Phalaris aquatica
Harding grass
Poaceae

Phalaris aquatica is now considered the correct name for *P. tuberosa* (Anderson 1961 The following desciption is from Munz and Keck (1968). *Phalaris aquatica* is a perennial grass forming large clumps with short rhizomes around the base. The culms are stout and can grow up to 150 cm tall. The panicle is narrow, 5-15 cm long, dense, spikelike, and unbranched. The glumes are 5-6 mm long with a scabrous (rough) keel. The fertile lemma is 4 mm long, ovate-lanceolate, and strigose (with sharp and stiff appressed straight hairs). There is usually one sterile lemma, about one-third as long as the fertile one.

P. aquatica can be distinguished from all but one other *Phalaris* species, *P. arundinacea*, by its rhizomatous growth habit. In the case of *P. arundinacea*, which also has underground rhizomes, the length of the sterile lemmas must be ascertained. In *P. aquatica* this length is 1.5 mm, whereas in *P. arundinacea* it is 1 mm.

Harding grass is probably a native of the Mediterranean region of Europe and was originally introduced to North America as a forage plant from Australia (Crampton 1974). It is now more or less naturalized at lower elevations in California. Harding grass is commonly seeded as a forage grass on valley and foothill rangelands in California. It is used in seeding prepared land in oak woodlands of the foothills as well as cleared brushlands. Because of its wide use as a forage plant, it has spread throughout most of the San Joaquin Valley and adjacent grasslands, as well as portions of northern and southern California.

Although most of the literature on *Phalaris aquatica* relates to its use as a forage plant, this information can give us clues about its control. Harding grass provides nutritious forage for sheep (Oram et al. 1974). It develops slowly but forms sizeable bunches after several years. It reseeds itself fairly well but not uniformly over rangeland (Crampton 1974). Harding grass is a particularly valuable forage plant when it is grown as a companion crop with winter annuals, especially legumes. It provides a prolonged period of green forage after annuals are completely dried. Established plants green up quickly with fall rains and provide early forage and stable sod when annuals are still small (Kay 1969). The major agronomic value of Harding grass is its role in extending the grazing season on annual rangeland.

At least some dormancy period is necessary for Harding grass seeds to germinate, and the length of this dormancy can vary widely depending on the genotype of the seed source. Sankary et al. (1969) found dormancy varied from 30 to 127 days depending on the origin of the plant genotype.

Several characteristics of the growth and productivity of Harding grass are related to early stages of its life history. Leaf size is directly proportional to both seed weight and seedling weight. Plants with higher seed weight tend to mature earlier and have fewer flowering heads (Clements and Latter 1973). Plants with rapid early growth (in terms of number of leaves and amount of tillering) are generally more productive when mature. Yields of plant biomass are directly proportional to mean leaf area (Sambo 1983). Harding grass has a relatively high net primary productivity (NPP). The tops of *P. aquatica* had the following NPP values (g carbon dioxide/ square meter/day) during different seasons: spring, 25; summer, 14; autumn, 23; and winter, 0 (Vickery 1972). The highest NPP was measured on pasture that had moderate grazing pressure (20 sheep/ha) as opposed to light (10) or heavy (30) grazing.

Canopy closure of the plant community may reduce growth of Harding grass, although this depends on the species composition of the community (Vickery 1972). Detailed information on growth patterns of Harding grass over the course of a year is contained in Sambo (1983), although little is known about its productivity and life history over several years. Harding grass is a valuable pasture forage plant because of its relatively high protein content. Protein content generally increases toward the end of the growing season

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and is particularly high in senescing foliage. However, there is wide variation in the phenology and concentration of protein in the foliage (Oram et al. 1974).

Harding grass can be harmful to grazing animals in some cases and has been shown to cause neurological disorders in sheep. Several alkaloids are the apparent cause of poisoning. Alkaloid content increases substan- tially after environmental stresses such as frost and drought severe enough to cause wilting (Williams 1972). Although poisoning is well-documented for sheep, it is not known what the effect of the alkaloids is on other animals.

The dominance of Harding grass in a plant community is often related to its ability to increase its biomass and spatial influence through tillering. Tillering appears to be controlled from the terminal meristem and/or additional elongating stems through the translocation of hormones. The degree of apical dominance is directly proportional to light intensity (Jewiss 1972). As in most grasses, *P. aquatica* has evolved with grazing pressure, and its horizontal spread can be enhanced by removal of the terminal meristem. Overall production and subsequent tillering of plants varies considerably depending on the timing and intensity of defoliation. This topic has been investigated extensively using both animals and mechanical clipping.

Localized occurrences of *P. aquatica* should not be viewed as a highly negative feature in grasslands or other plant communities that are otherwise of high quality. If the plant community is judged to be relatively competitive with Harding grass, it should not pose a great threat and can probably be adequately controlled. Adjacent pastures and disturbed areas should be considered potential sources of seed that could lead to the spread of the plant.

P. aquatica has the potential to establish in dense stands, at least in localized areas. It can displace native species particularly in preserves with grassland or some grass species. Areas that should be closely monitored are those that are adjacent to private grazed lands or weedy areas that contain Harding grass. Grazed lands with established Harding grass populations provide a source of seed that may disperse to adjacent areas and are, therefore, a constant threat.

