Biological Invasions of Alien Plants in the Interior Columbia River Basin

George Wooten and Peter Morrison
Pacific Biodiversity Institute
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INTRODUCTION

Biological invasions of alien plants present one of the most serious threats to long-term maintenance of ecosystem health and biodiversity (Westman, 1990, Tyser and Key, 1988, Mack, 1986, 1981) in the interior Columbia River basin (ICRB). Invasion and colonization by alien plants reduces the health and integrity of ecosystems in many ways. These invasions degrade resource values (Bucher, 1984, Pimental, 1986), alter ecosystem processes (Walker and Vitousek, 1991, Verstraete and Schwartz, 1991, Melgoza et. al., 1990), affect trophic levels (Vitousek et. al., 1987, Kerpez and Smith, 1987, Harty, 1986), and can lead to endangerment and extinction of native species (Flather, 1994, Parenti and Guerrant, 1991). Interspecific interactions between native and introduced species adversely affect more than 50% of all threatened and endangered species in the United States (Flather, 1994). This is the second most important cause of species endangerment (after habitat loss). Given these impacts, prevention and control of alien plant invasions should be integral to ecosystem management policies in the ICRB.

In most cases, biological invasions occur gradually and inconspicuously. By the time that public awareness develops, the effects are often irreversible and resources may be irretrievably committed, productivity lowered and biodiversity reduced (USDI-BLM, 1994). Land management agencies have made some efforts to control a certain class of biological invaders (noxious weeds), but have never seriously addressed the causes of biological invasions or understood the depth and extent of this problem. Control of invading plants has proven to be difficult, expensive and often ineffectual (Warnock and Lewis, 1980). Land management agencies should emphasize prevention of invasion rather than control of established invaders (USDI-BLM, 1994).

OBJECTIVES

- Prevent further invasion of alien plants into uncolonized areas in the ICRB.
- Increase education and awareness about biological invasions of alien plants.
- Revise federal land management policies to emphasize prevention of invasion rather than control of invaders.
- Revise or eliminate land management practices which inadvertently contribute to the spread of alien plants.
- Eliminate land management practices which deliberately spread alien plants.
- Develop attainable control strategies to reduce or eliminate alien plants without causing disruption of ecosystem components and processes.
- Incorporate surveys for new invaders, and monitor trends of established invaders.
- Include all alien plant invaders as species of concern when analyzing impacts of management activities and developing control programs. The narrow focus on currently defined "noxious weeds" should be expanded to include all alien species.
- Provide funding and manpower for long-term programs of alien plant management, including increased cooperation between agencies and the public.
- Initiate further research into the causes and consequences of biological invasions in the ICRB.

PRINCIPLES

Many ecologists have expressed concern about invading plant taxa because of their adverse environmental impacts (Soulé, 1990, Temple, 1990, Bazzaz, 1986, Vitousek, 1986). There is interest on the part of the public in these plants, as evidenced by the large number of popular books on weeds. There is a concern by some personnel in various agencies to focus attention on these important issues (USDI-BLM, 1994, Salwasser, 1989, Losensky, 1987).

Land management agencies have failed to address the causes of biological invasions of alien plants and develop effective prevention and control strategies. Plant invasions remain one of the most serious threats to the long-term maintenance of regional biodiversity (Johnson et. al., 1994, Clary and Medin, 1990). Severe costs—degradation or even destruction of biological resources—have resulted from policies of nonaction and inappropriate action (Cottam and Stewart, 1940). To be effective, policies need to be based on an understanding of the biology of invading species and must place higher priorities on prevention of new introductions and stopping the further spread of invaders (Campbell, 1993).

Terminology

This paper attempts to adhere to a consistent terminology (Bazzaz, 1986, Lincoln et. al., 1990). "Colonizing" species are those that have recently entered unoccupied habitats, while "invaders" are those colonizers that have gone on to displace native components or which have become dominant in parts of their new environment. "Noxious weeds" are used with reference to legally defined plant entities. "Alien" or "exotic" taxa refer to any species generally viewed as non-native, on non-indigenous to new parts of its present range, while "introduced" taxa will refer to those aliens disseminated by man.

