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Adaptive Strategies of Common Reed (*Phragmites australis*)

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Phragmites australis, common reed, is a highly invasive, native, 2-4 meter tall, coarse perennial grass found world wide in moist soil habitats especially those of tidal and nontidal wetlands. The aggressive nature of *Phragmites* is directly attributable to a combination of morphological features that is unique among herbaceous hydrophytes. *Phragmites* produces abundant, small, wind dispersed, viable seeds which makes it an outstanding colonizing species of disturbed wetland soils. Rhizomes and stolons provide a secondary source of propagules and allow the plant to rapidly spread to occupy preferred microhabitats. Abundant aerenchyma and high stomatal densities that can exceed 400/mm^2 on the abaxial leaf surface and 600/mm^2 on the adaxial surface provide an efficient system for the exchange of both carbon dioxide and water vapor. The resulting photosynthetic efficiency and high transpiration rates made possible by such high stomatal densities and abundant aerenchyma result in rapid growth and the ability to modify marginal habitats by providing oxygen to the rhizosphere and altering ambient soil moisture in ways that favor the expansion of *Phragmites*. Mechanical strength of living stems is the mechanism by which *Phragmites* attains its great height in high energy aquatic environments, where it serves as the dominant climax species. Mechanical strength of the living stems and persistence of dead stems are also responsible for the high stem densities that cause shading of understory plants, thereby reducing competition by other plant species. Finally, the tendency of dead stems to break at the 3rd-5th node produces a dense litter layer that is elevated above the wetland soil surface. The absence of soil contact slows decay and results in the formation of a dense thatch that effectively eliminates light penetration to other plant seeds residing in the soil. Thus, once established, *Phragmites* creates an environment that sharply limits competition by other plants. Taken collectively, these attributes make *Phragmites* a highly competitive species in wetlands systems and are responsible for its designation as a highly invasive wetland species. These same features also form the basis for particular management strategies designed to limit its spread and reduce the size of existing populations.

A History of *Phragmites australis* During the Last Few Millennia

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A lot has been written lately about the spread of *Phragmites australis* (common reed) into many coastal habitats. Although its spread has been well documented, there are still many questions that need to be answered. For instance, what is causing the spread of this plant? This very basic question has not been answered and is one that will be paramount to our understanding and control of this species. At present there are a number of possibilities that have been suggested for the recent surge of this plant throughout the landscape including the introduction of a new strain, a genetic shift in native populations (i.e., shift to or from a tetraploid), nutrient enrichment and an increase in soil disturbance associated with development of the coast this past century. First, it is important to realize that *Phragmites* is a native plant species, one that has been found along the upper border of tidal marshes for thousands of years. Although it is a native plant, there is the possibility that other strains have been transported to this country from other continents and they are now imposing themselves on the native variety. Some recent work out of Pennsylvania has made this very argument, although many of the factors used in that study to assess the spread of *Phragmites* (i.e., glume size) exhibit a lot of natural variation and are not very accurate to say for sure whether we have new genetic strain invading our coastal systems. There is a more intense genetic investigation currently being conducted by K. Saltonstall out of Yale, but that project is not yet completed. Early results from that study tend to suggest that, at least on a regional scale, there are no real changes in the *Phragmites* that could account for its change in colonization patterns. We must, therefore, begin to look elsewhere for explanations as to why *Phragmites* is spreading at the rate we see today.

Nutrient enrichment (i.e., the input of fertilizers) into our coastal zone is certainly a factor that must be considered in the spread of *Phragmites* and is one that will be very difficult to assess. There have been many studies that have shown that nitrogen and phosphorus levels in the soils can have a significant impact on plant community structure in old fields, inland wetlands and forests. How this relates to coastal marshes is still yet to be determined. We also know that *Phragmites* often invades soils that have been disturbed and that soil disturbances reached an all-time high during the last century with the advent of the gas engine. Therefore, it is reasonable to assume that at least some of the spread of *Phragmites* is due to a combination of factors.

