Colorado State Parks

COLORADO STATE PARKS
BEST MANAGEMENT PRACTICES
WEED PROFILE

Date Created: April 25, 2003
Revised: April 1, 2005
Author: Various
Parks Affected: Many

Reed canarygrass

Phalaris arundinacea L.

BMPs

Adapted from an Element Stewardship Abstracts (ESAs) prepared by The Nature Conservancy's staff and other land managers with current management related information on species and communities that are most important to protect, or most important to control. The Abstracts organize and summarize data from many sources including literature and researchers and managers actively working with the species or community.

The Nature Conservancy Wildland Invasive Species Program is responsible for updating and maintaining this ESA. Anyone with comments or information on current or past monitoring, research, or management programs for the species or community described in an abstract is encouraged to contact the TNC Wildland Invasive Species program at 124 Robbins Hall, University of California, Davis, CA 95616.

This abstract is a compilation of available information and is not an endorsement of any particular practices or products. Authors of this Abstract: Kelly E. Lyons (*Please do not remove this cover statement from the attached abstract.)*

SCIENTIFIC NAME

The genus name Phalaris is from the ancient Greek name for a grass with shiny spikelets. The specific epithet arundinacea means reed-like and is from the Latin 'arundo' for reed with the ending 'acea', indicating resemblance (Hyam & Pankhurst, 1995).

Numerous infraspecific forms, varieties, subspecies have been described for Phalaris arundinacea.

COMMON NAMES

In North America, Phalaris arundinacea is commonly called reed canarygrass. The ornamental, variegated form (P. arundinacea var. picta L.) is known as ribbon grass (Gray, 1908, 1970; Gleason & Cronquist, 1991) or, less commonly, as gardener's garters (Anderson, 1961).

DESCRIPTION & DIAGNOSTIC CHARACTERS

Reed canarygrass is a robust, cool-season, sod-forming (Hutchison, 1992) perennial grass that produces culms (stems) from creeping rhizomes (Holt, 1954). The culms grow 0.6-2 m tall (Gray, 1950). The leaf-blades are flat, 0.2-2 cm wide and up to 0.5 m long. Flowers are arranged in dense, branched panicles that can exceed 5-20 cm in length (Gray, 1950; Gleason & Cronquist, 1991). Immature panicles are compact and resemble spikes, but open and become slightly spreading at anthesis. Spikelets are lanceolate, 5 mm long and pale (Gray, 1950). Most contain three florets, two of which are extremely reduced, linear and infertile. One of the distinguishing features of the genus Phalaris is the presence
of some infertile florets (Anderson, 1961). The lemmas in the infertile florets are approximately 1 mm long (Gleason & Cronquist, 1963) while those of the fertile florets are 3-4.5 mm long (Hickman, 1993). The glumes are strongly compressed (Gleason & Cronquist, 1991) and wingless (Hickman, 1993).

Reed canarygrass is morphologically variable, and more than ten infraspecific categories (varieties, subspecies, forms and races) have been described. These categories are based on

characteristics such as the amount of branching, leaf color, size, shape and density of inflorescences. Differences in the height at maturity, and in size, shape, and color of the inflorescence may depend on the habitat. There are no known morphological features for this species that allow native individuals to be distinguished from non-natives (Anderson, 1961).

Phalaris arundinacea var picta L. (Gray, 1908), also referred to as P. arundinacea f. variegata (Parnell) Druce (Gray, 1970), is a common garden ornamental. This variety has white striped leaves and can occur in native populations (Gray, 1950). There is no indication that this variety is capable of thriving in natural habitats. Its pollen is reportedly 30-40% imperfect and the seeds do not mature (Anderson, 1961).

Confusion with Other Species

While P. arundinacea may be confused with P. aquatica (harding grass), Dactylis glomerata (orchard grass), and Calamagrostis canadensis (bluejoint), it can be distinguished from these other species by a number of reliable characters. Reed canarygrass has non-bulbous culms that arise from very stout rhizomes. Its glumes are usually wingless or, if wings are present at all, they are narrow and inconspicuous. Fertile florets of reed canarygrass are narrowly lanceolate and more or less circular in cross-section. The seeds are usually less than 2 mm long.

In contrast, harding grass has bulbous culms, fibrous or tufted roots, and rhizomes that are usually very short and poorly developed. Harding grass glumes are well developed with a prominent, winglike keel, and its fertile florets are broadly lanceolate, flattened and narrowly elliptic in cross-section. The seeds are usually more than 2 mm long (Britton & Brown, 1970). Dactylis glomerata has wider leaf-blades than reed canarygrass and narrower, more pointed inflorescences. Orchard grass also lacks hairs on its glumes and lemmas. Calamagrostis canadensis lacks the highly transparent ligule of reed canarygrass (Hoffman & Kearns, 1997).

