ALIEN PLANT MANAGEMENT

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Keywords: alien plants, invasion, introduction, naturalization, disturbance, control, eradication

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Summary

In the twentieth century, plant invasions became a severe problem, from both ecological and economic viewpoints. A survey of the biogeographical, ecological, and demographic aspects of the invasion processes led us to a generic "identikit" of both invasive species and invasion-prone ecosystems and communities. Different forms of intervention against alien plants are discussed, covering various aspects of education and awareness, control, introduction and spread prevention. Some examples of alternative management strategies are also provided.

1. Foreword: Plant Invasions: Not Only a Scientific Problem

The issue of limiting alien invasions has become a main international task as the result of an increasing awareness of the huge economic costs of harmful species introduction. Also, the need for a better understanding of the behavior of the plants likley to become weeds has been highlighted during the current debate, even the potential concerns of the escape from cultivation of genetically modified plants.

It is difficult to quantify the ecological and economical damages caused by exotic plant invasion all over the world. On the basis of the invasions that have occurred in six countries (USA, UK, Australia, South Africa, India, and Brazil), it has been calculated that about half a million species have been introduced worldwide, often far from their original countries. Alien plants not only directly threaten the native flora, but also they often cause dramatic transformations of the natural landscape. According to recent evaluations, nonindigenous species are second only to habitat destruction in harming native communities.

In the last few decades, human activity caused an exponential increase of severe invasion events: intense international trade and tourism magnified propagule pressure,

while various forms of disturbance and intense habitat fragmentation rendered many countries more invasion prone. If most of the introductions are directly linked to modern intensive agriculture and farming methods, which provide more than 98% of world food supply, on the other hand, they produced huge ecological (and thus economic) damages (see Table 1), often compromising entire production cycles.

Country	Crops	Pastures	Envir. Losses	Total
USA	27.90	6.00	0.15	34.05
UK	1.40	-	-	1.40
Australia	1.80	0.60	-	2.40
South Africa	1.50	-	0.09	1.59
India	37.80	0.92	-	38.72
Brazil	17.00[a]	-	-	17.00
Total	87.40	7.52	0.24	95.16

[a] crops + pastures

Table 1. Economic losses due to the competition of introduced weeds in crops and pastures and to environmental loss in the USA, UK, Australia, S Africa, India, and Brazil (US$1 × 10^9 yr^{-1})
Data from Pimentel et al. (2001), modified.

2. Present Knowledge of Invasion Biology

Since the 1980s, alien invasive species control and eradication has become an increasingly important economic problem. The need to correct environmental and agroforestry management policies and to make reliable cost-benefit evaluations stimulated many governments to fund on invasion biology research.

Based on the most relevant and up-to-date literature on plant invasions, the following note aims to show how, when, and where alien invasions occur throughout the world. A description of the main biogeographical, ecological, and demographic aspects of invasion processes and a qualitative "identikit" of invasive species are also presented. Some actions against alien plants are discussed, covering various aspects of (physical, chemical, and biological) control, education and awareness, introduction and spread prevention, information and recording, and future perspectives.

According to Rejmanék: "Successful management of invasive weeds will require active attempts to prevent new introductions, vigilant detection of nascent populations and persistent efforts to eradicate the worst invaders. To achieve these objectives, invasion ecology offers five groups of complementary approaches: (1) stochastic approaches allow probabilistic predictions about potential invaders based on initial population size, residence time and number of introduction attempts; (2) empirical taxon-specific approaches are based on previously documented invasions of particular taxa; (3) evaluations of the biological characters of non-invasive taxa and successful invaders give rise either to general or to habitat-specific screening procedures; (4) evaluation of environmental compatibility helps to predict whether a particular plant taxon can invade

specific habitats; (5) experimental approaches attempt to tease apart intrinsic and extrinsic factors underlying invasion success."

Successful invaders can effect the invaded communities in various ways, for example, reducing local diversity, driving rare native species to extinction (competing or hybridizing with them), changing habitat structures and ecosystem functions, water and nutrient cycles, modifying disturbance regimes (type, intensity, and frequency) and altering community functions (primary productivity, structure, growth rate, diversity, competition, mutualism, diseases, resistance and resilience, succession). Humans have been altering the composition of vegetation for a long time and are still doing it at a massive scale through disturbance (forest clearing, conversion to agriculture, burning, pollution, etc.) and through deliberate or accidental introductions.

