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

YEAR ONE

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# ENVIRONMENTAL IMPACTS, TREATMENT METHODOLOGIES AND MANAGEMENT CRITERIA FOR ESTABLISHMENT OF A STATEWIDE POLICY FOR THE CONTROL OF THE MARSH PLANT PHRAGMITES YEAR ONE

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## INTRODUCTION

*Phragmites australis* (common reed) is a large, coarse perennial grass 1.5 - 4 m in height. While primarily found in brackish and freshwater wetlands where it grows at and above mean high water, the plant is also common in moist uplands and the dune systems of Atlantic coast barrier islands (Brown and Brown, 1984; Fernald, 1970; Gleason and Cronquist, 1963). *Phragmites* seeds profusely and spreads vegetatively by a vigorous system of rhizomes and stolons. Once established, the plant forms dense stands and may invade adjacent areas crowding out more desirable wetlands species and reducing the overall species diversity of the affected system (Galinato and van der Valk, 1986; Szczepanska and Szczepanski, 1982; Weisser and Ward, 1982; Woodhouse and Knutson, 1982; Weisser and Parsons, 1981). Since it is a native plant, its status as a "pest" is probably related to its ability to survive changes induced by human activity impinging negatively on wetlands.

The large size, high reproductive potential and rapid growth rate of *Phragmites* are the underlying bases for the differences of opinions held by biologists and resource managers with respect to the plant's ecological value and potential usefulness for environmental enhancement (Anderson and Ohmart, 1985; Eleuterius and Gill, 1983; Kruczynski, 1983; Bibby, 1982). *Phragmites* reduces natural plant diversity and is not considered to be an important wildlife food or cover plant. However, it can be an important soil stabilizer and may have application as a nutrient sink for treating wastewater prior to release (Brix, 1987; Gersberg et al., 1986; Kamio, 1985; Bonham, 1983). These potential uses 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 (Smith and Kadlec, 1983; Best et al., 1981; Izatt, 1979; Linedale, 1978; Kasasian, 1977; Nir, 1976) . This incompatibility has led to three divergent policies of Phragmites management - eradication, control and tolerance.

To better evaluate the extent of Phragmites growth in Maryland, aerial reconnaissance of areas identified by members of the Department of Natural Resources as "problem" sites was conducted in the summer of 1987. A number of observations were made relevant to the establishment of a statewide Phragmites management policy. Most noteworthy were:

1. Practices which cause soil disturbance promote Phragmites colonization.

2. Phragmites in undisturbed areas often appear as circular colonies suggesting a single-parent origin.

3. Maryland, with the possible exception of Cecil County and Kent Island, generally lacks extensive acreage of _Phragmites_ common in other coastal states. Dense monotypic stands are more commonly found in isolated pockets or along stream borders. This distribution often poses problems for implementing preferred methods of control.

4. Management schemes which do not adhere to recommended control practices and do not include subsequent management for replacement species recruitment are generally ineffective.

5. _Phragmites_ provides some positive benefits through soil stabilization, nutrient removal and water filtration.

Based upon these observations, two studies were initiated by Anne Arundel Community College through support from the Maryland Department of Natural Resources, Tidewater Administration, Coastal Resources Division. The objectives of the first study were to:

1. Measure the effectiveness of recommended control measures and their ecological impacts under conditions typical to Maryland.

2. Determine ecological uses of monotypic _Phragmites_ stands.

3. Identify the factors influencing the recruitment in treated areas by species other than _Phragmites_.

4. Develop a predictive indicator for rates of vegetative recruitment following herbicide applications.

5. Provide recommendations for site evaluation in the establishment of <u>Phragmites</u> control programs in moist uplands and non-tidal wetlands.

The second study, to be conducted in 1989, is an extension of the first. The specific objectives of this study are to:

1. Measure the expansion rates of isolated <u>Phragmites</u> colonies in a tidal wetland. (Greens Island Wildlife Management Area).

2. Measure the decline in species diversity in and around these colonies.

3. Test the effectiveness for controlling these populations by the use of Rodeo in hand-held direct contact herbicide applicators.

This combination will provide the information necessary to finalize the <u>Phragmites</u> Management Policy for the State of Maryland.

## SITE SELECTION

All state properties designated for herbicide control of <u>Phragmites</u> in the fall of 1987 were evaluated as potential study sites. Final selection was restricted by an inability to secure EPA approval for applying Rodeo in tidal wetlands .

at the Greens Island Wildlife Management area, the presence of regionally threatened species at the Grove Neck Wildlife Sanctuary and prior history of attempted control at the Courthouse Point, a state-managed Army Corps of Engineers dredge spoil property.

Three study sites were established at the Army Corps of Engineers, Stemmers Run Wildlife Management Area in Cecil County, Maryland (Fig. 1). Two were modified non-tidal wetlands and the third was a disturbed upland area. The non-tidal sites were natural non-tidal wetlands prior to the development of the property as a dredge spoil repository in the 1960's. These two closely spaced, similar sites are located outside of the drainage ditch which surrounds the spoil impoundment. One wetland, identified as the "V" site, was designated for burning following herbicide application. The second, identified as the "W" site, was designated to serve as an unburned control. The upland site, established directly on the containment berm, was divided in half to evaluate the effects of burning. All sites were dominated by stands of *Phragmites* and received identical herbicide treatments.

Three site monitoring periods were scheduled for the first year. Pre-treatment inventories of plants and sediment collections for analysis of soil macroinvertebrates and seed stocks were made 10-87. Additional sampling was conducted 8 (6-88) and 12 (10-88) months post-treatment with one exception. In the spring of 1988, the Army Corps of Engineers began an extensive project to reinforce the spoils containment berm. This work, which was necessary to maintain the integrity of the berm for additional spoil treatment, destroyed the upland study site. As a result only data collected pre-treatment is included in this study.

## TREATMENT PROTOCOL

### Herbicide Application

Rodeo (Monsanto Co., St. Louis, MO., active ingredient: isopropylamine salt of glyphosate, N-(phosphonomethyl) glycine) is the herbicide of choice for controlling Phragmites in aquatic ecosystems (Nir, 1976; Nir and Raz, 1985; Bucsbalm et al., 1985; Sedon, 1981; Riemer, 1976; Hodkinson, 1974). This product, a water soluble liquid, mixes readily with water and nonionic surfactant (O'Sullivan et al., 1981). It is applied as a foliage spray for the control of most herbaceous plants. Rodeo is translocated through the plant from the point of foliage contact to and into the root and rhizome system. The mode of action of the compound is primarily through the interference with plant hormone function (Fedtke, 1982; Moreland et al., 1981).

For the control of Phragmites the recommended application rates of 4 pints per acre for a broadcast spray (or a 1 1/2 percent solutions for hand held spray equipment) were used. For aerial application, the broadcast rate with surfactant was adjusted with plus 3 - 20 gallons of water as a carrier (Monsanto Product Label, 1988; Evans, 1987; Sandberg et al., 1978; Riemer, 1973).

A fall application was made because of the abundance of foliage for absorption and because some selectivity may be achieved if Rodeo is applied at a time when deciduous perennials are entering dormancy (Prasad, 1984; Buhler and Burnside, 1983).

Rodeo was applied to all sites on October 15, 1987 from a Bell 47 Soloy helicopter. This craft had a boom width of 32 feet with an effective spray swath of 40 feet. The sprayer was turbine powered. A volume trigger timer in the cockpit with clock calibration was used to regulate spray rates and to continuously monitor flow. To avoid drift, application was restricted to periods where wind speeds were less than 5 mph. A similar system was used during the second application on October 15, 1988.

This system proved very effective. Uniformity of contact, as determined by visual inspection was excellent averaging 5-7 droplets per exposed leaf surface. Drift to areas outside of the designated spray areas was undetectable.

Burning

The upland and one of the non-tidal wetland sites were burned in February 1988. The necessary permits were obtained and the burn conducted by Maryland Forest and Parks personnel. Burning was effective in most areas, reducing standing crop to 1/16 to 1/8 inch of fine ash. Burning was not successful in areas adjacent to standing water.

## EXPERIMENTAL OBJECTIVES

1. Survey pre- and post-treatment use of *Phragmites* by mammals and terrestrial invertebrates.

2. Monitor pre- and post-treatment changes in the density of plants and macroinvertebrate terrestrial invertebrates.

3. Determine the availability of seed stock in site sediments.

4. Evaluate changes in the physical environment associated with the treatment program.

## METHODS

Pre-treatment use of the study sites by mammals and terrestrial invertebrates was determined by sightings, tracks, nests and scats.

Quadrats, 3.16 m long by 0.32 m wide, arranged in belt transects, were set up to monitor changes in the density of plants and macroinvertebrate terrestrial infauna. Transect locations were selected around the periphery of the *Phragmites* stands to evaluate differences in sunlight exposure, and border and canopy effects within and among the three study sites (Fig 2.). Transects began 1 m outside of dense *Phragmites* in order to sample adjacent vegetation. At each location transects extended into the stand until 5 consecutive belt transects included only *Phragmites* in the pre-treatment survey. The total number of quadrats for all sites was 147.

These transect locations were also used for collecting soil samples used to inventory macroinvertebrate terrestrial infauna and seed stock. Core samples, each a total volume of 100 cm3, were collected approximately 6 inches outside the midpoint of each transect. Samples were returned to the lab, and those intended for the inventory of sediment seed stock were stored in refrigerated chambers at 4 C for 100 days. This was done to overcome stratification requirements common to native plants in temperate environments. Those used for invertebrate analysis were placed in Berlase funnels and extracted for 4 days. Invertebrates were stored in 70% ethanol prior to counting.

The cold treated soil samples used to inventory seed stock were spread over a sterilized commercial potting soil in 1/2 gallon containers and were covered with 1/2 inch of vermiculite. Containers were bottom watered throughout to maintain uniformly high soil moisture. Plants were harvested after growth had occurred which was sufficient for precise identification.

Physical parameters of the site were measured in areas 10 m from transect locations to avoid problems associated with matting of vegetation. Temperature, relative humidity and light gradients were determined for each sites in areas of densest Phragmites growth.

Initially an impounded site was selected which insured water availability irrespective of seasonal precipitation. This site was located at the Grove Neck Wildlife Management Area in Cecil County, Maryland and was scheduled for Phragmites treatment. Ground truthing identified the presence of 2 plant species which are currently species of concern in the state, American Lotus and Sagittaria calycina. The presence of these species precluded Phragmites spraying at the site. The alternative non-tidal sites used in these studies were fed by 3 intermittent sources and typically have standing water on site. Unfortunately the record droughts resulted in zero on site water availability which eliminated the possibility of water column residue testing.
Soil moisture data is not presented because of the record drought recorded for the 1988 growing season.

## RESULTS

Survey pre-treatment and post treatment use of Phragmites by mammals and terrestrial invertebrates.

### Mammals

Phragmites stands at the wetland sites are frequented by whitetail deer, raccoon and muskrats. Trails through the stands are abundant and well used by these species. With the exception of muskrat no evidence of feeding activity was observed, thus the primary function appears to be one of cover. The upland site was also used by these species to a lesser degree. Some lack of use may be attributed to the moderately heavy presence of people and machinery at the upland site.

Birds

No nests were observed in areas of dense Phragmites. Bird use was minimal and was primarily restricted to short term resting by perching birds flushed from surrounding cover. Species observed were red-winged blackbirds, grackles, sparrows and finches.

Reptiles and Amphibians

Evidence for Phragmites use by reptiles and amphibians was minimal. The few sighting were of short duration which precluded accurate identification.

Insects and Spiders

Insects and spiders were the predominant forms associated with above ground biomass. Most were found in the inflorescences at the top of the plant canopy or the surface of soil leaf litter. Areas of dense stem growth supported relatively few species. This may be attributed to problems for the study of access and sampling in this type of cover.

Monitor pre- and post treatment changes in the density of plants and macroinvertebrate terrestrial invertebrates.

Total number of individual plants, pre- and post-treatment for all belt transects at each wetland study site is given for plants in Figures 3-5 and for soil macroinvertebrates in Figures 6-8. Representative examples of species inventoried for quadrats having high, moderate and low initial diversity are given in Figures 9-20. For the transects in this study these data indicate:

1. Average pre-treatment density of Phragmites was slightly lower in the W site (11.3 individuals/quadrat) than in the V site (15.1 individuals/quadrat).

2. No significant change in the number of plant species or macroinvertebrate taxa was observed between between the 8 and 12 month post-treatment inventories.

A summary of changes in vegetation 1 year after treatment is given in Table 1.

1. Phragmites was reduced by 83.5% at the unburned W site and by 64.5% at the burned V site.

2. Plant species other than Phragmites increased by 404% at the W site and by 546% at the V site.

3. Total number of all individuals decreased by 16% at the W site but increased by 142% at the V site.

Determination of Simpson's Index of Diversity (Table 2) showed:

1. A significant increase in plant species diversity at both the W and V sites at 8 and 12 months post-treatment;

2. Recruitment of vegetation following herbicide application was enhanced by burning.

3. Neither the application of Rodeo nor burning had a significant effect on the numbers and diversity of soil macroinvertebrates.

Determine the availability of seed stock in site sediments.

1. Seed stock were not representative of the types of vegetation present at the site prior to the wetland disturbance associated with the establishment of the dredge spoil.

2. Of the 12 species represented by seed stock in the pre-treatment soil collections from the W site, only 5 were inventoried on the pre-treatment W site. Of the 13 species represented by seed stock in the pre-treatment soil collections from the V site, only 7 were inventoried on the pre-treatment V site.

3. Of the 12 species represented by seed stock in the pre-treatment soil collections from the W site, only 7 were inventoried on the post-treatment W site. Of the 13 species represented by seed stock in the pre-treatment soil

collections from the V site, only 10 were inventoried on the post-treatment V site.

Evaluate changes in the physical environment associated with the treatment program.

Changes in temperature, relative humidity, and light transmission at pre-treatment and 1 year post-treatment for both sites are given in Table 3. Not surprisingly, Phragmites shades the soil and decreases temperature and light transmission while increasing relative humidity of the ambient air. When compared with the unburned control only light transmission was shown to be significantly affected at the V site. Improved light penetration caused by burning is a major factor for the enhanced recruitment at this site.

PROJECT SUMMARY

Determine ecological uses of monotypic Phragmites stands.

Phragmites at the Stemmers Run test sites serves as cover and resting areas for a variety of animals. This function can be maintained at the sites by recruiting vegetation which will ultimately reach comparable heights and densities During the transition phase, however, the availability of cover was diminished, especially at the V site where burning was added as a component of control. At this location other forms of cover are abundant and this temporary loss is not seen as damaging.

Measure effectiveness of recommended control measures and their ecological impacts under conditions typical to Maryland.