STEWARDSHIP SUMMARY

Reed canarygrass is a cool-season perennial grass that grows successfully in northern latitudes. It can be invasive in wet habitats and so is often a target for control. Since P. arundinacea is tolerant of freezing temperatures and begins to grow very early in the spring, it can outcompete many other species. Reed canarygrass spreads within sites by creeping rhizomes and forms dense and impenetrable mats of vegetation. New sites are colonized by seeds.

There is debate as to whether P. arundinacea is native to North America (Merigliano & Lesica, 1998). It is clearly native to Europe but some authors view it as native to Asia and North America as well (Anderson, 1961; Cronquist et al., 1977). Merigliano & Lesica (1998) found that collections of reed canarygrass from the inland Pacific Northwest pre-dated settlement of the area by people of European ancestry. Early collections indicate canarygrass formed large stands along low elevation rivers and could be found in small, scattered stands in mountainous areas. Modern Phalaris populations in this region may be a mixture of agronomic cultivars and native material. Reed canarygrass is widely regarded as non-native in more southern latitudes. The invasive character of some Phalaris populations may be the result of agronomic breeding for vigorous growth and drought tolerance (Merigliano & Lesica, 1998). The actual threats reed canarygrass poses to conservation targets (and its possibly native status) should be considered before it is targeted for control, especially since large stands are difficult to kill without harming desirable native plants.

Reed canarygrass has been referred to as a "Dr. Jekyl and Mr. Hyde kind of grass" (Hodgson, 1968). It is valued as a forage grass and for revegetating denuded ditchbanks. However, it can also overgrow irrigation ditches and small natural watercourses, alter soil hydrology, is poor forage for domestic stock when fresh, and invades native vegetation where it outcompetes desirable native species. Almost any moist, fertile habitat is suitable for this species. Reed canarygrass invades and dominates wetland and riparian areas. Anthropogenic disturbance and alteration of water levels encourage reed canarygrass invasion (Hoffman & Kearns, 1997).

A combination of management strategies over several years will yield the best results. For low quality sites, discing or tilling may be effective, especially if used in combination with competitive crop planting. Hand-pulling is recommended only for small populations. Covering the plants with mulch or plastic may work but is unreliable and labor intensive. Grazing may also be unreliable, and P. arundinacea can causes indigestion or illness to livestock. Cutting is effective andthe dried "harvest" may be used as hay. Prescribed fire and some herbicides are also effective. Biocontrol agents have not yet been identified. If a healthy native seedbank is not present, successful elimination of reed canarygrass may have to be
followed by seeding with desirable species. Otherwise, erosion or reinfestation by reed canarygrass or other weed species may occur.

IMPACTS (THREATS POSED BY THIS SPECIES)
Reed canarygrass can form dense, persistent, monotypic stands in wetlands, moist meadows and riparian areas. These stands exclude and displace desirable native plants and animals. Areas invaded by reed canarygrass may be of little use to wildlife (Hoffman & Kearns, 1997).

On TNC's Swan River Oxbow Preserve in Montana, reed canarygrass poses a threat to the federally endangered annual aquatic plant Howellia aquatilis (Lesica, 1997). Reed canarygrass invaded the preserve from a nearby national wildlife refuge where it was intentionally planted. Lesica found that an increase in the size of dense, monotypic patches of reed canarygrass coincided with a decrease in H. aquatilis patches. In just nine years, reed canarygrass cover increased 35% while H. aquatilis nearly disappeared. Although this correlation does not directly demonstrate that reed canarygrass displaced H. aquatilis, it suggests reed canarygrass was at least interfering with H. aquatilis growth and survival.

In replies to surveys in 1995, stewards of The Nature Conservancy indicated that reed canarygrass may threaten populations of many other species including Zygadenus glaucus (northeast, central Ohio Herrick Fen, Beck Fen and Brownslake Bog), Carex lyngbuei, Scirpus acutus, Equisetum fluviatile (Blind Slough Preserve, Oregon), Lomatium bradshawii, Erigeron decumbens, Aster curtus, Horkelia congesta, and Sidalcea nelsoniana (Willow Creek Nature Area Preserve, Oregon) (Randall unpublished data). Henderson (1991) found an upland oak savanna in south central Wisconsin threatened by reed canarygrass invasion. In this habitat reed canarygrass spread very slowly, but formed dense, monotypic stands that were shade tolerant and highly competitive despite the relatively dry conditions.

