

Phragmites Control in Delaware: Practical Tips & Techniques

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Bill Jones has been involved in Phragmites control efforts for the state of Delaware since 1985.

The Delaware Department of Natural Resources and Environmental Control's Division of Fish and Wildlife (DFW) has been involved in *Phragmites* control since 1949. At that time, more traditional methods, such as mowing and burning the plant, were implemented. However, moving machinery through a wet, muddy environment was difficult and often resulted in unacceptable damage to the marsh. Moreover, the *Phragmites* would re-sprout the following spring or sooner, with no apparent semblance of control.

Hindsight has taught us that the key to controlling established stands of *Phragmites* involves the destruction of the rhizome (underground stem) and root system. The control methods practiced early on in Delaware had little effect on this part of the plant.

In 1976, the DFW began experimenting with glyphosate-based herbicides made by Monsanto. Glyphosate is the common name for N-(phosphonmethyl) glycine. It inhibits an enzyme critical to the formation of specific essential amino acids in plants. When properly applied to the leaves and stems of actively growing vegetation, the herbicide is absorbed into the plant's food-transport tissues (phloem) and translocated throughout the plant. This "systemic" action allows glyphosate to reach underground rhizomes and roots and eventually inhibit aerial stem production.

The DFW used the Roundup® formulation of glyphosate initially on an experimental basis. Roundup® is used for agricultural, industrial, and home-site vegetation control, but is not labeled for use in wetlands. The product Rodeo® was introduced in 1982 and can be applied to emergent weeds in all fresh and brackish water bodies. Rodeo® is different from Roundup® in that it does not contain a surfactant, and there is a greater percentage of glyphosate in its makeup.

Since the patent on Rodeo® has expired, there are several aquatic herbicides on the market that have the same composition (53.8% glyphosate, 46.2% other ingredients) and the same labeling. As of this writing, known products include Aqua Neat™, AquaPro™, Aqua Star™, Aquamaster™, Glypro®, and Eagre®. (Note: Use of brand, trade, or company names in this article is for information purposes and does not imply endorsement.)

How to Control Phragmites on Your Property

Non-Chemical Methods. *Phragmites'* rhizomes (underground stems) must be affected to have any success in controlling the plant. For small patches, or for landowners who do not want to use pesticides, repeated mowing or hand-cutting of the aerial stems will gradually deprive the rhizomes of photosynthate (food) and stress the colony.

University of Delaware scientists have observed that *Phragmites* has the ability to send up shoots for a year and a half even while kept in the dark. Thus, the re-sprouting shoots will need to be cut multiple times over probably at least two growing seasons. This is very labor-intensive and may not be practical over large areas or where travel is difficult.

For larger sites with water-control structures, such as impoundment sites, manipulating flooding and salinity may be helpful. UD scientists found that increasing either salinity or flooding (timing flooding so as to use the most saline water from the estuary) decreased plant height, biomass, stem density, and stored reserves in the rhizomes. If the plant stems were cut near the soil and then the stubble was flooded, all the plants died.

Chemical Methods. Landowners may find that careful use of glyphosate herbicides may be the most practical, economical, and effective control method for the situation. Keep in mind that glyphosate products are broad spectrum, which means the herbicide has the potential to injure or kill any green vegetation with which it comes in contact. Any seeds lying in the soil will not be affected. Once glyphosate comes in contact with the soil or water column, it has no herbicidal activity.

Timing is crucial when using glyphosate herbicides as they need to be applied when sugars are being actively translocated into the rhizomes.

University of Delaware scientists determined that late July to early August just after the plant flowers is the ideal time for herbicide application since the plant's underground reserves are at their lowest, and sugar flow is at a maximum. Our experience with both aerial and ground applications has shown acceptable control levels (>80%) when sprayed from the flowering stage until late October. As long as the plant has some green tissue, it seems to absorb the herbicide.

For ground applications, we generally use a 1½% solution of aquatic glyphosate (2 ounces per gallon of spray solution) along with LI-700® Surfactant (Loveland Industries) at a rate of ½% per total spray volume (0.64 ounces per gallon of spray). Although any non-ionic surfactant labeled for use with herbicides can be used, LI-700 is a lecithin-based product that has very favorable environmental fate characteristics.

