Horticulture and the Invasive Plant Species Issue

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Abstract
The spread of invasive plant species is of growing concern to managers of natural resources and ecologists. Most invasive plant species are exotic where they have been introduced and can have serious impacts on the invaded communities. Invasive plant species form a heterogenous group of plants with regard to their taxonomic position, ecological traits and modes of introduction. Most invaders have been originally introduced as ornamentals and for the purpose of erosion control. Therefore, horticulture plays an important role in exchanging plant species around the world and introducing them to new areas. The spread of potentially invasive plant species has been recognized and attempts to prevent such spread are discussed.

INTRODUCTION
Ecologists, conservationists and managers of natural resources are increasingly concerned about the spread of non-native (non-indigenous, exotic, alien) plant and animal species that become naturalized or feral in natural communities (Luken and Thieret 1997; Mack 1997; Vitousek et al. 1997). The number of naturalized alien plant species has been rapidly increasing in many regions of the world during the last 200 years (Rejmánek and Randall 1994; Kowarik 1995). In California, for example, the number of naturalized alien plant species increased from 150 to 1000 between 1900 and 1990 (Rejmánek and Randall 1994).

Some of those species that become naturalized have a strong impact on the invaded ecosystem due to a rapid expansion, thereby affecting the invaded communities in various ways, e.g. reducing local diversity, or driving rare native species to extinction by competing or hybridising with them, changing habitat structures and ecosystem functions, and changing disturbance regimes such as fire frequency. The phenomenon is commonly referred to as biological invasions (Clout and Lowe 1997) and the species involved as invasive species. The International Union for the Conservation of Nature (IUCN) defines an invasive species as follows (IUCN, see www.issg.org): “An alien species which becomes established in natural or semi-natural ecosystems or habitats, is an agent of change, and threatens native biological diversity”. Thus, the term “invasive species” refers to species penetrating into natural and semi-natural areas and to those that have negative effects on the community; they are also called environmental weeds (Randall 1996). Weeds of agricultural areas do not belong to this group of plants, because they mostly differ in their ecological requirements and cannot grow outside cultivated fields (Mack 1997).

The reasons that lead to the spread of invasive species are mainly twofold: 1) humans have been altering the composition of vegetation for a long time and are still doing it on a massive scale through disturbance (forest clearing, conversion to agriculture, burning, and pollution) and 2) through the deliberate or accidental movement of species beyond their native ranges. The former provides new habitats that can be colonized by weedy species while the latter provides a pool of new species. Plant species are extensively exchanged between continents and introduced for various purposes, e.g. ornamental, timber production or soil stabilization.

The Scientific Committee on Problems of the Environment (SCOPE) launched a project on the "Ecology of Biological Invasions" and made the issue an important focus of ecological research (Mooney and Drake 1986, Drake et al. 1989, Di Castri et al. 1990).
This article highlights the significance of the invasive plant species issue, explores the role of horticulture in the spread of invasive plants, and highlights currently used approaches to manage and prevent plant invasions.

**HOW DOES A PLANT INVASION OCCUR?**

The spread of an exotic species into a new region is a dynamic process, and can be grouped into the stages introduction, establishment, and subsequent spread. An invasion always starts with the introduction of a species, whether seeds, living parts, or whole plants, into a new area. The movement of a species beyond its natural range is always assisted by man - either intentionally or accidentally. Intentional introductions comprise all species brought in from another region for a special purpose. Accidental introductions typically occur as a result of trade and tourism. For plants, examples are propagules in the ballast water of ships, hitchhikers on soils or intentionally introduced animals and plants, seed contamination, propagules carried and dispersed by vehicles, and seeds in packing material.

Most of the introduced species fail to reproduce or to grow outside the locations where they have been cultivated (crop fields, gardens, parks, and pastures). As a crude rule, 10% of introduced species are able to establish, and a further 10% of these are able to become invasive plants (Williamson 1996). However, the more alien species that are present in a region, the greater the likelihood that some of them are or will become invasive.

**WHAT ARE THE CHARACTERISTICS OF INVASIVE PLANT SPECIES?**

The question whether invasive plant species share some common traits that distinguish them from non-invasive plants is crucial but not easy to answer because generalizations are difficult if not impossible (Mack 1997; Williamson 1999). It is clear that “invasiveness”, i.e. the kind of negative impact an exotic species has, depends on many factors. These comprise species traits and community traits, as well as our perception of the weediness of a species. A successful invader must be a better competitor than the native species, otherwise the alien species won't be able to have a population growth that is higher than that of the native species. Characters that are frequently observed among invasive plants are related to physiology and ecology, but include also bio-geographical aspects (Table 1).

