

## Meadow Knapweed Invasion in the Pacific Northwest, U.S.A., and British Columbia, Canada

### Abstract

Most of the noxious weeds in western North America are non-native plants that have been introduced from Eurasia. Several *Centaurea* species (*C. maculosa* Lam., *C. diffusa* Lam., and *C. solstitialis* L.) apparently have become more abundant in North America than they are in their native habitats. Because all species do not have equal potential for expansion, this study was undertaken to determine the amount and distribution of another *Centaurea*, meadow knapweed, the hybrid swarm of intermediates between black knapweed (*Centaurea nigra* L.) and brown knapweed (*C. jacea* L.).

The survey began with locations on herbarium labels and was completed with locations and amounts obtained through field searches in British Columbia, Idaho, Montana, Oregon and Washington by professionals in weed education and control. Brown and black knapweed, both native to Europe and introduced in the Pacific Northwest around the turn of the century, have decreased since the 1950s. The distribution of meadow knapweed has increased, indicating that the hybrid is better adapted to conditions in the Pacific Northwest than either of its parents. Meadow knapweed was found in 4 locations in British Columbia, 2 counties in Idaho, 3 counties in Montana, 18 counties in Oregon, and 19 counties in Washington, for a total of almost 2,000 ha. New records for meadow knapweed include 3 locations in British Columbia, 2 counties in Idaho, 2 counties in Montana, 9 counties in Oregon and 10 counties in Washington. The plant is well adapted to moist meadows, irrigated pastures, riparian zones, and moist forest openings; therefore continued expansion of meadow knapweed in the Pacific Northwest is likely.

The significance of our research is in reporting new records, the success of the hybrid relative to the parent species and the type of sites susceptible to continued expansion of meadow knapweed. It also provides a baseline for monitoring continued expansion, or conversely, the success of weed control programs.

### Introduction

Due to losses in rangeland forage production caused by spotted and diffuse knapweed (*Centaurea maculosa* Lam. and *C. diffusa* Lam.) and yellow starthistle (*C. solstitialis* L.) (Harris and Cranston 1979, Lacey *et al.* 1986, Roché and Roché 1988), other *Centaurea* species have been added to noxious weed lists in the Pacific Northwest. This action was taken on the rationale that controlling exotic weeds before they become widespread is less costly, both economically and ecologically. One of these species is meadow knapweed (*C. jacea* L. × *C. nigra* L.). Although it was introduced in the Pacific Northwest in the early 1900s, its potential weediness had not been investigated. The objectives of this study were to determine the amount, distribution, and types of sites it currently occupies. This information is necessary to assess the status of meadow knapweed as a noxious weed.

### Meadow Knapweed Taxonomy

Meadow knapweed, also known as Protean knapweed, is a fully fertile hybrid of brown knapweed (*Centaurea jacea* L.) and black knapweed (*C. nigra* L.) (Elkington and Middlefell 1972, Marsden-Jones and Turrill 1954). Artificial hybrids

can be made easily with either species as the female parent since both parents and hybrid are tetraploid,  $2n=44$  (Marsden-Jones and Turrill 1954, Ockendon 1975, Roy 1937). Black knapweed is native in the British Isles with hybrids being common in the southern part of England where brown knapweed has been introduced from the European Continent (Marsden-Jones and Turrill 1954). The reverse situation has been described in France where brown knapweed is native and black knapweed occurs as an introduction (Ockendon 1975). In either situation, pure forms of the introduced species do not persist for long. Populations in western North America may be the result of local hybridization or perhaps introduced from Europe as a part of a hybrid swarm (Marsden-Jones and Turrill 1954). Continued exchange of genetic material is ensured by self-incompatibility and dependence on insect pollination for sexual reproduction (Lack 1976, Marsden-Jones and Turrill 1954).

Since meadow knapweed is a confirmed hybrid, the appropriate name is *C. jacea* × *C. nigra*. The most widely used name in North America, *C. pratensis* Thuill. (Abrams and Ferris 1960, Hitchcock and Cronquist 1974, Dennis 1980, and Hawkes *et al.* 1985), is not a legitimate name

(Marsden-Jones and Turrill 1954). In Europe, hybrids or segregants of *C. jacea* × *C. nigra* have been variously named *C. debeauxii* Gren. & Godron subsp. *thuillieri* Dostal (Dostal 1976) and *C. jugens* (Gugl.) C. E. Britton, *C. pratensis* Thuill., *C. drucei* C. E. Britton, *C. surrejana* C. E. Britton, and *C. microptilon* Gren. (Clapham *et al.* 1962).

