ELEMENT STEWARDSHIP ABSTRACT
for

Phragmites australis

Common Reed

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The Nature Conservancy
Element Stewardship Abstract
For *Phragmites australis*

I. IDENTIFIERS

Common Name: COMMON REED Global Rank: G5

General Description:
Phragmites australis is a large perennial rhizomatous grass, or reed. The name Phragmites is derived from the Greek word for fence, phragma, in reference to its fence-like growth along streams.

Diagnostic Characteristics:
Members of the genus Phragmites are superficially similar to Arundo. Sterile specimens of P. australis are sometimes misidentified as Arundo donax, a grass introduced to North America from Asia and now troublesome in natural areas, especially in California. The genera can be distinguished when in flower because the glumes of Phragmites are glabrous while those of Arundo are covered with soft, whitish hairs 6-8 mm long. In addition, the glumes are much shorter than the lemmas in Phragmites.

II. STEWARDSHIP SUMMARY

Communities that have stable Phragmites populations present but have been exposed to disturbance should be closely monitored. Management is necessary when evidence indicates that Phragmites has spread, or is spreading and threatening the integrity of rare communities, invading the habitat of rare plants or animals or interfering with the wildlife support function of refuges. Cutting, burning, application of herbicides (in particular Rodeo), or water management schemes are possible control measures. The measure(s) used will depend on a number of factors including the size and location of the infestation, the presence of sensitive rare species and the work-force available.

III. NATURAL HISTORY

Range:
Phragmites australis is found on every continent except Antarctica and may have the widest distribution of any flowering plant (Tucker 1990). It is common in and near freshwater, brackish and alkaline wetlands in the temperate zones world-wide. It may also be found in some tropical wetlands but is absent from the Amazon Basin and central Africa. It is widespread in the United states, typically growing in marshes, swamps, fens, and prairie potholes, usually inhabiting the marsh-upland interface where it may form continuous belts (Roman et al. 1984).

Because Phragmites has invaded and formed near-monotypic stands in some North American wetlands only in recent decades there has been some debate as to whether it is indigenous to this continent or not. Convincing evidence that it was here long before European contact is now available from at least two sources. Niering and Warren (1977) found remains of Phragmites in cores of 3000 year old peat from tidal marshes in Connecticut. Identifiable Phragmites remains dating from 600 to 900 A.D. and constituting parts of a twined mat and other woven objects were found during archaeological investigations of Anasazi sites in southwestern Colorado (Kane & Gross 1986; Breternitz et al. 1986).

There is some suspicion that although the species itself is indigenous to North America, new, more invasive genotype(s) were introduced from the Old World (Metzler and Rosza 1987). Hauber et al. (1991) found that invasive Phragmites populations in the Mississippi River Delta differed genetically from a more stable population near New Orleans. They also examined populations elsewhere on the Gulf coast, from extreme southern Texas to the Florida panhandle, and found no genetic differences between those populations and the one near New Orleans (Hauber, pers. comm. 1992). This increased their suspicion that the invasive biotypes were introduced to the Delta from somewhere outside the Gulf relatively recently.

Phragmites is frequently regarded as an aggressive, unwanted invader in the East and Upper Midwest. It has also earned this reputation in the Mississippi River Delta of southern Louisiana, where over the last 50 years, it has displaced species that provided valuable forage for wildlife, particularly migratory waterfowl (Hauber 1991). In other parts of coastal Louisiana, however, it is feared that Phragmites is declining as a result of increasing saltwater intrusion in the brackish marshes it occupies. Phragmites is apparently decreasing in Texas as well due to invasion of its habitat by the alien grass ARUNDO DONAX (Poole, pers. comm. 1985). Similarly, Phragmites is present in the Pacific states but is not regarded as a problem there. In fact, throughout the western U.S. there is some concern over decreases in the species habitat and losses of populations.

Habitat:
Phragmites is especially common in alkaline and brackish (slightly saline) environments (Haslam 1972, 1971b), and can also thrive in highly acidic wetlands (Rawinski, pers. comm. 1985). However, Phragmites does not require, nor even prefer these habitats to freshwater areas. Its growth is greater in fresh water but it may be outcompeted in these areas by other species that cannot tolerate brackish, alkaline or acidic waters. It is often found in association with other wetland plants including species from the following genera: SPARTINA, CAREX, NYMPHAEA, TYPHA, GLYCERIA, JUNCUS, MYRICA, TRIGLOCHIN, CALAMAGROSTIS, GALIUM, and PHALARIS (Howard et al. 1978).

Phragmites occurs in disturbed areas as well as pristine sites. It is especially common along railroad tracks, roadside ditches, and piles of dredge spoil, wherever even slight depressions hold water (Ricciuti 1983). Penko (pers. comm. 1993) has observed stunted

Phragmites growing on acidic tailings (Ph 2.9) from an abandoned copper mine in Vermont. Various types of human manipulation and/or disturbance are thought to promote Phragmites (Roman et al. 1984). For example, restriction of the tidal inundation of a marsh may result in a lowering of the water table, which may in turn favor Phragmites. Likewise, sedimentation may promote the spread of Phragmites by elevating a marsh's substrate surface and effectively reducing the frequency of tidal inundation (Klockner, pers. comm. 1985).

A number of explanations have been proposed to account for the recent dramatic increases in Phragmites populations in the northeastern and Great Lakes States. As noted above, habitat manipulations and disturbances caused by humans are thought to have a role. In some areas Phragmites may also have been promoted by the increases in soil salinity which result when de- icing salt washes off roads and into nearby ditches and wetlands (McNabb and Batterson 1991). On the other hand, bare patches of road sand washed into ditches and wetlands may be of greater importance. Phragmites seeds are shed from November through January and so may be among the first propagules to reach these sites. If the seeds germinate and become established the young plants will usually persist for at least two years in a small, rather inconspicuous stage, resembling many other grasses. Later, perhaps after the input of nutrients, they may take off and assume the tall growth form that makes the species easily identifiable . Increases in soil nutrient concentrations, may come from runoff from farms and urban areas. It has also been suggested increases in nutrient concentrations, especially nitrates, are primarily responsible for increases in Phragmites populations. Ironically, eutrophication and increases in nitrate levels are sometimes blamed for the decline of Phragmites populations in Europe (Den Hartog et al. 1989).

