EXECUTIVE SUMMARY

Previous research has shown that there are approximately 10 million hectares , or 8% of South Africa, invaded to some extent by alien woody plants. The invaded area is expanding rapidly, at a rate of perhaps 5% per year, leading to a doubling of invaded area in 15 years. Their impact in South Africa is particularly deleterious, using an additional 3300 million cubic metres of water per year, or 7% of South Africa's runoff.

Control and removal of the aliens is enormously expensive according to some relatively crude calculations, upwards of R600 million per year over 20 years will be required in order to bring the problem under control using current removal practices. Financial resources will be quite limited however and the use of any such money would have to be targeted carefully so as to maximize return on investment.

Purpose of This Study

The purpose of this study therefore is to investigate ways of achieving efficient use of limited resources. Principally, the aims of this project were to develop techniques for estimating:

1. How much money will be required to achieve effective control of water using invasive plants in the different provinces in South Africa?

2. How long will it take to achieve significant reductions in water lost due to alien invasion resulting from varying rates of expenditure on control?

3. What impact biological control will have on control costs in the long term.

In order to achieve these objectives one must know something about how fast the alien invaders are spreading and to what limits they can spread. These numbers are key parameters and variables of a modelling exercise. Different environmental conditions controlling the spread of aliens may operate in the future that do not operate at present. So a methodology was required to cope with changing futures. Apart from that, very little data exists on spread rates and it is very difficult to set a limit to what areas may be invaded. Consequently, the problem was approached by developing scenarios for alien invasion, in which the state of invasion in South

Africa 20 years hence was examined

The Process of Scenario Development

Scenarios are stories told about the future. Scenarios describe the possibilities of arriving in the future via a variety of trajectories or paths. These trajectories are influenced by "large scale forces" which "push the future" in different directions. The development of scenarios is not arbitrary or trivial, but involves a structured process, beginning with the focal issue, that is, the condition which South Africa finds itself in with regard to invasions by woody plants 20 years hence.

The process then included identification of all the driving forces which affect invasion. Those driving forces about whose direction of action (whether promoting invasion or retarding it) there exists uncertainty were extracted as key uncertainties. These key uncertainties became the logics around which the scenarios were developed. Logics control the themes in each scenario. The logics developed in this study are based on 1) the "strength of the South African economy" and 2) the "character of implementation of laws, policies and regulations" governing alien plant material (see Figure i).

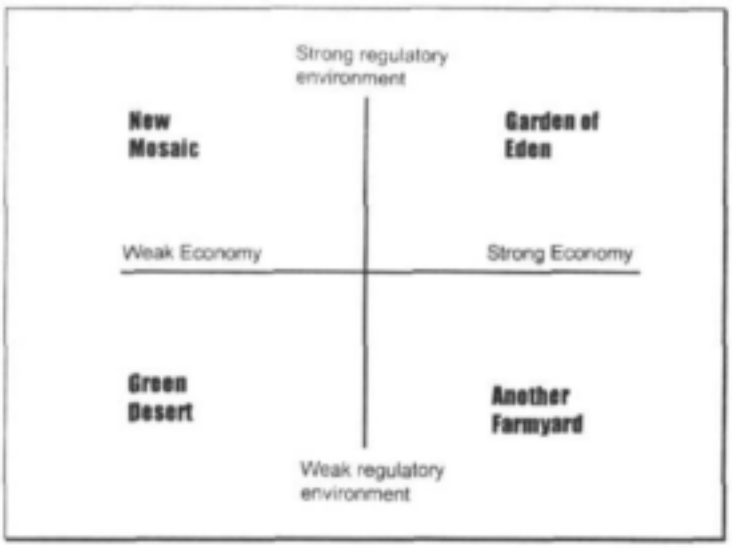

Figure i. Scenario logics and the logic names.

Scenarios were written for each of the four quadrants created by the logics. These attempt to convey the essence of what the future would look like with regard to alien invasion. An attempt was then made at developing the implications of these scenarios and what they meant for the key questions in terms of limiting area and rate of spread.

Conclusions from the Scenario Development Process

Three key conclusions and recommendations arise from this study:

1) A coherent set of laws, policies and regulations that control the import and distribution of invasive species needs to be rigorously and comprehensively implemented. This could be developed through a national weeds strategy or the development of a National Weeds Act;
2) Biological countermeasures can offer a very cost-effective solution to continuing invasion, continued investment is required for this to take place;
3) Control measures should not be delayed but be implemented now, as delays lead to rapidly increasing costs of future control efforts and
4) The ecology and economics of invasions are not well understood and the subject requires further research.

The regulatory environment governing the import of foreign biota, and its implementation, is where South Africa has the potential for the greatest leverage on the arrival of new species. Strong economic conditions, while necessary to combat the spread of invasions, also encourages the arrival of new species through increased trade. A National Weeds Strategy should have its focus on managing the current alien problem in the country, but also as a means to prevent the arrival of additional potentially invasive species.