Reed canarygrass is also considered a pest because it promotes silt deposition and the consequent constriction of waterways and irrigation canals (Hodgson, 1968). Conversely, reed canarygrass colonies perched on the edges of incised watercourses may promote further erosion of soil beneath the dense mats of rhizomes by causing cutaways where water flows rapidly.

It is generally thought that invasive populations of reed canarygrass are descendants of non-native cultivars or ecotypes (Apfelbaum & Sams, 1987; Hutchison, 1992) or the vigorous result of crosses between cultivated varieties and native strains (Baker, 1972; Barrett, 1983; Merigliano & Lesica, 1998). Many agronomists have been selecting vigorous strains of reed canarygrass for breeding purposes, and while characteristics desirable to farmers may not necessarily confer an advantage under wildland situations, strains with high fitness for a particular region can be selected. An example of such a selection program is described by Wilkins & Hughs (1932), who sought varieties of reed canarygrass that were vigorous and reliable under a variety of environmental and management conditions (e.g. irrigation and clipping). Once the desirable strain was identified the investigators distributed seeds to local farmers. Reed canarygrass has a long agronomic history and was cultivated for forage as early as 1749 in Sweden (Alway, 1931). In the US the first agronomic trials probably began in the 1830s when New England farmers began experimenting with crosses to increase palatability. There are now at least eleven reed canarygrass cultivars (Harrison et al., 1996).

Reed canarygrass may be more phenotypically plastic as a result of human intervention. Natural populations of reed canarygrass are primarily found in marshes and other wetland habitats, but farmers prefer strains that tolerate drought or upland conditions. Agronomic trials comparing yields of reed canarygrass to drought tolerant species demonstrate that canarygrass yields more hay than smooth brome, timothy, tall meadow oat, red top, meadow fescue and orchard grass under dry conditions (Wilkins & Hughes, 1932

GLOBAL RANGE

Reed canarygrass is the only member of the genus Phalaris that is circumboreal, and it may be the precursor to all New World taxa of the genus (Anderson, 1961). Clearly native to Europe, some authors view it as native to Asia and North America as well (e.g. Anderson 1961, Cronquist et al. 1977). The present-day range of reed canarygrass extends throughout the Old and New Worlds, where it is found primarily in northern latitudes (Jepson, 1953; Hutchison, 1992).

Reed canarygrass is a notorious global weed. According to Holm et al. (1991), it is a "serious weed" in Afghanistan, Hungary and Japan; a "principle weed" in Indonesia, Korea, Mauritania, New Zealand and Poland; a "common weed" in Italy and Portugal; and a weed in Argentina, Belgium, Canada, China, Colombia, The Czech Republic, England, Finland, Germany, Puerto Rico, Sweden and Turkey. It is also present in Australia, Ceylon, Hawaii, India and South Africa.

In North America, it is found from southern Alaska to eastern Maryland, and south to Kentucky, Illinois, Missouri, Oklahoma, New Mexico, and Arkansas. It is abundant in the west, including northern and eastern California, Washington, Oregon, Idaho, Nevada and western Utah and Montana. Southern Virginia marks its southern boundary on the US East Coast (Gray, 1950). It is absent from Mississippi, Alabama, Georgia, Florida, Louisiana, south & central Texas and southern California and the southwest corner of Arizona (Levesque & Mathur, 1983).

Merigliano and Lesica (1998) found that early botanical collections of reed canarygrass from the inland Pacific Northwest predated settlement of the area by people of European ancestry. These collections indicate canarygrass formed large stands along low elevation rivers and could be found in scattered small stands in mountainous areas. Modern populations of canarygrass in this region may be a mixture of agronomic cultivars and native material. The same may be true throughout the northern US and southern Canada (Dore & McNeil, 1980; Apfelbaum & Sams, 1987; Harrison et al., 1996). Reed canarygrass is widely regarded as non-native in the southern US.

HABITAT

Several TNC Stewards reported that riparian and streamside corridors are at the greatest risk of being invaded and dominated by reed canarygrass (Randall, unpublished) but any moist, fertile habitat provides good conditions for this species (Hutchison, 1992). Nature Conservancy stewards consider reed canarygrass a serious threat in wet meadows, wetlands, marshes, fens, old fields, floodplains, wet prairies, roadsides, ditchbanks. Streambanks, lake-shores (Gleason & Cronquist, 1991), and shore swales (Gray, 1950) also support the species. Munz (1959) states that all moist places in California below 1500 m (5000 ft) may be suitable for reed canarygrass, but it can also thrive on dry soils (Hutchison, 1992; Henderson, 1991; Klopatek & Stearns, 1978).