Ecology:

Salinity and depth to the water table are among the factors which control the distribution and performance of Phragmites. Maximum salinity tolerances vary from population to population; reported maxima range from 12 ppt (1.2%) in Britain to 29 ppt in New York state to 40 ppt on the Red Sea coast (Hocking et al. 1983). Dense stands normally lose more water through evapotranspiration than is supplied by rain (Haslam 1970). However, rhizomes can reach down almost 2 meters below ground, their roots penetrating even deeper, allowing the plant to reach low lying ground water (Haslam 1970). Killing frosts may knock the plants back temporarily but can ultimately increase stand densities by stimulating bud development (Haslam 1968).

Phragmites has a low tolerance for wave and current action which can break its culms (vertical stems) and impede bud formation in the rhizomes (Haslam 1970). It can survive, and in fact thrive, in stagnant waters where the sediments are poorly aerated at best (Haslam 1970). Air spaces in the above-ground stems and in the rhizomes themselves assure the underground parts of the plant with a relatively fresh supply of air. This characteristic and the species' salinity tolerance allow it to grow where few others can survive (Haslam 1970). In addition the build up of litter from the aerial shoots within stands prevents or discourages other species from germinating and becoming established (Haslam 1971a). The rhizomes and adventitious roots themselves form dense mats that further discourage competitors. These characteristics are what enable Phragmites to spread, push other species out and form monotypic stands.

Such stands may alter the wetlands they colonize, eliminating habitat for valued animal species. On the other hand, the abundant cover of litter in Phragmites stands may provide habitat for some small mammals, insects and reptiles. The aerial stems provide nesting sites for several species of birds, and Song Sparrows have been seen eating Phragmites' seeds (Klockner, pers. comm. 1985). Muskrats (ONDATRA ZIBETHICUS) use Phragmites for emergency cover when low lying marshes are swept by storm tides and for food when better habitats are overpopulated (Lynch et al. 1947).

Studies conducted in Europe indicate that gall-forming and stem- boring insects may significantly reduce growth of Phragmites (Durska 1970; Pokorny 1971). Skuhravy (1978) estimated that roughly one-third of the stems in a stand may be damaged reducing stand productivity by 10-20%. Mook and van der Toorn (1982) found yields were reduced by 25 to 60% in stands heavily infested with lepidopteran stem- or rhizome-borers. Hayden (1947) suggested that aphids (HYALOPTERUS PRUNI) heavily damaged a Phragmites stand in Iowa. On the other hand work in Europe by Pintera (1971) indicated that although high densities of aphids may bring about reductions in Phragmites shoot height and leaf area they had little effect on shoot weight. Like other emergent macrophytes, Phragmites has tough leaves and appears to suffer little grazing by leaf-chewing insects (Penko 1985).

As mentioned above, there is great concern about recent declines in Phragmites in Europe where the species is still used for thatch. In fact, the journal Aquatic Botany devoted an entire issue (volume 35 no.1, September 1989) to this subject. Factors believed responsible for the declines include habitat destruction and manipulation of hydrologic regimes by humans, grazing, sedimentation and decreased water quality (eutrophication) (Ostendorp 1989).

Detailed reviews of the ecology and physiological ecology of Phragmites are provided by Haslam (1972; 1973) and Hocking et al. (1983) and an extensive bibliography is provided by van der Merff et al. (1987).

Reproduction:
Phragmites is typically the dominant species on areas that it occupies. It is capable of vigorous vegetative reproduction and often forms dense, virtually monospecific stands. Hara et al. (1993) classify sparse stands as those with densities of less than 100 culms m-2 and dense stands as those with densities of up to about 200 culms m-2 in wet areas or up to 300 culms m-2 in dry areas. Mammalian and avian numbers and diversity in the dense stands are typically low (Jones and Lehman 1987). Newly opened sites may be colonized by seed or by rhizome fragments carried to the area by humans in soils and on machinery during construction or naturally in floodwaters.

The plants generally flower and set seed between July and September and may produce great quantities of seed. In the northeast, seeds are dispersed between November and January. However, in some cases, most or all of the seed produced is not viable (Tucker 1990). The seeds are normally dispersed by wind but may be transported by birds such as red-winged blackbirds that nest among the reeds (Haslam 1972). Following seed set, nutrients are translocated down into the rhizomes and the above- ground portions of the plant die back for the season (Haslam 1968).

Temperature, salinity and water levels affect seed germination. Water depths of more than 5 cm and salinities above 20 ppt (2%) prevent germination (Kim et al. 1985; Tucker 1990). Germination is not affected by salinities below 10 ppt (1%) but declines at higher salinities. Percentage germination increases with increasing temperature from 16 to 25 oC while the time required to germinate decreases from 25 to 10 days over the same temperature range. Barry Truitt (pers. comm. 1992) has observed that areas covered by thick mats of wrack washed up during storms and high water events are frequently colonized by Phragmites on the Virginia Coast Reserve. It is not clear whether it establishes from rhizome pieces washed in with the wrack or from seed that blows in later.

Once a new stand of Phragmites takes hold it spreads, predominantly through vegetative reproduction. Individual rhizomes live for 3 to 6 years and buds develop at the base of the vertical type late in the summer each year. These buds mature and typically grow about 1 meter (up to 10 m in newly colonized, nutrient-rich areas) horizontally before terminating in an upward apex and going dormant until spring. The apex then grows upward into a vertical rhizome which in turn produces buds that will form more vertical rhizomes. Vertical rhizomes also produce horizontal rhizome buds, completing the vegetative cycle. These rhizomes provide the plant with a large absorbent surface that brings the plant nutrients from the aquatic medium (Chuchova and Arbuzoba 1970). The aerial shoots arise from the rhizomes. They are most vigorous at the periphery of a stand where they arise from horizontal rhizomes, as opposed to old verticals (Haslam 1972).