Most affected areas can be managed to maintain a large component of desirable vegetation. There is no evidence that Harding grass threatens to dominate areas where the native vegetation is healthy. *P. aquatica* can be controlled with mowing or clipping and/or herbicide treatments. It is important to monitor areas adjacent to preserves where Harding grass populations occur and to attempt to mitigate the dispersal of seeds. *P. aquatica* populations on preserves should be monitored in order to determine if they are spreading. It is important to consider expansion not only in terms of numbers but also spatially because of its potential for extensive tillering.

The spread of Harding grass should be monitored by focusing on high density areas within preserves as well as on preserve boundaries where it could become established from adjacent lands.

P. aquatica populations are currently being monitored at Ring Mountain Preserve, CA (Larry Serpa, Area Manager). Infestations have been mapped, and the effectiveness of control procedures is being evaluated annually. Contact: Larry Serpa, Area Manager, Ring Mountain Preserve, 3152 Paradise Drive, Room 101, Tiburon, CA 94920 (415) 435-6465.

The following topics require more study with respect to *P. aquatica* control: the effects of mowing, mowing plus herbicide application, and prescribed burning. The effectiveness of herbicide treatment and manual removal of plants as control methods of *P. aquatica* is being evaluated at Ring Mountain Preserve.

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P. aquatica requires active management once it is established or if it threatens to invade across preserve boundaries.

In general, frequent removal of herbage during the active growth period of Harding grass reduces total biomass and promotes mortality. Intensive clipping reduces the amount of carbohydrate stored in the stem base, as carbohydrates are mobilized to provide sugars in other areas of the plant. Clipping three times during the growing season resulted in 75% growth loss per plant (compared to a single clipping), a 25% reduction in carbohydrate concentration, and up to 25% mortality (McKell et al. 1966). The greater the defoliation intensity, the lower the subsequent tiller survival (Westoby 1980). Tillering is restricted during reproductive development when the plant allocates resources to reproductive structures. There is some disagreement over the effect that the timing of clipping has on subsequent growth of Harding grass. Tillering is typically suppressed when plants are cut during flowering (Jewiss 1972), although McKell et al. (1966) found that clipping in the spring retarded growth more severely than clipping at the beginning of flowering. Clipping at the end of the growing season when soil moisture was low reduced growth the following year (Kay 1969). Mechanical methods seem to be able to control Harding grass rather effectively but only with repeated clipping or mowing treatments. As indicated in the discussion above, there is some disagreement as to the most effective time for mowing, but it should be done during the active growing period. Repeated defoliations (during a single growing season) will be most effective.

Burning the vegetative shoots of Harding grass during the winter can reduce subsequent growth for about two years and allow more competitive fire- adapted plants to increase their density and biomass. There is also some evidence that older Harding grass plants lose their vigor and that the number of living shoots and roots begins to decline. Annual grasses and shrub species are more competitive when Harding grass is in this declining stage (Doe Peak Allotment Files undated).

Several herbicides are effective in controlling Harding grass, although relatively high rates (at least 3.4 kg/ha) are necessary (Berry and Buchanan 1975). At 3.4 kg/ha, the following herbicides achieved good control of six-week-old seedlings: 2,4-D amine; 2,4,5-T; 2,4-D ester; dicamba, picloram; and 2,4-D plus atrazine. The pre-emergent herbicides naptalam, vernolate, alachlor, chloraopropham, diphenamid, and trifluralin provide good control at rates of 1 kg/ha (Berry and Buchanan 1974). The Northern California Coast Range Preserve has had some experience with eradicating Harding grass (Barrows pers. comm. 1985). Management staff there have obtained some control by digging the plants out, but this is very labor intensive and can disperse roots that may resprout. They have had good success controlling *P. aquatica* with Roundup (glyphosate) when applied at the time of peak plant growth. Repeated mowing and an application of Roundup to resprouts seem to be the most effective means of control. At Ring Mountain Preserve some degree of Harding grass control has been achieved through manual removal of plants (Wolley pers. comm. 1985). Herbicide treatments with Roundup have been marginally successful to date. Prescribed burning has been used with some success to control Harding grass (Doe Peak Allotment Files undated). Burning during the winter, when there are large numbers of new shoots, allows native species to compete more favorably. Harding grass required at least two years to recover. Therefore, burning at two-year intervals might be a management option.

The Northern California Coast Range and Ring Mountain preserves have management programs (described above) to control the spread of *P. aquatica*. Herbicide and manual methods are being used to control the spread of local infestations. Harding grass poses a moderate threat on these preserves. Contact: Area Manager, Ring Mountain Preserve, 3152 Paradise Drive, Room 101, Tiburon, CA 94920, (415) 435-

Control of *P. aquatica* requires careful monitoring of populations. Control can be maintained with mechanical means such as mowing if chemical methods are unacceptable. A variety of herbicides can provide reasonable control, although Roundup seems to be the best. Because Roundup is a broad spectrum

herbicide, damage to adjacent plants can also be expected. Best control of Harding grass is probably obtained with a combination of mowing and herbicide application.

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