

BIOLOGY AND MANAGEMENT OF REED CANARYGRASS, AND IMPLICATIONS FOR ECOLOGICAL RESTORATION

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INTRODUCTION

This paper presents an overview of the conservation and weed management concerns involving reed canarygrass (*Phalaris arundinacea*) in Western Washington and Western Oregon. This overview describes aspects of this species' biology as they pertain to the weed management of this species. Naglich (1994) provides a more detailed summary of the biology of this species, as well as additional discussion of techniques used historically in managing this species as a weed.

BACKGROUND

Reed canarygrass is a long-lived perennial, cool-season grass native circumboreally to the Northern Hemisphere. This species is a vigorous, tall-growing plant with an aggressive underground stem (rhizome) system. As a mature plant, reed canarygrass tolerates prolonged soil saturation and ponding, as well as dry soil conditions, but is intolerant of deep shade. It is considered by farmers in the Pacific Northwest to be one of the best forage grasses for wet situations, and has been and is currently widely planted and promoted for use as a forage/hay crop and in erosion/sedimentation management. The recent development of low-alkaloid cultivated varieties of this reed canarygrass has made this species even more attractive for use in agricultural areas of Washington and Oregon.

Despite debate regarding the nativity of reed canarygrass in the Pacific Northwest, there is strong evidence the species is native to this region, particularly because it is described as "widespread" in early floras for portions of the Columbia Basin. An analysis of early herbarium collections from the Inland Northwest found this species was collected from numerous, remote locations in the mid-1800's, suggesting reed canarygrass is native to this region (Merigliano and Lesica 1998). An intriguing aspect of this "native status" discussion involves the possibility that indigenous populations of reed canarygrass have been supplemented by a more aggressive germplasm introduced from Europe.

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The native status of reed canarygrass in Western Washington and Oregon is less clear. If this species was present in these regions prior to the arrival of European settlement (particularly in Western Washington), it was potentially a rare element limited to certain types of emergent wetland habitats as might be found along lake margins, or perhaps in riparian/floodplain zones. Many or most freshwater wetland systems in Western Washington at that time are thought to have been dominated by trees, predominantly conifers [typically western redcedar (*Thuja plicata*), Sitka spruce (*Picea sitchensis*), and western hemlock (*Tsuga heterophylla*)], which would have created understory conditions unsuitable for reed canarygrass. However, Native Americans apparently routinely burned some types of wetland habitats in the Willamette Valley and Puget Sound regions, which is expected to have had the effect of maintaining those habitats as emergent (herbaceous) communities. Such burned wetland communities may have provided suitable habitat for reed canarygrass (Martinez 1998). As settlement encroached into Western Washington and Oregon and wetlands were subsequently cleared, drained, disturbed, and cultivated, reed canarygrass established a presence to the point where this species is currently a dominant plant in emergent and deciduous forested wetlands throughout the region, particularly in agricultural and urban locations.

From an ecological perspective, reed canarygrass competitively excludes other native plant species and limits the biological and habitat diversity of host wetland and riparian habitats. These changes likely precipitate effects on other wetland and riparian functions such as wildlife habitat. Reed canarygrass also evapotranspires large quantities of soil moisture and potentially affects shallow groundwater hydrologic characteristics. This species' aggressive growth and significant biomass production affects hydraulic characteristics of surface waters by clogging ditches and stream courses with thick thatch and wrack. In many cases, infestations appear to form neo-climax communities (*sensu* Daubenmire 1968). These are plant communities that arise through human-caused perturbations and which subsequently prevent original climax vegetation from re-establishing except in the face of new perturbation. *Phalaris* also produces large quantities of pollen and can be a significant localized source of allergen.

