



Overview of Vol.6, No.3 - Invasive Nitrogen Fixers

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There is a growing awareness that invasive species can affect not only the community composition of invaded areas, but also the ecosystem processes (e. g. Feller 1983, D'Antonio and Vitousek 1992, Kaye and Hart 1998, Scholes and Nowicki 1998). All of the species treated in this section of the *Restoration and Reclamation Review* are nitrogen fixers; all are known to enrich soil nitrogen, and most have been demonstrated to speed nitrogen cycling through plants and soils.

Nitrogen cycling is enhanced by plants that produce litter with low carbon to nitrogen ratios, such as nitrogen fixers. Low carbon to nitrogen ratios and faster nitrogen cycling generally increase plant-available nitrogen in the soil due to decreased microbial immobilization of nitrogen (Binkley and Hart 1989). Nitrogen availability, in turn, exerts strong influences on plant community composition, and on community invasibility (Carpenter *et al.* 1990, Wilson and Tilman 1991, Burke and Grime 1996). Research also has shown that the effects of nitrogen additions on plant community dynamics can be long-lasting (decades) (Milchunas and Lauenroth 1995). This cascade of effects, from invasion to nitrogen enrichment to enhanced invasibility of affected ecosystems, make nitrogen fixers a logical grouping of organisms in a volume dedicated to invasive species and ecological restoration.

Nitrogen fixing capability is not the only trait that unites these species. They share many traits that are common among invasive species (see Table). Like many invasive species, all of these were deliberately introduced into the regions where they are invasive. And it is not particularly unusual that two of them, autumn olive (*Eleagnus umbellata*) and black locust (*Robinia pseudoacacia*), are still actively propagated in the regions where they are invasive. It may seem absurd to propagate an invasive species, but Sabo points out that horticulturalists are going one step further with *R. pseudoacacia*: research is underway to develop herbicide-resistant strains of this invasive species for use in Europe. Yet even the continuing development of 'improved' strains of invasive species is not particularly uncommon.

Table. Plant traits commonly associated with invasive species. Abbreviations: AS = *Acacia saligna*; EU = *Eleagnus umbellata*; LA = *Lupinus arboreus*; MF = *Myrica faya*; RP = *Robinia pseudoacacia*.

	AS	EU	LA	MF	RP
Rapid growth	x	x	x	x	x
Short juvenile period	x		x	x	x
Prolific seed production	x	x	x	x	x
Long-lived seeds	x		x		
Vegetative reproduction	x	x			x
Tolerates a wide range of soil conditions	x	x	x	x	x
Reduces native biomass	x	x	x	x	x

The introduction of these nitrogen fixers occurred for a variety of reasons, but one use is common to all of them. Because they all tolerate low nutrient conditions, and grow quickly, all have been useful in the stabilization of nutrient-poor soils that are subject to erosion. *E. umbellata* and *R. pseudoacacia* have also been used to reclaim polluted sites, such as mine spoils. The same two species provide shelter and food for wildlife, and *R. pseudoacacia* has been used as a crop source for human consumption. Port Jackson willow (*Acacia saligna*) can be harvested as fuelwood. Mehta points out that this feature of the plant has

been utilized in integrated control programs: harvest of fuelwood provides a source of income and serves as the initial site preparation where restoration activities are planned. Finally, firetree (*Myrica faya*) was imported to Hawaii as an ornamental, and for use in medicinal preparations.

Recommended control techniques range from extremely low-impact (with respect to non-target effects) to radical site transformation. The former is preferred in Hawaii where, as Seibold points out, the risks of herbicide use and of further species introductions (for biological control) have prompted efforts to enhance populations of native organisms that serve as biological control agents. At the other extreme, bulldozing sites that are heavily infested with *R. pseudoacacia* can only be described as a major disturbance, but most recommendations for these species are more moderate. A combination of physical and chemical control techniques seems to be the mode for three of the species treated here: *A. saligna*, *E. umbellata*, and *R. pseudoacacia*. Chemical control apparently is not common either for *M. faya*, for which the commonest control options appear to be biological, nor for *L. arboreus*, for which manual removal appears to be the best option.

Biological control is frequently touted as sound control technique (Pemberton 2000, van Wilgen *et al.* 2000), and some form of biological control is available for all five species treated here. Biological control techniques are least developed for *E. umbellata*, for which sheep or goat browsing is the only available option. Stark points out that sheep and goats are probably a poor choice for *E. umbellata* control because they require excessive maintenance and are not selective browsers. The authors describe a range of options for the other four species.

An interesting trend emerges regarding biological control agents. In two cases, the development of biological control organisms was halted due to concerns over possible damage to other non-native but economically important species in the region. In South Africa, there is ongoing resistance to the release of biological control organisms for *A. saligna* due to the importance of other *A. spp.*, and in Hawaii, concerns over possible impacts to avocados (*Persea spp.*) and mangoes (*Mangifera indica*) halted the investigation of two potential biological control organisms for *Myrica faya*. And Sabo mentions that the development of biological control agents for *R. pseudoacacia* may be problematic due to the potential for damage to planted individuals. There is no immediately obvious solution to such conflicts of interest (but see Higgins *et al.* 1997).

As mentioned above, the effects of these nitrogen-fixing invaders on the soils of invaded communities are known. Wozniak points out that in the case of yellow bush lupine (*Lupinus arboreus*), enhanced invasibility of *L. arboreus*-infested coastal dunes has been demonstrated. Seibold suggests that *M. faya* invasion was not correlated with other invasive species because it shades out the entire understory, and that removal of *M. faya* probably would allow other exotic species to exploit the nitrogen-enriched habitat. Feedbacks between nitrogen availability and community invasibility are well-studied, and it is reasonable to expect secondary invasions to be associated with any plant invader that fixes nitrogen.

What is remarkable when considering this group of species is the nearly complete lack of information on how to mitigate nitrogen enrichment. Wozniak describes a study in which all plant litter was removed from the site following removal of *L. arboreus*, in an attempt to reduce nitrogen enrichment. However, she points out that the study was conducted in an area that was accessible to heavy machinery, and suggests that information on the feasibility of such techniques in less accessible areas would be useful. An analysis of the economic feasibility of litter removal in large infestations is also needed. Wozniak and Mehta both suggest that burning biomass at infested sites would help to volatilize fixed nitrogen in biomass and litter. This is a good suggestion in fire-adapted systems, but probably will not be sufficient to remediate soil nitrogen dynamics. No soil remediation techniques were discussed for the other three species in this section.

Many researchers have examined the effects of nitrogen enrichment on plant communities. The feasibility of nitrogen depletion as a vegetation management strategy is a much newer area of research (e.g. McLendon and Redente 1992, Wilson and Gerry 1995, Seastedt *et al.* 1996, Reever Morghan and Seastedt 1999), and methods that effect long-term nitrogen depletion have yet to be demonstrated.

Hobbs and Humphries (1995) suggest that current invasive species management practices are generally inadequate, and that a focus on ecosystem management, rather than on the characteristics and control of specific invaders may be a better approach to the problem of invasive species. For invasive nitrogen fixing species, an ecosystem approach may be essential to habitat restoration.

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