The requirement to wait until *Phragmites* flowers to spray it presents challenges since the plant usually has attained its maximum height at this point, ranging from 8 to 14 feet. Any sprayer that can direct the spray stream into or over the canopy is suitable. I have heard of landowners standing on ladders to get above the plant to spray. The DFW has used backpack sprayers while standing on pickup trucks or tractors, tractor-mounted sprayers, and skid-mounted sprayers that fit in the bed of a pickup. Some landowners use sprayers that mount on ATVs.

Landowners may have to experiment with different nozzles to find one that can send a stream of spray as opposed to a fine mist. At least one-third of the stem should be covered on a spray-to-wet basis. If the spray is dripping off the plant, the solution is being wasted.

Landowners may want to hire a private contractor for the spraying. The Delaware Department of Agriculture's Pesticide Compliance Section maintains a list of aquatic certified pesticide applicators. Contact the department at (302) 698-4570 for more information.

Due to the difficulty of ground applications in wetland areas, the vast majority of *Phragmites* spraying by the DFW has been done using a helicopter. When spraying from the air, four pints of aquatic glyphosate are applied per acre at a total spray volume of five gallons/acre. Again, LI-700 surfactant is used at a rate of ½% per total spray volume (3.2 ounces per acre).

Ideally, the dead *Phragmites* stems should be burned off during late winter following herbicide applications on large acreages. Burning removes the shading effect from the stems and reduces the heavy litter to encourage more desirable plants. Physical removal of the stems by hand-cutting or mowing may be practical in small patches.

Landowners need to realize they are managing *Phragmites* rather than eradicating it in most situations. Multiple herbicide applications over several years may be needed to obtain a desirable control level, followed by "touch-ups." *Phragmites* that occurs in scattered patches provides some wildlife habitat and may provide some filtering benefits. Leaving *Phragmites* alone where it typically grows well, like the upper marsh, and keeping it from spreading through the interior marsh may be the best a landowner can hope for with this remarkable plant.

Cost-Share Program for Landowners. Since 1986, the DFW has offered a cost-sharing program for landowners who have five or more acres of *Phragmites* to treat. The program is not intended for developed areas in part due to the difficulty in treating around houses by helicopter. Combining state and federal funds has reduced landowner cost to approximately \$4 to \$5 per acre the last several years. Interested landowners can contact the DFW at (302) 739-9912.



David Barczak

Apply herbicidal controls right after the plant flowers.



Burning of Phragmites after herbicidal treatment.

Denise Seliskar



Sieven Billups

Denise Seliskar (author of this publication) and Jack Gallagher, marine botanists and co-directors of the University of Delaware's Halophyte Biotechnology Center, examine *Phragmites* in the greenhouse.

(Continued from page 4)

Phragmites makes an excellent model for a successful weed. It has an extensive system of rhizomes that lives through the winter, serving as a bud bank for new shoot growth in the spring.

These rhizomes extend down to a depth of more than 3 feet. From late summer through fall, *Phragmites* directs carbohydrates produced from photosynthesis downward to its rhizomes, where the food is stored for the plant's spring growth and the expansion of new rhizomes and stolons.

At UD's Halophyte Biotechnology Center, marine botanist Jack Gallagher determined that by autumn, *Phragmites* has stored enough fuel in its rhizomes that it can live in the dark, continually sending up new shoots for one-and-one-half years. Thus, this plant can sustain severe damage to its aboveground shoots and still have enough fuel reserved to put up new shoots, which explains why mowing or burning alone cannot control this species in the long term.

Phragmites' ability to tolerate high-salinity, coastal ocean water (containing 3% salt) also contributes to the plant's competitiveness along the coast. Even at

such high-salt concentrations, this resilient plant maintains the ability to fix carbon from the atmosphere and transport and store the resulting carbohydrates in its rhizomes below ground. Thus, while the plant's growth may be reduced, it is not stopped. This ability to tolerate and thrive in saline conditions allows *Phragmites* to compete with not only freshwater and brackish tidal marsh plants along the borders of mid- to upper estuaries, but also with true salt-marsh plants.



Phragmites' rhizomes (underground stems) are easily visible along this eroded creek bank.