### Methods and Materials

The locations of meadow, brown and black knapweed collections stored in herbaria in British Columbia, Idaho, Montana, Oregon and Washington were plotted on maps. A survey, similar to a survey of four other *Centaurea* species in eastern Washington (Roché and Roché 1988), was conducted. In 1987 a letter was sent to County Extension Agents and Weed Coordinators in Washington, the Provincial Weed Specialist in British Columbia, the State Weed Coordinator in Montana, the Program Supervisor for Noxious Weed Control in the Oregon Department of Agriculture, State Extension Weed Specialists in Washington, Oregon, and Idaho, and Herbarium curators at the Land Grant Universities in Idaho, Oregon, and Washington. The letter explained the survey, contained records of previous collections, color photographs and line drawings of the weed, and survey forms.

The color photographs showed details of the phyllary bracts of meadow knapweed, a plant in bud, and the appearance of a patch of plants in flower. Line drawings accompanied a description of meadow knapweed and the two parent species. The three plant species are differentiated by the shape of the middle rows of phyllary bracts (Figure 1).

The survey cooperators estimated the size of each population and recorded a brief description of the sites (e.g., roadside, pasture, urban) and the locations, either as legal descriptions or maps. The minimum population size was a single plant. Area occupied by the weed was estimated by length and width of infestations. Some infestations were undoubtedly missed as evidenced by historical collection sites that were not relocated. Due to inadequate label information, we could not determine whether those knapweed populations failed to survive or were not found. Some populations have received weed control treatments since being reported and were included even though the population is no longer present as reported.

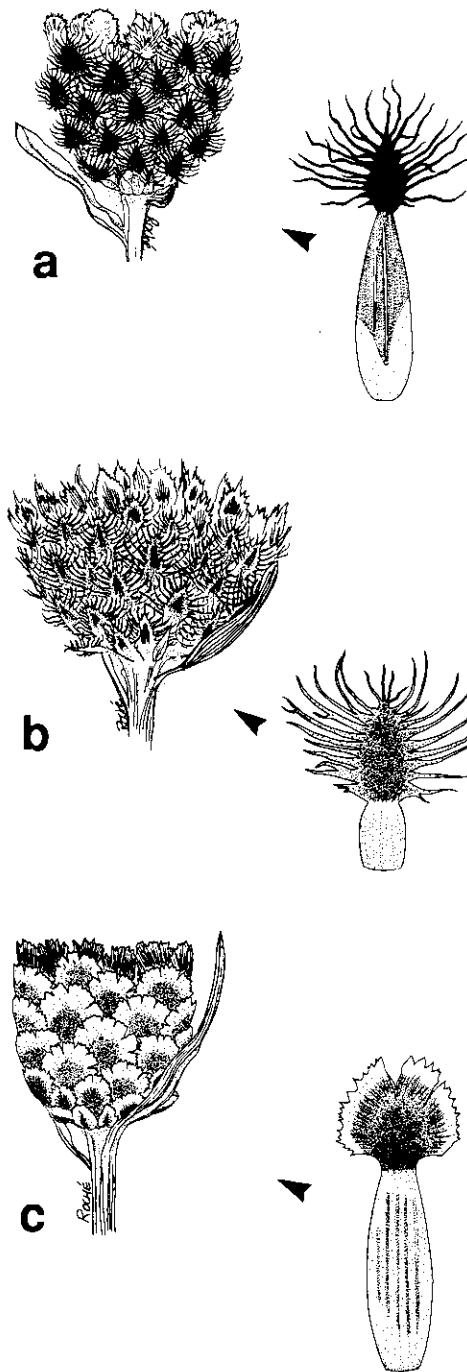


Figure 1. Involucre and detail of middle phyllary bract of a) black, b) meadow and c) brown knapweed.

The survey period included three field seasons with results compiled in February 1990. Survey

cooperators were visited in person or by phone at least once during the three year period. Collections from many of the sites in Oregon and Washington and all of the sites in Montana and Idaho have been filed in the Marion Ownbey Herbarium at Washington State University.