There may be other influences that can provide an understanding in the colonization of common reed. My paleoecological investigations during the last twenty years have begun to yield a picture of change imposed on these coastal marsh systems. The rate of change in the structure of plant community in coastal marshes throughout the region has increased significantly during the last few centuries. For over three thousand years prior to European settlement, the salt marshes exhibited major changes in the vegetation on an average of about 1 to 1 1/2 times per half century (half meter of peat). However, during the last three centuries, this average has doubled to over 3 changes per half meter of peat. Although the implications of such a change are numerous, it can be condensed down to one simple fact; the coastal marshes of today are significantly less stable then they have been during anytime over the last three to four thousand years. This instability in the plant community would then translate well to a species that favors disturbed habitats such as *Phragmites australis*. The combinations, therefore, of disturbed soils, increased nutrient loading and a less stable coastal environment are probably all contributing to the recent expansion of *Phragmites*. If a new genetic strain is imposed on this stressed system, then it is easy to see how this plant can appear to be taking over many habitats. However, even if it is not a genetic shift, it is still possible to see how the expansion of reed can come about in highly disturbed, unstable environments.

Managing *Phragmites* will be a challenge. If it turns out that instability of the natural environment and disturbance to these systems are responsible for the expansion of reed, then our control efforts will have to be tempered as to where and when we will manage these plants. Whatever the cause, failure to understand the factors responsible for the expansion of reed may mean that our management efforts will have little or no overall impact on our ability to control this species into the future.

Functional Roles of *Phragmites australis* in Tidal Freshwater Marsh Communities

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Nutrient flux, sedimentation, and plant community structure and species diversity within three paired *Phragmites australis* (Cav.) Trin. ex Steud. and *Spartina cynosuroides* (L.) Roth wetland plant communities were compared to investigate the effect of *P. australis* invasion on tidal freshwater marsh processes at Sweet Hall Marsh, Virginia. Nutrient flux (PO_4^{-3}, NH_4^{+}, NO_3^{-}+NO_2^{-}, DIN) was measured 3 times during the growing season using a benthic chamber method. Net annual inorganic mass flux and accretion rates were measured using depth of peak ^{137}Cs deposition. Vascular plant species richness, species diversity, species evenness, and community structure were investigated using ground cover, stem density, and frequency of occurrence measurements taken three times during the growing season. The invasive *P. australis* communities exhibited lower PO_4^{-3} release to tidal waters late in the growing season (-3.9 mmol m^{-2} h^{-1} and 28.3 mmol m^{-2} h^{-1} respectively), lower NO_3^{-}+NO_2^{-} uptake from tidal waters throughout the growing season (-58 mmol m^{-2} h^{-1} and -159.9 mmol m^{-2} h^{-1} respectively), and slightly higher values of species richness (14.3 and 11.7 respectively) and diversity (1.937 and 1.683 respectively) mid-season than the native *S. cynosuroides* communities. No differences in inorganic mass flux or accretion rates between the two communities were detected. Results indicate that predicting the effect of changes in species composition on community, and potentially ecosystem processes, is dependent on the species' role in the system and the type of process. In addition, invasive *P. australis* communities do not appear to be devoid of water quality (nutrient/sediment buffering) or habitat (richness/diversity) value compared to native communities in this marsh. Recognition of this potential ecological value in other ecosystems should be incorporated into the resource management decision-making process.

Distribution and Abundance of *Phragmites* in Estuarine Wetlands in Virginia's Portion of the Chesapeake Bay

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Phragmites australis or common reed is invading coastal marshes in the Chesapeake Bay, displacing valuable wetland plants. *Phragmites* is a wetland plant that can form large monotypic stands, eventually replacing natural marsh plants. While *Phragmites* stabilizes eroding shorelines, it has little food value for wildlife and reduces plant and animal diversity in coastal marshes. To fulfill a task of the Chesapeake Bay Waterfowl Management Plan regarding invasive plants, the U.S. Fish and Wildlife Service completed an aerial survey of the Bay's tidal marshes to determine the distribution and abundance of *Phragmites*. Eleven days of surveys were flown in Maryland and Virginia from 1995 to 1997.

The aircraft flew along most shorelines of the Bay and observers estimated the acreage of *Phragmites*. A Global Positioning System was used to determine the position of the aircraft at each sighting. A sighting may have been a single patch or many patches over a broad area depending on the area of marsh, the extent of *Phragmites* coverage, or the time the observer had to estimate the area.

