meetings resulted in a motivating document being presented to the fifth General Assembly of SCOPE in Ottawa, June 1982, which was accepted as the basis of a SCOPE sponsored project. Professor H A Mooney of Stanford University has been appointed as convener for the project and he, together with a small advisory committee, will work through national correspondents or their equivalent, to integrate the separate national research programmes.

The subject lends itself to intercontinental collaboration. Widely separate research groups encountering similar phenomena in different ecological situations will benefit greatly from the contact and exchange of ideas with distant colleagues. In this respect the project should make a significant contribution to the development of ecologically sound management strategies for tackling the problems of invasions. The progress of the project will depend largely on the activities of the separate national research programmes, with SCOPE providing an informal system of liaison built around seminars and workshops on specific aspects of the subject. The South African programme will contribute directly to the international project but will not be limited in any way by its finite timetable.

General research approach

The main questions to be resolved are:

- What are the factors that determine whether a species will become an invader or not?
- What are the site properties that determine whether an ecological system is susceptible or resistant to invasion?
- How should management systems be developed, using the knowledge gained from answering questions one and two?

International timetable

The status of the programme as of April 1983 is that it comprises about thirteen participating nations. Of these, six countries have formulated specific projects, the international correspondents of which form the ad hoc advisory committee of the SCOPE programme. These six countries are, Australia, Czechoslovakia, France, Great Britain, South Africa and the United States of America. The committee, which met for the first time in April 1983, is currently involved in encouraging scientists in other countries to develop their own independent programmes within the general framework described above. Existing national projects have varied emphases; for example those of the United States and Australia are concentrating on synthesis, while those of Czechoslovakia and Britain are involved primarily in modelling.

A timetable of events associated with the international programme is as follows (future dates with an asterisk (*) are fixed, others are tentative):

September 1980	Initial discussions at MEDCON III workshop, Hermanus, South Africa, on development of an international project.
August 1981	Contact between interested scientists at the International Botanical Congress in Sydney, which provided impetus for this proposal.
April 1982	Circulation of draft SCOPE proposal to interested parties, with invitations to formulate separate national contributions to the programme.
June 1982	Presentation of final proposal to SCOPE General Assembly in Ottawa and subsequent formal acceptance of the international project.
October 1983*	South African invasive species workshop for the fynbos biome.
October 1983*	Czechoslovakia first national meeting on biological invasions.

- April 1984* Lisbon European Weed Research Society (EWRS) meeting on Mediterranean weeds.
- August 1984* Mediterranean ecology synthesis - MEDECOS, Perth - followed by SCOPE project advisory committee meeting.
- August 1984* Australian synthesis of biological invasions - Canberra meeting, Australian Academy of Science.
- October 1984* Versailles INRA (National Institute for Agronomic Research) + CNRS (National Centre for Scientific Research) meeting - systematic botany + chorology of weeds.
- November 1984 U S national synthesis meeting - National Academy of Sciences.
- December 1984 British Ecological Society (BES) meeting - discussion group.
- February 1985 Czechoslovakia national synthesis meeting, general principles.
- First half 1985 2 or 3 working groups to report - producing SCOPE publications on modelling, nature reserves, stress etc.
- April 1985 Advisory committee meeting - Paris. Prepare report for SCOPE General Assembly.
- June 1985* SCOPE General Assembly.
- July 1985* British Ecological Society - colonization and succession meeting.
- 1986 Royal Society of London meeting.
- 1986 South African review meeting to produce a synthesis publication on invasive plants.
- August 1986 Stellenbosch international conference - general synthesis of overall programme.
SCOPE Advisory committee meeting + authors of potential synthesis report.
- January 1987 Final distillation - towards deriving general principles from the SCOPE project.

THE SOUTH AFRICAN PROGRAMME

LIMITS AND DEFINITIONS FOR THE PROGRAMME

The programme is intended to relate primarily to nature conservation problems. It is also intended to limit its relevance to invasions by alien species in areas of natural or semi-natural habitats. It will in general avoid overlap with the study of weeds in cultivated landscapes, and similarly avoid investigating encroachment-type phenomena, ie invasion by indigenous species in natural grazing land. Both of these important aspects of invasion involve processes and remedies that are of greatest importance to agricultural management systems.