IV. CONDITION

Threats:

IMPACTS (THREATS POSED BY THIS SPECIES)
Phragmites can be regarded as a stable, natural component of a wetland community if the habitat is pristine and the population does not appear to be expanding. Many native populations of Phragmites are "benign" and pose little or no threat to other species and should be left intact. Examples of areas with stable, native populations include sea-level fens in Delaware and Virginia and along Mattagota Stream in Maine (Rawinski 1985, pers. comm. 1992). In Europe, a healthy reed belt is defined as a "homogeneous, dense or sparse stand with no gaps in its inner parts, with an evenly formed lakeside borderline without aisles, shaping a uniform fringe or large lobes, stalk length decreasing gradually at the lakeside border, but all stalks of one stand of similar height; at the landside edge the

reeds are replaced by sedge or woodland communities or by unfertilized grasslands" (Ostendorp 1989).

Stable populations may be difficult to distinguish from invasive populations, but one should examine such factors as site disturbance and the earliest collection dates of the species to arrive at a determination. If available, old and recent aerial photos can be compared to determine whether stands in a given area are expanding or not (Klockner, pers. comm. 1985).

Phragmites is a problem when and where stands appear to be spreading while other species typical the of the community are diminishing. Disturbances or stresses such as pollution, alteration of the natural hydrologic regime, dredging, and increased sedimentation favor invasion and continued spread of Phragmites (Roman et al. 1984). Other factors that may have favored recent invasion and spread of Phragmites include increases in soil salinity (from fresh to brackish) and/or nutrient concentrations, especially nitrate, and the introduction of a more invasive genotype(s) from the Old World (McNabb and Batterson 1991; Metzler and Rosza 1987, see GLOBAL RANGE section for further discussion).

Michael Lefor asserts that one reason for the general spread of Phragmites has been the destabilization of the landscape (pers. comm. 1993). In urban landscapes water is apt to collect in larger volumes and pass through more quickly (flashily) than formerly. This tends to destabilize substrates leaving bare soil open for colonization. Watersheds throughout eastern North America are flashier due to the proliferation of paved surfaces, lawns and roofs and the fact that upstream wetlands are largely filled with post-settlement/post agricultural sediments from initial land-clearing operations.

Many Atlantic coast wetland systems have been invaded by Phragmites as a result of tidal restrictions imposed by roads, water impoundments, dikes and tide gates. Tide gates have been installed in order to drain marshes to harvest salt hay, to control mosquito breeding and, most recently, to protect coastal development from flooding during storms. This alteration of marsh systems may favor Phragmites invasion by reducing tidal action and soil water salinity and lowering water tables.

Phragmites invasions may threaten wildlife because they alter the structure and function (wildlife support) of relatively diverse Spartina marshes (Roman et al. 1984). This is a problem on many of the eastern coastal National Fish and Wildlife Refuges including: Brigantine in NJ; Prime Hook and Bombay Hook in DE; Tinicum in PA; Chincoteague in VA; and Trustom Pond in RI.

Plant species and communities threatened by Phragmites are listed in the Monitoring section. Some of these instances are described below:

1. Massachusetts, a brackish pondlet near Horseneck Beach supports the state rare plant MYRIOPHYLLUM PINNATUM (Walter) BSP, which Phragmites is threatening by

reducing the available open water and shading aquatic vegetation (Sorrie, pers. comm. 1985).

2. Maryland, at Nassawango Creek, a rare coastal plain peatland community is threatened by Phragmites (Klockner, pers. comm. 1985).

3. Ohio, at the Arcola Creek wetland, Phragmites is threatening the state endangered plant CAREX AQUATILIS Wahlenb. (Young, pers. comm. 1985).

Phragmites invasions also increase the potential for marsh fires during the winter when the above ground portions of the plant die and dry out (Reimer 1973). Dense congregations of redwing blackbirds, which nest in Phragmites stands preferentially, increase chances of airplane accidents nearby. The monitoring and control of mosquito breeding is nearly impossible in dense Phragmites stands (Hellings and Gallagher 1992). In addition, Phragmites invasions can also have adverse aesthetic impacts. In Boston's Back Bay Fens, dense stands have obscured vistas intended by the park's designer, Frederick Law Olmstead (Penko, pers. comm. 1993).

As noted above Phragmites is not considered a threat in the West or most areas in the Gulf states.

Restoration Potential:
Areas that have been invaded by Phragmites have excellent potential for recovery. Management programs have proven that Phragmites can be controlled, and natural vegetation will return. However, monitoring is imperative because Phragmites tends to reinvade and control techniques may need to be applied several times or, perhaps, in perpetuity. It is also important to note that some areas have been so heavily manipulated and degraded that it may be impossible to eliminate Phragmites from them. For example, it may be especially difficult to control Phragmites in freshwater impoundments that were previously salt marshes.

V. MANAGEMENT/MONITORING

Management Requirements:
Invasive populations of Phragmites must be managed in order to protect rare plants that it might outcompete, valued animals whose habitat it might dominate and degrade, and healthy ecosystems that it might greatly alter.

Management Programs:
Cultural, mechanical and/or chemical methods can be used to control Phragmites. The factors that are believed responsible for the alarming decreases of Phragmites beds in Europe and Texas include habitat destruction, increased soil nitrate levels, and eutrophication (Boar, Crook and Moss 1989, Ostendorp 1989, Sukopp and Markstein 1989) are not appropriate as management tools in natural areas.

BIOLOGICAL CONTROL: Biological control does not appear to be an option at this time. No organisms which significantly damage Phragmites australis but do not feed on other plant species have been identified. Naturally occurring parasites have not proven to be successful controls (Tscharntke 1988, Mook and van der Toorn 1982, van der Toorn and Mook 1982). In addition, some of the arthropods that feed on Phragmites are killed by winter fires and thus would likely be eliminated from the systems where prescribed fires are used. Coots, nutria, and muskrats may feed on Phragmites but appear to have limited impacts on its populations (Cross and Fleming 1989).