The objective of a Phragmites control program is twofold; to eradicate the Phragmites and to optimize recruitment of other plant species. This combination is desirable to minimize any loss of environmental function attributed to Phragmites prior to treatment. Treatment efficiency must thus be evaluated in light of these two goals.

At the burn site (V), there was reduced control efficiency, 64.5% vs. 83.5%, but greater diversity, Simpson's Index, 4.54 vs. 3.48. The decrease in control may be attributed to the same factor responsible for the increase in diversity. The reduction in standing crop, which favors recruitment of non-target species also favors seedling recruitment of Phragmites. The potential for site recruitment by Phragmites seedlings was shown to be high in the analysis of sediment seed stock. Interestingly, total vegetative density at the burned site increased by 142% and decreased by 16% at the unburned control. This suggests that despite reduced control efficiency, burning may have considerable value for maintaining ecological function during the critical transition period from Phragmites to other types of vegetation.

A more complete determination of how these two seemingly contradictory findings can be used in evaluating treatment protocols will require careful site evaluation, as planned, over the next two years.

Identify the factors influencing the recruitment in treated areas by species other than *Phragmites*.

The two principle physical factors limiting plant recruitment in dense stands of *Phragmites* are the availability of unoccupied soil and light. In the densest stands measured, the total number *Phragmites* stems averaged $160/m^2$, of which only 30 were living. Such densities severely limit soil space suitable for supporting colonization by other plants. Also, in stands of such density, light transmission to the soil level may be limited by up to 82%. Site burning, which has been shown to enhance recruitment diversity, improves the availability of both of these limiting factors and provides a partial explanation for the increased diversity found at the V site (Cerazzi, 1986; Shay and Shay, 1986; Best et al., 1982; Shay and Thompson, 1981).

Develop a predictive indicator for rates of vegetative recruitment following herbicide applications.

Pre-treatment plant inventories and analysis of pre-treatment soil sediments for seed stock were tested to develop a predictive model for plant recruitment at the treatment sites. Pre-treatment plant inventories were 69% (W site) and 64% (V site) effective as predictive indicators, while seed stock analysis was 58% and 77% effective respectively. Thus, both methods are useful as predictive indicators for evaluating recruitment potential in the development of a management strategy for a given property. Plant inventories are less costly and require less time, but are limited to the growing season. Soil seed stock analysis would be justified when time constraints preclude site evaluation during the growing season.

Provide recommendations for site evaluation in the establishment of *Phragmites* control programs in moist uplands and non-tidal wetlands.

## RECOMMENDATIONS

### Treatment Protocols

Regulations governing application rates, uses and restrictions for herbicides are a part of the label instructions provided by the manufacturer. Adherence to these label instructions is required by law; however, some flexability exists concerning application times, procedures and ancillary treatments.

The protocol used for this study and described in the methods provides good control of *Phragmites* for larger acreages where aerial application is an option. The key components of this protocol are the accurate application of the herbicide and surfactant at the approved rates, the timing of application to obtain some degree of selectivity, the removal of the standing crop by burning and the series of follow-up treatments. In other environments, modification of one or more of these components may be necessary.

Accurate application of Rodeo is made difficult by the plants' height and the hydric nature of the soils where it is commonly found. Aerial application, which circumvents these problems, is a convenient method for treating large populations of Phragmites. Ground applicators amenable to large spray operations requiring high spray booms on wet soils are available and have been successfully used on sugarcane plantations; however, these are not readily available in Maryland. Further this type of equipment would be extremely difficult to transport between sites on properties interrupted by streams. An option which should be evaluated for upland sites is the use of conventional ground applicators having adjustable boom heights. These may prove useful for treating road borders or the berms on impoundments constructed for waterfowl when aerial application is precluded because of drift hazzards or problems of access.

For smaller populations or where drift is unacceptable, hand-held applicators may be preferable. Small dense colonies can be successfully treated with backpack spray applicators. The limitation to this technique is the applicator's ability to direct spray to the interior foliage. Two options which overcome this problem are to cut the Phragmites during mid summer to sufficiently reduce plant height for an effective fall application or extend the treatment over a number of years, treating only the peripheral plants in a particular season. The former method seems preferable but has not been fully tested. A second type of applicator which works well when Phragmites has an abundant understory of desirable species is a contact applicator. These applicators have a reservior for holding the herbicide solution which is connected to a wick system. The chemical is literally wiped on the target plants; thus there is no danger of contact with plants being recruited to the site. This method of application, because of its simplicity is well suited to the homeowner interested in treating Phragmites.

Time of application is used to impart selectivity in Phragmites control programs and to optimize translocation of the active ingredient to the rhizomes. The active ingrediant of Rodeo, glyphosate, is toxic to most plant species; however, for the chemical to be effective it must be absorbed through the foliage and then translocated to other tissues of the target plant. One of the reasons a fall application is encouraged, is that unlike many other types of vegetation, Phragmites remains active longer. As a result, it remains susceptable to the compound when other plants, by entering dormancy, are not. This minimizes the dangers of drift and avoids killing more desirable species. In some applications, where accurate delivery is ensured, Rodeo could be applied safely at any point during the growing season. An example of such an application would be spot treatments using hand-held contact applicators.

The removal of the standing crop of Phragmites in dense colonies is advisable for rapid recruitment of desirable plant species ( see Table 1 and results). Removal exposes seeds to sunlight and provides a competitive growth environment. For dense stands, burning is the preferred method because erect stems and the thick layer of Phragmites thatch that accumulates above the soil surface are removed (Van der Toorn and Mook, 1982). Under these condition, mowing without biomass removal would provide a soil mulch which would interfer with recruitment by other plants (Vestergaard, 1985; McManus and Alizai, 1983; Mook and Van der Toorn, 1982; Polunin, 1982). In less dense stands where thatch accumulation is not a problem mowing or hand harvesting is effective.

Irregardless of the primary treatment used for the control of Phragmites, some measures must be taken to insure complete eradication and prevent Phragmites recruitment. Spot treaments of individual plants or clusters not killed in the initial control program is sufficient to remove remnant populations which persist along the borders of the treatment site. At these locations, herbicide application is often less effective because of interference by woody plant canopies (where they occur) or because the plants reside just outside of the original treatment area.

Preventing new recruitment is more difficult. Phragmites seed stock in the soil may be plentiful. Seeds may also be introduced by wind and animal vectors. In this study, it was shown that these seeds will grow if exposed to a nonlimiting environment (see results). The best method for discouraging this type of recruitment is to rapidly establish other forms of vegetation which serve to outcompete seedling growth. In some areas, natural seed reserves of desirable species may be adequate for this purpose. When this is not the case, effort should be made to vegetate exposed soils. This recommendation extends to marsh manipulations in areas where Phragmites is not an immediate problem but where recruitment potential is high. For example, during ditch and berm construction in moist soils stabilization with desirable vegetation should be a routine activity. This not only serves to minimize recuitment but also curbs erosion. In some applications temporary cover with annuals has been used to minimize Phragmites recruitment until more permanant stabilization plans can be implemented.

## Management Policy

### General

The objectives of this particular study were to measure the effectiveness of recommended Phragmites control procedures and to evaluate the effects of these procedures on ecosystem composition. The establishment of a management policy for _Phragmites_ requires additional factors to be considered. Most important is the public's perception of the plant and ownership as it affects implementation of control strategies. The perception of the plant by the the general public is favorable. _Phragmites_ has a number of ornamental features which, with its size, makes it one of the more recognizable wetland species. Given the attention currently placed on the preservation of wetlands vegetation, the policy must be thorough, anticipating concerns to be raised over _Phragmites_ control.

Four situations are common in the state which impact _Phragmites_ control. In most instances _Phragmites_ will have a minimal understory of mixed vegetation. These are:

1. small colonies occurring on a single property.

2. populations existing on multiple properties.

3. populations existing in areas, often urban, where preferred control methodologies are difficult to implement.

4. large populations occurring on a single property.

Following are recommendations for _Phragmites_ control and/or descriptions of issues which must be reconciled in the _Phragmites_ control policy for each of these situations.

1. Small colonies occuring on a single property.

Small colonies of Phragmites occurring on a single property may be controlled in a number of ways depending upon the size and density of the population. At densities of less than 10-15 stems/m2, where understory vegetation is present, satifactory control can be achieved through repeated pruning of the standing crop. Over time, this effectively starves the overwintering rhizome. The availability of sunlight to 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 for herbicide contact. Application rates should be those recommended by the manufacturer. Standing crop can be removed by burning or cutting depending on local fire regulations. Again, under these conditions, control of Phragmites will stimulate growth of understory vergetation.

The most difficult situation involving small populations on a single property is when the stand density is such that understory vegetation is lacking. This is a common occurence on waterfront properties where Phragmites serves to stabilize shoreline but restricts waterview. 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 brackish environments replacement with Spartina patens and S. alterniflora will negate this impact.

2. Populations existing on multiple properties.

Populations of Phragmites extending over several properties are common in urban areas. The 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. The fundamental problems are the invasive nature of Phragmites, the perception of Phragmites as a valuable wetland plant and objections raised over control procedures.

Since the plant is an invasive species control of only a portion of the population will result in rapid regrowth in the treated site. Without a cooperative agreement over control issues, partial treatment is inadvisable. Cases of this type are currently being examined in the judicial system.

3. Populations existing in areas, often urban, where preferred control methodologies are difficult to implement.

Phragmites may occur in environments where the implementation of preferred control mthodologies are precluded by topography, land use, or lack of cooperative agreements between landowners. An outstanding example of this situation is found along the Route 50 corridor, near Kent Narrows, in Queen Annes County. At this location the *Phragmites* is relatively extensive. It is distributed over a number of properties in tidal, non-tidal and upland environments. In this example, a control protocol needs to be inclusive but could be tailored to the individual properties and habitats. Such control would be expensive, requiring different methods of herbicide application and removal of standing crop. In additon, because of the natural richness and diversity of the area, mitigation measures to replace losses in ecological function would be desirable. This will be the most difficult situation to define in the management policy. A mechanism for flexible site by site analysis will be required to tailor control to the restrictions and management objectives of the particular location.

## State Lands

The control of large populations of *Phragmites* on state properties or private farms is an expensive, multiple year, labor intensive endeavor. These populations are commonly found along stream borders, in semi-isolated nontidal wetlands or as individual colonies existing in natural marshes. Where size warrants, control can be successful if the treatment protocols used in this study are followed (see methods). However, the ability to control *Phragmites* on these properties is only one of several factors which must be considered in establishing a management plan. Such a plan is advisable given the magnitude and importance of these areas. The following is a sequential checklist of the parameters which should be considered by land use planners in evaluating sites for a *Phragmites* control program. A brief rationale is given to illustrate the importance of each parameter.

1. Identify the management objectives for the site.

Identification of management objectives are central to the success of any program concerned with habitat manipulation. This is especially true for the establishment of a *Phragmites* control program because the plant has value for wildlife cover, soil stabilization and water treatment.

For example, populations of *Phragmites* growing within a dredge spoil impoundment were targeted for treatment in a 1987 control program. In this environment *Phragmites* is beneficial, serving as both a nutrient sink and a mechanical filter. Its destruction would have resulted in a loss of treatment efficiency, since it is unlikely that other forms of vegetation would be recruited in the area until water levels were stabilized. Clearly, in this instance, control would have been inconsistent with immediate management objectives.

2. Determine whether site characteristics and adjacent land use are compatible with meeting management objectives.

Conversion of areas of mixed wetlands to monotypic *Phragmites* stands is often concomitant with changes in adjacent land use. These changes may preclude a return of the site to a fully functioning wetland serving as high quality habitat. Control of *Phragmites* for the purpose of restoring habitat value should be carefully evaluated to avoid superficially attractive mitigation proposals.

3. Evaluate the site for recruitment potential by *Phragmites* following treatment.

In many areas *Phragmites* is found along shorelines where it serves as a soil stabilizer. Permits to remove *Phragmites* for reasons of aesthetics or because of the need to modify the shoreline in construction require some type of mitigation, often in the form of a replacement planting with more desirable wetland vegetation. Unless some management plan is directed toward the prevention of the vegetative spread of *Phragmites* from adjacent properties, these mitigation efforts will not be successful.

4. Evaluate the site to determine if *Phragmites* control by itself is adequate to achieve the desired management objectives.

*Phragmites* invasion is often associated with wetland modification. These activities may change drainage patterns and drastically alter soil hydrology. The return of such an area to a mixed wetland will require more than the removal of *Phragmites*. It will require restoration of soil hydrology to levels compatible with a diverse wetland community. Restoration may require reconstruction of historic drainage patterns, land excavation and/or installation of some form of water control structure. These activities compound the difficulty of project planning because of the need for extensive departmental reviews and approvals.

5. Determine whether site characteristics and adjacent land use are compatible with the treatment protocols necessary to effectively control *Phragmites*.

Current treatment protocols for *Phragmites* strongly recommend the inclusion of some measure to reduce standing biomass following herbicide application. The methods most commonly suggested are mowing or burning. In many areas mowing is difficult because of soil characteristics and burning is objectionable because of interferences with human activity or for reasons of safety. State foresters are an excellent resource in evaluating sites for the applicability of these methods at a given site.

6. Conduct an on site evaluation of resident biota and existing ecological function.

In Maryland, *Phragmites* is most often found mixed with other wetland plant species. In 1987, ground truthing of potential treatment sites has prevented herbicide application to at least 2 regionally threatened (B1 on the Maryland State Heritage Program list) species, Nelumbo lutea, American Lotus and Sagittaria calycina, Deep Water Duck Potato, at one location. (See Appendix I)

7. Identify all permits and reviews which must be obtained for treatment of the site.

Federal, state and local departments involved with regulating areas capable of supporting Phragmites are numerous and diverse. At the time this project was initiated, there was a general lack of information exchange between departments concerning the types of approval needed to enact a Phragmites control program on a given property. Although this problem has been greatly alleviated, an interagency orientation/information exchange meeting is encouraged.

8. Establish a sequence of activities needed to meet project objectives.

The control of Phragmites is a multiple year effort which may be only one component of a total site development plan. Implementation of the plan requires coordination among diverse activities. Further, the preferred sequence of these activities will influence the effectiveness of control and the avoidance of the reinvasion of Phragmites following treatment. Interruptions or inappropriate sequencing in the process will result in a significant loss of both control and investment.

9. Establish a time line for all activities necessary for site development.

In manipulating biotic systems, seasonality is the driving force dictating activities. Reconciling biological requirements with the multitude of potential implementation inputs associated with habitat modification demands precise planning.

10. Secure all funding, permits and cooperative agreements necessary for project implementation.

Long term uninterrupted commitment is required for projects involving Phragmites control. Securing funding, permits and cooperative agreements is a safeguard against diversions from management and control strategies.