In order to clarify the intent of the programme further, there are two central terms that deserve definition:

- alien species - a species remote from its centre of origin, usually from a different continent or subcontinent. This term is preferred to "exotic" or "weed" in order to avoid the ambiguity associated with the common, public use of such terms.
- invader (-invasion) - a species (or process) having the ability to establish self-sustaining populations in natural communities, with a tendency to dominate those communities.

HISTORICAL PERSPECTIVE

Plants

Alien vascular plants currently pose ecosystem managers with their biggest problem as far as invasive species are concerned. Many were introduced by early pastoralists and, following European colonization, by foresters, agriculturalists, horticulturalists and more recently by "collectors". Possibly even greater numbers of species have arrived accidentally. However most of the current problems are posed by species intentionally introduced for plantations, sand binding or fruit production. Aquatic aliens have also had major impacts on freshwater ecosystems throughout the country. Only a few of our current problem species are accidentally introduced "international weeds".

Early botanical garden curators had as one of their main objectives the introduction of alien plants, many of which have since become invasive. With the growing awareness of the wealth of the indigenous flora, this trend has been reduced since the turn of the century. The botanical garden/horticultural trend has become increasingly focused on the cultivation of indigenous species. Together with propaganda campaigns organized by botanical societies and the conservation authorities, this has resulted in a strong "anti invasive alien plant" groundswell. In future it is likely that most invasive plant species arriving in South Africa will do so by accident.

The impact of invasive alien fungi is generally unknown. However there are indications, associated with the harvesting of wild flowers, that such invasions have a potential for serious disruption of local plant communities in the fynbos areas of the Cape Province. These indications provide a warning that the control of fungal introductions deserves recognition as a global goal for nature conservation.

Animals

Compared with Australia and New Zealand, alien invasive mammals have not been a problem in South Africa. This suggests that the diversity of African mammalian fauna, through competition, predation, parasitism or disease, provides an apparent resistance to invasive species. There is possible support for this suggestion in the extensive measures that both pioneer and modern livestock producers have had to employ to enable their domestic alien mammals to thrive. However the abundance of "game" in southern Africa would have provided a disincentive for early colonists to introduce wild alien mammals. This is evident from the relative success and persistence of "acclimitization societies" in Australia and New Zealand if compared with their local equivalents.

Whatever the reason, the only successful alien mammals are three rodents and a cat, all of which are commensal with man, and a small population of the Himalayan thar on Cape Town's Table Mountain. The latter area has had the majority of its indigenous large mammal fauna annihilated by man and is subject to so much ecological disturbance that the successful establishment of an alien ungulate comes as no surprise.

Generally, alien bird species have only been able successfully to invade man-modified ecosystems in southern Africa. Virtually all introductions have been intentional, most have failed, and the few that have thrived have most of their impact on the human environment (urban areas, gardens and orchards). Those impacts are generally acknowledged to be in conflict with man.

Alien fish present a totally different picture to that of the mammals or birds. In this group there have been numerous intentional (a few accidental) introductions of a range of species into the freshwater ecosystems of southern Africa. Established aliens now occupy the vast majority of the cold waters present on the subcontinent, with only the more tropical rivers still having reasonably intact fish communities. In conservation circles there is less social stigma attached to the introduction of alien fish than to any other order of biota. South Africa's provincial conservation authorities arose from inland fisheries departments that were created to administer and encourage the introduction of aliens for angling purposes. To this day it is still considered a legitimate activity for these agencies. As elsewhere these introductions have been shown to markedly reduce the populations of some indigenous fish species to the extent that a few are now threatened with extinction. It would be reasonable to assume that the food webs of these threatened species have similarly suffered gross disruption, although there is no firm evidence in support of this contention.

The extent of the invasion of southern Africa by alien invertebrates has never been assessed. The impacts of a few of the known introductions, such as the Argentine ant (unintentional) and cochineal beetle (intentional) have been profound. Most invertebrate introductions are accidental and prevention is virtually impossible.

