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Exotic Plant Records in the Northwest United States 1950-1996: an Ecological Assessment

Abstract

Nonnative plant species continue to be introduced into North America both accidentally and intentionally for horticultural and agricultural purposes. Some new species will spread extensively and some will become weeds of importance. We used a floristic database (INVADERS) to examine the status of incipient plant invasions in the northwest United States (Washington, Oregon, Idaho, Montana and Wyoming). We queried INVADERS for distribution records of plant species exotic to North America that were first recorded in the northwest states during 1950-1996. The query resulted in records for 288 species, of which 133 were judged to have become established (based on collector notes), or to have high potential to spread beyond artificial environments such as lawns and gardens. Inherent potential for invasion was based on examination of several invasive plant lists and the international literature on plant invasions. Thirty species have become moderately widespread (reported from >5 counties) in the five-state northwest region, and several are known to be aggressive invaders in other regions of North America or in other parts of the world. Five species discussed in the text are notable for rapid spread and/or indications of aggressiveness: *Polygonum cuspidatum* (syn: *Fallopia japonica*, *Reynoutria japonica*), *Bryonia alba*, *Impatiens glandulifera*, *Hieracium pratense* and *Scorzonera laciniata*. Compared with the early exotics (mid 1800s - early 1900s), which tended to be annual herbs, the post-1950 exotic flora shows a trend toward greater proportions of perennials and woody growth forms (shrubs and trees). Some applications of floristic databanks in regional-scale management of plant invasions are discussed.

Introduction

The establishment and spread of exotic plant species have occurred at high rates in North America since the time of European colonization (Forcella 1985, Mack 1986, 1989, Lesica et al. 1993, Rejmánek and Randall 1994), and constitute a major human effect on ecosystems (Usher 1988, Heywood 1989, Rice 1991, Beerling 1995, Vitousek et al. 1996). A large number of exotics, including many of today's most problematic weeds, became established in the northwest United States during the period 1850-1920 coincident with the influx of early agricultural settlers (Forcella and Harvey 1983). Important modes of introduction were contaminated crop seed, shipping ballast, adhesion to imported animals, and deliberate introductions of forage, ornamental and medicinal plants (Baker 1986, Mack 1986, 1991). The establishment of the western railroad network by 1890-1900 enhanced the potential for rapid and widespread dissemination of exotic plant propagules (Forcella and Harvey 1983; Mack 1989). Regional spread patterns have been primarily latitudinal (west-east) routes, corresponding

to the interstate roadway and railway system, with important introduction centers occurring at junctions in the transportation network (Forcella and Harvey 1988). Despite improved quarantine measures and laws governing seed purity, new exotics have continued to arrive (Forcella 1985, Mack 1986, Westbrooks 1991). The rate of introduction is likely to remain high over the next few decades, due to both accidental introductions and intentional introductions for horticultural and agricultural purposes (Rejmánek and Randall 1994, Reichard and Hamilton 1997).

We examined the status of incipient plant invasions (1950-1996) using a large floristic database (Rice 1998). The database contained most of the potentially available distribution data on exotic plant species in the northwest United States. Our objective was to make a preliminary assessment of the recent exotic flora in relation to geographic extent of spread and reported invasive behavior within the region and elsewhere. Some potential applications of floristic databases in regional-scale management of plant invasions are also discussed.

Methods

We studied the five-state region in northwestern USA (the "northwest states") comprising Washington, Oregon, Idaho, Montana and Wyoming (latitude 41° - 49°N, longitude 104° - 124° 45' W). The five states cover a total area of 1,285,072 km². Boundaries of their 199 counties (avg. area 6,458 km²) have been stable since the early 1900s (Cheney 1983, Yates and Yates 1987, Beck and Haase 1989).

INVADERS (Rice 1998) is a relational database containing ca. 80,000 distribution records for 3,022 plant species in Washington, Oregon, Idaho, Montana and Wyoming, spanning 1875-1996. Of these species, 868 are believed to be exotic to North America, and 75% of the distribution data are on the exotics. Fields include county, place name, date, collector and a comments field for miscellaneous low constancy data on associated vegetation, environmental factors, severity and size of weed infestations, etc. Sources are the following:

1. Herbarium records (38,576 total): Inventories of specimens (1875-1995) of exotic plant species and selected native species at Washington State University (WS, 10,877 records), Oregon State University (OSC, 10,011 records), Montana State University (MONT, 5,936 records), University of Montana (MONTU, 5,785 records), and University of Idaho (ID, 5,067 records); 703 records from University of Wyoming (RM); and smaller numbers of records from University of Washington (WTU), University of Oregon (ORE), Western Washington University (WWB), Willamette University (WILLU), Whitman College (WCW), University of British Columbia (UBC), and University of Idaho Collection of Forestry (IDF).

2. Extension Service identification records (17,421 total): 1990-96 for Washington, Oregon, Idaho and Montana, and records from 1949-90 compiled by Richard Old.

3. Agency records (16,477 total): U.S. Forest Service Region 1 ECODATA and Region 6 Ecology Plot data, the Oregon, Montana, Washington and Wyoming Departments of Agriculture, the Columbia River Basin Ecosystem Management Project 1995 weed survey data (Mike Karl, U.S. For. Serv.), and the Montana Weed Seed Free Forage Program.

4. Other records (7,550 total): Forcella and Harvey's (1988) original data, *Madroño*, data from Sheley (1994), and reports received and verified by Peter M. Rice (University of Montana).

Lack of a complete inventory of specimens at RM means that the exotic flora of Wyoming is currently under represented in the database, although the Forcella and Harvey (1988) data set does provide additional records based on specimens held at RM. Some new records could be added by a complete inventory at WTU, but records from WS (the largest herbarium in the region), OSC, and the Washington Extension Service provide good coverage of the state of Washington.

Nomenclature generally follows Hitchcock and Cronquist (1973). For species not in Hitchcock and Cronquist, Bailey et al. (1976), Tutin et al. (1964-80), Great Plains Flora Assoc. (1986), Hickman (1993), and Kartesz (1994) were consulted for accepted names and synonyms.

