INT 4901 Publication Reprint #147

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IN:

Proceedings—National Wilderness Research Conference: Current Research

Fort Collins, CO, July 23-26, 1985

General Technical Report INT-212

Published 1986

Compiler:

ROBERT C. LUCAS, Project Leader, Intermountain Research Station, Forest Service, U.S. Department of Agriculture

Conference Sponsors:

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Aldo Leopold Wilderness Research Institute: Publication # 147

CITATION: Marion, Jeffrey L.; Cole, David N.; Bratton, Susan P. 1986. Exotic vegetation in wilderness areas. In: Lucas, Robert C., compiler. Proceedings--national wilderness research conference: current research; 1985 July 23-26; Fort Collins, CO. Gen. Tech. Rep. INT-212. Ogden, UT: USDA For. Serv., Intermountain Research Station: 114-120.

EXOTIC VEGETATION IN WILDERNESS AREAS

Jeffrey L. Marion, David N. Cole, and Susan P. Bratton

ABSTRACT: Exotic plant species have been introduced and dispersed throughout most, if not all, of our wilderness areas. Although most of these species are restricted to disturbed areas, some have become naturalized and are capable of invading and displacing native vegetation. This paper examines the reasons why wilderness managers should be concerned about these exotic species, their introduction and dispersal mechanisms, extent of occurrence, implications for managers, and potential methods for control.

INTRODUCTION

A pristine wilderness has value as both a recreational and scientific resource. Increasing numbers of recreationists are attracted to our wilderness areas largely because of their undeveloped and natural environments. Information about naturally functioning ecosystems from these undisturbed environments is becoming increasingly valuable as baseline data for the identification and evaluation of human-induced changes in developed environments. The values our society attaches to wilderness areas are directly tied to the present and continued purity of their natural ecosystems.

This paper examines one potential threat to the purity of wilderness ecosystems: the introduction and spread of exotic plant species. Plant species that are exotic for a particular area are those not indigenous to the area that have been either intentionally or unintentionally introduced.

These exotic plant species should be of concern to wilderness managers for three primary reasons. First, because they are not indigenous, exotic plants represent deviations from natural conditions. The Wilderness Act directs wilderness managers to maintain the "primeval character and influence" of these environments and to "preserve (their) natural conditions." Managers are therefore responsible for the protection of native biota and the preservation of functioning natural ecosystems.

Paper presented at the National Wilderness Research Conference, Fort Collins, CO, July 23-26, 1985.

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A second reason for concern about exotics is that their presence, particularly on disturbed recreation sites, provides the visitor with a false image of the area's natural vegetation. Most wilderness visitors would not recognize an exotic plant as being nonindigenous to a given area unless it was a highly publicized species, such as kudzu (Pueraria lobata) in the Southeast. However, wilderness visitors spend the majority of their time on trails and campsites where these species are prevalent. A visitor's perceptions of wilderness environments and vegetation are therefore influenced by the dominant plants on these recreation sites. Exotic species such as dandelions (Taraxacum officinale), plantain (Plantago spp.), and clover (Trifolium spp.), that are common both on campsites and in suburban lawns, might lead visitors to think that wilderness vegetation is little different from that in their own backyards.

A third cause for concern is that exotic plants may invade and displace native plant species. This could alter many natural processes, including plant succession and system productivity, diversity, and stability. Previous research has shown that exotic species have displaced native plants on many wildland recreation sites and grazed meadows, but for the most part are restricted to these areas. In the West, grazing pressure on native plants often promotes the invasion of exotic plant species. Even following the removal of grazing pressures, these species can continue to survive and reproduce, permanently altering the ability of an area to return to its original state. Similarly, disturbance-associated exotics can still be found on many prewilderness resort sites, home sites, and logging camps in the Boundary Waters Canoe Area Wilderness (BWCA) of Minnesota even though they have received no disturbance following site restoration work in the 1960's (Ahlgren and Ahlgren 1984).