Jack Gallagher

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Phragmites australis: A Closer Look at a Marsh Invader

by Denise M. Seliskar

P*hragmites australis*, or common reed, is a tall, perennial grass that is native to the United States and grows on every continent except Antarctica. The plant has been in North America for at least 11,000 years. In 1978, stem fragments of the plant, dating between 11,000 to 40,000 years old, were found in the fossilized fecal remains of the extinct Shasta ground sloth in a cave in the Grand Canyon.

In documenting the flora of the New World, early European naturalists described *Phragmites* as a minor wetland plant, usually confined to the upper elevations of the wetlands and along the edges of ditches and ponds. In 1910, there was one report of *Phragmites* being plentiful in swamps behind New Jersey salt marshes, but as recently as 1950, *Phragmites'* expansion was not considered a problem in saltwater environments in the United States.

Over the past six decades, however, there has been a rapid expansion of *Phragmites* into wetlands once dominated by other plants, including considerable spread into salt- and brackish-water tidal wetlands. In some areas, a monoculture of a salt-marsh plant with high ecological value, such as smooth cordgrass (*Spartina alterniflora*), is invaded. At other locations, a diverse community of brackish to freshwater plants is overtaken by *Phragmites*. Such a widespread invasion is detrimental to wetland values because it disrupts the natural hydrology (distribution and movement of water) and plant architecture of the marsh, thereby affecting the marsh's function.

Today, *Phragmites* is considered an invasive species because of its rapid expansion and the problems it causes. The U.S. Department of Agriculture's Natural Resources Conservation Service defines invasive plants as "introduced species that can thrive in areas beyond their natural range of dispersal. These plants are characteristically adaptable, aggressive, have a high reproductive capacity, and their vigor combined with a lack of natural enemies often leads to outbreak populations."

About the Author



Denise M. Seliskar is a research scientist at the University of Delaware's College of Marine and Earth Studies, where she also co-directs UD's Halophyte Biotechnology Center. She has been studying the physiology and ecology of wetland and sand dune plants for more than 30 years.



Bob Bowden

A stand of *Phragmites*, its fringed tassels aglow in the sun, borders a Delaware tidal creek.

Why Has Phragmites Become So Invasive?

The reasons for *Phragmites'* expansion in recent decades are not well understood. In some cases, the plant's invasion can be correlated with changes or disturbance in the environment, such as a drop in salinity and an increase in soil aeration where water flow in an estuary has been reduced, or where tidal flooding has been restricted due to highway construction.

Nutrient enrichment of rivers and estuaries may also encourage the plant's colonization. Due to its physiology, *Phragmites* can benefit more from higher nitrogen availability than other common salt-marsh grasses, such as *Spartina* and *Distichlis*. Yet many invasive situations are unexplained by environmental factors, and there is accumulating evidence that the expansion may be of a non-native genotype or strain of the species.

In 2002, Kristin Saltonstall, a scientist at Yale University, analyzed numerous populations of *Phragmites* including herbarium specimens from the early 20th century. Her research showed that a distinct strain — "Haplotype M" — appears to be the invasive form. It is thought to have been introduced to North America from Europe.



This bulletin was published by the Delaware Sea Grant College Program and the Delaware Department of Natural Resources and Environmental Control (DNREC), with assistance from the University of Delaware Office of Public Relations, Research Communications Initiative. Tracey Bryant, editor; David Barczak, art director; and Pamela Donnelly, production coordinator.

Delaware Sea Grant is a member of a national network of universities committed to research, education, and technology transfer designed to meet the changing needs of our ocean, coastal, and Great Lakes regions. The program is funded by the National Oceanic and Atmospheric Administration in the U.S. Dept. of Commerce; the State of Delaware; and the University of Delaware. For more information, contact the UD Marine Public Education Office at (302) 831-8083 or MarineCom@udel.edu. For other Delaware Sea Grant publications, visit www.ocean.udel.edu/seagrant.

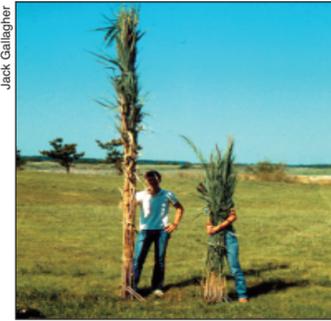
Meeting the Science Education Standards

This publication provides facts about *Phragmites australis* that support the fundamental concepts and principles of the National Science Education Standards, as well as the Delaware State Science Standards. It can be used to foster such activities as classroom discussions about invasive species, student reports, laboratory and field investigations, and other educational projects.

