J. Aquat. Plant Manage. 48: 52-55

NOTES

Planting Strategies to Reestablish Aquatic Grasses

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INTRODUCTION

A goal of most aquatic-habitat restoration and enhancement projects conducted by the Florida Fish and Wildlife Conservation Commission (FWC) is to reestablish desirable native aquatic plant communities. Natural expansion of native vegetation generally occurs following treatments for aquatic plant control, but this response is often slow. Because invasive or exotic species are frequently the first to revegetate a treated area (Moyer et al. 1995, Smart et al. 1998), native plants such as aquatic grasses (Egyptian paspalidium [*Paspalidium geminatum*] and maidencane [*Panicum hemitomon*]) are commonly planted to accelerate the establishment of desirable species.

The FWC staff initially planted whole plants (i.e., entire stems with the roots intact and at least one green leaf per stem) to reestablish aquatic grasses. Because of logistical constraints and the high costs associated with nursery-reared propagules, we usually obtained donor plants from permitted wild collection sites. We harvested and removed plants in their entirety, which may have posed some risk to donor sites. Permit conditions usually specified that no more than 5 to 10% of any stand could be collected to prevent damage to source populations. For large-scale revegetation projects (≥10,000 plants), suitable and convenient collection sites can be difficult to secure (Mallison et al. 2006). An alternative approach is to plant vegetative cuttings (i.e., cut stems with at least one node and one green leaf, but no roots), which may be collected without disturbing the root system of donor plants.

Planting vegetative cuttings via tractor and disk is an effective method for establishing grasses in pastures (Adjei and Mislevy 2001). This method was used during an extreme drawdown on Lake Tohopekaliga, Florida, in 2004 (Pouder et al. 2006). Although establishment of disked Egyptian paspalidium cuttings was documented in moist areas, the overall limited success was attributed to desiccation of cuttings during the low-water event. For that project, source plant material (4.1 million Egyptian paspalidium cuttings) was mechanically harvested with a Kelpin 800 harvester (Haller 1996) from nearby Lake Kissimmee. Because pre- and post-harvesting stem densities were not significantly different at any time during the 3- to 26-week evaluation period, we concluded that harvesting Egyptian paspalidium cuttings had minimal effect on source plants (Mallison et al. 2006). This collection strategy exploited a renewable resource, and the donor site was left intact. In contrast to harvesting whole plants, a greater percentage of donor stands may be harvested (mechanically or manually) to collect cuttings without affecting source populations. Furthermore, cuttings may be successfully collected from areas that are too deep (>1 m) for manual harvesting of whole plants. With fewer restrictions on collecting cuttings from donor sites, more and/or larger source populations would potentially become available, thus improving the efficiency with which cuttings can be collected during revegetation projects.

We previously reported survival of manually-planted aquatic grass cuttings and whole plants in Florida lakes, but we did not quantify survival rates (Mallison et al. 2006). Observations indicated that survival rates and subsequent expansion of plantings was similar for Egyptian paspalidium and maidencane. Both species are perennial, rhizomatous aquatic grasses (Taylor 2009). They often occupy the same areas within littoral zones of Florida lakes (water depths up to 2.5 m) and provide similar habitat value for fish and wildlife (FWC Kissimmee Chain of Lakes Standing Team, pers. comm.). The objective of this project was to compare the rates of retention (the proportion of live plants plus dead plants remaining) and survival (the proportion of live plants remaining) of planted whole plants to those of planted cuttings for Egyptian paspalidium and maidencane on two Florida lakes.

METHODS

Aquatic grasses were planted in Lake Tohopekaliga (7615 ha) during 29 July to 5 August 2005 and in Lake Yale (1635 ha) on 13 May 2008. Permits for collecting aquatic grasses for revegetation were obtained from the Florida Department of Environmental Protection. Source plants (50 to 150 cm in length) were collected from robust stands within each lake. Whole plants were either dug with a shovel or pulled by hand, and cuttings were either pulled by hand or cut with pruning shears. Sediments were rinsed from the roots of all collected whole plants. Plants were transported by boat to

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study sites within 5 km of all collection sites. Collected plants were kept hydrated by laying them in lake water or pouring water over them as needed (e.g., hourly) during transplanting. Within 7 hours of collection, the vegetation was planted by using a shovel to separate sediments to a depth of 10 to 20 cm. After planting, sediments were compacted by stepping several times all around the plantings to anchor them in place. Planting activities were completed by FWC personnel on Lake Tohopekaliga and by a contractor on Lake Yale.