In a BWCA campsite recovery study, sites closed 12 to 14 years exhibited significant differences in vegetative composition when compared to adjacent undisturbed areas (Marion 1984). Exotic species accounted for an average of 20 percent of the cover on these sites, but were not observed to be spreading into undisturbed vegetation. Six of the eight closed sites had developed extensive graminoid cover, which prohibited reinvasion by forest herbaceous species.

Exotic species which are not disturbance-associated are cause for even greater concern. In the BWCA, Ahlgren and Ahlgren (1984) found one aggressive exotic species, goutweed (Aegopodium

podagraria), once planted on a resort site, that had naturalized and spread vigorously since the lodge closed in 1955. This species has unique characteristics that enable it to outcompete native vegetation in undisturbed areas (Ahlgren and Ahlgren 1984):

> Very few herbs or shrubs grow in association with goutweed because it produces substances toxic (allelopathic) to many native species that would otherwise be found here. The plant grows well in sun or shade , and its carpet now extends six hundred feet along the shore and four hundred feet back into the woods behind the lodge site, eliminating native plants as it spreads. A taller, aggressive form with no color variegation on the leaves has appeared in shadier spots. It is spreading even more vigorously, giving good indications that it is a truly naturalized part of the flora.

In the Southwest, Cole (1985) reported that one exotic grass (Bromus rubens) "covers more ground, even on undisturbed sites, than any other species--probably in the entire Grand Canyon." In eastern National Parks, Butler and others (1981), Baron and others (1979), Bratton and Butler (1982), and Rosen and others (1982) repeatedly found Japanese honeysuckle (Lonicera japonica) and kudzu (Pueraria lobata) to be widespread and potentially threatening to native vegetation. These species are poor invaders of unlogged forest, however, and generally require further human disturbance to invade mature stands.

Other well-known examples of naturalized "problem" species are: purple loostrife (Lythrum salicaria), tamarisk (Tamarix spp.), cajeput tree (Melaleuca quinquenervia), Australian pine (Casuarina equisetifolia), and peppertree (Schinus terebinthifolius). Species such as these are capable of outcompeting and replacing native plants over large areas and thus pose a significant threat to natural wilderness plant communities. If these species become dominant, they are capable of altering succession and exerting far-reaching changes in plant and animal interrelationships in the wilderness ecosystem. Both scientific and esthetic values of wilderness areas would be severely compromised by the widespread presence of exotic plant species.

The introduction and dispersal of exotic plant species in wilderness areas, extent of plant occurrence, important management implications, and possible control methods are discussed in the following sections. A review of the literature and recent wilderness and backcountry studies from the West, Midwest, and East are used to illustrate these topics and the current status of exotic plant species in our wildland environments.

INTRODUCTION AND DISPERSAL MECHANISMS

Exotic plants have been introduced to wilderness areas in many ways. Many exotics were introduced and became well-established prior to wilderness designation. Plantain, a common exotic from Europe, was called "white man's foot" by Indians who noticed that it seemed to appear wherever the newcomers walked (Ahlgren and Ahlgren 1984). This is just one of the many weedy exotics that were unintentionally introduced by settlers and early homesteaders. Other exotics, such as shade and fruit trees, ornamental shrubs, and flowers, were planted intentionally around homesites and resorts in wilderness areas prior to wilderness designation. In most instances, these exotic plant species were not removed or destroyed when the buildings were later removed. In some instances, early wilderness managers introduced exotics during rehabilitation efforts through the use of popular ground cover seed mixes containing exotics or impure native seed mixes (Smith 1982; Stephenson and others 1980).

Pack and saddle stock are an important source of exotics in many wilderness areas. Seeds from exotic species that grow on farms and ranches are transported into wilderness areas in hay used for supplemental pack stock feed. Seeds of plants consumed by pack stock prior to entry into a wilderness area may also germinate following excretion within the wilderness area. Another source is the wilderness visitor, who unintentionally transports exotics into the wilderness in soil on boots and in equipment. Wind, water, and native birds and animals are also capable of introducing exotics.

