The Native Status of Reed Canarygrass (*Phalaris arundinacea* L.) in the Inland Northwest, USA

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ABSTRACT: Reed canarygrass (*Phalaris arundinacea* L.) can be invasive in wet habitats and is often a target for control. There is no consensus on its native status in North America; published sources treat it as either exotic or native. We examined the locations and habitats of early collections of reed canarygrass in the inland Northwest in the context of Euro-American settlement and early agronomic research. Early collectors found *P. arundinacea* along streams, lake margins, springs, and meadows. This species predates agronomic trials in the United States and was collected in remote areas before settlement. Modern populations of reed canarygrass may be a mixture of agronomic cultivars and native material.

Index terms: exotic species, native species, *Phalaris arundinacea*, reed canarygrass

INTRODUCTION

Opinions vary as to whether reed canarygrass (*Phalaris arundinacea* L.) is native in North America. Some authors view it as native to North America, Europe, and Asia (e.g., Piper 1924, Schoth 1929, Anderson 1961, Cronquist et al. 1977), while others view it as introduced from Europe (e.g., Walton 1983, Taylor 1990, Markow 1994, Friedman et al. 1995). The Natural Areas Association's compendium of exotic species (Natural Areas Association 1992) includes *P. arundinacea*, furthering the second view. A third view is that North American populations are a mixture of native genotypes and European cultivars (Dore and McNeil 1980, Apfelbaum and Sams 1987, Harrison et al. 1996). In many situations reed canarygrass behaves like an aggressive exotic, displacing native marsh and fen communities by forming monospecific stands (Apflebaum and Sams 1987, Dore and McNeil 1980, Harrison et al. 1996, Lesica 1997).

The native status of canarygrass has implications for natural area management. Control of reed canarygrass is difficult and expensive (Apfelbaum and Sams 1987). Decisions to control reed canarygrass in natural areas may be based, in part, on whether the population is native or introduced. The purpose of our study was to use herbarium specimens of reed canarygrass collected by early explorers to determine where in the inland northwestern United States this species is likely to be native. We also attempted to identify native habitats. In addition, we make suggestions for further research that would help refine our knowledge of this species in North America.

METHODS

We defined the inland Northwest to include most of the states of Idaho, Montana, and Wyoming (Figure 1); this region served as a core area for our inquiry. We focused on the inland Northwest because we are familiar with the local history and field settings in this area. Furthermore, early botanical collectors were more likely to have visited this area, which was settled relatively recently, before Euro-American settlement (Raynolds 1868, Hayden 1872 and 1873, Haines 1955, Fite 1966, Hampton 1971, Sale and Karn 1979, Limerick 1987, Beck and Haase 1989, Horton et al. 1989, Goetzmann 1991, Moulton 1994, Utley 1997).

Our collection data were from ten herbaria: Harvard University's Gray Herbarium, Cambridge, Massachusetts (GH); University of Idaho, Moscow (ID); Royal Botanic Gardens Kew, Richmond, Surrey, England (K); Montana State University, Bozeman (MONT); University of Montana, Missoula (MONTU); New York Botanical Garden, New York City (NY); Academy of Natural Sciences, Philadephia (PH); Rocky Mountain Herbarium, Laramie, Wyoming (RM); U.S. National Museum, Washington, D.C. (US); and Washington State University, Pullman (WSU). We used all information on the labels from specimens predating approximately 1900 in Idaho, Montana, and Wy-