UNDERSTANDING THE BIOLOGY OF REED CANARYGRASS

Reed canarygrass infestation is an important concern in the design and construction of wetland and riparian creation, enhancement, or restoration projects. Infestations may be present on a site chosen for such activity, or reed canarygrass may become established after construction of those projects. In such cases, weed management measures have included mowing, herbicide application, grazing, cultivation, burning, micronutrient management (boron), macronutrient management (nitrogen), shading (competitive exclusion), flooding, mechanical barriers, and bombing. The growth and reproduction of reed canarygrass is important in understanding the efficacy of these measures.

Sexual Reproduction

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Reed canarygrass establishes on a site either via seed or by the arrival of rhizome pieces or rootwads. Seeds have the ability to germinate immediately upon ripening and apparently have no known dormancy requirement (Apfelbaum and Sams 1987). There is no information available on the longevity of viable seed. A seedbank study in Illinois showed that the seedbank in a reed canarygrass stand was often completely dominated by this species (Apfelbaum and Sams 1987). Although typically fertile and showing good germination, seed appears to have some characteristic that impedes rapid stand development, at least in Western Washington (Fransen 1996; Wasser 1982). In fact, a field may require several consecutive seedings (for agricultural stand development) in Western Washington (Fransen 1996).

There is some speculation that seedlings do not compete well with seedlings of non-jointed grasses [particularly creeping grasses such as redtop (*Agrostis alba*) and creeping red fescue (*Festuca rubra*)] or non-grass species such as sedges and rushes. Reed canarygrass grows vertically for five to seven weeks after germination, after which tillering occurs (Comes et al. 1981). This delay in tillering may limit its early competitive ability in the face of rapidly tillering species such as redtop and creeping red fescue. Once tillering begins, however, reed canarygrass gains distinct competitive ability. The USDA NRCS is currently testing reed canarygrass establishment in the presence of mixtures of native sedges, annual ryegrass, and native wetland grasses (USDA NRCS 1996).

Vegetative Propagation and Phenology

In the Pacific Northwest, reed canarygrass is one of the earliest grasses to begin growth in the late winter and early spring. Growth may start as early as mid-December in some years, with foliage potentially reaching 2 ft in height by mid-March. Such growth is initiated and developed largely at the expense of previously established food reserves in the rhizome system.

Reed canarygrass forms dense, highly productive monocultures that spread radially from an underground stem (rhizome) system. Though the rhizomes are thick and densely produced, this species is relatively shallow-rooted. In one study, at least 88 percent of the new shoots in a stand originate from the upper 5 cm of soil; 100 percent of all shoots arose from the upper 20 cm of soil (Comes et al 1981). Laboratory studies have shown that 74 percent of new shoots originate from rhizomes. The remaining shoots arise from axillary buds on basal nodes (Casler and Hovin 1980). Vegetative vigor is related to maximum root and shoot production. Significantly increased growth was found to be associated with macronutrient enrichment (primarily nitrogen).

Productivity of reed canarygrass in Wisconsin peaked between mid-June (just prior to seed ripening) and mid-August, with primary productivity (aboveground standing crop) greatest in September (Klopatek and Stearns 1978). Plants can continue producing new shoots until the occurrence of hard frosts, usually sometime in November in the Pacific Northwest, but can also be winter-evergreen in some or most years at low elevations.

Available carbohydrate reserves were found to be greatest during the winter months (in West Virginia), declining to a low point in mid-July and with conspicuous depletion events occurring as the growing point was elevated (late May) and as the seed head developed (early June) (Decker et al. 1967). The plants accumulated higher concentrations of available carbohydrates during the fall than at any other time of the year.

MANAGING EXISTING REED CANARYGRASS STANDS

Management of existing reed canarygrass stands typically involves one of two objectives: 1) reducing the vigor of existing stands; and 2) killing stands or portions of stands. Several methods are available to achieve these goals. These are discussed below.

Mowing/Grazing/Disking/Burning/Flaming/Mulching

Graber et al. (1927) found that the quantity, quality, and availability of those reserves sharply limited the amount of both shoot and root growth. Progressive exhaustion of such reserves by early, frequent, and complete shoot removal ultimately resulted in the death of plants. Nevertheless, this early growth (and the large number of growth apices involved) gives reed canarygrass a substantial competitive advantage. This particular aspect of the plant's biology has critical implications in the management of this species.