We queried INVADERS for exotic species first reported during 1950-1996. *Tamarix chinensis*, *T. ramosissima* (syn: *T. odessana*, *T. pentandra*), and *Tamarix* sp. all were first recorded in the northwest region ≥ 1955 , but *T. gallica* was collected in Idaho as early as 1938 (Washington Co., *Christ 9409*, WS, ID; Owyhee Co., *Christ 9569*, ID). Because separation of these three species in the field is doubtful (Brock 1994), we treated them as a single taxon with earliest year of record 1938, thus excluding them from the present analysis. Also, *Chondrilla juncea* was excluded although it was not collected until 1965 in Kootenai County, Idaho (*Presby 24*, MONTU), but had been reported from near Spokane, Washington as early as 1938 (INVADERS record from Sheley 1994).

The initial species list was reduced by examining the individual distribution records. We assessed the ecological status of each species based on collector notes, if available, describing species abundance, associated vegetation, and site conditions. Each species was assigned to one of the following status categories: (1) Invasive—the distribution and/or abundance of the species in the wild is increasing regardless of habitat (Pyšek 1995), (2) Established—the species has been reported growing outside of cultivation in the northwest region, but the presence of self-regenerating populations undergoing further spread is uncertain, (3) Localized—the species has been reported as a waif or localized escapee in disturbed

environments, but longer range invasion within the region has not been reported, and (4) Unknown—no collector comments were available to assess the status of the species in the northwest region, meaning that some or all of the records for the species could be from horticultural settings. We omitted from the analysis species for which no comments had been recorded if we could find no other evidence of its invasion potential. Species were judged to have inherent potential for invasion if they had been reported in the literature as invasive in other temperate regions of the world or on the following invasive plant lists: Campbell (1997), Randall and Marinelli (1996), Parsons and Cuthbertson (1992), and the noxious weed lists for Washington, Oregon, Idaho, Montana, Wyoming and their neighboring states and provinces, California, Nevada, Utah, Colorado, Nebraska, South Dakota, North Dakota, Saskatchewan, Alberta and British Columbia. Universal access to the INVADERS database, including records for the excluded species, is provided via Internet at <http://invader.dbs.umt.edu>.

Results and Discussion

There were 1,349 distribution records for 288 species believed to be exotic to North America. The reduced list of species reported here (Appendix) consists of 133 species judged to have become established (based on collector notes), or to have high potential to spread beyond artificial environments such as lawns and gardens. Most of the post-1950 exotics have been reported from five or fewer counties, although several have become more widespread (6 to 25 counties, Figure 1). Only one species has been reported from >25 counties (*Polygonum cuspidatum*, 52 counties). Nineteen of the 133 species have been declared noxious in one or more northwest states. Fourteen species have been listed as noxious by Washington, seven by Oregon, four by Idaho, and one by Montana. Only one species is on the noxious weed list of more than two northwest states: *Crupina vulgaris* is noxious in Washington, Oregon, Idaho and Montana, and is also one of two species on the federal noxious weed list (Animal Plant Health Inspect. Serv. 1995). An additional six species not listed in any of the northwest states have been declared noxious in one or more neighboring states or provinces. Several other species have been reported as problematic in other regions of North America or on other continents.

Fig. 1

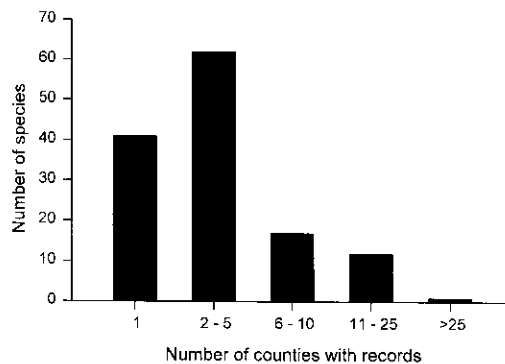


Figure 1. Histogram showing number of counties of record in Washington, Oregon, Idaho, Montana and Wyoming versus number of plant species exotic to North America and first recorded ≥ 1950 in the five-state region.

Some of the recent exotics in the northwest states have been spreading at rapid rates, and several species are in horticultural use but have been escaping frequently from cultivation.

Table 1 contains brief notes and references on 31 species of interest, selected subjectively based on review of the distribution records and plant invasion literature. Five species were chosen for additional discussion in the following section.

Species Notable for Rapid Spread and/or Indications of Aggressiveness

Japanese knotweed *Polygonum cuspidatum* (Polygonaceae; syn: *Fallopia japonica*, *Reynoutria japonica*) is native to southeast Asia (Japan, North and South Korea, Taiwan and China) and was introduced into Europe ca. 150 years ago (Beerling et al. 1995). It has become widespread, invading lowlands and some mountainous regions (to 900 m) from northern Portugal and Spain at 42° N latitude to the coasts of Norway and Finland at 63° N latitude (Beerling et al. 1995). This rhizomatous perennial is an aggressive weed in the British Isles and central and northern Europe where it often forms dense stands along water courses, replacing the native riparian vegetation (Perrins et al. 1992, Brock et al. 1995, de Waal 1995). *P. cuspidatum* was introduced into the United States in the late 1890s as an ornamental, and has been reported from northwestern California, the Pacific Northwest, several north-central and eastern states, and several Canadian provinces (Brock et al. 1995).

TABLE 1. Notes and references related to the occurrence or ecology of selected vascular plant species exotic to North America that were first recorded in the northwestern United States during 1950-1996.

