Invasive Plants: Their Impacts and Control in Changing Environments

JUDITH H. MYERS, MADLEN DENOTH, AND JACQUELINE SHABEN

Department of Zoology and Faculty of Agricultural Sciences, University of British Columbia, 6270 University Boulevard, Vancouver, BC, V6T 1Z4, Canada, email myers@pop.zoology.ubc.ca

Abstract: While it is frequently stated that invasive species are second only to habitat destruction as a cause of species extinctions, this generalization does not apply to plants. In this paper, we briefly discuss three issues concerning the impacts of exotic plants: the impact of an introduced plant species on a rare native plant species, the potential long-term impacts of exotics on plant communities, and the possible interactions between biological control success and climate change.

Purple loosestrife (*Lythrum salicaria*), is a European plant species that is now widespread in wetland areas of northern North America. We predicted that the invasion of purple loosestrife might reduce the density of a rare plant species, Henderson's checker-mallow (*Sidalcea hendersonii*), in a tidal marsh habitat in British Columbia; however, this was not the case. Thus, just because a new species becomes common does not mean it will threaten rare native species. Predicting species interactions is difficult.

Introduced plants, however, can have long-term impacts on plant communities. For example, legumes can change soil nitrogen, and through soil enrichment, can create long-term changes to invaded communities. Plants that efficiently use soil moisture can also prevent the reestablishment of native species and can reduce biodiversity. In these situations, the invasive plants act as ecological engineers. We discuss two examples of this: the invasion of threatened Garry oak (*Quercus garryana*) meadows by Scotch broom (*Cytisus scoparius*) and the persistence of crested wheatgrass (*Agropyron cristatum* ssp. *pectinatum*) in dry rangelands. In these situations, the invasive plants could possibly act as ecological engineers.

Models of climate change predict increased drought in some regions of Canada. Between 2001 and 2003, rainfall in the Okanagan Valley was well below normal levels, although similar drought conditions have occurred in the recent past. Over this same time period, an invasive rangeland weed, diffuse knapweed (*Centaurea diffusa*), declined dramatically in density following high levels of attack by a recently introduced biological control agent, a weevil, *Larinus minutus*. Rainfall and knapweed density are related, and the feeding damage by this weevil likely increased the drought stress of knapweed plants and may have contributed to their demise.

These three case studies demonstrate that predicting the impacts, control, and long-term influences of exotic plants in changing environments will require detailed experimental analysis. Patterns will not be simple.

Key Words: ecological engineers, diffuse knapweed, *Centaurea diffusa*, purple loosestrife, *Lythrum salicaria*, Henderson's checker-mallow, Henderson mallow[1], *Sidalcea hendersonii*, invasive plants, biological control, *Larinus minutus*, climate change, British Columbia

Introduction

Climate Change and Introduced Plants

Long-term climate changes may influence the distribution and abundance of introduced plants in two primary ways: (1) by increasing disturbance, and (2) by modifying the distribution of either the introduced species or the native species with which they compete (Zavaleta and Royval 2002). If climatic conditions shift in terms of average or extreme temperatures, native species may be more stressed and less competitive against invading exotic species. This could benefit the spread and establishment of exotic plants. Disturbance, such as that caused by fires that are associated with reduced precipitation, could also benefit exotic species. For example, the forest fires that occurred in British Columbia (B.C.) during the summer of 2003 are considered by some to have been exacerbated by drought conditions. We cannot presently predict if exotic plant species will benefit from these recent fires; however, it is possible that given current restoration practices, some of the burned areas may be reseeded with mixes of grass seeds that contain exotic species such as crested wheatgrass (*Agropyron cristatum* ssp. *pectinatum*). This would certainly benefit exotic species and could potentially cause permanent changes to rangeland biodiversity. The interactions between exotic grasses, fire, and global climate change were reviewed by D'Antonio and Vitousek (1992).

The actual impact of climatic change on plant distributions, whether they are native or exotic species, will depend on the species' biology. The success and geographic range of plant populations may be influenced as much by changes in the distribution of precipitation during the year as in variation in the average amount of precipitation. Changes in temperature means or extremes could also affect plant populations. Predictions of distribution changes of plant species must be on a species-by-species basis. For example, Zavaleta and Royval (2002) analyzed the distribution of an exotic shrub *Tamarix* as it relates to climate. They found that the distribution of this invasive species in the United States is limited to dry regions. Its occurrence is greatest in areas with mean annual precipitation of 47 mm per year, and the species drops out when precipitation levels reaches 1150 mm per year. Although climate models did not permit detailed predictions, they did predict that declining precipitation, which might occur with increased atmospheric CO_2, could allow the distribution of *Tamarix* to increase in the western United States

Zavaleta and Royval (2002) predicted that 48% of invasive plants and animals currently established in the United States would benefit from warming climates by expanding their

[1]NatureServe Explorer (version 4.0, July 2004) lists *Sidalcea hendersonii* as Henderson mallow.

distributions northward. In particular, they suggested that tropical species now limited to southern parts of the country could move farther north. In Canada, it might be more likely that drought tolerant species will expand their ranges. It would be interesting to survey the current distributions and habitat preferences of exotic plants that now occur only in the United States and have not yet extended their ranges or become established in Canada.