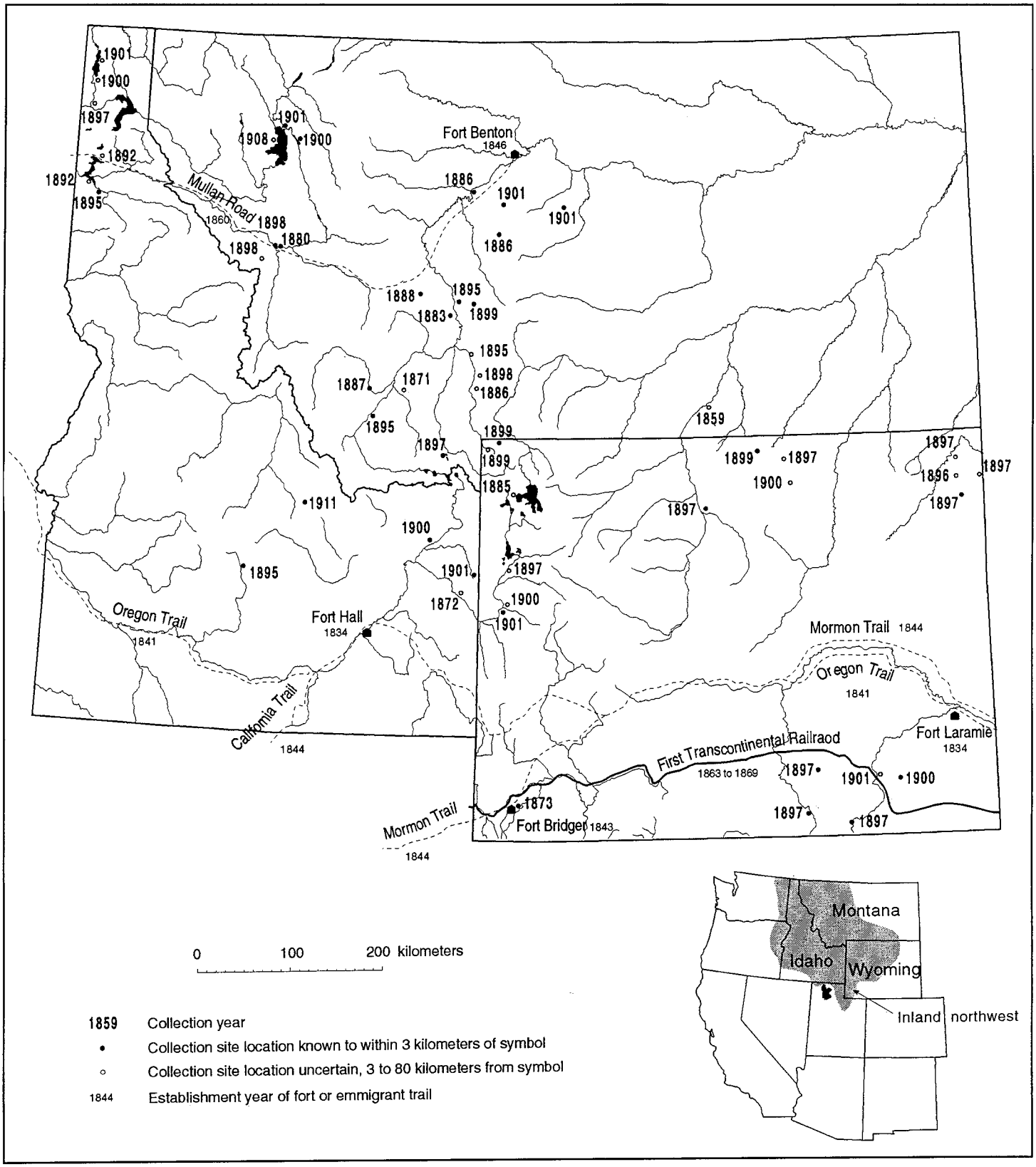

Figure 1. Location and timing of early *Phalaris arundinacea* collections in the inland Northwest. Emigrant routes and forts provide a Euro-American settlement context. See Figure 2 for a more complete illustration of settlement patterns from 1840 to 1900.

oming. We were not strict about the date and area so that we could include potentially interesting specimens from locales outside our core area in Wyoming, Montana, and Idaho, as well as specimens from northern Colorado, Utah, and Washington. We augmented the label data with information from related publications, including government surveys conducted by the War Department (WD), the U.S. Geological Survey (USGS), and the U.S. Department of Agriculture (USDA).

Drawing from our past field experience, past work by others (Anderson 1961, Dore and McNeill 1980), and cursory examination of herbarium material, we knew that reed canarygrass shows great variation in panicle width, panicle density, and leaf width. Thus, to find a temporal pattern in these characteristics, we classified specimens from US, PH, and MONTU by panicle character (width and density combined) and by maximum leaf width of the second highest culm leaf. We used an ordinal variable from 1 to 4 (in half-steps) for panicle character and measured leaf width in millimeters. These three herbaria provided enough pre- and post-1900 specimens to allow an assessment. We also noted striped-leaf specimens (forma *picta*) (Anderson 1961).