TABLE 1: Summary of changes in vegetation 1 year after treatment with Rodeo at the burned and unburned non-tidal study site. Percent change is calculated from pretreatment samples, a (-) indicates a decrease in the total numbers of individuals for the posttreatment survey.

Individuals Sampled

| | 1 Month Pretreatment | | 12 Months Posttreatment | | Relative % Change | |
|---|---|---|---|---|---|---|
| | Burned | Unburned | Burned | Unburned | Burned | Unburned |
| Phragmites | 878 | 691 | 312 | 114 | -65 | -84 |
| Other species | 231 | 145 | 1262 | 586 | +546 | +404 |
| Total | 1109 | 836 | 1574 | 700 | +142 | -16 |

TABLE 2: Simpson's Index of Diversity for plant species and soil macroinvertebrate taxa inventoried at *Pharcmites* test sites located at The Stemmers Run Wildlife Management Area, Cecil County, Maryland. Treatment consisted of a single aerial application of 4 pints per acre Rodeo on 15 Oct. 1987. The "V" non-tidal wetland was burned 4 months after treatment.

| Plant Species | Pre-treatment 10 Oct. 1987 | 8 Months Post Treatment | 12 Months Post Treatment |
|---|---|---|---|
| "W" Non-tidal Wetland | 1.43 | 3.48 | 3.48 |
| "V" Non-tidal Wetland | 1.57 | 4.54 | 4.54 |
| Upland | 4.06 | N.A. | N.A. |

| Soil Macroinvertebrate Taxa | Pre-treatment 10 Oct. 1987 | 8 Months Post Treatment | 12 Months Post Treatment |
|---|---|---|---|
| "W" Non-tidal Wetland | 1.82 | 1.99 | 2.01 |
| "V" Non-tidal Wetland | 1.37 | 1.72 | 1.75 |
| Upland | 1.84 | N.A. | N.A. |

TABLE 3: Percent change in temperature, relative humidity and light transmission at the soil level from values obtained 2 M above (approx. height of pretreatment plant canopy). Percent change is calculated from pretreatment sample values, a (-) indicates a decrease in the parameters.

| | Percent Change | | |
|---|---|---|---|
| | Pretreatment | Posttreatment Burned | Posttreatment Unburned |
| Temperature | -12.0 ± 3.0 | 0 ± 0.1 | -5 ± 0.1 |
| % Relative Humidity | +50 ± 9.0 | +1 ± 0.4 | 0 ± 0.6 |
| % Light Transmission | -82 ± 3.0 | 0 ± 0.3 | -50 ± 0.3 |

# Appendix I

Heritage Status - The Maryland State heritage program (MSHP) ranks species according to the following list (abbreviated for use in this report):

A3 = Rare throughout range (close to extinction)
B1 = Threatened regionally and critically state rare (in danger of extinction in Maryland)
B2 = Critically state rare (in danger of extinction in Maryland)
B3 = State rare (in danger of extinction in Maryland)
C = Uncommon, local, or seriously declining in MD

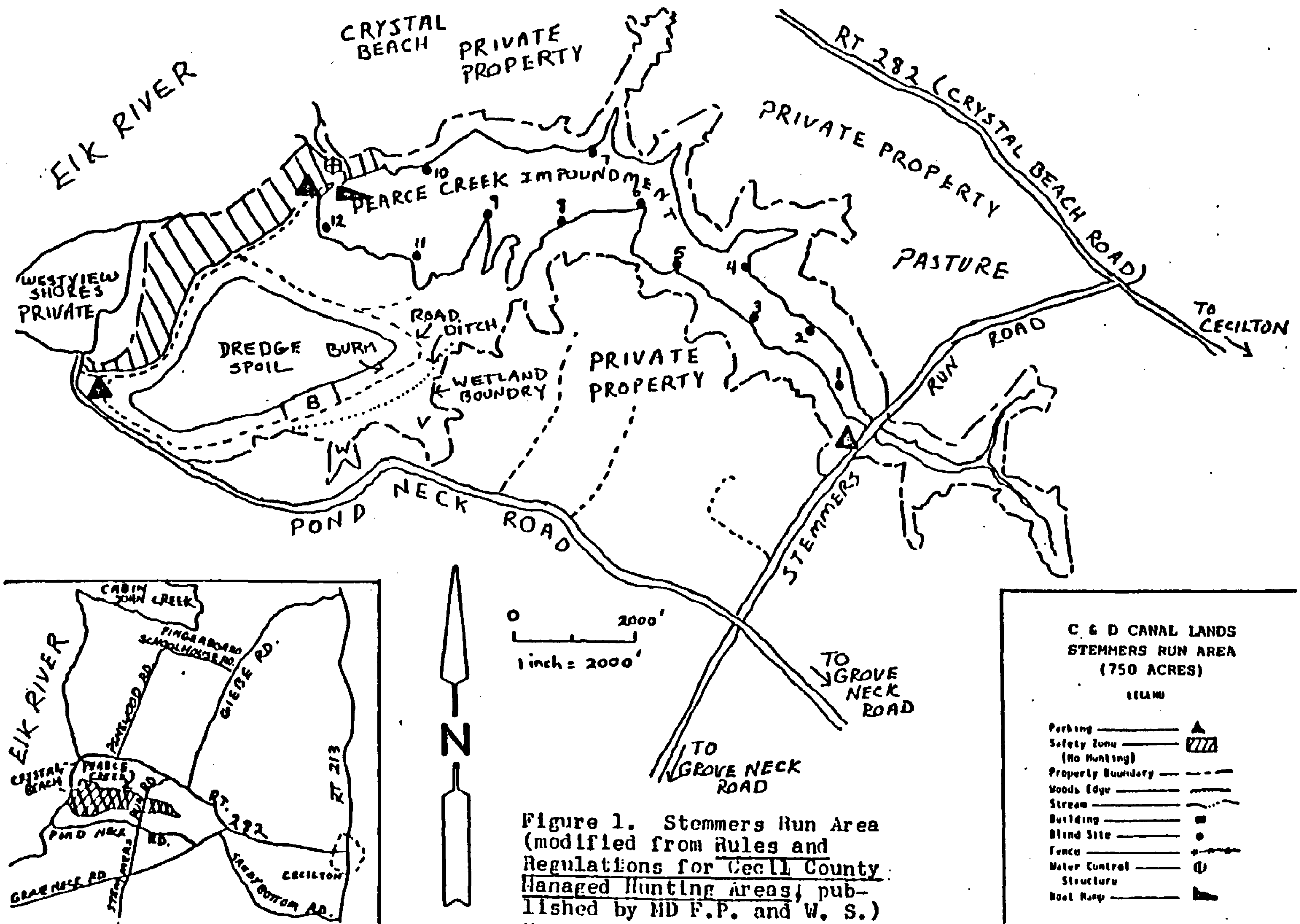
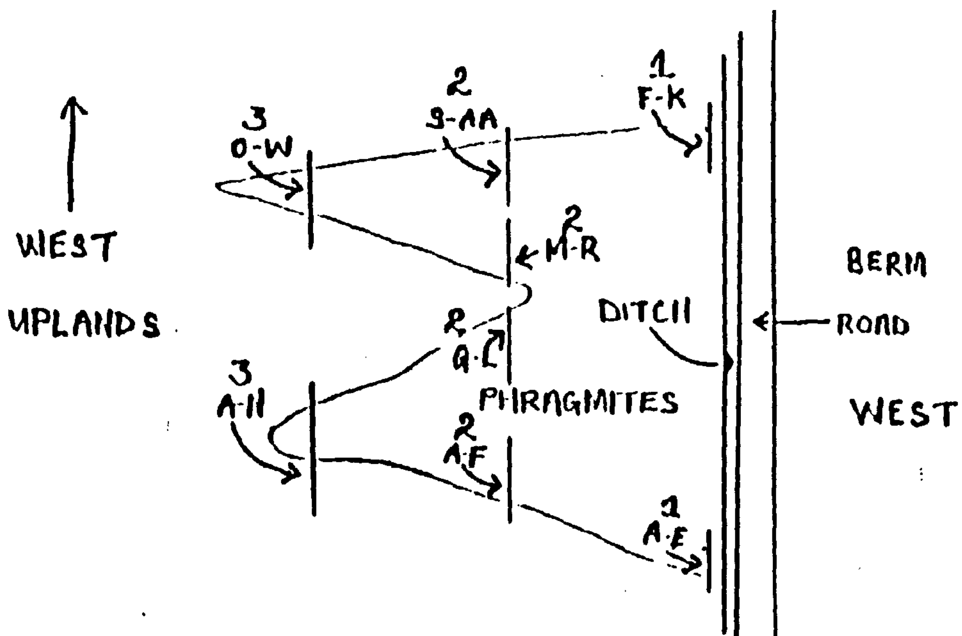
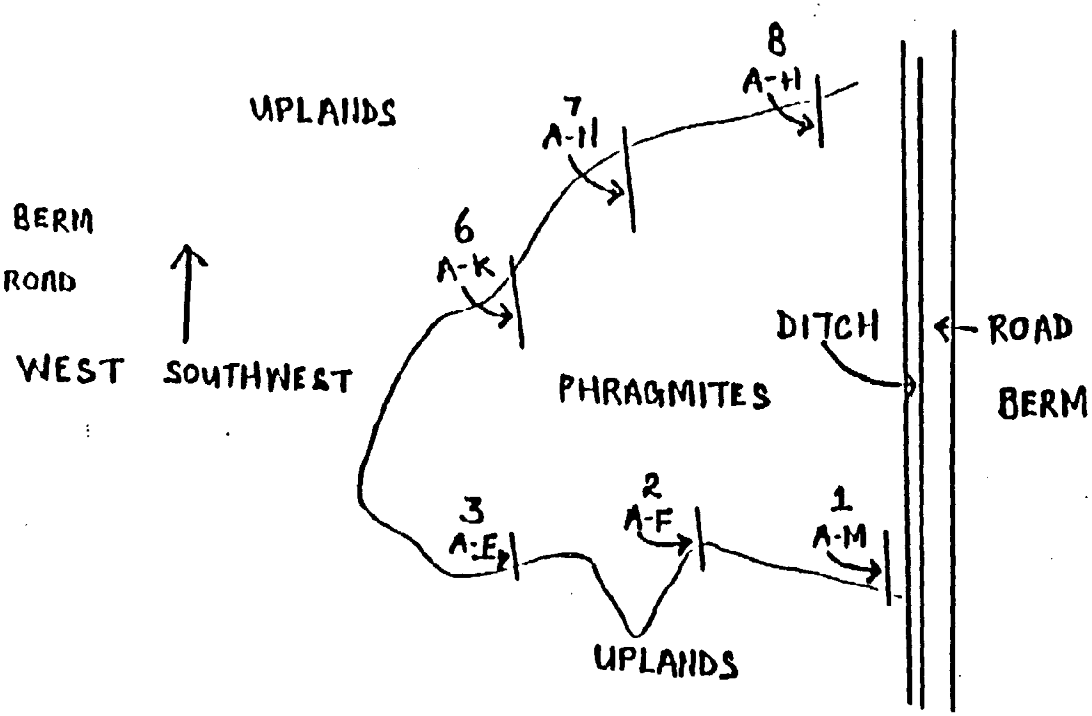


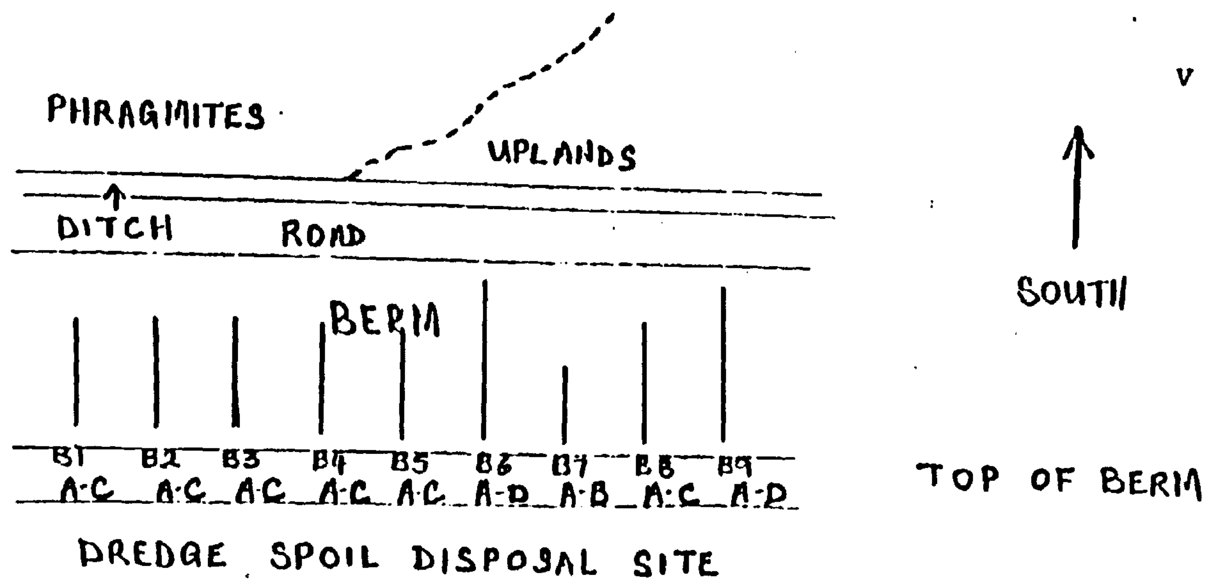

Figure 1. Stemmers Run Area (modified from Rules and Regulations for Cecil County Managed Hunting Areas, published by MD F.P. and W. S.) Not to scale.