Species	Notes	References
<i>Alliaria petiolata</i>	invades woodlands in midwestern and northeastern U.S.	Brothers and Spingarn 1992, Anderson et al. 1996
<i>Anthriscus sylvestris</i>	invades nutrient-rich grasslands in The Netherlands	van Mierlo and van Groenendael 1991
<i>Bryonia alba</i>	spreading rapidly in northwestern U.S.—see text	Mack 1991, Novak and Mack 1995
<i>Buonomus umbellatus</i>	aggressively invades wetland habitats	Anderson et al. 1974, Staniforth and Frego 1980
<i>Centaurea montana</i>	escapes from cultivation	
<i>C. virgata</i>	potentially serious grassland invader	Roché and Roché 1989
<i>Chaenorrhinum minus</i>	spreading rapidly in northwestern U.S.	Widrechner 1983
<i>Crocasmia x crocosmiiflora</i>	reported as a weed in Australia and New Zealand	Johnson 1982, Scott and Delfosse 1992
<i>Crupina vulgaris</i>	probably multiple introductions	Couderc-LeVaillant and Roché 1993, Roché et al. 1997
<i>Epipactis helleborine</i>	one of the few invasive orchids in North America	Brunton 1986
<i>Eragrostis curvula</i>	weed of pasture and conservation areas in Australia	Scott and Delfosse 1992
<i>E. minor</i>	spreading rapidly in northwestern U.S.	
<i>Euphorbia myrsinites</i>	escapes from cultivation	
<i>Heracleum mantegazzianum</i>	escapes from cultivation	Pyšek 1991
<i>Hieracium floribundum</i>	first recorded in northwestern U.S. in 1989	Wilson et al. 1997
<i>H. piloselloides</i>	first recorded in northwestern U.S. in 1988	Wilson et al. 1997
<i>H. pratense</i>	spreading rapidly in northwestern U.S.—see text	Wilson et al. 1997
<i>Hypericum androsaemum</i>	invades pastures and native bushland in Australia	Parsons and Cuthbertson 1992
<i>Impatiens glandulifera</i> ¹	escapes from cultivation, highly invasive—see text	Perrins et al. 1993, Pyšek and Prach 1995
<i>Nardus stricta</i>	reported spreading near Fort Klamath, OR since 1962	
<i>Nicotiana glauca</i>	invasive phreatophyte	Loope et al. 1988, Burgess et al. 1991
<i>Paspalum dilatatum</i>	established along ditches and creek banks in SW Oregon	
<i>Peganum harmala</i>	potentially invasive in semiarid grassland and shrubland	Parsons and Cuthbertson 1992
<i>Pennisetum setaceum</i>	large aggressive bunchgrass	Loope et al. 1988, Burgess et al. 1991
<i>Polygonum cuspidatum</i>	spreading rapidly in northwestern U.S.—see text	Patterson 1976, Beerling et al. 1995, Brock et al. 1995
<i>Prunus avium</i>	widely naturalized; drought tolerant and aggressive	Johnson and Steele 1978
<i>Rosa multiflora</i>	animal-dispersed aggressive shrub; escapes plantings	Patterson 1976, Brothers and Spingarn 1992
<i>Scorzonera laciniata</i>	spreading rapidly in Montana—see text	Brandes 1994, Sivinski et al. 1994
<i>Spartina anglica</i>	invasive in Pacific estuaries	Dachler and Strong 1996
<i>Sisymbrium orientale</i>	present in Arizona by 1931	Burgess et al. 1991
<i>Ventenata dubia</i>	widespread in eastern WA, eastern OR and western ID	

¹*Impatiens glandulifera* was first collected in Snohomish County, WA, in 1944, but with all subsequent records >1950.

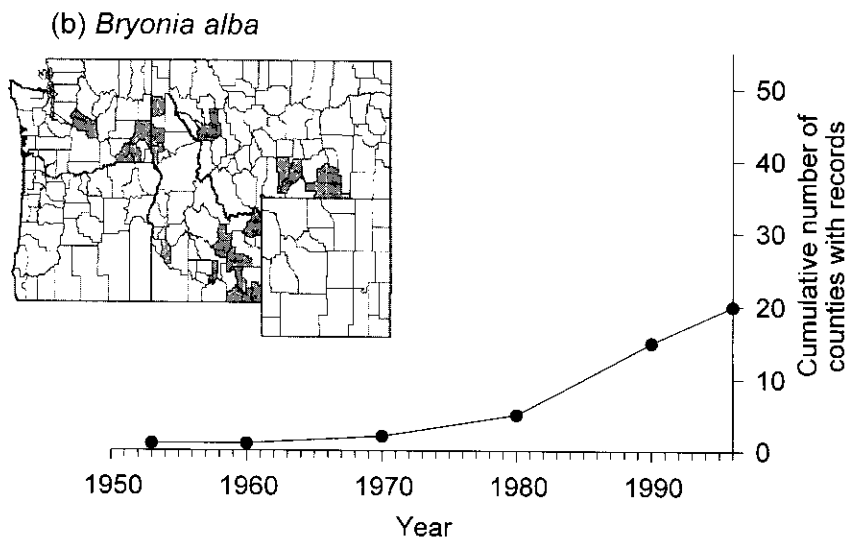
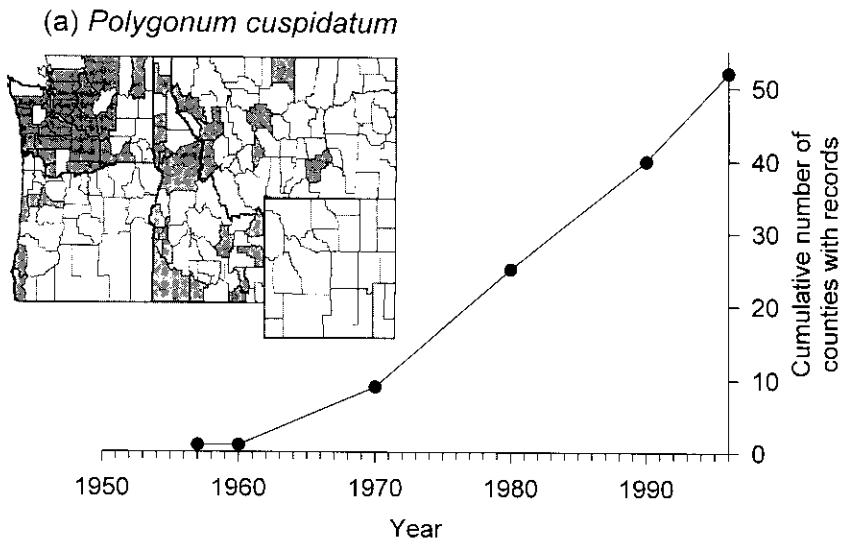
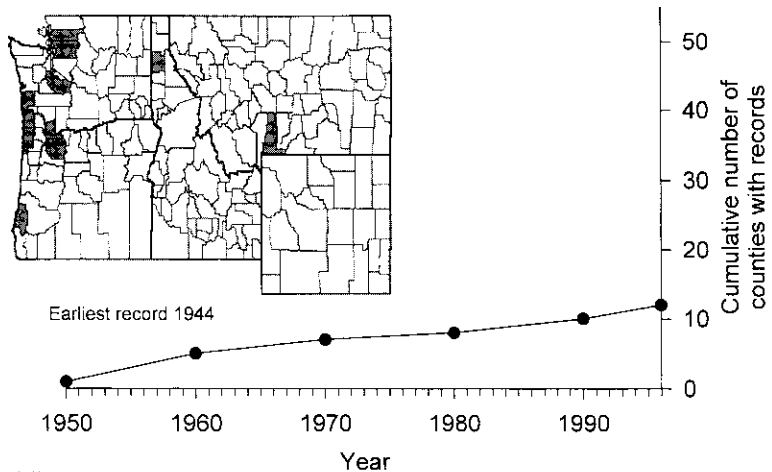