Each reed canarygrass stem is sexually reproductive, annually elevating its growing point above the crown of the plant. This characteristic makes reed canarygrass susceptible to cutting damage, especially when cut low (less than 4 in) during the joint phase of plant growth (when the growing point is elevated during early and mid-spring). Repeated shoot removal damages plants through stress when plants are not allowed to rest between shoot disturbance events. Such stress is manifested by reduced vigor, reduced flowering and seed set, and stand thinning. If extremely stressed, stands may thin sufficiently to allow the germination and establishment of other plant species. Continued removal or disruption of the shoot system would eventually eliminate a stand.

To control reed canarygrass, plants should be cut or fields disked or plowed as the plants are coming into flower, to take advantage of the low available carbohydrate reserves present in the rhizome system at that time. Hovin et al. (1973) found that all stands of reed canarygrass were killed when the stems were cut off just before or at anthesis.

Mulching using deep layers of organic material or sheets of opaque plastic, rubber, or road felt (or other materials) eliminates light to the plants, thereby killing the buried or covered plants. The grass is typically cut to within a couple inches of the ground before the mulch is placed. The mulching materials need to be sufficiently deep or thick/opaque such that light does not pass through and plants are unable to grow through the medium. Plastic sheet barriers tend to quickly deteriorate in the presence of ultraviolet radiation. All sheet barriers need to be firmly anchored

to the ground to prevent being uplifted by the growth of reed canarygrass. The use of 3 ft to 6 ft circles or squares of mulching materials around newly planted woody material is generally thought to be regarded as a successful technique for establishing individual woody plants in a reed canarygrass stand.

Intensive grazing by cows, sheep, and goats shows promise in reed canarygrass management. The grass is most palatable in early spring, before levels of alkaloids increase and stems become tough. Under continued overgrazed conditions, a reed canarygrass stand will typically thin sufficiently to allow the establishment of desirable native species, many of which have less favorable palatability. Unfortunately, reed canarygrass often occurs in wetlands, where the practice of grazing animals in wetland and riparian habitats raises a different set of water quality and biodiversity concerns (fecal contamination, erosion, sedimentation, damage to desirable plant life, and so forth) that may not be balanced by control benefits.

Flooding

Reed canarygrass is tolerant of prolonged soil saturation, prolonged shallow inundation (particularly during the dormant season), as well as periodic (short-term) deep inundation. This species survives prolonged flooding by producing anoxia-tolerant rhizomes (Brandle 1983). Reed canarygrass is commonly found in areas subjected to periodic shallow flooding during the first half of the growing season or more. Reed canarygrass is less tolerant of prolonged deep inundation or seasonal fluctuations in hydrology during the middle part of the growing season (Taylor 1993).

Reed canarygrass may only tolerate deep inundation (at least 1 ft of water) for two years before it succumbs (USDA NRCS 1996). Stevens and Vanbianchi (1993) report that permanently flooding areas with more than 5 ft of water for at least three growing seasons has successfully eliminated reed canarygrass stands. The length of time this species can withstand deep inundation depends on temperature, current, and silt content of the water (Wheaton 1993).

Flooding is most useful in managed wetland systems that have water control systems capable of impounding sufficient water. Beaver introduction into hydrologically unmanaged wetland systems may offer a related tool in managing reed canarygrass. However, dramatic changes in flooding regimes may adversely impact desirable upland and wetland habitats, a fact that needs to be considered if flooding management of reed canarygrass is an option.