A variety of dispersal mechanisms distribute exotic plant species once they are established in a wilderness. Seeds are easily transported along trails and between campsites by visitors and pack stock. For example, herbaceous plant seeds can readily adhere to damp tent bottoms or tarps and are transported from one camp to the next before falling off and germinating. Some seeds have hooked appendages that catch on clothing until they are brushed off. The ease of dispersal associated with use of horses is readily apparent in areas receiving heavy horse use, such as the Bob Marshall Wilderness in Montana. Highly distinct zones of exotic vegetation parallel extensive sections of trail in this wilderness. Natural methods of seed dispersal may also be important, particularly in distributing seeds to naturally disturbed locations in the wilderness.

EXTENT OF OCCURRENCE

Exotic plant species appear to be present in most, if not all, wildlands in the United States. Furthermore, exotic vegetation is often geographically widespread within these areas, although largely restricted to areas of human and natural disturbance. Reported findings of exotic vegetation in both Wilderness and National Park backcountry areas are presented below.

Studies of campsite impacts provide the majority of information concerning exotic vegetation in Wilderness areas. In the West, Cole (1977) found 27 species of exotics on campsites in the Eagle Cap Wilderness of Northeastern Oregon. Although restricted primarily to campsites, trails and

grazed meadows, exotics were widespread at elevations below 7,000 feet. However, only three exotic species were found on campsites--and they were not common--at higher elevations (Cole 1982). Since dispersal is not a problem, this suggests that exotics are poorly adapted to subalpine and alpine environments. In the Bob Marshall Wilderness of Montana, 27 exotic species were identified on campsites (Cole 1983). Large numbers of exotic species were also noted along trails and in grazed meadows throughout the wilderness.

In the Midwest, Marion (1984) found 22 exotic species on campsites in the BWCA. Nearly two-thirds of the 96 campsites studied had at least one exotic species present. However, Ahlgren and Ahlgren (1984), long-time botanists of the region, report that 92 species, over 11 percent of the 817 known BWCA flowering plant species, have been introduced. Twenty-three plant families and 70 genera are represented by the exotic species, 84 of which originated from Europe. Clearly, studies of a sample of campsites fail to pick up a large proportion of the exotic species present in a given area.

In the Southeast, White (1982) found 288 (20 percent) of the vascular plant species in the Great Smoky Mountains National Park (GSMNP) were exotics. Most of these species were confined to old home sites, lawns, and roadsides, but a few, such as Japanese honeysuckle, were displacing native understory species. Lindsay (1978) found 3.2 percent exotics on high elevation burn scars and up to 15.1 percent exotics on grassy balds (open mountain meadow communities) in GSMNP. In the backcountry of the park, exotics on campsites vary from 0 percent of the flora on sites with little disturbance to 30 percent around highly disturbed shelter sites.

Some ecosystems and climatic zones are more susceptable to exotic invasion than others. Oceanic islands are very vulnerable. Temperate and some high elevation grasslands are easily invaded by exotic forbs and grasses, many of which are preadapted to grassland habitats with short disturbance rotations. The native meadows in National Parks such as Yosemite are, in many cases, now dominated by exotic species. Exotics may establish quickly on geologically unstable sites, such as river banks, gravel bars, and barrier islands. Tamarix spp. have, for example, successfully occupied both the banks of the Colorado in Grand Canyon National Park and the banks of the Rio Grande in Big Bend National Park. On the other hand, some extreme environments, such as far northern and tundra sites, support few exotics. Undisturbed temperate deciduous forest and tropical rain forest are resistant to invasion due to vigorous competition from native species.

