MARYLAND

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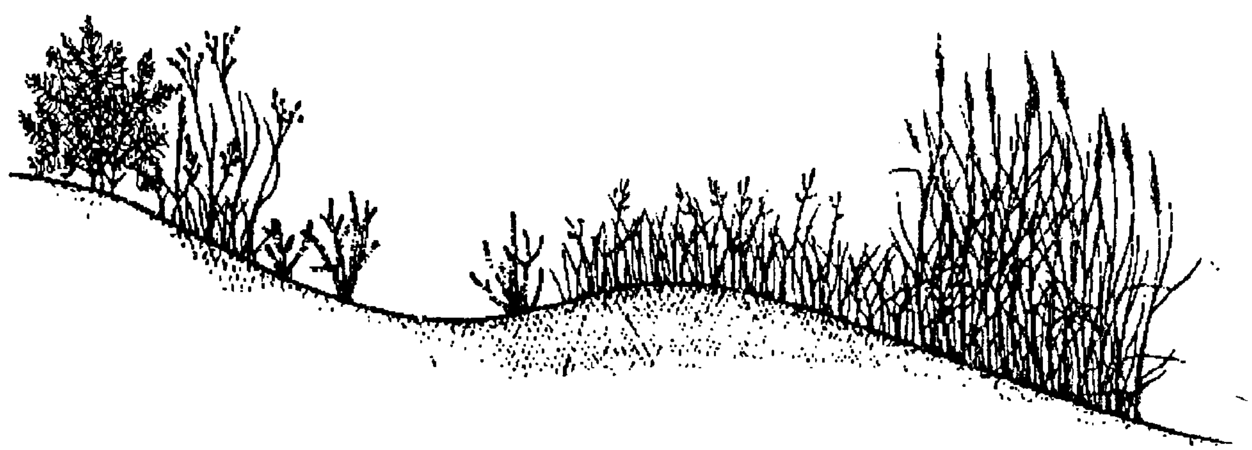
ANNAPOLIS, MARYLAND

TASK 22

ENVIRONMENTAL IMPACTS, TREATMENT METHODOLOGIES AND MANAGEMENT CRITERIA FOR ESTABLISHMENT OF A STATEWIDE POLICY FOR THE CONTROL OF THE MARSH PLANT Phragmites

FINAL REPORT: DECEMBER 1991



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INTRODUCTION

In 1987 a four-year study was initiated by the Environmental Center of Anne Arundel Community College for the Maryland Department of Natural Resources Tidewater Administration to assess the environmental impacts, evaluate treatment methodologies, and devise management criteria for the control of Phragmites. The first year's study concentrated on evaluating the nature of Phragmites growth in Maryland and to establish belt transects in two nontidal wetland environments to evaluate changes in diversity of plants and terrestrial invertebrates following an aerial application of the herbicide Rodeo (Monsanto, St. Louis, MO). This study was expanded in 1989 to measure the expansion rates and changes in plant diversity occurring in Phragmites populations present in tidal wetlands. The methods employed and the experimental results of these studies were presented in the annual reports covering years one and two of the project (Ailstock et al., 1988, 1989). In 1989 a third component was added the objective of which was to evaluate the factors which contribute to the establishment of Phragmites colonies. This report summarizes the findings of the entire study.

EXPERIMENTAL OBJECTIVES - YEAR FOUR

A. To continue post treatment inventories of plant and terrestrial invertebrate diversity in previously treated nontidal wetlands study sites.

B. To establish inventories of plant diversity within untreated isolated colonies of Phragmites in a tidal wetland environment.

C. To measure the expansion rates of these isolated colonies of Phragmites at the tidal wetland study sites.

D. To evaluate the factors which contribute to the establishment of Phragmites colonies.

METHODS

A. To continue post treatment inventories of plant and terrestrial invertebrate diversity in previously treated nontidal wetlands study sites.

Specific details of quadrat description, inventory techniques, Rodeo application rates, and treatment protocols are provided in the 1988, year one, summary report.

In brief, all plants falling within the previously established quadrats at the two, nontidal wetlands study sites (designated "W" and "V") were identified and counted in the late Summer or Fall of 1987, 1988, 1989, 1990, and 1991. This information was used to calculate Simpson's Index of Species Diversity and to monitor changes in the vegetative community before and for four succeeding years after Phragmites control methods were effected.

Two soil samples were taken near each quadrat in the previously established nontidal wetland sites "W" and "V" during October of 1987, 1988, 1989, 1990, and 1991. Samples were obtained with a coring device measuring 6 cm in diameter and 12 cm in height. The volume of each sample was approximately 340 cubic cm. Total volume sampled in each year was approximately 20 liters for the "V" site and 21 liters for the "W" site.

Of the two samples, one was reserved for later seed bank determinations and the other was used to identify and enumerate the soil fauna. Organisms were extracted from samples using Tullgren funnels with 40 watt light bulbs operated continuously for four days. Extracted invertebrates were preserved in 95% alcohol and later identified using a stereomicroscope.

B. To establish inventories of plant diversity within untreated isolated colonies of Phragmites in a tidal wetland environment.

Two well established Phragmites colonies were selected at the Green's Island/Fishing Creek Wildlife Management Complex in Dorchester County, Maryland. These are subsequently referenced as colony "A" and colony "B". Two belt transects, one oriented in an east-west and the other a north-south direction, were established through the approximate center of each colony.

In colony A, the north-south (NS) transect consists of 24, linear (rectangular, 1 x 10 sides), 1 m^2 quadrats (24 m^2) running a total length of approximately 75.84 m. The east-west (EW) transect in colony "A" contains 16 similar quadrats (16 m^2) with a total length of approximately 50.50 m.

In colony B, the NS transect consists of 12 quadrats (as above - 12 m^2) running a total length of approximately 37.92 m. The east-west (EW) transect in colony "A" contains 15 similar quadrats with an approximate length of 47.40 m.

All plants falling within the quadrats of each belt transect of colonies A and B were identified and counted during the growing seasons of 1989, 1990, and 1991. This information was used to calculate species diversity indices for both sites.

C. To measure the expansion rates of these isolated colonies of Phragmites at the tidal wetland study sites.

In Phragmites, colonies expand peripherally by horizontal, typically subterranean, rhizome growth. The upright, aerial stems, which form the obvious manifestation of the presence of the plant, serve mainly for photosynthesis and seed formation. These aerial stems are derived from buds on the rhizome which are probably formed during a previous year's growth. At the end of each growing season all the aerial stems die and are replaced in the following year by the development of the pre-existing rhizome buds.

It follows then that during a given season, two distinct but related growth activities are occurring simultaneously:

1) the growth of aerial stems from buds of the previous year(s); and

2) horizontal rhizome growth for peripheral expansion of the colony margin.

Consequently, it is possible to estimate one year's expansion growth, along a given radius, by measuring the distance from the previous years outermost aerial stem, identified by the outermost dead aerial stem on that radius, and the current years outermost stem, identified by the outermost living stem on the same radius.

Selected measurements were taken on the periphery of colonies "A" and "B" to determine the distances from the last, aerial, Phragmites growth of the previous year, identified by the outermost dead stem on a given radius line, and the current limit of aerial growth, identified by the outermost living stem on the same radius. The purpose of these measurements was to estimate the rate of colony expansion.

Measurements were made along the four radii created by the two transects in each colony. Also, measurements were made along at least two additional radii selected between each of the four transect radii for each colony. Criteria for selection of the interpolated radii were the presence of clearly identifiable outermost living stems of the current year at subjectively estimated even spacing units between the transect radii. In the case of the transect radii, the closest living stem on the outermost periphery was chosen to establish the radius line for measurement.

D. To evaluate the factors which contribute to the establishment of Phragmites colonies.

Contrary to popular belief, Phragmites is a native species. The misconception that Phragmites is alien probably comes from the listing in Gray's Manual of Botany (Fernald, 1970), which gives the distribution of Phragmites as: "—Eurasia, and with its varieties, nearly cosmopolitan". This means that the main (post ice age) center of distribution for the plant was Eurasia, but that it is now found nearly all over the world. It has been in North America since before the earliest human inhabitants. Berlandier, who died in 1855, is given credit for the discovery of the North American variety, which was named (var. Berlandieri) in his honor. Since Berlandier discovered the plant and brought it to the attention of the botanical world in his life time (1805-1855), it seems probable that it was not nearly as abundant then as it is now. It would otherwise have been discovered much earlier, given the ample botanical explorations of eastern North America in the eighteenth century.

Accurate records verifying patterns of change in Phragmites populations in North America are unavailable. However, sufficient evidence from South Africa (Weisser and Parsons, 1981) and anecdotal verification from numerous senior wetlands managers supports the concept that rapid increases in Phragmites populations have and are occurring. These increases correlate well with increasing human manipulation of wetland ecosystems. Understanding how marsh manipulation may accelerate the colonization of wetlands by Phragmites may provide alternatives which will reduce the cost of Phragmites control by Rodeo, limit the quantities of herbicide needed to control Phragmites, and provide insights on Phragmites control in areas for which herbicide treatments are impractical.

