Invasive Species Management: Ensuring the 'Cure' Is Not Worse Than the Condition

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Published in PRAIRIE INVADERS: PROCEEDINGS OF THE 20TH NORTH AMERICAN PRAIRIE CONFERENCE, UNIVERSITY OF NEBRASKA AT KEARNEY, July 23–26, 2006, edited by Joseph T. Springer and Elaine C. Springer. Kearney, Nebraska : University of Nebraska at Kearney, 2006. Pages 381-386.

INVASIVE SPECIES MANAGEMENT: ENSURING THE 'CURE' IS NOT WORSE THAN THE CONDITION[1]

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Proceedings of the North American Prairie Conference 20:381-386

Key words: Chinese bush clover, *Elaeagnus angustifolia, Gambusia affinis*, *Lespedeza cuneata,* Russian olive, saltcedar, sericea lespedeza, silky bush clover, *Tamarix ramosissima*, *T. chinensis,* western mosquito fish

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The challenge in effectively managing invasive species arises out of our subjective response to the problem: 1) these species do not belong in our ecosystems; and 2) their impact on our ecosystems will be negative. These visceral responses typically dove-tail into the fundamental management objective: get rid of it! Society promotes the idea that good management is timely, and the best approach is to catch an invasive species before it reaches exponential population growth and becomes widespread. Although this is a sound approach, multiple examples illustrate that it is not universally applicable. Exotic species that are intentionally introduced either for resource improvement or classical biological control purposes are now themselves targets of management programs. Negative publicity associated with adverse outcomes of invasive species management has resulted in widespread 'management paralysis'. Risk assessment is presented here as a viable strategy to offset this trend, and can be significantly enhanced through the adoption of best management practices.

Invasive species management should be timely, but this goal is realistic only to a point. Most invasive species have attained high density, widespread populations by the time they are detected. Furthermore, a significant lag between detection and approval (allocation of funds) for management programs is typical. There are also drawbacks to timely treatment. The far-reaching consequences of management actions are not always fully understood before implementation. Managers may also find that they are implementing control or resource improvement measures without fully understanding their potential efficacy. Even well planned and executed management implemented with the best of intentions can sometimes backfire. Some species, whether exotics intentionally introduced to North America or natives transplanted outside their historic range, either for biocontrol or resource improvement purposes, are now themselves targets of management programs. A discussion of 2 notable examples follows.

Sericea Lespedeza

The perennial shrub sericea lespedeza (*Lespedeza cuneata*), also known as Chinese bush clover or silky bush clover (and hereafter referred

[1] This paper is based on the final keynote address to the conference and was not referreed.

to as "sericea"), was initially introduced to the U.S. in 1896 at the North Carolina Agricultural Experiment Station and beginning in the 1930s, was intentionally planted throughout the U.S. This species was valued as livestock forage due to its high protein content, as a measure to control soil erosion, and to provide wildlife cover (Ohlenbusch et al. 2001). This drought tolerant perennial legume thrives across a broad range of soil acidities and fertilities (Cline and Silvernail 1997), propagating vegetatively through its extensive root system and a high volume seed rain (Guernsey 1970). Sericea has adapted to a broad range of climatic conditions, with its North American range extending from Florida to Texas, north to Nebraska, and east to Michigan and New York (USDA-NRCS 2004). Haying activities are thought to be a primary source of new infestations. Native grass seed mixture collected from sericea infested rangelands used for seeding Conservation Reserve Program (CRP) lands has also been implicated in the spread of this invasive species (Munger 2004). Sericea has been considered a problem invasive species since the 1980s, although it continues to have some proponents.

Sericea does provide high quality forage, but only if it is regularly mowed or grazed. Old shoots are tough with high tannin levels which are unpalatable to most livestock. Sericea's high reproductive success, due to its dual modes of reproduction, allows it to become dominant within many invaded vegetation community and habitat types. Sericea's root exudates are thought to be allelopathic, further increasing its competitive ability with desirable vegetation, and in turn decreasing the overall diversity of infested areas. The perception that this species delivers high quality forage from marginal rangeland is not entirely accurate. Sericea is a metabolically inefficient species and its low photosynthetic rate requires an abundance of water to produce forage. The assumption that as a leguminous species, sericea significantly adds to localized nitrogen fixation is similarly inaccurate. Now that it has become a management target, control of this species is complicated by its close resemblance to desirable native legumes (especially slender lespedeza) (USDA-NRCS 2004).