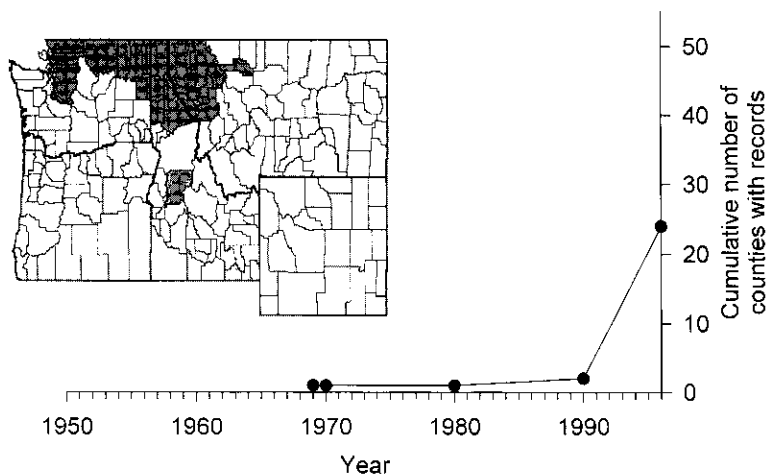
Figure 2. Cumulative number of counties with records for five exotic plant species during 1950-1996. Map insets have shading in counties with distribution records as of 1996. (Continued...)

Figure 2. (Continued)

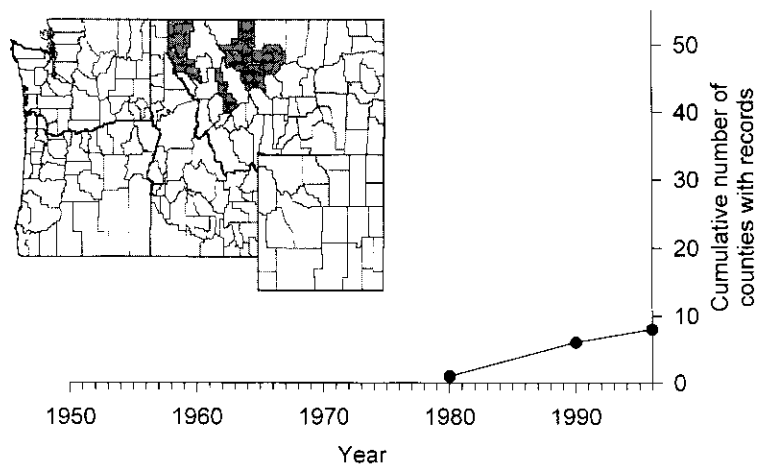
(c) *Impatiens glandulifera*



(d) *Hieracium pratense*



(e) *Scorzonera laciniata*



It has been spreading rapidly in the northwest states since the 1950s (Figure 2a), and has been declared noxious in California, Oregon and Washington. Climate is suitable for *P. cuspidatum* throughout much of the northwest region, but it may be restricted to riparian and other moist habitats due to its requirement for high soil moisture (Beerling et al. 1995). The distribution records suggest that escape from ornamental plantings has contributed to its rapid rate of spread in the northwest states.

White bryony *Bryonia alba* (Cucurbitaceae), a herbaceous perennial vine, has also been spreading rapidly in the northwest United States since the 1950s (Figure 2b). It is native to much of central and eastern Europe and parts of central Asia (Novak and Mack 1995). It was available as an ornamental in the United States as early as 1860, but apparently did not become naturalized until its recent invasion in southeastern Washington, Idaho, Montana and northern Utah (Mack 1991). This invasion probably resulted from 2 or 3 separate introductions (Novak and Mack 1995). It has been reported frequently from riparian habitats and wooded ravines within grassland, sagebrush and ponderosa pine zones. *B. alba* has been declared noxious in Washington.

Himalayan balsam *Impatiens glandulifera* (Balsaminaceae) was first collected in the northwest United States in 1944 in Snohomish Co., Washington (Gleason 600, WS), but all subsequent records are >1950. It deserves mention here because of its high invasive potential and continuing range expansion (Figure 2c). *I. glandulifera* is native to the Himalayas and was introduced into Europe as an ornamental in the first half of the 19th century (Perrins et al. 1993, Pyšek and Prach 1995). Its European distribution extends northward to 64° on the east coast of Sweden and correlates with an annual heat sum 2,195 day-degrees (0°C base) (Beerling 1993). It is the tallest annual plant in Europe (up to 2.5 m), and its rapid growth rate and frost tolerance contribute to its strong competitiveness in native communities (Perrins et al. 1993, Pyšek and Prach 1993). In the British Isles and Czech Republic it forms dense stands in damp woodlands and riparian habitats, replacing the native flora (Perrins et al. 1993, Pyšek and Prach 1995). Of the 20 distribution records for *I. glandulifera* in the northwestern U.S., several mention that it had formed large and/or dense colonies in moist habitats such as marshes and ditch banks.