W SITE UNBURNED WETLAND




V SITE BURNED WETLAND

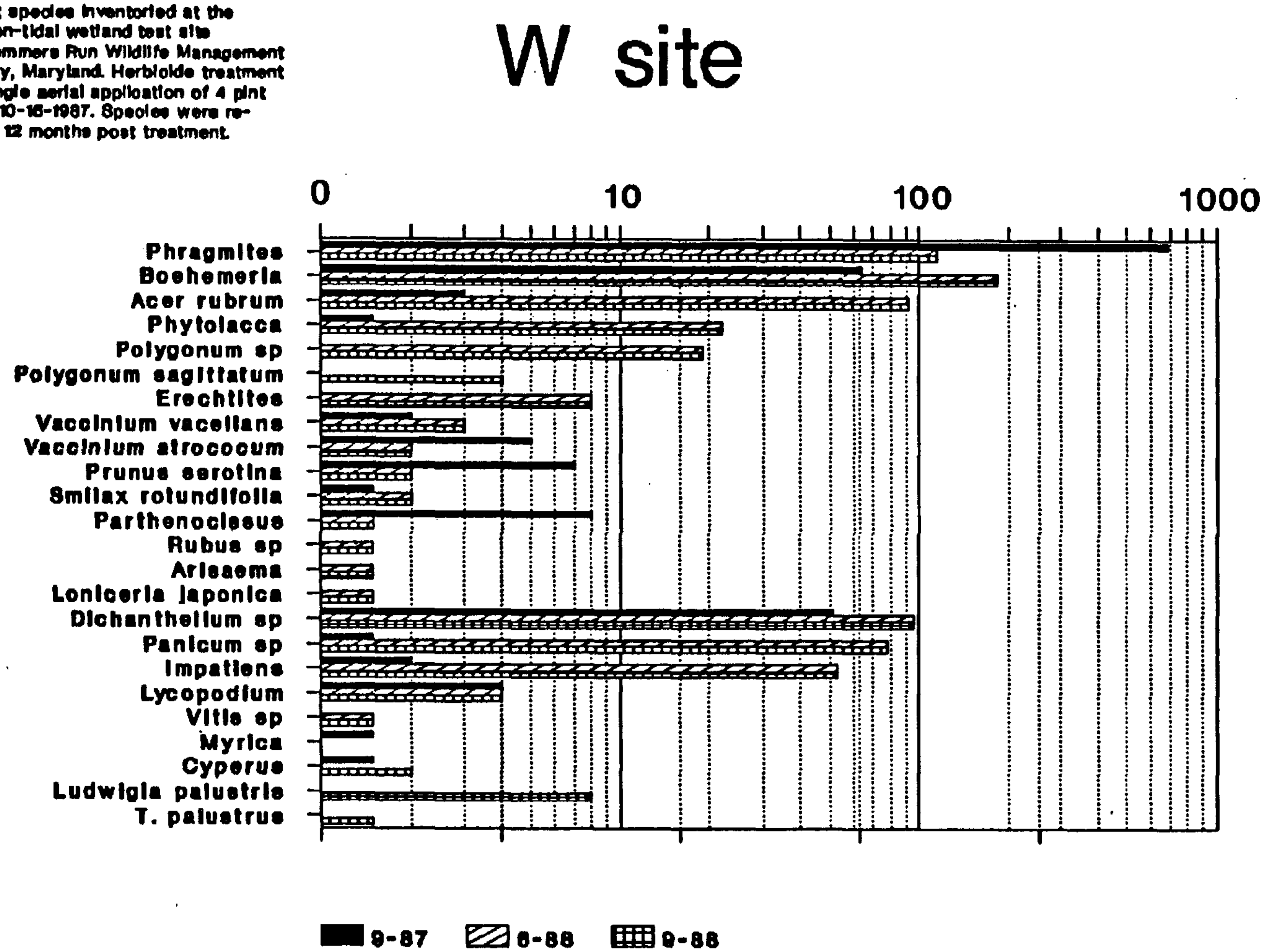



B SITE UPLAND

Fig. 2 Diagramatic representation of the 3 study sites showing the approximate location of all belt transects and quadrats. Belt transects are indicated by number, quadrats by letter.

Figure 3

Summary of plant species inventoried at the unburned ("W") non-tidal wetland test site located at the Stemmers Run Wildlife Management Area, Cecil County, Maryland. Herbicide treatment consisted of a single aerial application of 4 pint 1 acre. Rodeo on 10-16-1987. Species were re-inventoried 9 and 12 months post treatment.



## Figure 4

Summary of plant species inventoried at the burned ("U") non-tidal wetland. For additional detail see Legend, Figure 3.

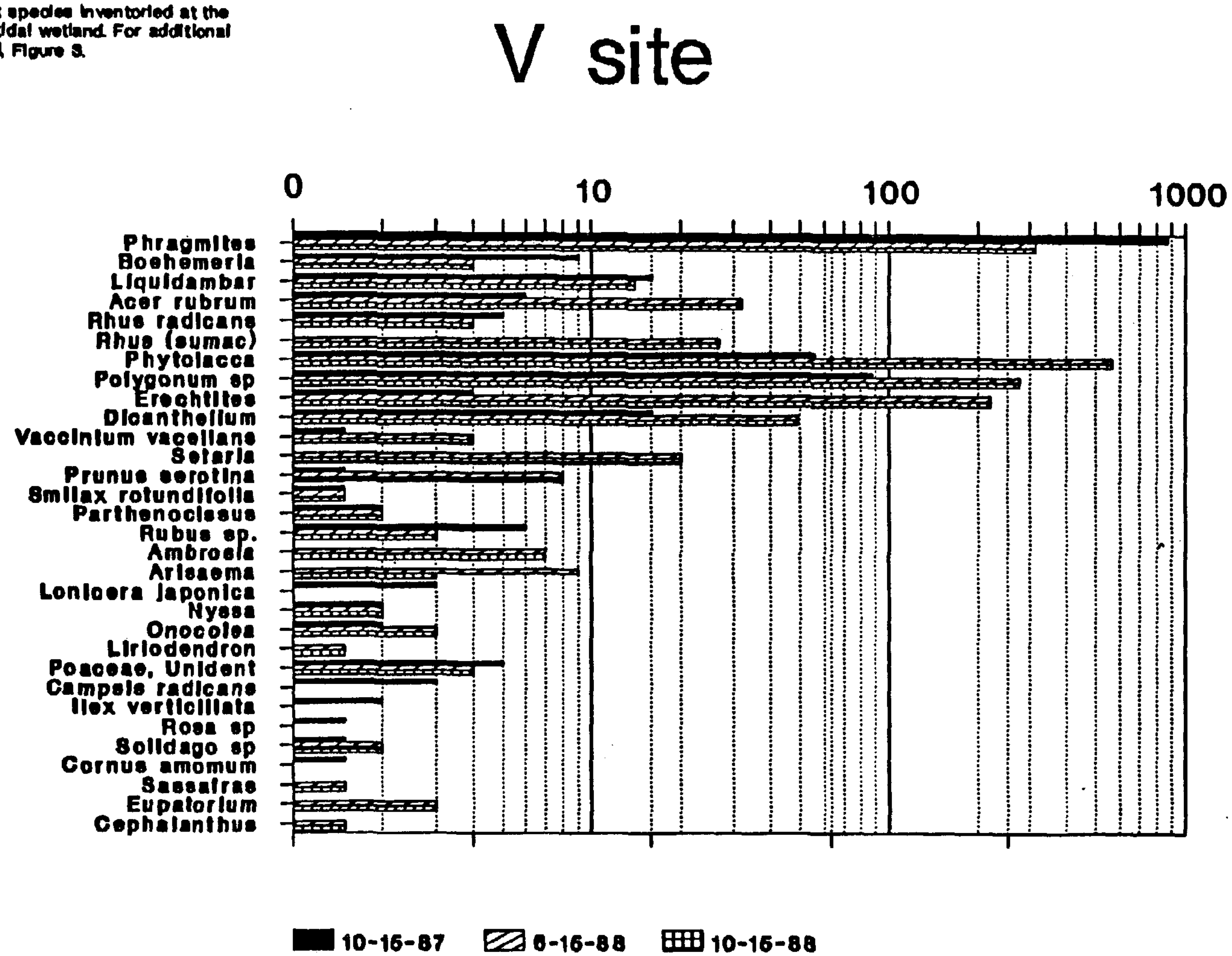


Figure 5

Summary of plant species inventoried at the upland ("B") site. For additional detail see Legend, Figure 3.

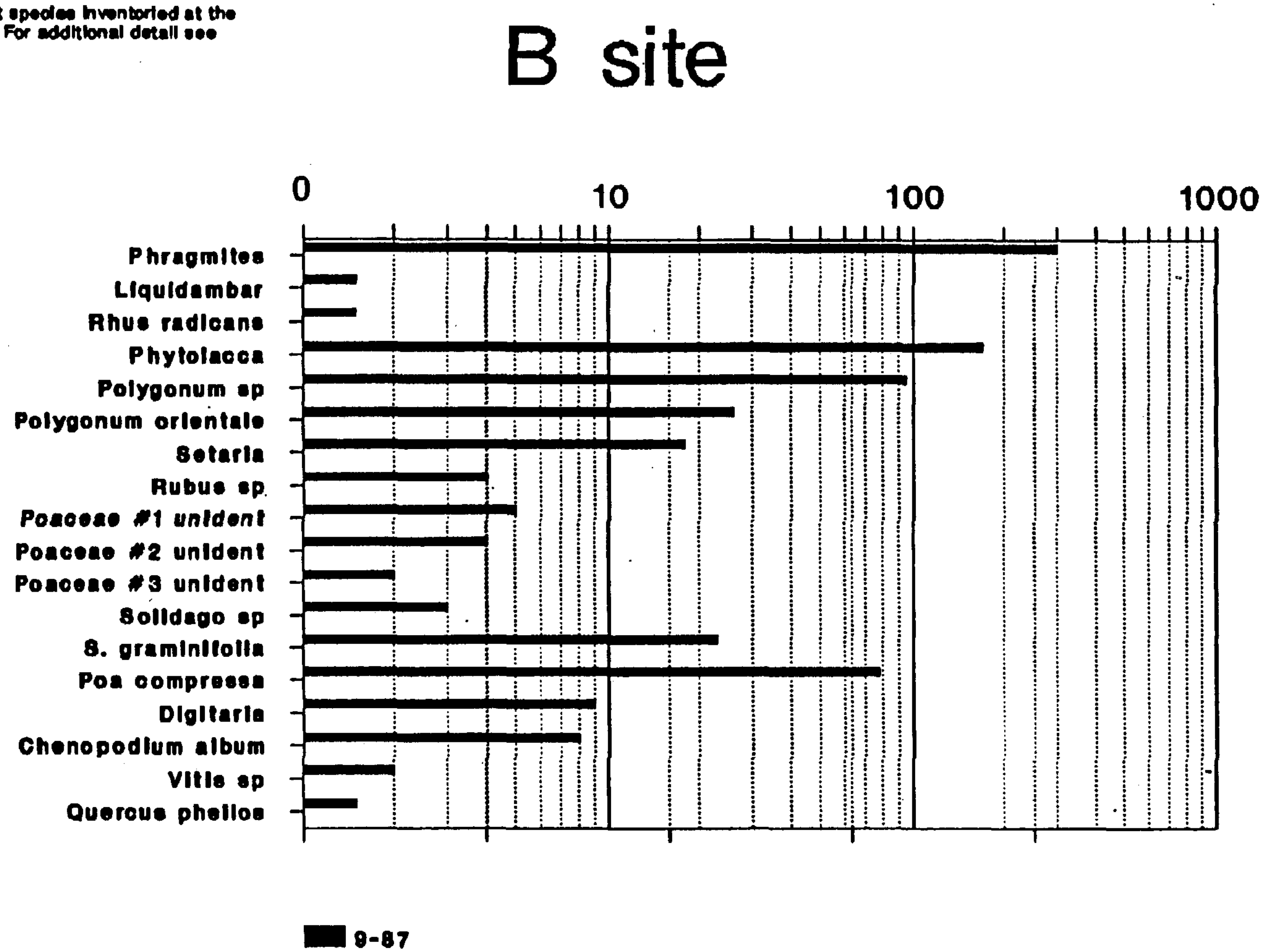
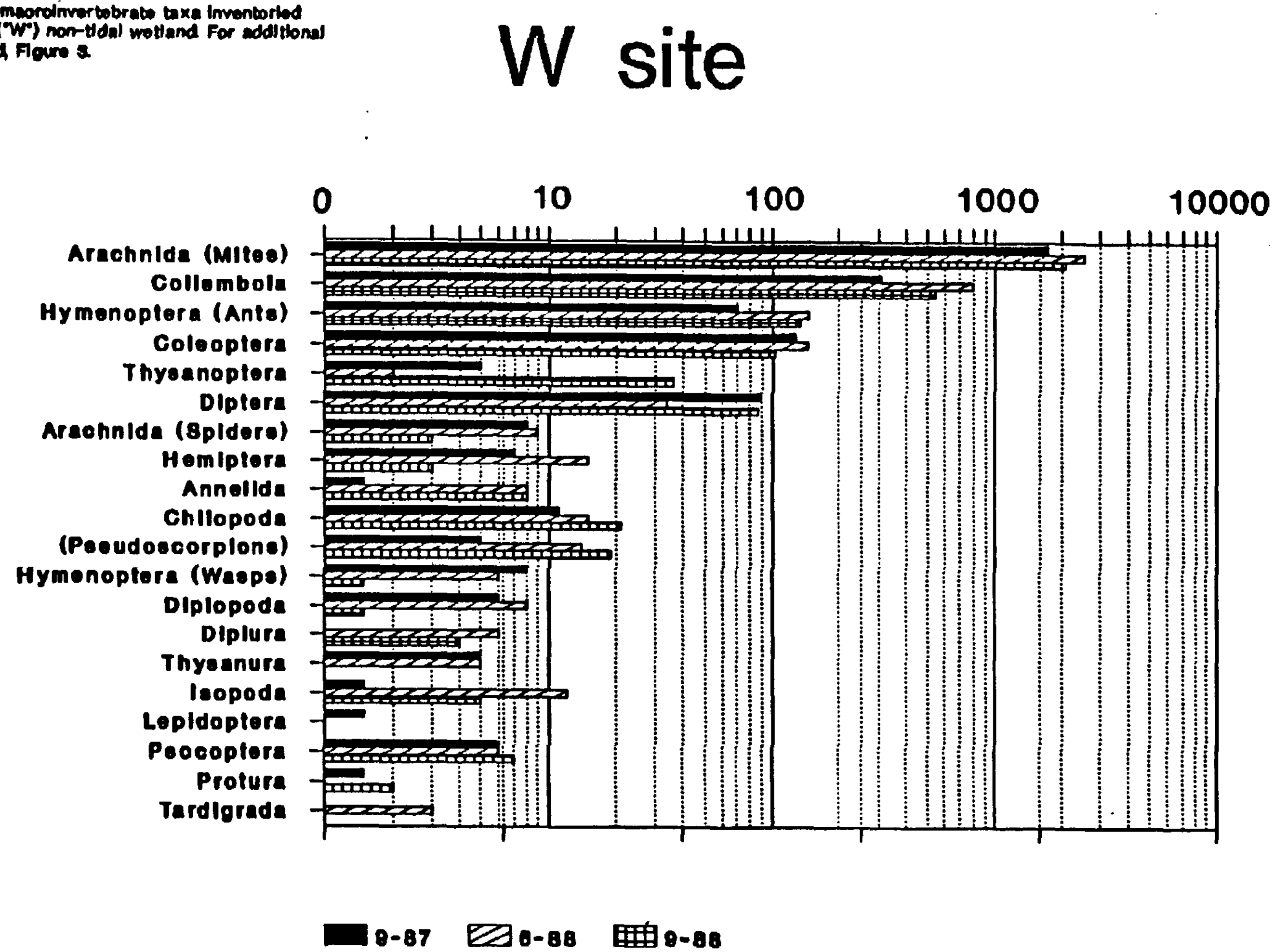


Figure 6

Summary of soil macroinvertebrate taxa inventoried at the unburned ("W") non-tidal wetland. For additional detail see Legend, Figure 3.



