# Community Level Impact and Potential Management Practices of West Indian marsh grass in the Myakka River Watershed

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## Final Project Report

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## Summary

Invasion of exotic plants constitute a major threat to aquatic ecosystems. West Indian marsh grass, *Hymenachne amplexicaulis* (Rudge) Nees, is currently invading the watersheds of central and south Florida. During this process, native flora and fauna are being displaced by this aggressive grass. We investigated the impact of *Hymenachne* invasion to flora and macroinvertebrates in Myakka River State Park and evaluated the effect of herbicides for its control.

Sites invaded by *Hymenachne* had larger accumulation of biomass, reduced macroinvertebrate abundance and simpler trophic structure than native sites. There was no indication that native insect herbivores were colonizing *Hymenachne* and this could be explained by the relatively recent arrival of this grass into Florida. The herbicide experiment suggested that *Hymenachne* can be controlled using a tankmix of glyphosate and imazapir, and the timing of its application should be targeted for early growing season (February to May) when the plant is under stress and before flowering. Management of this invasive grass in infested wetlands must include a combination of strategies such as winter burning, herbicide application and hydroperiod control. Prevention by monitoring and early control is ideal in uninfested wetlands.

## General Introduction

Invasion of exotic species poses a serious threat to Florida's sensitive ecosystems. International trade, tourism, agricultural and urban disturbance have increased the probability of establishment of exotic plants. In Florida wetlands, exotic species spread rapidly due to floods, large interconnected waterway systems, and increased use of commercial and recreational boats. Fertilizer and sediment runoff from agricultural lands and waste water from beef and dairy operations contribute to successful establishment of aquatic exotic plants.

Wunderlin and Hansen (2003) reported 1,316 exotic plants species naturalized in Florida, with 125 species being serious threats to natural areas (FLEPPC 2005). Of those, 65 are considered highly invasive because they are disruptive to native plant communities. West Indian Marsh Grass, *Hymenachne amplexicaulis* (hereafter referred as *Hymenachne*), is one of many species currently invading sensitive wetlands in Florida.

*Hymenachne* is a native of South America and the West Indies and has spread to most countries of the neo-tropics. The pathway and timing of the introduction of this grass into Florida are uncertain; however, the first herbarium record was from a ponded pasture in Palm Beach County in 1957 (University of Florida Herbarium). This suggests that the grass could have been intentionally introduced as forage. The next record was from a wet pasture in Collier county in 1977 (University of Florida Herbarium). Current records confirm that *Hymenachne* is present in wetlands and rivers in 16 counties in Florida.

*Hymenachne* is present in most the counties included in the Charlotte Harbor National Estuary Study Area (University of Florida Herbarium and personal communication with aquatic plant managers) (Fig. 1). Large monocultures of

*Hymenachne* can be found in the rivers, canals and wetlands located in the Myakka and Peace River Basins. Nutrient enrichment, especially with nitrogen and phosphorous, of surface water due to runoffs from agricultural fields and geological deposits of phosphate may have facilitated the establishment and dominance of *Hymenachne* in these rivers (Charlotte Harbor Environmental Center, 2002).

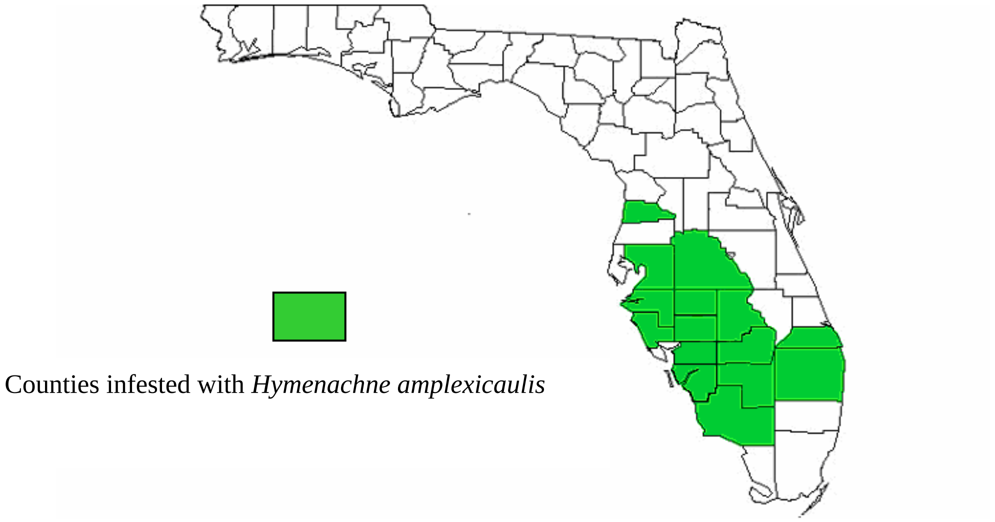
🟩 Counties infested with *Hymenachne amplexicaulis*

Figure 1. Current distribution of *Hymenachne amplexicaulis* in Florida.

Invasion of *Hymenachne* is favored by aggressive mechanisms of reproduction and dispersal. In Australia, a single inflorescence can produce more than 4000 seeds (Tropical Weeds Research Centre 2003) with approximately 98% viability (Lyons 1996). Another method of reproduction is through vegetative material (stolons). *Hymenachne* experimental colonies in the Indian River Research & Education Center at Fort Pierce are easily reproduced by planting small pieces of stems containing at least one node. Moreover, ponded pastures in Australia were easily established by simply casting pieces of the grass from boats (Lukacs 1996). Summer floodwaters in Florida can transport *Hymenachne* seeds and stolons great distances through watersheds complicating management programs.

Simplification of wetland ecosystems due to the invasion of *Hymenachne* could have severe impacts in the native fauna. Diverse aquatic habitats are places for feeding, resting, refuge and reproduction for wading birds, wood stork, snail kite, killifishes, live bearers, juvenile sunfishes, southern leopard frog, pig frog, green tree frog, American alligator and American crocodile, among others (Mitsch and Gosselink 2000).

The present study had two objectives a) assess the impact of *Hymenachne* on the flora and macroinvertebrate fauna and b) evaluate the use of herbicides as a means to control *Hymenachne*.

# Impacts of *Hymenachne amplexicaulis* on plant and arthropod communities

## *Introduction*

Large infestations of exotic grasses can reduce biodiversity in aquatic ecosystems. Recent studies in wetlands demonstrate that exotic grasses are capable of simplifying the plant diversity and reducing or changing the arthropod community (Herrera and Dudley 2003, Houston and Duivenvoorden 2002, Talley and Levin 2001, Posey 1988). These changes can be linked to alteration of trophic structure, and habitat usage by birds, fish and other vertebrates. Despite the large areas infested and visible reduction of wetland plants, no studies have been conducted to quantify the impact of *Hymenachne* on Florida native plant and arthropod communities. The objectives of this study were to quantify the impact of *Hymenachne* on native flora and macroinvertebrates assemblages in floodplain marshes.

