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Effect of Metsulfuron Methyl and 2,4-D on Denseflower Knotweed

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ABSTRACT

Water stabilization has resulted in excessive growth of some emergent plant species that have degraded fisheries habitat within shallow littoral areas of many Florida lakes. Development of a selective, maintenance herbicide program is needed to sustain or promote desirable aquatic plants while controlling dense vegetation. We evaluated the effectiveness and selectivity of herbicides applied during a drawdown of Lake Tohopekaliga, Florida. Denseflower knotweed (*Polygonum densiflorum* Meis.) was treated with metsulfuron methyl {methyl 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino] carbonyl]amino]sulfonyl]benzoate} at 63 g a.i./ha, and 2,4-D (2,4-dichlorophenoxy acetic acid, dimethylamine salt) at 3.3 l a.i./ha. Stem density of denseflower knotweed and frequency of occurrence for emergent and terrestrial vegetation were monitored within 4-ha study areas in a metsulfuron-methyl treatment zone, a 2,4-D treatment zone, and a control (no-treatment) zone. At 18 months post-treatment, percent frequency of denseflower knotweed declined by 99% in the metsulfuron-methyl treatment area, 57% in the 2,4-D treatment area, and 2% in the control area. Stem density of denseflower knotweed was significantly ($P < 0.05$) lower in the metsulfuron-methyl treatment area, but not significantly different between the 2,4-D treatment and control areas. Comparing 18 months post-treatment to 30 months post-treatment, there was minimal change in percent frequency, and stem density was significantly lower in both treatment areas than the control area. Percent frequency of desirable aquatic grasses Egyptian paspalidium (*Paspalidium geminatum* [Forssk.] Stapf) and maidencane (*Panicum hemitomon* Schult.) doubled in the herbicide treatment areas after three months.

Key words: drawdown, Escort, habitat enhancement, Lake Tohopekaliga, selectivity, aquatic herbicide.

INTRODUCTION

Lake Tohopekaliga is a 7,615 ha eutrophic lake located within the Kissimmee Chain of Lakes in Osceola County, Florida. Historically, the lake fluctuated between 14.9 and 18.1 m above MSL (mean sea level), a range of 3.2 m. Following implementation of flood-control modifications and infrastructure in the 1960s, water levels were maintained between 15.7 and 17.1 MSL (range = 1.4 m) from 1964 to 1970, and 15.8 to 16.8 MSL (range = 0.9 m) after 1970 (Holcomb and Wegener 1971, Wegener et al. 1974). Years of regulated water levels promoted establishment of dense monocultures of aquatic vegetation, such as cattail (*Typha* spp.) and pickerelweed (*Pontederia cordata* L.), and accumulation of organic sediments in the littoral zone (Moyer et al. 1995). These plant communities (nearly 100% vegetated) were found to provide lower quality fisheries habitat than areas containing sparse-to-moderate coverage of Egyptian paspalidium, maidencane, and spikerushes (*Eleocharis* spp.) over sandy substrate.

In response to this habitat degradation, the Florida Fish and Wildlife Conservation Commission (FWC) implemented drawdowns (artificial lowering of water levels) on Lake Tohopekaliga in 1971 and 1979 to promote drying and decomposition of accumulated organic sediments (Wegner and Williams 1975, Williams et al. 1992). Continued sedimentation prompted a pilot project during the next drawdown in 1987 to evaluate mechanical removal of 136 ha of vegetation and organic sediments (hereafter, muck removal) from the littoral zone (Moyer et al. 1995). Initial evaluations documented improvements in substrate, aquatic plant diversity, and standing crops of sport fish in muck-removal areas. However, plant communities dominated by dense monotypic stands of cattail and pickerelweed returned to predrawdown levels by the third year (Moyer et al. 1995). During the 1987 drawdown, denseflower knotweed (*Polygonum densiflorum* Meis.) expanded on the exposed (dry) lake bottom and persisted after refilling of the lake (Hulon et al. 1998). This response was also observed on Lake Jackson, where denseflower knotweed became established during a drought in 2001 (Mallison et al. 2003). Excessive growth of denseflower knotweed may impede angler access and compete with desirable aquatic grasses, which are generally considered preferable plant species for fisheries habitat due to patchy growth patterns combined with minimal leaf litter.