# Figure 7

Summary of soil macroinvertebrate taxa inventoried at the burned ("V") non-tidal wetland. For additional detail see Legend, Figure 8.

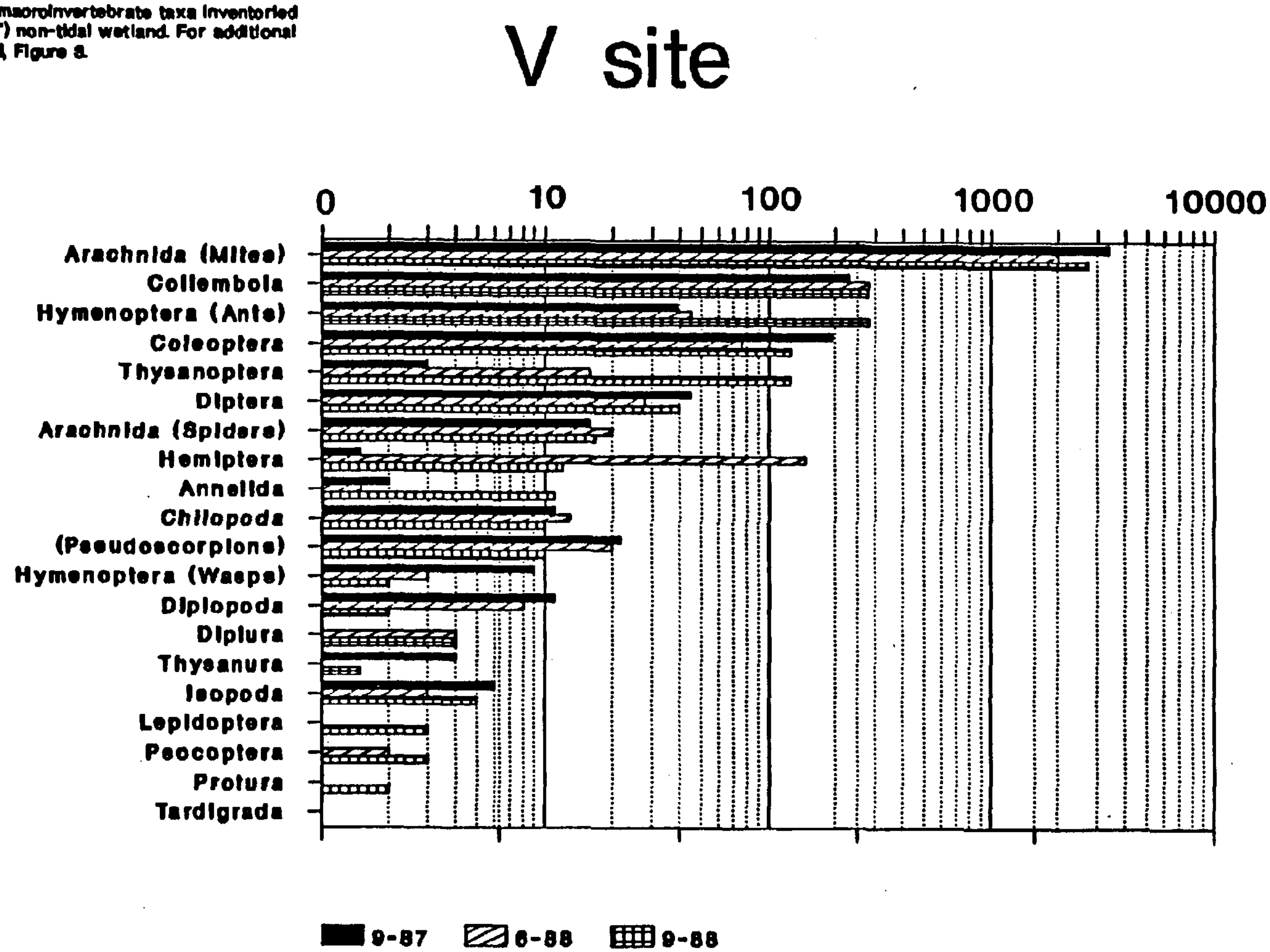


Figure 8

Summary of soil macroinvertebrate taxa inventoried at the upland ("B") site. For additional detail see Legend, Figure 3.

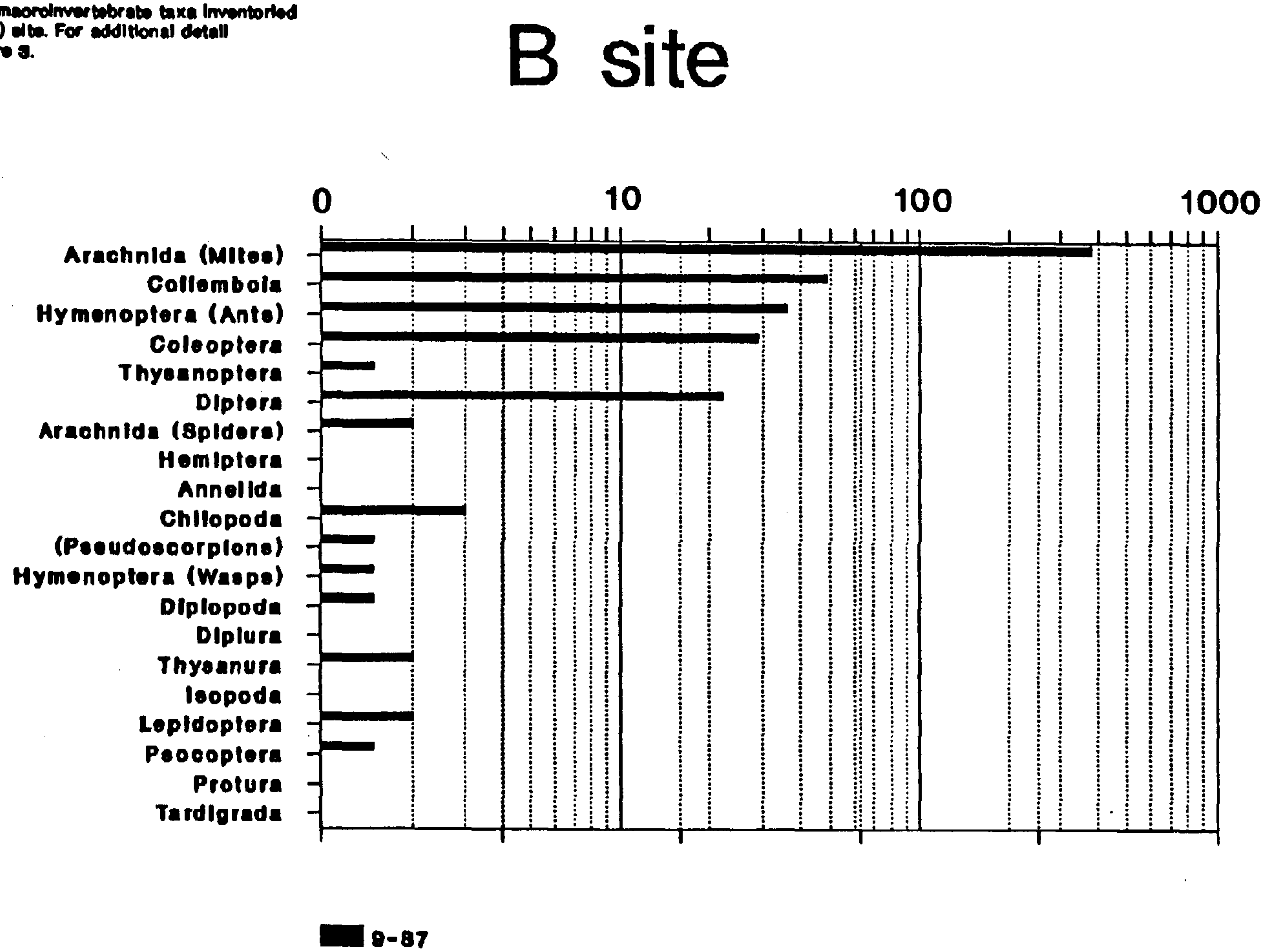


Figure 9

Plant species inventoried from quadrat W3O which had the greatest initial plant diversity at the unburned ("W") non-tidal wetland site.

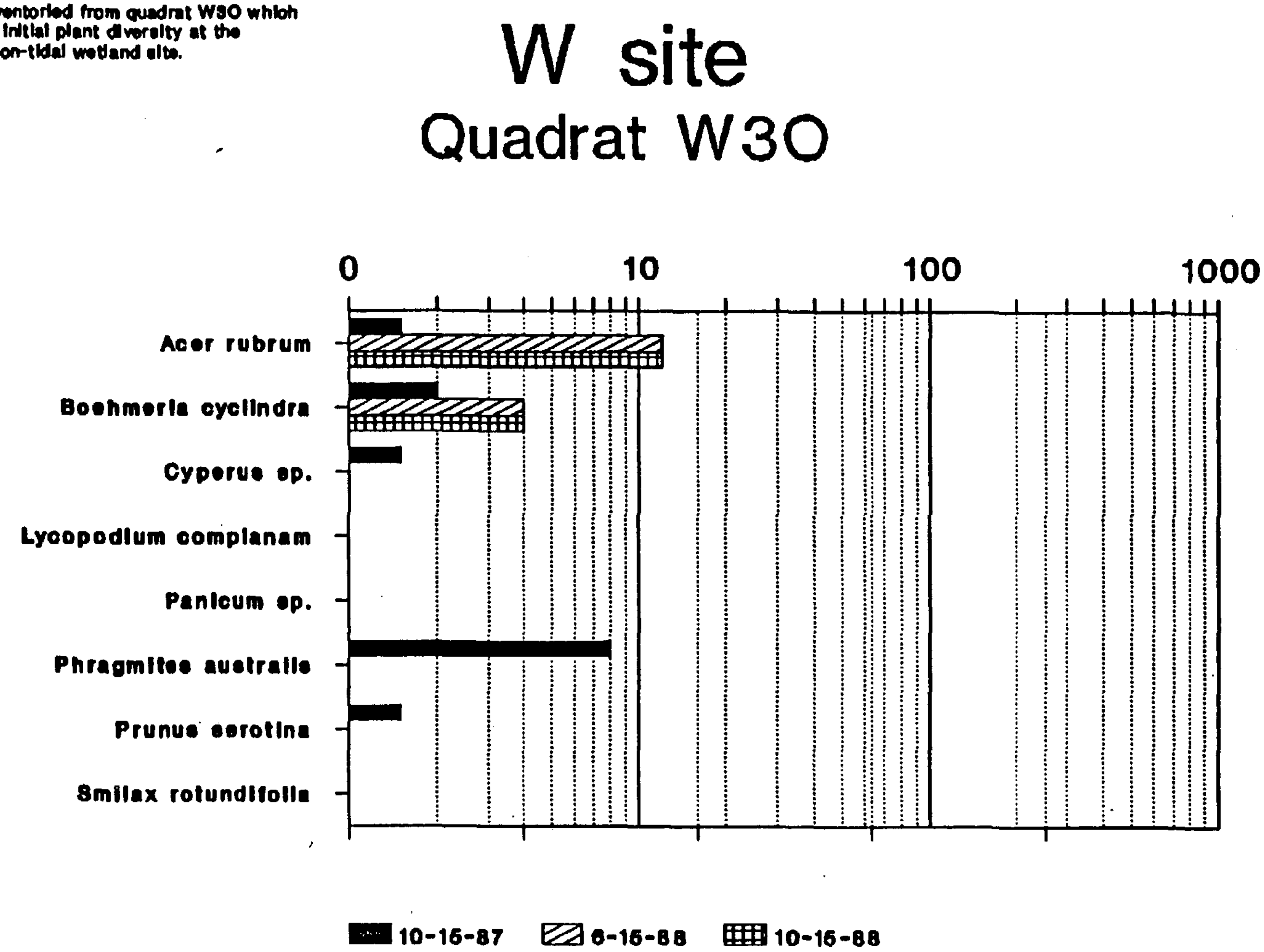


Figure 10

Plant species inventoried from quadrat W3N which had moderate initial plant diversity at the unburned ("W") non-tidal wetland site.

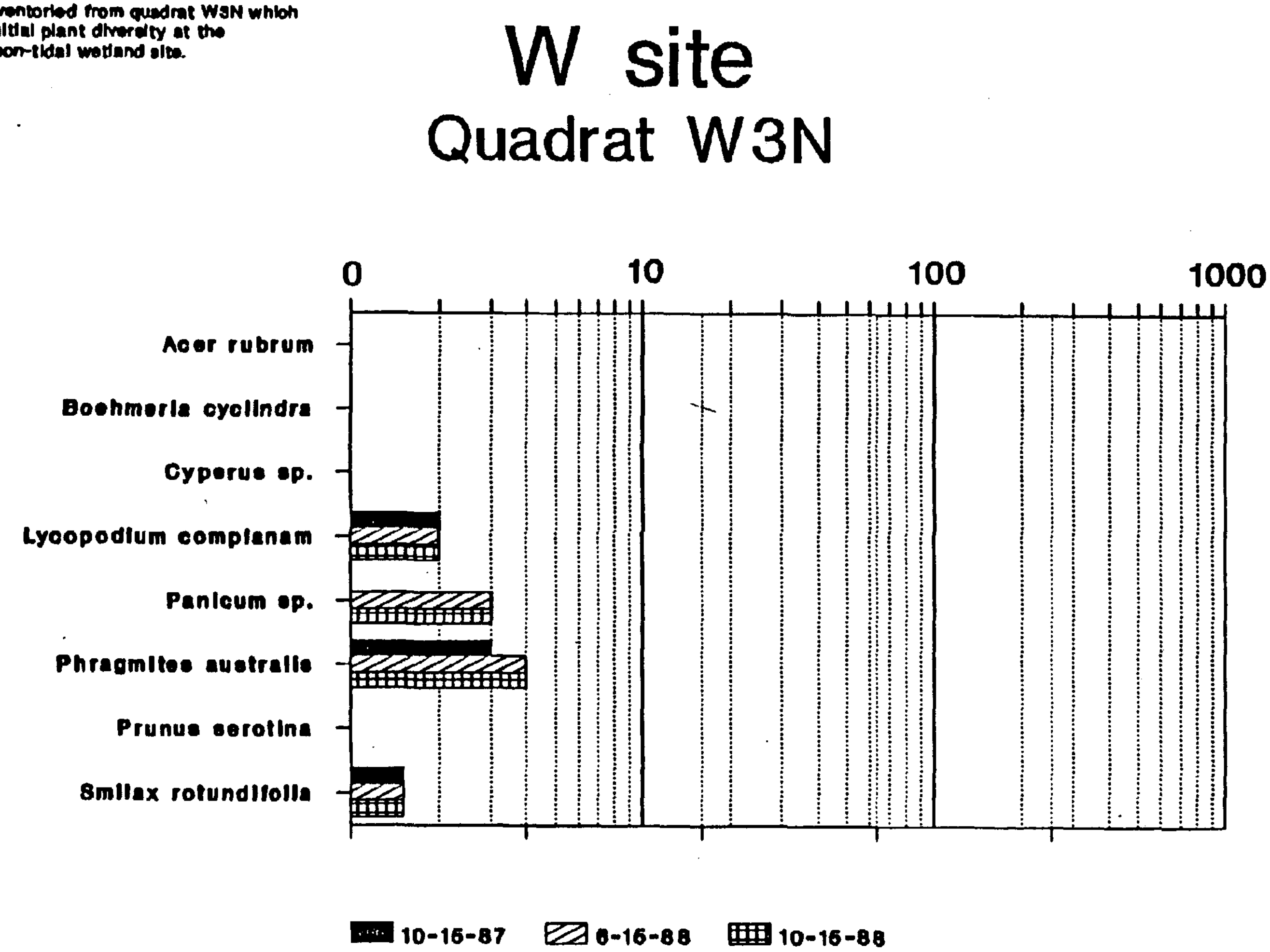


Figure 11

Plant species inventoried from quadrat W1D which had the least initial plant diversity at the unburned ("W") non-tidal wetland site.