## *Material and Methods*

### Study area

The Myakka River flows through 45 square miles of Myakka River State Park, which is located in Sarasota County in southwest Florida. The land cover in the upper river basin is dominated by a mosaic of pastures, hardwood forest, palms, citrus groves and row crops. Rainfall is seasonal with most of the rain falling between April and October (Kushlan 1990). Heavy rain triggers floods during the summer in the park. In the last four years, increased hurricane activity generated large discharges of water into marshes next to the river. Vegetation of marshes adjacent to the Myakka River is composed of: (a) emergent plants dominated by *Panicum hemitomon* (native), *Brachiaria mutica* and *Hymenachne amplexicaulis* (exotics), and *Polygonum* spp.; (b) free-floating plants, including *Salvinia minima, Lemna* spp. and in lesser abundance, *Eichornia crassipes*; (c) littoral plants, including *Quercus* spp, *Sabal minor* and *Sabal palmetto*. The park also contains flag marshes that are dominated by *Pontederia cordata*, *Saggitaria spp.*, *Thalia geniculata* and other species with flag-like leaves. Flag marshes occur where the wet season water depth is between 0.3 and 1 m and the hydroperiod extends more then 200 days per year (Kushlan 1990).

### Sampling

Three floodplain marshes ($27^0$16’N, $82^0$16’W; Fig. 2) located in the east side of the Myakka River were monitored. In each marsh, there were sites dominated by either *H. amplexicaulis* (exotic) or *P. hemitomon* (native) and separated at least by 10 meters. At each site a linear transect was established randomly along the longer axis of the patch. Four sampling stations separated by 10 meters were located along the transect. Sites were sampled once for water quality and plant diversity during August 2006. At each sampling station the following variables were measured: plant diversity and coverage, water quality, aerial and aquatic arthropod abundance, light attenuation and above ground biomass. Plant diversity was measured within 0.50 $m^2$ quadrats and cover was assessed with the Daubenmire coverage scale (1= 1-5%, 2= 6-25%, 3=26-50%, 4=51-75%, 5=76-95%, 6=96-100%) (Elzinga et al 2001).

Water quality parameters were collected once during August 2006 with a YSI 556 Multi Probe System between 9 and 11 AM at a depth of 20 cm and included temperature, pH, conductivity and dissolved oxygen. Aerial and aquatic samples were collected once in the summer (August) and once in fall (November) of 2006. Aerial arthropod abundance was estimated using sweeping nets (24x20 mesh per inch, BioQuip, California). Ten strokes separated by one meter were collected at each station. All the material collected in the net was transferred to plastic bags containing 70% EtOH. Aquatic arthropods were collected at a depth of ca. 30 cm using a D-shaped aquatic net (500 micron Nytex, BioQuip, California). The aquatic net was vigorously agitated inside the plant community for a period of 30 seconds covering an area of 1.5m wide and 2 m long. All insect samples were identified to family level using the taxonomic keys from Borror et al. (1989) and later pined for preservation.

Light attenuation was estimated using a light meter (Extech Digital Foot Candle/Lux Light Meter). Measurements were collected at the top of the canopy and at the bottom (water surface). Above ground biomass was estimated at each station using a small PVC quadrat (0.50 $m^2$) and hand clippers. Plants were removed from above the substratum, placed in plastic bags and then dried for ten days at $70^0$C.

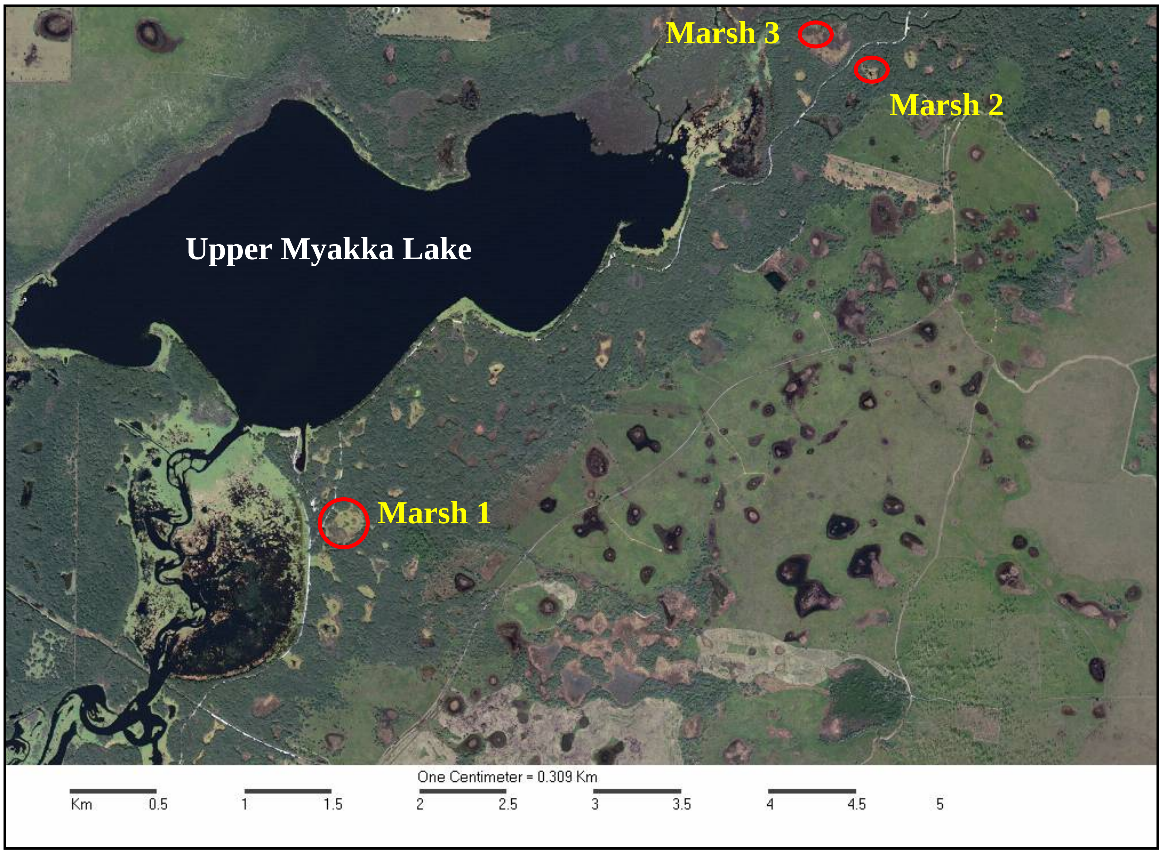

Figure 2. Location of marshes at Myakka River State Park (27$^{0}$16’N, 82$^{0}$16’W).

## Statistical Analysis

Macroinvertebrate diversity among native and *Hymenachne* sites was compared using the Shannon-Wiener Index, Simpson diversity Index and Evenness. Abundance of macroinvertebrate orders was tested using ANOVA (Proc GLM, SAS Institute) with plant community as a factor. We performed the analysis only for the summer sampling due to a missing aquatic sample in the fall. Low water levels in Marsh 1 during the fall of 2006 limited the collection of samples. The exotic blissid *Ischnodemus variegatus* was found in large quantities in areas where *Hymenachne amplexicaulis* was present and its abundance was not included in the analysis.

# *Results*

## Marsh characteristics

*Hymenachne amplexicaulis* colonized the deeper part of marshes where standing water was present most of the year. Floating mats where observed in the deeper part of the marshes and they might contribute to short distance dispersal inside the marsh during flooding events. Water quality parameters were not different between the marshes (Table 1).

## Plant community and biomass accumulation

Plant communities had very few species. Invaded sites were dominated by *Hymenachne amplexicaulis* and native sites by either *Panicum hemitomon* or *Leersia hexandra* (Table 2). Scores of plant cover were higher in the *Hymenachne* sites indicating complete dominance of the space available compared with native sites. There was a greater accumulation of biomass in the *Hymenachne* sites, especially in Marsh 1. This could be attributed to the deeper water levels (Table 1). During flooding events in the summer of 2004 and 2005 at Myakka River State Park, the only plant emerging from the water was *Hymenachne amplexicaulis*, demonstrating its potential for outcompeting native species. We hypothesize that *Hymenachne* is more problematic in deeper marshes located adjacent to the Myakka River due to the direct influence of nutrient runoff and drastic changes in the hydroperiod.