Transplant experiments and greenhouse studies have proven to be a valuable tool for developing predictive models of the way species may behave in natural environments. To evaluate the factors which contribute to the establishment of Phragmites colonies, the three naturally produced propagules of Phragmites, seeds, rooted shoots, and rhizome fragments, were cultivated in high and low marsh environments under three conditions normally associated with wetland habitats. These are: 1) naturally vegetated areas; 2) areas where surface vegetation has been burned as a part of normal marsh management programs; and 3) in bare soil which is a common result of many construction activities occurring in wetlands. In addition, similar propagules were cultivated in greenhouse flats .

For transplant studies, two locations in the Green's Island Wildlife Management Area which differed in elevation, extant plant species, and soil hydration were selected. One, representing a high marsh environment, supported Panicum virgatum and Hibiscus palustris as the dominant cover species. The other, representing a low marsh environment, was dominated by Spartina patens, Distichlis spicata and Juncus roemerianus. At each site, 9, 1 m^2 quadrats were established. Three were left naturally vegetated, and three were burned to remove above ground biomass. The remaining three quadrats were excavated to a depth which exposed the mineral soils.

Ten rhizome fragments, each approximately 10 cm in length, each containing a single, unexpanded bud, were dropped on the surface of one quadrat of each experimental condition at each location. Also, ten rooted shoots and 0.5 g of seeds were planted, each respectively, in one quadrat of each experimental condition at each location. To eliminate predation and the influence of seasonal weather patterns, 9, 1 m^2 quadrats were established in large planting flats (1 m X 1 m X 0.2 m) under greenhouse conditions. These flats were filled with commercial potting soil (ProMix). To replicate the burned and unburned marsh habitat, six flats were planted with a complete cover of a 1 to 1 mixture of K-31 (tall fescue) and annual rye six weeks prior to inoculation with Phragmites propagules. Three were left intact and three were burned prior to planting. The remaining three flats, containing only potting soil, were used to simulate bare soil conditions.

Survival and growth of these propagules were evaluated, bi-weekly for 12 weeks, for all treatments in all locations.

RESULTS

EXPERIMENTAL OBJECTIVE A: To continue post treatment inventories of plant and terrestrial invertebrate diversity in previously treated nontidal wetlands study sites.

Objective A-I. Plant Data

In our previous reports we established four critical parameters which chart the course of recovery for the W and V test sites at the Stemmer's Run study area. These are: 1) Simpson's index of diversity; 2) total number of Phragmites stems; 3) the total number of individuals, including Phragmites; and 4) the total number of species present.

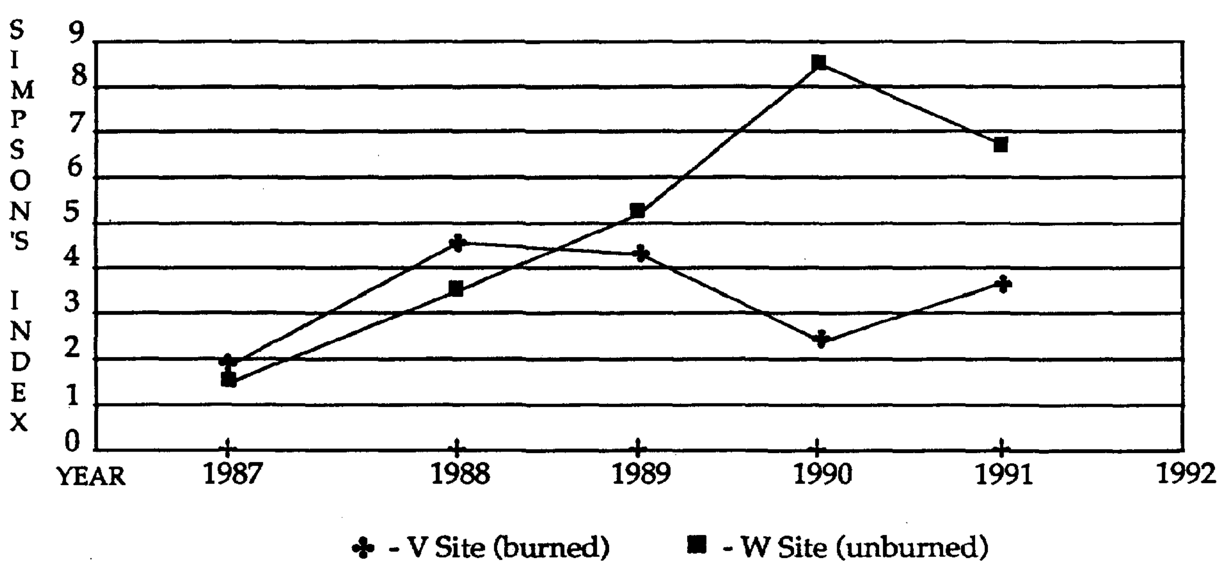
Parameter 1: Simpson's Diversity Index

Table 1 shows the change in the Simpson's Diversity Index calculated for the pre-treatment and four post-treatment plant communities of both test sites A graphic analysis of these data is shown in Figure 1.

Table 1. - Change in the Simpson's Diversity Index for both sampling sites (see text).

YEAR		1987	1988	1989	1990	1991
W SITE	UNBURNED	1.52	3.48	5.01	8.52	6.91
V SITE	BURNED	1.57	4.54	4.26	2.48	3.76

Figure 1. Change in the Simpson's Diversity Index for both sampling sites (see text).



The initial difference between these two curves in the first post-treatment year is probably due the presence of the thick layer of dead Phragmites stems, or 'thatch', built up over years of growth and death cycles, which was left unburned in the W site but which was mostly burned off in the V site.

At site W, the large quantities of persistent 'thatch', especially in the drier areas of the site, create a shade effect which has, apparently, significantly retarded new growth. New species none-the-less continue to be recruited (see below). The most abundant species at site W were initially only several hundred individuals strong. About half the species were represented by only a few individuals. Under these statistical circumstances, the Simpson's Index tends to be high, being limited practically by the number of different species which can be recruited.

At site V, on the other hand, the relative lack of thatch (some isolated clumps of thatch were missed by the 1987 burning of site V due to small differences in elevation, and these areas remain relatively barren) has encouraged rapid initial establishment and growth in some species which undoubtedly contributed to the higher initial diversity index at V site (burned).

In the 1990 enumeration, one species, Panicum verrucosum (warty panic grass), which was either first identified or newly recruited in 1990, had nearly 2000 individuals which fell into established quadrats. The presence of a few relatively high numbers, in a set for calculation of the Simpson's Index, has a profound depressing effect on the index value. In the 1991 census, the number of individuals of P. verrucosum increased only slightly (to nearly 2500) and so the depressing effect of this species did not continue. With the addition of some new species and an overall evening of the numbers, the Simpson's Index at V site has begun to rise appreciably.

At W site, in 1991, Panicum verrucosum, as well as another (unidentified) grass and two species of Polygonum (smartweed), were present in quadrats in high numbers. The overall effect was to greatly lower the diversity index. The W site (unburned) diversity index remains higher than that of the V site (burned), however, due to the more even balance of numbers.

Table 2, which lists the total number of individuals for the nine most abundant species at the Stemmer's Run study site, as enumerated in the Fall of 1991, will give a better insight into the dynamics of diversity differences between the two sites.

Parameter 2: Total Phragmites

Table 3 shows the change in the total number of Phragmites calculated for the pre-treatment and four post-treatment plant communities of both test sites. Each number is ranked in terms of the abundance position of Phragmites among the species at the given site and time. When graphed, the total Phragmites data produce Figure 2, modified from our previous reports.

The two curves are quite similar and may be statistically indistinguishable. The average, over time, of all the W site values is 328; that for the V site is approximately 348. If unchecked, Phragmites abundance will likely show steady increases in the future until pre-treatment numbers are reached.

Table 2. - The nine most abundant species at the Stemmer's Run study site in the fall of 1991 (see text).