When possible, we plotted collection locations and year of collection on a map. The earliest collectors had few geographic reference points to work with, while some later collectors were less specific in their descriptions of location than they could have been. If a specific town or other distinct geographic location was noted on the label, we used this information directly. If only a county was noted, we mapped the collection entity at the geographic center of the county. Better located collections (< 3 km) were distinguished from poorly located ones (3–80 km). Typically, we had enough information to plot an entity to within 16 km of its probable collection location. Early travel routes on our maps were based on summaries by Goetzmann (1991), Anonymous (1993), and Peters (1996).

RESULTS

Early collectors found reed canarygrass throughout the inland Northwest between 1825 and 1911 (Figure 1, Tables 1 and 2). We were able to fix the location of 61 of the 90 nonduplicate collections that fit our criteria. There were 8 duplicate locations, where more than one collector visited an area at different times; in these cases we used the earliest date. Thus, we show 53 mapped locations on Figure 1. Many of the specimens were collected by prominent botanists including E. Bessey, J.M. Coulter, F. Kelsey, C.A. Geyer, A. Gray, D. Lyall, A. Nelson, C.V. Piper, P. Rydberg, F.L. Scribner, C.L. Shear, F. Tweedy, and S. Watson. Ten mapped specimens appear to predate Euro-American settlement in

Table 1. Mapped collections of *Phalaris arundinacea* that probably predate Euro-American settlement in the surrounding region.

Collector	Year	Location	Remarks
COLLECTIONS FROM UNSETTLED AREAS			
F.V. Hayden	1859	Bighorn Mts., Wyoming	(NY)[a] Area settled after 1860 (Raynolds 1868)
J.M. Coulter	1872	Snake River Valley, Idaho	(PH) Area settled around 1898 (Horton et al. 1989, unpublished documents) see also Hayden 1873
F. Tweedy	1885	Yellowstone Lake, Wyoming	(RM, PH) poachers, thieves, and some tourists present (Hampton 1971)
COLLECTIONS FROM REMOTE AREAS NEAR SETTLEMENT			
S.Watson	1880	Hellgate Canyon, Montana	(PH)
P.A. Rydberg	1896	East Gallatin Swamps, Montana	(PH, US, NY)
A. & E. Nelson	1899	Madison River, Yellowstone National Park	(US) U.S. Cavalry and tourists present (Hampton 1971)
J.W. Blankinship	1899	Deep Creek Canyon, Big Belt Mts., Montana	(MONTU)
Rydberg & Bessey	1897	Cliff Lake, Montana	(PH, US, NY)
Merrill & Wilcox	1901	Sulphur Springs Bar, 20 miles South of Jackson, Wyoming, along Snake River	(US) Jackson was settled around 1884 (Moulton 1994). Rugged terrain, no road along Snake River canyon until 1939
T.A. Williams	1897	Head of Beaver Creek, Bear Lodge Mts., Wyoming	(US) Mountains not grazed at this time (Williams 1898)

[a] Herbarium abbreviations — see "Methods."

the region or were collected from remote and presumably undeveloped areas soon after settlement in the general area. These mapped, noteworthy specimens are shown in Table 1. Table 2 includes specimens that we could not map because of vague geographic descriptions. These are the earliest collections (1825–1858) we obtained; their vague location descriptions probably reflect the crude knowledge of geography at the time of collection. Figure 2 summarizes European-influenced settlement in the inland Northwest and surrounding areas. By comparing the data in Tables 1 and 2 and Figure 1 with the settlement patterns in Figure 2, we concluded that reed canarygrass was extant in the inland Northwest before settlement.

Habitat information from specimen labels indicates that reed canarygrass was found along streams as well as lacustrine and palustrine habitats such as bogs, lake shores, sloughs, wet meadows, and "springy places." Nine specimens collected between 1895 and 1900 provide information on both habitat and abundance. Of the six specimens from riverine habitats, five indicated that reed canarygrass was abundant, while all three specimens from meadows and springs indicated that the plant was uncommon or rare.