Table 1. Water quality data collected in native (N) and *Hymenachne* (H) sites[1] in three marshes at Myakka River State Park

| **Variable** | | **Marsh 1** | | **Marsh 2** | | **Marsh 3** | |
|---|---|---|---|---|---|---|---|
| | | N | H | N | H | N | H |
| Depth (cm) | | 59.8 | 101.8 | 57.8 | 64.3 | 60.3 | 65.8 |
| | s.d. | 2.99 | 2.75 | 6.13 | 4.11 | 3.30 | 2.75 |
| Temperature ($^0$ C) | | 26.4 | 26.4 | 25.9 | 26.0 | 26.1 | 26.2 |
| | s.d. | 0.08 | 0.24 | 0.20 | 0.24 | 0.13 | 0.49 |
| Dissolved oxygen (mg $^{L-1}$) | | 2.91 | 3.04 | 1.24 | 1.39 | 1.57 | 1.18 |
| | s.d. | 0.42 | 0.16 | 0.28 | 0.23 | 0.40 | 0.56 |
| pH | | 3.14 | 4.67 | 5.10 | 5.00 | 4.70 | 4.90 |

[1] Mean and S.D. of four samples

Table 2. Average emergent stems and cover in native (N) and *Hymenachne* (H) sites[1] in three marshes at Myakka River State Park

| | **Marsh 1** | | | | **Marsh 2** | | | | **Marsh 3** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | N | Cover | H | Cover | N | Cover | H | Cover | N | Cover | H | Cover |
| *Hymenachne amplexicaulis* | 0.25 | <1 | 48.25 | 6 | 0.5 | 1 | 41.25 | 5 | - | - | 40 | 5 |
| *Panicum hemitomon* | 32 | 4 | - | - | 68.5 | 5 | 25 | 2 | 39 | 4 | 13.25 | 1 |
| *Polygonon* sp. | 1.25 | <1 | - | - | 3 | 1 | 3 | 1 | - | - | - | - |
| *Salvinia minima* | - | - | Present | <1 | - | - | - | - | - | - | - | - |
| *Pontederia cordata* | - | - | - | - | 0.5 | 1 | - | - | - | - | 0.25 | <1 |
| *Leersia hexandra* | 21 | 3 | - | - | - | - | - | - | - | - | - | - |
| Vine | 0.25 | <1 | - | - | 1.5 | 1 | - | - | 1.75 | 1 | - | - |
| Biomass (g $0.5m^{-2}$) | 180.3 | | 530.0 | | 250.3 | | 337.8 | | 126.5 | | 295.0 | |
| Biomass S.D. | 40.2 | | 129.6 | | 104.5 | | 72.8 | | 56.7 | | 71.0 | |
| Species richness | 5 | | 2 | | 5 | | 3 | | 2 | | 3 | |
| Light attenuation | 632 | | 519.5 | | 756.5 | | 1117 | | 589.5 | | 379 | |
| Light SD | 90.5 | | 222.8 | | 511.4 | | 44.0 | | 386.0 | | 251.6 | |

[1]Coverage scale: 1=1-5%, 2=6-25%, 3=26-50%, 4=51-75%, 5=76-95%, 6=96-100%

## Macroinvertebrates Summer

A total of 1841 invertebrates were collected in the native sites versus 628 in the *Hymenachne* sites during the summer of 2006. Fifteen invertebrate orders were collected from the six sites (Table 4, Table 5). Insects compromised most of the invertebrates collected in the aerial and aquatic samples. The insect orders Coleoptera and Hemiptera had more families in the native than in the *Hymenachne* sites (Table 4). Insect families common in the samples included Formicidae, Chironomidae, Curculionidae, Noteridae, and Cicadellidae. These families had greater number of individuals in the native sites. Insect herbivore families such as Acrididae, Tettigonidae, Tetrigidae, Curculionidae and Cicadellidae were less abundant in the *Hymenachne* sites (Table 4). The native blissid *Ischnodemus brunnipennis* was found in large numbers in the native sites (Table 4). This sap-sucking herbivore feeds primarily in the phloem of *Panicum hemitomon* and its population builds during the summer and fall. Ichneumonidae, Braconidae and other parasitic Hymenoptera were only found in the native sites, which may suggest the presence of more complex food webs functioning in these sites.

The Shannon-Wiener Index, Simpson Index and Evenness were not different in the *Hymenachne* and native sites (Table 5). However, there was a clear simplification of macroinvertebrate fauna in the *Hymenachne* sites (Table 4, 5). Mean abundance of macroinvertebrate orders Diptera, Coleoptera, Hemiptera, Orthoptera and Araneae were significantly greater in the native sites compared to the *Hymenachne* sites (Fig.3).

Table 4. Macroinvertebrates collected from aquatic and aerial samples during Summer 2006