Effect of Alien Plants on Ecosystems in the ICRB

Alien plants alter ecosystem function and composition in several ways:

- native species are displaced through competitive exclusion by invaders (Thompson and Grime, 1979, Weaver et. al., 1989, Harris, 1967).
- changes occur in the outputs of ecosystem processes (Hobbs and Huenneke, 1992), e. g., nutrient cycling (Vitousek, 1986), erosion (Lacey et. al., 1989), disturbance frequency (Young and Evans, 1978), net primary productivity (Vitousek, 1986, Nadelhoffer et. al., 1985), evapotranspiration (Kerpez and Smith, 1987, Horton, 1977).
- habitat for native organisms may be reduced or eliminated (Nee and May, 1992, Brothers and Spingarn, 1992).
- food webs may be disrupted by elimination of important native primary producers (Orians and Solbrig, 1977, Marks and Bormann, 1972) or replacement by maladaptive herbivores (Edwards and Gillman, 1987, Daubenmire, 1940).

The following examples illustrate how plant invasions have recently altered ecosystems in the Pacific Northwest:

- Displacement of native plants and reduced plant diversity resulted following entry of *Centaurea maculosa* (spotted knapweed) (Tyser and Key, 1988).
- Increased surface runoff and sediment yield occurred in areas infested with *Centaurea maculosa* (spotted knapweed) (Lacey et. al., 1989).
- Interference by *Cirsium vulgare* (bull thistle) resulting in lowered growth rate and survival of *Pinus ponderosa* in forest plantations (Randall and Rejmánek, 1993).
- Displacement of native bunchgrasses by *Bromus tectorum* (cheatgrass) following fire (Melgoza et. al., 1990).
- *Bromus tectorum* (cheatgrass) dominance caused permanent changes in fire regime, increased frequency and severity of stand-destroying fires, eliminated shrub cover, increased erosion, and lowered outputs of forage (Billings, 1983, Peters and Bunting, 1994, Humphrey, 1984, Young and Evans, 1976, Harniss and Murray, 1973, Wright and Klemmedson, 1965).
- Changes in uptake and cycling of soil nutrients have resulted from elimination of cryptobiotic crusts, which accompany species changes resulting from soil disturbance (Bolton et. al., 1993, Anderson et. al., 1982, Kleiner and Harper, 1972).
- Loss of species diversity occurred in timberline vegetation with exotic invasion by *Poa pratensis* (Kentucky bluegrass) and *Phleum pratense* (timothy) (Weaver et. al., 1989).

- Steady increases in the spread of *Acroptilon repens* (Russian knapweed) patches appear to be caused by allelopathy, or plant chemical defense (Kelsey and Bedunah, 1989).
- Reductions in survival and growth of *Pinus lambertiana* (sugar pine) seedlings were correlated with reductions in the formation of beneficial ectomycorrhizal fungi following seeding of the non-mycorrhizal grass *Lolium multiflorum* (annual, or Italian rye) (Amaranthus and Perry, 1994).

Causes of Plant Invasions in the ICRB

Plant invasions are largely caused by human activities which disturb native ecosystems (Sheley, 1994, USDI-BLM, 1994, Harrod, 1994). Vegetation removal and ground disturbing activities create opportunities for colonization by alien plants (Orians, 1986, Bazzaz, 1983). Transportation of alien plant propagules is often accomplished through deliberate or inadvertent human activities or the behavior of livestock (Guillerm 1991, Durgan, 1989). On public lands, the primary activities which promote the spread of alien plants are road building and road use, logging, grazing, forage seeding, and some erosion control and fire rehabilitation measures (Saunders et. al., 1991, Tyser and Worley, 1990, Wilcove, 1989, Le Houérou, 1987).

Consequences of Plant Invasions

Management activities associated with logging, roads, and grazing are rapidly accelerating the rate of plant invasions on public lands in the ICRB (Johnson et. al., 1994, Tyser and Worley, 1992, Scott et. al., 1988). Infestations of noxious weeds (only a small subset of alien taxa) are doubling every 5-6 years on BLM lands in the ICRB (USDI-BLM, 1994). A total of approximately 393 taxa have currently been identified as invaders within the North Cascades and Columbia Basin (Wooten and Morrison, in prep.) These alien plants have already lead to great resource damage resulting in considerable economic costs (USDI-BLM, 1994, O'Toole, 1988). Alien plant invasion have led to endangerment of native species and plant communities (Weaver et. al., 1989, Chicoine et. al., 1988, Tyser and Key, 1988). Numerous cases exist where environmental and legal thresholds for degradation and disturbance have been exceeded (Penders, 1995, Warnock and Lewis, 1980). Public agencies are unprepared to face coming land management challenges in this rapidly changing field. Prevention of further spread into unroaded, unmanaged and relatively pristine areas is critical to long-term conservation of ecosystem resources, as these areas still retain undisturbed native flora and natural resilience to management-induced disturbances (DeAngelis and Waterhouse, 1987, Johnson et. al., 1994, Hobbs and Huenneke, 1992, West, 1993, Wilson, 1989).