Meadow hawkweed *Hieracium pratense* (Asteraceae) was introduced into the United States as early as 1828, and is now common from Québec and Ontario to as far south as Georgia and Tennessee (Wilson et al. 1997). It was first collected in the western U.S. in Pend Oreille County, Washington, in 1969 (Layser 829, WS), and has been spreading rapidly in northern Washington, northern Idaho, and northwestern Montana (Figure 2d). The rapid expansion phase probably began earlier than suggested in Figure 2d as most of the post-1990 records resulted from various agency targeted weed surveys. This stoloniferous perennial is native to Europe. It is invasive in mountain meadows and other open habitats in forest zones, as well as in permanent pastures, hayfields and cleared timber units (Wilson et al. 1997). Climate appears suitable for its continued eastward and southeastward expansion throughout much of western Montana and into portions of central Montana (Rice et al. 1997). It has been declared noxious in Washington and Idaho and is proposed for listing in Montana.

False salsify *Scorzonera laciniata* (Asteraceae) was first reported in North America around Boulder, Colorado in the 1950s, and quickly became a locally abundant weed along the foothills of the Front Range (Great Plains Flora Assoc. 1986). It has subsequently spread to Kansas, and has also become a common weed in north and west-central New Mexico (Sivinski et al. 1994). In New Mexico it has been recorded as a weed of lawns and disturbed areas, but also as an adventive component of natural vegetation (Sivinski et al. 1994). The recent records from central and northwest Montana (Figure 2e) similarly note this species occurring in lawns, as well as in disturbed portions of native prairie and in saline habitats near ponds and marshes. Brandes (1994) described its association with saline sites in central Europe, and suggested that the recent strong decline of *S. laciniata* in that region may be due to the coincident decline of salt quarrying which had maintained favorable habitat on tailings. Although its fruits are equipped with a pappus, the effectiveness for long distance dispersal is thought to be minimal because height of the plant is low and the fall rate of fruits is rapid (avg. 53 cm/s, twice that of *Cirsium arvense* fruits) (Brandes 1994). These observations are particularly interesting considering the rapid expansion of *S. laciniata* over a wide portion of the western U.S., and

underscore the relatively greater importance of human-mediated versus natural dispersal mechanisms in large-scale plant invasion (Noble 1989, Panetta and Scanlan 1995).

It should be emphasized that several species recorded recently in the northwest states are exotics well established in other areas of North America that continue to expand their geographic ranges (cf. Rejmánek and Randall 1994). One example is squarrose knapweed *Centaurea virgata*. Not recorded in Oregon until 1988, *C. virgata* was collected in California in 1950 and in Utah in 1954, and was noted anecdotally in Utah as early as 1928 (Roché and Roché 1989). It was estimated to have spread over >20,000 ha in California and Utah as of 1988. The spread of other long-established species into new areas remains a great concern for a number aggressive weeds including *Centaurea diffusa*, *C. maculosa*, *C. repens*, *C. solstitialis*, *Cytisus scoparius*, *Echium vulgare*, *Euphorbia esula*, *Hypericum perforatum*, *Isatis tinctoria*, *Linaria dalmatica*, *Lythrum salicaria*, *Potentilla recta*, *Senecio jacobea*, and *Tamarix* spp.

Composition and Origin of the Recent Exotic Flora

The recently-arrived exotics continue to originate predominantly from Europe and Asia (Table 2). However, the relatively high proportion of perennials and woody growth forms (trees and shrubs) is interesting. The early invaders (mid 1800s - early 1900s) were predominantly herbaceous species, especially annuals (Mack 1986). Time lags between introduction and the beginning of an invasion are generally longer for perennials compared with annuals, and lags may be much longer on average for woody compared with herbaceous growth forms. Lag phases between the first record of occurrence and the beginning of invasion (exponential phase) in central Europe were estimated at 40 years for *Impatiens glandulifera* (annual), 80 years for *Heracleum mantegazzianum* (monocarpic perennial), 46 years for *Polygonum cuspidatum* (polycarpic perennial) and 83 years for *Polygonum sachalinense* (polycarpic perennial) (Pys'ek and Prach 1993). Lag phases between the first release for cultivation and the first record from non-cultivated settings averaged 147 years for woody species (131 for shrubs, n=118, and 170 for trees, n=66) introduced in Brandenburg, Germany (Kowarik 1995). Length of the maturation period (time to first reproduction) defines the

TABLE 2. Composition and origin of the recent exotic flora of northwest United States.

	Number of species	% of total
Growth form		
Rush	2	1.5
Grass	13	9.8
Forb	86	64
Vine	5	3.8
Shrub	15	11
Tree	12	9.0
Duration		
Annual	37	27
Biennial	5	3.8
Perennial	91	68
Continent(s) of Origin ¹		
Africa	5	3.8
Asia	25	18
Europe	40	30
Eurasia	55	41
South America	4	3.0
South America and Australia	1	0.8
Tropical America, Africa, Asia	1	0.8
interspecific hybrids ²	2	1.5
Total	133	

¹ Notes: Sources are Bailey et al. (1976), Hultén and Fries (1986), Tutin et al. (1964-80), Hitchcock and Cronquist (1973), Great Plains Flora Assoc. (1986) and Balslev (1980). Several species classified here as ?Eurasian have native ranges extending into northern Africa.

² The recent amphiploids *Tragopogon mirus* and *T. miscellus* are considered here to be exotic to North America - see Hitchcock and Cronquist (1973).

minimum lag between first introduction and the start of an invasion (Richardson et al. 1994, Kowarik 1995). The timing of subsequent events in the invasion process may be difficult to predict since they are probably determined by complex interactions among life history traits, stochastic environmental factors and genetic plasticity (Richardson et al. 1994, Kowarik 1995, Higgins and Richardson 1996), and socioeconomic factors (Hobbs and Humphries 1995). Nevertheless, Kowarik's (1995) results show that successful invaders do not always begin invasions more rapidly than less successful species. The possibility of long lag phases implies that the number of species invading will continue to increase for a period of time, independently of new introductions.