For example, the techniques developed to control invasive *Phragmites* and to adapt the plant for beneficial uses support several content standards including "Science and Technology," "Physical Science," "Life Science," and "Science in Personal and Social Perspectives." The discussion of *Phragmites'* historical uses around the world and the plight of the Marsh Arabs support the "History and Nature of Science" standard.

For the Delaware State Science Standards, this publication contains concepts and principles that meet the "Nature and Application of Science and Technology," "Energy and Its Effects," "Earth's Dynamic Systems," "Life Processes," "Diversity and Continuity of Living Things," and "Ecology" standards. Social Studies standards, including Civics, Geography, and History, also are addressed and provide an interdisciplinary approach to this extraordinary plant.

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These *Phragmites* plants were collected from a low-salinity marsh along Delaware Bay (left), and from a high-salinity site on Indian River Bay, Delaware (right).

The term “haplotype” refers to the genetic makeup of DNA in the chloroplast, the chlorophyll-containing organelle in the plant cell. There are three lineages of *Phragmites australis* currently recognized in North America: the native (Haplotypes A – H, S, Z, AA), the Gulf Coast (Haplotype I), and the introduced (Haplotype M).

Regardless of the origin of the invasive form, substantial efforts have been made to control and reverse the spread of *Phragmites*. Unfortunately, these control efforts often have been undertaken without knowledge of the potential harm to native, non-invasive populations of the plant.

According to Robert Meadows, an environmental scientist at the Delaware Department of Natural Resources and Environmental Control, the non-invasive *Phragmites* may be less likely to reestablish in an area where it was inadvertently removed through herbicidal spraying, leaving the area more likely to be colonized by the invasive form of the plant.

Why Are We So Worried about Invasive *Phragmites*?

Salt marshes are nursery and feeding grounds for many species of fish, birds, and other animals we value. However, as noted earlier, when *Phragmites* invades a marsh, it changes the way the marsh functions by modifying its hydrology and canopy architecture. For example, a natural salt marsh dominated by species such as smooth cordgrass (*Spartina alterniflora*), which ranges from 1 to 4 feet tall in Delaware, and other species, such as *Distichlis spicata* and *Iva frutescens* in the higher-elevation areas, can be

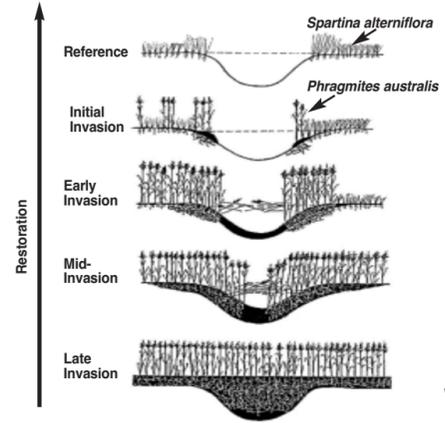
converted to a dense monoculture of *Phragmites* (6 to 14 feet tall).

As *Phragmites* moves into a marsh, a dense rhizome (underground stem) network grows and a large volume of plant litter accumulates, transforming a salt marsh once dissected with numerous tidal creeks carrying flood and ebb waters into a much drier marsh with few tidal creeks, no open pools, and less frequent tidal inundation.

The filling of the tidal creeks reduces access by fish to large areas of the marsh — areas important for feeding and reproduction. Even the arthropod communities in the marsh change significantly upon *Phragmites*’ invasion. For example, plant leafhopper and marsh spider populations decrease.

From the aboveground plant architecture alone, one can see how the marsh’s usage by birds and other animals would be affected. The creek-bank habitat for large wading birds is decreased, as is the resting and feeding area for migratory waterfowl.

Fortunately, however, the process can be reversed. Marine scientist Kenneth W. Able and his colleagues at Rutgers University have shown that fish usage is restored to a marsh when *Phragmites* is removed and *Spartina* is allowed to re-vegetate the marsh surface. Natural arthropod communities return in time, as well. Likewise, usage of the salt marsh by bird species typical of that habitat eventually is restored.



