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SPREAD OF PHALARIS ARUNDINACEA ADVERSELY IMPACTS THE ENDANGERED PLANT HOWELLIA AQUATILIS

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Key words: exotic, invasion, endangered plant, Phalaris arundinacea, Howellia aquatilis, natural area, Montana.

Invasive exotic species are considered one of the primary threats to native communities (Mooney and Drake 1986) and are a major concern to natural areas managers (Bratton 1982, Harty 1986). Exotics often displace native dominants, sometimes altering community function as well as composition (Vitousek et al. 1987). They are also implicated in the decline of rare species, but such cases have rarely been documented for plants (Huenneke and Thomson 1995, Lesica and Shelly 1996). Here I present evidence that Phalaris arundinacea L. (reed canarygrass), an aggressive rhizomatous grass with native and exotic genotypes, is gradually displacing native marsh vegetation, including the endangered plant Howellia aquatilis Gray.

SPECIES DESCRIPTIONS

Phalaris arundinacea (Poaceae) is a strongly rhizomatous perennial grass. Native to northern Europe and northern North America (Dore and McNeill 1980), it has been cultivated for forage and hay in Europe since at least the early 1800s (Schoth 1929). Much of the P. arundinacea now found in North America is thought to be derived from cultivars introduced for agriculture (Dore and McNeill 1980, Apfelbaum and Sams 1987), and many of these cultivars have been selected for vegetative vigor (Alderson and Sharp 1994). Phalaris arundinacea forms dense monocultures, up to 2 m high in Montana. It is capable of invading native wetlands, causing declines in native species (Apfelbaum and Sams 1987).

Howellia aquatilis (Campanulaceae) is an annual aquatic plant, dependent on yearly recruitment from the seed bank. Seeds of H. aquatilis require an aerobic environment to germinate (Lesica 1992), but plants require an aquatic environment to grow and produce flowers and fruits. Large, temporary declines in abundance occur following years when ponds fail to dry by late summer (Lesica personal observation). Seeds germinate in Montana in the fall, growth begins in the spring, and plants grow up through the water column, producing leaves and flowers at or below the surface. Flower production starts in June and continues until drying occurs, usually late August. Howellia aquatilis occurs in ephemeral ponds or the margins of shallow permanent ponds dominated by emergent macrophytes, such as Equisetum fluviatile L., Sium suave Walt., and the tussock-forming Carex vesicaria L. These species do not usually form a closed canopy, and H. aquatilis generally grows in the spaces between these taller plants. It is known historically from northern California, western Oregon, western and eastern Washington, northern Idaho, and northwest Montana; however, many of these populations are thought to be extirpated. Howellia aquatilis is considered threatened or endangered throughout its range in the Pacific Northwest (Lesica and Shelly 1991) and is listed as threatened under the Federal Endangered Species Act.

STUDY AREA AND METHODS

I conducted my study on The Nature Conservancy’s Swan River Oxbow Preserve along the Swan River 5 km south of the town of Swan Lake in Lake County, Montana. Howellia aquatilis occurs in marshy areas adjacent to a large oxbow slough. Phalaris arundinacea is found throughout many of the wetlands of the preserve, where it likely invaded from plantings on the adjacent Swan Lake National Wildlife Refuge.

Phalaris arundinacea occurs on the edge of 2 shallow bays, ca 100 m apart, of a large river

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oxbow (designated North and South marshes; 47°53'N, 113°51'W; 945 m elevation) that also support colonies of *H. aquatilis*. These colonies experience the same hydrologic regime that controls the sometimes significant annual fluctuations in abundance of *H. aquatilis* (see Lesica 1992) but have different depths and distribution of dominant vegetation. In 1987 I established a permanent post in the center of the *Phalaris* colony in the North Marsh. The distance from the center post to the edge of the solid *Phalaris* sward was measured for 6 radii at 20° intervals (1 interval was 30°) by a hand-held compass. Measurements were repeated in 1991 and 1996. Data were analyzed by repeated measures analysis of variance, with each radius treated as an independent measure of the growth of the sward. Total area estimates for the 110° portion of the colony in 1987 and 1996 were calculated as the sum of the geometrically derived areas of each arc section.