BURNING: Prescribed burning does not reduce the growing ability of Phragmites unless root burn occurs. Root burn seldom occurs, however, because the rhizomes are usually covered by a layer of soil, mud and/or water. Fires in Phragmites stands are dangerous because this species can cause spot-fires over 100 feet away (Beall 1984). Burning does remove accumulated Phragmites leaf litter, giving the seeds of other species area to germinate. Prescribed burning has been used with success after chemical treatment for this purpose at The Brigantine National Wildlife Refuge, NJ (Beall 1984) and in Delaware (Lehman, pers. comm. 1992). Occasional burning has been used in Delaware in conjunction with intensive spraying and water level management. This helps remove old canes and allows other vegetation to grow (Daly, pers. comm. 1991)

At Wallops Island, Virginia, a small (100' x 400') brackish to saline to dry wetland was burned November 1990 to control Phragmites (M. Ailes, pers. comm. 1992). A variety of other species appeared in the year following the burn but they appeared leggy while the Phragmites remained vigorous. A second winter burn is planned and monitoring of transects will continue (there are no pre-treatment data).

At Wertheim National Wildlife Refuge in New York, a 20-30 acre freshwater impoundment was drained in the fall of 1989, burned the following winter and then reflooded (Parris, pers. comm. 1991). Phragmites was eliminated from the half of the marsh that was treated and the area remained free of the grass through 1992.

According to Cross and Fleming (1989), late summer burns may be effective, but winter and spring burning may in fact increase the densities of spring crops. Thompson and Shay (1985) performed experimental burn treatments on Delta Marsh, Manitoba. They found that spring, summer and fall burns resulted in higher total shoot densities and lower mean shoot weights than on controls primarily as a result of greater densities of shorter, thinner vegetative shoots. Shoot biomass was greater in spring-burned and fall-burned plots than in control areas but less on summer- burned plots. They also found that below-ground production increased following spring and fall burns but not following summer burns. The increase in light availability following burns generally appears to benefit Phragmites. A variety of understory responses to these burns was noted. For example, summer burns increased species diversity, richness, and evenness, although certain species declined (Thompson and Shay 1985).

In Connecticut late spring burns followed by manual flooding with salt water was successful in reducing Phragmites height and density (Steinke, pers. comm. 1992). After three years, the fuel load was exhausted; the process was very expensive and self-regulating tide gates were installed instead (see MANIPULATION OF WATER LEVEL AND SALINITY).

In Europe, experimental removal of litter in winter resulted in doubling the above-ground biomass (Graneli 1989). Increased light availability at the soil surface and aeration of the soil around the rhizomes may have been responsible for this increase. Burning in the winter in an experimental field caused little damage, while burning during the emergence period led to the death of the majority of Phragmites shoots (van der Toorn and Mook 1982).

CHEMICAL: RodeoTM, a water solution of the isopropylamine salt of glyphosate is commonly used for Phragmites control. This herbicide is not, however, selective and will kill grasses and broadleaved plants alike. Toxicity tests indicate that it is virtually non-toxic to all aquatic animals tested. It should be noted that many of these tests were performed by or for Monsanto, the company which manufactures Rodeo. Bioconcentration values for glyphosate in fish tissues were insignificant. Glyphosate biodegrades quickly and completely in the environment into natural products including carbon dioxide, nitrogen, phosphate and water. Finally, since glyphosate does not volatilize, it will not vaporize from a treated site and move to a non-target area (Brandt 1983; Comes, Bruns and Kelly 1976; Folmar, Sanders and Julin 1979; Monsanto 1985).

Rodeo must be mixed with water and a surfactant which allows it to stick to and subsequently be absorbed by the plant (Beall 1984). Instructions for application, amounts needed per acre, the approved surfactants and ratios for mixing, are on the Rodeo label. Glyphosate must be mixed with clean or, if possible, distilled water because it binds tightly to sediments and is thus rendered non-toxic to plants (Lefor, pers. Comm. 1992). This limits its effectiveness but also may help prevent it from acting on plants that were not originally targeted. Rodeo should not by applied in windy conditions, as the spray will drift (I. Ailes, pers. comm. 1985). It also should not be applied if rain is forecast within 12 hours because it will wash away before it has a chance to act (Daly 1984). Application rates may vary but, as one example, effective control of Phragmites in a Delaware marsh was achieved with 4 pints/acre of concentrate (Lehman, pers. comm. 1992).

Application of Rodeo must take place after the tasseling stage when the plant is supplying nutrients to the rhizome. At this time, when Rodeo is sprayed onto the foliage of aquatic weeds, it translocates into the roots. Rodeo interferes with essential plant growth processes, causing gradual wilting, yellowing, browning and deterioration of the plant. Studies on tasseling at the Augustine Tidal area, in Port Penn Delaware, indicated that tasseling in a stand is never 100% but that it is possible to spray when 94% of the plants are tasseling. In dense stands, subdominant plants are protected by the thick canopy and thus may not receive adequate herbicide. For these reasons, touch up work will be necessary (Lehman 1984).

At Brigantine National Wildlife Refuge, Rodeo was applied aerially after the plants tasseled in late August. The application resulted in a 90% success. The following February, a fast moving prescribed burn was carried out to remove litter, exposing the seed bed for re-establishment of marsh vegetation. However funding was not available for several years and Phragmites has returned to 90% of the previously treated areas (Beall, pers. comm. 1991). Treatment was resumed in fall 1991.

