

# Conversion of Torpedograss (*Panicum repens*) to Submerged Aquatic Vegetation in an Operational Stormwater Treatment Area for the Everglades

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## INTRODUCTION

The Everglades stormwater treatment areas (STAs) are constructed wetlands that are managed to remove phosphorus from agricultural runoff prior to discharge into the Everglades Protection Area (Guardo et al. 1995). The STA flow ways are compartmentalized by levees and water control structures into cells that range in size from 100-1400 ha and are managed as either emergent wetlands or for submerged aquatic vegetation (SAV) (Burns and McDonnell 2003).

Establishment and maintenance of SAV cells has required frequent herbicide applications to control floating and emergent vegetation that can interfere with nutrient uptake and removal by the submerged plant species and associated periphyton complex. Although the potential imposition of emergent plant species can be effectively addressed during the STA startup phase (i.e., prior to initial inundation) (Toth 2007), planned enhancements of existing STAs envision conversions of emergent cells to SAV while maintaining flow-through operations and associated water quality treatment. Conversions present greater impediments for achieving the desired rapid establishment of submerged plant species. Effective herbicide treatment of emergent species is more problematic in inundated wetlands and will add to the accumulated layer of submerged plant litter that can interfere with the colonization of SAV.

The purpose of this study was to evaluate establishment of SAV following an herbicide treatment of torpedograss (*Panicum repens*) in an operational STA. Torpedograss is an exotic and common nuisance species in STAs and forms dense mats that are difficult to control in south Florida wetlands (Smith et al. 1993, Hanlon and Langeland 2000, Hanlon and Brady 2005). Results have management implications for planned conversions of STA cells from emergent to submerged aquatic vegetation.

## STUDY AREA

The study was conducted in a recently created SAV cell of STA 3/4, which was constructed to remove nutrients in run-

off from the Everglades Agricultural Area south of Lake Okeechobee, Florida. Prior to startup approximately 138 ha of torpedograss covered a portion of this cell that had been previously used for sod production. Although most of this cover was eliminated by herbicide treatments, dense patches of torpedograss redeveloped in several untreated experimental plots (3 ha) that had been burned a month prior to initial inundation of the cell in June 2004. By April 2005, extensive beds of southern naiad (*Najas guadalupensis*) had established throughout most of the treated area, but colonization of SAV was precluded by the dense regrowth of torpedograss in the untreated, burned plots (Toth 2007). One of these 3 ha plots was used for this study.

## METHODS

Eight 400 m<sup>2</sup> (20 m × 20 m) plots were established in dense torpedograss in July 2005. Four plots were randomly selected for herbicide treatment and the remaining plots were used as control replicates. Imazapyr (HABITAT®) @ 0.56 kg active ingredient/ha was applied to inundated (mean depth = 28 cm) treatment plots in August 2005. Pre- and post-treatment water depths were derived from average ground elevations in the eight plots and daily stage data at inflow and outflow structures for this STA cell.

Ten randomly selected standing crop biomass samples were taken from each plot in July 2005 (i.e., prior to herbicide treatment), February-March 2006 (5-6 months after treatment) and October-December 2006 (14-16 months after treatment). Samples were collected by harvesting all above-ground plant biomass within a 0.25 m<sup>2</sup> quadrat. Reference (i.e., comparative) SAV biomass samples were taken in June 2005 from ten 1.0 m<sup>2</sup> quadrats in beds of southern naiad that were located approximately 400 m west of the study plots. These reference samples were indicative of SAV beds that had established in the surrounding area one year after the cell was initially flooded. Harvested plant biomass was rinsed to remove loose debris, separated by species, and weighed after drying at 50°C for 3-7 days.

Homogeneity of pre-treatment torpedograss biomass in treatment and control plots was evaluated with a nested ANOVA. Randomized block ANOVAs were used to analyze statistical differences in mean torpedograss and SAV biomass between sampling dates. Post-hoc Bonferroni (t) pairwise comparisons were used to differentiate significant differenc-

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es in torpedograss biomass between individual sample dates in control plots, while a priori orthogonal contrasts were employed for comparisons between pre-treatment and post-treatment samples of SAV biomass in treated plots. The potential influence of dead torpedograss biomass on SAV colonization in treated plots was evaluated with a simple linear correlation analysis. A one-way ANOVA with orthogonal contrasts was used to compare mean SAV biomass from the June 2005 reference samples with post-treatment samples from replicate treated plots.