A Numerical Model for Simulating Alien Spread and Control Effort

A simulation model was also developed, which characterizes the alien invaders and the work directed at controlling them as being part of an "ecological" system, with significant feedback loops and modifiers, the key one being the amount of money spent on mechanical clearing operations. An important aspect of controlling alien invaders is that the priority for spending money within a clearing operation is on doing follow-up operations on land that has been initially cleared of aliens before continuing with initial clearing operations. Thus the larger the area that needs to be follow-up in any one year, the less money that can be apportioned to initial clearing.

Simulations show how spread progresses, and how the cost of clearing rises with time. As money is spent on initial clearing and follow-ups, the model shows how the spread of aliens is contained. By repeated simulations with varying quantities of money as input, different funding rates for clearing operations can be determined. However, this is based on the assumptions of the order in which clearing takes place - lighter infestations first, as this has been shown to be more effective than tackling the smaller dense infestations.

Applying the Simulation Model to South African Landscapes

Using the scenarios and applying these to key landscapes, such as mountain catchments, riparian zones, open commercial farmland and rural commons, "experimental" data sets are developed in which the limits and rate of invasion vary according to each scenario.

The rate of spread is highest in the riparian zones where disturbance along these linear features is caused by flooding and human influences. The mountain catchments are the next most vulnerable, especially those that are not burned very frequently (> 3-4 year cycle). In the rural commons the spread rate of woody species is low because of the intense use of alien plants by rural people for energy sources and building purposes.

The cost of clearing is tightly linked to the spread rate. Where clearing activities are delayed, future costs of clearing rise rapidly, as high as five times for a delay of 10 years in the case of riparian zone invasions. This is the primary reason why clearing should take place as early as possible. Note that in Table I, the Unit Reference Value, which is used as a means of project economic evaluation, clearly shows that there is a much higher economic efficiency to be obtained by clearing the fastest spreading alien invading plants.

Biological counter-measures (biocontrol) can have a big impact on future costs of clearing, even if biocontrol agents are not particularly efficient and only reduce the spread rate by half. Table I also illustrates this point. A point is also made that catchment managers should not rely on biocontrol agents being available to deal with invasions in situations where clearing has been delayed. Biological countermeasures should be considered as an area of research of and development of national importance.

Table I The relationship between spread rates, the investment rate to clear a specific area in 20 years and the Unit Reference Value. The simulations assume that at the end of the 20 year investment period the project area will be clear of aliens invading plants.

Spread rate *r*	Investment rate for clearing alien plants over 20 years (R million / yr)	URV (R / m^3)
0.38	0.35	0.01
0.33	0.32	0.02
0.25	0.27	0.02
0.15	0.20	0.05
0.09	0.17	0.07
0.04	0.14	0.10

Recommendations for Further Research

Several requirements for further research have become evident from this work. They can be broadly described as a need for a greater insight into the ecology, environmental impact, and the economics and management of invasions:

The key drivers of invasions. This includes both human dimensions as drivers of alien invasion, as well the biophysical drivers. The human dimensions include population growth, international trade links, global economic trends, the forestry and horticultural industries, land redistribution policies of government and laws, policies and regulations

Spread rates of the different species. The simulations of cost of control are sensitive to the rate of spread variable, yet there is very little data on which to develop better models. Data is also required on spread rates of species only partially controlled by biological countermeasures.

The hydrological impacts of different alien species. There are very few data on the streamflow reduction of alien species other than commercial forestry species.

The costs of clearing the different species. The simulations of the costs of control are also sensitive to alien clearing costs. Better data is required for a variety of clearing and control techniques. This includes the investment required for biological controls.

Different alien management control options. The extent of alien invasion is so large in South Africa that mechanical and chemical means will not be able to control the increase in the area invaded. Nor will biological controls solve all the problems. An example was given that judicious use of fire could be a useful technique, but this needs further research.

Further model development. The numerical simulation model has useful applications, but also requires refinement. This could come through trial use of the model and could include addition of graphics capabilities.

Conclusions

Four key conclusions and recommendations arise from this study:

1. A coherent set of laws, policies and regulations that control the import and distribution of invasive species needs to be rigorously and comprehensively implemented;
2. Biological countermeasures can offer a very cost-effective solution to continuing invasion, but other methods of control also need to be investigated,
3. Control measures should not be delayed because of the cost implications,
4. Projects for clearing alien plant invaders should use rate of spread as a means of prioritization, and
5. The ecology and economics of invasions are not well understood and the subjects need investment.
6. Both scenario development and simulation modelling offer powerful analytical techniques for better understanding alien invasion and the strategies necessary to combat invasion

Footnote

The numerical simulation model is available from RA Chapman as an executable. He can be contacted at the CSIR in Stellenbosch:

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