Research and management

Much of the study and control of alien invasive species in South Africa has been seen as an agricultural undertaking, limited to vascular plants of economic importance. Of the plants invading natural and semi-natural areas, only a few species such as *Opuntia* spp, *Hakea sericea*, *Lantana camara* and *Stipa trichotoma* have received sustained attention. For these species, concentrated research has produced useful results, as a coherent ecological picture emerges, providing a basis for integrated, extensive control programmes. Work on the ecology of invasive acacias, though limited, has also shown the benefits of an integrated research programme. Other studies have usually been intermittent at best and have varied from regional or province-wide inventories and surveys (eg Stirton 1978) to the many experimental trials of herbicides and mechanical control techniques.

A feature of all these efforts is that each study has been orientated towards a specific problem and has been approached separately in order to find a species- or site-specific solution. The fundamental aspects of the invasion process and of ecosystem response have not yet been tackled in any systematic way, neither has the scientific basis for formulating integrated control programmes. Organizations responsible for research in this field have ranked their priorities according to the problems experienced by their clients, and there has been little opportunity for integration at a national level. The need and opportunity for a coordinated effort towards this end is now widely recognized among workers in all the agencies involved.

Invasive species other than vascular plants have received very little attention and research to date is therefore inadequate in this respect. There is a need to look at such groups as fungi, fish and birds in order to counter-balance the current emphasis on plants.

In South Africa, the National Programme for Environmental Sciences (NPES) is involved in the coordination and management of many cooperative research programmes. From 1973 the NPES Working Group on Weeds was involved in staging the first two National Weeds Conferences in 1974 and 1977 (Anon 1977). Both these meetings had a strong emphasis on non-agricultural invaders. In 1979 this function was taken over by the Southern African Weeds Science Society, the membership of which includes agricultural and agro-chemical interests. As a result, the Third National Weeds Conference had a strongly agricultural bias (Neser and Cairns 1980), and the NPES Working Group on Weeds was disbanded. In 1980 the Committee for Nature Conservation Research of the NPES, recognizing the threat posed by alien invasives to indigenous biotic communities, called for the establishment of a Task Group for Invasive Biota.

The present proposal has been drafted by this Task Group, initiated at its first meeting held on 2nd December 1981. The programme is intended to add to and complement the work of organizations already active in the field and enhance the opportunities for cooperation, both nationally and internationally.

ORGANIZATIONS CURRENTLY ACTIVE IN RESEARCH ON INVASIVES

The following organizations have been and are currently involved in research on invasive species in natural and semi-natural ecosystems in South Africa: A directory of institutions, individuals, their addresses and telephone numbers is included in the appendix.

- Botanical Research Institute (Department of Agriculture)
 - inventories of invasive plant species, cytotaxonomy and other taxonomic studies
- Plant Protection Research Institute (Department of Agriculture)
 - surveys, monitoring, and weed status assessment
 - physiological studies and development of biological and other control measures for each species, according to priority
- Directorate of Forestry of the Department of Environment Affairs
 - surveys in protected areas; integration of control with veld management
- National, provincial and other nature conservation agencies
- Biological science departments at universities in Cape Town, Stellenbosch, Grahamstown, Port Elizabeth, Pietermaritzburg, Pretoria and the Witwatersrand
- Various state and provincial museums and herbaria

The current activities of these research agencies that are relevant to this programme are summarized as a list of separate project titles in the section headed "Current research" and a record of South Africa's published work on invasive species will be found in the bibliographies mentioned on page 11.

OBJECTIVE

To achieve an understanding of biological invasions so as to derive the ecological principles necessary for management systems that will prevent and control invasions by plants and animals.

APPROACHES TO RESEARCH

Intercontinental comparisons

Invasions, particularly of plants, have reached problem proportions in every major biome in South Africa. Thus ecosystem surveys and syntheses of

information at the national level are essential. Invasions are, however, far more serious in some ecosystems than in others. Without doubt it is South Africa's mediterranean region - the fynbos biome - that is most threatened by invasions.

A considerable amount of research has already been undertaken to describe the structure, functioning and conservation status of ecosystems in this biome (Jarman et al 1981). This work provides a good basis for further, more penetrating research on invasions and how they relate to ecosystem properties.