Reed canarygrass invasion is promoted by disturbances such as ditching of wetlands, stream channelization, deforestation of swamp forests, sedimentation, overgrazing and intentional planting (Hoffman & Kearns, 1997). For example, three sites in an Iowa lake were colonized by reed canarygrass during a period of 50 years, and these episodes were probably promoted by anthropogenic degradation of the watershed by the addition of sewage water and agricultural runoff (Volker & Smith, 1965). Natural disturbances such as scouring floods (Lunte, personal communication) and low water conditions (Lebold, personal communication) also promote invasion.

The "natural" varieties of reed canarygrass are well suited to periods of inundation and cool climates and are never injured by severe winter weather. They grow especially well in clay/loam soil and in sand (if the water content is high enough) but do not do well in peaty soils (Piper, 1924). Reed canarygrass is categorized as a hard water species by Moyle (1945).

BIOLOGY

1. Phenology and Growth

Reed canarygrass shoots emerge from rhizomes or seeds and grow vertically through the soil surface during the first 5-7
weeks of spring (Hutchison, 1992). Vegetative growth peaks in mid-June and declines in mid-August. Reed canarygrass has two periods of growth, one prior to seed maturation and one after (Klopatek & Stearns, 1978; Evans & Ely, 1941). As plants age they have more roots per node, while tillers per plant, total axillary shoot length, and node diameter decrease (Casler, 1980). After the second growth period in mid to late summer, culms collapse and form dense, impenetrable mounds (Hoffman & Kearns, 1997).

Four to six leaf primordia are present in each rhizomatous axillary bud at the beginning of winter (Holt, 1954). Culms arise in spring from these firm, scaly axils that are enclosed by papery bracts. Inflorescences do not overwinter. The transition from vegetative to reproductive growth in the shoot tips occurs in early- to mid-April, and inflorescence development continues into May. Klopatek & Stearns (1978) measured hay production of several marsh species in a rich marsh and found reed canarygrass exhibited comparatively rapid and vigorous growth. The estimated total net productivity for reed canarygrass was 2028 g/m2/year, substantially higher than for other species (e.g. Typha latifolia, and Scirpus fluviatilis). Maximum production for reed canarygrass was 18.12 g/m2/day in the growth period from April 26th (the first frost-free date) to June 10th.

2. Reproduction: Flowering, Pollination and Seeds

Reed canarygrass flowers June-July (Gray, 1908). It is a long-day species with a critical photoperiod of 13.5 light-hours (Allard & Evans, 1941) and requires cold temperatures (vernalization) to induce flowering (Hanson & Sprague, 1953). In Minnesota, transplants generally do not flower in the first year but do in the second. In contrast, Iowa transplants flower in the first year due to the cold but frost-free temperatures extending later into autumn. This gives rhizomes more time to prepare developmentally to receive vernalization signals (Heichel et al., 1980).

Reed canarygrass is an obligate out-crosser (Casler, 1980). Smith (1944) found very low seed set (0.018 seeds/floret) under selfing conditions as compared to 0.429 seeds/floret with open pollination.

Reed canarygrass' commercial usefulness is limited as seeds of the inflorescence shatter asynchronously (Baltensperger & Kalton, 1958) and do not germinate readily or regularly (Griffith & Harrison, 1954). They are also short-lived when inundated with water (Comes et al., 1978). Vose (1962) found that under favorable conditions some seeds germinated after ten days while others took three weeks. Seeds germinate more readily immediately after maturation. Rates of germination decrease through winter and are poor the following summer. Vose (1962) used various seed treatments to identify a method to increase germination rates. The most effective was soaking seeds in water at 50°C. Water may dilute
or rinse away water-soluble dormancy-enforcing compounds. Mechanical damage, increased light, and oxygen also successfully broke seed dormancy. Temperature changes had little effect on germination.

MANAGEMENT PROGRAMS

As with most invasive species the best management strategy is prevention (Lesica, 1997). Control is difficult due to the rhizomatous nature of the species and may require herbicide treatment for several years. In addition, few herbicides may be used in wetlands or areas near running water, where reed canarygrass is usually most troublesome. When reed canarygrass is eliminated, there may be a danger of soil erosion if other species fail to cover the area quickly.

Reed canarygrass is itself especially good at invading denuded areas and one way to prevent it from becoming established is to control erosion and replant eroded sites with competitive native species (Hoffman & Kearns, 1997).

Hutchison (1992) suggests that reed canarygrass should never be completely removed from a site because it is impossible to tell the difference between native and nonnative strains. If you determine that the plants are rapidly spreading, extremely competitive, and displacing many native species at a rapid rate, however, consider complete eradication as a goal.