In 1988 I established 2 permanent transects to monitor the abundance of *H. aquatilis* and *Phalaris*: 40 m in the North Marsh and 32 m in the South Marsh. Both transects began in colonies of *Phalaris* and extended through *Carex vesicaria–Equisetum fluviatile* marsh that supported colonies of *H. aquatilis*. I used the line intercept method (Mueller-Dombois and Ellenberg 1974) to estimate cover of solid *Phalaris* swards and *H. aquatilis*. Clusters of *H. aquatilis* stems were treated as if they were the crowns of shrubs, and the distance overlapped by the line was recorded. When the line crossed a single strand, it was recorded as 1 cm (the minimum distance recorded). Transects were read annually in mid-July from 1988 to 1996.

**RESULTS AND DISCUSSION**

*Phalaris arundinacea* colonies consist of a monoculture core area surrounded by a periphery where ramets occur among the marsh dominants, *C. vesicaria*, *E. fluviatile*, and *S. suave*. In the North Marsh cover of *Phalaris* increased from 20% to 95% in 9 yr in the 3-m-wide ecotonal zone adjacent to the core area at the beginning of the transect. In this same period canopy cover of *H. aquatilis* declined steadily to near zero. Cover along the entire transect fluctuated but did not show a similar overall declining trend (Fig. 1). *Phalaris arundinacea* was completely absent from the other end of this transect in 1988 but was common by 1996. In the South Marsh cover of *Phalaris* remained stable over the course of the study, and there was no apparent change in the canopy cover of *H. aquatilis* in the ecotonal zone.

In the North Marsh the extent of the solid *Phalaris* sward intercepted increased for 4 of 6 radii between 1988 and 1996, and this difference was marginally significant ($F_{2,10} = 2.86, P = 0.10$). The power of this test is limited by the small sample size, so $P = 0.10$ is a reasonable significance level (Taylor and Gerrodette 1993). The estimated area of the sampled *Phalaris* sward was 155 m$^2$ in 1988 and 209 m$^2$ in 1996, an increase of 35% in 9 yr.

My study provides indirect evidence that *Howellia aquatilis* is being displaced by *Phalaris arundinacea* in the North Marsh. The size of the *Phalaris* monoculture increased in the North Marsh over the course of the study, while the canopy cover of *H. aquatilis* declined to near zero in the area of invasion, even in 1996 when abundance reached a 9-yr high in the entire marsh. The fact that *H. aquatilis* declined in the presence of *Phalaris arundinacea* while

![Fig. 1. Percent canopy cover of (A) *Phalaris arundinacea* in the Phalaris-marsh ecotone, (B) *H. aquatilis* in the ecotone, and (C) *Howellia aquatilis* in the entire North Marsh from 1988 to 1996.](image-url)
increasing elsewhere in the marsh does not prove but strongly suggests interference by *P. arundinacea*.

*Phalaris arundinacea* forms dense swards that likely produce deeper shade than the more open, native marsh vegetation. Furthermore, *P. arundinacea* monocultures produce deep, continuous, thatch-like litter that decomposes slowly compared to the patchy, quickly decomposing litter produced by the native vegetation. This dense litter layer may inhibit the growth of seedlings (Bergelson 1990), thereby excluding *H. aquatilis*. *Howellia aquatilis* is, however, capable of persisting in mixtures of *P. arundinacea* and native marsh.

*Phalaris arundinacea* is capable of displacing native wetland vegetation (Apfelbaum and Sams 1987), but the rate of invasion is liable to depend on individual site characteristics. In the North Marsh *P. arundinacea* is increasing at ca 3% per year toward the center as well as around the margins. On the other hand, extent of seedlings (Bergelson 1990), thereby excluding *P. arundinacea* in the South Marsh did not increase along the transect over the 9 yr of the study.

It is generally acknowledged that *P. arundinacea* is native to the northern portions of North America; however, introduced cultivars are now common throughout much of North America, obscuring the geographic range and habitat of native ecotypes (Anderson 1961, Dore and McNeill 1980). It is generally believed that invasive populations of *P. arundinacea* are derived from nonnative, agricultural cultivars (Apfelbaum and Sams 1987), although the morphological variability of the species makes discrimination between native and nonnative populations impossible (Anderson 1961). Genetic introgression from cultivated into native ecotypes, resulting in more aggressive weeds, has been demonstrated in other species (Baker 1972, Barrett 1983) and may also be occurring in *P. arundinacea*.

*Howellia aquatilis* is currently known from 7 areas in the Pacific Northwest, and *P. arundinacea* is present at most of these sites. Results of my study, although limited in scope, suggest that this aggressive exotic could reduce populations of *H. aquatilis* throughout much of its range. Although eradication of *P. arundinacea* may not be possible, preventing establishment in unininvaded wetlands and controlling spread in others will be necessary to protect this rare species.

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