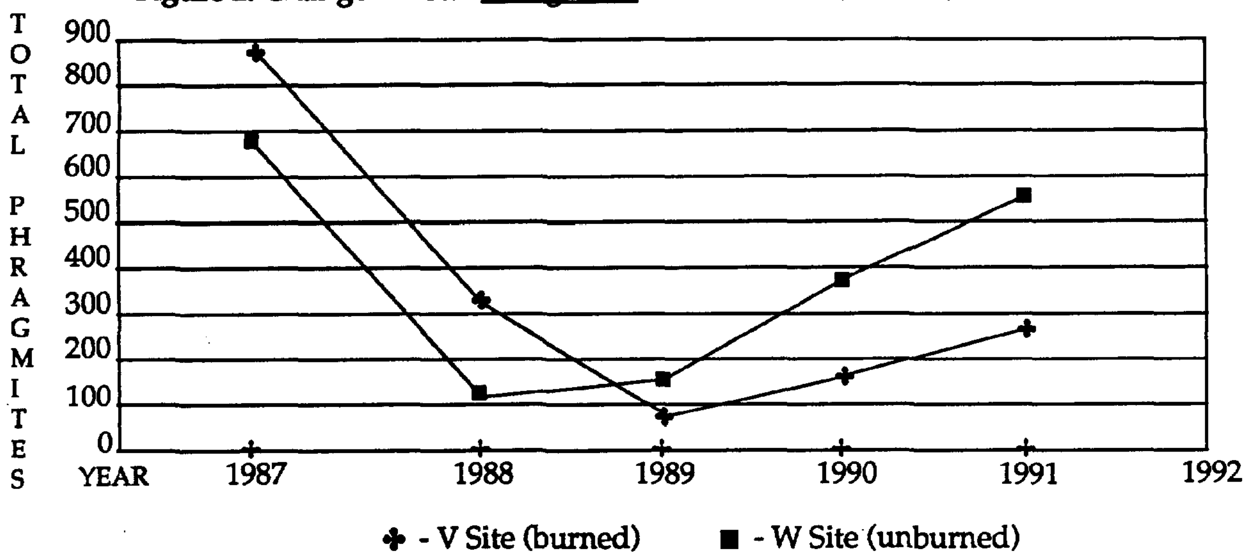
W Site (unburned) Simpson's Index = 6.91	
Species	**Number**
Panicum verrucosum	1858
Unidentified grass (1)	1062
Polygonum punctatum	777
Polygonum sagittatum	766
Phragmites australis	331
Erechtites hieracifolia	250
Unidentified grass (2)	236
Impatiens capensis	127
Leerzia oryzoides	127

V Site (burned) Simpson's Index = 3.76	
Species	**Number**
Panicum verrucosum	2469
Polygonum sp.	580
Phragmites australis	275
Erechtites hieracifolia	189
Polygonum punctatum	169
Scirpus cyperinus	158
Acer rubrum	154
Rubus sp.	150
Setaria sp.	118

Table 3. - Change in total Phragmites for both sampling sites. Each number is ranked in terms of the abundance postion of Phragmites among the species at the given site and time (see text).

YEAR		**1987**	**1988**	**1989**	**1990**	**1991**
W SITE	UNBURNED	691 (1st)	114 (2nd)	152 (2nd)	381 (1st)	552 (5th)
V SITE	BURNED	878 (1st)	312 (1st)	85 (6th)	189 (2nd	275 (3rd)

Figure 2. Change in total Phragmites for both sites (see text).



Parameter 3: Total Number of Individuals

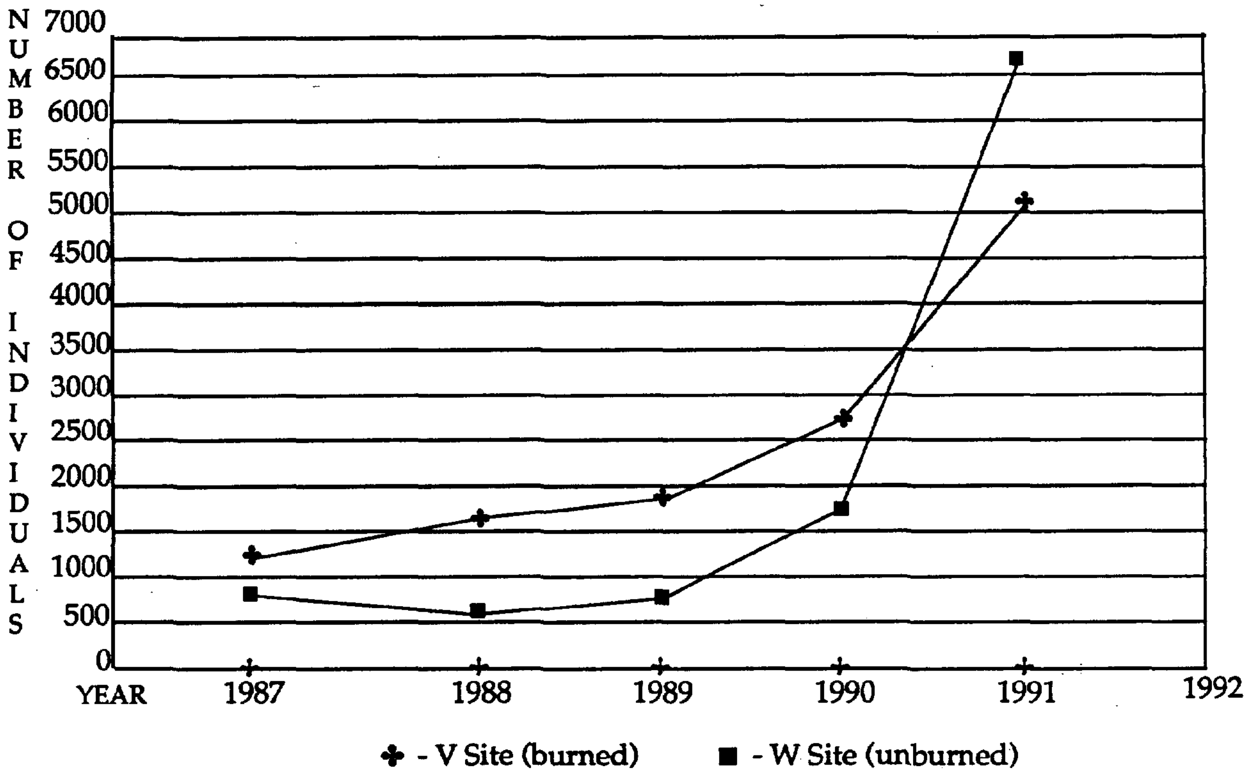
Table 4 shows the change in the total number of individuals of all species for the pre-treatment and four post-treatment plant communities of both test sites. When graphed, the total number of individuals data produce Figure 3, modified from our previous reports.

Table 4. - Change in total number of individuals of all species for both sampling sites (see text).

YEAR		1987	1988	1989	1990	1991
W SITE	UNBURNED	858	506	777	1569	6624
V SITE	BURNED	1109	1574	1991	2754	5025

The initial depression of the total number of individuals seen in the W site data is a result, we believe, of the shading effect of the unburned Phragmites thatch. The two curves are otherwise quite similar. The average of all W site values, over time, is approximately 2067; that for V site is 2491. The percent difference between the two sites is nearly the same at the beginning of the observation period ('87) and at the end ('91) except that the site with the greatest abundance of individuals is reversed. In 1987, V site had 29% more individuals falling within established quadrats than W site. In 1991, V site had 24% fewer than W site. The most significant aspect of these data is that the number of individuals falling within established quadrats has increased dramatically since 1987. For the W site the increase is approximately sevenfold (6.72). The V site increase is approaching fourfold (3.53).

Figure 3. Change in total number of individuals of all species for both sampling sites (see text).



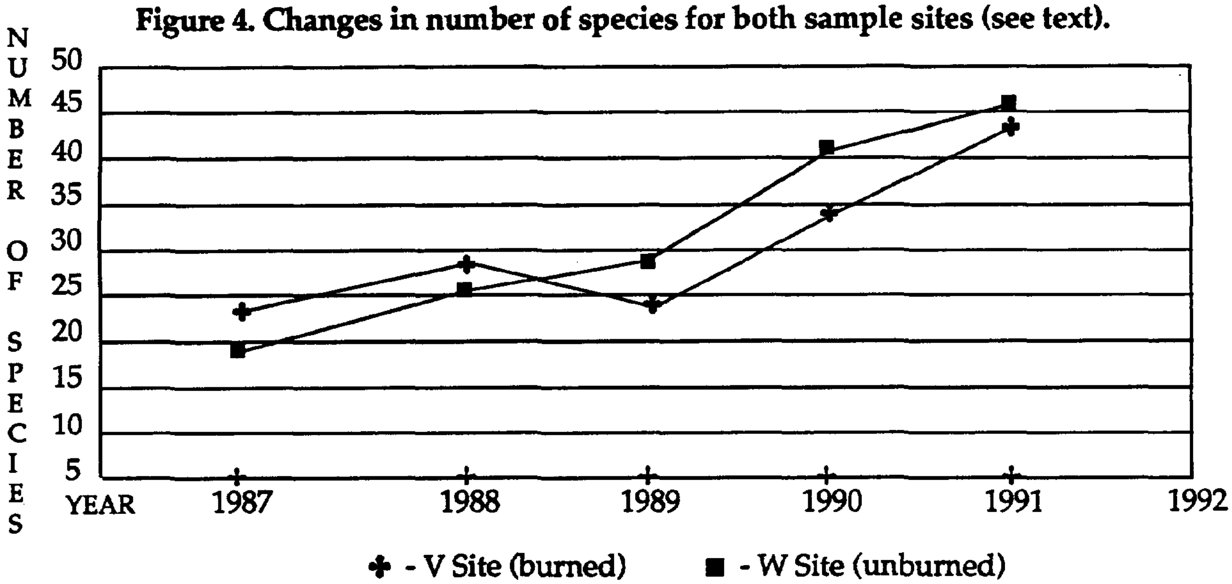
Parameter 4: Number of Species

Table 5 shows the change in the number of species for the pre-treatment and three post-treatment plant communities of both test sites. When graphed, the total number of individuals data produce Figure 4, modified from our previous reports.

Table 5. - Change in number of species for both sampling sites (see text).