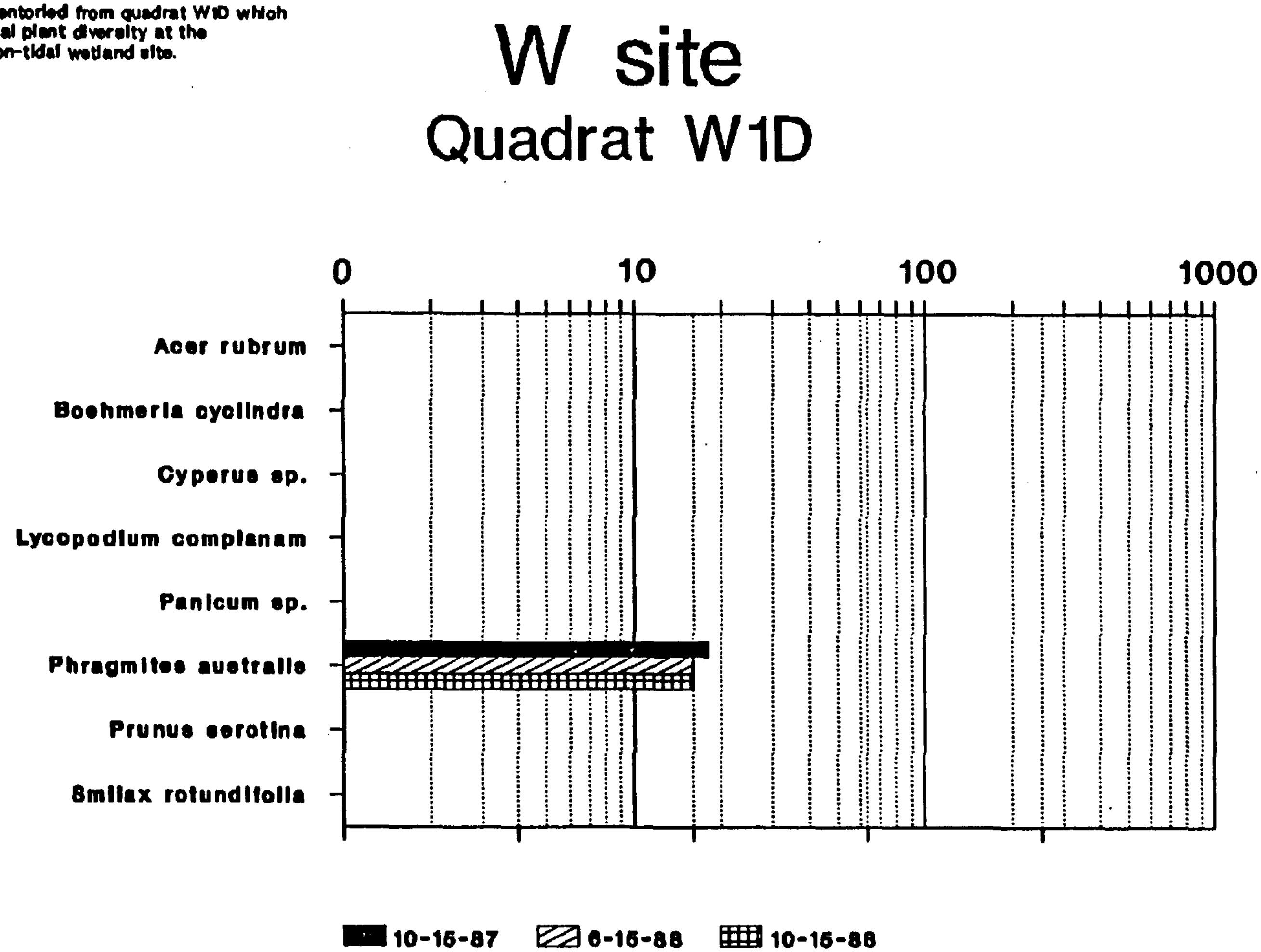


Figure 12

Plant species inventoried from quadrat V8A which had the greatest initial plant diversity at the burned ("V") non-tidal wetland site.

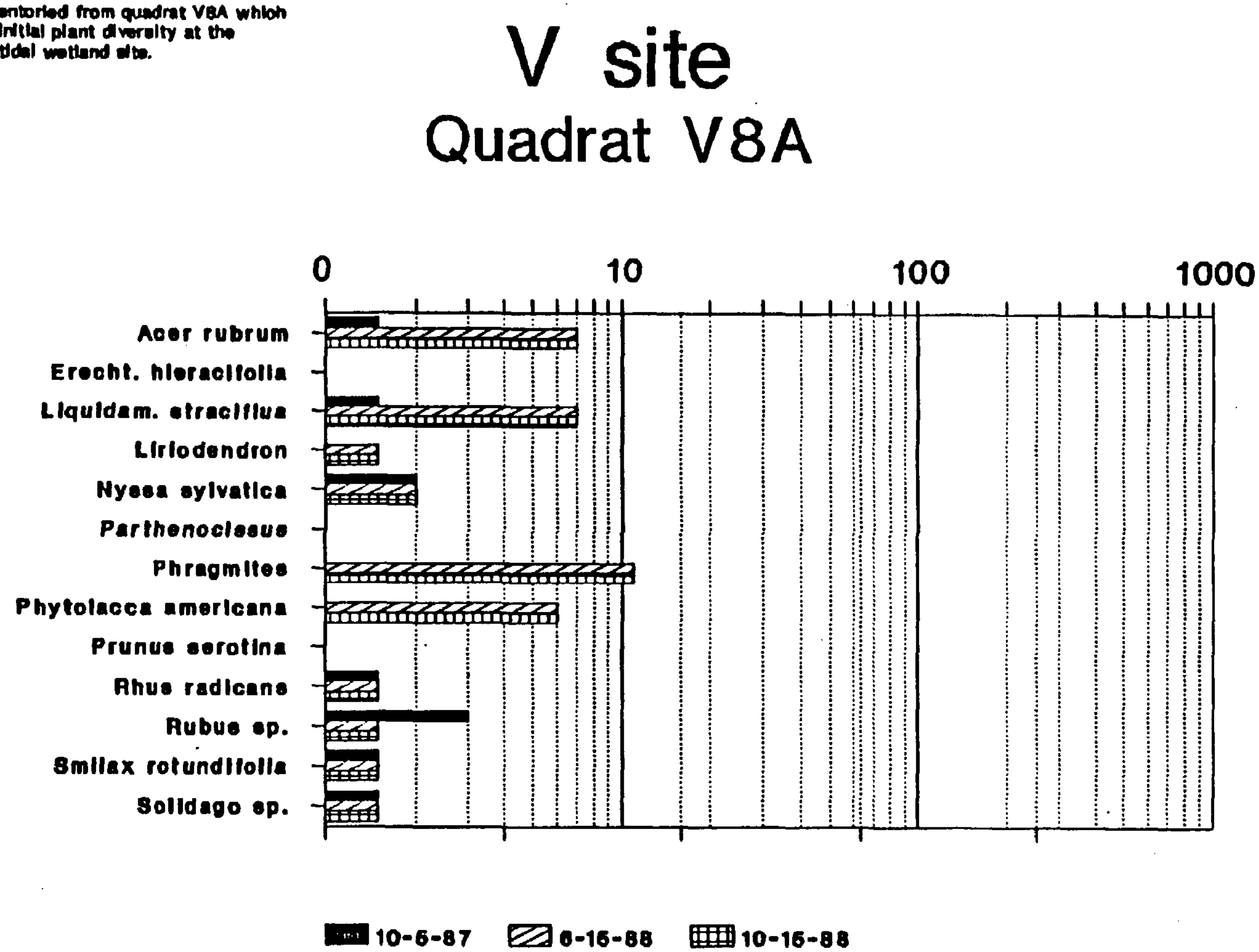


Figure 13

Plant species inventoried from quadrat V8C which had moderate initial plant diversity at the burned ("V") non-tidal wetland site.

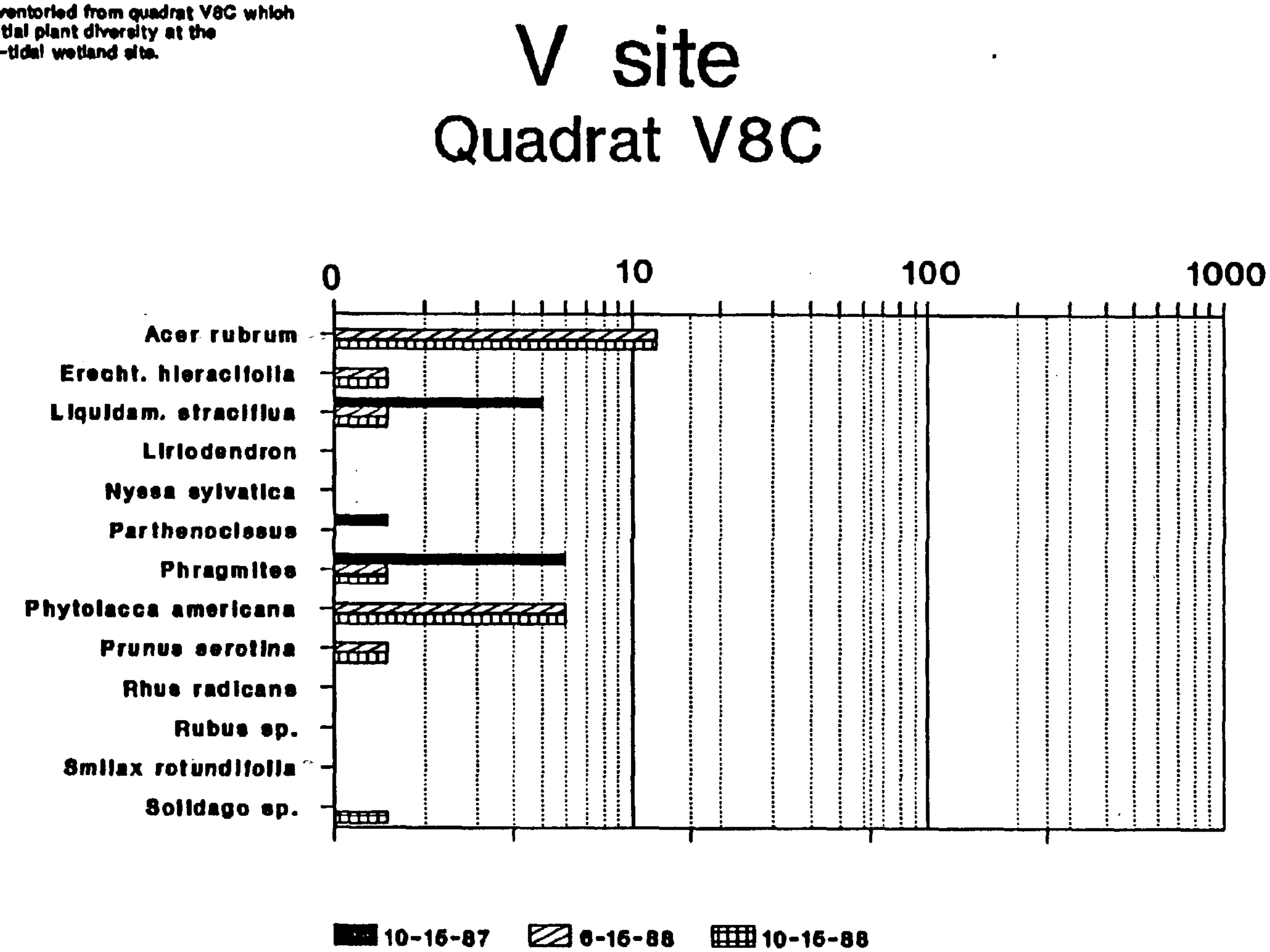


Figure 14

Plant species inventoried from quadrat V8F which had the least initial plant diversity at the burned ("V") non-tidal wetland site.