## RESULTS AND DISCUSSION

Study plots were flooded to an average ( $\pm$  standard deviation) depth of  $34.9 \pm 16.0$  cm for 530 consecutive days prior to treatment. Plots remained continuously inundated through the December 2006 sampling period with depths averaging  $28.2 \pm 13.6$  cm and ranging between 16-35 cm 80% of the time.

Prior to herbicide application mean ( $\pm$  SE) biomass of live torpedograss was very similar ( $p(F) = 1.0$ ) in replicate treatment ( $1966.8 \pm 338.4$  g/m<sup>2</sup>) and control ( $1961.3 \pm 207.6$  g/m<sup>2</sup>) plots (Figure 1). Although this study area had been burned in May 2004 pre-treatment standing crop biomass of torpedograss was only slightly less than reported for torpedograss stands (2.6-4.4 kg/m<sup>2</sup>) in deeper water (0.8-1.7 m) on nearby Lake Okeechobee (Hanlon and Langeland 2000). Mean torpedograss biomass in control plots continued to increase ( $p(F$  and Bonferroni  $t) < 0.05$ ) during the February-March 2006 ( $3041.2 \pm 173.3$  g/m<sup>2</sup>) and October-December 2006 ( $3111.7 \pm 124.9$  g/m<sup>2</sup>) sampling periods, which appeared to represent maximum culm densities and associated standing crop in the prevailing water depths at this study location. Mean live torpedograss biomass in treated plots declined to  $10.0 \pm 1.2$  g/m<sup>2</sup> six months after treatment and to  $1.4 \pm 0.3$  g/m<sup>2</sup> during the last sampling period, and indicates that a single application of imazapyr largely eliminated the torpedograss. A mean of  $1542.8 \pm 219.7$  g/m<sup>2</sup> of dead torpedograss remained in treated plots (i.e., 78% of live pre-treatment torpedograss biomass) during February-March 2006 sampling but declined to  $524.5 \pm 163.1$  g/m<sup>2</sup> by the October-December sampling period.

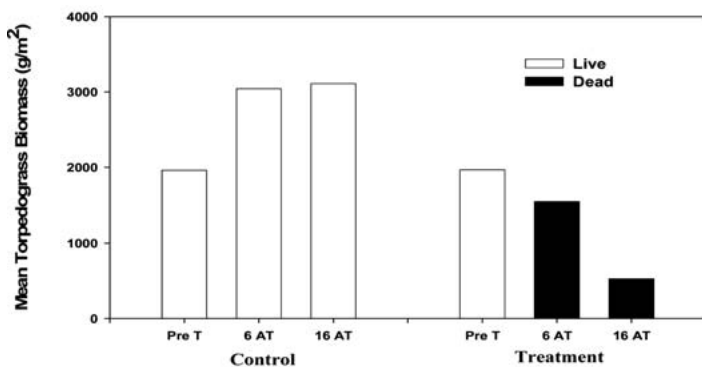


Figure 1. Mean dry standing crop biomass of torpedograss in replicate ( $n = 4$ ) control and treatment plots prior to herbicide applications (Pre T) (July 2005) and during sampling periods 5-6 months after treatment (AT) (February-March 2006) and 14-16 months AT (October-December 2006). Open bars represent live torpedograss biomass while black bars show the dead torpedograss biomass that remained in treated plots.