**WHAT ARE THE EFFECTS OF INVASIVE PLANTS?**

An invasion can be viewed as a succession towards a community that did not exist before, and the extensive spread of invasive plants may result in a wide range of changes of the invaded communities and ecosystems. These can be grouped into direct and indirect effects on the native species and their interactions, and include effects on primary productivity, nutrient dynamics, soil moisture conditions, disturbance regime, and community dynamics. The nature and degree of these impacts vary greatly and depend on the species involved and the habitats invaded. Ecosystem traits such as soil nitrogen content may be increased in the presence of invasive plants, e.g. by nitrogen-fixing legumes, or decreased. Similarly, water content of the soil may decrease if the alien plants are consuming much water (e.g. *Tamarix* sp.). If invasive plants don't have direct ecological effects on soil properties or the composition of the fauna and flora, they always have the effect of occupying space that otherwise would be available to native species. In many instances, invasive plants form large and dense populations, covering large areas with "monocultures". In such populations, native species richness is strongly reduced.

Since many invasive plants are being controlled in conservation areas, the impacts are associated with costs to control them and to restore invaded and degraded landscapes.

**INVASIVE PLANT SPECIES OF THE WORLD: A CHARACTERISATION**

A recent literature survey (Weber, unpublished) identified about 770 plant species that are considered to be serious invaders of natural habitats in various regions. These
species comprise all life forms including ferns and succulents (Fig. 1). Most species are, however, herbaceous perennials and annuals. Taxonomically, the most important families are the Poaceae, Fabaceae and Asteraceae. In order to recognize any patterns with regard to the modes of introduction of these plants, the species were allocated to different categories of economic uses (Fig. 1). These were extracted from Wiersema and León (1999). The analysis revealed that about 40% of the species have no special use, these are mostly herbaceous weeds accidentally introduced. The majority of intentionally introduced species (ca. 40% of all species) is used as ornamentals. Other important purposes include erosion control, soil stabilization and soil improvement. These figures make clear that most invasive plants have been intentionally introduced for a special purpose and planted on a large scale. Horticulture plays an important rôle because for ornamental purposes many different species originating from a wide range of families and life forms are being introduced and improved by breeding programs. Some major invaders such as *Lantana camara* or *Eichhornia crassipes* have originally been introduced to new areas as ornamentals.

**MANAGEMENT OF INVASIVE PLANTS**

Current management practices of plant invasions include the control of existing invasive plants and the restoration of their invaded habitats, and the prevention of new invasions. Widespread invasive plants are controlled in many regions at a large expense.

The best control measure, however, would be prevention (Zamora et al. 1989). Prevention of new plant invasions requires several steps (Westbrooks 1991, Zamora et al. 1989): 1) Identification of foreign species that could cause problems, 2) Early detection of infestations if the species is already established, 3) Assessing the invader's noxious potential, and 4) Taking the necessary measures to control or eradicate new weed species. In several countries, it is a common practice to apply a weed risk assessment for any new species that should be introduced. Examples of risk assessment protocols are provided by Reichard and Hamilton (1997) and Pheloung et al. (1999). Such risk assessments rate a species according to its biological and ecological traits, and based on this rating it is accepted or rejected. The development of reliable risk assessments remains, however, difficult (Groves et al. 2001). Nevertheless, species that are purposefully to be introduced into a new area, should be carefully evaluated for their weediness.

It is clear that the potential for new plant invasions is given as more and more aliens are becoming naturalized. New plant invasions can originate mainly from three sources: 1) by the onset of spread of already established exotic species that have currently a low abundance or a restricted range. As Kowarik (1995) points out, alien species that at present are not very abundant and widespread might become so in future due to the presence of lag-phases. 2) By natural immigration of exotic species from other countries. This includes dispersal and range expansion, and may be facilitated by changes in land use. 3) By intentional or accidental introductions of new species from other countries and continents and subsequent spread. Each of these introduction modes may lead to the spread of new invasive plants.

**Literature Cited**


Kowarik, I. 1995. Time lags in biological invasions with regard to the success and failure


Table 1. General characteristics of invasive plant species. After Roy (1990).

| Physiology and ecology | - Great longevity of seeds  
|                        | - No specific germination requirements  
|                        | - High relative growth rate  
|                        | - High acclimation potential  
|                        | - High phenotypic plasticity  
|                        | - Early reproductive maturity in trees  
|                        | - High seed output  
|                        | - Vigorous vegetative growth in perennials  
|                        | - Absence of natural enemies  
| Demography             | - High population growth rate  
|                        | - Effective seed dispersal  
|                        | - 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 belongs to unspecialized families  
| Experience             | - Species has weedy congeners  
|                        | - Species is a weed elsewhere  

Fig. 1. Lifeform distribution (a) and economic issues (b) of serious invasive plant species of the world. The species were compiled from the literature (n=774).