

The impact of weeds in national parks

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Summary

Weeds of national parks are generally exotic species, many of which are useful plants outside conservation areas. Disturbance is critical for weed invasion, but even natural systems are subject to disturbance and are liable to invasion. Tourists are probably much less important as vectors of weed seeds than are natural vectors such as birds and mammals. Australia's parks contain a very high proportion (21%) of exotic species. Globally, reserves in savannas and deserts are the least affected by weeds, and islands the most. There is a strong positive relationship between the number of native species in a park and the number of exotics. The effects of weeds on natural ecosystems have not been well studied, but the few studies available show dramatic consequences of weed invasions.

Introduction

Declaring an area as a national park does not mean an end to invasions by exotic organisms. For example, the floating weed *Salvinia molesta* first became a problem in Kakadu (Northern Territory) in the late 1980s, roughly ten years after the park was declared. What follows is a brief attempt to seek generalizations about weed invasions in national parks.

Prerequisites for weed invasions into national parks

A pool of weedy species

There is unfortunately no shortage of plant species capable of becoming weeds in national parks. However, the pool of potential immigrants varies with biome: clearly, there are no potential immigrants into Antarctica (21). In general, weeds in national parks tend to be

exotic species, and they may be known elsewhere, not necessarily as weeds, but also as useful plants (Table 1).

Table 1 Some examples of serious weeds in conservation areas, compiled from the literature

Species	Location	Uses	Dispersal
<i>Salvinia molesta</i>	Kakadu, Australia	Aquaria	Water
<i>Psidium guajava</i>	Hluhluwe, S. Africa	Food	Birds
<i>Lantana camara</i>	Baluran, Java	Ornamental	Birds
<i>Pennisetum polystachion</i>	Khao Yai, Thailand	Pasture	Wind
<i>Melaleuca quinquenervia</i>	Everglades, U.S.A.	Afforestation	Wind, water

Disturbance

Disturbance seems crucial to the success of invasions (e.g., 8,9), and Crawley (7) has clearly shown from a survey of the British flora that the most disturbed communities have the highest proportion of exotic species. The percentage of alien flora was highest in man-made habitats, particularly wasteland (79%), and least in the uplands (0-12%). This is also true of Australia, with, for example, the comparatively unexploited Northern Territory having 5% of its flora being alien (17), compared with Tasmania, long developed, at 31% (11).

Heavy grazing from exotic ungulates such as cattle can result in the invasion of unpalatable woody weeds e.g., the expansion of introduced guava *Psidium guajava* in the Galapagos islands (4). The clearing of native vegetation for roads and camping grounds also creates opportunities for weeds, such as the annual herb *Tagetes minuta* along roadsides in the Serengeti (15), or *Hyptis suaveolens* in Kakadu.

Bazzaz (1) attempted to distinguish between "colonizers" of disturbed land and

“invaders” of undisturbed communities, but I contend that all communities experience some periodic disturbance (10). Natural communities may, for example, be subject to such disturbance as seasonal flooding, fire, and grazing from native animals. An example of a natural disturbance promoting the establishment of an alien weed is the establishment of the leguminous tree *Myrica faya* following volcanic activity in Hawaii (24). On the other hand, frequent fire is possibly the reason that exotics are unimportant in the grasslands and open woodlands of the Serengeti (15).

Vectors of invasive species

The vectors of weed seeds in national parks are likely to be animals, wind and water, (Table 1), road-building equipment and, probably much less importantly, tourists. This last is perhaps a contentious statement, as both Clifford (5) and Wace (25), for example, have shown that passenger cars carry weed seeds. However, in a survey of tourist vehicles, entering Kakadu National Park over one year, the density of seeds was low (13). A total of 1,852 seeds were collected from 304 tourist vehicles and most cars carried one seed or less. Certainly, nine species of known tropical weeds were found amongst the samples, as well as 10 species not known in the Park. However, the numbers of seeds in different weed species were completely unrelated to the abundance of those species in the Park (13).

Macdonald *et al.* (16) showed a positive relationship between annual visitation rate and the number of alien plant species. This may have resulted, not from the visitors, but from the disturbance associated with facility development. As Wace (25) pointed out, “it is striking that ... attempts to prevent the spread of weeds on vehicles are usually made in almost total ignorance of what species are being carried about by motor vehicles”.

Animals and birds are important vectors of weed seeds in nature reserves. Re-analyzed data from a survey of the Kakadu weed flora (6) found that 42 of 84 species were mammal dispersed and found at five times as many sites as those that were not ($t = 6.7$, $d.f. = 82$, $P < 0.001$). Only three species were bird dispersed, but these were found at 11 times as many sites as those that were not ($t = 2.9$, $d.f. = 82$, $P < 0.01$). The mammals involved probably included feral pigs and buffalo, whereas there

are no exotic bird species in Kakadu. There are other examples of exotic birds dispersing exotic weeds: e.g., *Myrica faya* by the exotic mejiro *Zosterops japonica* in Hawaii (24).

Weed floras of national parks

Weed floras in different continents and biomes

It is now impossible to find any nature reserve with no exotic species (21). Islands are more highly affected by exotic plants (33% of the flora); for example, Australia (21%), Africa (7%) (Table 2). Usher (21) also showed islands to be the most invaded biomes, with savannas and deserts the least (7%) (Table 3). Island nature reserves contain proportionally more exotics than temperate urban and agricultural landscapes (Table 3). Possible reasons for this include the lack of ungulates in particular, and thus the flora can be susceptible to ungulate-grazing when they are introduced (23). This argument would also hold for Australia. Data are scarce or non-existent for Asia, Europe, and South America.