| **Taxon** | **Native sites** | | | ***Hymenachne* sites** | | |
|---|---|---|---|---|---|---|
| | Marsh 1 | Marsh 2 | Marsh 3 | Marsh 1 | Marsh 2 | Marsh 3 |
| INSECTA | | | | | | |
| Hymenoptera | 6 | 14 | 68 | 54 | 7 | 5 |
| Formicidae | 1 | 13 | 67 | 54 | 7 | 5 |
| Vespidae | 2 | 0 | 0 | 0 | 0 | 0 |
| Ichneumonidae | 1 | 0 | 0 | 0 | 0 | 0 |
| Braconidae | 0 | 1 | 0 | 0 | 0 | 0 |
| Parasitic Hymenoptera | 2 | 0 | 1 | 0 | 0 | 0 |
| Orthoptera | 28 | 3 | 11 | 2 | 3 | 7 |
| Acrididae | 22 | 1 | 6 | 2 | 3 | 2 |
| Tettigonidae | 4 | 0 | 5 | 0 | 0 | 5 |
| Gryllacrididae | 0 | 1 | 0 | 0 | 0 | 0 |
| Tetrigidae | 2 | 1 | 0 | 0 | 0 | 0 |
| Diptera | 288 | 173 | 110 | 127 | 14 | 87 |
| Unknown Diptera | 74 | 3 | 26 | 8 | 11 | 4 |
| Chironomidae (larvae) | 214 | 170 | 84 | 117 | 3 | 81 |
| Culicidae larvae | 0 | 0 | 0 | 0 | 0 | 1 |
| Diptera larvae | 0 | 0 | 0 | 2 | 0 | 1 |
| Coleoptera | 81 | 121 | 133 | 36 | 48 | 61 |
| Anthicidae | 0 | 0 | 1 | 0 | 2 | 0 |
| Silvanidae | 0 | 1 | 0 | 0 | 0 | 0 |
| Dysticidae | 2 | 0 | 0 | 0 | 0 | 0 |
| Tenebrionidae | 2 | 1 | 5 | 0 | 1 | 3 |
| Dryopidae | 1 | 1 | 0 | 1 | 0 | 0 |
| Carabidae | 0 | 1 | 0 | 0 | 0 | 0 |
| Chrysomelidae | 3 | 0 | 6 | 0 | 1 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Curculionidae | 3 | 29 | 44 | 4 | 1 | 22 |
| Haliplidae | 0 | 3 | 4 | 0 | 3 | 0 |
| Hydrophilidae | 4 | 32 | 4 | 1 | 5 | 4 |
| Noteridae | 10 | 18 | 52 | 26 | 18 | 21 |
| Scarabidae | 0 | 2 | 3 | 0 | 0 | 2 |
| Staphylinidae | 33 | 4 | 1 | 4 | 12 | 7 |
| Unknown Coleoptera | 7 | 3 | 0 | 0 | 0 | 0 |
| Unknown larvae | 16 | 26 | 13 | 0 | 5 | 1 |
| Hemiptera | 99 | 346 | 268 | 47 | 44 | 94 |
| Aphididae | 0 | 0 | 1 | 0 | 0 | 1 |
| Belastomatidae | 2 | 20 | 5 | 0 | 2 | 2 |
| Blissidae | 2 | 1 | 12 | 0 | 0 | 2 |
| Cicadellidae | 58 | 9 | 47 | 11 | 21 | 33 |
| Delphacidae | 5 | 0 | 6 | 1 | 0 | 5 |
| Dictyopharideae | 2 | 0 | 2 | 0 | 0 | 0 |
| Pleidae | 0 | 0 | 0 | 1 | 0 | 0 |
| Hebridae | 0 | 0 | 1 | 0 | 0 | 0 |
| Ischnodemus brunnipennis | 20 | 305 | 190 | 4 | 2 | 35 |
| Ischnodemus variegatus | 0 | 0 | 0 | 26 | 17 | 4 |
| Ischnodemus sp. | 0 | 0 | 0 | 2 | 1 | 1 |
| Lygaeidae | 0 | 1 | 0 | 0 | 0 | 0 |
| Membracidae | 0 | 0 | 1 | 0 | 0 | 0 |
| Miridae | 1 | 0 | 0 | 0 | 0 | 0 |
| Naucoridae | 1 | 1 | 0 | 1 | 0 | 0 |
| Notonectidae | 1 | 0 | 0 | 0 | 0 | 0 |
| Pentatomidae | 6 | 2 | 0 | 0 | 0 | 0 |
| Phymatidae | 0 | 0 | 1 | 0 | 0 | 0 |
| Reduviidae | 0 | 0 | 1 | 0 | 0 | 11 |
| Tingidae | 0 | 0 | 0 | 1 | 0 | 0 |
| Unknown Hemiptera | 1 | 7 | 1 | 0 | 1 | 0 |
| Thysanoptera | 2 | 8 | 0 | 0 | 2 | 0 |
| Lepidoptera | 1 | 0 | 1 | 0 | 2 | 0 |
| Collembola | 0 | 0 | 0 | 0 | 3 | 0 |
| Entomobriidae | 0 | 0 | 0 | 0 | 3 | 0 |
| Odonata | 3 | 1 | 1 | 1 | 1 | 4 |
| Coenagrionidae | 1 | 0 | 0 | 0 | 0 | 2 |
| Nymph | 2 | 1 | 1 | 1 | 1 | 2 |
| Trichoptera | 0 | 0 | 0 | 0 | 0 | 1 |
| Mantodea | 0 | 0 | 1 | 0 | 0 | 0 |
| Mantidae | 0 | 0 | 1 | 0 | 0 | 0 |
| Plecoptera | 0 | 7 | 0 | 2 | 0 | 0 |
| larvae | 0 | 7 | 0 | 2 | 0 | 0 |
| Blattaria | 0 | 0 | 0 | 0 | 0 | 1 |
| Blattidae | 0 | 0 | 0 | 0 | 0 | 1 |
| ARACHNIDA | | | | | | |
| Araneae | 31 | 19 | 13 | 5 | 3 | 17 |
| Acari | 4 | 0 | 0 | 0 | 0 | 1 |
| Ixodida | 0 | 0 | 0 | 0 | 0 | 1 |
| Acariformes | 4 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Insecta Order richness | 8 | 8 | 8 | 7 | 9 | 8 |
| Coleoptera family richness | 9 | 11 | 9 | 4 | 8 | 7 |
| Hemiptera family richness | 9 | 6 | 10 | 6 | 3 | 6 |
| Total abundance | 543 | 692 | 606 | 274 | 127 | 278 |
| Total abundance without I. variegatus | **543** | **692** | **606** | **248** | **110** | **274** |

Table 5. Total count of arthropods and diversity indexes. Summer 2006.

| | **Native sites** | | | ***Hymenachne* sites** | | |
|---|---|---|---|---|---|---|
| **ORDER** | Marsh 1 | Marsh 2 | Marsh 3 | Marsh 1 | Marsh 2 | Marsh 3 |
| Hymenoptera | 6 | 14 | 68 | 54 | 7 | 5 |
| Orthoptera | 28 | 3 | 11 | 2 | 3 | 7 |
| Diptera | 288 | 173 | 110 | 127 | 14 | 87 |
| Coleoptera | 81 | 121 | 133 | 36 | 48 | 61 |
| Hemiptera | 99 | 346 | 268 | 21 | 27 | 90 |
| Thysanoptera | 2 | 8 | 0 | 0 | 2 | 0 |
| Lepidoptera | 1 | 0 | 1 | 0 | 2 | 0 |
| Collembola | 0 | 0 | 0 | 0 | 3 | 0 |
| Odonata | 3 | 1 | 1 | 1 | 1 | 4 |
| Trichoptera | 0 | 0 | 0 | 0 | 0 | 1 |
| Mantodea | 0 | 0 | 1 | 0 | 0 | 0 |
| Plecoptera | 0 | 7 | 0 | 2 | 0 | 0 |
| Blattaria | 0 | 0 | 0 | 0 | 0 | 1 |
| Araneae | 31 | 19 | 13 | 5 | 3 | 17 |
| Acari | 4 | 0 | 0 | 0 | 0 | 1 |
| | | | | | | |
| Shannon-Index | 2.94 | 2.55 | 2.68 | 2.6 | 3.65 | 3.05 |
| | | | | | | |
| Order Richness (S) | 10 | 9 | 9 | 8 | 10 | 10 |
| | | | | | | |
| Total Abundance | 543 | 692 | 606 | 248 | 110 | 274 |
| | | | | | | |
| Simpson Diversity Index | | | | | | |
| D: | 0.34 | 0.34 | 0.29 | 0.34 | 0.27 | 0.26 |
| 1-D: | 0.66 | 0.66 | 0.71 | 0.66 | 0.73 | 0.74 |
| 1/D: | 2.92 | 2.9 | 3.45 | 2.95 | 3.65 | 3.8 |
| | | | | | | |
| Evenness | 0.61 | 0.59 | 0.65 | 0.65 | 0.71 | 0.66 |