## Results

### Brown knapweed

The earliest report of brown knapweed in the Pacific Northwest is from meadows at Cedar Hill,

Victoria, Vancouver Island, in 1887 (Macoun 1890). Herbarium collections of brown knapweed are dated from 1919 through 1948 (Roché and Talbott 1986). These include 3 counties in Oregon (Marion, Douglas, and Wasco) and collections in Pullman in 1923, 1924, 1938 and 1948 (Figure 2). Muenscher (1930) reported brown knapweed as a "new weed in Whatcom County, Washington, since 1920." In addition to herbarium specimens, brown knapweed was sent to Washington State University for identification from the following Washington locations: Wahkiakum County in 1949, Fargher Lake Community, Clark County, in 1959,

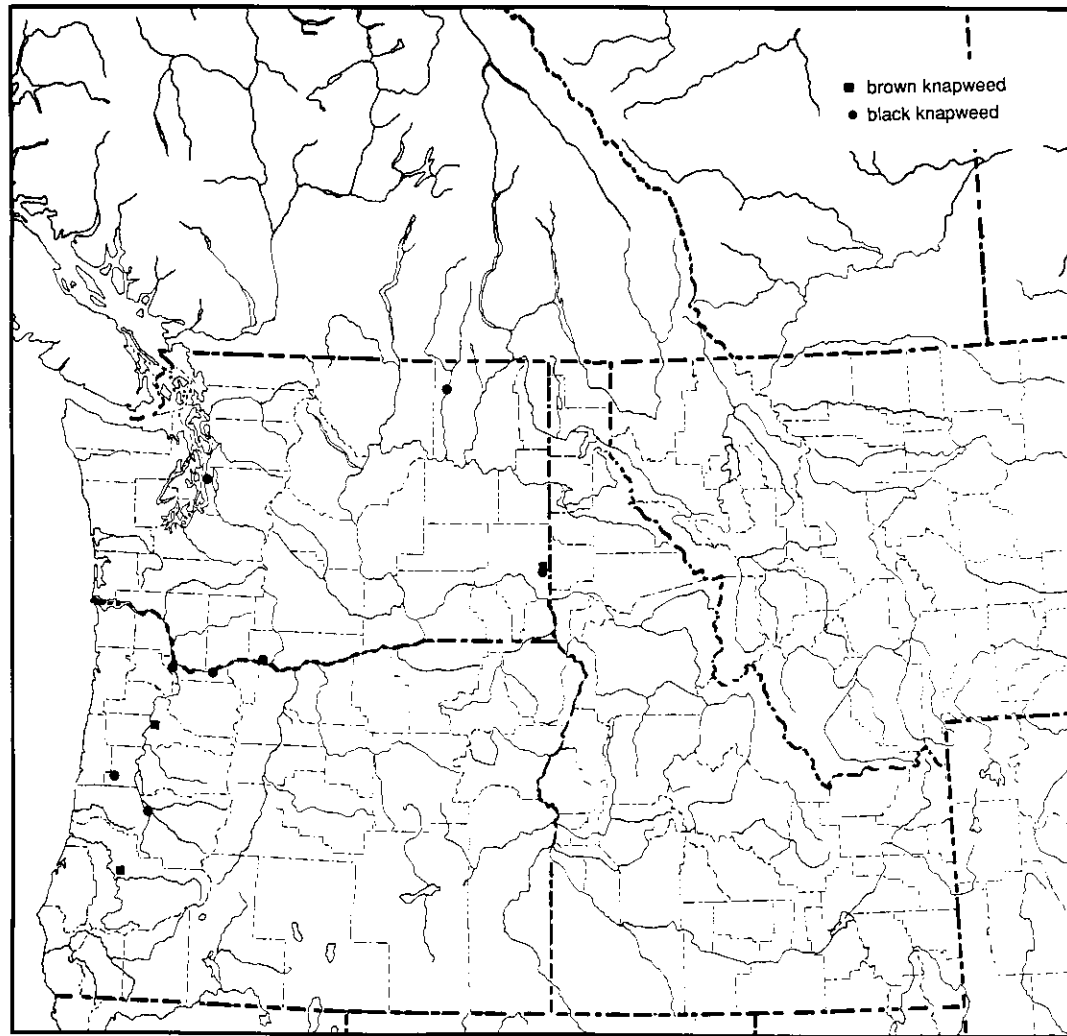


Figure 2. Collection locations of black and brown knapweed in British Columbia, Idaho, Montana, Oregon and Washington prior to 1980, according to herbarium records.