2.1. From Introduction to Invasion: A Dynamic Process Involving Not Only Alien Species

In many works concerning plant invasions the terms "naturalized" and "invasive" have been often misused. This greatly biased the formulation of robust generalizations on invasion mechanisms. Following Richardson et al.: "*introduced* must be considered a plant (or its propagule) which has been transported by humans across a major geographical barrier. *Naturalization* begins when the alien species succeeds to pass through several reproductive barriers, while *invasion* requires that introduced plants reproductive offspring colonize in areas distant from sites of introduction." Taxa well adapted to the abiotic environment may be able to invade disturbed, seminatural communities. Invasion of successionally mature, undisturbed communities usually requires that the alien taxon overcome community- and ecosystem-level barriers. "Only about 10% of invasive plants can change ecosystem composition, structure and function over wide areas: they should better be termed *transformers*." For example, the North American black locust (*Robinia pseudacacia*) had a strong impact on Central European landscape by seriously affecting the total number of species and the spatial and temporal structure of the original woodland communities. Alien spreading often induces disruptive feedback which cause dramatic changes of hydrological (*Tamarix* sp.) and edaphic (*Acacia* in South Africa) cycles, fire intensity and frequency (*Pinus* sp.), and so forth.

Despite of the wide literature on alien and invasive plants, it is still quite difficult to foresee their behavior. In the biotopes subject to intense and frequent human disturbance many anthropochorous and ruderal plants show invasive attitudes. These species represent a serious bias to alien invasion effect interpretation, as it is often quite difficult to state with certainty whether they are alien or native but established in habitats different from those of origin (apophytes). We must check their presence, their distribution, and eventually their spread, as the disturbance they induce is not negligible: like aliens they reduce overall ecosystem diversity, by monopolizing space and resources and diffusing diseases, driving many native species to extinction.

On the other hand, not all alien species become invasive, and invasion does not work forever and everywhere: many species which show excellent performances in disturbed sites present a syndrome of traits (ruderal life history, good dispersal ability, rapid

growth, good stress tolerance, etc.), which can be liabilities in undisturbed habitats. Many ruderal and segetal invaders normally disappear as a result of the increasing competition among species during succession. For example, many species formerly achieving weed status (agrestal and semiruderal weeds) are unable to compete in today's intensively managed agricultural landscapes, and they are more or less in decline, mainly because of seed cleaning and herbicide and fertilizer use.

2.2. Invasive Plants: Is There a Way to Detect Them in Advance?

It is quite difficult to sketch an invasive species portrait, and all the efforts to produce a general model are mainly based on probabilistic arguments. Table 2 summarizes these efforts.

Physiology
Great longevity of seeds
No specific germination requirements
High relative growth rate
High phenotypic plasticity
High phenological plasticity
High-efficiency photosynthetic path
Early reproductive maturity (in trees)
High seed output
Vigorous vegetative growth (in perennials)
Ecology
Absence of natural enemies (predators, parasites, competitors, etc.)
Good tolerance to intensity- and frequency-varying disturbance
High acclimation potential (due to similar climatic and/or biogeographic origin)
High ability to occupy habitats different from those of origin
Demography
High population growth rate
Effectiveness of the seed dispersal mechanisms
High transition probabilities between at least two stages of the life cycle
Genetics
High genetic variation
Self-compatibility, wind pollinated or unspecialized pollination
Biogeography and taxonomy
Large native range
Species belonging to unspecialized families
Experience
Species with weed congeners
Species acting as a weed elsewhere

Table 2. Comprehensive "identikit" of invasive plant species
After Roy in di Castri et al. (1990), modified.

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Biographical Sketch

Salvatore Pasta was born in Palermo (1968). He has took a degree in Natural Sciences after writing an experimental thesis on Palermo Mountains vegetation (Palermo, 1993), and a PhD degree in Biosystematics and Vegetal Ecology (Florence, 1997) with a thesis entitled "Phytogeographical Analysis of Circum-Sicilian Islands Flora". He collaborates with several Italian Academic institutions and with some environmentalist associations managing Sicilian nature reserves. His main fields of interest are island biogeography, vegetation dynamics, and natural landscape history.