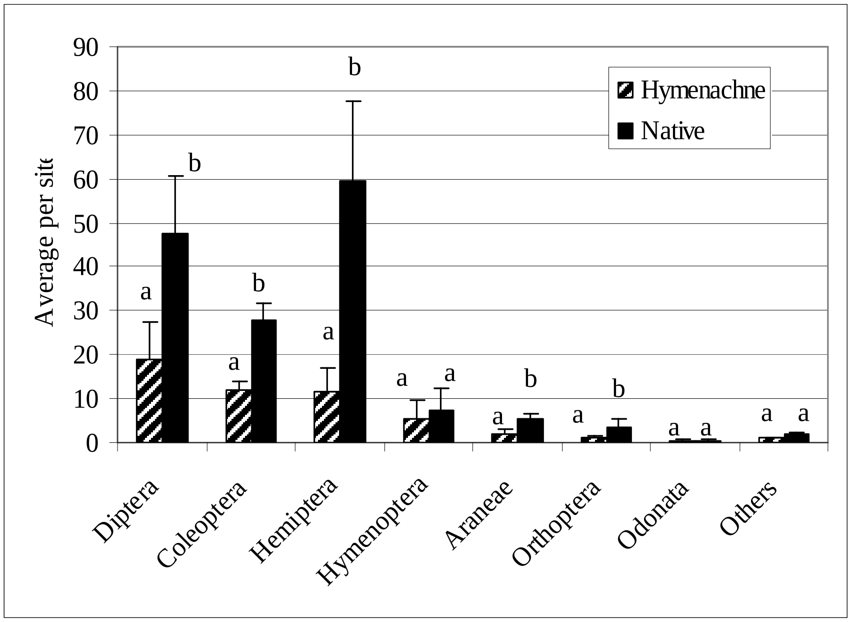

Figure 3. Mean abundance of arthropods in native and Hymenachne sites. Summer 2006. (ANOVA, d.f. 1,4, *P* <0.05).

## Macroinvertebrates Fall

Overall, there was a lower number of invertebrates collected during the fall than in the summer. A total of 813 invertebrates were collected in the native sites versus 657 in the *Hymenachne* sites during the fall of 2006. Thirteen invertebrate orders were collected in the aerial and aquatic samples. Insect orders with greatest number of families included Hemiptera and Coleoptera. The insect families Chironomidae, Hydrophilidae and Cicadellidae were more abundant in the native than in *Hymenachne* sites (Table 6). Insect families containing species only in the native sites included: Berytidae, Coreidae, Naucoridae, Pentatomidae, Tingidae, Hesperidae and Chrysopidae. One specimen of the parasitic order Strepsiptera (cicadellid host) was found in the native site in Marsh 2. Insect herbivore families such as Acrididae, Curculionidae and Cicadellidae were less abundant in the *Hymenachne* sites (Table 6). The exotic blissid *Ischnodemus variegatus* was found in large numbers in *Hymenachne* sites (Table 6) and it was the most common insect species on these sites. Similar to *I. brunnipennis, I. variegatus* is a specialist phloem feeder and reproduces primarily on *Hymenachne amplexicaulis*. Host range studies conducted in greenhouses at the Biological Control Research and Containment Laboratory (BCRCL)-Fort Pierce determined that *I. variegatus* can maintain stable populations only on *Hymenachne amplexicaulis.* However, under outbreak conditions *I. variegatus* can spill-over temporally to nearby grasses.

The Shannon-Wiener Index, Simpson Index and Evenness were not different in the *Hymenachne* and native sites (Table 7). Additionally, there was no difference between mean abundance of invertebrate orders between the sites (Figure 4).

Table 6. Macroinvertebrates collected from aquatic and aerial samples during Fall 2006

| **Taxon** | | **Native** | | | ***Hymenachne*** | |
|---|---|---|---|---|---|---|
| | Marsh 1 | Marsh 2 | Marsh 3 | Marsh 1 | Marsh 2 | Marsh 3 |
| INSECTA | | | | | | |
| Hymenoptera | 0 | 2 | 13 | 2 | 1 | 3 |
| Formicidae | 0 | 1 | 11 | 1 | 1 | 1 |
| Parasitic Hymenoptera | 0 | 1 | 2 | 1 | 0 | 2 |
| Orthoptera | 3 | 3 | 6 | 0 | 0 | 3 |
| Acrididae | 3 | 3 | 6 | 0 | 0 | 3 |
| Diptera | 8 | 287 | 87 | 89 | 102 | 148 |
| Bibionidae | 0 | 18 | 16 | 14 | 0 | 18 |
| Chironomidae (larvae) | . | 236 | 58 | 50 | 100 | 109 |
| Culicidae | 2 | 26 | 3 | 5 | 0 | 7 |
| Culicidae larvae | . | 0 | 0 | 2 | 0 | 1 |
| Unknown larvae | . | 1 | 1 | 0 | 0 | 0 |
| Unknown Diptera | 6 | 3 | 8 | 18 | 2 | 13 |
| Coleoptera | 1 | 84 | 53 | 28 | 81 | 49 |
| Carabidae | 1 | 1 | 3 | 0 | 0 | 1 |
| Chrysomelidae | 0 | 1 | 1 | 3 | 0 | 0 |
| Coccinellidae | 0 | 1 | 0 | 1 | 0 | 1 |
| Curculionidae | 0 | 10 | 13 | 0 | 1 | 9 |
| Dysticidae | . | 0 | 0 | 1 | 0 | 0 |
| Haliplidae | . | 1 | 6 | 0 | 4 | 1 |
| Hydrophilidae | . | 26 | 8 | 10 | 19 | 5 |
| Noteridae | . | 9 | 11 | 8 | 49 | 19 |
| Phalacridae | 0 | 0 | 2 | 0 | 0 | 1 |
| Staphylinidae | . | 8 | 6 | 2 | 1 | 1 |
| Tenebrionidae | . | 1 | 0 | 0 | 0 | 1 |
| Unknown Coleoptera | 0 | 0 | 0 | 2 | 0 | 1 |
| Unknown larvae | 0 | 26 | 3 | 1 | 7 | 9 |
| Hemiptera | 73 | 50 | 95 | 168 | 560 | 380 |
| Aphididae | 1 | 1 | 3 | 12 | 0 | 0 |
| Belastomatidae | . | 1 | 2 | 0 | 4 | 0 |
| Berytidae | 0 | 1 | 0 | 0 | 0 | 0 |
| Cicadellidae | 15 | 11 | 32 | 3 | 16 | 17 |
| Coreidae | 0 | 0 | 2 | 0 | 0 | 0 |
| Delphacidae | 0 | 4 | 13 | 0 | 2 | 4 |
| Derbidae | 0 | 0 | 0 | 0 | 0 | 1 |
| Gerridae | . | 0 | 0 | 0 | 0 | 1 |
| Rhyparochromidae | 0 | 0 | 2 | 0 | 0 | 1 |
| Hebridae | . | 0 | 1 | 0 | 1 | 0 |
| Ischnodemus brunnipennis | 1 | 30 | 4 | 0 | 0 | 0 |
| Ischnodemus sp.1 | 0 | 0 | 5 | 0 | 0 | 0 |
| Ischnodemus variegatus | 54 | 0 | 24 | 153 | 536 | 354 |
| Lygaeidae | 1 | 0 | 0 | 0 | 0 | 1 |
| Naucoridae | . | 1 | 0 | 0 | 0 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Pentatomidae | 0 | 1 | 7 | 0 | 0 | 0 |
| Tingidae | 1 | 0 | 0 | 0 | 0 | 0 |
| Thysanoptera | 6 | 1 | 0 | 2 | 1 | 0 |
| Lepidoptera | 3 | 0 | 3 | 0 | 3 | 2 |
| Hesperidae | 1 | 0 | 0 | 0 | 0 | 0 |
| Unknown larvae | 0 | 0 | 2 | 0 | 0 | 2 |
| Unknown moth | 2 | 0 | 1 | 0 | 3 | 0 |
| Odonata | 2 | 3 | 10 | 2 | 2 | 7 |
| Coenagrionidae | 2 | 1 | 6 | 0 | 2 | 1 |
| Unknown nymph | . | 2 | 4 | 2 | 0 | 6 |
| Ephemeroptera larvae | 0 | 0 | 0 | 0 | 1 | 0 |
| Neuroptera | 4 | 0 | 0 | 1 | 2 | 0 |
| Neuroptera larvae | 1 | 0 | 0 | 1 | 2 | 0 |
| Chrysopidae | 1 | 0 | 0 | 0 | 0 | 0 |
| Unknown Neuroptera | 2 | 0 | 0 | 0 | 0 | 0 |
| Strepsiptera | 0 | 1 | 0 | 0 | 0 | 0 |
| Collembola | 0 | 0 | 4 | 0 | 0 | 0 |
| Sminthuridae | . | 0 | 4 | 0 | 0 | 0 |
| Araneae | 14 | 29 | 46 | 41 | 3 | 19 |
| | | | | | | |
| Insecta Order richness | 9 | 8 | 8 | 7 | 9 | 7 |
| Coleoptera family richness | 1 | 9 | 9 | 6 | 5 | 9 |
| Hemiptera family richness | 5 | 8 | 9 | 2 | 4 | 6 |
| Total abundance | 114 | 460 | 317 | 333 | 756 | 611 |
| Total abundance without I. variegatus | 60 | 460 | 293 | 180 | 220 | 257 |