Management Implications

Regional-scale management of exotic plant invasions historically has been a reactive effort.

Harmful exotics have often been targeted for expensive control measures only after they became widespread and their negative impacts were apparent. Pro-active management will require greater emphasis on early detection and rapid response to eradicate or contain incipient infestations of potentially harmful species (Westbrooks 1991, Hobbs and Humphries 1995). However, high numbers of exotics continue to establish themselves in the northwest states, and many others are potentially available for escape and naturalization. Predicting which species will invade extensively, and which ecosystems will be affected, remain difficult challenges for plant ecologists. More studies like those of Scott and Panetta (1993), Pyšek et al. (1995), Tucker and Richardson (1995), Rejmánek (1996), and Reichard and Hamilton (1997) are needed to improve decision guidelines for regulatory screening and prioritization of limited resources for management.

Some limitations on the use of floristic data need to be emphasized (Pyšek 1991). Sampling effort is unevenly distributed in space and time, and many remote areas will not have been sampled at all. The situation is improved some by the availability of Extension Service identification records since the 1950s, which frequently provide occurrence reports from private lands. Herbarium records and agency data more frequently come from public lands including roadsides. A species is more likely to be collected if it is worthy of note from a biogeographical or ecological perspective (such as new state or county records), or for some other property. For example, species with dermaltoxic sap are reported frequently to Extension Service personnel (R. Old, personal communication). A species is more likely to be detected early in the invasion process if it is distinctive and conspicuous (e.g. *Centaurea solstitialis*, *Heraclium mantegazzianum*). Unequivocal interpretation of floristic data is constrained for taxonomic complexes (*Cardaria*, *Myriophyllum*, *Tamarix*, etc.)

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with a history of misidentification and taxonomic confusion. However, the rapid expansion of a species complex, especially one from a nonnative genus (Rejmánek 1996), is generally indicative of a problem plant.

Floristic databases do offer several clear advances in the management and study of regional-scale plant invasions. They provide ecologists and land managers with easy access to current known distributions of exotic plant species over broad geographical scales. Species lists of relatively new and less well known exotics can be generated for particular sub-regions such as counties, National Forest districts or other multi-county project areas. Increased awareness of these species can enhance early detection of new occurrences. Systematic analysis of the exotic flora in and adjacent to such areas should provide a basis for improved risk assessments of exotic plant invasions. Furthermore, the floristic data can provide information on the species ecology and the types of habitats occupied. Occurrence records can be linked to existing spatial data sets to determine possible correlations with environmental and land use factors (e.g., Sanders 1976, Panetta and Dodd 1987, Sindel and Michael 1992). Reconstructions of the temporal and spatial dynamics of spread are also facilitated by rapid access to the historical distribution data.

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APPENDIX. One hundred thirty-three exotic vascular plant species first reported during 1950-1996² in the five-state region of Washington, Oregon, Idaho, Montana and Wyoming, determined by query of the INVADERS Database Release 6.5. The number of counties with records as of 1996 is based 199 counties in the five states. See **Methods** for the definitions of terms used to describe ecological status. Presence on state or provincial noxious weed lists (any category) is indicated for the five-state region and adjacent states and provinces (and Fed. for 2 species on the federal noxious weed list).

Species	Earliest record	No. counties with records	Regions with records ²	Ecological status	Regulatory status
<i>Aegopodium podagraria</i> L.	1959	14	WWA, EWA, WOR, EOR, SID, WMT	Localized	
<i>Ajuga reptans</i> L.	1970	5	WWA, EWA, WOR	Localized	
<i>Alchemilla vulgaris</i> L.	1975	2	WOR, WMT	Established	
<i>Alliaria petiolata</i> (Bieb.) Cavara & Grande	1959	1	Multnomah Co., OR	Established	
<i>Alopecurus arundinaceus</i> Poir.	1963	9	EWA, NID, WMT, EMT, WWY	Invasive	
<i>Anchusa barrelieri</i> (All.) Vitman	1991	1	Whatcom Co., WA	Established	
<i>Anthriscus sylvestris</i> (L.) Hoffm.	1985	7	WWA, EWA, NID	Invasive	WA
<i>Atriplex heterosperma</i> Bunge	1953	19	WWA, EWA, NID, WMT, EMT, FWY	Invasive	
<i>Atriplex oblongifolia</i> Waldst & Kit.	1966	1	Toole Co., MT	Established	
<i>Barbarea verna</i> (Mill.) Asch.	1986	2	WOR, WMT	Established	
<i>Bidens pilosa</i> L.	1993	1	Lake Co., OR	Unknown	
<i>Bryonia alba</i> L.	1953	20	EWA, NID, SID, WMT, EMT	Invasive	WA
<i>Butomus umbellatus</i> L.	1956	5	NID, SID, WMT	Invasive	
<i>Campánula glomerata</i> L.	1958	19	WWA, FWA, NID, SID, WMT, EMT	Localized	
<i>Carthamus balticus</i> (Boiss. & Reut.) Lara	1987	1	Jackson Co., OR	Established	OR, CA
<i>Carthamus tinctorius</i> L.	1957	24	WWA, EWA, WOR, NID, SID, WMT, EMT	Invasive	
<i>Centaurea dealbata</i> Willd. Per.	1988	3	WWA, WMT, EMT	Localized	
<i>Centaurea montana</i> L.	1960	6	WWA, EWA, WOR, SID, WMT	Localized	
<i>Centaurea trichocephala</i> Bieb. ex Willd.	1983	1	Yakima Co., WA	Established	
<i>Centaurea virgata</i> Lam.	1988	5	WOR, EOR	Invasive	OR, CA, CO, UT
<i>Centranthus ruber</i> (L.) DC.	1970	6	WWA, EWA, WOR	Established	
<i>Cerastium dubium</i> (Bast.) O. Schwarz.	1981	5	WWA, EOR, SID	Invasive	
<i>Cerastium siculum</i> Guss.	1969	5	FWA, EOR	Invasive	
<i>Chaenorrhinum minus</i> (L.) Lange	1976	9	EWA, EOR, NID, WMT	Invasive	WA
<i>Chelidonium majus</i> L.	1955	3	WWA, EWA, WMT	Established	
<i>Coronilla varia</i> L.	1951	12	EWA, WOR, SID, WMT	Invasive	
<i>Cotoneaster franchetti</i> Bois.	1977	1	Lewis Co., WA	Unknown	
<i>Cotoneaster lacteus</i> W. W. Smith	1993	1	Polk Co., OR	Unknown	
<i>Crataegus monogyna</i> Jacq.	1966	5	WWA, WOR	Established	
<i>Crepis tectorum</i> L.	1983	4	EWA, WOR, WMT, EMT	Localized	AB
<i>Crococsmia x crocosmiflora</i> (V. Lemoine ex E. Morr) N. E. Br.	1983	1	Lincoln Co., OR	Established	
<i>Crucianella angustifolia</i> L.	1991	1	Clearwater Co., ID	Established	
<i>Crupina vulgaris</i> Cass.	1969	6	WWA, EOR, NID	Invasive	ID, OR, MT, WA, BC, CA, Fed
<i>Cryptomeria japonica</i> (L. F.) D. Don	1953	3	WWA, WOR, EOR	Unknown	