Western Mosquitofish

The western mosquitofish, *Gambusia affinis* (hereafter referred to as mosquitofish), is an indigenous North American species that has been introduced to waterways well beyond its relatively narrow historic native range (Courtenay and Meffe 1989). Prized for its perceived value as a biological control for mosquitoes, the mosquitofish adapts well and readily to a broad range of hostile environmental conditions encountered outside of its native habitat (Krumholz 1944, Al-Daham and Bhatti 1977). Individuals of this species are thought to be capable of consuming > 80% of their own body weight in mosquito larvae daily (Chipps and Wahl 2004). However, typical mosquitofish mosquito larvae consumption is probably no greater than that of several native fish species (Childs 2006, Billman et al. 2007). Furthermore, that consumption rate has been documented to drop significantly when the diet is supplemented with zooplankton (Bence 1988). The mosquitofish's aggressive nature undoubtedly has a negative impact on the survival of native species (Lloyd et al. 1986, Courtenay and Meffe 1989). Known and probable victims of the mosquitofish include: Plains topminnow (*Fundulus sciadicus*), Gila topminnow (*Poecilliopsis o. occidentalis*), Yaqui topminnow (*P. o. sonoriensis*), pupfish (*Cyprinodon* spp.) in general, and White Sands pupfish (*Cyprinodon tularosa*) in particular (Courtenay and Meffe 1989, Minckley et al. 1991). The mosquitofish is frequently released for mosquito control outside of its native range under the assumption that it would have a minor impact on terrestrial and aquatic life because it would not over winter under local conditions. A recently completed risk assessment evaluating the risk of establishment and deleterious impacts on native minnows and species of concern from mosquitofish in Montana waterways identified some rivers with a high enough mean January temperatures due to the influence of hot springs to be at risk of supporting locally persistent populations of mosquitofish (Schleier et al. 2008).

"Management paralysis" arises as the result of negative publicity associated with adverse outcomes of invasive species management. In order to fully understand the true nature of repercussions from such negative publicity and adverse outcomes, one should probably briefly review the history of Federal oversight of environmental affairs in the United States. The National Environmental Policy Act (NEPA) was established in 1969. The twin aims of NEPA, with regard to resource management, are to ensure that: 1) Federal agencies have adequately exercised their obligation to consider every significant aspect of the environmental impacts of proposed management actions; and 2) said agencies will inform the public that environmental concerns have been considered in the decision-making process associated with selecting and implementing management actions. NEPA's guidelines for conducting and publishing environmental impact statements are codified in the Council on Environmental Quality's Regulation 40 CFR Section 1502.

Regulation 40 CFR Section 1502.22 deals with adverse effects: "If the incomplete information relevant to **reasonably foreseeable significant adverse impacts** is essential to a reasoned choice among alternatives and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement." In other words, the agency must address data gaps for a range of treatment scenario outcomes, even when existing information about the subject is inadequate to state a conclusion from the scientific record alone. If development of the data is affordable, then it must be developed and provided within the body of generally available science. If missing data are prohibitively expensive to collect, then their absence and relevance to the project must be documented, a summary of related, credible data must be provided, and an agency evaluation of the potential impacts of the missing or unavailable data (generally developed through modeling) must be developed and presented. Methods used to fill data gaps can be theoretical, but must be generally accepted by the scientific community, cannot be based on pure conjecture, and must fall within the rule of reason.

Modeling is a sanctioned method for achieving NEPA's requirement that "reasonable and reasonably foreseeable significant adverse effects" of management actions are appropriately characterized. Risk assessment is a standardized and objective modeling approach for presenting known information about hazard (also known as effect), pattern of use (exposure), and dose-response relationships between environmental hazards and receptors. Risk assessment can also serve to document the agency's integrated characterization of potential risk, including projections of information addressing data gaps in all of the three previously identified information sets.

On a more practical note, by understanding the environmental risks associated with invasive species and associated management tactics, we can systematically identify data gaps in invasive weed management, prioritize management decisions and actions, separate opinions from facts, provide objective comparisons of risks and benefits associated with multiple potential control options (= comparative risk assessment), and provide resource managers with decision and communication tools. Models, including risk assessments, are not a panacea: no model can reliably predict the outcome of management actions without a reasonable amount of background information, but they can be very useful in incorporating general ecological principles into management strategies. When models incorporate structured observations that have been reported over time, they can be used to facilitate adaptive management.

Under the best productively collaborative circumstances, researchers can advise resource managers tasked with fulfilling NEPA obligations regarding the anticipation of reasonable and reasonably foreseeable significant adverse effects of management actions by: conducting targeted research that characterizes and quantifies treatment impacts, identifying general ecological principles to incorporate into management strategies, help in developing appropriate decision-making and monitoring tools for selecting treatments, then assess their impacts and efficacy. In the context of invasive species management, this amounts to developing, adopting and adhering to a set of clearly defined best management practices. Table 1 is adapted from the code of best management practices for biological control of weeds. Foremost among these should be ensuring that the invasive species' impact justifies any risks associated with the adopted management action. Furthermore, when considering "how bad ***is*** the invader?", "bad" needs to be considered in terms of the full range of ecological, economic, aesthetic, social and political impacts. A discussion of examples follows, where failure to follow a key best management practice led to negative publicity associated with adverse outcomes of invasive species management.