Study sites were selected based on suitable water depth (25 to 65 cm), substrate (primarily hard sand with some clay), lack of aquatic vegetation, and proximity to existing stands of aquatic grasses (to confirm that aquatic grasses could grow in that region of the lake). The study site on Lake Tohopekaliga included 12 adjacent plots (3 m by 3 m) marked with wooden stakes and numbered. Plots were systematically planted in a randomly selected sequence for three replications of the following planting treatments: (1) Egyptian paspalidium whole plant, (2) Egyptian paspalidium cutting, (3) maidencane whole plant, and (4) maidencane cutting. Twenty-five plants per plot were planted in five rows of five plants. On Lake Yale, three study sites were selected. Study site #1 was located along a sheltered area of shoreline; study sites #2 and #3 were more exposed to wind and wave action. At each site, five adjacent plots (6 m by 3 m) were marked with PVC poles and numbered. Four planting treatments were conducted as described above. The fifth plot was an unplanted control plot. At each site, sequence of planting was selected at random. For each treatment plot, 50 plants were planted in five rows of 10 plants.

All plants (including live and dead plants) remaining in each plot (R) were counted between 55 and 75 days after planting. Between 196 and 210 days after planting, the remaining live plants (S) were counted in each plot. Counts were completed by carefully wading through each plot to inspect for presence/absence and survival of individual plants. Retention rate was defined as the proportion of live plants plus dead plants remaining, or R/P, where P = the number of plants initially planted. Survival rate was defined as the proportion of live plants remaining, or S/P. Adjusted survival rate was defined as the proportion of survival per retention, or S/R (i.e., the survival rate of plantings that did not wash away).

Statistical analyses were performed by FWC's researchers at the Center for Biostatistics and Modeling using SAS v 9.2 (SAS Institute, Inc., Cary, NC). Model residuals and fit statistics were compared for a 3-way ANOVA (PROC MIXED) and a 3-way generalized linear model assuming binomial distribution (PROC GLIMMIX). The ANOVA was deemed a more appropriate fit for the data and was selected to test for differences in rates of retention, survival, and adjusted survival between the lakes (Tohopekaliga and Yale), stem treatments (whole plant and cutting), and plant species (Egyptian paspalidium and maidencane). Multiple comparisons (Tukey) were used to determine treatment differences. All analyses were conducted at the P = 0.10 level of significance.

RESULTS AND DISCUSSION

Mean retention rates of planted aquatic grasses were significantly different between stem treatments ($F_{1, 16} = 60.5$, $P < 0.01$), averaging 88 ± 5% for whole plants and 33 ± 5% for cuttings (Table 1-A). Retention rates were not significantly different between lakes or plant species, and there were no significant interactions (all $P > 0.10$).

Mean survival rates were significantly different between stem treatments ($F_{1, 16} = 24.1$, $P < 0.01$), averaging 54 ± 6% for whole plants and 11 ± 6% for cuttings (Table 1-B). Survival rates were also significantly different between lakes ($F_{1, 16} = 7.3$, $P = 0.02$), averaging 44 ± 6% on Lake Yale and 20 ± 6% on Lake Tohopekaliga. However, any effect of lake must be interpreted with caution because there was a significant interaction between lakes and plant species ($F_{1, 16} = 3.7$, $P = 0.07$). Survival of maidencane was significantly higher on Lake Yale (51 ± 9%) than Lake Tohopekaliga (11 ± 9%). No significant differences were observed in the survival rates of Egyptian paspalidium between lakes (37 ± 9% on Lake Yale and 30 ± 9% on Lake Tohopekaliga), survival rates between plant species within each lake, or any other interactions. No aquatic grasses were observed in control plots at any time during the study, and we assumed that all plants within treatment plots grew from plantings.

Similarly, mean adjusted survival rates were significantly different between stem treatments ($F_{1, 16} = 9.4$, $P < 0.01$), averaging 58 ± 6% for whole plants and 30 ± 6% for cuttings (Table 1-C). Adjusted survival rates were also significantly different between lakes ($F_{1, 16} = 8.1$, $P = 0.01$), averaging 57 ± 6% on Lake Yale and 31 ± 6% on Lake Tohopekaliga. Again, there was a significant interaction between lakes and plant species ($F_{1, 16} = 4.5$, $P = 0.05$). Adjusted survival of maidencane averaged 16 ± 9% on Lake Tohopekaliga, which was significantly lower than that of any other planting treatment. No significant differences were observed between the adjusted survival rates of maidencane on Lake Yale (61 ± 9%) and those of Egyptian paspalidium on Lake Tohopekaliga (47 ± 9%) or Lake Yale (53 ± 9%), or any other interactions.

All differences in retention rates were attributed to stem treatments. Survival rates and adjusted survival rates were influenced by stem treatments, lake experiments, and interactions between lakes and plant species. The latter two factors were punctuated by relatively poor survival of maidencane on Lake Tohopekaliga. The two lake treatments incidentally occurred at different times of the year: Lake Yale was planted in spring and survival was determined within the same growing season, whereas Lake Tohopekaliga was planted in summer and survival was determined the following spring. Therefore, the varying survival rates of maidencane between lake experiments may have been influenced by the different lakes, the different planting seasons, and/or the different growing seasons. We assumed that any influences of these variables equally affected survival rates and adjusted survival rates of whole plants and cuttings.