YEAR		**1987**	**1988**	**1989**	**1990**	**1991**
W SITE	UNBURNED	19	26	28	41	45
V SITE	BURNED	23	27	24	34	44

Figure 4. Changes in number of species for both sample sites (see text).



The two curves shown above are statistically identical, and, if unchecked, will likely show steady increases in the near future until such time as Phragmites or some other species begins to dominate the communities to the point of species exclusion. An increase in number of species, with a concomitant increase in diversity (parameter 1), may be generally interpreted as positive change in a natural environment, and is the probable goal of Phragmites control in nontidal wetlands (barring the need for near 100% replacement with a single, more desirable species).

Objective A-II. Invertebrate Data

Table 6 shows the changes in the Simpson's Index of Diversity for both sites over the five sampling efforts. The same data are graphically represented in Figure 5. Essentially, the diversity (at the ordinal level) increases after treatment and returns to the baseline figure at both sites. The changes are as likely to be the results of physical changes which accompany the reduction in biomass, as they are to be directly related to Phragmites presence or absence or the presence or absence of any other vegetation. There is no indication that the Rodeo application itself has in any way caused changes in the soil macroinveretebrates. This is supported by Figures 6 and 7, which illustrate the relative lack of any directional change in any of the major ordinal taxa which comprise the soil fauna.

Table 6. - Simpson's Index for soil macroinvertebrates at both sampling sites (see text).

YEAR		1987	1988	1989	1990	1991
W SITE	UNBURNED	182	2.01	2.66	2.50	1.94
V SITE	BURNED	1.37	1.75	1.70	1.61	1.41

Figure 5. Simpson's Diversity Index for soil macroinvertebrates at both sampling sites (see text).

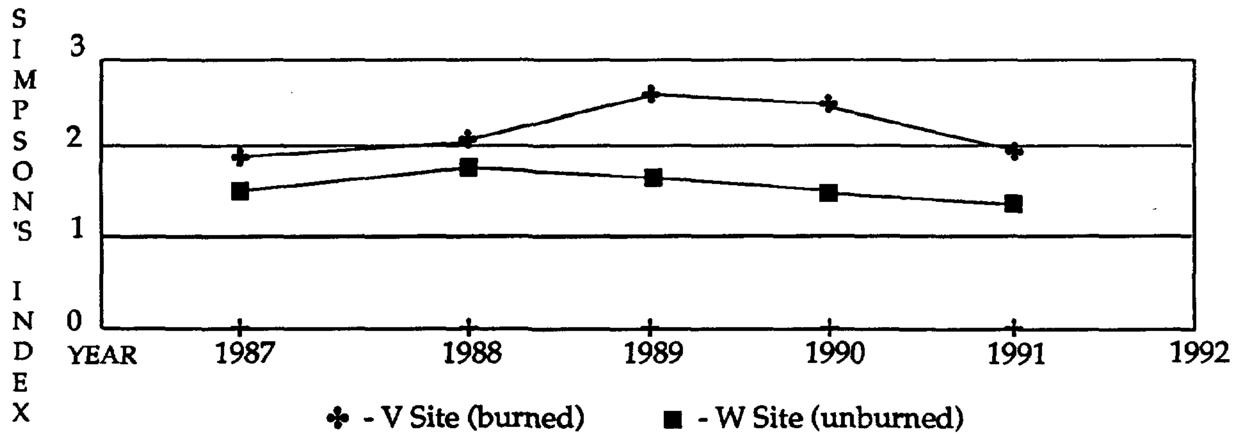


Figure 6. A graph of the changes in the total number of individuals of the five most dominant types of soil macroinvertebrates sampled at the entire W (unburned) site.

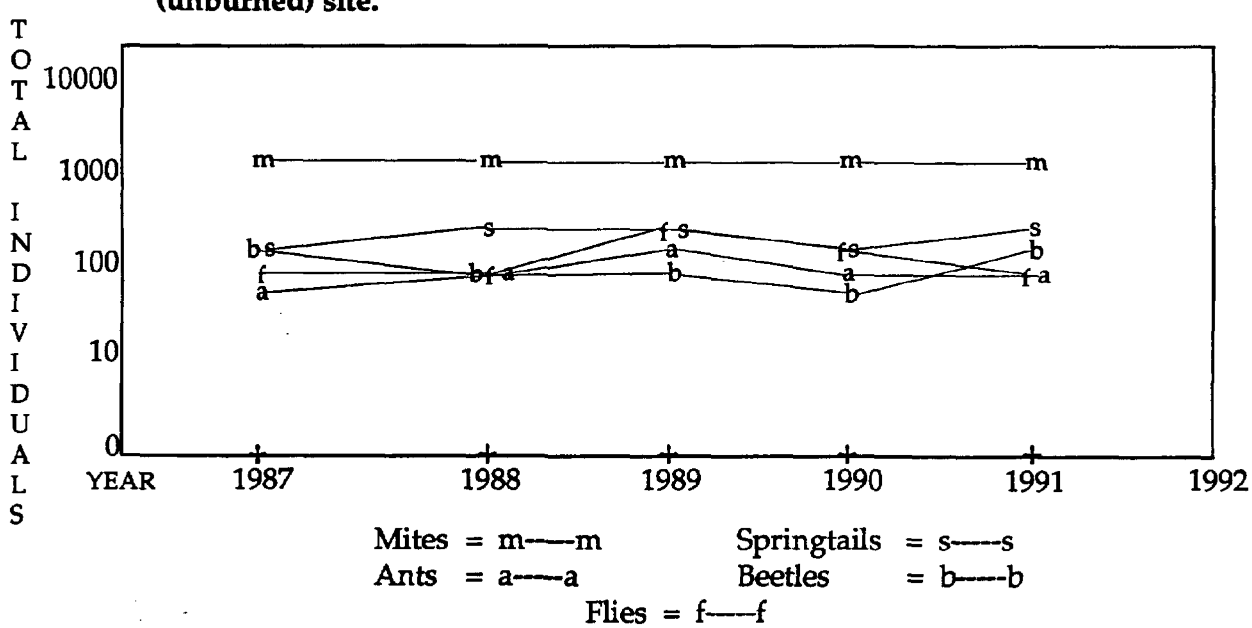
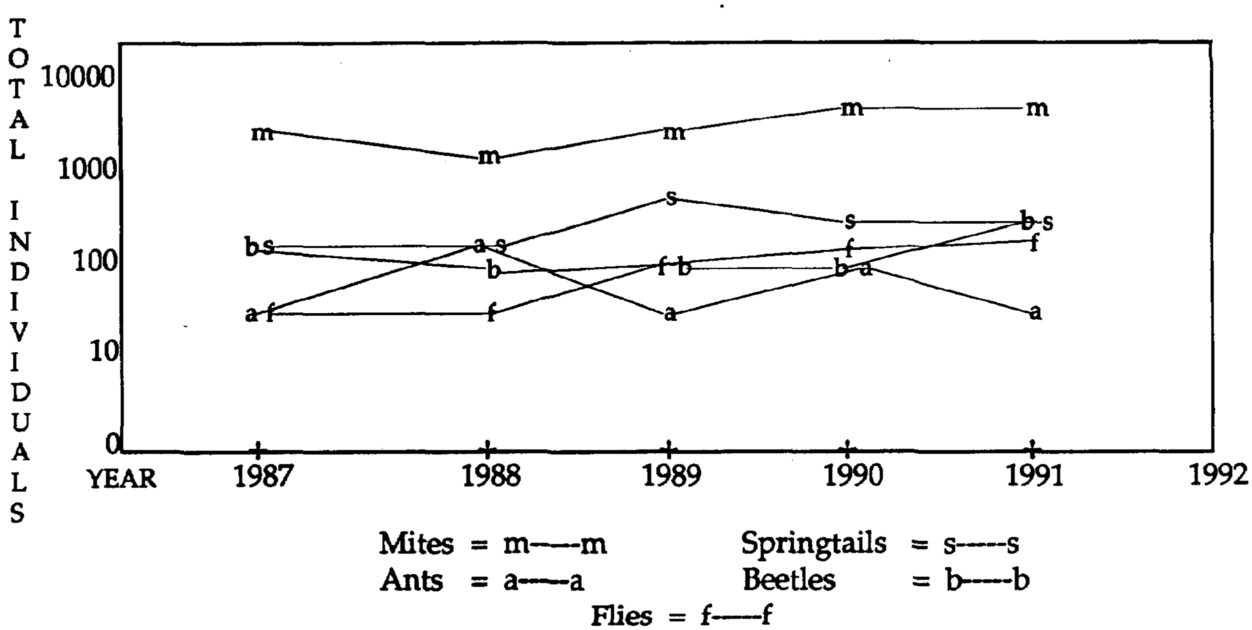


Figure 7. A graph of the changes in the total number of individuals of the five most dominant types of soil macroinvertebrates sampled at the entire V (burned) site.



We continue to maintain that, in light of the poorly understood nature of the soil community, and within the ability that we have to identify the major (mainly ordinal) categories of soil macroinvertebrates, there has been no significant effect on the soil organisms as a result of the treatment protocol and the changes in the community from year to year are entirely within the expected variation for such data.