Table 1. Suggested code of best management practices for invasive species. (Adapted from Balciunas and Coombs 2004).

1. Ensure that ecological or economic impact can be attributed to the invasive species, and that impact is significant enough to justify the known and potential risks associated with the management action.
2. Obtain multi-agency agreement on the need to control the species.
3. Select control measures with known potential to control the target weed.
4. Use only safe and approved control measures.
5. Ensure that only the intended control measures are used.
6. Use appropriate protocols for application and documentation.
7. Monitor impacts on the target species.
8. Stop using ineffective control measures, and suspend treatment when control is achieved.
9. Monitor impacts on potential non-target species.
10. Encourage assessment of changes in plant and animal communities.
11. Monitor potential interactions among control measures.
12. Communicate results to the public.

Salt Cedar

The non-native shrub or small tree saltcedar (*Tamarix ramosissima*, *T. chinensis* and their hybrids) introduced to North America from Asia for use as a windbreak, ornamental and aid in erosion control (Robinson 1965), has become significantly invasive throughout western U.S. riparian areas. Biological control of saltcedar has been confounded by its use as a nesting tree by an endangered species, the southwestern subspecies of the willow flycatcher (*Empidonux trailii extimus*). Nesting occurs in areas where saltcedar has displaced its native hosts, willow and cottonwood, in riparian areas where seasonal water levels are regulated by dams (Busch and Smith 1995). Although the USDA Agricultural Research Service was directed to investigate saltcedar biocontrol, the U. S. Fish and Wildlife Service voiced concerns that the bird might lose critical habitat if saltcedar were extirpated through biocontrol (Lovich and DeGouvenain 1998). This case exemplifies the need for determining *a priori* if other resource management entities agree that the invasive species is an appropriate management target. The legal and public relations implications of interagency turf wars, potential benefits of management cost-sharing and other economic considerations support obtaining multi-agency approval before implementing management against invasive species.

Russian Olive

In a similar example, Russian olive *(Elaeagnus angustifolia)*, has been planted in shelterbelts throughout the western U. S. to reduce wind erosion and improve wildlife habitat. This program has been historically supported by the Natural Resources Conservation Service (NRCS, formerly the U.S. Soil Conservation Service or SCS). Negative environmental impacts associated with the uncontrolled spread and local dominance of Russian olive include: dewatering of sites, crowding out of native species leading to a significant reduction in biodiversity, and significant native wildlife habitat deterioration (Brock 1997). Continued local support for this species can be summed up in 2 statements: 1) Russian olive shelterbelts provide excellent habitat for exotic game bird species; and 2) "what else is going to grow in eastern Montana?", even though the NRCS has now issued statements of caution about planting this highly invasive species near riparian areas (USDA-NRCS-WY 2006). These examples also illustrate how the intent to implement management actions through environmentally and economically sound control measures that have proven efficacy is frequently thwarted by lack of information. "Environmental and economic soundness" and the "proven efficacy" of management efforts is frequently unknown or highly variable, and is likely to change as more information becomes available.

Caveats

Significant caveats for using risk assessment are linked to informational and therefore predictive limitations.

1) Risk assessments can only be used to determine the acceptability of known risks (= parameterized through existing data) associated with management actions.
2) Risk assessments are far from comprehensive in environmental impact scope. Performing a risk assessment often clearly indicates the need for more data.
3) The underlying costs of environmental and economic risks should be integrated components of a 'systems' analytical approach. Risk assessment alone identifies only potential costs or risks without weighing associated benefits.

Effective risk assessment and anticipation of reasonable and reasonably foreseeable significant adverse effects of management actions depend on a solid commitment to using appropriate protocols for documenting, applying and monitoring treatments. Feedback through monitoring is the only way to determine the efficacy of treatments under local conditions and monitoring non-target species is essential.

In our opinion, 2 key factors that will improve the odds that management tactics will not make the invasive species problem worse are: 1) feedbacks through systematic, structured and objective monitoring of management impacts; and 2) enhanced cooperation and communication among managers, researchers and policy makers.

Finally, perhaps it is time for a complete paradigm shift. Can we reduce negative environmental impacts resulting from invasive species management actions simply by extending the objective of management beyond the control of individual species? Can this be accomplished by developing management strategies that instead focus on facilitating the restoration or improving the productivity and diversity of invaded habitats?

LITERATURE CITED

Al-Daham, N. K., and M. N. Bhatti. 1977. Salinity tolerance of *Gambusia affinis* (Baird and Girard) and *Heteropneustes fossilis* (Bloch). Journal of Fish Biology 11:309-313.