Planting whole plants was approximately five times more effective than planting cuttings to reestablish aquatic grasses. The retention rates were three times higher for whole plants than for cuttings, and the adjusted survival rates were two times higher. The advantages of using cuttings (e.g., minimal damage to source populations and improved efficiency during plant collection) may be negated by the lower survival rates. More planting material and effort would be required to attain the target number of surviving plants. Thus, plant-

Table 1. (A) Number of aquatic grass plants remaining and mean retention rates (±1 SE); (B) number of live aquatic grass plants remaining and mean survival rates; and (C) percent adjusted survival (survival/retention) per planting treatment in Lake Tohopekaliga (September 2005 to February 2006) and Lake Yale (July 2008 to November 2008). E = Egyptian paspalidium, and M = maidencane.

		(A) # plants remaining				(B) # live plants remaining				(C) Adjusted survival (%)			
Planting treatment	# planted per plot	Plot 1	Plot 2	Plot 3	Mean retention (%)	Plot 1	Plot 2	Plot 3	Mean survival (%)	Plot 1	Plot 2	Plot 3	Mean
Lake Tohopekaliga													
E whole plant	25	19	23	22	85.3 ± 4.8	12	8	20	53.3 ± 14.1	63.2	34.8	90.9	62.9 ± 16.2
E cutting	25	6	6	4	21.3 ± 2.7	1	3	1	6.7 ± 2.7	16.7	50.0	25.0	30.6 ± 10.0
M whole plant	25	15	17	22	72.0 ± 8.3	5	1	8	18.7 ± 8.1	33.3	5.9	36.4	25.2 ± 9.7
M cutting	25	14	13	10	49.3 ± 4.8	0	0	2	2.7 ± 2.7	0	0	20.0	6.7 ± 6.7
Lake Yale													
E whole plant	50	50	42	48	93.3 ± 4.8	31	10	50	60.7 ± 23.1	62.0	23.8	100	61.9 ± 22.0
E cutting	50	24	5	11	26.7 ± 11.2	14	2	4	13.3 ± 7.4	58.3	40.0	36.4	44.9 ± 6.8
M whole plant	50	50	50	49	99.3 ± 0.7	50	35	39	82.7 ± 9.0	100.0	70.0	79.6	83.2 ± 8.8
M cutting	50	40	6	6	34.7 ± 22.7	27	1	2	20.0 ± 17.0	67.5	16.7	33.3	39.2 ± 15.0
Control	0	0	0	0		0	0	0					

Combined data for stem treatments	Total # planted	Total # plants remaining	Mean retention (%)	Total # live plants remaining	Mean survival (%)	Mean adjusted survival (%)
Total whole plant	450	407	87.5 + 5.0	269	53.8 + 6.2	58.3 + 6.4
Total cutting	450	145	33.0 + 5.0	57	10.7 + 6.2	30.3 + 6.4

ing whole plants would generally be preferable to planting cuttings. However, when location or size of the project precludes availability of suitable donor locations for whole plants, revegetation with cuttings may be preferred. Logistics may also prevent or hinder manual planting at some threshold and a mechanical strategy may be more appropriate. The FWC staff also disked aquatic grass cuttings mechanically; however, confounding variables prevented reliable evaluation of survival (Pouder et al. 2006).

Future research could explore conditions or strategies to improve survival of plantings, particularly of aquatic grass cuttings. On Lake Yale, the highest rates of retention, survival, and adjusted survival of cuttings for both plant species occurred at plot #1 (Table 1), which was more sheltered from wind and wave action than the other plots. Additional areas outside of the study plots on Lake Yale were planted with whole plants and cuttings of both plant species, but sampling in these areas was outside the scope of this study. However, observations in areas where plantings were not inundated (i.e., within moist, sandy sediments along the lake shore) indicated that retention and initial survival rates were similar in the treatments with whole plants and cuttings. Retention rates of cuttings may be improved by planting them in sheltered areas or in moist sediments above the water table during low-water periods. Adjusted survival rates of cuttings may be improved by preconditioning (fertilizing) donor plants to stimulate sprouting at the nodes prior to harvest (Adjei and Mislevy 2001). This procedure may be more appropriate for a nursery setting rather than for wild collection sites. Finally, survival of individual plantings may be improved by planting multiple (e.g., 3 to 5) cuttings at a time, rather than one.

ACKNOWLEDGMENTS

We thank David Douglas and Bill Pouder for technical reviews and comments on this work, Patrick McCord and Chris Ludy for assistance with planting aquatic grasses on Lake Tohopekaliga, Erin Leone for assistance with statistical analyses, and Aquatic Plants of Florida, Inc. for completing all planting activities per FWC specifications on Lake Yale.

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