Intriguingly, reed canarygrass appears to tolerate prolonged deep inundation under certain hydroperiods. At least one large power-generation reservoir on the Columbia River in British Columbia supports hundreds of acres of reed canarygrass (Van Dijk 1998). The Upper Arrow Reservoir (operated by BC Hydro) typically begins to draw down in October, reaching its lowest elevation in February and March and then filling again rapidly in May and June. There is great variation in the annual water management regime. Typically, areas vegetated with reed canarygrass are inundated between July and October with the main growing season restricted to a

two month period in the spring (mid April or early May through June). Some years, upper elevations are either exposed year round, periodically throughout the summer as water levels fluctuate, or in late summer and early autumn as the reservoir draws down, providing another period of growth. In 1998, areas vegetated with reed canarygrass were flooded to a depth of two to three meters and plants appeared to continue to photosynthesize (i.e. plants were turgid and green as the water receded). This observation needs to be confirmed. BC Hydro is establishing a more comprehensive monitoring program that will examine flooding and exposure tolerances more closely.

The species occurs in the drawdown zone, but is inundated between December and August. Plants are emersed for only a short period at the end of the normal growing season. In these situations, reed canarygrass grows while submersed, effectively behaving like rooted aquatic species.

Herbicide Application

Application of glyphosate has been shown to be an effective tool and commonly used in managing stands of reed canarygrass. The timing of applications may be important in how quickly this non-selective translocated herbicide is moved into the rhizome system, but this must be balanced by the logistical difficulties of spraying this tall-growing grass.

Reed canarygrass can reach heights of 6 ft or greater, which presents significant difficulties in terms of herbicide application during the middle and late growing season. Fransen reports that effective herbicide control has been obtained in stands that had been mown at flowering to a height of 3 ft, and then sprayed using backpack sprayers (Fransen 1996). Stands can also be mown to lesser heights and sprayed after the plants have produced a subsequent (but lower) crop of foliage.

Spraying should occur when the species has minimum available carbohydrate reserve (at and immediately after flowering). However, maximum carbohydrate accumulation in the rhizome system would occur after July, and thus, herbicide translocation would be greatest during this post-flowering period. Comes et al. (1981) found best control (in Indiana) when glyphosate was applied at flowering time. General observations in Western Washington suggest that late summer (September) applications are effective. Frequently a second application is needed in mid-spring (May) of the subsequent year to knock out any remaining plants.

Boron has also been shown to be an effective herbicide in controlling reed canarygrass (Marquis et al. 1984). Complete tissue necrosis occurred three weeks after leaves and roots were exposed to 300 ppm of boron. It is unknown if plants were killed by this method.

Shading

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Planting of coniferous trees is highly effective in eliminating reed canarygrass from a stand or habitat. The conifers need to be planted relatively densely in wide (rather than narrow) blocks in both the wetland system and in adjoining buffers. If the blocks in buffer or wetland habitats are too narrow, side-lighting (particularly during the early portion of the growing season) allows the reed canarygrass infestation to persist in the understory. Other methods of reed canarygrass control may need to be used on a short-term basis to ensure that the planted conifers have opportunity to establish in and overtop the reed canarygrass stand.

A related effective technique showing promise in parts of Western Washington involves the eradication of reed canarygrass from large-diameter circular planted areas within stands of reed canarygrass. Herbicides are typically used to eliminate reed canarygrass from these circles. Once the grass is dead, the circles are densely planted with desirable native vegetation such as willows (*Salix* spp.), appropriate conifers, and/or deciduous shrubs. This planted material typically establishes well in the absence of reed canarygrass. As the circles of vegetation grow and mature, the canopy begins to influence the immediately adjacent areas of reed canarygrass, largely due to shading. As the shaded areas of reed canarygrass begin to decline in vigor and density, desirable native plants become established and the circles begin to grow in size. Attachment A describes this technique in better detail.

Nitrogen Management

Decker et al. (1967) found that nitrogen was an important variable in the vigor of reed canarygrass stands. For purposes of reducing the vigor of existing stands, inputs of nitrogen to those stands should be curtailed.

Integrated Strategies

Combinations of the methods described above have been shown to be effective in reducing stand size and vigor, and, in some cases, in eradicating the grass from an area. Reed canarygrass management at the Ridgefield National Wildlife Refuge in Washington observed the best control using spring herbicide application and fall disking (Crockett et al. 1995).