In September, 1983, at the Prime Hook Wildlife Refuge in Delaware, 500 acres of freshwater impoundments were sprayed with Rodeo from a helicopter for Phragmites control. The plants yellowed within 10 days. The following May aerial and ground evaluations of the sprayed area revealed a 98% kill of Phragmites (Daly 1984). In addition to applying herbicide, Prime Hook manipulates water levels with a stop log to stress Phragmites; winter water levels are held at an elevation of 2.8' msl until June, when water would otherwise be held at 2.2 msl. The combined spraying and water management approach was successful and many aquatic plants returned. A regime of spraying in August-September for two years followed by flooding has been used through 1991 (Daly, pers. comm. 1991). Annual costs of Phragmites control are $20K annual at Prime Hook (1,000 acres) and $3K at Bombay Hook (20-60 acres); monitoring costs, which include reading vegetation transects for species presence and density each September are not included in the cost.

Aerial spraying has been used since 1983 in many Delaware state wildlife refuges (Lehman, pers. comm. 1992). Using Rodeo, the state sprays freshwater and brackish impoundments, brackish marshes, and salt marshes from early September to early October; this is combined with winter burns between the first and second year of spraying. Areas will be spot-treated whenever needed after that. The herbicide treatments consist of 4 pints/acre the first year and 2 pints/acre the second, with an average cost of $65/acre. The state is involved with cost-sharing programs with private landowners where the state pays half the spraying cost with a willing owner. Desirable native vegetation usually returns after spraying; no revegetation is done. Occasionally become open mud flats that are eventually repopulated by Phragmites.

At Chincoteague National Wildlife refuge, an aerial spraying program initiated in 1986 in an 18-mile long freshwater impoundment was terminated due to budget cuts. Phragmites quickly reclaimed the area, estimated to be 100-150 acres total in small scattered stands (I. Ailes, pers. comm. 1991). In September 1991, spraying with Rodeo began again; it is expected that the entire area will be sprayed again in 1992, and that small areas of re-growth will be sprayed in 1993. Because the area is impounded, the water level usually is lower in the spring, which helps prevent Phragmites regrowth.

Herbicides are used at Tinicum Environmental Center, because other control options are limited. Unplanned burns do occur, but prescribed burns are not allowed due to the proximity to the highway and airport. Tinicum was recently granted $2M to restore a 18-

acre site. Here they will be altering the elevation of the marsh, seeding with native plants, and monitoring the results (Nugent, pers. comm. 1991).

At Parker National Wildlife Refuge, an aerial spraying program (annual budget $5K) for 50 acres of a 100-acre freshwater impoundment began in mid-August 1991. A winter burn is anticipated and a second year of spraying planned. Results will be monitored by using aerial photos to delineate the boundaries of the Phragmites clones. A nearby tower also provides a suitable viewing point to observe progress (Healey, pers. comm. 1992).

In more fragile situations where Phragmites is threatening a rare plant or community, aerial spray techniques are inappropriate because such large-scale application could kill the community that the entire operation was designed to protect. Glyphosate can be applied to specific plants and areas by hand with a backpack sprayer. Wayne Klockner of The Nature Conservancy's Maryland Field Office has been successful in eliminating most Phragmites at the Nassawango preserve by applying glyphosate by hand with a backpack sprayer (Klockner, pers. comm. 1985). The control program there began in 1983; actual spraying is conducted along the power line ROW by Delmarva Power (Droege, pers. comm. 1991). Delmarva Power generally sprays with trucks, backpacks or helicopter, depending on the accessibility of the area and presence of rare plants nearby (Johnstone, pers. comm. 1991). They use Rodeo in tidal areas, and AccordTM (another glyphosate product) in non-tidal areas from mid-August to mid-October, when the plants are going to seed. They spray intensively the first year, and conduct touch-up spraying the second year which eliminates 90-95% of the plants. They then return every three years to eliminate any new plants. They do not spray if the plants are not tasselling and are short.

Rodeo was used at Cape May Meadows in 1989, 1990, and 1991. It was applied with a 30 gallon gas-powered tank with spray nozzle mounted on a truck, Indian pump sprayers, 2.5 gallon hand-held sprayers, and wick applicators (Johnson, pers. comm. 1991). This appeared to kill most, if not all, of the treated Phragmites in this 20-acre area; plants found in the area following treatment were shorter and the stand was less dense (determined visually). However the dead stalks remained and blocked views from the trail.

In Connecticut a 5m x 23 m patch of Phragmites has been treated with a hand-held spray of Rodeo (1988 and 1989) and Roundup (1990 and 1991) for four years in late August-early September. The Phragmites is shorter and less dense at the site but it is still present (Lapin pers. obs.). Actions to supplement and enhance herbicide applications including the removal of tassels (1991) and removal of dead stalks (planned 1992), have been and will be taken.

Other chemicals have been used on Phragmites and are described in Cross and Fleming (1989).

Also see CUTTING at Constitution Marsh for another method of application.

CUTTING: Cutting has been used successfully to control Phragmites. Since it is a grass, cutting several times during a season, at the wrong times, may increase stand density (Osterbrock 1984). However, if cut just before the end of July, most of the food reserves produced that season are removed with the aerial portion of the plant, reducing the plant's vigor. This regime may eliminate a colony if carried out annually for several years. Care must be taken to remove cut shoots to prevent their sprouting and forming stolons (Osterbrock 1984). In the Arcola Creek Preserve in Ohio, cutting reduced the vigor of the Phragmites colony. Also in Ohio, at Morgan Swamp, cutting began in mid to end of July (before tassel set) in 1989 around a gas well in a freshwater wetland (Seidel, pers. comm. 1991). The preferred tool was an old-fashioned hedge trimmer with an 8" flat blade with serrations manufactured by Union Fork and Hoe. The trimmers worked better than loppers and were safer than sickles; a circular blade on a weed whacker was also used and proved to be faster and good for staff but it was more dangerous for volunteers and detracted from the atmosphere of the work-day (Huffman, pers. comm. 1992).

Small patches (10' x 50') in a New York freshwater system were cut at the end of July or the beginning of August for two successive years with positive results (Schneider, pers. comm. 1990). The hand-cut material was removed from the site and thrown on a brush pile (unfortunately it was located too close to the water and returned to the system).