The survey was designed to look more at the distribution of *Phragmites* than to provide estimates of acreage. We estimate that 80 to 90 percent of the *Phragmites* along the coast was identified. Some surveys were conducted in winter during waterfowl surveys; thus, it is possible that similar appearing species such as big cordgrass (*Spartina cynosuroides)* or wild rice (*Zizania aquatica)* were counted, or that *Phragmites* was not counted because of mis-identification from the air. Areal extent of *Phragmites* stands were estimated by the observer and the largest areas were verified – when possible – from aerial photographs taken during the survey and the USGS Digital Orthographic Quarter Quadrangles in a GIS. We attempted to verify all areas estimated to be above 5 acres, but less than half of the *Phragmites* patches could be on the photography. Nevertheless, the database is a good indicator of the distribution of *Phragmites* and the relative extent of marshes that have been invaded. This data can be used as a baseline to monitor the spread of this invasive plant and to target control efforts.

We found over 1,700 acres of *Phragmites* in over 1,500 sightings in Virginia's wetlands along the Chesapeake Bay. By contrast, this survey found approximately 8,500 acres of *Phragmites* in 4,138 sightings in Maryland's wetlands along the Chesapeake Bay. The largest patches of *Phragmites* were located in or near dredge spoil areas, and highly disturbed marshes. The area with the greatest extent of *Phragmites* in natural marshes was the upper Eastern Shore south of the Pocomoke River and on the lower James River. Other areas with extensive coverages of *Phragmites* include the marshes near Tappahannock and on the lower Pamunkey River. The areas with the least amount of *Phragmites* in its marshes were the lower Eastern Shore and the Western Shore marshes along the Bay.

The Impact of *Phragmites* on Rare Species and Natural Communities

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Although *Phragmites australis* is reported to be in decline in other regions of the world, it is nonetheless acting as an invasive species in Virginia and in other states across the country. From Washington in the northwest to South Carolina in the east, ecologists in many states are concerned with the impact of this plant on rare species and natural communities. On the west coast, this species is expanding into the estuarine habitat of Puget Sound where it is competing with the native grass, *Dechasmpsia cespitosa*. In areas south and east of the Great Lakes, including Ohio, Indiana, Kentucky and New York, *P. australis* is becoming established in rare fens and other wetland communities where it may significantly reduce the local biodiversity including fringed orchid (*Platanathera blephariglottis*), bog turtle (*Clemmys muhlenbergii*), and Mitchell's Satyr (*Neonympha mitchellii*). On the Atlantic coast, *P. australis* is believed to be impacting several types of plant communities including freshwater lunar-tidal marshes, oligohaline lunar-tidal marshes, oligohaline wind-tidal marshes, and sea-level fens. Each of these community types also supports species that are either globally or state rare. In Virginia these species include, but are not limited to, sensitive joint-vetch (*Aeschynomene virginica*), Carolina lilaeopsis (*Lilaeopsis carolinensis*), winged seedbox (*Ludwigia alata*), and the rare skipper (*Problema bulenta*). In all, an informal survey of Heritage biologists across North America generated a list of 69 state-rare species and 9 natural community types being impacted by *P. australis*.

Landscape Level Land-Use Changes and *Phragmites australis* on the Northwest River Watershed, 1937-1995

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Over the past several decades, populations of common reed (*Phragmites australis)* have increased dramatically in brackish and freshwater wetlands of the East Coast. These new populations tend to colonize with the highest success on disturbed areas, such as dredging spoils or constructed wetland areas. Population expansion also occurs, however, in areas with little or no visible recent anthropogenic disturbance. In these areas, a clear cause-and-effect relationship is difficult to discern. Due to the inaccessible nature of many of these wetland *Phragmites*-dominated sites and the difficulties associated with ground mapping, analysis of remote imagery can be a viable option for inventory and monitoring.

The 2257-acre Northwest River Natural Area Preserve is located in southeast Virginia in the City of Chesapeake (formerly Norfolk County), and is owned by the Virginia Department of Conservation and Recreation and managed by the Division of Natural Heritage. The Preserve is managed for the protection of rare plant and animal species and natural communities. Other protected lands along the river corridor are owned by The Nature Conservancy and the City of Chesapeake. Land use activities within the 71,000 acre Northwest River watershed have changed drastically in the last 50-60 years. This investigation analyzed land-use activities in four categories (agriculture, residential, industrial, and intensive forest management) from 1994/1995 color infrared digital orthophotoquads (DOQ's). The area of land in each category was then compared to similar categories derived from scanned and geo-referenced 1930's era black and white aerial photographs. The extent of *Phragmites australis* occupation on the Natural Area Preserve was derived in 1999 by manual aerial photo interpretation, and field-verified in early 2000. Although the *Phragmites* patches are difficult to quantify from the early black and white photographs, there appears to be a considerable increase in population size during the last 5 or 6 decades, along with significant changes in land-use activity. Possible but as of yet untested hypotheses for this shift in plant community composition include water chemistry changes from increased non-point source pollution, salinity fluctuations, or hydroperiod variation due to increased groundwater withdrawals.