Mediterranean-type ecosystems appear to be particularly susceptible to invasions. As these ecosystems form clearly defined, well isolated biomes on each of five continents, and because of a traditionally active, internationally coordinated programme of ecological study, the mediterranean-type zones lend themselves to intercontinental comparative work. The opportunities for effectively coordinating active research and therefore of a positive contribution being made to the international project, is therefore good.

Interbiome comparisons

General hypotheses about the mechanisms of invasions may be developed and tested internationally within one broad category of biomes. However whether these hypotheses are generally relevant in South Africa should be determined by comparative studies between local biomes of differing susceptibility to invasion. Such work would analyse, (a) the biology of the respective invasive species, (b) the history and processes of invasion, and (c) the nature of the respective ecosystems, to expose both the generally valid principles for management of invasions, as well as the particular details that relate only to special situations. Biomes selected for such comparative studies would be those with most acute problems but also those where there is real potential for effective research in the medium term : the fynbos, karoo and grassland biomes seem obvious candidates. For instance, invasion processes in the karoo clearly differ from those in fynbos: the predominance of animal borne dispersal mechanisms as opposed to wind borne; the dependence on rainfall patterns for growth as opposed to nutrients, fire or other disturbances, are two obvious examples. In addition, ecosystems that have not been invaded ought to serve as "controls" to test the explanations offered for severe invasions elsewhere.

KEY QUESTIONS FOR RESEARCH

Biogeography of invasions

- What are the bioclimatic, geological and habitat features of the native source regions of alien invaders in South Africa, and how do these features correlate with those of the distribution range of the species in its new habitat?
- How does release from native biotic control affect the potential limits to distribution and performance of the alien invader in its South African habitat?

- Are there suites of invasive species common to similar biomes on different continents, that facilitate the prediction of invasions?

Autecology of invasive species

- What are the physiological optima of important invasive species and their ecotypes, how do these fit the species to their native habitats, and how do these optima determine their habitat limits in South Africa?
- How do competition, predation and herbivory, and coevolutionary and symbiotic relationships regulate the distribution and abundance of an invasive species in its native and adopted regions?
- What are the common sets of life-history characteristics of invasive species (eg concerning reproduction and dispersal), and to what extent can they indicate an invader syndrome?

Characteristics of invaded ecosystems

- Does the evolutionary history of a biome predispose it to invasion, for example through excessive species extinctions?
- Do measurable differences in the degree of invasion of different ecosystems correlate with their characteristic ecological factors?
- How do trends in the disturbance of ecosystem processes, for instance by fire, erosion, pollution and eutrophication, explain trends in invasions?
- What factors affect the rate and extent of recovery of an invaded ecosystem during and after eradication or control of the invading species? How do these relate to the stability or resilience of the ecosystem?

Processes of invasion

- What can be deduced from the history of an invasion about the relative roles of man, plant-animal interactions and other dispersal agents in determining the invasion?
- What are the general features and phases of invasions by different species, and how can these be used to plan early control of recent or new invasions?
- What are the chief population-genetic events in the development of invasions of various types (small-founder, continual influx, fluctuations with bottlenecks)?

Impacts of invasions on natural and semi-natural ecosystems

- What are the effects of invasions on native habitats and species in terms of diversity, habitat utilization and the stability of species interactions?
- What are the effects of invasions on the energy, water and nutrient balances of ecosystems?
- What are the physical effects of invasions on factors relating to the practical management of ecosystems, such as fire hazard, penetrability of vegetation, etc?

Systems for management and prevention

- How can threat criteria or the impacts of invasions be used to rank invasive species?
- What are the costs and benefits of the control of major invaders, including the environmental impacts of the control measures themselves (such as the effect of herbicides)?
- How can a predictive knowledge of invasive species be used to prevent new invasions, such as by means of legislation?
- To what extent can the biomass or other products from invasive species be used to encourage control and offset costs?
- What options are available for control when the invasive species is simultaneously a useful crop or otherwise valuable asset in the same region?
- How can control systems be developed when invasive species are useful and desirable in one area but undesirable elsewhere?
- How can fire and herbivore management be adapted to minimize alien invasions and optimize control programmes?