The method and frequency of human-related introductions also influence the number of exotic invaders. In the Bob Marshall Wilderness of Montana, Cole (1983) found campsites utilized primarily by backpackers to have relatively few exotic species with little relative cover (5 percent) when compared to campsites utilized by private and commercial horse parties, which had larger numbers of exotics with extensive relative cover (43 and 61 percent, respectively). In the BWCA, campsite history was found to be an important factor influencing the number of exotics on campsites (Marion 1984). For example, 57 percent of campsites established in previously natural undisturbed vegetation had exotic species, with an average of 1.9 exotics per site. In comparison, all of the campsites established on former resort sites had exotic species present, with an average of 5.3 exotics per site. The campsite with the largest number of exotics (12) had been established on an old logging camp. These camps employed horses and oxen, and many of the exotics commonly associated with the hay brought in to feed these animals (including many grass and clover species) are still present, even in currently undisturbed areas.

A list of exotic plants found in these and other studies of wildland recreation sites in the United States is presented in table 1. A significant number of these species are found in more than one area, indicating not only their widespread occurrence, but that relatively few herbaceous species possess the morphological and life-history characteristics necessary for survival in highly disturbed environments.

MANAGEMENT IMPLICATIONS

Although exotic species are already present in most, if not all, wilderness areas, there are steps that managers can take to minimize future introductions, and to control, reduce, and possibly eliminate exotics currently in an area. The first step in an exotic species management program is to conduct a comprehensive inventory within an area to identify the exotic species present, including their distribution, frequency, and cover.

Representative specimens should be collected for each exotic species and a botanical biography, including each plant's identifying characteristics, requirements, phenology, and reproductive methods, should be developed.

The second step is to group exotics on the basis of extent of occurrence, relationship to disturbance, and ability to threaten undisturbed vegetation. Proposed groupings for management are:

1. Common disturbance-associated species -- exotics with ruderal characteristics that are common on and restricted to campsites, trails, and grazed meadows.

2. Uncommon relict species -- exotics that were intentionally planted around homesites and resorts prior to wilderness designation and were not removed during site restoration work or rare species only established in a few places.

3. Competitive "pest" species -- exotics that are able to displace native undisturbed vegetation.

Table 1.--Herbaceous exotic plant species reported on wildland recreation sites

SPECIES	CITATION
Achillea millefolium	Marion (1984); Lindsay (1978)
Agropyron repens	Cole (1983); Marion (1984)
Agrostis alba	Cole (1977,1983); Marion (1984); Lindsay (1978)
Arabis glabra	Cole (1983)
Arenaria serpyllifolia	Cole (1977)
Artemesia vulgarus	Cole (1977)
Bromus brizaeformis	Cole (1977)
Bromus inermis	Cole (1983); Marion (1984)
Bromus rubens	Cole (1985)
Bromus tectorum	Cole (1977,1983,1985)
Capsella bursa-pastoris	Cole (1977,1983); Marion (1984)
Cerastium vulgatum	Marion (1984)
Cichorium intybus	Lindsay (1978)
Chenopodium album	Cole (1983); Marion (1984)
Cirsium arvense	Cole (1977); Marion (1984)
Cirsium vulgare	Cole (1977)
Chrysanthemum leucanthemum	Marion (1984); Lindsay (1978)
Cynoglossum officinale	Cole (1977)
Dactylis glomerata	Sutton (1976); Cole (1977,1983); Lindsay (1978)
Daucus carota	Lindsay (1978)
Erodium cicutarium	Cole (1985)
Festuca rubra	Marion (1984)
Filago arvensis	Cole (1983)
Galinsoga ciliata	Lindsay (1978)
Hieracium aurantiacum	Marion (1984)
Holcus lanatus	Lindsay (1978)
Hordeum leporinum	Cole (1985)
Hypericum perforatum	Cole (1977)
Lactuca serriola	Cole (1977)
Lappula echinata	Cole (1977)
Lepidium virginicum	Cole (1977)
Lychnis alba	Cole (1983)
Matricaria matricarioides	Cole (1983); Marion (1984)
Medicago lupulina	Cole (1977,1983)
Phleum pratense	Cole (1977,1983); Marion (1984); Lindsay (1978)
Plantago lanceolata	Sutton (1976); Saunders (1979); Ranz (1979); Lindsay (1978)
Plantago major	Cole (1977,1983); Ranz (1979); Fichtler (1980); Marion (1984); Lindsay (1978)
Poa annua	Ranz (1979); Fichtler (1980); Cole (1982,1983); Saunders (1979); Lindsay (1978)
Poa palustris	Cole (1983); Marion (1984)
Poa pratensis	Dale and Weaver (1974); Sutton (1976); Cole (1977,1983); Saunders (1979); Fichtler (1980); Marion (1984)
Polygonum aviculare	Cole (1983); Marion (1984)
Polygonum cilinose	Saunders (1979)
Potentilla argentea	Cole (1983)
Prunella vulgaris	Sutton (1976); Marion (1984); Lindsay (1978)
Ranunculus acris	Saunders (1979); Marion (1984)
Rumex acetosella	Cole (1977,1983); Ranz (1979); Lindsay (1978)
Rumex crispus	Cole (1983)
Rumex obtusifolius	Lindsay (1978)
Sisymbrium altissimum	Cole (1977)
Spergularia rubra	Ranz (1979); Cole (1982)
Taraxacum officinale	Cole (1977,1983); Saunders (1979); Ranz (1979); Fichtler (1980); Marion (1984); Lindsay (1978)
Thlaspi arvense	Cole (1977,1983)
Tragopogon dubius	Cole (1977,1983,1985)
Trifolium pratense	Sutton (1976); Cole (1977,1983); Marion (1984); Lindsay (1978)
Trifolium procumbens	Marion (1984)
Trifolium repens	Dale and Weaver (1974); Sutton (1976); Cole (1977,1983); Ranz (1979); Saunders (1979); Marion (1984); Lindsay (1978)
Verbascum thapsus	Cole (1977,1983)
Veronica serpyllifolia	Marion (1984)