Massachusetts Audubon staff have cut the perimeter around a 0.25 acre Phragmites patch at the end of July since 1986 in a freshwater wetland at Daniel Webster Preserve in Marshfield, Massachussetts (Anderson, pers. comm. 1992). They have monitored their success in keeping it from spreading by using a map and hand compass.

Stands of Phragmites of less than 1 acre in extent that block views in Everglades National Park are cut just before the onset of the rainy season. The rise in water elevation from the rains that follow stresses the roots of the plant. This works to a degree but Phragmites returns (Dowlen, pers. comm. 1985).

In Quincy, Mass., the town used small Bobcats with lawnmower clippers mounted on the buckets with a flexible cable to cut an area with 75% cover of Phragmites and 20-25' of muck (Wheelwright, pers. comm. 1991; Dobberteen pers. comm. 1991). Cutting this 10-acre plot three times during the summer (April, June, August) cost $150K. The cut material was stockpiled nearby where it was to be burned in the winter when it was washed away in a severe storm. In winter 1992, the town plans to open the tide gate and allow flushing to prevent further return of Phragmites. Results are not yet known.

Cutting culms to 6" followed by addition of rock salt on a 10' x 10' patch appeared to have reduced the height and density of Phragmites in a salt marsh in Greenwich, CT (Jontos and Allan 1984). Continued observations indicated that this trend appeared to continue (Jontos, pers. comm. 1992).

Cutting an area 25' x 25' to waist height with a hedge clippers and the applying one drop of Roundup with a syringe with a large needle (horse size) into the top of the plant in a brackish- freshwater marsh was begun in Constitution Marsh in New York in 1991 (Keene, pers. comm. 1991). Initial results indicate 90% eradication.

In Connecticut, cutting below the first leaf at the end of July in 1986, 1989, 1990, 1991, and 1992 in a freshwater tidal wetland around the perimeter of a one-acre patch has prevented subsequent expansion of the patch. Monitoring using aerial photos taken at five-year intervals indicated the control success. Cutting was done with hand-held cutters and gas-powered hedge trimmers, which were very efficient. Cut material was removed from the site and allowed to decompose on upland areas. In a second area, similar efforts in a calcareous wetland 1990-1992 were monitored by placing red survey wires around the perimeter of the patch. Preliminary observations indicate a cessation of Phragmites expansion.

In Europe, Weisner and Graneli (1989) found that oxygen transport was reduced by cutting the culms above and below the water surface;cutting below the water in June almost totally inhibited regrowth of shoots the following summer, while cutting above water reduced regrowth of shoots. Cutting in August did not reduce growth the following summer. Cutting in sandy substrates was minimally effective, while cutting on calcareous muds caused decreases in oxygen levels.

Also see MANIPULATION OF WATER LEVEL AND SALINITY.

GRAZING, DREDGING, AND DRAINING: Grazing, dredging, and draining are other methods that have often been used to reduce stand vigor (Howard, Rhodes and Simmers 1978). However, draining and dredging are not appropriate for use on most preserves (Osterbrock, 1984).

Grazing may trample the rhizomes and reduce vigor but the results are limited (Cross and Fleming 1989). Van Deursen and Drost (1990) found that cattle consumed 67-98% of above-ground biomass; in a four year study, they found that reed populations may reach new equilibria under grazing regimes.

MANIPULATION OF WATER LEVEL AND SALINITY: A self-regulating tide gate which reintroduced saltwater tidal action was used to help restore a diked marsh in Fairfield, Connecticut (Thomas Steinke pers. comm. 1992; Bongiorno et al. 1984). A 1-3 foot reduction in stem height resulted over each of three years . In addition to reduced height, plant density declined dramatically from 11.3 plants m-2 in 1980 to 3.3 plants/ m-2 the following year. In following years, Phragmites continued to decline, although less dramatically. In addition to the decreased height and density of the Phragmites stands, typical marsh flora including SALICORNIA, DISTICHILIS, SPARTINA ALTERNIFLORA Loisel. and S. PATENS (Aiton) Muhl. returned. Depending on topography and elevation, Phragmites was eliminated in large areas and continues to remain short and sparse in other areas through 1992. Hence, reintroduced tidal action and salinity can reduce Phragmites vigor and restore the community's integrity. This has been implemented successfully in other degraded former salt marshes in Connecticut (Rozsa, pers. comm. 1992).

Flooding can be used to control Phragmites when 3 feet of water covers the rhizome for an extended period during the growing season, usually four months (Beall 1984). However, many areas can not be flooded to such depths. Furthermore, flooding could destroy the communities or plants targeted for protection.

Open Marsh Water Management (OMWM) has been used as a method to control Phragmites. Plugging of ditches and addition of culverts to raise the soil salinities appears to have caused Phragmites die-back over the last four growing seasons at Fireplace Neck, New York (Niniviaggi, pers. comm. 1991; Rozsa, pers. comm. 1992).

Hellings and Gallagher (1992) found that Phragmites was negatively impacted by increasing salinity and increased flooding. They also found that cutting and subsequent flooding also reduced growth and survival in outdoor experiments. They suggest that Phragmites may be controlled by increasing flooding and salinity levels. Matoh, Matsushita and Takahashi (1988) also found reduction in vigor with increased salinity. However death apparently occurred only when cutting was combined with brackish flooding (Hellings and Gallagher 1992).

In Europe, episodic freshwater flooding occurring early in the growing season has been suggested as one of the reasons for reed population declines (Ostendorp 1991). McKee et al. (1989) investigated root metabolic changes due to freshwater flooding and labelled Phragmites as a flood-tolerant species.

Also see Chincoteague NWR under CHEMICALS, Wertheim NWR under BURNING, and Town of Quincy under CUTTING for additional references.

MOWING, DISKING, AND PULLING: Beall (1984) discourages mowing and disking. Mowing only affects the above ground portion of the plant, so mowing would have to occur annually. To remove the rhizome, disking could be employed. However, discing could potentially result in an increase of Phragmites since pieces of the rhizome can produce new plants. Cross and Fleming (1989) describe successful mowing regimes of several year duration during the summer (August and September) and discing in summer or fall.