Klickitat County in 1951 and Clallam County in 1975 (Roché and Talbott 1986).

The current survey found that brown knapweed populations have persisted in Montana (Glacier National Park, Bozeman and Belgrade), in Washington (Bellingham, Ellensburg, Pullman, and San Juan Island), and in Oregon (Hood River) (Figure 3).

#### Black Knapweed

Black knapweed was found in Pullman, Washington, in 1895 (Nelson 1917). Herbarium

collections dated from 1895 through 1955 (Roché and Talbott 1986), after which no further collections were found. It was collected from seven locations, including 4 counties in Washington and 2 counties in Oregon (Figure 2). The only collections made east of the Cascade Mountains were from Republic, Pullman, and Bingen. All of the collections from the Alsea Valley, Benton County, Oregon, were made in the 1950s. Black knapweed was sent to Washington State University for identification from Conboy Lake Basin, Klickitat County, Washington, in 1981.

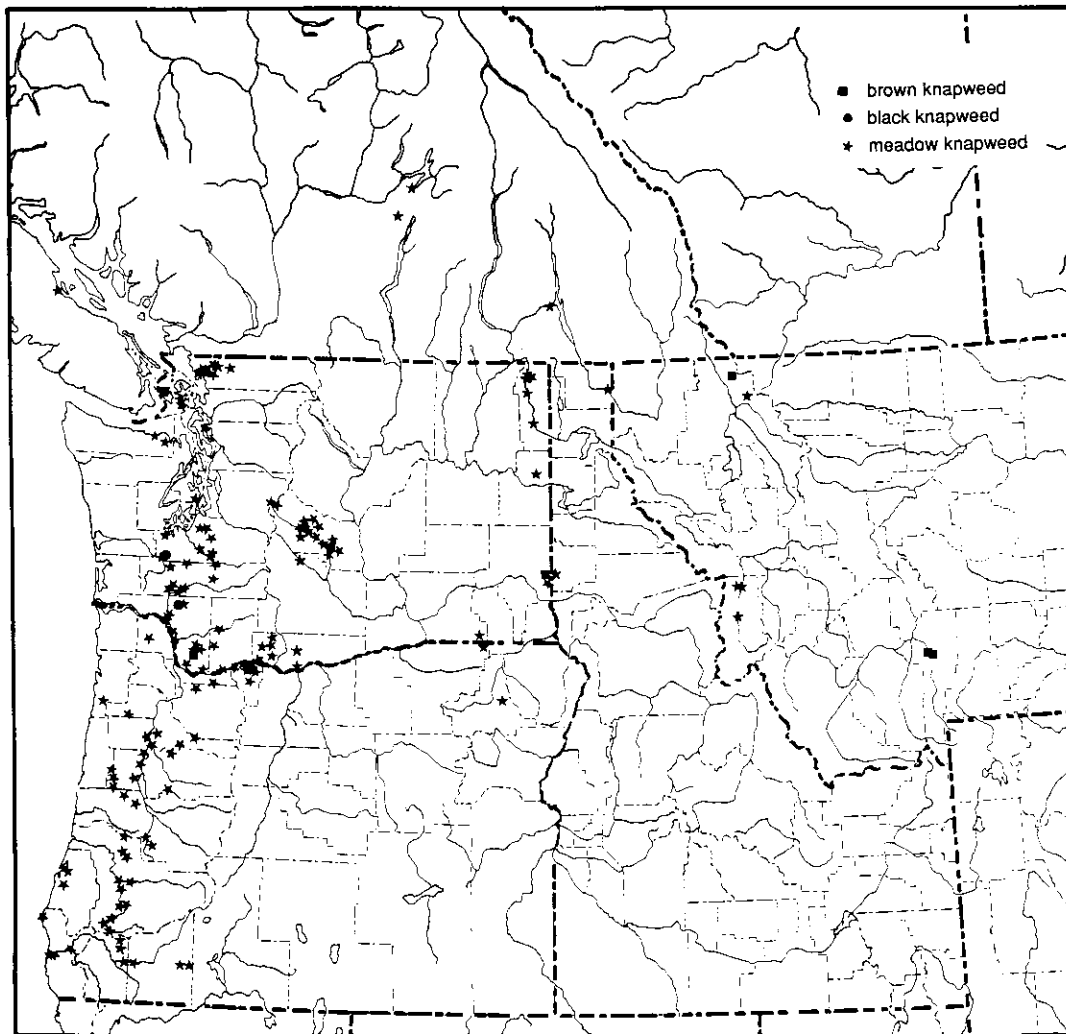


Figure 3. Distribution of meadow, black and brown knapweed in British Columbia, Idaho, Montana, Oregon and Washington, locations reported in survey as of February 1990, not including unrelocated collection sites.