The third step is to formulate management policies that will minimize the introduction of exotics. For example, managers may require horse users to carry only pelletized feed instead of hay. Seed used in restoration or rehabilitation work should be of native species and pure (purchased seed typically contains a small percentage of extraneous seeds from other species). A number of specialized seed companies can supply pure seed for a wide variety of native species.

The fourth step is to formulate management policies for the control of exotics presently in an area. Because most exotics are restricted to disturbed areas, managers should try to minimize the amount of disturbed land within wilderness boundaries. In GSMNP, for example, canopy opening, due either to park maintenance practices or to visitor trampling, has encouraged exotic establishment. Further, Bratton and others (1978) and Bratton and others (1982) have shown that the amount of visitation is correlated to disturbance of campsite understories and to reduction in basal area of the canopy. Site management that reduces the destruction of canopy and of leaf litter will thus tend to discourage exotic invasion. As discussed by Cole (1981), visitor dispersal strategies tend to increase the total area of disturbance; visitor concentration strategies may need to be encouraged. Managers should also try to minimize the amount of grazing by horses, perhaps through regulations requiring the carrying of pelletized feed.

Management actions involving the removal of exotics should be related to groupings of exotics such as those proposed above. Common disturbance-associated species, which are typically not a threat to undisturbed vegetation, are almost inevitable on recreation sites. Managers can reduce or minimize the spread of these exotics, particularly through the minimization of human-related vegetation disturbance. However, DeVos and Bailey (1970) noted that, to some extent, the presence of these disturbance-associated exotics is fortuitous, as they partially protect the soil from erosion as well as contribute some organic matter that helps maintain the soil structure.

Uncommon relict species, such as shade trees, ornamental shrubs, and garden flowers, are found in areas of past disturbance and can occasionally be a threat to undisturbed vegetation. These species should generally be removed whenever encountered, but in most instances natural successional processes will eliminate them over time. Few of these exotics are strong competitors under closed canopies.

Competitive "pest" species that have the potential to invade and replace native undisturbed vegetation are of the greatest concern for managers. Control of these species will require active management programs. Complete elimination of these species is often not possible or cost-efficient.