Phragmites australis Invasion of Constructed Wetlands and Mechanisms to Prevent Recolonization

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Are we mortgaging our wetlands future? The use of constructed wetlands to replace natural wetlands impacted by development has become widespread. Mitigation banking, in lieu fee programs, and compensatory mitigation are all policies being employed in an attempt to allow continued expansion and development while maintaining a wetland resource. Yet, the oldest constructed wetlands are only a few decades old. Can we replace a few-thousand year old wetland with a new one and expect it to function at the same level as the natural system? What if these wetlands are colonized by undesirable plant species after a couple of decades? Constructed wetlands are susceptible to invasion by *Phragmites australis* due to both the plant's ability to colonize disturbed soil and its rapid growth. If wetlands are being constructed to replace a specific type of wetland and after a few decades these wetlands are overrun and dominated by *Phragmites*, the function and value of the system could be compromised. Some methods can be used to minimize *Phragmites* colonization of constructed wetlands. Perimeter ditches, attention to site elevation, dense sprigging, and the use of scrubs and shrubs at the upper elevations can be effective in controlling *Phragmites* in newly constructed wetlands sites.

Application Techniques, Methods, and Chemical Treatments for Effective Control of *Phragmites* – An Operational Perspective

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While the rapid invasion of *Phragmites* can drastically reduce the ecological value of our precious marshlands, safe products and precise applications offer readily available control options for the resource manager, the government agency, and the private landowner.

Ensuring our federally registered and labeled herbicides are applied properly is essential to restoring the health of these critical areas. Thanks to the availability of safe herbicides, Global Positioning Systems, and experienced applicators, resource managers can depend on practical and economical treatment solutions. Application methods, timing, product and rate selection, proper equipment, costs, and *steadfast patience* are all important considerations when designing a treatment program.

Whether treatment areas are big or small, safe applications of Rodeo can be made by either backpack or helicopter. For the smaller jobs, the herbicide, the surfactant and the backpack are readily available through your local distributor. *Hand applications can be made on private lands by private individuals.*

Operationally, the success of an aerial treatment program is largely driven by cooperation from the landowner(s). From the applicator to the landowner, there are many shared responsibilities in making these beneficial programs become a reality. Legible maps, helicopter routing, the designation of safe heliports, and landowner notification are just a few of the necessary logistical duties needed to aid in the efficiency of the operation.

For the willing landowner, numerous resources are currently available and in place to tackle the aggressive invasion of *Phragmites*. It is a battle which can be won.

Challenges and Opportunities for Developing Biological Control of *Phragmites australis* in North America Using Native or Introduced Insects

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Phragmites australis (common reed) populations in North America have dramatically increased in both freshwater and brackish wetlands, particularly along the Atlantic Coast. This invasion has changed basic ecosystem processes and resulted in replacement of mixed wetland plant communities by monotypic *Phragmites* stands. Dense *Phragmites* stands decrease native biodiversity and quality of wetland habitat, particularly for migrating waterfowl species. Recommendations for *Phragmites* control include the use of herbicides, mowing, disking, dredging, flooding, draining, burning, and grazing. The most widespread and successful approach appears to be the application of glyphosate late in the growing season, followed by prescribed burning or mechanical removal of dead stalks. Costs of chemical control with glyphosate are approx. $60-100/acre, however, re-treatments are usually necessary every 3-5 years and negative side-effects of non-selective herbicides and other control measures on non-target species are inevitable if used over large areas. At present, there is no long-term species-specific control measure and increased interest in developing biological control of common reed.

Classical biological weed control is the introduction of host specific natural enemies (herbivores, usually insects, less often pathogens) from the native range of an introduced plant. In the case of *Phragmites* the status of the species as native or introduced remains unresolved. An abundance of specific species exists outside North America that could have potential as biocontrol agents. Many of these species have been studied extensively in Europe where they are considered pests of reed beds. A number of these European insects have recently been introduced accidentally to North America providing opportunities to assess their potential for biological control. These include rhizome and stem feeding moths, shoot flies, aphids, mealybugs, and stem boring wasps that complement a few native species that are known to attack *P. australis*. Based on currently available evidence, none of the species feeding on *P. australis* in North America has potential to control common reed, however, we lack quantitative evidence for their impact and additional work using experimental studies is urgently needed. Many of the treatments used to control common reed have negative impacts on the associated insect fauna, potentially limiting their effectiveness in curbing the spread of their host plant.