We did not detect any morphological pattern among the early specimens and could not distinguish them from more recent collections. None of the early material had the white and green striped leaves indicative of the *picta* form; the earliest *picta* specimen we found dated from 1934.

DISCUSSION

The timing and geographic distribution of reed canarygrass collections indicate that

Table 2. Unmapped collections of *Phalaris arundinacea* L. that probably predate Euro-American settlement in the surrounding region.

Collector	Year	Location	Remarks
Unknown	1825	banks of rivers, NW America	(K)[a]
Douglas	1823–33	common on (illegible) banks of streams from western ocean to Hudson's Bay	(K) no date written on the sheet. Herbarium stamp date is 1867, thus David Douglas is the likely collector[b]. D. Douglas collected in W North America 1823–1833 and deposited material at Kew.
Gray, A.	1839	North American terr. (+3 illegible abbreviations)	(K)
Unknown (probably C.A. Geyer)	1843–44	Fremont's 2nd Exped. to N. California and Oregon	(K) see Figure 2 for route
C. A. Geyer	1845	banks of rivulets in meadows upper Oregon with *Phragmites communis.* Aug.	(K) "Oregon" relates to Oregon Territory
C. A. Geyer	1845	Missouri and Oregon, Rocky Mountains	(K) "Missouri" likely means Missouri River. Geyer may have joined Fremont's 1845 expedition, as he did in earlier ones.
Dr. Lyall	1858	Sumass Prairie 49 N Lat	(K) Oregon Boundary Commission[c] (Dr. Lyall = David Lyall[b])
Dr. Lyall	1859	Cascade Mountains 49 N Lat	(K) Oregon Boundary Commission[c] Chulukweyuk Prairie, B.C.
Dr. Lyall	1860	Columbia River from Lat 46 to 49 N (+illegible place name)	(K) Oregon Boundary Commission[c]
Dr. Lyall	1861	Banks of Pend Oreille River also E side Rocky Mtns 49 N Lat	(GH, K) Oregon Boundary Commission From Ft. Colville to Rocky Mountains

[a] K = Kew Gardens (Royal Botanic Gardens Kew), GH = Gray Herbarium, Harvard University.

[b] Collector history from Harvard Herbarium database.

[c] Collections are from west of our defined inland northwest focus area (Figure 1).

this species was present in the inland Northwest before and during early Euro-American settlement (Figures 1 and 2, Tables 1 and 2). The emigration history of Euro-Americans into western North America is complex, and descriptions of the events and factors important to plant emigration or introduction are scattered throughout historical texts and original reports (Raynolds 1868; Hayden 1872, 1873; Haines 1955; Fite 1966; Hampton 1971; Sale and Karn 1979; Limerick 1987; Beck and Haase 1989; Horton et al. 1989; Goetzmann 1991; Moulton 1994; Utley 1997). Even the term Euro-American is simplistic; many ethnic races were involved in important ways, but we use this term for simplicity and to reflect the European domination of early politics. To clarify the presence of reed canarygrass prior to Euro-American settlement, we provide a historical sketch of exploration, fur-bearer trapping, and early settlement. Much of this is from Beck and Haase (1989) and Goetzmann (1991).