Development of an effective and efficient exotic control program involves careful evaluation of both the exotic species of concern and the range of potential control methods. Information concerning exotic species and control methods can be obtained from universities and colleges, federal, state, and county agricultural departments, the U.S. Forest Service, National Park Service, and other federal agencies. Libraries are another excellent source of information and in particular, a quarterly publication known as the Natural Areas Journal provides a continuing source of information regarding the control of exotic "pest" species.

METHODS OF CONTROL

A variety of methods, including the application of herbicides, prescribed burning, mowing, bulldozing, hand digging, cutting, and biological control may be used to kill or remove existing exotic vegetation. Research has indicated that herbicides, in many instances, will offer the most efficient form of control but may have detrimental impacts on wilderness environments. Their use should be carefully evaluated before application. Important considerations include:

1. Effectiveness against target species. Some herbicides kill grasses but have little impact on forbs. Others kill broad-leafed species but are less effective on conifers.

2. Optimal strategies of application. Some herbicides are more effective early in the growing season; others may be more effective late in the season when plants are translocating starch to the roots. Application more than once a year is frequently necessary, particularly on woody plants that are likely to resprout. Too little or too much herbicide may be used, especially by inexperienced applicators. Too much of some sprays, for example, will top-kill the plant without allowing time for the toxin to translocate to the roots.

3. Half-life of the herbicide and decomposition by products. Some herbicides remain in soil and water much longer than others. Some compounds break down into inorganic substances; others may produce potentially toxic compounds.

4. Possible impacts on nontarget species. Some herbicides are very general and will kill any vascular plant. Some compounds present more danger to animals than others, and some may be carcinogenic.

5. Method of application. Injection, for example, allows the herbicide to be applied to individual woody plants, whereas broadcast spraying may result in problems with drift to nontarget species. Rosen (1982) used preliminary broadcast spraying of large areas of kudzu. After a majority of the plants had died he used a very fine nozzle to apply herbicide to individual remaining kudzu plants.

6. Use of the site for scientific studies. In some cases, local contamination with pesticides may be undesirable because the site is being used for pollution monitoring or other research. This is true of some National Park wilderness watersheds.

Many effective control programs use more than one control technique or carefully timed applications of the same technique. Most woody exotics root- or stump-sprout and may need treatment more than once a growing season. Fire may be very effective for initial suppression of exotics, but often needs to be followed by cutting, mowing, or herbicides. Timing of these treatments can be very critical. A spring burn may help reduce exotic populations, whereas a fall burn does not, or vice versa. The intensity of the fire may also determine the success of the effort. A fire that is too cool may not remove the target species; a fire that is too hot may eliminate native vegetation and leave the site prone to further exotic invasion. Alternative methods, such as pulling, digging, and cutting by hand, are labor intensive. These methods are seldom 100 percent effective, particularly with species that easily resprout (Stephenson and others 1980).

Preventative measures may in the case of some types of exotic plants be the only realistic management. Many exotic herbs, for example, will reinvade disturbed areas following removal efforts and will continue to outcompete native species on badly trampled sites. It is therefore extremely important to encourage the reestablishment of native vegetation. This may be done by protection. A campsite may be closed to reduce trampling and allow reestablishment of native species after exotics are removed. In severely disturbed areas, or those previously dominated by exotics, planting may be used to speed succession, to prevent soil erosion, and to change local environmental conditions. Rosen (1982), for example, tested planting of both deciduous and coniferous tree seedlings, after initial herbicide treatment, on sites occupied by kudzu. Although drift killed some seedlings, most survived the later herbicide treatments directed at individual kudzu crowns.

Exotic plant management programs cannot be one-shot efforts. To be successful, these programs must be long-term, incorporating control efforts into routine resource management efforts. A monitoring program to evaluate the ongoing status of exotic vegetation is vital to successful control. Periodically, a reassessment of the type, number, location, and distribution of "pest" exotic species should be made. Information collected could also be used to evaluate the success of control measures and removal techniques.

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