Environmental Effects of Weed Control with Herbicides

In 1989, a five year injunction against herbicide spraying by the Pacific Northwest Region Forest Service was lifted after preparation of the Final EIS and Accompanying Record of Decision on Managing Competing and Unwanted Vegetation (Torrence, 1988), and the associated mediated agreement between the USDA and plaintiffs Northwest Coalition for Alternatives to Pesticides (O'Brien, 1989), in which provisions for priority of prevention strategies and use of herbicides only as a last resort, were stipulated along with government requirements to perform site-specific analysis and monitoring.

The excessive reliance on chemical control measures commonly found in federal land management policies has no place in an integrated weed management strategy and sound ecosystem management. This emphasis also dominated the scientific contract report on noxious rangeland weeds for the Interior Columbia Basin Ecosystem Management Project (Sheley, 1994). This violates both the letter and intent of the mediated agreement in which herbicide use is to be used only as a last resort.

For years herbicides were widely used to control plant invasions. Adverse environmental and human health effects associated with herbicide application are becoming increasingly apparent (Feldman, 1991, Warnock and Lewis, 1980, Katan and Eshel, 1973, Pimental, 1982), as in the following examples:

- Much of our native fauna is threatened by the synergistic effects of synthetic compounds on living estrogenic activity. These estrogenic compounds are associated with many herbicides and pesticides (Guillette in press, Colburn et al. 1993, Fox 1992).
- Herbicide application is implicated as one of the causes in the global decline of amphibian populations (Blaustein and Wake 1995).
- Replacement of beneficial mycorrhizal flora and the iron chelators they produce with allelopathic actinomycetes resulted in the conversion of productive forestland to unforested openings (Perry and Amaranthus, 1994, Amaranthus and Perry, 1987, Perry 1984).
- Persistence of herbicides through soil and humus binding is unaccounted for in most quantitative measurements of toxicity used to determine safe exposure levels (Bordeleau and Bartha, 1971), and the possibility exists that they may be released at unexpected times in the future (Pramer and Bartha, 1980).
- Transport of pesticides up food chains and concentration in lipid tissues of secondary consumers can result in exposures to fish 49,000 times higher than to target organisms (Reinert, 1967).
- Destruction of plants seeds resulted in declines of nontarget gophers (Brown, 1978).
- Destruction of nontarget plants resulted in lowered species richness and replacement by introduced species following 2,4-D treatment of native *Veratrum californicum* in an alpine plant community (Anderson and Thompson, 1993).
- So-called “inert” ingredients laws allow the application of toxic compounds such as kerosene, diesel fuel or fungicides to be used as 98% of a mixtures application rate (Grier, 1994).
- Surfactants in different commercial preparations of glyphosate result in 400-fold greater toxicity to sockeye salmon fry (Monroe, 1988).
- Human and other nontarget mammalian effects are well-documented in all herbicides used on public lands. Organ systems prone to suffer damage are the nervous system, immune system, cellular respiration cycle, electron-transport chain, cell membrane function and diverse oncogenic and teratogenic effects (O'Brien, 1984).
- As a result of chemical exposure, reproductive sterility has resulted in females, reduced sperm counts has resulted in males (Sharpe and Skakkebaek, 1993) and birth defects have occurred in children (Kurzel and Cetrulo, 1981, Wilson, 1977).
- The most comprehensive weed management plans still may cause irreversible and irretrievable resource commitments, such as crop losses associated with drift of supposedly non-toxic chlorosulfuron (Fletcher et. al., 1993) or the 1995 herbicide spill resulting from the

crash of an herbicide truck into a creek (and release of herbicides into water) on the Okanogan National Forest in Washington.