PRIORITIES FOR THE SOUTH AFRICAN PROGRAMME

Bibliography

A bibliography has been compiled on the literature relating to alien invasive plants in South Africa (Moran and Moran 1982). It includes about 500 references on the ecology, management and control of some 35 species of vascular plant invaders. A similar bibliography of work on faunal invaders is intended to be produced, also in the National Scientific Programmes Report series published by the CSIR.

Synthesis

Information available on invasions in South Africa, including documented experience, should be drawn together in a single report with the following objectives:

- to document the known extent and degree of invasions in the different biomes
- to indicate the present level of understanding of invasions with regard to their processes and impacts
- to evaluate the established and hidden costs and benefits of control programmes
- to assess the relevance of research on measures for control and prevention

CURRENT RESEARCH AND FUTURE PRIORITY PROJECTS

Titles listed as "Current research" under each heading below, include recently completed as well as currently active projects.

Inventory and synthesis

Current research:

- South African weeds list. Botanical Research Institute and Plant Protection Research Institute. 1971 - ongoing.
- Survey of the alien woody invaders in the Transvaal. Botanical Research Institute. 1980 - 1983.
- Inventory of woody invasives in Natal's reserves. Natal Parks Board. 1980 - ongoing.
- Biology, ecology and control of the weed *Chromolaena odorata*. Institute of Natural Resources, University of Natal. 1981 - 1982.
- Periodic inventory of invasive plants on unafforested state forests and mountain catchment areas. Directorate of Forestry, Division of Forest Management. Ongoing.
- Survey of lowland fynbos invasive plant species. Botanical Research Institute (Stellenbosch). Ongoing.
- Quantitative surveys of South African weeds. Plant Protection Research Institute. (Priorities are *Lantana camara*, *Opuntia* spp, *Acacia longifolia*, *Acacia saligna*). Ongoing.
- Continuous inventory of invasive plants on military training areas. South African Defence Force. 1981 - ongoing.

Future priorities:

- Comparative sample surveys to assess invasive biotas in different South African biomes.
- Annotated inventory of invasive vertebrates.

Biogeography of invasions

Current research:

No specific projects: some background investigations for development of control measures provide information on the bioclimates and ecological features of source regions of target species (*Hakea sericea*, *Opuntia* spp, *Stipa trichotoma*).

Future priorities:

- Multivariate analysis for classification of bioclimates of source regions and invaded ecosystems.
- Definition of limits to spread in South Africa of recognized invasive species using bioclimatic and similar indices.

Autecology of invasive species

Current research:

- Ecophysiological studies of *Acacia* spp, *Opuntia* spp, *Stipa trichotoma*, *A longifolia*, *A dealbata*, *Chromolaena*, *Salvinia* and *Eichhornia*. Plant Protection Research Institute, University of Port Elizabeth. Ongoing.
- Studies of reproductive biology in *Opuntia* spp, *Stipa*, *Lantana*, *Rubus*, *Solanum*, *Sesbania*, *Hakea*, *Chromolaena*, *Acacia saligna*, *Acacia mearnsii*. Plant Protection Research Institute, University of Natal, Pietermaritzburg, Department of Botany. Ongoing.
- Effects of insect herbivory on control of *Sesbania punicea*. Department of Zoology and Entomology, Rhodes University. 1982 - 1984.
- Ecological genetics of house sparrow populations in relation to invasion rate. Percy FitzPatrick Institute of African Ornithology.
- Biology and taxonomy of *Cortaderia selloana* and other *Cortaderia* spp (pampas grasses) and their invasion of communities on the Witwatersrand. University of the Witwatersrand. Ongoing.
- Studies on feral cats (*Felis felis*) on Marion and Dassen Islands, Mammal Research Institute, University of Pretoria. Ongoing.

Future priorities:

- Analysis of species fitness and dispersal and establishment patterns in *Hakea sericea* in native and adopted habitats.
- Determination of limiting factors for incipient invasive species such as *Acacia implexa* and *Acacia podalyriaefolia*.
- Comparative roles of predators and herbivores in controlling populations of *H sericea* in Australia and South Africa.
- Photogrammetric and population-structure analyses of phases and patterns of colonization and population growth in representative plant invaders.
- Studies of dispersal among representative invasive plant species in different biomes.