Recommendations

Based on the current knowledge of reed canarygrass biology and ecology, and recent attempts in managing this species, several options are available to deal with existing infestations of reed canarygrass:

1. Plant wetland and riparian buffers and existing wetlands with appropriate tree species, emphasizing conifers.

As suggested by the above discussion, conifer forests are highly effective in eliminating reed canarygrass from a stand or habitat. The conifers need to be planted relatively densely in wide (rather than narrow) blocks in both the wetland system and in adjoining buffers. If the blocks in buffer or wetland habitats are too narrow, side-lighting (particularly during the early portion of the growing season) allows the reed canarygrass infestation to persist in the understory.

In some cases, a situation might call for “designed succession” in which faster more competitive plants [such as willow, red alder (*Alnus rubra*), and/or cottonwood (*Populus trichocarpa*)] are installed and allowed to grow. These early “colonizers” are selectively thinned several years later and underplanted with appropriate conifer species, which would be expected to establish in the less harsh environment provided by a thinned deciduous canopy.

2. Avoid excavation as means of eradicating existing stands of reed canarygrass or a reed canarygrass seed store.

Such activities waste potentially valuable topsoil and are generally expensive to accomplish. Excavation should be driven by project goals for altering hydrologic regimes, rather than as a direct weed management tool.

3. If large-scale field-burning is not possible, consider the use of flaming.

Flaming may not create the same level of air quality and safety hazards that prescribed burning may. In addition, flaming can be done at any time of the year and, in most case, without a burn permit from local jurisdictions. Numerous hand-held or implement-based flaming devices are available (for example, Flame Engineering, Inc., P.O. Box 577, West Highway 4, LaCross, Kansas 67548; 800-255-2469). Repeated burnings or flamings over a year or more may be needed to eradicate or weaken established stands of reed canarygrass. The dead culms and leaves from previous year’s growth should be removed prior to starting a flaming regime to minimize the fire and smoke hazards and to create better flame access to emerging shoots.

4. Consider herbicide applications as a valuable tool in managing reed canarygrass.

Despite known and unknown, short- and long-term effects of the use of herbicides in aquatic systems, glyphosate shows significant utility in managing reed canarygrass, particularly when integrated with other management tools. The frequent “knee-jerk” reactions among the public and some professionals against the use of glyphosate in ecosystem restoration needs to be balanced by the consideration that the effects of herbicide applications in aquatic systems may be

greatly exceeded in the long term by dramatic improvement in riparian and wetland habitats.

ANTICIPATING INFESTATIONS OF REED CANARYGRASS IN NEWLY CONSTRUCTED WETLAND/RIPARIAN PROJECTS

Reed canarygrass is sufficiently abundant and widespread that wetland managers and restorationists should anticipate that their lands or projects may potentially host infestations of this weed in the future. Based on the current knowledge of reed canarygrass biology and ecology, and recent attempts in managing this species, several options are available to discourage potential infestations or reduce the risk of invasion by reed canarygrass.

1. Design coniferous forested wetland plant communities and wetland habitats that have perennial inundation greater than 1 foot for most of the year.
2. Attempt eradication for existing reed canarygrass infestations on sites to be used for newly constructed wetland/riparian projects.

Numerous methods are available for eradicating this species from a project site, including mowing, burning, flaming, cultivation, and herbicide applications, and various combinations thereof. Sufficient time should be allowed for repeat treatments to ensure eradication of existing stands. If a project area is too large for eradication management, or if there are limited funds, localized mulching barriers or shading may be used to create planting spaces for trees and other competing vegetation.

3. If large-scale field-burning is not possible for a project or in an area, consider the use of flaming.
4. When possible, deplete the reed canarygrass seed store in existing soils prior to restoration plantings.