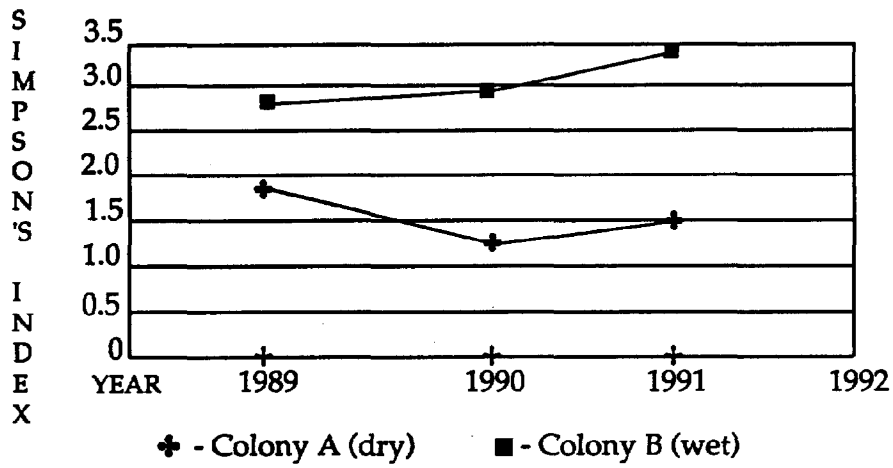
EXPERIMENTAL OBJECTIVE B: To establish inventories of plant diversity within untreated isolated colonies of <u>Phragmites</u> in a tidal wetland environment.

The two untreated, isolated <u>Phragmites</u> colonies (A and B) at the Greens Island/Fishing Creek Wildlife Management Complex in Dorchester County were inventoried in three successive growing seasons (1989, 1990, and 1991). Table 7 compares the Simpson's Index of Diversity for the two colonies. Figure 8 gives the same data in graphic form.

Table 7. - Comparison of Simpson's Index of Diversity for Colony A and Colony B (see text).

YEAR	1989	1990	1991
Colony A	2.66	2.50	1.94
Colony B	1.70	1.61	1.41

Figure 8. Comparison of change in the Simpson's Index of Diversity for Colony A and Colony B (see text).



The most significant features of these data are: 1) that Colony B exhibits consistently higher diversity than Colony A; and 2) the diversity in Colony B appears to be increasing. Whether this is real or an artifact of repeated inventory (and hence familiarity with the site flora) can only be determined by future repeated observations.

Unfortunately, Colony A was burned between the '90 and '91 inventories. The burning which reduces <u>Phragmites</u> competitive height advantage over other species may be responsible for the rise in diversity during this period.

The abundance of the three dominant species in each of the two colonies is listed in Table 8 for the three observation periods.

The depression in numbers observed in 1990 was concomitant with exceptionally heavy rainfall in the Spring. Otherwise, whether the differences are indicative of trends in these colonies, or if the numbers will vary in some predictable way in the future, can only be determined with more inventories. At the moment we have no opinion about what may be causing the apparent fluctuation in numbers.

<u>Spartina</u> and <u>Distichlis</u> numbers are very difficult to ascertain with precision in the Colony A site. They are often so numerous within the quadrats that they would be uncountable without excavation and consequent destruction of the plants, which would not be desirable since it would greatly influence future numbers. In the 1989 count, estimates were made on the basis of destruction of nearby areas measured to quadrat size and apparently equivalent in plant density. In 1991, estimates for those quadrats which were in the too-numerous-to-count category were made by doubling the number of the highest individual count.

The other numbers (<u>Phragmites</u> for Colony A and all numbers for Colony B) are deemed reliable.

Table 8. - The abundance of the dominant species in Colony A and B (see text).

YEAR	1989	1990	1991
Colony A (dry site)			
Phragmites australis	2683	1407	2219
Spartina patens	29848	3300	32201
Distichlis spicata	10172	6343	8990
Colony B (wet site)			
Phragmites australis	2221	823	1659
Juncus roemerianus	1824	862	1424
Distichlis spicata	3353	862	1225

EXPERIMENTAL OBJECTIVE C: To measure the expansion rates of these isolated colonies of Phragmites at the tidal wetland study sites.

The two untreated, isolated Phragmites colonies (A and B) at the Green's Island/Fishing Creek Wildlife Management Complex in Dorchester County were measured for radial expansion in three successive growing seasons (1989, 1990, and 1991).

Average radial expansion in both colonies was greater in 1991 than 1990 and greater in 1990 than in 1989. Table 9 shows the changes in radial expansion over the three successive observations.

Table 9. - Changes in the average radial expansion of Colony A and B (see text).				
Colony	Number of Measurements	Average Increase in Radius (m)		
	Year:	1989	1990	1991
Colony A (dry)	15	0.604	0.704	2.037
Colony B (wet)	12	0.525	0.792	1.050

Average colony expansion in diameter was just slightly more than 1 m in 1989, while it was nearly 1.5 m in 1990. In 1991 this figure doubled to over 3 m.

To better appreciate the meaning of this expansion in terms of area, the approximate areas of the two colonies were estimated by taking the two initial belt transects to be representative diameters of each of the two colonies which, for the purposes of calculation and estimation, were assumed to be circular. An area was then calculated and compared to the yearly increases for each colony. Results indicate that during the three years, Colony A increased in area by a total of approximately 680 square meters, an approximate 22% increase. Colony B increased a total of approximately 318 square meters which represents a 23% increase.

EXPERIMENTAL OBJECTIVE D: To evaluate the factors which contribute to the establishment of Phragmites colonies.

Phragmites australis can be propagated in nature by three structures: seeds, rooted shoots, and rhizome fragments. Survivorship of these structures varies according to the environmental conditions in which they are placed.

Plants were established from seed and survived for twelve weeks on bare soil in the greenhouse and in a high marsh (Table 10). The dramatic difference in survivorship is a result of competition. When seeds were placed in greenhouse soils where plant cover had been reduced by burning, seeds sprouted within 1 week, however, by the 6th week no seedlings remained. This decline corresponded to the regrowth from the burned vegetation which smothered the young seedlings. This observation also provides an explanation for the failure to establish seeds in the vegetated and burned sites in the high and low marshes. No explanation is readily apparent for the failure of seeds to become established in the bare areas of the low marsh.

Small rooted shoots were also successfully established in bare soil in the greenhouse and the high marsh. Competition was again a factor in survival as can be seen from the data presented in Table 11. It is important to note that while establishment under natural conditions may be low, the survival of a single shoot is sufficient to establish a new colony. Once the colony is established, expansion may occur at rates measured in the previous section.

Plants with rhizomes are frequently propagated using fragments of the rhizome. The data in Table 12 suggests establishment of Phragmites by rhizome fragments is less efficient than establishment by seeds or rooted shoots when placed on the surface of bare, burned, or vegetates soils. Under these conditions the small rhizome fragments are prone to desiccation especially when they are exposed to high temperatures and low soil moisture content. These conditions are characteristics of the summer months when this study was conducted. To better assess the survivorship of rhizome fragments, 10 rhizome fragments were buried 1/2 inch deep in both bare greenhouse soils and three treatment conditions in the high and low marsh study sites. In the greenhouse, survival was 100% and in 12 weeks the number of plants had more than doubled. In the field studies, plants became established in the bare soil of the low marsh and under all treatment conditions of the high marsh. Thus, a way for plant establishment of Phragmites by rhizome fragments is burial of the rhizomes. This "planting" of rhizomes is likely to occur during many types of construction activities.

Table 10. - Seed establishment and survival in high marsh, low marsh and greenhouse soils which were bare, vegetated, or treated to remove standing biomass by burning (see text).

Bare Soil	Number of seeds established and surviving.					
Week Number	2	4	6	8	10	12
Low Marsh	0	0	0	0	0	0
High Marsh	0	0	0	0	1	3
Greenhouse	+++	+++	++	+++	+++	121

Vegetated	Number of seeds established and surviving.					
Week Number	2	4	6	8	10	12
Low Marsh	0	0	0	0	0	0
High Marsh	0	0	0	0	0	0
Greenhouse	0	0	0	0	0	0

Burned	Number of seeds established and surviving.					
Week Number	2	4	6	8	10	12
Low Marsh	0	0	0	0	0	0
High Marsh	0	0	0	0	0	0
Greenhouse	++	+	0	0	0	0

Survival after 12 weeks.

Seeds	Low Marsh	High Marsh	Greenhouse
Bare Soil	0	0	121
Vegetated Soil	0	0	0
Burned Soil	0	0	0

+ = Estimates of abundance. Individual counts would have destroyed the seedlings.

Table 11. - Rooted shoot establishment and survival in high marsh, low marsh and green house soils which were bare, vegetated, or treated to remove standing biomass by burning (see text).