Characteristics of invaded ecosystems

Current research:

No specific projects. Ongoing research in the fynbos biome and newly launched projects in the grassland and karoo will provide general background information.

Future priorities:

- Characteristics of fire and other causes of ecological perturbation as determinants of invasion processes in different biomes.
- Characteristics of community structure as determinants of ecological processes - niche occupation and competition.
- Role of land transformation in the invasion process: effects of creation of new habitats (monocultures) and of degraded areas that serve as stepping stones for invaders.

Processes involved in biological invasions

Current research:

No specific studies, but ongoing monitoring of distribution and rate of spread of *Hakea sericea*, *Opuntia* and waterplants will provide certain relevant information.

Future priorities:

- Historical analysis of plant invasions: synthesis of information for *Opuntia* spp, *Stipa trichotoma*, *Hakea sericea* and implications for management, legislation and administration.

- Historical analysis of invasions in nature reserves and protected areas: human vs "natural factors" governing invasions.
- Dispersal and establishment of riparian invaders in the Transvaal.
- Comparative analysis of dispersal spectra and regeneration niches among plant invaders in different South African biomes.

Impacts of invasions on natural and semi-natural ecosystems

Current research:

- Studies of hydrological effects of transformed vegetation cover (forest hydrology). South African Forestry Research Institute. Ongoing.
- The relation of critically rare plant populations to invasive species. Bolus Herbarium. University of Cape Town. Ongoing.

Future priorities:

- Impact of alien fish species on lotic systems and their communities.
- Interactions between *Chromolaena* invasion, fire frequency and forest margins in coastal lowlands of Natal.
- Recovery of fynbos communities after clearing operations: interactions between density of invasive stand, intensity of clearing measures and the physical site in determining rate of recovery.
- Effects of the superabundance of fruit from invading plant populations on abundance and movement of indigenous frugivores and its consequences for the dispersal of native plants.
- Distribution and impact of the Argentine ant (*Iridomyrmex humilis*) in fynbos.

Systems and techniques for management and prevention

Current research:

- Evaluation of the effects of biological control on *Lantana camara*, *Opuntia* spp, *Hakea sericea*, *Hypericum perforatum*, *Acacia longifolia* and *Acacia saligna*. Plant Protection Research Institute and Rhodes University, Department of Zoology. Ongoing.
- Influence of a pathogen on *Hakea sericea*. Plant Protection Research Institute. Ongoing.
- Development of an integrated control programme for *Hakea sericea* in mountain fynbos ecosystems. Directorate of Forestry. 1981 - 1985.

- Chemical and biological control studies on *Opuntia*, *Stipa*, *Acacia longifolia*, *Prosopis* (Karoo region) and *Pinus* spp. Plant Protection Research Institute. Ongoing.
- Chemical control studies on phyllodal *Acacia* spp, *Hakea sericea* and *Pinus pinaster*. Forestry Faculty, University of Stellenbosch. 1979 - ongoing.
- Studies on chemical control of *Eichhornia*. National Institute for Water Research. Ongoing.
- Cost-benefit analysis of control programmes on selected military training areas. South African Defence Force. 1982 - ongoing.
- Studies on current legislation for weeds. Law Faculty, Stellenbosch.

Future priorities:

- Cost-benefit analysis of control programmes: case studies on selected species in nature reserves, mountain catchments and in natural veld grazing lands in different biomes.
- Influence of pathogens on *Acacia longifolia*, *A saligna* and *A cyclops*.
- Study on the efficacy and potential of customs control measures: the problem of intercepting potentially invasive species.
- An evaluation of the control of *Eichhornia* infestation at Hartbeespoort Dam and comparison with problems on the Pongolo and Usutu River systems.
- Study of opportunities for *Myriophyllum* control.
- Socio-economic factors governing the design and development of control programmes:
 - *Acacia mearnsii* and the wattle bark industry.
 - *Acacia* spp as weeds and as a rural resource on Cape coastal lowlands
 - Emergence of *Opuntia ficus-indica* as an economic resource for rural development in the eastern Cape.

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