Southern naiad and bladderwort (*Utricularia* spp.) were present in 24% of pre-treatment samples ( $n = 80$ ) but had low mean ( $\pm$  SE) biomass that was not significantly different ( $p(F) = 0.21$ ) in replicate treatment ( $14.1 \pm 13.8$  g/m<sup>2</sup>) and control ( $1.6 \pm 0.5$  g/m<sup>2</sup>) plots. Variability of mean SAV biomass in treatment plots was due to relatively high biomass of southern naiad in two of the samples from one of the replicate plots. During February-March 2006 (i.e., six months after treatment) mean biomass of SAV at treated ( $0.1 \pm 0.1$  g/m<sup>2</sup>) and control plots ( $2.0 \pm 0.7$  g/m<sup>2</sup>) was not significantly different ( $p(F) > 0.7$ ) than that found at these sites prior to treatment. The potential relationship between this slight decline in mean SAV biomass at treated plots and the herbicide application could not be determined but a previous study has shown that submerged plant species were not affected when emergents were treated with imazapyr (Patten 2003). No SAV was found in control plots in October-November 2006 but mean SAV biomass at treated plots increased to  $202.5 \pm 76.9$  g/m<sup>2</sup>, which was significantly greater ( $p(F) = 0.018$ ) than pre-treatment SAV biomass at these plots. During this sampling period biomass of SAV was negatively correlated with dead torpedograss biomass ( $r = -0.54$ , Figure 2), which suggests that the limited colonization of SAV during February-March 2006 may have been due to the accumulation of dead (i.e., treated) torpedograss litter that remained six months after treatment. Mean SAV biomass in replicate treated plots during the last sampling period ( $202.5 \pm 76.9$  g/m<sup>2</sup>) was not significantly different ( $p(F) = 0.265$ ) than reference SAV biomass ( $139.8 \pm 10.8$  g/m<sup>2</sup>), which was taken from an adjacent area during late June 2005.

Planned enhancements of the nutrient uptake and removal capability of Everglades STAs (Dierberg et al. 2002, Knight et al. 2003) require further compartmentalization with conversion of cells from emergent plant cover to predominantly submerged aquatic vegetation. Results of this study indicate colonization of SAV following an herbicide treatment of dense torpedograss in an operational (i.e., flooded) STA was delayed by accumulated plant litter but occurred by the end of the first growing season (spring-summer) after treatment. The thick accumulation of dead torpedograss thatch that

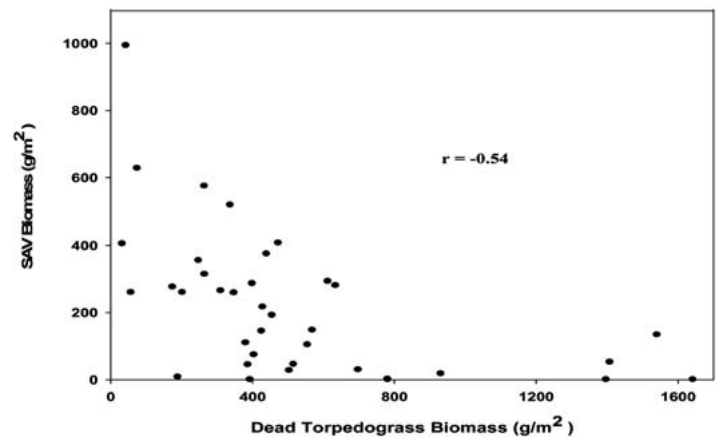


Figure 2. Negative correlation between dry standing crop biomass of submerged aquatic vegetation (SAV) and remaining dry biomass of dead torpedograss in samples ( $n = 40$ ) taken from treatment plots in October-December 2006 (14-16 months after treatment).

remained six months after herbicide treatment provided similar conditions as untreated torpedograss and temporarily prevented establishment of SAV by blocking light penetration through the water column and precluding diaspore contact with a suitable rooting medium. Light attenuation declined as the treated torpedograss sank below the water surface and submerged litter became coated with periphyton, which can facilitate an important mechanistic pathway for coprecipitation and permanent retention of phosphorus (Dierberg et al. 2002). Southern naiad subsequently colonized this submerged mat of partially decomposed litter and periphyton. Although a dense stand of torpedograss surrounded the treated plots, hydrochoric transport of diaspores from adjacent beds of SAV likely provided the source for post-treatment colonization of naiad (Barrat-Segretain 1996). The similarity (i.e., statistically insignificant difference) between mean biomass of the southern naiad beds that established 14-16 months after herbicide treatment and the standing crop of SAV after 12 months of growth at an adjacent reference site confirms the feasibility of successful vegetation manipulations for rapid conversion of emergent STA cells.

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