In the current survey, populations containing recognizable black knapweed plants were found in Cowlitz, Thurston and Whatcom counties, Washington (Figure 3).

#### Meadow Knapweed

The earliest collection of meadow knapweed was in 1918 from waste areas in Eugene, Lane County, Oregon (Roché and Talbot 1986). Howell (1959) reported this hybrid to be "occasional or sometimes common along roads and in fields, variable and widespread." Before 1960 most of

the meadow knapweed was collected west of the Cascade Mountains from southern Oregon into British Columbia (Figure 4). Counties in Washington included Clark, Cowlitz, King, Klickitat, Pierce, San Juan, Snohomish, Thurston, Wahkiakum, and Whatcom. Oregon counties included Benton, Clackamas, Columbia, Douglas, Hood River, Josephine, Lane, Lincoln, Marion, Multnomah, and Wasco. Meadow knapweed was also found in Lincoln County, Montana, and at New Westminster, Vancouver, Nakusp, Sidney, Westwold, and Edgewood, British Columbia.

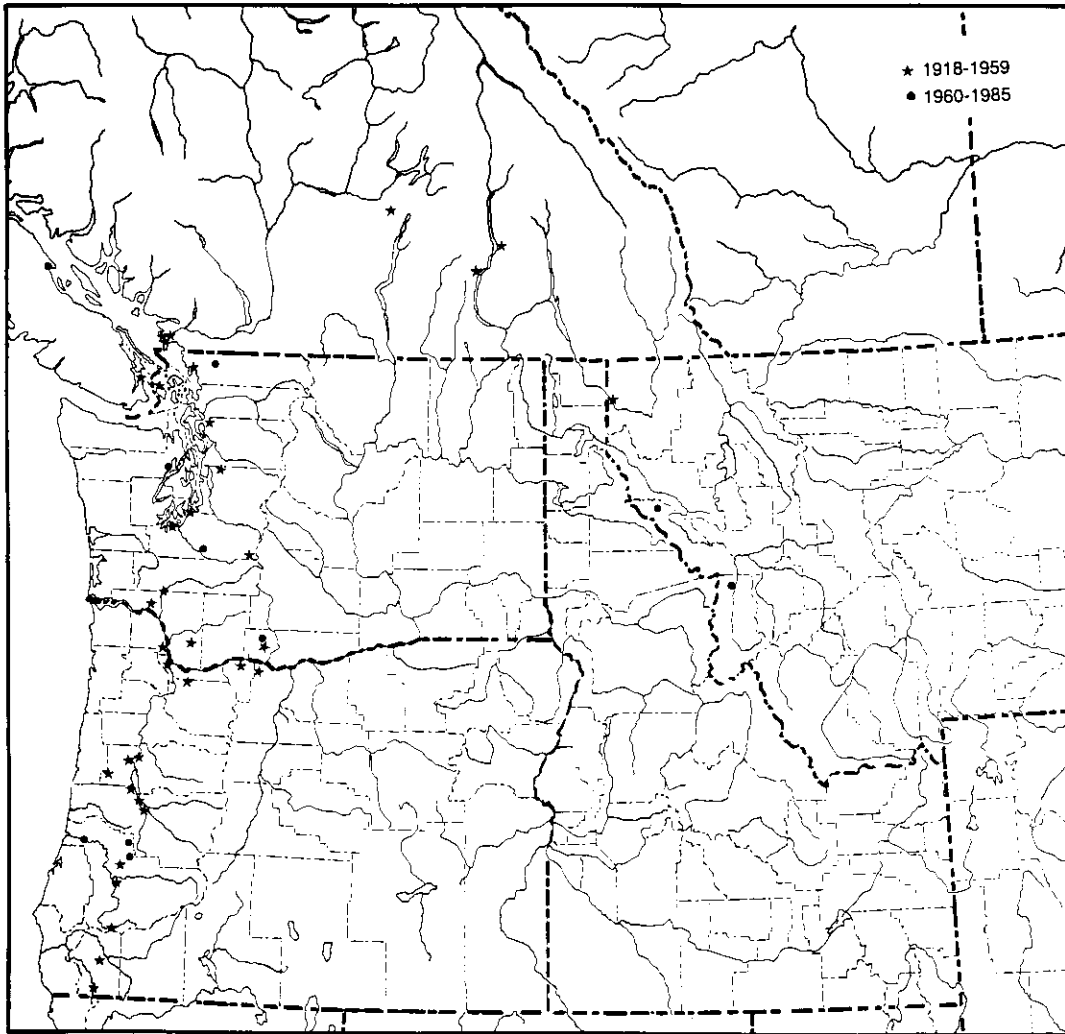


Figure 4. Collection locations of meadow knapweed in British Columbia, Idaho, Montana, Oregon and Washington, according to herbarium records.

TABLE 1. Estimated meadow knapweed population size by State or Province in hectares.

Location	Amount	Location	Amount
<b>British Columbia</b>		<b>Washington Counties</b>	
Harrop	trace <sup>1</sup>	Clallam	trace
Salmon Arm	trace	Clark	560
Fanny Bay	trace	Cowlitz	13
Westwold	12	Island	4
subtotal	12	King	1
<b>Idaho Counties</b>		Kitsap	3
Boundary	2	Kittitas	82
Latah	trace	Klickitat	51
subtotal	2	Lewis	22
<b>Montana Counties</b>		Pend Oreille	3
Flathead	trace	Pierce	65
Mineral	trace	San Juan	1
Ravalli	2	Skamania	1
subtotal	2	Spokane	trace
<b>Oregon Counties</b>		Thurston	8
Benton	5	Walla Walla	trace
Clackamas	50	Wheatecom	486
Coos	0.5	Whitman	trace
Curry	2	Yakima	1