Environmental Effects of Integrated Weed Management

- Biological controls are insects or pathogens that control populations of undesirable species. Such pathogens may be natural components in the original habitat of a weed, that are absent in the new environment. After confirmation of specificity to target plants, biological controls have resulted in spectacular effects on target organisms (Piper, 1984, Kelleher, 1984), as exemplified by the following example. Tansy ragwort (*Senecio jacobaea*), a noxious weed affecting much of Oregon and Washington, has been reduced to about 10% of mid-1970 infestation rates by a biological control program. Benefits of the program, utilizing cinnabar moth, ragwort seedhead fly and ragwort flea beetle, approximate $5 million annually, a return on investment of 83%, a benefit-to-cost ratio of 13:1 (USDI-BLM, 1994).
- Mechanical controls such as mowing are effective on obligate outbreeders such as diffuse knapweed (*Centaurea diffusa*) when the treatment is timed to preceed flowering (Harrod, 1991).
- Manual controls are the most selective methods toward target organisms and may be the only available method in certain situations, for example wilderness, along riparian areas or in rocky areas.
- Cultural controls that affect revegetation are important, and are often specified in treatments. However the indiscriminate use of nonnative seeding mixtures has resulted in great damages occurring as a result of treatment. In Hell's Canyon RNA yellow star thistle (*Centaurea solstitialis*) was present in a seed mix applied after the 1988 TeePee fire (Bob Williams - Wallowa Whitman NF, personal communication) resulting in over $200,000 in ongoing control costs. The regular seeding of strongly competitive and aggressive alien grasses or clover following National Forest management causes dramatic displacement of native vegetation (Ralphs and Busby, 1979).

RECOMMENDATIONS AND GUIDELINES

Program Development and Cooperative Agreements

Each agency or jurisdiction in charge of maintaining land-based resources needs to develop and maintain an alien plant program with funding and manpower responsible for the prevention and control of invading species. Individual programs should be designed to be compatible with ecosystem processes for the particular area, and be specific to the invading plants and characteristic causes of invasions for each area.

Cooperative agreements between private interests, non-governmental organizations, federal, state and local governments should be encouraged in countering the invasion of alien plants. Land managers, field personnel, ecologists, botanists and biologists should be consulted about the nature and spread of invading taxa, as well as invaded ecosystems. Public interest and environmental groups should be allowed a chance to contribute. These groups can give invaluable support and manpower in solutions to weed spread. Efforts should be made to contact and educate all groups whose activities may increase the spread of alien plants.

Information Gathering

Identification of the nature and extent of plant invasions in each jurisdiction should be conducted by combining a review of known occurrences with additional surveys for new invaders. Baseline monitoring data will allow subsequent surveys to determine population trends, causative factors, rate of spread, persistence and potential for further spread into adjacent ecosystems. Review and amend lists of invading taxa and policies for their prevention and control following analysis of this data.

Prevention Strategies

Prevention strategies should be stressed over control measures, as control measures are futile once a certain population threshold is attained in the invading species. Prevention should be based on prioritization of areas based on a combination of ecosystem values and the threat of invasion as follows:

Priority 1 are those areas with intact ecosystem processes, essentially free of invaders. No management activities should be allowed which cause deliberate or inadvertent introduction of alien plants. Management objectives should put maintenance of unpolluted flora as a top priority.

Priority 2 are intact ecosystems which possess only a few invading taxa. Invaders threaten the ecosystem, plant community structure or landscape-level processes, but control efforts may be successful. No management activities should be allowed which cause further introduction of alien plants. Management objectives should emphasize environmentally benign but aggressive biological and mechanical control measures to reduce or eliminate alien plant populations.

Priority 3 are intact native ecosystems which possess only a few invading taxa that do not appear to threaten the ecosystem, but the spread of which may still be worth controlling. No management activities should be allowed which cause further introduction of alien plants. Management objectives should emphasize environmentally benign biological and mechanical control measures to reduce or eliminate alien plant populations.

Integrated Weed Management

Strategies for control are both more complicated and more costly. Control is a treatment strategy—not a prevention strategy. In general, control measures should be undertaken based on a prioritization procedure combining nature, quantity and number of invading species, their potential for spread to adjacent ecosystems, the nature of affected ecosystems, loss of values because of their spread, and long-term costs of control. Strategies based on these attributes are documented in USDI-BLM (1994), Harrod (1994), USDA Forest Service (1990), Torrence (1988, and the associated mediated agreement) and Hoglund et. al. (1991). Control strategies come under agency guidelines for integrated weed management (IWM). IWM begins with

information gathering, surveying, and determination of a damage threshold (Hoglund, 1991). For control measures, action strategies are then further developed that incorporate education, prevention, mitigation, and control alternatives (USDI-BLM, 1994). Environmentally benign mechanical and biological control methods should be used in almost all cases on public lands. Herbicide use should be considered as *a last resort* only after biological consultation to ensure no damage will occur to native flora and fauna and human health is not endangered. All other measures must be exhausted before herbicide use is contemplated.