# V site
## Quadrat V8F

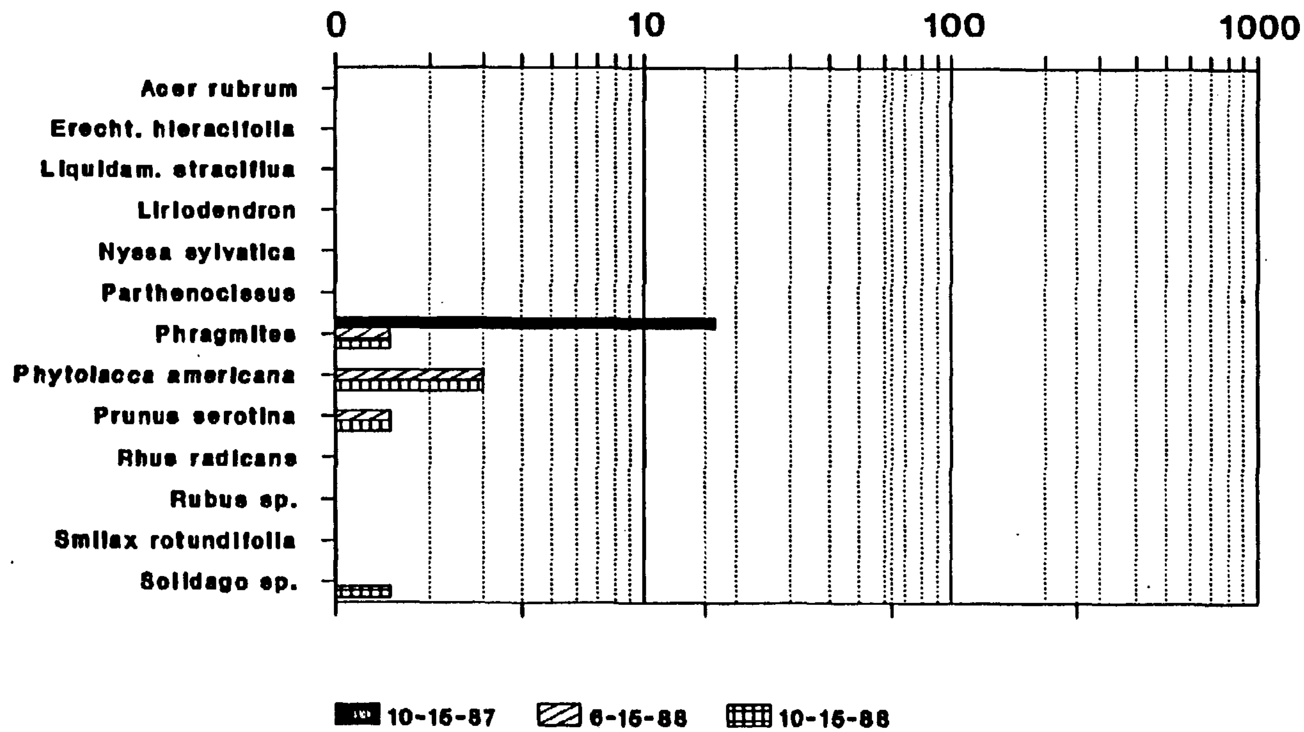


Figure 15

Soil macroinvertebrate taxa inventoried from quadrat W3O which had the greatest initial diversity at the unburned ("W") non-tidal wetland site.

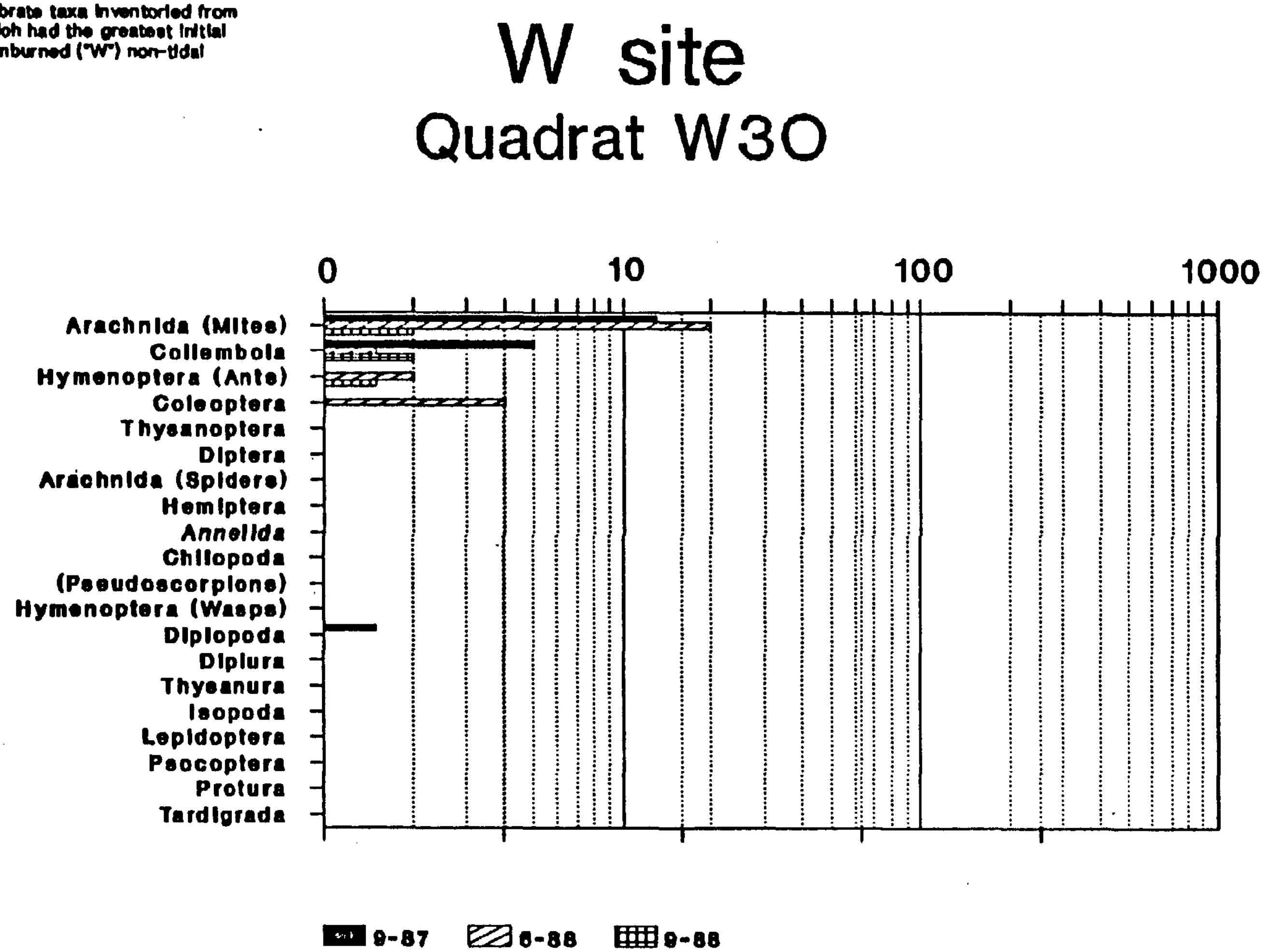


Figure 16

Soil macroinvertebrate taxa inventoried from quadrat W3N which had moderate initial diversity at the unburned ("W") non-tidal wetland site.

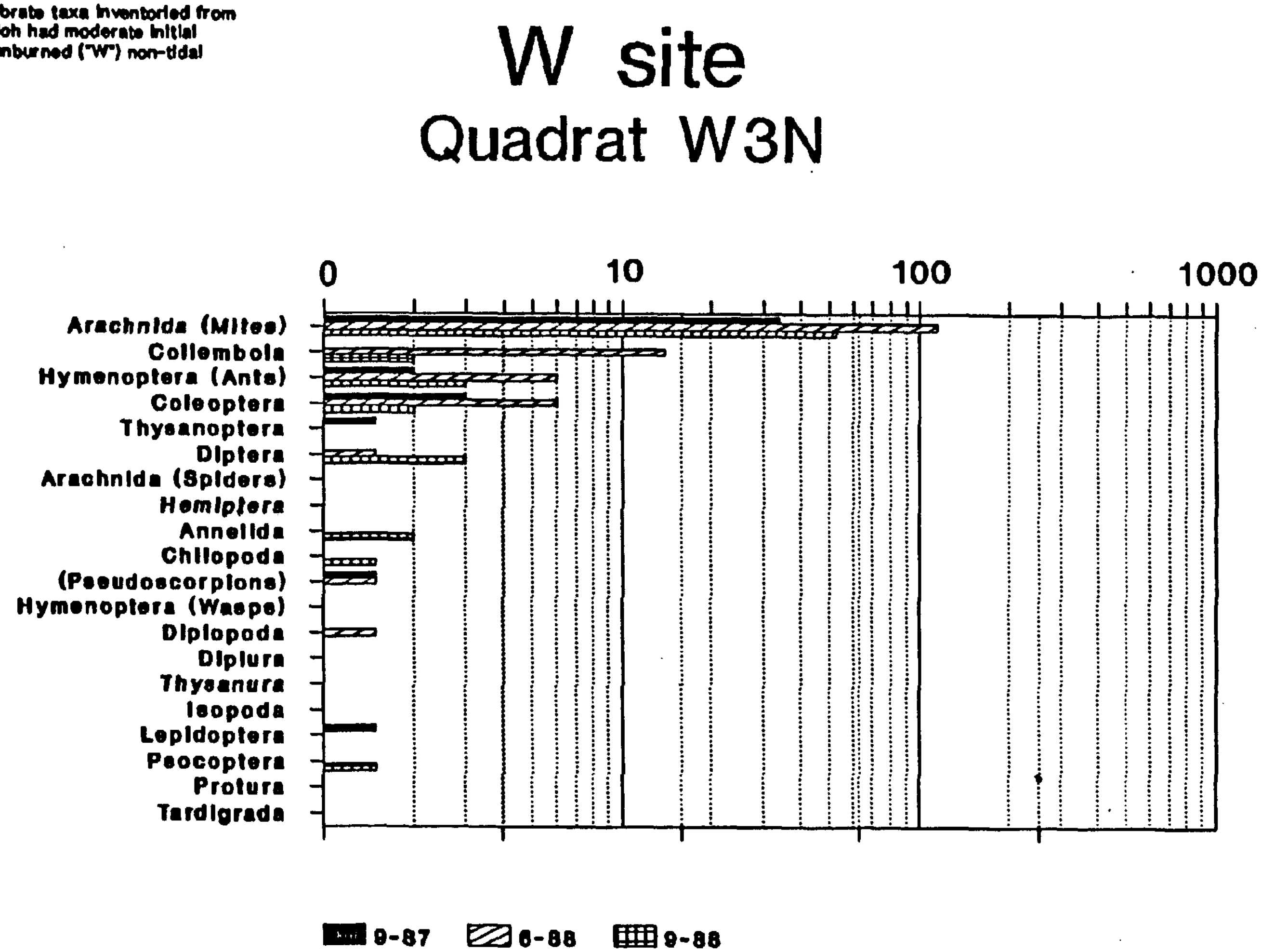


Figure 17

Soil macroinvertebrate taxa inventoried from quadrat W1D which had the least initial diversity at the unburned ("W") non-tidal wetland site.

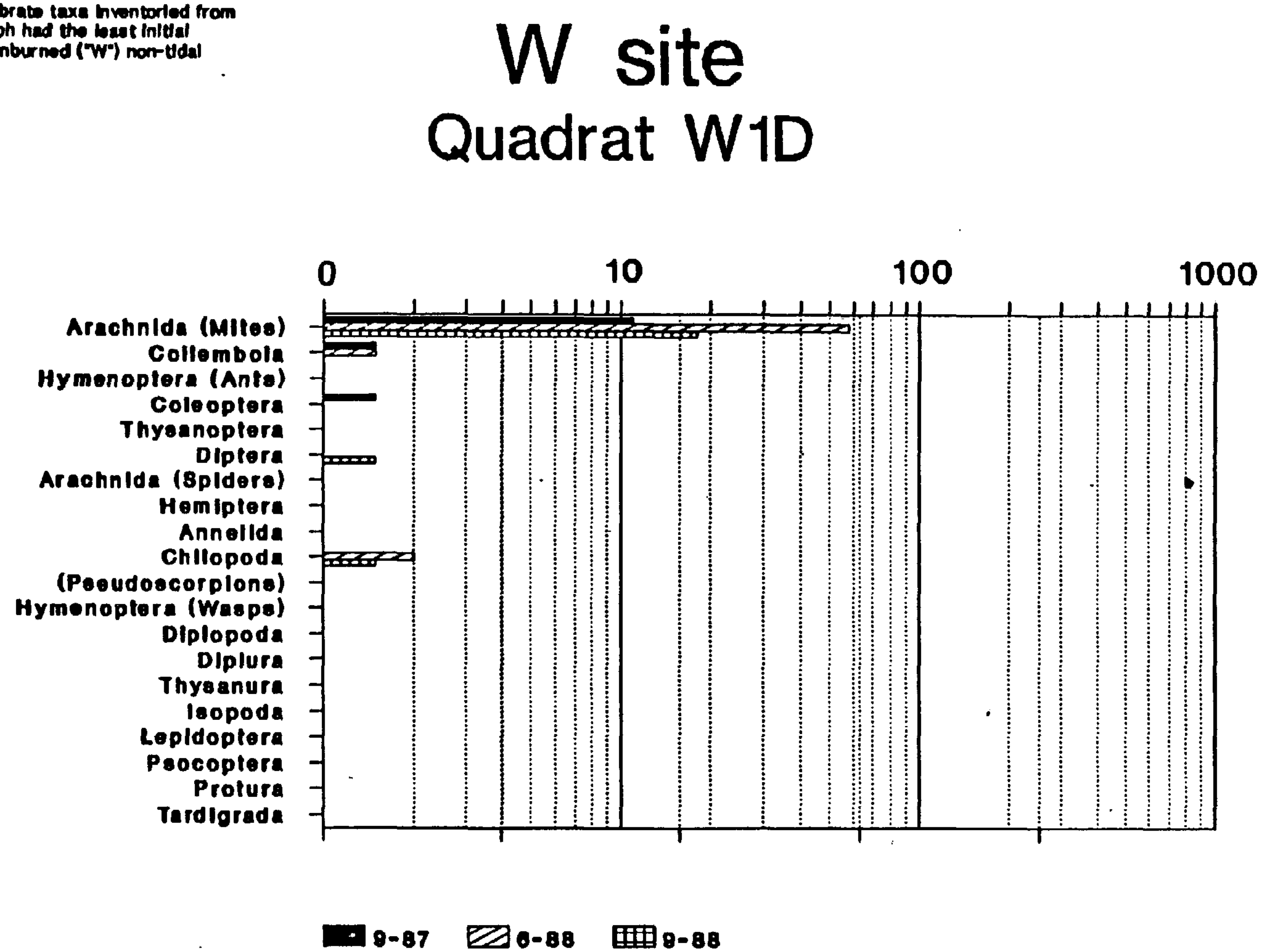


Figure 18

Soil macroinvertebrate taxa inventoried from quadrat V8A which had the greatest initial diversity at the burned ("V") non-tidal wetland site.

