DYNAMICS OF WEED INVASION: IMPLICATIONS FOR CONTROL

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Summary. While existing problem weeds receive most attention in terms of research and control, the contiued introduction of species into Australia over the last century makes it likely that many currently unimportant species will become important problems in the future. Many invasive species remain in restricted foci for long periods before undergoing explosive range expansions. Early recognition of species beginning rapid range expansion could allow early and more cost-effective control. There is a need for the development of a proactive approach to limit future weed problems.

INTRODUCTION

Weed control necessarily focusses on those weeds which cause extensive economic or environmental damage. These are the well-established problem weeds which cover large areas and are often spreading rapidly (8). There are, however, many other introduced species which can become locally abundant or problematic or remain in localised areas without necessarily becoming a weed problem. An important question to be considered is how many of the currently non-problematic introduced species have the potential to become important weedy species. An associated question is whether we have the capacity to recognise potential weed problems at an early stage and hence carry out more cost-effective control. Early recognition and treatment of problems could result in the prevention of costly invasions and control measures in the future. In this paper, patterns of weed spread are examined, the potential for future weed problems is discussed and the possibilities of developing methods of early detection of problems are explored.

PAST PATTERNS OF WEED INTRODUCTION AND SPREAD

Plant introduction into Australia has been a continuous and on-going process since the arrival of Europeans, with a near linear increase in naturalised species in all states of Eastern Australia (6,16; Fig. 1), which continues more or less unabated despite quarantine laws. Examination of the history of introduction of some of today's most important environmental weeds indicates that most were introduced some time ago (8). Further examination of the dynamics of range extension of species for which information exists illustrates that, in many cases, populations remained small and localised for long periods before a sudden explosive range expansion (1,2,3,5,12) . This corresponds to a pattern observed more widely for a range of different invading plant species, as well as for diseases (11; Fig. 2).

Combining the information in Figs 1 and 2 provides some sort of estimate of the potential for the development of further major weed problems in Australia. Lag times between initial colonisation and the explosive phase of range expansion can be as much as 70-100 years. Given that many of our current weed problems were among the earlier introductions and that the number of introduced species has increased by almost an order of magnitude in the last century, it seems likely that we can expect an increasing number of introduced species to move into an accelerated rate of spread. Since current control measures are inadequate to deal with the present suite of problem species, the prospect of an ever-increasing supply of new problems should be viewed with concern.

PREDICTION AND EARLY DETECTION OF RAPID SPREAD

Attempts to predict which invading species are likely to become important weeds have largely met with a lack of success. While a broad set of characteristics of successful invaders can be put together (14,15), this still does not provide a useful mechanism for predicting the responses of individual species (4,9,10,13). This is in part because a successful invasion depends not only on the characteristics of the invading species but also on the characteristics, dynamics and history of the site being invaded (9,10). This suggests that invasions are somewhat individualistic in nature, depending on the chance congruence of a number of plant and site factors at a particular time (4). If this is the case, predicting the onset of a rapid range spread by any one species can be expected to be a difficult, if not impossible, task. However, given the likely extent of the problem in the future, this task should receive further attention.

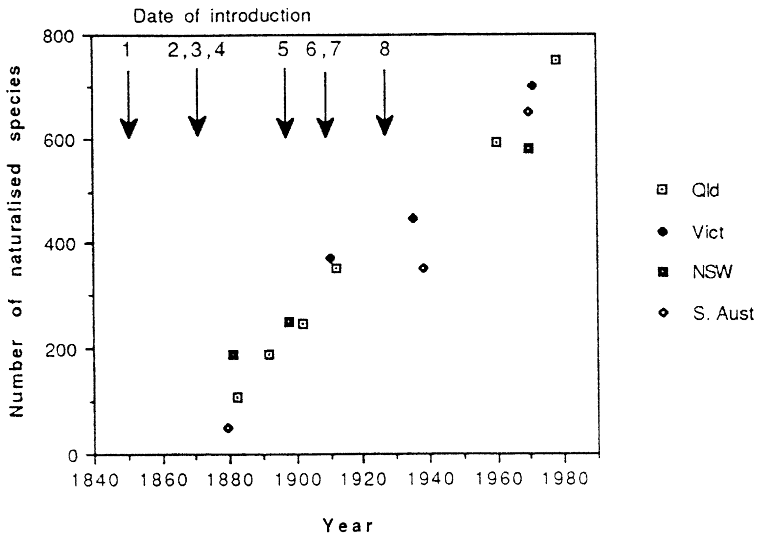

Figure 1. Number of naturalised plants in the four eastern Australian states, 1870-1980 (from 6,16), and estimated date of introduction of selected species (data from 8): 1; *Crysanthemoides monloifera*; 2, *Cryptostegia grandiflora*; 3, *Myrsiphyllum asparagoides;* 4,*Mimosa pigra*; 5, *Eichornia crassipes; 6; Parkinsonia aculeata;* 7, *Tamarix aphylla*; 8, *Prosopis* spp.