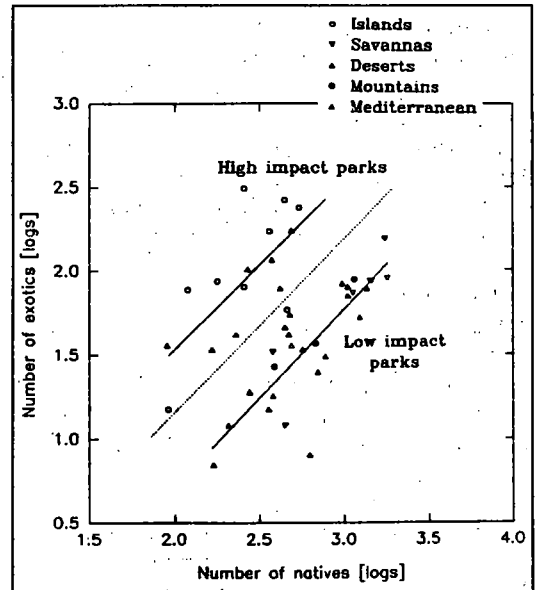


Figure 1 The relationship between the number of exotic and native species, for various conservation areas around the world. The dashed line arbitrarily divides the high from low impact parks. The solid lines were fitted by regression, with equations as follows: for high impact parks, $\log E = -0.48 + 1.01 \log N$; ($r = 0.71$, $n = 16$, $P = 0.002$); and for low impact parks, $\log E = -1.39 + 1.06 \log N$; ($r = 0.84$, $n = 28$, $P < 0.001$), where E is the number of exotics, and N the number of native species.

Table 2 Proportion of the flora that is exotic in various continents of the world. (Sources: 4, 7, 11, 12, 14, 15, 16, 19, 23)

Continent	Parks and reserves only		All data sets	
	Proportion exotic (%)	n	Proportion exotic (%)	n
Islands	33	12	33	16
Africa	7	19	7	19
Australia	21	10	20	22
N. America	14	11	19	26

Predictors of weed floras in parks

Figure 1. shows that the best predictor of the number of exotic species in a park is the number of native species. National parks seem to break down into two groups, each characterized by a different relationship between the exotics and natives (Figure 1). Interestingly, the two slopes are almost identical, but the intercept changes. What I will define loosely as the high impact parks have an intercept of 0.333 exotic species, eight times as many as the low impact parks, with 0.041 exotics. As the slopes are similar at around unity, for an x - fold increase in native species, there will be an x - fold increase in exotics.

Table 3 Proportion of the flora that is exotic in various biomes. (Sources as in Table 2).

Continent	Parks and reserves only		All data sets	
	Proportion exotic (%)	n	Proportion exotic (%)	n
Islands	33	12	33	16
Savannas	7	8	7	8
Temperate urban/agric.-	-	-	29	24
Desert	7	5	7	5
Mountains	10	5	16	13
Mediterranean	12	20	13	21

The high impact group includes eight of the nine island parks, all the Mediterranean biome parks in north America and Australia, and three of them in South Africa. The remainder of the South African Mediterranean parks are in the low impact group, along with the savanna, desert, and mountain parks (Figure 1).

Another correlate for the number of exotics is park area ($r = 0.57, n = 44, P < 0.001$). Not unexpected, given the relationship between the number of native species and area ($r = 0.86, n = 45, P < 0.001$). This relationship with area

may explain the correlation between the number of exotics and visitation rate (16,21), as bigger parks probably have more visitors.

Effects of weeds in national parks

Biological invasions alter ecosystems (22). Examples of such invasions include the Everglades by the swamp forest tree *Melaleuca quinquenervia* (8), and of the Sepik River in Papua New Guinea by the floating fern *Salvinia molesta* (18).

Effects on plant populations

In northern Australia, a negative effect from the presence of *Mimosa pigra* on the abundance and diversity of flood plain herbs and on the density of native tree seedlings, probably resulting from heavy shading, has been reported (3). The invasive shrub *Myrica faya* has increased nitrogen fixation in open sites in the Hawaii Volcanoes National Park, with potentially far-reaching successional consequences (24).

Effects on animal populations

Mimosa pigra was found to have dramatically reduced the abundance of flood plain dwelling birds and lizards, but to have increased the abundance of certain mammals (3), for instance, the rare marsupial *Sminthopsis virginiae* (2). *Salvinia molesta* affected fish yields from Papua New Guinea within ten years of introduction (18).

Effects on the water table

Invasion of *Tamarix* spp. into waterways in the south west of the U.S.A. increased water loss, thus lowering the water table (22). Conversely, invasion of *Andropogon* in Hawaii lowered transpiration rates, relative to native rain forest, resulting in boggy conditions (20).

Conclusions: the importance of weed information

Weeds can dramatically affect ecosystem function. It is imperative that park managers know the exotic flora of their parks, and also monitor the status of invasive species in the surrounding region. If necessary, they should promote the control of weed infestations outside the park boundary. Kakadu National Park provides a good example of this approach - weeds are monitored and controlled in the approaches to the park as well as within it, and

the exotic flora of the park has been, and is being, well-studied (e.g., 6,13).

Acknowledgments

I thank G. Farrell, C. Smith, and R. Williams for helpful comments on the manuscript.

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