A mixed management strategy may prove most successful for control of reed canarygrass. For example, Paveglio & Kilbride (1996) compared five different treatments: disking, mowing, early and late treatments with glyphosate herbicide, late glyphosate treatment alone, and early glyphosate treatment + disking. Glyphosate was applied as a 0.5% solution of Rodeo at 5.26L/ha (2.25 quarts/A) plus LI-700 surfactant. The early glyphosate treatment plus disking suppressed reed canarygrass and promoted the growth of other species. The early and late glyphosate application was also effective, providing 99% control in the first year.

The type of control chosen should depend on site characteristics. Where reed canarygrass is mixed with other species, burns or mechanical removal will be more effective as the area will be readily occupied by species that could potentially outcompete reed canarygrass and control erosion. Non-selective herbicides like glyphosate are most effective on sites that are totally dominated by reed canarygrass (Henderson 1987). Any patch left denuded is subject to erosion and re-invasion.

MECHANICAL
Removal of reed canarygrass by hand-pulling is practical only for small stands and requires a large time commitment (Hutchison, 1992). Henderson (1987) found hand-pulling was effective if done over the entire population 2-3 times per year for five years.

Hoffman and Kearns (1997) suggest covering reed canarygrass infestations with black plastic. They claim that for this method is to be successful, light levels should be reduced to less than 40% of normal intensity and the plants should not be allowed to grow beyond the plastic. (Shoots emerging beyond the edges of the covering will provide food to covered rhizomes.) Following successful control with black plastic, the area can be seeded with local, native species. However, this method was found to have little success by Apfelbaum & Sams (1987), who observed plants persisting even after two years under cover.

COMPETITIVE CROPS/RESTORATION
Native grasses and forbs are the best plants to use as competitors. Seeds can be collected and raked into the soil after reed canarygrass control. Competitive crop management has been most effective when used in conjunction with prescribed burning (Hutchison, 1992).

Desert saltgrass (Distichlis stricta) may be used as a "replacement species" in alkaline or saline soils where erosion may pose a problem after herbicide application and subsequent removal of reed canarygrass (Marquis et al., 1984). While native to the United States, desert saltgrass is found primarily in salt marshes and alkaline habitats (Hickman 1993) and may grow poorly outside of these habitats.

CUTTING/GRAZING
Cutting can effectively control reed canarygrass. Reed canarygrass was practically non-existent in fields after they had been cut five times in one season, even though the fields that had started out as roughly equal mixtures of reed canarygrass, Kentucky bluegrass (Poa pratensis), timothy (Phleum sp.) and mixed clovers (Trifolium spp.) (Wilkins and Hughs, 1932). If the plots were cut only twice during the season, reed canarygrass persisted.

Grazing may be effective means for controlling reed canarygrass but the palatability of reed canarygrass is questionable--the genus Phalaris is notoriously unpalatable and an illness associated with the affects of consumption is called ‘Phalaris staggers’ (Marten et al., 1976). Grazing can also be inappropriate in wetland settings (Hutchison, 1992). However, Haslam (1973) suggests employing wetland meadows for the production of "marsh hay." Ponies are preferable grazers as they are more agile in waterlogged soils and may be left unattended while cattle and sheep may get stuck in the mud and perish.

Palatability decreases with plant maturity (Marten et al., 1976; Gomm, 1979) and continuous grazing may decrease palatability. Plants’ chemical and physical defenses may be induced by herbivory, but cutting often fails to elicit the same defensive response (Agrawal, 1998). The literature does not address the response of reed canarygrass alkaloid concentrations in response to grazing.

BURNING

Fire is an effective form of control for reed canarygrass in highly productive wetlands. Some wetland species are unable to out-compete reed canarygrass without prescribed burning (Hutchison, 1992). Fire should be reserved for sites containing a healthy seed bank of fire-adapted native species that will readily colonize the area after a burn.

Apfelbaum & Sams (1987) describe a study that successfully contained reed canarygrass in low quality areas of a wetland using a two-year or three-year burn rotation cycle. Prescribed fire may be required for five or six years. The timing of burns is important. Henderson (1991) found that early spring burns accelerate the spread of reed canarygrass while late spring burns weakened reed canarygrass stands. Unfortunately, these late-season burns can harm other species. Late autumn burns are also beneficial.