Table 7. Total count of arthropods and diversity indexes. Fall 2006.

| | **Native sites** | | | ***Hymenachne* sites** | | |
|---|---|---|---|---|---|---|
| **ORDER** | Marsh 1 | Marsh 2 | Marsh 3 | Marsh 1 | Marsh 2 | Marsh 3 |
| Hymenoptera | 0 | 2 | 13 | 2 | 1 | 3 |
| Orthoptera | 3 | 3 | 6 | 0 | 0 | 3 |
| Diptera | 8 | 287 | 87 | 89 | 102 | 148 |
| Coleoptera | 1 | 84 | 53 | 28 | 81 | 49 |
| Hemiptera | 19 | 50 | 71 | 15 | 24 | 26 |
| Thysanoptera | 6 | 1 | 0 | 2 | 1 | 0 |
| Lepidoptera | 3 | 0 | 3 | 0 | 3 | 2 |
| Odonata | 2 | 3 | 10 | 2 | 2 | 7 |
| Ephemeroptera | 0 | 0 | 0 | 0 | 1 | 0 |
| Neuroptera | 4 | 0 | 0 | 1 | 2 | 0 |
| Strepsiptera | 0 | 1 | 0 | 0 | 0 | 0 |
| Collembola | 0 | 0 | 4 | 0 | 0 | 0 |
| Araneae | 14 | 29 | 46 | 41 | 3 | 19 |
| | | | | | | |
| Shannon-Index | 4.036 | 2.3 | 3.59 | 2.62 | 2.48 | 2.73 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Species Richness (S) | 9 | 9 | 9 | 8 | 10 | 8 |
| Total Abundance | 60 | 460 | 293 | 180 | 220 | 257 |
| Simpson Diversity Index | | | | | | |
| D: | 0.193 | 0.439 | 0.208 | 0.328 | 0.363 | 0.385 |
| 1-D: | 0.807 | 0.561 | 0.792 | 0.672 | 0.637 | 0.615 |
| 1/D: | 5.172 | 2.28 | 4.805 | 3.05 | 2.755 | 2.599 |
| Evenness | 0.848 | 0.517 | 0.793 | 0.654 | 0.539 | 0.624 |

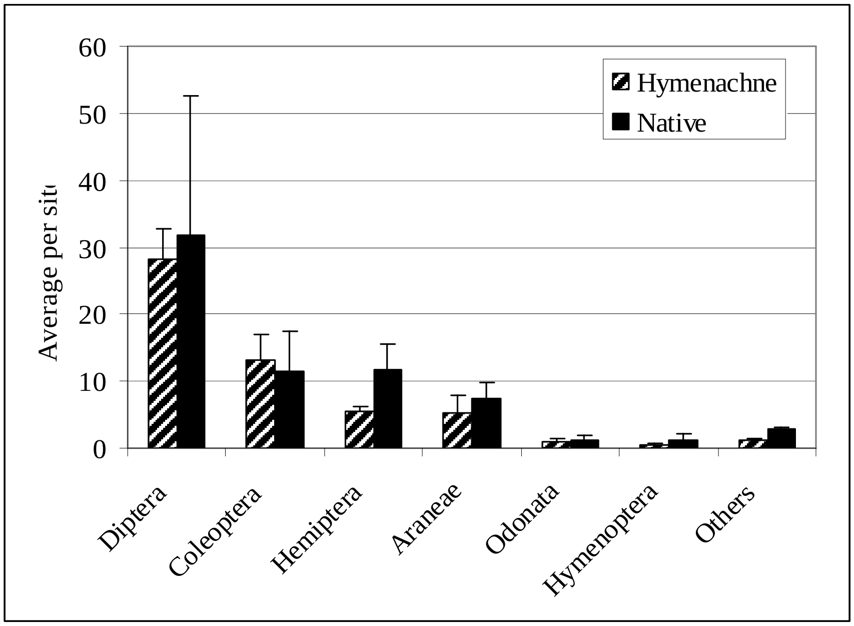

Figure 4. Mean abundance of arthropods in native and Hymenachne sites. Fall 2006

## *Discussion*

The invasion of *Hymenachne amplexicaulis* in Myakka River is an ongoing process that creates major changes in the wetland communities. *Hymenachne* was able to out-compete native plant species and dominate in the deeper parts of the marshes. The adaptation to rapid changes in the water level and nutrient uptake could provide a competitive advantage for *Hymenachne* in Florida, especially during summer flooding. Physiological adaptations to rising in water levels include rapid elongation of stems, formation of adventitious roots, presence of aerenchyma in the stem, leaf and root tissues, and changes in leaf:shoot ratio (Kibbler and Bahnisch 1999). In the Brazilian Pantanal, its native range, *Hymenachne* grows within four plant formations: marsh ponds, waterlogged basins, tall grasslands and forest edges (Pinder and Ross 1998). Observations of marshes in Myakka River State Park suggest that when subject to inundation, *Hymenachne* is capable of fast stem elongation, increase in foliage volume and rapid nodal adventitious root production (R. Diaz observations). This adaptation to wetter conditions could be used as a management strategy since *Hymenachne* is known to be less tolerant to drought (Medina and Motta 1990). Changes in the hydroperiod in managed wetlands could ameliorate the invasion of *Hymenachne* in Florida.

The total plant biomass in the *Hymenachne* invaded sites was larger than in the native ones. This trend is confirmed from Australian wetlands where *Hymenachne* is an aggressive exotic weed. Houston and Duivenvoorden (2002) found that invaded wetlands in Queensland had up to 30 fold greater biomass allocation than native sites. *Hymenachne* is also recognized in the native range as important forage for cattle. In Venezuela, Tejos (1978) found a positive relationship between *Hymenachne* growth and depth of flooding. Biomass *production* ranged from 5,911 - 18,162 t/ha/yr during the flood period and from 5,553 - 7,836 t/ha/yr during the dry season.