Bare Soil	Number of shoots established and surviving.					
Week Number	2	4	6	8	10	12
Low Marsh	0	0	0	0	0	0
High Marsh	0	0	0	0	1	3
Greenhouse	28	34	43	47	48	62

Vegetated	Number of shoots established and surviving.					
Week Number	2	4	6	8	10	12
Low Marsh	0	0	2	0	0	0
High Marsh	0	1	1	0	0	0
Greenhouse	0	0	15	1	0	0

Burned	Number of shoots established and surviving.					
Week Number	2	4	6	8	10	12
Low Marsh	0	0	0	0	0	0
High Marsh	0	0	0	0	0	0
Greenhouse	15	15	19	18	19	13

Survival after 12 weeks.

Rooted Shoots	Low Marsh	High Marsh	Greenhouse
Bare Soil	0	3	62
Vegetated Soil	0	0	0
Burned Soil	0	0	13

Table 12. - Rhizome establishment and survival in high marsh, low marsh and greenhouse soils which were bare, vegetated or treated to remove standing biomass by burning (see text).

Bare Soil	Number of rhizomes established and surviving.					
Week Number	2	4	6	8	10	12
Low Marsh	0	0	0	0	0	0
High Marsh	0	0	0	0	0	0
Greenhouse	0	0	0	0	0	0

Vegetated	Number of rhizomes established and surviving.					
Week Number	2	4	6	8	10	12
Low Marsh	0	0	0	0	0	0
High Marsh	0	0	0	0	0	0
Greenhouse	0	0	3	3	1	2

Burned	Number of rhizomes established and surviving.					
Week Number	2	4	6	8	10	12
Low Marsh	0	0	0	0	0	0
High Marsh	0	0	0	0	0	0
Greenhouse	0	1	1	1	0	1

Survival after 12 weeks.

Rhizome	Low Marsh	High Marsh	Greenhouse
Bare Soil	0	0	0
Vegetated Soil	0	0	2
Burned Soil	0	0	1

DISCUSSION

There are two significant aspects to the managment of Phragmites in wetland habitats: A) The control of existing populations and; B) The development of strategies which reduce the spread of Phragmites.

A. The control of existing Phragmites populations

A major component of the management of Phragmites in wetland habitats is the decision to control existing populations. Since Phragmites provides many of the same environmental benefits associated with most other wetland vegetation, i.e., soil stabilization, nutrient removal and cover, the decision for control is dependent upon two factors. These are: 1) The existence of an effective control protocol and 2) the likelihood that the treated area will be rapidly colonized by desirable vegetation.

1) Control Protocol

The only practical method of controlling Phragmites involves the use of the herbicide Rodeo. Non-herbicidal control methods which have been evaluated include excavation, flooding, repeat harvesting, and the use of black plastic mulches. These methods of control are either ineffective or alter the hydrologic features of the site to a degree which precludes the reestablishment of a habitat similar to the one displaced by Phragmites colonization (See Appendix A).

Several techniques can be used to apply Rodeo to Phragmites. The selection of a particular application technique is dependent upon the size, location, and density of the colony, land use features (which may preclude some application options), and the need to restrict herbicide application solely to the target species.

For treatment of large populations occurring in areas where the selection of application technique is unrestricted, aerial application of the herbicide such as that used in this study at the Stemmer's Run sites provides an excellent cost effective control procedure. Initial reductions in Phragmites numbers are high and re-vegetation by other species is rapid. Burning Phragmites following treatment encourages recruitment with little apparent affect on wetland function during the initial transition from a wetland donimated by Phragmites.

Burning does affect cover by reducing the density of above ground biomass, however, this loss of cover occurs at a time when cover of the type provided by Phragmites is least important to wildlife. In contrast, feeding opportunities which are minimal in standing Phragmites populations are improved by burning, which provides greater surface feeding opportunities for birds and small mammals.

A second method of treating large populations is land application by a vehicle capable of accessing wetland environments. Excellent results have been achieved when the herbicide was applied to a 30 acre site using bombadeer tractor with a 6 psi footprint and a radiarc sprayer. (See Appendix B). Initial site control with this procedure was very high; however, control was restricted to areas outside of the vehicle's footprint. The poor control in the track lines observed was a result of 2 factors: 1) reduced herbicide contact (spray is directed from the rear of the tractor to reduce driver exposure in this system); and 2) the breakage of rhizomes which prevents translocation of the herbicide from the foliage to the perennating buds (Stout, 1992). A following treatment in the second year using the same application system but new track lines yielded virtually total control.

Hand held application equipment provides excellent control for small populations. The two types of applicators suitable for this purpose are backpack sprayers and wick applicators. The former is best suited for general application to pure Phragmites populations, the latter to treat isolated stems invading areas previously uncolonized. These applications may also be used for spot treatment of problem areas following initial large scale herbicide applications.

Regardless of the technique used for applying the herbicide, satisfactory long term control is not achieved by a single application. This is evident by the initial reduction and subsequent increase in Phragmites observed at both Stemmers Run sites following a single aerial treatment. At other comparable sites, a three year program, which included 2 successive whole site treatments followed by spot treatment in the 3rd year, provided total control of existing Phragmites. This series of treatments is recommended for all control programs.

2) Site Revegetation

The second primary factor which influences management decisions in the control of existing Phragmites populations is the rate at which the treated Phragmites colony will be recolonized by desirable vegetation. An initial concern was that wetlands function would be reduced during the transition phase. The rapid recolonization by diverse species at the Stemmer's Run sites suggests that the soil seed bank is sufficient to mitegate any effect of control procedures. Little effect on soil microinvertabrates was observed during the four year study, probably because of the rapid regrowth of other wetland plant species. A different situation exists when Phragmites appears in high energy environments along shorelines. Under these conditions recruitment, usually by a combination of Spartina alterniflora and S. patens, is slow and thus the treated area is subject to erosion. A satisfactory method of avoiding this problem is to couple herbicidal control with plantings of Spartina after the first herbicide application. This technique works especially well if Phragmites stems can be removed to increase sunlight exposure to the plantings (Ailstock, Personal Observations). Care must be taken in the 2 subsequent herbicide treatments to avoid pesticide contact with the planted Spartina. This can be achieved by the use of wick applicators or by a carefully directed spray from backpack applicators operated at lower pressure.

B. The development of strategies which reduce the spread of Phragmites

A second important aspect of Phragmites management is the development of strategies which reduce the spread of Phragmites. Phragmites can be established by three reproductive structures; rooted shoots, rhizome fragments, and seeds. These structures can be dispersed by both artificial and natural vectors.

Rooted shoots, rhizome fragments, and seeds may be present in soils excavated from areas supporting _Phragmites_ populations. These soils, which are common at many state highway construction areas, are a source of preplanted _Phragmites_ when they are removed off site. Measures must be taken to treat these spoil materials subsequent to removal either by herbicide treatment or composting (Ailstock, 1990). Soils containing _Phragmites_ propagules may also be transported in the tracks of construction machinery. In one count, 60 rhizomes fragments were observed in the treads of a bulldozer used to excavate soil from a _Phragmites_ colony at Kent Island, Maryland. It is thus advisable to clean machinery prior to moving equipment to new construction sites capable of supporting _Phragmites_.

Propagules may also be dispersed by natural means. Wind dispersal of seeds can be readily observed on windy days in the late fall and winter. The small tufted seeds may also adhere to animals and waterfowl. It is likely that _Phragmites_ appearing in isolated marginal habitats along migratory routes are distributed in this manner. Long distance spread of rooted shoots and rhizome fragments by animals is unlikely, however short distance transport is possible. Long distance transport by water of shoots and rhizome fragments has been frequently observed in areas where _Phragmites_ occurs along erodible shorelines in fresh to brackish water (Ailstock, Personal Observation). Plant parts break by the erosive forces and are distributed by currents. No comparable information is available on the water transport of seeds.

Little can be done to reduce the spread of _Phragmites_ by natural vectors other than reducing the number and size of existing populations. However, artificial transport can be addressed. It is recommended that provisions be made to reduce dispersal during construction activities by imposing some minimal requirements. For state projects occurring in wetlands supporting _Phragmites_, procedures for treating spoil materials and machinery should be incorporated as a part of the planning process. In preliminary discussions, the State Highway Administration has been receptive to such a requirement and has expressed interest in developing a punch sheet for activities to address _Phragmites_ issues on construction projects. The development of such a list is made difficult by the great variation encountered in the federal, state, and county regulations governing wetlands.

The regulations governing activities in _Phragmites_ dominated wetlands is unclear. It is essential that these regulations be clarified for all levels of government. For example, the conversion of a _Phragmites_ dominated wetland to a more diverse wetland has been accepted as a mitigation for wetlands destruction at the federal level. This acceptance is contrary to a policy which emphasizes no net loss of wetlands and sets a dangerous precedent for future mitigation requirements. At the state level the role of the nontidal wetlands program is unclear. This group specifically regulates the destruction of vegetation in nontidal wetlands occurring outside of the critical areas, yet they have not required permits for _Phragmites_ control in some instances. The appearance of _Phragmites_ in both _The National List of Plant Species That Occur in Wetlands_ and _Vascular Plant Species Occurring in Maryland Wetlands_ would seem to require a review of _Phragmites_ control projects by the Nontidal Wetlands Program. County regulations are even more variable. A strong recommendation is made for Tidewater Administration to resolve these issues by establishing a coordinated policy among the various regulatory agencies involved in _Phragmites_ management issues.