In Cape May Meadows, New Jersey, a brackish to freshwater non- tidal sandy area, an attempt was made to remove rhizomes by pulling to a depth of three feet (Johnson, pers. comm. 1991). This resulted in a very sparse Phragmites stand the following year. However it was very labor-intensive (using 130 people- hours to cover a 50 ft2 patch) and could be applied best to sandy soils.

In a private yard, Phragmites was mowed and a thin layer of soil and grass seed were added. This was mowed weekly over the course of the summer. In the second summer shoots of Phragmites occurred around the edges. The rhizomes were decomposing after this treatment (M. Ailes, pers. comm. 1992).

PLASTIC: Clear plastic six-mil thick, 12 x 17 m, weighing 51.8 kg, was carried into a North Carolina marsh by air and held in place by sandbags (Boone et al. 1987, 1988). Plants were initially cut to 6-8" with a hand-pushed bush hog (Boone, pers. comm. 1991) or a weedeater with blade, with an area of 20 x 20 m taking several days to cut. The cut material was left and the plastic put over the area. The high temperatures under the plastic caused die-off of Phragmites in 3-4 days. After 8-10 weeks, the plastic deteriorated. The rhizomes appeared to have died back, but the project was of short duration and the results were not monitored the following year (Boone, pers. comm. 1991). Turner (pers. comm. 1992) noted that follow-ups in subsequent years indicated Phragmites returned but not as densely. Plastic management in each 12 x 12 m plot took an average of 53 hours, compared with 17 hours to cut and three hours to burn (Boone et al. 1987).

Clear plastic in two narrow swaths (70 m x 20 m) was placed along the edge of a tidal brackish pond after hand-cutting the Phragmites at the end of July 1991 (Anderson, pers. comm. 1992). One plot, in total sun, had a complete kill of Phragmites in 10 days, while the plot in partial shade had a partial kill. It is unknown how the plastic was kept in place or what was done with the cut material.

Clear and black plastic were used on 50' circular areas at Constitution Marsh in New York in 1990 and 1991 (Keene, pers. comm. 1991). Although there was difficulty due to tidal influence, the plastic was weighted down with rocks and appeared to kill what is under it. Runners along the edge were treated with a syringe application of Roundup in August. In November 1991, a hole cut in the middle of the black plastic provided the opportunity for cattail shoots to germinate. After the first year there was viable Phragmites in the areas covered. It appeared that the black plastic was more effective, due to the higher heat levels attained (Rod, pers. comm. 1992).

Monitoring Requirements:
Phragmites populations require close monitoring in order to determine whether they are increasing in area or not. Populations that are growing may quickly threaten or even eliminate rare elements. Monitoring provides the data needed in order to decide if control measures are necessary. If and when a control program is begun it is important to monitor targeted populations so that the program's effectiveness can be determined. If it is possible to leave untreated control areas without jeopardizing the success of the control program these should be monitored as well for comparison. It is imperative to continue monitoring even if a control program succeeds initially because Phragmites may reinvade and the sooner this is detected the easier it will be to combat.

To assess if a Phragmites colony is spreading, quantitative measurements should be made of percentage of aerial cover, stem density and culm height, especially at the periphery of the stand. Annual data should be compared to detect if the colony is expanding and the stand gaining vigor. Inventories of the vegetation in and near the colony should also be carried out in order to determine whether declines in species diversity are occurring.

In Europe, reed declines have been documented by comparing areas covered by Phragmites colonies on up-to-date maps or aerial photographs with older sources, monitoring permanent quadrats within or at the border of the reed belt and mapping the stubble fields left after die-back (Ostendorp 1989). In lakes (Stark and Dienst 1989), wooden poles 5 m apart were connected with string and the numbers of reed stalks directly below the strings were counted each year in the spring.

Monitoring Programs:
The programs listed below used various methods to control Phragmites populations and are monitoring the success of these actions including the degree of recovery of native species and the longevity of the control.

CONNECTICUT Monitoring Phragmites reduction and replacement vegetation after reintroducing tidal flow, using transects and line intercept. Contact: Charles T. Roman, William Niering, Scott Warren Dept of Botany Connecticut College New London, CT 06320

Monitoring Phragmites reaction to reintroduction of tidal flow and salinity. Contact: Tom Steinke Fairfield Conservation Commission, Independence Hall 725 Old Post Road Fairfield, CT 06430 203-256-3071

Addition of rock salt and casual observation of reduction of Phragmites height and density; also potential impact of inadvertent spill of used fryerlator oil. Contact: Robert Jontos, Jr. Land-Tech Consultants, Inc. Playhouse Corner Suite 205 Southbury, CT 06488 203-264-8300

Reintroduction of salt water into degraded former salt marshes, removal of dredge material and restoration of tidal creek in several sites in CT with transect and line intercept monitoring of results. Contact: Ron Rozsa Long Island Sound Program Department of Environmental Protection 165 Capitol Avenue Hartford, Ct 06106 203-566-7404

Annual cutting of perimeter of one-acre stand and monitoring with aerial photos on five-year basis; herbicide application on small patch at edge of salt marsh. Contact: Beth Lapin The Nature Conservancy 55 High Street Middletown, CT 06457 203-344-0716

DELAWARE Aerial spraying of RodeoTM (glyphosate) and water management plan using stoplogs and vegetation analyses (using transects that measure density and species of plants) of replacement species. Contact: Paul Daly Bombay Hook National Wildlife Refuge RD #1 Box 147 Smyrna, DE 19977 302-653-9345

Monitoring the ecological factors (water table level, PH, salinity) governing the growth of Phragmites in 4 habitats; 1) open high salt marsh, 2) open low salt marsh, 3) brackish water impoundment, 4) freshwater impoundment. Investigating Phragmites control with glyphosate. Contact: Wayne Lehman and Bill Jones Delaware Division of Fish and Wildlife P.O. Box 1401 Dover, DE 19903 302-653-2079

LOUISIANA See RESEARCH PROGRAMS section below.