Douglas	325	subtotal	1,301
Hood River	152	TOTAL	1,877
Jackson	2		
Josephine	2		
Lane	12		
Lincoln	trace		
Linn	4		
Marion	2		
Multnomah	1		
Polk	trace		
Tillamook	trace		
Umatilla	trace		
Union	2		
Yamhill	trace		
subtotal	560		

<sup>1</sup>Trace is less than 0.5 ha.

In the current survey, meadow knapweed was reported from 4 locations in British Columbia, 2 counties in Idaho, 3 counties in Montana, 18 counties in Oregon and 19 counties in Washington, for a total of 1,877 infested ha (Table 1). It increased from the original distribution in the Puget Trough and Willamette Valley to both slopes of the Cascades and outlier populations in Idaho and Montana (Figures 3 and 4).

**British Columbia.** Early collections from Vancouver between 1937 and 1945, Nakusp in 1940 and 1946 (Roché and Talbott 1986), Sidney in 1943 and Edgewood in 1953 were not relocated. The infestation at Westwold, first reported in 1951, was estimated at 12 ha in 1988 (Table 1). Additional infestations were found at Harrop, Salmon Arm and Fanny Bay (Figure 3).

**Idaho.** The first records of meadow knapweed in Idaho were discovered during the survey. In 1988 a single plant was found on the University of Idaho campus in Moscow, Latah County. In Boundary County, plants were found growing along roadsides, in a lawn and in a cutover forest area in 1989 (Figure 3).

**Montana.** Collected near Troy, Lincoln County, in 1932 (Roché and Talbott 1986), meadow knapweed was found in Ravalli and Mineral counties by the late 1970s, along recreation trails and associated with logging activities. The meadow knapweed in Lincoln County was not relocated. Additional meadow knapweed sites were reported in Flathead and Ravalli counties in irrigated hayfields and pastures, along roadsides, trails, and an

irrigation canal, for a total of approximately 2 ha (Table 1, Figure 3).