Based on these results, a maintenance herbicide program was implemented to control primarily pickerelweed and cattail following a 1996 drawdown and muck-removal project on Lake Kissimmee (Hulon et al. 1998). A combination of glyphosate (N-[phosphonomethyl] glycine, isopropylamine salt) and 2,4-D (2,4-dichlorophenoxy acetic acid, dimethylamine salt) was applied aerially to an average of 359 ha/yr from 1996 to 2002 to prevent formation of dense, monotypic stands of vegetation (FWC, unpubl. data). In addition, treatments targeted denseflower knotweed prior to refilling of the lake in 1996. Prolonged benefits of habitat enhancement (i.e., diverse fish communities with a relatively high proportion of sport fish in managed areas) were documented and partially attributed to control of nuisance plant communities with herbicides (Tugend and Allen 2004). However, control

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of nontarget plants was also observed, and all emergent vegetation in treatment areas was suppressed by the nonselective herbicide combination. A goal of 40 to 70% aquatic plant canopy coverage consisting of 50 to 75% desirable plants, including aquatic grasses, bulrushes (*Schoenoplectus* spp. = *Scirpus* spp.), spikerushes, and native submersed species, based on best professional judgment and historical observations, was not attained in most muck-removal areas until 2003-2004, after treatments were terminated (Tim Coughlin, FWC, personal communication).

A selective herbicide program is needed to facilitate expansion (or survival) of desirable aquatic plants while controlling nuisance vegetation, with the goal of establishing (or maintaining) quality fish and wildlife habitat during regulated hydrological conditions and during periods with fluctuating water levels (e.g., droughts and drawdowns). Due to the large size of management areas and mixed growth of nuisance and desirable plants, adequate herbicide application to control target plants cannot be achieved without incidental treatment of intermixed, nontarget plants. Thus, identifying selective herbicides suitable for broadcast application was considered the appropriate approach. Herbicides currently labeled for aquatic use that may selectively control undesirable broadleaf plants include triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid, triethylamine salt) and 2,4-D (Nelson and Getsinger 2000, Petty et al. 2003). Chiconela et al. (2004) demonstrated that metsulfuron methyl {methyl 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoate} may selectively control broadleaf aquatic plants that are often problematic in Florida lakes, but this herbicide is not labeled for use in aquatics. The objective of this study was to evaluate the effectiveness and selectivity of metsulfuron methyl and 2,4-D on denseflower knotweed.

METHODS

Study Area

From November 2003 to June 2004, FWC conducted another drawdown combined with muck removal to control dense emergent vegetation and accumulated organic sediments within the littoral zone of Lake Tohopekaliga. Prolonged drying of the lakebed stimulated expansion of several terrestrial and aquatic plant species, including denseflower knotweed. In early April 2004, preliminary herbicide treatments were conducted on 80-m^2 test plots to examine control of denseflower knotweed using various rates of 2,4-D and triclopyr. Based on test-plot results, 2,4-D at 3.3 l a.i./ha was selected for a larger-scale application and a special local need 24(c) label was obtained to authorize application of metsulfuron methyl within exposed areas of the littoral zone.

Treatment and control zones were established within heavily vegetated locations of the littoral zone near Makinson Island, Lake Tohopekaliga, where the lake bottom was exposed due to drawdown conditions. Pre-drawdown surveys (conducted in 2000 and 2002) had documented a dominance of aquatic grasses at ≥40% estimated coverage, and ≤5% estimated coverage of denseflower knotweed within these zones (FWC, unpubl. data). On April 28, 2004, herbicides were applied via helicopter by a contractor for FWC. In a 24-ha zone, metsulfuron methyl was applied at the maximum 24(c)-label rate (63 g a.i./ha) in spray solution with a non-ionic surfactant (0.6% v/v) and water (187 L/ha). In an adjacent 20-ha zone, 2,4-D (3.3 L a.i./ha) was applied in spray solution with a sticking agent (0.3% v/v) and water (94 L/ha). Three 4-ha study areas were established: the first within the metsulfuron-methyl treatment zone, the second within the 2,4-D treatment zone, and the third within the control (no-treatment) zone. Denseflower knotweed was the dominant macrophyte within all study areas. We chose study areas within treatment zones that contained desirable aquatic grasses so that selectivity could be evaluated.

During August and September 2004, three hurricanes passed within 50 km of Lake Tohopekaliga. The lake basin refilled by mid-August and reached flood stage by early September, 4.5 months after treatments. Water levels receded to normal stage (i.e., regulation schedule) by the end of October, six months after treatments.