Adaptive Management

Deleterious management practices that contribute to the spread of alien taxa should be reexamined and revised. These would include seeding invasive species, using contaminated seed mixes, feeding with contaminated grain, transporting of weeds on stock, gear and clothing, and avoidable disturbances to soil, water and nutrients. Some of these are ingrained practices that will require infrastructure changes of land management agencies.

Further plant invasions caused by vegetation removal and ground disturbance (e.g. roading, logging and grazing), can be prevented by restricting these activities from intact native ecosystems (e.g. roadless areas and wilderness), where the effects of man are still largely unfelt. These areas are the highest priority for prevention strategies, and retain the last vestiges of resiliency present in native ecosystems of the ICRB. There is little moral or ethical ground for degrading these last remnants of pristine landscape. In other areas where alien plants are already well established, there must be some acceptance that biological invasions are often irreversible.

Education

The need for management of invading plants requires a long-term commitment to education and awareness of the nature and extent of this problem. Plant and weed identification needs to be routine for land managers and should also be available to the public. Signs, brochures, posters and news articles offer a chance for communication about the problem. Workshops and classes are recommended that bring interested people together in informative, problem-solving formats

Research

There is an overwhelming need for more data on the ecology and biology of plant invasions in the ICRB. Agencies and educational institutions need to invest in research and methods that have the potential for solving the problems of invading species. Through cooperative agreements, cost-sharing and data-sharing, a better understanding of plant invasions will produce more effective prevention strategies and control techniques. Affected ecosystem components need to be studied, and at-risk ecosystems such as riparian areas should receive high priority. Specific topics that deserve attention include nutrient cycling, mycorrhizal connections, effects on wildlife, effects on biodiversity, biological controls, cultural (ecological) controls, research on target-specific or non-toxic herbicides, mechanisms of spread, genetics

and reproductive biology of invading species, and the effects of varying the nature, severity and kind of causative disturbances.

FEDERAL AND STATE LAW ADDRESSING PLANT INVADERS

Numerous federal laws, regulations and policies have been established that address management of plant invaders on public lands. Designated "noxious weeds" receive individual consideration through several of these policies. A recent USDI publication (US Department of the Interior, BLM, 1994, Appendix 2), lists those laws pertaining to the agency's role in their management, and includes brief interpretations of the intent of those laws:

> *Federal Land Policy and Management Act (FLPMA) of 1976*. Directs the BLM to 'take any action necessary to prevent unnecessary and or undue degradation of the public lands.'
>
> *Public Rangelands Improvement Act (PRIA) of 1978*. Requires that BLM will manage, maintain and improve the condition of the public rangelands so that they become as productive as feasible.
>
> *Carlson-Foley Act of 1968*. Directs agency heads to enter upon lands under their jurisdiction with noxious plants and destroy noxious plants growing on such land.
>
> *Federal Noxious Weed Act of 1974, as amended by Sec. 15, Management of Undesirable Plants on Federal Lands, 1990*. Authorizes the Secretary 'to cooperate with other federal and state agencies, and others in carrying out operations or measures to eradicate, suppress, control or prevent or retard the spread of any noxious weed. Each Federal agency *shall* 1) designate an office or person adequately trained to develop and coordinate an undesirable plants management program for control of undesirable plants on federal lands under the agency's jurisdiction, 2) establish and adequately fund an undesirable plants management program through the agency's budgetary process, 3) complete and implement cooperative agreements with State agencies regarding the management of undesirable plant species on federal lands, and 4) establish integrated management systems to control or contain undesirable plant species targeted under cooperative agreements.'
>
> *BLM Final Supplemental Environmental Impact Statement for Noxious Weeds (1987)*. Declares that the BLM has the statutory duty to control and eradicate noxious weeds on public lands.
>
> *BLM Departmental Manual 517*. Prescribes policy for the use of pesticides on the lands and waters under the jurisdiction of the BLM and for compliance with the Federal Insecticide, Fungicide, and Rodenticide Act, as amended.
>
> *BLM Departmental Manual 609*. Prescribes policy to control undesirable or noxious weeds on the lands, waters, or facilities under the jurisdiction of the

BLM, to the extent economically practicable and as needed for resource protection and accomplishment of resource management objectives.

BLM Manual 9011. Provides policy for conducting chemical pest control programs under an integrated pest management approach.

BLM Manual 9014. Provides guidance and procedures for planning and implementing biological control in Integrated Pest Management Programs.

BLM Manual 9015. Provides policy relating to the management and coordination of noxious weed activities among the BLM, organizations and individuals.