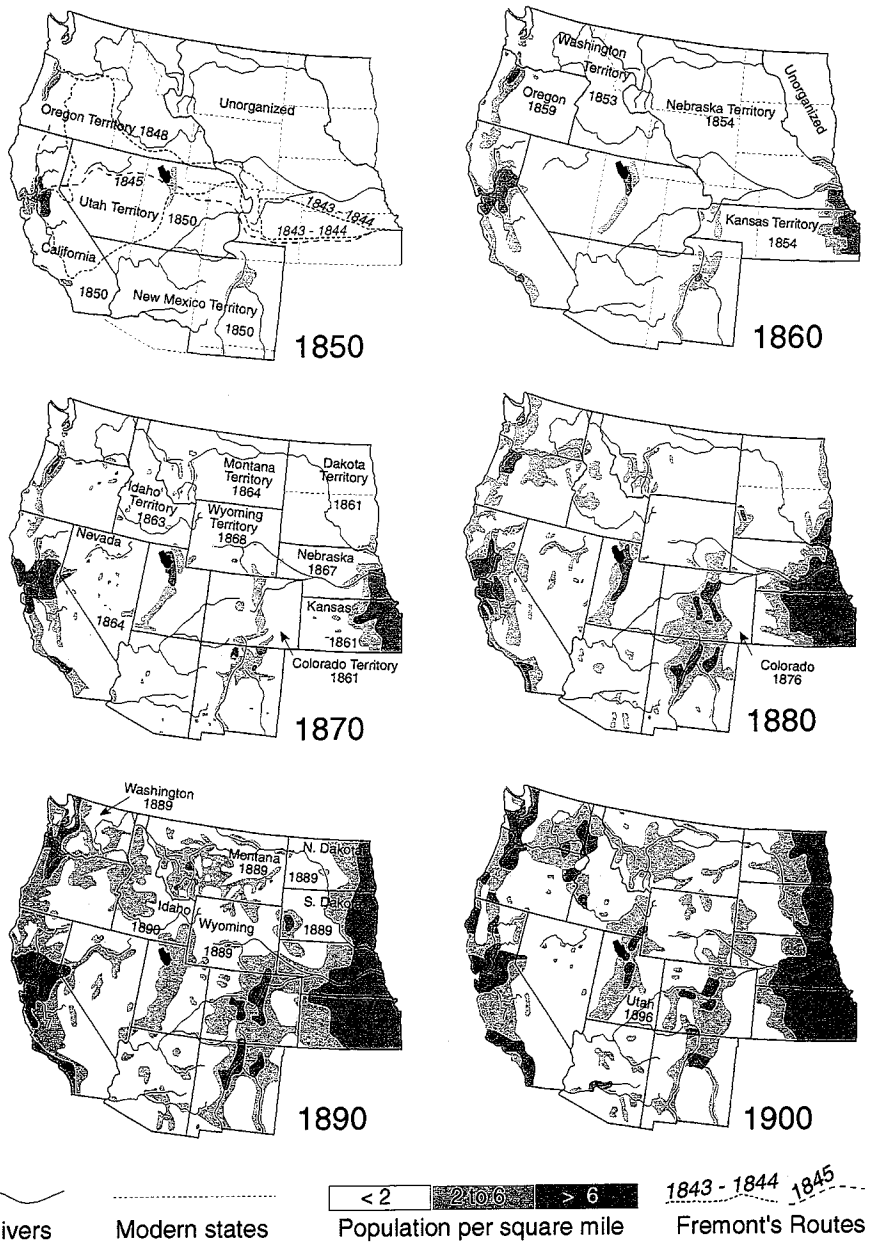

Figure 2. Progress of settlement in the western United States of America. The dates for each map indicate the end of the decade. Much of the United States east of what is shown here was settled by 1850, except for present-day west Texas, Minnesota, northern Maine, and southern Florida. Before 1850 nearly all of the area mapped above was vacant of non–Native Americans, except for trapping outposts in the Northwest and small isolated settlements in today's California and New Mexico. Adapted from Sale and Karn 1979.

Early exploration began with Alexander McKenzie's cross-continent trips through what is now Canada in 1789 and 1793. The Lewis and Clark expedition crossed the heart of the Northwest to the Pacific Ocean in 1805 and returned to St. Louis in 1806. Fur trappers began their exploits in the country explored by Lewis and Clark in 1806; the era of large-scale fur-trapping ended about 1845. Knowledge of the Northwest's geography and resources increased with fur-trappers' experience, but much of it was not documented. Later, this experience guided the explorations sponsored by the U.S. government.

Government explorations with scientific objectives resumed with Stephen Long's expedition, 1819 to 1820. Long's expedition contributed relatively little to botany; the expedition botanist died two months into the journey. Captain Benjamin Bonneville's work, conducted while he was on leave from the military, was intended to both serve the trapping enterprise and meet more scientific objectives. His most valuable contribution was a map, which largely duplicated Albert Gallatin's map of the previous year (1836). When these two disparate maps are compared, the crude nature of geographic knowledge at the time becomes apparent. Given the level of geographic knowledge and the difficulties of access and travel, the collections dating from 1825 and 1839 (Table 2) are remarkable. John Fremont's explorations in the Northwest, beginning in 1842, were the most scientifically valuable since Lewis and Clark's expedition. Because we obtained at least one collection related to Fremont's expeditions (Table 2), his routes show on Figure 2.