Oregon. Meadow knapweed was not reported in the survey for Columbia or Wasco counties, where it had been collected in 1932 and 1955, respectively (Figure 4). New records included Coos, Curry, Jackson, Linn, Polk, Tillamook, Umatilla, Union and Yamhill counties (Figure 3). Meadow knapweed was most abundant in Douglas and Hood River counties (Table 1), where it now dominates pastures, fence rows, river floodplains, waste areas, and roadsides. In counties reporting less than one hectare, meadow knapweed grew only on roadsides. These sites were not restricted to high traffic areas such as Interstate 5 and cities in the main north-south corridor. Isolated plants or patches were found in relatively remote logging communities or roads (Glenn Miller, Oregon Dept. of Agric., pers. comm.). The bulk of the meadow knapweed remained concentrated in western Oregon, with the major area of expansion on the east slope of the Cascade Mountains in Hood River County.

Washington. Meadow knapweed was not found in Jefferson, Snohomish, or Wahkiakum counties, where it had previously been collected. New records occurred in Island, Kitsap, Kittitas, Lewis, Pend Oreille, Skamania, Spokane, Walla Walla, Whitman and Yakima counties (Figure 3). From the previous western Washington distribution, meadow knapweed had expanded into the mesic areas on the east slope of the Cascade Mountains around Liberty in Kittitas County and the Conboy Basin in Klickitat County. Four counties reported 91 percent of the Washington infestation: Clark, Whatcom, Kittitas, and Klickitat (Table 1). Infestations occurred on sites similar to those in Oregon; roadsides, waste areas, moist meadows, irrigated pastures, openings in forested areas and on floodplains of rivers and streams.

## Discussion

### Weed Introduction

These knapweeds have no obvious special mechanism for seed dispersal; seeds shaken out of the mature capitula by wind or passing animals usually fall within a few decimeters of the parent plant so that long distance dispersal is mainly by humans (Marsden-Jones and Turrill 1954). The original introductions in North America appear to have been by seeds in ships' ballast unloaded at

Western seaports and intentional planting as ornamental flowers or as a forage species for livestock or bees. In the early 1900s ballast grounds at Albina and Linnton (near Portland), Oregon, were popular collecting areas for botanists who sometimes transplanted immature plants to their home gardens in order to identify the specimens later (Nelson 1917). This is likely the source of the black knapweed Suksdorf grew in his garden in Bingen in 1928 (Roché and Talbott 1986).

As an ornamental, black knapweed (also known by the common name of hardheads) was described in *The Standard Cyclopedia of Horticulture* (Bailey 1922) as "a very striking border plant, useful in dry or open places." Brown and black knapweed are still available in retail seed catalogs, listed by name, and in "wildflower" mixes. The two parent species appear to have been planted on college campuses or perhaps became established through careless handling of collected materials: brown knapweed at Willamette University, Salem, 1919, and Pullman, 1923; black knapweed in Pullman, 1895, and on the campus of the University of Washington, Seattle, 1935 (Roché and Talbott 1986). Some counties reported movement of meadow knapweed by individuals transplanting it as a wildflower (Blair Wolfley, Clark County, and Mary Fries, Lewis County, pers. comm.).

Brown knapweed was planted for hay and forage in eastern Canada in the 1850s (Rousseau 1968). A farmer near Freilighsburg, Missisquoi County, planted it as a source of pollen for honey bees around 1880 (Moore 1969). Meadow knapweed was cultivated as a source of winter forage near Roseburg, Douglas County, Oregon in 1952 (Howell 1959).

Although herbarium collections are an incomplete record of the historical distribution, they indicate that meadow knapweed was probably introduced as a hybrid and did not arise exclusively from brown and black knapweed hybridization in the Pacific Northwest. Pullman is the only location where both parents were collected: black knapweed in 1895 and brown knapweed from 1923 to 1985 and no hybrids have been found there. The closest meadow knapweed was an isolated patch found in 1986 approximately 30 km south of Pullman, near Uniontown. Both brown and black knapweed were collected earlier than the hybrid, and the frequency of collection has declined with time. The parent species were apparently introduced independently and met one of three fates: they were absorbed

into hybrid populations, persisted as relatively "pure" populations, or failed to survive. In contrast, meadow knapweed collections increased. The survey verified the trend of increasing distribution of the hybrid while the parent species declined. As judged by its increase in distribution, meadow knapweed is better adapted to conditions in the Pacific Northwest than either of its parents. The variability in its genetic makeup has undoubtedly been an asset in exploiting a variety of habitats, providing the basis for natural selection (Turrill 1964). Hybrid vigor may also be important. Marsden-Jones and Turrill (1954) found no morphological differences between seedlings of brown and black knapweed, but hybrid seedlings grew faster.