Invasive plants usually change the faunal composition in the adventive range because they reduce the diversity of foods available, simplify habitats and reduce chances of colonization. The simplification of the macroinvertebrate composition in the *Hymenachne* sites may be explained by the lack of adaptation of native fauna to this grass, reduction of physical space due to higher density of stems, and greater accumulation of leaf litter and sediments. The simplification of faunal assemblages in areas invaded by exotic plants has been extensively documented (Herrera and Dudley 2003, Houston and Duivenvoorden 2002, Tadley and Levin 2001, Posey 1988, Degomez and Wagner 2001, but see Hager and Vinebrooke 2004). In this study, the changes in macroinvertebrate fauna was evident particularly in the summer sampling where *Hymenachne* sites had lower abundance of individuals, especially in the orders Diptera, Coleoptera and Hemiptera compared to native sites. The only insect species that was collected in large numbers in *Hymenachne* sites was the exotic true bug, *Ischnodemus variegatus*, which is a *Hymenachne* specialist native to South America. Abundance of other insect herbivore families was much lower in the *Hymenachne* sites. The paucity of predators (spiders, reduviids, dragonflies) that responded to the increase in *I. variegatus* abundance during the fall of 2006, coupled with the low abundance of insect herbivores present in the *Hymenachne* sites, support the hypothesis that the colonization of exotic plants by native insects is a slow process.

Freshwater marshes in Myakka River are threatened by the invasion of *Hymenachne amplexicaulis* due the drastic changes in the flora and fauna and allocation of large biomass in the wetland. This study demonstrated that sites invaded by *Hymenachne* contain simple macroinvertebrate assemblages. The expansion and impact of this highly competitive grass in Florida might increase due to the interconnection of watersheds and erratic changes in the hydroperiod associated with summer floods.

# Effectiveness of herbicides for controlling *Hymenachne amplexicaulis* in marshes

## Introduction

Management of invasive plants in wetlands relies heavily on the use of registered herbicides. The wetland environment presents several challenges for the application of herbicides due to drastic changes in the hydroperiod, accessibility to the site and potential water contamination. Control of *Hymenachne* in Florida is done mostly with applications of glyphosate. Despite the importance of *Hymenachne* in Florida wetlands, there is no information on the effectiveness of herbicides in controlling this grass, or of the influence of burning on its survival. The objectives of the present study were to evaluate the use of herbicides to control *Hymenachne* and to measure the effect of a spring burning on *Hymenachne* survival.

## Material and Methods

Two field experiments were established on November 3, 2005 at the Myakka River State Park. These sites are approximately 5 km apart, and designated as 'North' and 'South'. A total of 10 plots were established at each site. All herbicides were applied with a 2-person, 3-meter boom (Fig.1) calibrated to deliver 468 L/ha at 262 kPa while walking 1.6 kph. Weather conditions at the time of application were $25^0$C with 79% RH and an average wind speed of 4 kph.

In the original proposal, the following treatments were to be applied: glyphosate (4.20 kg/ha), imazapyr (1.12 and 1.68 kg/ha), penoxsulam (0.05 kg/ha), imazapic (0.21 kg/ha), and 2,4-D amine (2.13 kg/ha). Based on data from a preliminary study, penoxsulam, imazapic and 2,4-D were removed and replaced with a tankmix of glyphosate + imazapyr (4.2 + 1.12 kg/ha).

Control was estimated visually on a 0-100% scale, where 0% equals no control and 100% equals complete plant death one and three months after treatment. In addition, a total of 5 whole plant samples were removed from individual plots from three replications. These plant samples were taken to the greenhouse where individual nodes were planted to monitor regrowth potential of the entire plant (Figure 2). Data for visual control ratings were analyzed with analysis of variance and means separated with Fisher's Protected LSD at $P$=0.05.

Figure 1. Three meter boom for herbicide application.

Figure 2. Evaluation of node survival in greenhouse conditions.

## *Results and Discussion*

Percent ground cover ranged from 60 to 90% at the North site and 80 to 100% at the South site on the day of application. Standing water was present at each site, with 40 and 20 cm of standing water at the North and South sites, respectively.

*Hymenachne* control was different among sites, but the trend was similar one month after treatment (Table 1). Glyphosate provided the least control with 79 and 86% control at the North and South sites, respectively. Imazapyr at 1.1 and 1.7 kg/ha provided similar control among application rates and at both sites (Figure 3). The tank-mix of glyphosate and imazapyr provided equal control to that of imazapyr at the North site, while this treatment provided the highest level of control at the South site. The difference between the two sites may be due, in part, to the difference in the amount of standing water (North=40 cm; South=20 cm). Tissue below the water surface was green and regrowth from individual nodes was present in some plots at this evaluation date. Ongoing studies by Dr. Brent Sellers at University of Florida at Ona will confirm whether the water depth influences the translocation of the herbicides to lower nodes.

Table 1. Visual control of *Hymenachne amplexicaulis* at the Myakka River State Park 1 month after treatment.

| | Rate | North | South |
|---|---|---|---|
| Treatment | kg/ha | --% control-- | |
| Glyphosate | 4.2 | 79 | 86 |
| Imazapyr | 1.1 | 86 | 89 |
| Imazapyr | 1.7 | 89 | 90 |
| Glyphosate + imazapyr | 4.2 + 1.7 | 89 | 95 |
| LSD (0.05) | - | 7 | 2 |