Phragmites’ invasion causes changes in the marsh-surface topography and elevation, making creeks and the marsh surface less accessible to fish. Restoration of the marsh can re-establish this important function. The black area depicts the filling of an intertidal creek due to the accumulation of leaf and stem litter and the rhizome mat. The dotted line indicates water level at mid-high tide. Figure reprinted with permission of The Estuarine Research Federation and Dr. Ken Able, Rutgers University.

Phragmites: Lessons in Botany & Ecology

The vigorous wetland plant *Phragmites australis*, or “common reed,” has an interesting anatomy. Take a look at the plant’s major parts, and then learn how some of these features give invasive *Phragmites* a competitive edge.

Anther — the bi-lobed structure that bears the pollen and sits atop the slender filament; the anther and filament make up the stamen (the male reproductive structure)

Culm — the grass stem

Floret — small flower or reproductive unit of a grass spikelet

Inflorescence — a cluster of flowers having a common axis

Node — region of a stem, rhizome, or stolon from which leaves, buds, or roots grow

Panicle — a branched grass inflorescence (flower cluster) with stalked spikelets

Peduncle — uppermost portion of the stem that holds the inflorescence (flower cluster)

Rachilla — central axis of a spikelet bearing the florets

Rhizome — horizontal underground stem that can produce roots and/or shoots at the nodes, thus allowing the plant to reproduce vegetatively

Spikelet — a flowering unit containing one or more florets

Stigma — that portion of a pistil (female reproductive structure) that serves as a surface on which pollen germinates

Stolon — horizontal aboveground stem that can produce roots and/or shoots at the nodes, thus allowing the plant to reproduce vegetatively

Taxonomy

Kingdom: Plantae (plants)

Subkingdom: Tracheobionta (vascular plants)

Superdivision: Spermatophyta (seed plants)

Division/Phylum: Magnoliophyta (flowering plants)

Class: Liliopsida (monocotyledons — one embryonic leaf within the seed)

Order: Cyperales

Family: Poaceae (grass family)

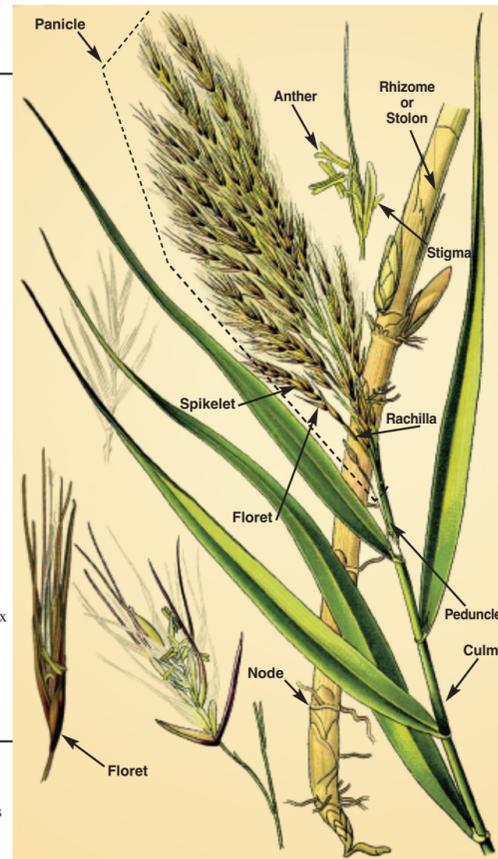
Genus: *Phragmites* (reed)

Species: *Phragmites australis* (Cav.) Trin. ex Steud. (common reed)

◆ Native lineage

◆ Gulf Coast lineage

◆ Introduced lineage



Adapted from Flora von Deutschland, Österreich und der Schweiz, 1885

What makes the exotic *Phragmites* more invasive than the native form?

University of Delaware research indicates the following: (1) the exotic emerges significantly earlier in spring than the native, giving the exotic a longer growing season; (2) the ratio of above- to below-ground biomass (weight) is much higher in the taller exotic, indicating a more efficient root/rhizome system or higher-quality reserves; (3) the rhizomes of the exotic *Phragmites* have longer spaces between the nodes, which may enable faster expansion of the exotic population; (4) while native *Phragmites* has more buds per rhizome than the exotic form, the native buds remain dormant longer, resulting in the production of fewer shoots per rhizome when the canopy is damaged; (5) leaf pigment concentration is greater in the exotic, allowing it to capture more of the sun’s energy; and (6) the roots of the exotic exude more of a substance (gallic acid) that is toxic to other plants than do roots of the native *Phragmites*.