Balciunas, J. K., and E. M. Coombs. 2004. International code of best practices for classical biological control of weeds. Pages 130-136 *in* E. M. Coombs, J. K. Clark, G. L. Piper, and A. F. Confrancesco, Jr. (editors), Biological control of invasive plants in the United States. Oregon State University Press, Corvallis, Oregon USA.

Bence, J. R. 1988. Indirect effects and biological control of mosquitoes by mosquitofish. Journal of Applied Ecology 25:505-521.

Billman, E. J., E. J. Wagner, and R. E. Arndt. 2007. A comparison of mosquito consumption and prey selection between least chub (*Lotichthys phlegethontis*) and western mosquitofish (*Gambusia affinis*). Western North American Naturalist 67:71-78.

Brock, J. H. 1997. The ecological role of tamarisk and Russian olive: interaction with native species and other exotic plants. Colorado State University, U.S. Department of Interior - Bureau of Land Management, and the U.S. Fish & Wildlife Service Woody Plant Wetland Workshop: Saltcedar and Russian Olive. 3-4 September 1997. Grand Junction, CO.

Busch, D. E., and S. D. Smith. 1995. Mechanisms associated with decline of woody species in riparian ecosystems of the southwestern U. S. Ecological Monographs 65:347-370.

Childs, M. R. 2006. Comparison of Gila topminnow and western mosquitofish as biological control agents of mosquitoes. Western North American Naturalist 66:181-190.

Chipps, S. R., and D. H. Wahl. 2004. Development and evaluation of a western mosquitofish bioenergetics model. Transactions of the American Fisheries Society 133:1150-1162.

Cline, G. R., and A. F. Silvernail. 1997. Effects of soil acidity on the growth of sericea lespedeza. Journal of Plant Structure 20:1657-1666.

Courtenay, W. R., and G. K. Meffe. 1989. Small fishes in strange places: a review of introduced poeciliids. Pages 319-331 *in* G. K. Meffe and F. F. Snelson, Jr. (editors), Ecology and evolution of livebearing fishes (Poeciliidae). Prentice Hall, Englewood Cliffs, New Jersey, USA.

Guernsey, W. J. 1970. Sericea lespedeza: its use and management. Farmers' Bulletin No. 2245. U. S. Department of Agriculture, Washington, D. C., USA.

Krumholz, L. A. 1944. Northward acclimatization of western mosquitofish, *Gambusia affinis affinis*. Copeia 1944:82-85.

Lloyd, L. N., A. H. Arthington, and D. A. Milton. 1986. The mosquitofish: a valuable mosquito-control agent or a pest? Pages 6-25 *in* R. L. Kitching (editor), The ecology of exotic animals and plants: some Australian case histories. John Wiley & Sons, Brisbane, Australia.

Lovich, J. C., and R. C. DeGouvenain. 1998. Saltcedar invasion in desert wetlands of the southwestern United States: ecological and political implications. Pages 447-467 *in* S. K. Majumder, E. W. Miller, and S. J. Brenner (editors), Ecology of wetlands and associated systems. Pennsylvania Academy of Science, Easton, Pennsylvania, USA.

Minckley, W. L., G. K. Meffe, and D. L. Soltz. 1991. Conservation and management of short-lived fishes: the cyprinodontoids. Pages 247-282 *in* W. L. Minckley and J. E. Deacon (editors), Battle against extinction: native fish management in the American west. University of Arizona Press, Tucson, Arizona, USA.

Munger, G. T. 2004. *Lespedeza cuneata*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. <www.fs.fed.us/database/feis> Accessed in September 2007.

Ohlenbusch, P. D., T. Bidwell, W. H. Fick, G. Kilgore, W. Scott, J. Davidson, S. Clubine, J. Mayo, and M. Coffin. 2001. Sericea lespedeza: history, characteristics, and identification. MF-2408. Agricultural Experiment Station, Cooperative Extension Service, Kansas State University, Manhattan, Kansas, USA.

Robinson, T. W. 1965. Introduction, spread and areal extent of saltcedar (*Tamarix*) in the western states. U. S. Geological Survey Professional Paper 491-A.

Schleier, J. J., III, S. E. Sing, and R. K. D. Peterson. 2008. Regional ecological risk assessment for the introduction of *Gambusia affinis* (western mosquitofish) into Montana watersheds. Biological Invasions. <www.springerlink.com/content/f353t2740657t45h/fulltext.pdf>

USDA-NRCS (U. S. Department of Agriculture, National Resource Conservation Service). 2004. PLANTS database. <plants.usda.gov/> Accessed in September 2007.

USDA-NRCS-WY (U. S. Department of Agriculture, National Resource Conservation Service - Wyoming). 2006. National Resource Conservation Service – Conservation Practice Standard: Tree/Shrub Establishment. Code 612.