Seed store depletion is accomplished by leaving a cleared project area devoid of vegetation (fallow) for at least one growing season. Multiple fallow growing seasons are preferable to one. Emerging seedlings are killed by repeated cultivation (disking or harrowing), flaming, and/or periodic herbicide applications. The goal of fallow cultivation is to prevent emerging seedlings or sprouts from tillering and flowering. Repeated cultivations continue to expose new seeds in the seed store. Herbicide applications alone deplete only the seed in the upper elevations of the soil column.

5. If seed store depletion is not possible, consider competitive exclusion as a means to

discourage reed canarygrass seedling establishment on disturbed soils.

Seeding a site with competitive grass species such as tufted hairgrass (*Deschampsia cespitosa*), slough grass (*Beckmannia syzichachne*), bentgrass (*Agrostis* spp.), or turf-forming varieties of red fescue (*Festuca rubra*) may present a significant obstacle to reed canarygrass seedling establishment. Seedings should be heavy (50-100 lbs/ac). If used, woody material should be planted prior to seeding.

6. Seriously consider herbicide applications as a valuable tool in managing reed canarygrass.

EPILOGUE

The magnitude and persistence of reed canarygrass infestations in aquatic and terrestrial systems presents restorationists, land managers, and local citizenry with a complex array of challenges. Chief among these is the need to view reed canarygrass infestation in the context of a broad landscape perspective, rather than on site-by-site bases. Another challenge asks us to re-discover the timeframes in which plant succession operates, and to possibly adjust our expectations of what we can achieve and when we can achieve it in conducting restoration activities.

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ATTACHMENT A

USING POLE PLANTINGS IN WETLAND AND RIPARIAN RESTORATION

(based on a draft by Russell Link, Washington State Department of Fish and Wildlife, with modifications by Clayton Antieau, Parametrix, Inc. November 17, 1998)

The use of black cottonwood (*Populus balsamifera*) and willow (*Salix* spp.) polewood in wetland and riparian restoration has shown promise in areas dominated by the aggressive grass, reed canarygrass (*Phalaris arundinacea*). These poles are essentially gigantic live stakes or dormant hardwood cuttings. The large size of the poles allows rooting below the reed canarygrass rootmass, and shooting above the dense reed canarygrass thatch. Thus, plants obtained from rooted polewood cuttings have a strong competitive edge over the reed canarygrass and can assist in shading out this nuisance weed.

The polewood material is typically taken from young sapling trees or from larger branches and suckers on more mature trees in existing wetland and riparian habitats. If your projects extend over many years, you may want to consider establishing coppice beds for the desired species—fields of the desired species that are harvested every couple of years for their polewood material. Over the long-term (potentially many decades), coppice beds will provide a predictable steady supply of polewood material while having less impact on existing wetland and riparian habitat where the material would otherwise be collected.

We suggest that the native black cottonwood be used, not the hybrid cottonwoods commonly being planted for pulpwood production. Most native willows will propagate by this method. Material is collected and planted during the dormant season (November through February). Although the dimensions can vary, preferred polewood material is between 2 and 4 inches in diameter at the base, 1 to 3 inches in diameter at the top, and 6 to 8 feet long. Poles are sawn off from the donor plant and all branches are removed with a saw or pruning shears. A 12 to 18 inch long lateral branch can be retained for use by perching birds.

Once a batch of poles has been prepared, oriented uniformly, and bundled, spray-paint the tops of all the poles with tree-marking paint. This provides an easy way to identify the tops of the poles from the bottoms and also prevents the poles from being lost or becoming a safety problem after being planted.

The poles are then planted in holes prepared using post-hole diggers, soil augers, or shovels. Poles should never be driven into the ground using hammers or sledges. The idea is to plant one half to two thirds of the bottom end of the pole in the ground. The base of each pole can be wounded with a hatchet to enhance rooting, but is generally not necessary. Make sure the bottom of the pole is planted, not the top of the pole. Protecting the above-ground portion of the pole from rodent damage and deer rubbing is usually required.

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