How do roots in saturated soils get enough oxygen? Although *Phragmites* can tolerate a wide range of environments, the plant is typically found in wet, mucky areas. *Phragmites* can live in saturated soils thanks to a specialized network of air spaces and channels that run from the leaf sheaths to the stems, then down through the stems into the rhizomes, and out into the roots. One interesting means of aeration in *Phragmites*, described by researchers Jean and William Armstrong at the University of Hull, is “venturi-induced convection.” Gas flows via this mechanism when wind blows across the broken-off tops of tall, dead stems of *Phragmites*. This creates a vacuum, which pulls gases through these taller stems from the rhizome system connected to shorter, less wind-exposed, dead, broken stems nearby. Thus, a gradient of flow from short, broken stems through the rhizome system to the tall, dead stems is operating and keeping the below-ground parts of the plant oxygenated even when the soils are hypoxic, that is, contain little oxygen.



Native *Phragmites* (left) changes color earlier in the fall than the exotic form (right). In summer, the native *Phragmites* has a lighter, somewhat yellow-green leaf color compared to the gray-green of the exotic.

How Does *Phragmites* Become Established in a Marsh?

Phragmites becomes established in a marsh in one of three ways. First, seeds can germinate when they land in bare or sparsely vegetated areas with appropriate soil conditions. In a mature marsh, vegetative reproduction is the dominant means of shoot production, and seedlings are seldom found. However, in a restored marsh where *Phragmites* has been cleared or in a newly created marsh where no vegetation is present, seedling colonization is a very important means of plant establishment.

One factor determining whether *Phragmites* seedlings or those of desirable plant species will be the ones to colonize the marsh is the amount of sulfide, a sulfur compound, in the soil. The sulfide content depends on two factors. The first is the amount of sulfate in the water that floods the marsh. Since seawater is a natural source of sulfate, the greater the proportion of seawater in the flooding waters, the greater the amount of sulfate. Thus, marshes farther from the mouth of the estuary will contain less sulfate available to be converted to sulfide.

The second factor is the oxygen level in the soil. The less oxygen, the greater is the chemical reduction of sulfate to sulfide. Sulfide levels in soils of natural *Spartina alterniflora* salt marshes along the Atlantic coast range from 0 to 7 millimolar (mM). Sulfide at even low levels is toxic to most plants that have not evolved in soil containing this naturally occurring chemical compound. And plants that are tolerant to high sulfide levels when mature, such as *Spartina* and *Phragmites*, are not nearly so tolerant when they are seedlings.

Our research at the University of Delaware Halophyte Biotechnology Center determined the sensitivity of seedlings of five marsh species that might be expected to colonize Mid-Atlantic bare salt- or brackish-marsh surfaces. Only *Spartina alterniflora* seedlings could withstand higher levels of sulfide than *Phragmites*. *Phragmites* seedlings tolerated up to 0.9 mM, but at levels of 0.9 to 1.6 mM, *Spartina alterniflora* seedlings had the decided advantage. Therefore, *Phragmites* seedlings would be able to colonize the less salty, brackish marshes; however, they probably could not live in the more saline marshes at the mouth of the estuary due to the higher soil sulfide content.



Phragmites can extend stolons (runners) up to 30 feet or more and then send up shoots when it reaches advantageous soil conditions.

The second and most common means of *Phragmites*’ establishment in a tidal marsh is by stolons or “runners” (stems that grow along the surface), or by rhizomes (stems that grow underground) from the upland fringe.

Phragmites typically grows along the upper edge of the marsh, and from here it can send stolons of 30 feet or more over the surface and into the interior of the marsh where the plant can root and put out shoots. By maintaining a connection with the mother plant in the higher elevation, it is able to establish itself in the interior of the marsh where soil conditions are not optimal. The mother plant can provide the daughter plants with oxygen and nutrients until they develop large enough structures to provide oxygen and food to below-ground parts on their own. This process is called “clonal integration.” In this way, the plant gets around the problems faced by seedlings, such as high sulfide and low oxygen in the soil.