Appendix A

REGULATION, METHODS AND MANAGEMENT STRATEGIES FOR THE CONTROL OF PHRAGMITESAUSTRALIS IN MARYLAND NONTIDAL WETLANDS.[1]

M. Stephen Ailstock[2]

ABSTRACT

Phragmites australis, common reed, is classified in the National List of Plant Species that Occur in Wetlands as a facultative, wetland perennial, emergent grass. This designation and Phragmites frequent appearance in Maryland wetlands makes control projects subject to review by numerous local, state and federal regulatory agencies. In an effort to accommodate the concerns of these groups, several methods for controlling Phragmites have been examined. These methods include excavation, flooding, black plastic, repeat harvesting and herbicides. Herbicides provide the best control of Phragmites populations and cause minimal alteration of the wetland habitat. None of the control techniques are completely effective as a single treatment and some are restricted by constraints of property ownership and topography to specific applications. Thus, Phragmites control in wetlands requires a careful assessment of site conditions and the development of comprehensive management plans which must conform to existing regulations governing activities occurring in these habitats.

Introduction

Phragmites australis (common reed) is a large 1.5-4.0 m, coarse perennial grass commonly found in brackish and freshwater wetlands (Brown and Brown, 1984; Fernald, 1970). Phragmites seeds profusely and spreads vegetatively by a vigorous system of rhizomes and stolons. Once established, the plant forms dense stands which may invade adjacent areas, thereby crowding out more desirable wetland species (Galinato and van der Valk, 1986; Szczepanska and Szczepanski, 1982; Weisser and Ward, 1982; Woodhouse and Knutson, 1982).

The large size, high reproductive potential, rapid growth rate, and preference for wetland habitats by Phragmites are the underlying basis for the differences of opinions held by many biologists and resource managers with respect to its ecological value, potential usefulness for environmental enhancement, and the need for control programs (Anderson and Ohmart, 1985; Kruczynski, 1983; Bibby, 1982; Eleuterius, 1974). Phragmites reduces natural plant diversity and it is not considered to be an important wildlife food or cover plant. However, Phragmites can be an important soil stabilizer and may have an application as a nutrient sink for treating both surface and wastewater (Brix, 1987; Gersberg et al., 1986; Kamio, 1985; Bonham, 1983). These positive attributes have led to several efforts for developing propagation and field establishment protocols (Stout, 1977; Eleuterius, 1974). Unfortunately, because Phragmites produces an abundance of propagules which can be dispersed by wind, water, animal vectors and machinery, programs for control and use are largely incompatible.

In the summer of 1987, aerial and ground reconnaissance of areas identified by the Maryland Department of Natural Resources as Phragmites problem sites were conducted to better evaluate the nature of Phragmites growth in the state's nontidal wetlands. A number of observations were made relevant to the establishment of an interim statewide Phragmites management policy.

[1]In: R.R. Bellinder (Editor), Proceedings of the Forty-sixth Annual Meeting of the Northeastern Weed Society Supplement, In Press.

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Most noteworthy were: 1) practices which cause soil disturbance promote Phragmites colonization; 2) Phragmites in undisturbed environments often appear as more or less circular colonies which suggests establishment can occur from a single propagule; 3) Maryland generally lacks the extensive acreage of Phragmites common in other coastal states, instead, monotypic stands occur in isolated wetlands or along stream borders; 4) Phragmites may provide some positive benefits through soil stabilization, nutrient removal and water filtration in both natural and created wetlands and; 5) monotypic Phragmites stands support fewer animal species than more diverse stands of wetland vegetation occupying similar habitats. Subsequent to this assessment, Maryland adopted a policy deterring the use of Phragmites in all wetland plantings.

Efforts were then placed on the development of management criteria for establishing a limited Phragmites control program to reduce the number of existing populations. Studies were devised to classify populations according to size, ecological role and characteristics affecting control options, to evaluate methods applicable for the control of these populations, and to develop management criteria for the implementation of control projects in Maryland. Concomitant with these studies, state legislation was enacted which provides additional protection to both tidal and non-tidal wetlands. This paper outlines the management recommendations made as a result of these studies and the current regulations governing the control of Phragmites in jurisdictional non-tidal wetlands.

Regulations

The designation of Phragmites australis in the National List of Plant Species That Occur in Wetlands as a facultative, wetland perennial, native emergent grass coupled with the frequent appearance of Phragmites in Maryland nontidal wetlands makes control projects subject to review by numerous local, state, and federal regulatory agencies. In 1984, the state's Critical Areas Act required county governments to devise regulations governing all land use activities within 1000 feet of the Chesapeake Bay and its tidal tributaries. The purpose of this legislation was in part to preserve wetland buffers occurring within these boundaries by restricting actions which would diminish their quality or quantity. No distinctions were made concerning the desirability of one wetland type over another. As a result, each county has devised unique regulations concerning Phragmites control in wetland habitats. These regulations are quite variable. When land use planners were queried on their counties Phragmites control policy one had "no conditions—never heard of it" and another responded "up until now we haven't required anything". In contrast, St. Mary's County requires a Critical Area Environmental Permit. Applicants must appear in person for a "rough filing permit" and provide a property deed or other proof of ownership. An accurate site plan is required in addition to all other applicable state or federal permits. The most exacting requirements for Phragmites control projects are found in Anne Arundel County. Here, applicants must submit a Buffer Management Plan which describes existing conditions, the plan of action and a 40 scale site plan. Proposed project sites are inspected by county planners who may require replanting of the site with other wetland plant species if Phragmites plants are removed. The posting of bonds until project sites are revegetated may also be required for permit issuance. The remaining counties have regulatory programs which are similar but less extreme than these examples.

In 1987, the state enacted a burden sharing program with the Army Corps of Engineers for regulating activities in all nontidal wetlands not protected through the Critical Areas legislation by establishing the Maryland Department of Natural Resources Nontidal Wetlands Program. This program extends wetland protection beyond that provided under Section 404 of the Clean Water Act. Specifically regulated, via permit, are activities which destroy or remove vegetation in nontidal wetlands. In projects where removal or destruction of wetlands vegetation also require federal approval, permits are automatically linked to a second state regulatory program, The Maryland Department of the Environment Standards and Certification Division which issues a water quality certification permit. Projects which employ the use of herbicides to control Phragmites lengthen the review and permit process. Herbicide application must be approved by the Maryland Department of the Environment Hazardous and Solid Waste Administration Industrial Point Source Waste Division. Prior to permit issuance, this application must be reviewed by the state's Fisheries Administration and the Department of Health and Mental Hygiene and may be reviewed by other state agencies at the request of any of the participating parties. Fortunately, the state's lengthy review process is efficient. Permits are often obtained within 10-14 days of the date of application.

Control Options

The diverse interests represented in the regulatory process have provided numerous suggestions for controlling Phragmites in wetlands. In evaluating these recommendations three criteria must be considered in developing control procedures: 1) the treatment must be effective for reducing Phragmites numbers; 2) it must encourage non-Phragmites plant recruitment and; 3) it must have minimal negative effects on the beneficial attributes of a wetland during the transition from a Phragmites dominated habitat to one supporting a variety of vegetative types.

The methods of control most frequently discussed during the various permit processes include excavation, flooding, repeat harvesting, black plastic mulch, and herbicides. The first four techniques are often recommended because they are perceived to be safe alternatives to the use of pesticides in the sensitive environment of wetlands. Contrary to this popular belief these "biological" controls are often ineffective for control and may be more damaging to wetlands than measures employing herbicides.

Excavating or flooding Phragmites wetlands as control measures are expensive and destroy the hydrology which existed prior to Phragmites colonization. By another name, these are dredge and fill operations. They are prohibited by the various regulatory agencies; however, they frequently find their way into discussions on Phragmites control for large projects in wetlands. Their applications are limited. For excavation to be effective soil must be removed to a depth greater than maximum rhizome penetration. In many wetland soils, rhizomes penetrate to depths of 60 cm. Excavation to this depth in hydric soils frequently results in the creation of shallow water habitats which cannot be restored as the diverse emergent wetland which existed prior to Phragmites colonization. Similarly, flooding, which requires the creation of impoundments, also significantly alters site conditions. Berms, which are used for containment, must be constructed outside the periphery of the Phragmites colony in areas of adjacent wetlands. Not only is the filling of these wetlands undesirable, the flooding of the impoundment alone is only marginally effective as a control measure for well established colonies. For flooding to be effective as a control measure consistent water levels must be maintained for long periods and the Phragmites plants must be cut prior to flooding to disrupt the aerenchyma channels which provide oxygen to the rhizosphere. These requirements are inconsistent with the goal of rapidly restoring natural wetland plant diversity.

The use of black plastic mulch has been routinely suggested as a viable alternative for controlling Phragmites populations. This technique is labor intensive and expensive. Harvest of the stems prior to installation of the mulch and subsequent installation is generally done by hand because of the small areas involved or because typical agricultural equipment used for mulch installation is unsuited to the softer marsh soils. Black plastic mulches are also ineffective for controlling Phragmites. First, regrowth of Phragmites from rhizomes easily penetrates 10 mil thick plastic mulches. Second, the mulch provides habitat for small animals, which attract foxes and raccoons. These large animals destroy the integrity of the mulching materials while in search of their smaller prey. Mulches which have been tested have lasted for as little as 48 hours and as much as 4 weeks depending upon mulch thickness. Neither of these times are adequate for control.