Plant Assessments

Frequency of occurrence of emergent vegetation was estimated with procedures modeled after U.S. Department of the Interior (1996). One fixed-line transect (250 m in length) was established through the center of each study area, at a 45-degree diagonal to the shoreline. Transect endpoints were marked with PVC poles and the corresponding GPS (Garmin 76) coordinates were recorded. Two samples (20-cm diameter) were taken at 5-m intervals, approximately 3 m apart and perpendicular to the transect line. Exact position of individual samples was variable among dates. Presence (hit) was defined as occurrence of any part of a living plant (i.e., containing one or more green leaves) within the sample area. Hits were recorded for all emergent and terrestrial plant species for each sample. Percent frequency for each species within each transect was calculated by dividing the total number of hits per species by the total number of samples per transect, × 100. Reduction in frequency for each sampling event was the difference between after-treatment percent frequency and initial percent frequency, divided by initial percent frequency, × 100. Frequency was sampled at the time of treatments and 3, 6, 12, 18, and 30 months after treatments. At 18 and 30 months after treatments, 10 points per transect were randomly selected for stem-count sampling, where the number of living stems (of denseflower knotweed) occurring within a 50 cm by 50 cm (0.25 m^2) quadrat was counted and recorded. Due to non-normal distributions and heterogeneous variances, nonparametric statistics were used for analyses. Mean stem density per treatment was compared ($\alpha = 0.05$) using a Kruskal-Wallis Test, and Tukey's multiple comparisons on ranks was used to determine treatment differences (SAS 2004).

RESULTS AND DISCUSSION

At the time of herbicide treatments, vegetation was present in all samples along all transects (Table 1). The metsulfuron-methyl treatment area had a lower initial frequency of occurrence of denseflower knotweed than the other study areas as a result of selecting a location with abundant aquatic

TABLE 1. PERCENT FREQUENCY OF OCCURRENCE OF MAJOR PLANT GROUPS (I.E., FREQUENCY >10% DURING AT LEAST ONE SURVEY) COLLECTED PRETREATMENT AND 3, 6, 12, 18, AND 30 MONTHS AFTER TREATMENTS (MO. AT) ALONG ONE TRANSECT LINE (100 SAMPLES) PER AREA WITHIN METSULFURON-METHYL TREATMENT, 2,4-D TREATMENT, AND CONTROL AREAS DURING APRIL 2004 TO NOVEMBER 2006 IN LAKE TOHOPEKALIGA, FLORIDA. AQUATIC GRASSES INCLUDED EGYPTIAN PASPALIDIUM AND MAIDENCANE.

	No vegetation	*Polygonum densiflorum*	Aquatic grasses	*Eupatorium capillifolium*	Terrestrial grasses/sedges	*Nelumbo lutea*
Metsulfuron methyl						
Pretreatment	0	65	23	39	98	0
3 mo. AT	1	11	45	9	85	0
6 mo. AT	47	5	51	0	0	0
12 mo. AT	55	1	45	0	0	0
18 mo. AT	70	1	29	0	0	0
30 mo. AT	40	0	44	0	0	32
2,4-D						
Pretreatment	0	96	10	13	95	0
3 mo. AT	1	53	21	5	97	0
6 mo. AT	36	40	25	0	0	0
12 mo. AT	48	36	16	0	0	0
18 mo. AT	52	41	7	0	0	0
30 mo. AT	30	33	9	0	0	38
Control						
Pretreatment	0	99	0	18	99	0
3 mo. AT	0	92	1	16	98	0
6 mo. AT	16	84	1	0	0	0
12 mo. AT	9	91	0	0	0	0
18 mo. AT	3	97	0	0	0	0
30 mo. AT	2	98	0	0	0	0

grasses for evaluation of herbicide selectivity. Six weeks after herbicide applications, no living denseflower knotweed and no effects on aquatic or terrestrial grasses and sedges were observed within treatment boundaries. Although no sampling was completed at that time, observations confirmed that both herbicide treatments were successfully applied to the target vegetation. Areas treated with 2,4-D initially appeared identical to those treated with metsulfuron methyl.

By three months after treatment, regrowth of denseflower knotweed was observed in both treatment areas. Compared to pretreatment samples, the percent frequency of occurrence of denseflower knotweed had declined by 83% in the metsulfuron-methyl treatment area, 45% in the 2,4-D treatment area, and 7% in the control area (Figure 1). Percent frequency of aquatic grasses initially doubled in both treatment areas, but remained minimal (≤1%) in the control area. A slight decline in percent frequency of denseflower knotweed was observed in all study areas between three and six months after treatments (Table 1), and was likely a result of the hurricanes (high winds and/or water levels). Elimination of terrestrial vegetation was observed in all study areas and was attributable to high water levels.

By 18 months after treatment, the percent frequency of denseflower knotweed had declined by 99% in the metsulfuron-methyl treatment area, 57% in the 2,4-D treatment area, and 2% in the control area (Figure 1). Stem density was significantly different among areas ($\chi^2 = 13.7$, $\nu = 2$, $P < 0.01$; Table 2). Estimated mean stem density of denseflower knotweed was zero in the metsulfuron-methyl treatment area, and ranked stem counts were significantly lower than the 2,4-D treatment area ($t = 2.80$, $\nu = 9$, $P = 0.02$) and the control area ($t = 4.89$, $\nu = 9$, $P < 0.01$), which were not significantly different ($t = 2.09$, $\nu = 9$, $P = 0.11$).