Given that it is difficult to predict which species will become problem weeds from species characteristics alone, we need to develop a predictive capability based on other factors. Early recognition of the transition to the phase of rapid spread may hold some promise. Some work has been conducted into factors which accelerate the rate of spread of invaders. For instance, spread will be more rapid if numerous widely-spaced foci of invasion develop than if spread is mainly from a single focus (Fig. 3; 11). Examples of rapid plant spread show a mixture of short-distance dispersal around a primary focus and long-distance spread to new sites, with subsequent short- and long-distance dispersal from the secondary sites (17). Monitoring for this process of the formation of widely-spaced secondary foci could provide one means of early detection of potential problems. Similarly, species which are currently present in small abundances but in many localities could also receive priority attention.

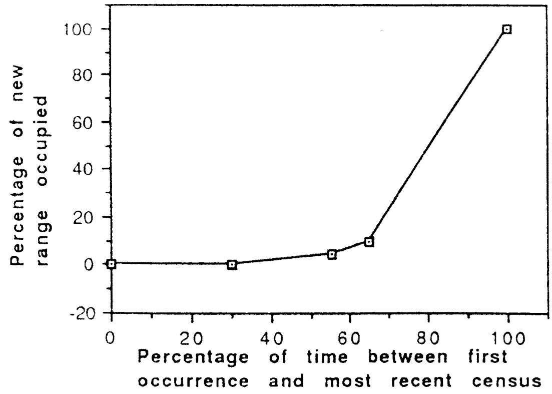

Figure 2. Stylised representation of spread of an invasive plant species plotted against the percentage of the new range occupied versus the percentage of time between first occurrence and the most recent census (derived from 11)

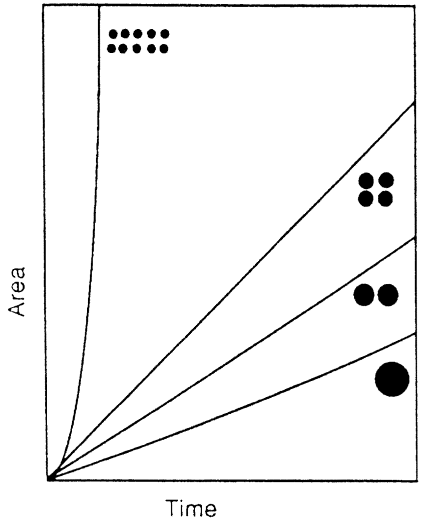

Figure 3. The addition of foci increases the rate of new range occupation quadratically, even if the total area initially occupied and rates of spread are the same (11).

The importance of multiple foci in speeding up invasion is also relevant to control programs: if the control measures centre on the primary focus and ignore smaller infestations, these will simply act as secondary foci and negate the effects of the control program. The need for early control of species not yet seen as major problems also has to be communicated to managers, who may be unwilling to divert resources from other apparently more pressing problems. A simple cost-benefit analysis of early versus delayed control on any of the exisiting major weed problems would provide a convincing extension tool.

More attention to site factors which enhance invasion potential might also be useful. Disturbance, especially, is a factor frequently invoked in permitting invasion (7), and this includes human-induced disturbances such as road building and logging, and natural disturbances such as fires and floods. While not all serious weed problems can be linked directly to disturbance, the linkage is frequent enough to provide some degree of predictability. The combination of an unusual disturbance or climatic event and the presence of multiple foci of a potential invader could be used as an early warning alert for an incipient problem.

CONCLUSION

The two approaches discussed above may provide the start of a framework for assessing and predicting potential future weed problems. However, they need to be tested and developed in practice, other approaches need to be considered, and the whole area requires more theoretical and practical research. Until now the question of predicting future weed problems has always been put in the "too hard" basket. Considering the extent and costs of current weed problems and the huge potential for future problems, a small degree of effort put into developing early warning systems now may pay huge dividends in the future, if invasions can be detected and controlled before they reach the stage of explosive spread. In addition to reactive management to deal with today's massive problems, we also need proactive research and management to minimise tomorrow's.

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