Several government expeditions to the Northwest followed after Fremont's expedition; the most important of these were

William Raynolds' expedition to the Yellowstone basin (Raynolds 1868) and the Hayden surveys (e.g,. Hayden 1872, 1873). Hayden was with Raynolds and collected reed canarygrass along the Bighorn River drainage in 1859 (Table 1). Although Raynolds's trip was relatively late (1859–1860), the country they explored was relatively unknown to Euro-Americans; even their very experienced guide, Jim Bridger, was unfamiliar with some of the area. Upon reaching the Oregon Trail in Wyoming, Raynolds commented on the high amount of emigrant traffic and numerous small outposts along the trail. His comment underscores the difference between most of the West and the main travel routes, which at the time were primarily used to access the West coast (Fite 1966) through the essentially nonsettled areas in the inland Northwest (Figures 1 and 2). The concentrated inland Northwest settlements during the mid-1800s were largely associated with mining (Limerick 1987). Extensive settlement of the inland Northwest occurred between 1870 and 1890 (Beck and Hasse 1989) (Figure 2). For example, Hayden (1872) mentioned that the upper Ruby River in Montana already had cattle, horses, and sheep when he collected reed canarygrass there in 1871. Hayden (1873) also mentioned the presence of alfalfa (*Medicago sativa* L.) near Fort Hall, Idaho. This is not surprising: Nathaniel Wyeth built Fort Hall in 1834 (Utley 1997), after which it became a node of western travel. Nonetheless, the earliness of some collections and the remoteness of some later ones (Tables 1 and 2) indicate that reed canarygrass was a part of the pre-agricultural, native flora of the inland northwest.

An understanding of the dynamics of geographic expansion of known introduced species provides insight into the native status of reed canarygrass. There tends to be a lag of 20 to 40 years before an introduced plant becomes widespread (Forcella and Harvey 1988, Cousens and Mortimer 1995). In view of this, it is unlikely that reed canarygrass could have had such an extensive range by 1890 (Figure 1) due to introductions via settlement in the inland Northwest, which began in earnest only a decade earlier (Figure 2). Forcella and Harvey (1988) identified Portland, Oregon, as an important, early point of introduction for exotic species, but all of the early travel and exploration that precedes our collection data was from the East (Beck and Haase 1989). The center of diversity and differentiation of *Phalaris* is in the Mediterranean region (Anderson 1961, Baldini 1993), and reed canarygrass may have been introduced with very early European explorers (such as Columbus and the Pilgrims) and thus spread throughout North America via traveling Native Americans and waterfowl during and after the 1600s.

Reed canarygrass occurred in many different habitats in the presettlement inland Northwest, from low-elevation riparian areas to montane wetlands. Collections made in the late 1890s suggest that reed canarygrass formed large stands along lower elevation rivers and was present but much less abundant in mountainous habitats. These observations may indicate that riverine habitats were more favorable than montane sites for indigenous reed canarygrass; but travel may have been biased toward river valleys, and it is difficult to assume equal collection effort across habitats. Another explanation is that riverine sites may have already been influenced by invasive, introduced genotypes by the turn of the century, and that less aggressive, indigenous populations occurred primarily in montane habitats. Dore and McNeil (1980) noted that more northern populations in Quebec did not form large monospecific stands and appeared to be growing in native habitats. However, this explanation is unlikely in view of the comments of the earliest collectors, who noted that reed canarygrass was common along rivers (Table 2).