BLM Manual 9220. Provides guidance for implementing integrated pest management on lands administered by the BLM. The objective is to ensure optimal pest management with respect to environmental concerns, biological, effectiveness, and economic efficiency while achieving resource management objectives.

Additional policies are directed toward other federal or state agencies (Hoglund et. al., 1991):

The National Environmental Act (NEPA) of 1969. (Sec. 102(C)(v)). Planners are required to describe any 'irreversible and irretrievable commitments of resources.' Most biological invasions are nearly irreversible and any actions which may promote the spread of alien plants can be viewed as an irretrievable commitment of resources.

National Forest Management Act of 1976. (Sec. 6, 90 Stat. 2949). The principal legislative mandate directing the conservation of biological diversity and recognizing the value of adapted plant and animal communities. This legislation also prohibits stand conversions, the process of management-induced irreversible change from one ecosystem to another. The inadvertent or deliberate conversion of a plant community dominated by natives to one dominated by aliens can be viewed as a stand conversion.

Code of Federal Regulations, Title 36, Part 219, Section 27, Subsection G. 'Management prescriptions, where appropriate and to the extent practicable, shall preserve and enhance the diversity of plant and animal communities, including endemics and desirable naturalized plant and animal species, so that it is at least as great as that which would be expected in a natural forest and the diversity of tree species similar to that existing in the planning area. Reductions in diversity of plant and animal species from that which would be expected in a natural forest, or from that similar to the existing diversity in the planning area, may be prescribed only where needed to meet overall multiple-use objectives. Planned site conversion shall be justified by an analysis showing biological, economic, social, and environmental design consequences, and the relation of such conversions to the process of natural change.'

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Alien plants prefer the annual and perennial herbaceous vegetation in both Europe and Japan (about 80 % of all species). Fewer invaders can be found in the vegetation of floodplain shrubs and -forests and only a few in aquatic vegetation. The success of aliens is related to human impacts in river ecosystems in both areas. While there are few or no aliens in the more natural upper courses of rivers, they become more abundant in the lower courses, where river dynamics are weakened, due to the influence of dams and where there are settlements, which are sources for the dispersal of aliens. Introd Exotic plant invasions into riparia often result in shifts in vegetative composition, altered stream function, and cascading effects to biota at multiple scales. Characterizing the distribution patterns of exotic plants is an important step in directing targeted research to identify mechanisms of invasion and potential management strategies.Â @article{AlChokhachy2013ExoticPC, title={Exotic Plant Colonization and Occupancy Within Riparian Areas of the Interior Columbia River and Upper Missouri River Basins, USA}, author={R. Al-Chokhachy and A. Ray and Brett B. Roper and Eric Archer}, journal= {Wetlands}, year={2013}, volume={33}, pages={409-420} }. River restoration activities are challenging for the native vegetation and the colonization process.Â facilitate biological invasions, in particular for alien plant species [6] [7] . In recent years, there has been an increasing interest in the consequences of the spread of invasive alien species (IAS) [8] . According to the International Union for Conservation of Nature [IUCN], invasive alien species are the second most significant cause of extinction [9] . A large number of studies describe how alien species are consciously or unconsciously introduced into various environments by. The provincial Invasive Alien Plant Database shows current C. diffusa distribution ex-tending northward to around Williams Lake (52Â°7â€™ latitude) and C. stoebe reaching to Fort St. John (56Â°10â€™ latitude), with isolated populations at the Yukon border (B.C. Min-istry of Forests, Lands and Natural Resource Operations 2012; see Figure 1). The first North American report. of C. stoebe was by Macoun in Victoria, B.C., in 1893 (Groh 1943). Centaurea diffusa was first reported in Grand Forks, B.C., in 19251 and subsequently in the Okanagan Valley in the late 1930s (Groh 1943).Â 1983. Diffuse knapweed invasion into rangeland in the dry interior of British Columbia. Canadian Journal of Plant Science 63:981â€“987. Myers J., C. Jackson, H. Quinn, S. White, & J. Cory. Active biological invasions of alien species in natural ecosystems are a serious threat to. biodiversity [1, 2] and cause significant economic damage to the regions [3]. At present, the study of. plant invasions goes beyond simply identifying and analyzing alien floras [4, 5, 6]. The foundations. invasive ecology, biology and biogeography, explores the possibilities for the use of invasive plant.Â Since 2004, we conducted studies of biological invasions in the. Middle Russian forest-steppe ecosystems, which aim at studying the role of alien species in the. transformation of plant communities forest-steppe complex and the development of measures to. improve the sustainability of natural plant communities in terms of cenotic press of invasive species. In.