A final alternative to herbicides is repeat harvesting which starves the perennating buds of Phragmites. Harvesting of the photosynthetic stems to ground level must be consistent for a period of years depending upon the age and density of the phragmites colony. This repetitive cutting of large populations prolongs the transition period for wetland reestablishment. Selective cutting of Phragmites by hand can stimulate control through competition with emerging understory wetland species which are favored by this approach. Such selective cutting is however limited to very small populations or those initially encroaching on new areas.

The most effective and least damaging methods of controlling Phragmites is the use of herbicides. In Maryland, The only approved herbicide for Phragmites control is Rodeo, (Monsanto Inc., St. Lewis, Mo.) active ingredient isopropylamine salt of glyphosate, ((N-phosphonomethyl) glycine). Rodeo is a water soluble liquid which is mixed with a non-ionic surfactant and applied as a foliar spray (O'Sullivan et al., 1981). It is translocated from the point of foliar contact into the rhizome where it interferes with hormone metabolism (Fedtke, 1982; Moreland et al., 1981). Rodeo may be applied with any appropriate spray equipment or placed directly on plants with wick applicators (Monsanto Product Label).

Selectivity can be achieved by the choice of applicator and by restricting applications to the fall (Prasad, 1984; Buhler and Burnside, 1983).

Optimal selectivity in Maryland is obtained when application is made between October 1 and 15. At this time Phragmites tends to lodge but remain in a state of active growth. The dense canopy of Phragmites prevents spray from reaching desirable understory vegetation. Deciduous perennials which frequently form borders around Phragmites colonies are generally inactive at this time and thus are protected from the effects of the herbicide. In one study Simpson's Index of diversity increased form 1.52 to 3.48 in one year following a single aerial application (Ailstock, et al., 1989). During this period Phragmites was decreased by 84% while other wetland plants increased by 135%. In a similar study where the aerial application was followed by removal of the standing biomass through burning, Phragmites declined by 64% over the post treatment surveys while other species rose by 446%. Simpson's Index increased from 1.57 to 4.54 during the same period. These general trends have been observed at both sites for 3 years. Thus, herbicidal control best meets the conditions for Phragmites control programs; reducing Phragmites populations while stimulating recruitment of diverse wetland vegetation. In the past year this method of control has been routinely accepted by most participating regulatory agencies, providing the herbicide is used as a part of a comprehensive management plan.

Projects

Phragmites control projects in Maryland can be divided into four categories based upon the size of the Phragmites colony, its distribution with respect to property boundaries and current land use. These categories are: 1) small colonies occurring on a single property; 2) large colonies occurring on a single property; 3) colonies which extend over multiple properties and; 4) those populations existing in areas where preferred control methods are difficult to implement.

Small colonies of Phragmites occurring on a single property may be controlled in a number of ways depending on the size and density of the population. At densities of less than 10-15 stems/m2, where understory vegetation is present, satisfactory control can be achieved through repeat harvesting of the standing crop. The availability of sunlight to the understory plants encourages their growth and thus there is no loss of environmental function. At higher plant densities, but where some understory vegetation is present, chemical treatment coupled with a reduction in standing crop is needed. Rodeo can be applied as a spray with hand-held equipment or wiped directly on the plant with a contact applicator. Either of these methods protects understory vegetation from herbicide contact.

Removing the Phragmites standing crop by burning or cutting stimulates the growth of non-Phragmites plants.

The most difficult situation involving small populations on a single property is when the stand density is such that understory vegetation is lacking and the Phragmites is providing a valuable environmental benefit. This is a common occurrence on waterfront properties where Phragmites serves to stabilize shorelines but restricts waterviews. Control may be obtained by any of the described treatments; however, control will result in increased erosion if the protective function is not replaced. In the brackish environments, common in Maryland, replacement with Spartina patens and S. alterniflora is advisable to negate this impact.

Large colonies existing on a single property where no restrictions are placed on the methods of control are perhaps the easiest to manage. These populations are frequent on state lands and large farms located on the Eastern Shore of Maryland where they exist along stream borders, in semi-isolated nontidal wetlands or as individual colonies within natural marshes adjacent to tidal tributaries. Control under these conditions is best achieved by two successive, yearly, aerial applications of Rodeo followed by spot treatments with hand-held equipment. With this treatment, recovery of the wetland is rapid with minimal loss of function during the transition period. Burning, which accelerates the recruitment of other species, is feasible at these sites and is often included after the first herbicide application.

Population of Phragmites extending over several properties are present in many urban areas. These colonies may be as large as 10-30 acres or quite small, less than 1/4 acre. Under these conditions effective control is difficult and a sensitive issue unless agreements can be reached between property owners. Agreements, which are necessary because of the invasive nature of Phragmites, are seldom reached as a result of concern over control procedures and the perception that Phragmites is valuable wetlands species. Without these agreements single property control becomes an annual preventive maintenance program which is only marginally effective and expensive. Cases of this type are currently being explored in the judicial system. Until these ownership issues are resolved in this forum, concurrent control for populations on multiple properties remains problematic.

Phragmites may also occur in environments where the implementation of preferred control methodologies are difficult for reasons of topography, location or existing land use. For example, the United States Navy is in the process of restoring 30 acres of Phragmites marsh at its Transmitter Facility in Anne Arundel County, Maryland. This facility provides communication to submarines worldwide through a complex array of elevated and subsurface antennas. Aerial application is thus precluded as is the use of applicators capable of compacting the hydric soils which would damage the underground antenna complex. Restrictions on control may result from the presence of endangered species. The beachfront of the Columbia Liquid Natural Gas complex in Calvert County, Maryland, supports populations of the endangered tiger beetle, Cicindela dorsalis. Phragmites, which has invaded the property, colonizes the sand beach habitat required by the beetles. In this instance, protection of the beetles is dependent upon eradication of the Phragmites. Obtaining the necessary permits to apply herbicides under these conditions was a long and arduous process. These projects are described in more detail in a subsequent paper.

Management Plans

Despite the procedural variations between the regulatory agencies governing Phragmites control programs in Maryland the components of successful management plans are remarkably consistent. Management plans must provide a rationale for controlling Phragmites, evaluate existing site conditions which may affect control , describe the procedures to be used for control and to identify all jurisdictional requirements.

Management plans should:

1. Identify the management objectives of the site to be treated.
2. Determine whether site characteristics and adjacent land use are compatible with the management objectives.
3. Evaluate the site for potential recruitment by Phragmites following treatment.
4. Evaluate the site to determine if Phragmites control by itself is adequate to achieve the desired management objectives.
5. Determine whether site characteristics and adjacent land use are compatible with the treatment protocols necessary for control.
6. Conduct an on site evaluation of resident biota and identify ecological function of the Wetland.
7. Identify all permits and reviews which must be obtained for treatment of the site.
8. Define all activities needed to meet project objective.
9. Establish a time line for all activities necessary for site development
10. Secure all funding, permits and cooperative agreements necessary for complete project implementation.

Projects which have adhered to these guidelines have provided an acceptable method for controlling Phragmites while restoring diversity in wetland environments. The net affect in Maryland has been to improve the quality of wetlands in a manner consistent with regulations governing wetland modifications.

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Appendix B

ALTERNATIVES TO AERIAL HERBICIDE APPLICATION FOR THE CONTROL OF PHRAGMITES AUSTRALIS IN NONTIDAL WETLANDS.[1]

M. Stephen Ailstock[2]

ABSTRACT

Aerial application of the herbicide Rodeo is a preferred method of controlling large populations of Phragmites australis, common reed, in both tidal and nontidal wetlands. In Maryland, populations of common reed frequently exist which cannot be treated in this manner. This paper examines two case studies where Rodeo has been applied to both large and small Phragmites populations by methods other than aerial application.

The first study was conducted at the U.S. Naval Transmitter Station, Annapolis, Maryland. This facility provides a complex array of elevated and subsurface antennas. The antenna system precludes use of aerial applications or land applicators capable of compacting the hydric soils which support Phragmites and covers 40 acres of the complex. A radiarc sprayer pulled by a diesel powered Bombadeer tractor having a 6 lb/sq in footprint was used to deliver herbicide. This system provided excellent delivery; however, control was limited to those areas outside of the vehicle tracks. Presumably, damage to the plants prevented translocation of Rodeo to the perennating buds of the treated plants. A second study was undertaken along the beachfront of the Colombia Liquid Natural Gas Complex in Calvert County, Maryland. At this site, Phragmites has invaded one mile of sand beach habitat required by the endangered tiger beetle Cicindela dorsalis. Following a lengthy regulatory review process, back pack spray units and wick applicators were used to apply herbicide in an effort to contain Phragmites expansion.

[1]In: R.R. Bellinder (Editor), Proceedings of the Forty-sixth Annual Meeting of the Northeastern Weed Society Supplement, In Press.

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