DISCING/PLOWING

Reed canarygrass is quite sensitive to discing or plowing, and in some situations other plant species readily outcompete reed canarygrass afterwards. Paveglio and Kilbride (1996) found that an early season herbicide application (Rodeo at 5.26liters/ha) followed by discing three times late in the season suppressed reed canarygrass. The herbicide application prior to discing causes reed canarygrass rhizomes to deteriorate. Applying an herbicide prior to discing eases the task of discing and suppresses post-discing seedling emergence. Later applications of herbicide may be necessary to control seedlings.

ALTERATION OF WATER LEVELS

When wetlands have had their water levels lowered (for example, by ditching) restoration of original water levels may control reed canarygrass. Vegetative portions of reed canarygrass are generally regarded as intolerant of prolonged inundation (Hutchison, 1992) but some studies have found opposing results where rhizomes tolerate prolonged inundation (LeFor, 1987).

The seeds of reed canarygrass are generally short-lived when inundated. Long periods of inundation may serve to eliminate reed canarygrass seeds from soils. Comes et al. (1978) found most reed canarygrass seeds decomposed and/or germinated after only three months but germination rates of some seed remained high for 3-12 months after inundation. After 48 months of inundation, however, seeds of reed canarygrass no longer germinated.

CHEMICAL

Several herbicides have been tested and proven effective for controlling reed canarygrass. The most effective include glyphosate and fluazifop butyl. When applying herbicides, take precautions to avoid contact with non-target species.

In general, reed canarygrass is more effectively controlled by herbicides on upland, drier areas of a site (Hodgson, 1968). In one experiment, upper areas on a canal ditch had 100% control while in the lower, wetter areas only 50% of the reed canarygrass was removed. Bruns (1973) was also

unable to kill all shoots at the waterline. This was due to dilution of the herbicide when applied at or near the water and removal of the herbicide from the soil by water.

Reed canarygrass is rarely fully eradicated and yearly, or even monthly, attention to the control of this weed is necessary. Hodgson (1968) found consecutive, yearly treatments were required to control reed canarygrass. Hoffman & Kearns (1997) suggest that old vegetation be removed before herbicides are applied to ensure that the herbicide contacts new growth. Where large populations of reed canarygrass are eliminated, seeds of other species should be sown to increase competition with resprouts and prevent erosion.

FLUAZIFOP-D (FUSILADE, HORIZON)
Apply fluazifop at 0.28-0.42 kg ai/ha (0.25-0.375lb ai/A) (1 to 1.5 pint product/A) to actively growing reed canarygrass with 1% v/v crop oil concentrate or 0.25% v/v nonionic surfactant. Fluazifop acts very slowly (2-4 weeks before results are seen). Do not apply to stressed grasses. If regrowth occurs, repeat application. Do not use crop oil concentrate if treating reed canarygrass ornamentals. Do not apply if rainfall is expected within 1 hour (William et al., 1997).

GLYPHOSATE (RODEO OR ROUNDUP)
Rodeo is a formulation of glyphosate that is specifically designed for use in aquatic habitats. It will kill reed canarygrass if applied to young plants according to the manufacturer's directions. It should be applied in early spring when reed canarygrass is just sprouting and before other wetland species germinate. Rodeo is nonselective and should be applied only in areas where damage to other species is unlikely (Hutchison, 1992). Roundup is not registered for use in aquatic areas and is designed for use only where there is no standing water. Rodeo and Roundup (1.4 to 2.8 kg ai/ha; 1.2 to 2.25lb ai/A) should be applied to actively growing plants at early heading or in the fall. Follow the manufacturer's instructions
regarding surfactants (William et al., 1997).

An application of Roundup according to the manufacturer's recommendations and combined with the burning of dead residue was moderately effective in Illinois (Hutchison, 1992). In Prosser, Washington, glyphosate was applied to seedlings of three species (reed canarygrass, red top and creeping fescue) at three, five, seven, and ten weeks post-emergence and to 15 month old plants in the spring. Applied at 1.1 kg/ha, a decrease in reed canarygrass at all age stages was observed without causing much damage to red top and fescue. For 15 month old plants, glyphosate applied at 2.2 kg/ha yielded up to 95% control (Comes, 1976). At TNC's Middle Fork John Day preserves, Roundup was reported to be an effective control measure at high concentrations (Youtie, personal communication).

SULFOMETURON (OUST)
Apply at 26-43 g ai/ha (3 to 5 oz product/A) to preemergent or early postemergent plants. Oust is labelled for use on non-cropland only. Do not apply to frozen ground. Maintain constant agitation while mixing in spray solutions. Add 0.25% v/v nonionic surfactant to increase the activity of postemergence applications. Powder, dry soils and light, sandy soils should not be treated when there is little likelihood of rainfall after treatment (William et al., 1997).