In our research here at UD, we found that “living fences” consisting of multi-layered walls of *Baccharis halimifolia*, *Iva frutescens*, *Juncus roemerianus*, and *Spartina patens* planted at key invasion points along the upper marsh edge were effective in restricting *Phragmites*’ spread.

The third and probably least common way that *Phragmites* establishes itself in new territory is from vegetative fragments, such as pieces of stems, stolons, or rhizomes, that somehow break free and lodge in somewhat elevated hummocks or mounds in the marsh where the soil is better aerated. However, in order for these fragments to successfully root, they need to be relatively large and buried in well-drained, low-salinity sites. Thus, construction, dredging, and other activities that disturb the soil may provide an opportunity for *Phragmites* to gain a foothold in new areas.

(Continued on back page)

Beneficial Uses of *Phragmites*



Phragmites is used to thatch houses in Great Britain.

Since *Phragmites* is widely distributed around the world, it is not surprising that humans have found many uses for this tall, robust, hollow-stemmed grass. A story is told in China of how *Phragmites* rhizomes (underground stems) were harvested from the riverbanks around a city and used as food, enabling the citizens to survive a winter siege in a war with a neighboring province. The young stems can be eaten raw or cooked until tender. Older stems can be harvested, dried, and beaten to dislodge the largely carbohydrate “flour.” Stalks that are wounded exude a gum that can be eaten raw or toasted when hardened. Gruel can be prepared from reed seeds.

The archaeological record substantiates the usefulness of *Phragmites* to Native Americans for light arrow shafts to hunt birds and for tobacco holders and woven mats. The hollow stems, or reeds, are used to make toys and jewelry. They also are used to build boats in Peru and houses in Iraq (see below). In Great Britain, the reeds are of economic importance for thatching roofs. In eastern Europe, *Phragmites* is used as pulp in paper making.

A modern use, developed in Germany, for living *Phragmites* plants is in wastewater treatment, where they speed up the drying of treated biosolids. Scientists at the University of Delaware’s Halophyte Biotechnology Center have developed a variegated (green-and-white striped) strain of *Phragmites* that has great potential as a “sludge buster” for two reasons. First, since it does not produce viable seedlings, the plant cannot be spread by the wind. Second, if plant stems or rhizome pieces somehow escape from a wastewater treatment facility, the strain could be easily recognized by its “stripes,” and the wastewater facility could be held accountable. Tissue-culture methods for the mass propagation of this variant currently are under development.



The variegated strain of *Phragmites* developed at the University of Delaware (left) is planted in the drying beds at the wastewater treatment plant in Bridgeville, Delaware (right).

Can Mesopotamian Marshes Be Restored?

Along the North and Mid-Atlantic coast of the United States, marshes dominated by invasive *Phragmites* are considered to be ecologically unhealthy and less functional than marshes occupied by the grass it replaced. But in the Middle East, particularly in Iraq where the Tigris and Euphrates rivers meet, *Phragmites* marshes had been home to a people known as the Marsh Arabs for 5,000 years.

Their culture thrived in this region of Mesopotamia known as the “Garden of Eden,” where wetlands once covered some 7,000 square miles. They lived in houses made of *Phragmites* in the lowlands along the marsh edges and on manmade islands built from the plant. They lived as a component of the marsh ecosystem — fishing, farming, raising water buffalo, and weaving.

Since the 1960s, more than 30 dams have been built on the two rivers, diverting water from the wetlands. Then in the 1990s, the wetlands were dealt a lethal blow when Saddam Hussein, angry at the Marsh Arabs for their uprising against him, diverted vast quantities of water from the rivers and conducted large marsh drainage projects. This resulted in the desertification of more than 90% of the wetlands in this once-rich and fertile region and displaced the Marsh Arabs from their homes.

Efforts to restore Iraq’s *Phragmites* marshes are now under way. According to Curtis Richardson, a Duke University professor involved with the work, 20% of the original marsh area had been reflooded by 2004, and the *Phragmites* growing along the branches of the Tigris and Euphrates rivers which feed water into the marshes, is providing propagules (seeds and/or pieces of shoots or rhizomes) to revegetate the reflooded areas. Richardson believes that although problems of high salinity exist and need to be addressed, the potential for successfully restoring this Mesopotamian region is high.



Marsh Arabs collect *Phragmites* in a mashuf (Arab canoe) in the remaining Al Hawizeh natural marsh on the Iranian border in June 2003.