Additional work in Europe has identified a number of promising potential biocontrol agents attacking rhizomes and stems of *Phragmites* and a current research focus is to assure that native plants are not at risk from the introduction of European insect*s*. We anticipate that attack of below-ground rhizomes will kill above-ground shoots, reduce storage tissues and recovery potential, and sever and disconnect rhizomes further reducing the competitive ability of *P. australis*. The most promising of the species identified in Europe are: (1) the shoot boring moth *Archanara geminipuncta*, a species responsible for reed-dieback in Europe; (2) the shoot and root mining moth *Chilo phragmitellus*; (3) the moth *Schoenobius gigantellus* where larvae that mine shoots of flooded *Phragmites* below the water level, cause considerable damage to attacked shoots which wilt and break apart; and (4) the shoot fly *Platycephala planifron*s attacking shoots very early in the growing season.

The next steps in the development of a biocontrol program are to assess the impact of the accidentally introduced insects on *P. australis* and to engage in a dialogue with various stakeholders about benefits and risks of biological control of common reed. In the meantime, research in Europe will continue to evaluate the specificity and impact of the most promising biocontrol candidates.

A Strategic Approach to a Sustained *Phragmites* Control Effort in the North Landing and Northwest River Watersheds

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Invasion of *Phragmites australis* represents one of the top threats to the globally rare, wind-tide marshes of the North Landing River. In 1999, The Nature Conservancy (TNC) along with its partners that include the Virginia Department of Conservation and Recreation – Division of Natural Heritage (DCR-DNH), Back Bay National Wildlife Refuge (BBNWR), City of Virginia Beach, Hampton Roads Planning District Commission (HRPDC), and Back Bay Restoration Foundation received a grant from the National Fish and Wildlife Foundation to develop and implement an integrated control strategy for *Phragmites* in the 150-square mile marshland complex of Back Bay and North Landing/Northwest River watersheds, VA. The objectives of this project are to:

- Establish the Back Bay-North Landing River *Phragmites* Working Group;
- Document the distribution and abundance of *Phragmites* in the project area;.
- Develop and pilot a priority-setting tool to help land managers at this and other sites select weed patches to be treated on the basis of (1) proximity to critical resources and (2) likelihood of treatment success;
- Conduct a four-phase weed control effort (two applications each of herbicide and prescribed burn treatments) on priority patches;
- Develop and implement a streamlined monitoring protocol to evaluate treatment efficacy and track the spread of *Phragmites* throughout the project area;
- Increase public awareness of the negative impacts of *Phragmites* on native ecosystems and species.

The project is half way through its first year. The working group is getting started, and the initial distribution and abundance survey is complete. As technology and funding improves, the precision of these surveys should increase dramatically. It was clear from the beginning that funding would not allow treatment of all the *Phragmites* in the project area, which necessitated a strategic approach to patch selection. Patches were ranked according to attributes such as size, density, proximity to nearby targets (rare plant communities and species), ease of treatment, etc. After pre-treatment monitoring was completed, the first aerial herbicide treatment was contracted in September of 2000. Prescribed burns are being planned for February 2001. We have received positive media support and are planning to increase our public outreach efforts.

Critical to the long-term success of *Phragmites* control in this watershed is the inclusion of <u>all</u> of the stakeholders in the area: government agencies, private landowners, non-profit organizations, and the general public.

Phragmites Management at Hog Island Wildlife Management Area by the Virginia Department of Game and Inland Fisheries

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The Virginia Department of Game and Inland Fisheries has attempted to control *Phragmites* on a 600-acre restored wetland system in Surry County, Virginia. Rodeo herbicide was applied with aircraft and from the ground at a rate of 6 pints to the acre. Applications were made during the September - October window in 1997, 1998, and again in 2000. Areas treated were prescribed burned and in some instances disced. The two consecutive treatment years (1997 - 98) resulted in noticeable reductions in *Phragmites* density. No application was administered in the year 1999. By 2000, all areas that had previously shown improvements in vegetation response had been recolonized and again dominated by *Phragmites*. Vegetative transect study findings are pending.