BIOCONTROL
No biocontrol agents for reed canarygrass are known (Hutchison 1992)

REFERENCES

Agrawal, A. 1998. Induced responses to herbivory and increased plant performance. Science 279:1201-1202.

Allard, H.W. & M.W. Evans. 1941. Growth and flowering of some tame and wild grasses in response to different photoperiods. Journal of Agricultural Research 62:193-228.

Alway, F.J. 1931. Early trials and use of reed canary grass as a forage plant. Journal of the American Society of Agronomists. 23:64-66.

Anderson, D.E. 1961. Taxonomy and distribution of the genus Phalaris. Iowa State Journal of Science 36:1-96.

Apfelbaum, S.I. & C.E. Sams. 1987. Ecology and control of reed canary grass. Natural Areas Journal 7:69-74.

Baker, H.G. 1972. Migration of Weeds In Taxonomy, Phytogeography and Evolution. Academic Press, London. pp. 327-347.

Baltensperger, A.A. & R.R. Kalton. 1958. Variability in Reed Canarygrass, Phalaris arundinacea L. II. Seed Shattering. Agronomy Journal 51(37-38).

Barrett, S.C.H. 1983. Crop mimicry in weeds. Economic Botany 37:255-282.

Britton, N & A. Brown. 1970. An Illustrated Flora of the Northern United States and Canada. Dover, New York.

Bruns, V.F. 1973. Studies on the control of reed canarygrass along irrigation systems. Agriculture Research Service, U.S. Department of Agriculture Publication ARS-W-3. 17pp.

Comes, R.D. 1976. Response of 3 ditchbank grasses to glyphosate, dalapon & amitrol-T. Abstracts Weed Society of America p. 2-3.

Comes, R.D., V.F. Bruns, A.D. Kelley. 1978. Longevity of certain weed and crop seeds in fresh water. Weed Science 26(4):336-344.

Cronquist, A., A.H. Holmgren, N.H. Holmgren, J.L. Reveal, and P.K. Holmgren. 1977. Intermountain Flora: Vascular Plants of the Intermountain West, U.S.A. Volume 6, the monocotyledons. New York Botanical Garden, New York.

Dore, W.G. and J. McNeill. 1980. Grasses of Ontario. Monograph 26, Agricultural Canada, Research Branch, Biosystematics Research Institute, Ottawa, Ontario.

Evans, M.W. & J.E. Ely. 1941. Growth habits of reed canary grass. Journal of the American Society of Agronomists. 33:1017-1027.

Gleason, H.A., A. Cronquist. 1963. Manual of the Vascular Plants of the Northeastern United States and Adjacent Canada. D. VanNostrand Company, Inc., Princeton, NJ.

Gleason, H.A., A. Cronquist. 1991. Manual of the Vascular Plants of the Northeastern United States and Adjacent Canada. D. VanNostrand Company, Inc., Princeton, NJ.

Gomm, F.B. 1979. Accumulation of NO3 and NH4 in reed canarygrass. Agronomy Journal 71:627-630.

Gray, A. 1908. Gray's Manual of botany; a handbook of the flowering plants and ferns of the central and northeastern United States and adjacent Canada. 7th ed. New York, American Book Company.

Gray, A. 1950. Gray's Manual of botany; a handbook of the flowering plants and ferns of the central and northeastern United States and adjacent Canada. 8th ed. New York, American Book Company.

Gray, A. 1970. Gray's Manual of Botany; a handbook of the flowering plants and ferns of central and northeastern United States and adjacent Canada, 8th ed. D. VanNostrand Co., New York.

Griffith W.L. & C.M. Harrison 1954. Maturity and curing temperature and their influence on the germination of reed canarygrass Agronomy Journal 46:163-168.

Harrison, R.D. N.J. Chatterton, R.J. Page, M. Curto, K.H. Assay, K.B. Jemson, and W.H. Horton. 1996. Competition, biodiversity, invasion, and wildlife usage of selected introduced grasses in the Columbia and Great Basins. Research Report 155, Utah Agricultural Experiment Station, Utah State University, Logan.

Haslam, S.M. 1973. The management of British wetlands. I. Economic and amenity use. Journal of Environmental Management 1:303-320.

Heichel, G.H., A.W. Hovin & K.I. Henjum. 1980. Seedling age and cold treatment effects on the induction of

panicle production in reed canarygrass. Crop Science 20:683-687.

Henderson, R.A. 1987. Controlling reed canarygrass in a degraded oak savanna (Wisconsin). Restoration & Management 8(2):254.