Reed canarygrass has a long agronomic history (Schoth 1929). Cultivation began in Sweden in 1749 (Alway 1931). By 1812 experiments in England showed that the striped-leaved *picta* form was more palatable to livestock than the wild strain (Alway 1931). *Phalaris arundinacea* seed was commercially available in Hamburg, Germany, by 1836 (Alway 1931). The first trials with reed canarygrass in the United States probably began in the mid-1830s, when New England farmers increased the amount of the *picta* form via root transplants because of its higher palatability (Alway 1931). During the 1850s wild reed canarygrass from Massachusetts received considerable attention and was recommended for reclaiming peatlands and marshes (Alway 1931). During the late 1890s, the Agrostology Division of the USDA explored the potential of many species for forage improvement of western rangelands. We encountered a specimen that was cultivated in the Division of Agrostology's grass garden in Washington, D.C., in 1897. Many of the wild specimens we encountered in herbaria were collected by agrostologists working on range improvement (e.g., Williams 1898, Nelson 1898). The USDA agrostologist F. Lamson-Scribner inquired among leading cattleman and farmers in western states about the potential cultivation of forage grasses (Williams 1898). The consensus was that the native grasses were highly desirable and any improvement would come from a drought-tolerant grass for the foothills. Further work indicated that reed canarygrass could resist drought as well as any cultivated grass (Pammel et al. 1901, in Wilkins and Hughes 1932).

However, due to the difficultly of seed harvest, reed canarygrass cultivation was limited in the United States until 1918 (Wilkins and Hughes 1932). Schoth (1929) attributed most of the stands of reed canarygrass on the Pacific Coast to a cultivated stand in Coos County, Oregon, that was established in 1885. Schoth (1929) surmised that populations farther inland were native. Several of the collections we obtained (Figure 1, Table 1 and 2) predate the Coos Bay planting, and Frank Tweedy's collection in 1883 near Wenatchee, Washington (east of the Cascade Mountains), also supports Schoth's opinion.

More organized agronomic trials for reed canarygrass began in Iowa in 1918 (Wilkins and Hughes 1932). These trials began with seed supplied by an Iowa farmer; by 1928 nothing was known about this seed's original source (Wilkins and Hughes 1932). Now there are at least 11 reed canarygrass cultivars (Harrison et al. 1996).

Although reed canarygrass appears to be native in the inland Northwest, many modern populations may be derived from introduced cultivars (Dore and McNeil 1980, Apfelbaum and Sams 1987, Harrison et al. 1996). Many cultivars have been selected for vegetative vigor (Alderson and Sharp 1994), a trait that could promote invasion. In addition, genetic introgression from cultivars into native genotypes, resulting in more aggressive weeds, has been demonstrated in other species (e.g., Baker 1972, Barrett 1983) and may be occurring in reed canarygrass. The species' traits of wind pollination and prolific seed production facilitate the spread of nonindigenous genotypes, especially along major waterways where there are no significant barriers to dispersal. Introduction of genotypes selected for vegetative vigor could help explain the invasive nature of reed canarygrass in native plant communities.

Unfortunately, morphological variability of *Phalaris arundinacea* makes discrimination between native and non-native populations difficult (Anderson 1961, Dore and McNeil 1980). Our findings agree with this observation. For example, Baldini (1993) examined *Phalaris* specimens from Italy and divided *P. arundinacea* into three species based on ploidy level and morphology. Using his classification, we found pre-1900 herbarium specimens from remote areas (including the earliest collection from 1825) that resembled *P. rotgesii*, which is putatively endemic to southern Europe (Baldini 1993, Harrison et al. 1996). Furthermore, it would be difficult to locate native populations of this wind-pollinated grass that have unambiguously not been exposed to gene flow from widespread, non-native cultivars. It may be possible, however, to identify genetic markers unique to European or western North American populations using herbarium specimens collected before European settlement (e.g., Table 1 and 2). Polymerase chain reaction (PCR)-based methods would allow amplification of DNA extracted from dried material. PCR fragment polymorphism or sequencing techniques developed for other grass species (e.g., rice maize) could be used (Arnheim et al. 1990, see Soltis et al. 1992 for examples of molecular methods in plant systematics). Once DNA markers unique to both continents are identified, the native or hybrid nature of extant populations could be determined. In this way indigenous populations of *P. arundinacea* could be identified and preserved or used in restoration. Unless morphological characters distinguishing native from introduced types are found, it will not be possible to identify and control all introduced populations. Nonetheless, determination of the native status of populations in important natural areas may be feasible as PCR-based genetic analysis becomes more available and less costly.

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