By 30 months after treatment, the percent frequency of occurrence of denseflower knotweed had declined by 100% in the metsulfuron-methyl treatment area, 66% in the 2,4-D treatment area, and 1% in the control area (Figure 1). Stem density was significantly different among areas ($\chi^2 = 15.2$, $\nu = 2$, $P < 0.01$; Table 2). Estimated mean stem density of denseflower knotweed was nine stems per 0.25 m^2 in the control ar-

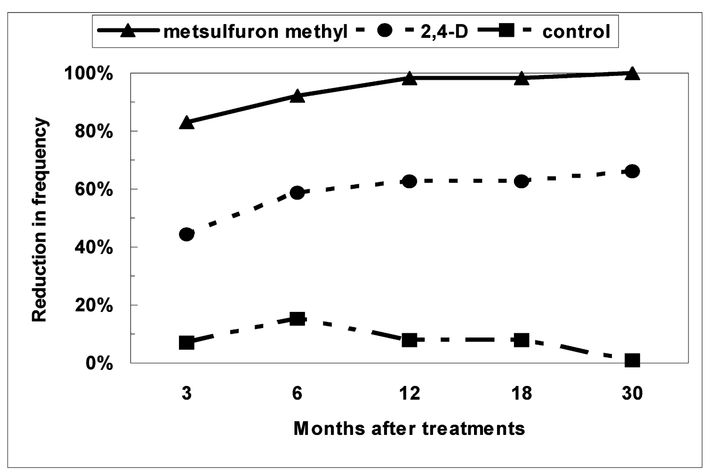

Figure 1. Reduction in frequency of denseflower knotweed compared to initial (pre-treatment) frequency along line transects within metsulfuron-methyl treatment, 2,4-D treatment, and control areas during July 2004 to November 2006 in Lake Tohopekaliga, Florida.

TABLE 2. MEAN STEM COUNTS AND RANKS FOR DENSEFLOWER KNOTWEED ALONG TRANSECT LINES WITHIN METSULFURON-METHYL TREATMENT, 2,4-D TREATMENT, AND CONTROL AREAS IN LAKE TOHOPEKALIGA, FLORIDA, NOVEMBER 2005 (18 MONTHS AFTER TREATMENT) AND NOVEMBER 2006 (30 MONTHS AFTER TREATMENT). DIFFERENT LETTERS REPRESENT SIGNIFICANT DIFFERENCES BETWEEN TREATMENT MEAN RANKS (P < 0.05).

Area	Number of stem counts	Mean (stems/0.25 m^2)	Standard error of mean	Mean rank	Standard error of ranks
November 2005					
Metsulfuron methyl	10	0.0	0.0	8.5[a]	0.0
2,4-D	10	9.5	3.9	16.2[b]	3.1
Control	10	18.4	1.1	21.9[b]	1.1
November 2006					
Metsulfuron methyl	10	0.0	0.0	10.0[a]	0.0
2,4-D	10	2.6	1.7	13.7[a]	2.4
Control	10	9.1	1.3	22.9[b]	1.7

ea, and ranked stem counts were significantly different than the metsulfuron-methyl treatment area ($t = 5.29$, $\nu = 9$, $P < 0.01$) and the 2,4-D treatment area ($t = 3.8$, $\nu = 9$, $P < 0.01$), which were not significantly different ($t = 1.5$, $\nu = 9$, $P = 0.31$). Nearly all denseflower knotweed was eliminated (100% reduction in frequency) within the metsulfuron-methyl treatment area, and observations indicated similar results throughout the entire metsulfuron-methyl treatment zone. In herbicide treatment areas, an expansion of aquatic grasses was documented for 12 months after treatments. By the end of the study, frequency of aquatic grasses was two times the initial frequency in the metsulfuron-methyl treatment area, but not different than the initial level in the 2,4-D treatment and control areas.

Application of metsulfuron methyl during dewatered conditions provided excellent control of denseflower knotweed, and frequency of desirable aquatic grasses doubled within this treatment area. Based on Chiconela et al. (2004), similar results may be expected for other broadleaf target plants, with minimal impact to bulrushes. We recommend evaluation of metsulfuron methyl for selective control of pickerelweed, which frequently grows to problem levels among desirable aquatic grasses and bulrushes in central Florida lakes. Results also showed that 2,4-D may reduce denseflower knotweed without affecting aquatic grasses, but data indicate that repeated applications of 2,4-D would be required to approach the level of control achieved with one application of metsulfuron methyl.

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