Henderson, R.A. 1991. Reed canarygrass poses threat to oak savanna restoration and maintenance (Wisconsin). Restoration & Management Notes 9(1):32.

Hickman, J.C. 1993. The Jepson Manual: Higher Plants of California. University of California Press, Berkeley, CA.

Hodgson, J.M. 1968. Chemical control of reed canarygrass on irrigation canals. Weeds 16:465-468.

Hoffman & Kearns. 1997. Wisconsin Manual of Control. Recommendations for Ecologically Invasive Plants.

Holm, L.G., J.K. Pancho, J.P. Herberger, P.L. Plunkett. 1991. A Geographical Atlas of World Weeds. Krieger Publishing Co. Malabar, Florida.

Holt, I.V. 1954. Initiation and development of the inflorescences of Phalaris arundinacea L. and Dactylis glomerata L. Iowa State College Journal of Science. 28(4):603-621.

Hutchison, M. 1992. Vegetation Management Guideline: Reed Canary Grass (Phalaris arundinacea L.). Natural Areas Journal 12(3):159.

Hyam, R., & R. Pankhurst. 1995. Plants and their names: a concise dictionary. Oxford University Press, Oxford.

Jepson,W.L. 1953. A Manual of Flowering Plants of California. University of California Press, Berkeley.

Klopatek, J.M. & F.W. Stearns. 1978. Primary productivity of emergent macrophytes in a Wisconsin freshwater marsh ecosystem. The American Midland Naturalist 100(2):320-332.

LeFor, M.W. 1987. Phalaris arundinacea L. (reed canarygrass-Gramineae) as a hydrophyte in Essex, Connecticut, USA. Environmental Management 11(6):771-773.

Lesica, P. 1997. Spread of Phalaris arundinacea adversely impacts the endangered plant Howellia aquatilis. Great Basin Naturalist 57(4): 366-368.

Levesque, M.P. & S.P. Mathur. 1983. Effect of liming on yield and nutrient concentration of reed canarygrass grown in two peat soils. Canadian Journal of Soil Science 63:469-478.

Lowe, K.F. & T.M. Bowdler. 1981. Performance of some Phalaris accessions under irrigation in southeastern Queensland. Australian Journal of Experimental Agriculture and Animal Husbandry 21:203-209.

Marten, G.L., R.M. Jordan, A.W. Hovin. 1976. Biological significance of reed canarygrass alkaloids and association with palatability variation to grazing in sheep and cattle. Agronomy Journal 68:909-914.

Merigliano, M.F., and P. Lesica. 1998. The native status of reed canarygrass (Phalaris arundinacea L.) in the inland Northwest, U.S.A. Natural Areas Journal 18:223-230.

Moyle, J.B. 1945. Some chemical factors influencing the distribution of aquatic plants in Minnesota. The American Midland Naturalist 34:402-420.

Munz, Philip A 1959. A California flora. University of California Press, Berkeley.

Paveglio, F.L. & K.M. Kilbride. 1996. Integrated management techniques show promise for control for reed canarygrass (Phalaris arundinacea) in seasonal wetlands (Washington). Restoration and Management Notes 14(1):79-80.

Piper, C.V. 1924. Forage Plants and Their Culture. The MacMillian Co., New York.

Smith, D.C. 1944. Pollination and seed formation in grasses. Journal of Agronomy Research 68:79-95.

Volker, R. & S.G. Smith. 1965. Changes in the aquatic vascular flora of Lake East Okoboji in historic times. Proceedings Iowa Academy of Science 72:65-72.

Vose, P.B. 1962. Delayed germination in Reed canarygrass, Phalaris arundinacea L. Annals of Botany. 26:197-206.

Wilkins, F.S. & H.G. Hughes. 1932. Agronomic trials with reed canary grass. Journal of the American Society of Agronomy. 24:18-28.

William, R.D., D. Ball, T.C. Miller, R. Parker, J.P. Yenish, R.H. Callihan, C. Eberlein, G.A. Lee, D.W. Morishita. 1997. Pacific Northwest Weed Control Handbook.

Oregon State University Extension Publication.

Zeiders, K.E. & R.T. Sherwood. 1985. Environmental interactions among reed Canarygrass genotypes for nutritive value, height and disease severity. Agronomy Journal 77(1):94-98.

LAST UPDATE: December 22 1998
AUTHORED BY: Kelly E. Lyons
EDITED BY: John M. Randall, Mona Robison, TunyaLee Morisawa, Barry Meyers-Rice

The Nature Conservancy
Wildland Invasive Species Program
124 Robbins Hall
Department of Vegetable Crops & Weed Science
University of California
Davis, CA 95616