Case Study #1

Impacts of Invasive Species on Rare Native Plants

Exotic invasive plants are often considered to be a threat to rare native species simply because of their high densities. Daehler (2003) recently reviewed studies in which the competitive abilities and life history characteristics of natives and exotics were compared. He found that the performance of natives was often comparable to that of the invasive species. Invasive species did best when resources were abundant and physical disturbance was high or departed from the normal pattern. Denoth (2004) recently completed a study in which she measured the performance of a rare native species, Henderson's checker-mallow (*Sidalcea hendersonii*), in competition with an exotic species, purple loosestrife (*Lythrum salicaria*), and two other native species that occur in the same habitat—a tidal marsh. In both field and lab comparisons, the rare native species performed as well when competing with the other native species as it did when competing with the exotic, purple loosestrife. Small differences in plant growth in the early spring and in habitat preferences of *Sidalcea* and *Lythrum* are thought to explain the persistence of the native plant species in the marsh, which had been invaded by purple loosestrife. The high densities attained by many introduced species suggest that they must displace native plant species, but the competitive interactions often appear to be very subtle.

Case Study #2

Invasive Plants as Ecological Engineers

Some invasive plant species have long lasting impacts on habitats, which makes restoration of native plant communities impossible or greatly delays restoration even after the invasive plants have been removed. An example of this is the impacts created by exotic legumes that fix nitrogen and enrich formerly nutrient-poor areas (Vitousek 1990).

Scotch broom (*Cytisus scoparius*), has invaded the Garry oak (*Quercus garryana*) meadows of Vancouver Island and the southern Gulf Islands. This species is a legume and has the ability to fix nitrogen and thus modify soil nutrient conditions. To determine the impact of broom on soil nitrogen levels in Garry oak ecosystems, we have begun monitoring available soil nitrogen in broom-invaded and non-invaded areas within Garry oak habitats. There is concern that an increase in available soil nitrogen might facilitate further plant invasions by highly competitive nonnative grasses. We are measuring Scotch broom's impact on the success of orchard-grass (*Dactylis glomerata*), an invasive grass species.

Crested wheatgrass provides another example of the type of impacts that an invasive plant species can have on native plant communities. Crested wheatgrass has been widely planted as a forage species on rangeland in western Canada, and once established, it is very persistent. Native species only slowly reinvade sites that have been planted with crested wheatgrass. Broersma et al. (2000) compared ungrazed native rangeland to that planted to crested wheatgrass. They found that in native rangeland, plant cover was greater and species richness was twice that recorded in rangeland that was planted to crested wheatgrass. These differences, however, could not be attributed to differences in soil characteristics. Thus, the long-term habitat changes resulting from the presence of exotic plants must be considered in conjunction with the influence of climate change on the distribution of those exotic species.

Case Study #3

Biological Control of Invasive Plants under Climate Change

Biological control—the introduction of natural enemies of exotic plants to reduce their density, distribution, and competitive ability—is the only long-term solution for controlling invasive plant species. Climate matching is important for selecting appropriate biological control agents (Myers and Bazely 2003); thus, changes in climate may be detrimental to currently successful biological control programs, or they may facilitate the impact of agents by stressing the target plants. For example, diffuse knapweed (*Centaurea diffusa*) is a major exotic rangeland weed that has invaded dry areas from British Columbia south to Colorado. Long-term monitoring of knapweed density at a study site south of Penticton, B.C. showed that precipitation in May and June was related to knapweed density the next year (Myers 1995): higher levels of moisture allowed better survival and growth of young plants. In recent years, and following the establishment of an introduced biological control agent, a weevil, *Larinus minutus*, the density of knapweed has declined (personal observation). Adult *Larinus* feed on the epidermis of knapweed plants, and the resulting damage is particularly detrimental during dry conditions. In 2001 to 2003, spring rainfall in this area was approximately half of average levels.

Again, predicting the impact of climate change on biological control programs will be on a case-by-case basis. Drought or warming may benefit control in some cases but may disrupt it in others. Increased fires associated with drier conditions could also potentially disrupt biological control programs and could require reintroduction of successful control agents.

Conclusions

Invasive species are a major component of changing patterns of biodiversity around the world. Although it may be possible to predict how particular species will respond to modifications in temperature, precipitation, and habitat disturbance associated with climate change, generalizations are unlikely to be feasible. Invasive plant species that modify the habitat in a major way, such as by changing nitrogen levels or by preventing the establishment of other species over the long term, will themselves generate major shifts in biodiversity. The success of biological control programs must also be considered in attempts to predict the impacts of climate change on invasive plant species. Some programs may become more successful and others less. Predicting the impact of climate change on invasive plants is almost as complex as predicting the patterns of future climate change.

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