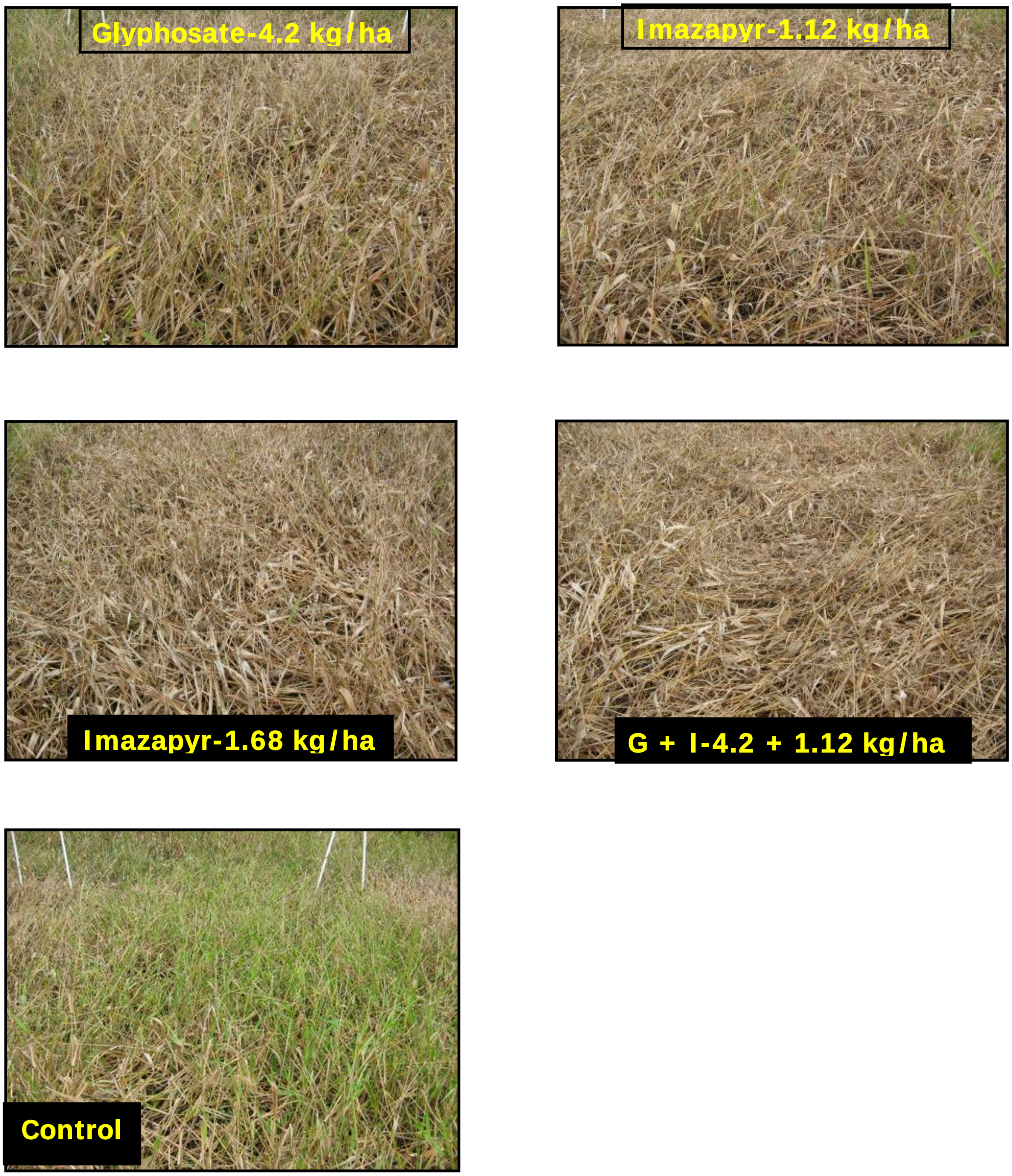

Figure 3. Plant conditions 1 month after the herbicide application.

Node survival assessed in the greenhouse was not significantly different among treated plots (Table 2). There was no node survival in the glyphosate + imazapir treatment.

Table 2. Node survival in plots treated with herbicides.

| | | 1 Month | | 3 Month | |
|---|---|---|---|---|---|
| Treatment | Rate | North | South | North | South |
| | kg/ha | -----------no. of nodes------ | | | |
| Untreated | 0 | 3.28 | 3.00 | 0.27 | 0.11 |
| Glyphosate | 4.2 | 0.07 | 0.08 | 0.06 | 0.02 |
| Imazapyr | 1.1 | 0.03 | 0.00 | 0.02 | 0.00 |
| Imazapyr | 1.7 | 0.00 | 0.00 | 0.01 | 0.00 |
| Glyphosate + imazapyr | 4.2 + 1.7 | 0.00 | 0.00 | 0.00 | 0.00 |
| LSD (0.05) | - | 0.4 | 0.3 | 0.07 | 0.06 |

During February of 2006, staff at the Myakka River State Park performed a control burn in several marshes along the river. We observed the reduction in standing biomass of *Hymenachne* (Fig. 5, A). However, the burn did not kill the lower nodes that were under wet conditions in the highly rich organic matter typical of *Hymenachne* beds (Fig. 5, B, C, D). Observations during the summer and fall of 2006 confirmed that *Hymenachne* was the dominant plant in the marsh.

Figure 4. Dry biomass of *Hymenachne* in Myakka River marshes. Date:3/3/2006.

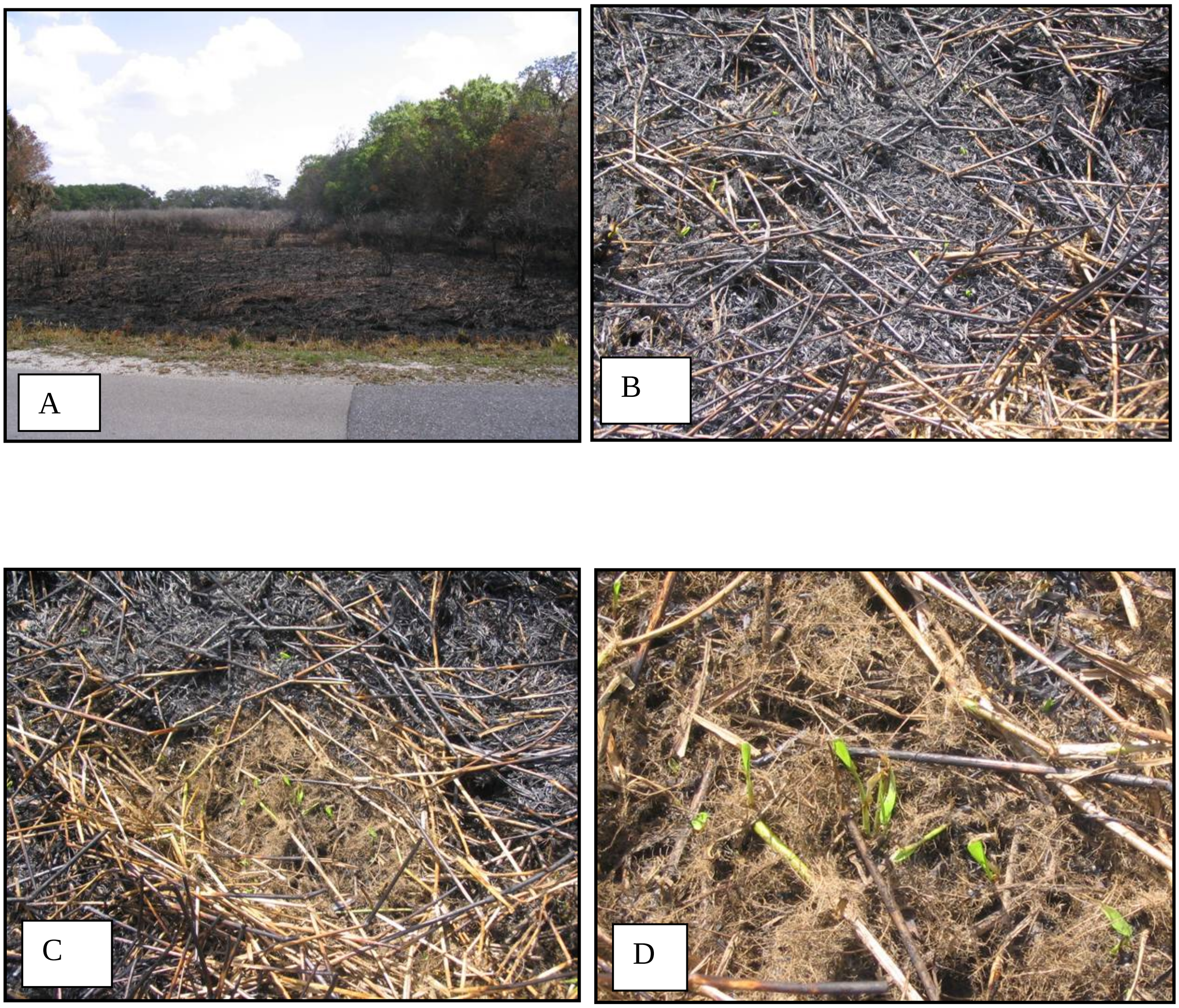

Figure 5. *Hymenachne* biomass burned. A) Burned plot, B) Top mass burned, C and D) Live below ground stolons with new shoots.

The management of *Hymenachne* would have to include several strategies such as winter burning, herbicide applications and control of hydroperiod. The control of stolons in moist conditions is crucial since most of aggressive growth in the following season originates from the lower nodes. The use of herbicides could be targeted for early in the growing season (February-May) when the nodes are under stress due to low water levels and cold temperatures. Herbicides should be applied before *Hymenachne* starts flowering (October to December). Management of hydroperiod in water reservoirs could also be used to stress by drying or drowning the plant (Csurhes el al 1999). Preventive measures such as monitoring could greatly improve the chances to control *Hymenachne* downstream.

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