Protecting Wildlife Habitat in a Private Marsh

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The brackish and freshwater tidal marshes of the Rappahannock River and of similar tributaries leading off the Chesapeake Bay are remarkable for their biodiversity. They are known spawning and nursery grounds for anadromous fish as well as resident fish and crabs, and are of critical importance to migratory waterfowl for food and habitat. They support a vast array of wildlife including the threatened Bald Eagle – resident ones as well as eagles wintering here from the North and summering here from the South. *Phragmites* in its invasive form is a very real threat to this biodiversity. These tidal marshes and their nutrient food webs must be protected.

There is no state or federal mandate to notify landowners of the presence of an invasive species in their marshes, so it was by accident that I discovered *Phragmites* in my marsh in the summer of 1999. It took me three months to get the advice and help necessary to do a helicopter spray in October of 1999. Although Rodeo, the herbicide we used, is non-selective, we were able to "select" *Phragmites* by the timing of the spray. Other marsh plants had completed their growth cycles while *Phragmites* was still growing vigorously. Since it was a new infestation and thatch had not built up, there was no need to burn afterwards. The results were spectacular. In the spring, wild rice, arrow-arum and the whole spectrum of marsh plant life rebounded from the seed bed under the killed *Phragmites*.

As a direct result of my experience, the Rappahannock Phragmites Action Committee (RPAC) was formed in January of this year. Although we are focusing on the Rappahannock, we are sharing our results with localities, statewide. We are inventorying the *Phragmites*, identifying and notifying marsh owners, raising awareness, and offering and seeking advice and help. This fall RPAC coordinated a helicopter spray of 66 acres of *Phragmites* for eight landowners. By doing so we "protected" almost 4,000 acres of the 12,000 acres of tidal marsh in our focus area. Next year we will offer another coordinated effort with its attendant economies of scale. We are in the process of publishing a brochure, creating a traveling display for an outreach program, and seeking funding to reduce *Phragmites* in the areas it has invaded and to keep it from spreading into new areas.

The bad news is that *Phragmites* is invading these critical areas. The good news is that it has just begun and therefore can be successfully controlled before it is the problem it has become in other areas. If notified owners in each marsh area cooperate with each other and take prompt action, their marshes can be protected. It has been my experience that the marsh owners do want to participate once they have the necessary information, particularly if offered a means of doing so.

Phragmites needs to be monitored, landowners and maintenance workers need to be notified and educated, and centralized reporting and help lines need to be established. The state needs to support the effort to monitor the invasion and to notify and educate the owners of these critical marshes. The vectors of the spread, often highways, utility right-of-ways, and disturbed wetlands, need to be monitored and obligations imposed.

Lessons Learned from the DCR Experience with *Phragmites* in the 1990's

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The Southern Watersheds Common Reed Project was an interagency effort led by DCR during the mid-1990's to demonstrate control methods for the invasive wetland plant, common reed (*Phragmites australis* (Cav.) Trin. ex Steud.) while simultaneously increasing public awareness of the common reed problem and encouraging preventive measures in southeastern Virginia. Components of the project were as follows:

- Select 40 to 80 hectares of common reed stands imminently threatening the biological resources of the Southern Watersheds and demonstrate effective control of the plant.

- Produce and disseminate educational materials and programs for use by project cooperators designed to increase public awareness of the common reed issue.

- Initiate a cooperative effort regarding control of common reed among land managers.

The Southern Watersheds is an area of high ecological significance in southeastern Virginia. The extent of common reed in wetlands of the Southern Watersheds has increased drastically over the past two decades. A group of fifteen cooperating agencies and organizations selected 28 stands of common reed in the Southern Watersheds as the targets of control efforts. Treatment stands were subjected to two applications of herbicide in successive autumns. When possible, prescribed burns were executed between the two herbicide applications. Results of quantitative monitoring indicated that satisfactory control of common reed was achieved only in those stands which were sprayed twice and burned. Unburned stands experienced some control, but common reed was still present and was expected to increase to pre-treatment vigor without subsequent treatment.

Based upon the experiences from this project, cooperators made the following recommendations:

- Form the Southern Watersheds Common Reed Working Group.
- Employ remote sensing for monitoring of common reed.
- Continue and expand public education initiatives.
- Encourage preventive measures.
- Advocate research on common reed.
- Continue control efforts.
- Pursue funding to facilitate the implementation of the above recommendations.