MASSACHUSETTS Cutting three times in one season, followed by opening of tidal flood gate to restore natural water regime, with initial 1 m random quadrats to measure stem density and plant height Contact: Mike Wheelwright Department of Public Works Town of Quincy Quincy, MA 02169 617-773-1380 x210 Contact: Ross Dobberteen Lelito Environmental Consultants 2 Bourbon St. #102 Peabody, MA 01960 508-535-7861

Aerial spray of RodeoTM (glyphosate) two years in a row, with winter burning; aerial photos to determine decrease in affected boundaries. Contact: Joann Healey Parker National Wildlife Refuge Northern Blvd. Plum Island Newburyport, MA 01950 508-465-5753

Clear plastic over cut bands along edge of tidal pond and cutting around perimeter of 0.25 acre stand. Contact: Jeanne Anderson Massachusetts Audubon Society South Great Road Lincoln, MA 01773 617-259-9500

Plastic mulch experiments Contact: Edward Stashko Brookline Massachusetts Conservation Commission 617-730-2088

Restoration of saltmarshes now dominated by Phragmites Contact: Larry Oliver U.S. Army Corps of Engineers New England Division 424 Trapelo Road Waltham, MA 02254 617-647-8347

MARYLAND Nassawango Creek, A Nature Conservancy Preserve RodeoTM (glyphosate) applied with backpack sprayer. Monitoring site to determine both reaction of natural plant community and evidence of Phragmites re-invasion. Contact: Wayne Klockner The Nature Conservancy Chevy Chase Center Office Building 35 Wisconsin Circle, Suite 304 Chevy Chase Maryland 20815 301-656-8073

Spraying with RodeoTM (glyphosate), burning; monitoring vegetation and invertebrates, annual expansion of Phragmites in untreated areas. Contact: Steve Ailstock Environmental Center Anne Arundel Community College Arnold, MD

NEW JERSEY Aerial spraying with RodeoTM (glyphosate), prescribed burn to remove litter, evaluating success. Contact: David Beall Edwin B. Forsythe National Wildlife Refuge Brigantine Division PO Box 72, Great Creek RD Oceanville, NJ 08231 609-652-1665

Pulling rhizomes, chemical spray; visual monitoring of presence/absence, sense of height and density. Contact: Liz Johnson The Nature Conservancy 17 Fairmont Road Pottersville, NJ 07979 908-439-3007

NEW YORK Cutting (herbicide use would require a permit), using visual assessment for success. Contact: Kathy Schneider Department of Environmental Conservation 700 Troy-Schenectady Road Lathan, NY 12110-2400 518-783-3932

Cutting and covering with plastic (black and clear); dripping herbicide in cut stems with syringe at Constitution Marsh, New York. Contact: Chuck Keene Museum of Hudson Highlands The Boulevard P.O. Box 181 Cornwall-on-Hudson, NY 12520 914-534-7781 Contact: Jim Rod National Audubon Society RFD 2, Route 9D Garrison, NY 10524 914-265-2601

Open Marsh Water Management with GIS infrared aerial photos and black and white photos (1986 & 1990) to monitor success Contact: Dominick Niniviaggi New York DEC Building 40 SUNY Stony Brook, NY 11790-2356 516-751-7900 x379 516-751-2719

Using water level manipulation and burning and visual monitoring Contact: Bob Parris Wertheim NWR P.O. Box 21 Smith Road Shirley, NY 11967 516-286-0485

PENNSYLVANIA Tinicum National Environmental Center Chemical application, 18 acre restoration with seeding Contact: Dick Nugent Tinicum Environmental Center Scott Plaza 2 Philadelphia, PA 19113 215-521-0663

OHIO Arcola Creek Wetland, Morgan Marsh Controlling Phragmites by cutting when reserves are in the aerial portion of the plant (before nutrients are translocated into the rhizomes); using aerial photos to map extent of areas, small (1 x 1 m plots) to measure stem density. Contact: Terry Seidel The Nature Conservancy Ohio Field Office 1504 West 1st Ave. Columbus, Ohio 43212 614-486-6789

VIRGINIA RodeoTM (glyphosate) application and monitoring program, with transects (mainly used for changes in vegetation and not in Phragmites) and vegetation maps on "topo" scale. Contact: Irvin Ailes Chincoteague National Wildlife Refuge Chincoteague, VA 23336 804-336-6122

Winter burns, checking progress in summer with six 400 m transects perpendicular to the shore that measure % cover and list species in 0.1 m2 plots every ten meters; success marginal. Contact: Marilyn Ailes Public Works Office Building Q29 Aegis Combat System Center Wallops Island, VA 23337 804-824-2082

VI. RESEARCH

Management Research Programs:

LOUISIANA Aerial photographs of the Mississippi River Delta indicated that different stands of Phragmites had different infrared signatures. Isozyme analyses were performed on samples from these stands in order to determine whether they differed genetically and constituted different clones. Two distinct clones were found and both differed from stands elsewhere on the Gulf coast. Additional isozymal work is planned on populations from elsewhere on the Gulf coast and, if time allows, from populations in the eastern and Great Lakes states as well

For research on population biology and control methods refer to BIOLOGICAL MONITORING PROGRAMS section.

Research Needs (General):
What are the genetics of natural populations and how do stable and invasive populations differ?

Management Research Needs:
Research on the following facets of Phragmites invasions and basic biology are needed: 1. what types and levels of disturbance and stress induce Phragmites to invade and/or dominate an area?; 2. how effective are various control programs and what conditions promote or allow Phragmites to reinvade areas from which it has been removed?; 3. if Phragmites does reinvade how long does this process take?; 4. are there ways to alleviate or mitigate for the stresses that induce the spread of Phragmites?; 5. can the use of competitive plantings of TYPHA or other desirable species be used to control Phragmites.

VII. ADDITIONAL TOPICS

VIII. INFORMATION SOURCES

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IX. DOCUMENT PREPARATION & MAINTENANCE

Edition Date: 93-05-12

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