Species	Earliest record	No. counties with records	Regions with records ²	Ecological status	Regulatory status
<i>Cunninghamia lanceolata</i> (Lamb.) Hook.	1987	3	WOR	Unknown	
<i>Cymbalaria muralis</i> E. Mey & Scherb.	1988	3	EWA, WOR	Unknown	
<i>Cynara cardunculus</i> L.	1968	2	WWA, WOR	Localized	CA
<i>Cytisus monspessulanus</i> L.	1988	1	Coos Co., OR	Established	OR, CA
<i>Daphne mezereum</i> L.	1969	3	EWA, WOR, WMT	Unknown	
<i>Delphinium consolida</i> L.	1995	2	Gallatin Co., MT	Established	
<i>Dioscorea batatas</i> Decene.	1990	1	Union Co., OR	Unknown	
<i>Echinops ruthenicus</i> Bieb.	1954	5	EWA, WMT	Established	
<i>Echinops sphaerocephalus</i> L.	1990	2	EWA, EOR	Established	
<i>Eichhornia crassipes</i> (Mart.) Solms-Laub	1996	1	Cowlitz Co., WA	Established	
<i>Elymus junceus</i> Fisch.	1951	11	WMT, FMT	Invasive	
<i>Epilobium hirsutum</i> L.	1984	2	WWA	Established	
<i>Epipactis helleborine</i> (L.) Crantz	1985	3	WOR, WMT	Established	
<i>Eragrostis curvula</i> (Schrud.) Nees	1990	2	WOR, FOR	Established	
<i>Eragrostis minor</i> Host	1984	9	EWA, EOR, NID, SID, WMT	Invasive	
<i>Euonymus fortunei</i> (Turcz.) Hand.-Mazz.	1980	2	WWA, SID	Unknown	
<i>Euphorbia lathyris</i> L.	1991	9	WWA, EWA, WOR, EOR	Established	
<i>Euphorbia myrsinites</i> L.	1977	22	WWA, EWA, WOR, EOR, NID, SID	Invasive	CO
<i>Forsythia suspensa</i> (Thunb.) Vahl	1980	2	WWA, FMT	Established	
<i>Fumaria parviflora</i> Lam.	1992	1	Baker Co., OR	Established	
<i>Galium pedemontanum</i> (Bellardi) All.	1974	4	NID, WMT	Invasive	
<i>Geum urbanum</i> L.	1970	2	EWA, WOR	Established	
<i>Glaucium corniculatum</i> (L.) J.H. Rudolph	1964	1	Stillwater Co., MT	Invasive	
<i>Gypsophila elegans</i> Bieb.	1995	1	Minidoka Co., ID	Unknown	
<i>Halimodendron halodendron</i> (Pallas) Voss	1995	1	Broadwater Co., MT	Established	CA
<i>Hemerocallis fulva</i> L.	1978	2	SID, WMT	Established	
<i>Heracleum mantegazzianum</i> Somm. & Levier	1962	8	WWA, EWA, WOR	Established	WA, Fed
<i>Hieracium floribundum</i> Wimmer & Grab	1989	4	WWA, NID, WMT	Invasive	
<i>Hieracium piloselloides</i> Vill.	1988	2	WWA, WMT	Invasive	
<i>Hieracium pratense</i> L.	1969	24	WWA, EWA, NID, SID, WMT	Invasive	ID, WA
<i>Hieracium vulgatum</i> Fries	1960	2	WWA, WOR	Established	
<i>Hordeum distichon</i> L.	1976	4	EWA, SID, EMT, WWY	Established	
<i>Hypericum androsaemum</i> L.	1983	4	WWA, WOR	Localized	
<i>Hypochaeris glabra</i> L.	1978	1	Curry Co., OR	Established	
<i>Impatiens balfourii</i> Hook.	1970	4	WWA, WOR	Unknown	
<i>Impatiens glandulifera</i> Royle	1944	12	WWA, WOR, NID, WMT	Invasive	
<i>Juncus compressus</i> Jacq.	1979	2	FWY	Established	
<i>Juncus planifolius</i> R. Br.	1969	2	WOR	Established	
<i>Kickxia spuria</i> (L.) Dumort.	1956	5	WOR, WMT	Invasive	
<i>Koeleruteria paniculata</i> Laxm.	1987	4	WOR, SID	Unknown	
<i>Lamium hybridum</i> Vill.	1956	2	WOR	Localized	WA
<i>Leprodiclis holosteoides</i> Fenzl.	1986	2	EWA, NID	Invasive	WA