### Weed Migration

The two most important forces in the continued migration of meadow knapweed appear to be water and vehicles. Meadow knapweed was found growing on the floodplains of the Columbia, Umpqua, Rogue, Naches, Teanaway, Willamette, and Yakima rivers, Swauk and Spring creeks, and along irrigation ditches. Meadow knapweed infestations from vehicle-borne seeds range from the median of Interstate 5 to remote forest roads. Populations found along roadsides, in campgrounds, urban and industrial sites, including old mill yards, all implicate vehicles. Lacking a pappus, seeds may be carried in mud on equipment or vehicles.

Controlling scattered infestations while they are small outliers is important in containing the spread of an alien species (Moody and Mack 1988). The widely scattered infestations of diffuse and spotted knapweed in the 1950s (Roché and Talbott 1986) increased to major infestations of 173,000 ha of diffuse knapweed in Washington (Roché and Roché 1988) and 1,911,000 ha of spotted knapweed in Montana (Lacey 1989). While the ecologic amplitude of meadow knapweed appears to be narrower than that of diffuse or spotted knapweed, the potential invasion sites are more productive or environmentally sensitive (e.g., riparian areas). Meadow and riparian sites can produce 3 to 10 times more biomass than semi-arid sites (Roath 1985, Quigley *et al.* 1989). Although previously cultivated for winter forage, meadow knapweed's coarseness makes it generally less palatable to livestock than associated species. Pastures near Hood River, Oregon, have been left idle following

invasion and dominance by meadow knapweed (Rob Varga, Hood River County Weed Control, pers. comm.). However, palatability is relative and we observed prostrate plants in closely cropped pastures in Klickitat and San Juan counties.

In addition to detrimental effects on forage production, meadow knapweed is an undesirable invader of native plant communities, especially on floodplains and in disturbed forests. When exotic species invade natural communities they reduce natural diversity by causing extinctions and shifts in patterns of relative abundance (Temple 1990). Although it is probably too late to eradicate meadow knapweed in western North America, large infestations can be contained. Recent expansion of meadow knapweed distribution justifies local eradication of the small infestations.

### Acknowledgments

The project was funded by the Renewable Resources Extension Act through Washington State University Cooperative Extension. Individuals who contributed estimates and locations of meadow knapweed populations are listed as follows:

*British Columbia:* Roy Cranston, Robert Drinkwater; *Idaho:* Rich Old, Dan Kidder, Tim Miller, Phil Allegretti; *Montana:* Celestine Lacey, Reeves Petroff, Roxa French, Andy Kulla, Klaus Lackschewitz; *Oregon:* Eric Coombs, Ken French, Glenn Miller, Tim Butler, Dan Sharratt, Richard Halse, LaRea Dennis Johnston, Michael Meszaros, Rob Varga, Jerry Igo, Robert Brown, Dave Humphrey, Maura Naughton; *Washington* (by counties): Clark: Blair Wolfley, Georgia Hoglund, Gale Mayer; Cowlitz: Tony Olea, Joe Kropf, Len Cade; Jefferson: Irene Creso; Kitsap: Ellen Bentley, Diane Dolstad; Kittitas: Charlie McKinney, Skip Mynar, Glen Sachet; Klickitat: Bob Gorman, Eva Chapple; Lewis: Mary Fries, Olaf Flatness, Beth Williams; Pend Oreille: Sharon Bancroft; Pierce: Tom Bertram, Eugene Shaw, Duane Reichel, Marge Winebrenner, Mary Fries; San Juan: Lee Campbell; Skamania: Jack Peterson; Spokane: Georgia Hoglund, R. Scott Nielsen; Thurston: Mike McKay, Rick Johnson; Walla Walla: John Cato; Whatcom: Mickey Tucker, Ray Fann, John McLean, Laurel Baldwin; Whitman: John Hall, Larry Hunt, Dave Stiles; Yakima: Roy Van Denburgh, Jim Griffin, Tom Wright.

We thank the following herbaria for their assistance in providing records of collections: British Columbia Provincial Museum, University

of British Columbia, University of Idaho, Montana State University, University of Montana, University of Oregon, Oregon State University (including Willamette University), University of Puget Sound, Pacific Lutheran University, Washington State University, University of Washington, Western Washington University.

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Received 20 May 1990

Accepted for publication 30 July 1990