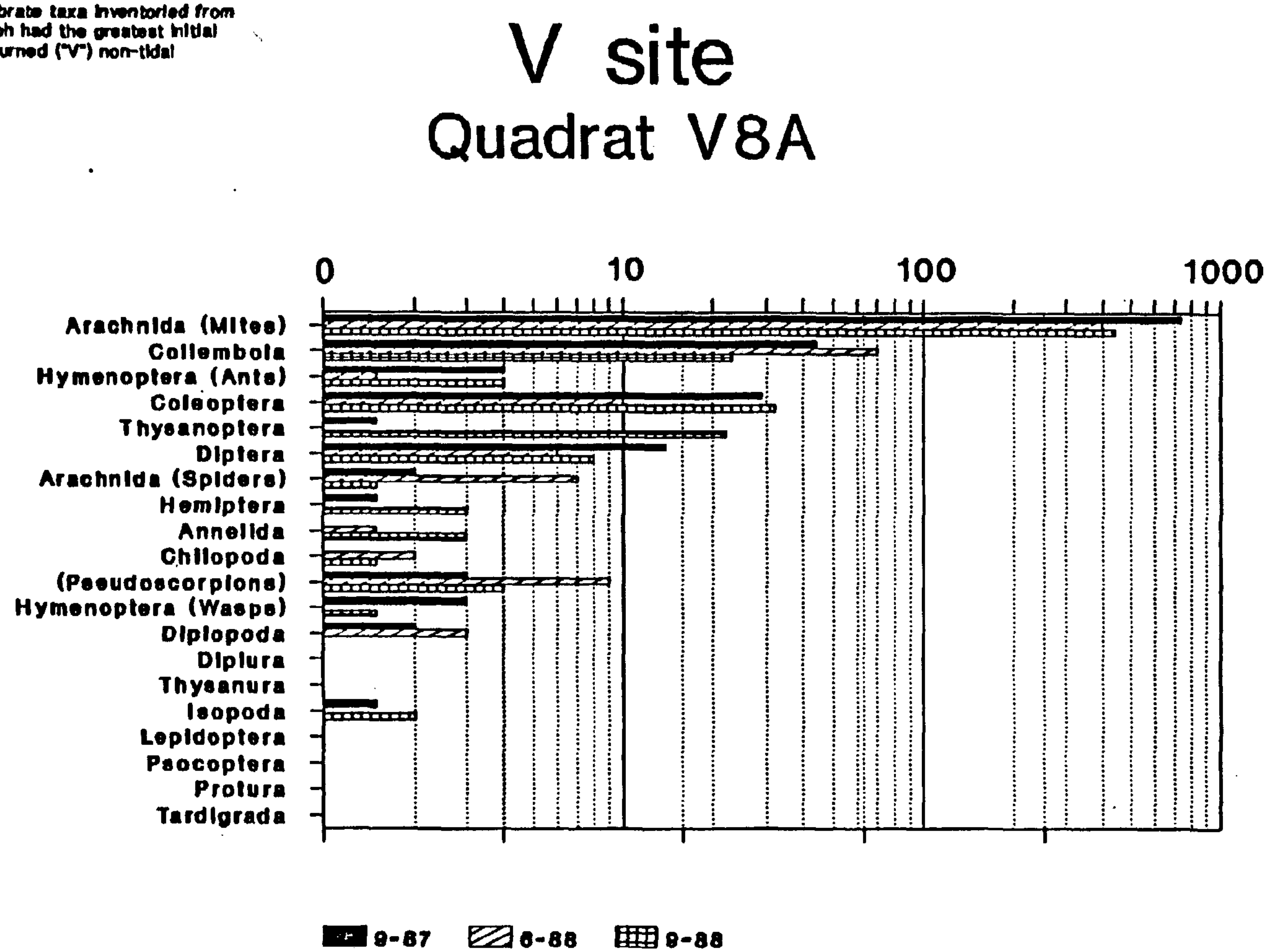


Figure 19.

Soil macroinvertebrate taxa inventoried from quadrat V8C which had moderate initial diversity at the burned ("V") non-tidal wetland site.

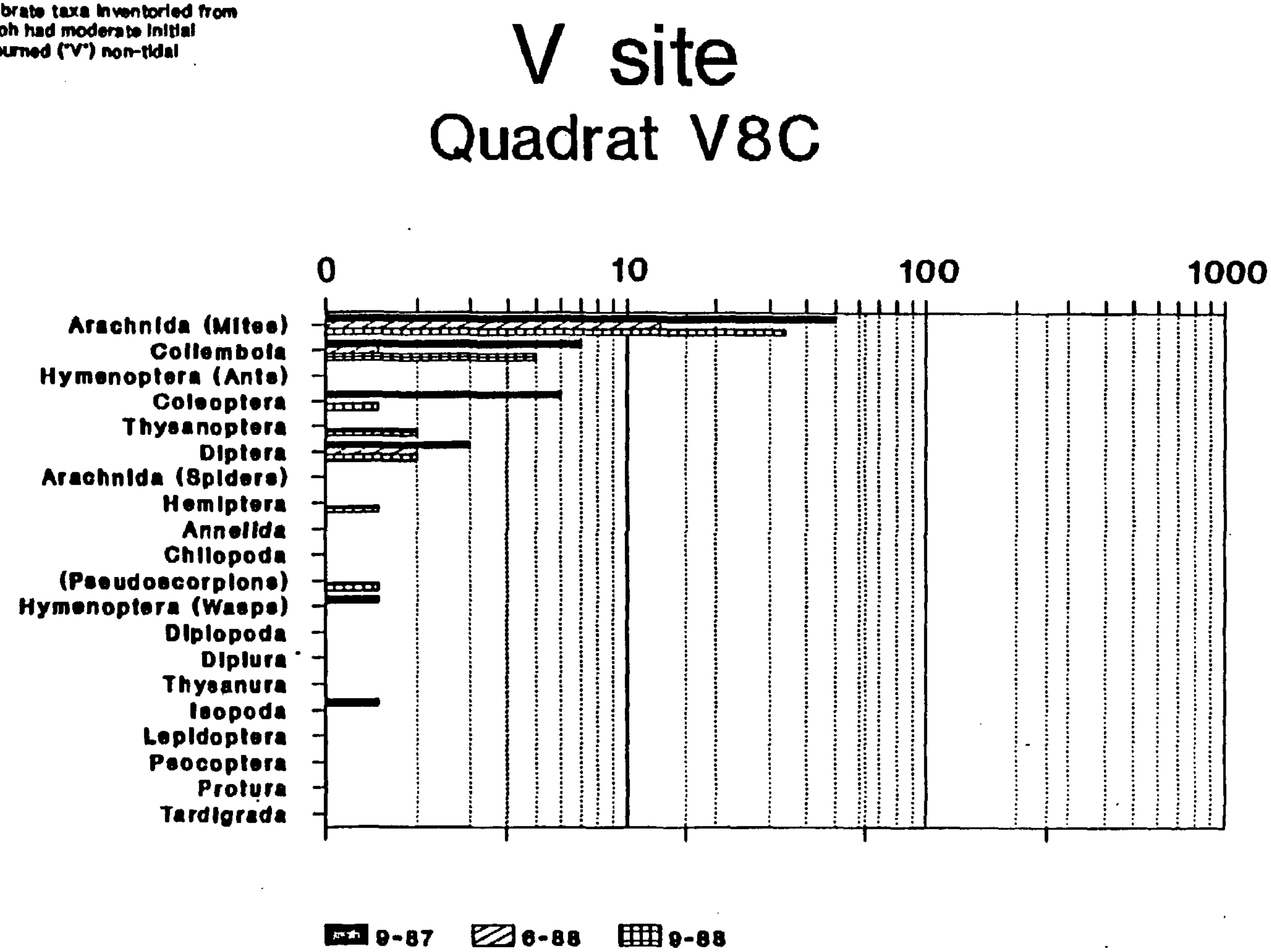


Figure 20

Soil macroinvertebrate taxa inventoried from quadrat V8F which had the least initial diversity at the burned ("V") non-tidal wetland site.

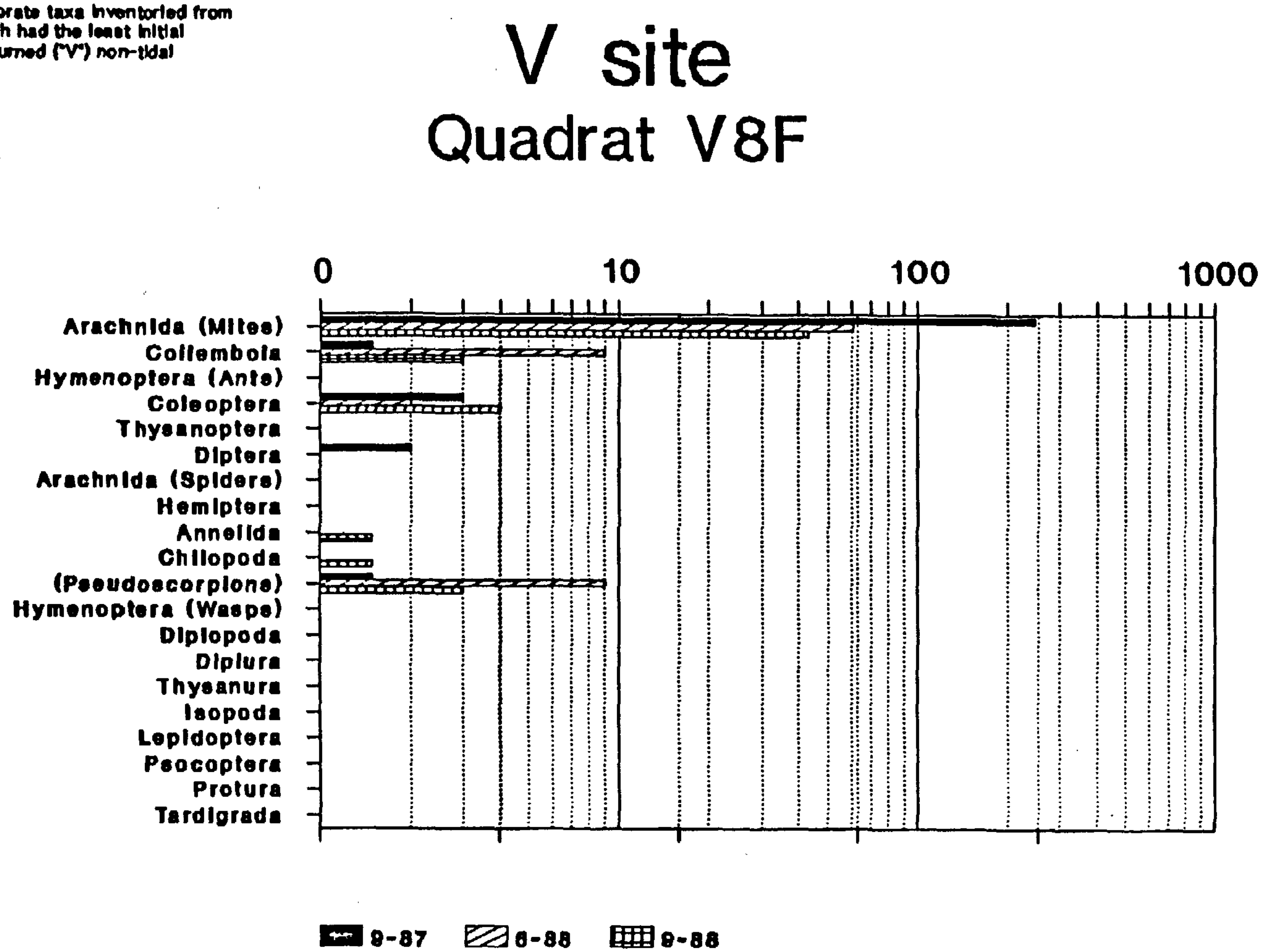
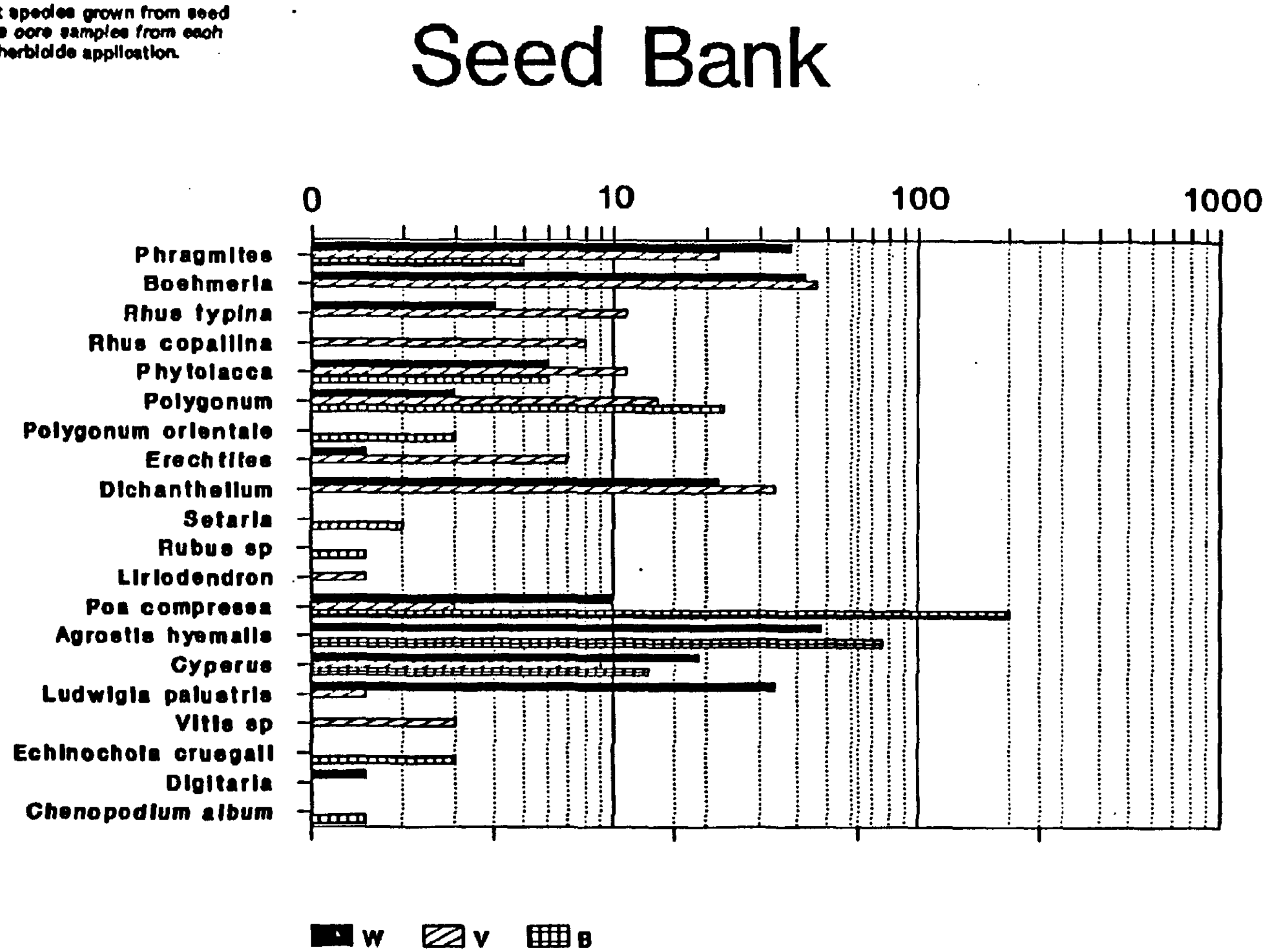


Figure 21

Summary of plant species grown from seed stock collected as core samples from each test site prior to herbicide application.



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