Species	Earliest record	No. counties with records	Regions with records ²	Ecological status	Regulatory status
<i>Ligustrum japonicum</i> Thunb.	1981	1	Benton Co., WA	Unknown	
<i>Ligustrum sinense</i> Lour.	1990	2	WOR	Unknown	
<i>Lonicera etrusca</i> Santi	1988	2	WOR	Established	
<i>Lonicera maackii</i> (Rupr.) Maxim.	1994	1	Ada Co., ID	Unknown	
<i>Lonicera nitida</i> E. H. Wils.	1957	4	WOR	Localized	
<i>Lynchnis dioica</i> (L.) Clairv.	1961	4	WWA, WOR, WMT	Established	
<i>Lythrum virgatum</i> L.	1990	1	Phillips Co., MT	Unknown	MT, WA, ND
<i>Milium vernale</i> Bieb.	1987	2	NID	Invasive	ID
<i>Nardus stricta</i> L.	1962	1	Klamath Co., OR	Invasive	ID, OR
<i>Nicotiana glauca</i> Graham	1968	1	Spokane Co., WA	Unknown	
<i>Origanum vulgare</i> L.	1975	6	EWA, WOR, EOR, NID, SID	Localized	
<i>Ornithogalum nutans</i> L.	1991	1	Linn Co., OR	Invasive	
<i>Paspalum dilatatum</i> Poir.	1979	4	WOR	Invasive	
<i>Paulownia tomentosa</i> (Thunb.) Steud.	1984	4	WWA, WOR	Unknown	
<i>Peganum harmala</i> L.	1967	4	EWA, EOR, EMT	Invasive	OR, WA, CA, CO, NV
<i>Pennisetum setaceum</i> (Forssk.) Chiov.	1982	2	WOR	Unknown	
<i>Picris echioides</i> L.	1978	3	WOR, WMT	Unknown	
<i>Picris hieracioides</i> L.	1981	2	WWA	Invasive	WA
<i>Polygala vulgaris</i> L.	1994	1	Coos Co., OR	Localized	
<i>Polygonum aubertii</i> Litt.	1967	3	WWA, EWA	Unknown	
<i>Polygonum cuspidatum</i> Siebold. & Zucc.	1957	52	WWA, EWA, WOR, NID, SID, WMT, EMT	Invasive	OR, WA, CA
<i>Prunus armeniaca</i> L.	1974	6	EOR, NID, SID, EMT	Invasive	
<i>Prunus avium</i> L.	1957	9	WWA, EWA, WOR, NID	Invasive	
<i>Prunus padus</i> L.	1973	6	WWA, WMT, EMT	Unknown	
<i>Prunus persica</i> (L.) Batsch.	1978	2	NID, SID	Unknown	
<i>Prunus tomentosa</i> Thunb.	1965	25	WWA, EWA, WOR, EOR, SID, WMT, EMT	Unknown	
<i>Ranunculus ficaria</i> L.	1988	1	Multnomah Co., OR	Established	
<i>Ranunculus parviflorus</i> L.	1983	3	WOR	Established	
<i>Rhamnus frangula</i> L.	1992	1	Ada Co., ID	Unknown	
<i>Rorippa austriaca</i> (Crantz) Bess.	1969	6	EWA, SID, WMT	Invasive	WA, CA, NV
<i>Rosa multiflora</i> Thunb. ex Murr.	1984	1	Polk Co., OR	Established	
<i>Rumex sanguineus</i> L.	1978	2	WOR, WMT	Established	
<i>Salix babylonica</i> L.	1953	3	EOR, NID, WMT	Established	
<i>Salix pentandra</i> L.	1957	2	WMT	Unknown	
<i>Salsola collina</i> Pallas	1961	5	WMT, EMT, EWY	Established	CA, CO, SK
<i>Saponaria ocyroides</i> L.	1956	4	WWA, WOR, EOR	Invasive	
<i>Satureja acinos</i> (L.) Scheele	1983	2	NID, WMT	Established	
<i>Scorzonera hispanica</i> L.	1984	1	Pondera Co., MT	Localized	
<i>Scorzonera laciniata</i> L.	1980	8	WMT	Invasive	
<i>Senecio mikanioides</i> Otto.	1976	1	Richland Co., MT	Unknown	
<i>Senecio viscosus</i> L.	1991	1	Boundary Co., ID	Localized	
<i>Sisymbrium orientale</i> L.	1973	1	Lane Co., OR	Established	
<i>Sorghum alnum</i> Parodi	1961	1	Multnomah Co., OR	Established	UT
<i>Sorghum sudanense</i> (Piper.) Stapf.	1983	3	WWA, EWA, WOR	Established	
<i>Spartina anglica</i> C.E. Hubbard	1983	1	Island Co., WA	Invasive	WA
<i>Thalictrum aquilegifolium</i> L.	1953	2	WWA, WOR	Localized	
<i>Thesium linophyllum</i> L.	1992	1	Madison Co., MT	Invasive	

Species	Earliest record	No. counties with records	Regions with records ²	Ecological status	Regulatory status
<i>Tragopogon mirus</i> Ownbey	1951	3	WWA, WMT	Established	
<i>Tragopogon miscellus</i> Ownbey	1957	7	EWA, NID, WMT, EWY	Invasive	
<i>Trifolium vesupinatum</i> L.	1991	1	Linn Co., OR	Localized	
<i>Tussilago farfara</i> L.	1991	1	Jefferson Co., WA	Localized	
<i>Ulmus parvifolia</i> Jacq.	1974	1	Franklin Co., WA	Unknown	
<i>Ventenata dubia</i> (Leers) Coss. & Dur.	1957	14	WWA, EWA, WOR, EOR, NID, SID	Invasive	
<i>Verbascum virgatum</i> Stokes	1986	1	Bannock Co., ID	Established	
<i>Veronica triphyllus</i> L.	1961	4	EWA, EOR	Invasive	
<i>Veronica verna</i> L.	1961	10	EOR, NID, WMT	Invasive	
<i>Vitis vinifera</i> L.	1974	4	WWA, EWA, NID	Established	

¹*Impatiens glandulifera* was first collected in Snohomish County, WA, in 1944, but with all subsequent records >1950.

²County names are given for species with records from a single county. For species with records from >1 county, the following region codes are used: WWA (western Washington), EWA (eastern Washington), WOR (western Oregon), EOR (eastern Oregon), NID (northern Idaho), SID (southern Idaho), WMT (western Montana), EMT (eastern Montana), WWY (western Wyoming) and EWY (eastern Wyoming).