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Response of Selected Nontarget Native Florida Wetland Plant Species to Metsulfuron Methyl

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ABSTRACT

We tested five rates (10.5, 21, 42, 84, and 168 g a.i./ha) of metsulfuron methyl on selected nontarget native wetland plants. Metsulfuron methyl applied at rates up to 168 g a.i./ha had minimal effects on sand cord grass (*Spartina bakeri*) and soft rush (*Juncus effusus*), but severely affected lizard's tail (*Saururus cernuus*), golden canna (*Canna flaccida*), fireflag (*Thalia geniculata*), swamp fern (*Blechnum serrulatum*) and cinnamon fern (*Osmunda cinnamomea*). Soft rush and sand cord grass exhibited <20% necrosis 12 weeks post-treatment. Survival rates of these two plants were >87% at all application rates of metsulfuron methyl. Buttonbush (*Cephalanthus occidentalis*) exhibited >80% survival at all application rates, but regrowth was coppice sprouting. Swamp lily (*Crinum americanum*) survival rates were variable (19 to 88%) but indicated this species is tolerant of metsulfuron methyl up to rates 168 g a.i./ha. Necrosis was 100% for lizard's tail, fireflag, and golden canna at four to five weeks post-treatment, and survival was 0% for these plants. Swamp fern was very susceptible to metsulfuron methyl but had limited survival at low rates. Cinnamon fern mortality was 100% for all rates of metsulfuron methyl. The results of this study indicated that aerial application of metsulfuron methyl may effectively and selectively control invasive species such as Old World climbing fern (*Lygodium microphyllum*) within habitat dominated by grass and sedge species. However, where susceptible non-target species are common, there is high potential for severe non-target damage and conservative ground applications should be implemented instead of aerial applications.

Key words: Escort XP herbicide, nontarget wetland plants, survival rates.

INTRODUCTION

Metsulfuron methyl (Escort XP; methyl 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid) is a selective, systemic sulfonylurea herbicide with post-emergent and pre-emergence activity. This herbicide is generally more effective when applied foliar to actively growing weeds following emergence or dormancy break (DuPont 2006). Selectivity to metsulfuron methyl by some plants is due to metabolic breakdown of the herbicide (Brown 1990, Boutin et al. 2000). Persistence in the soil is one to six weeks, and degradation occurs through hydrolysis and microbial breakdown (Blair and Martin 1988, Vencill 2002). Sulfonylurea herbicides such as metsulfuron methyl inhibit the enzyme acetolactate synthase (ALS) and prevent synthesis of branched-chain amino acids (valine, leucine, and isoleucine) found in plants and microorganisms (Brown 1990, Hay 1990). Acute and chronic toxicity of metsulfuron methyl is very low to low for bluegill sunfish (96 h LC_{50} > 150 ppm), mallard duck (LD_{50} > 2510 mg/kg), and rats (LD50 > 5000 mg/kg; DuPont 2005).

Cell division stops shortly after application of metsulfuron methyl, and plant death occurs within one to three weeks after application (Brown 1990). Sulfonylurea herbicides are more phytotoxic to susceptible plants by several orders of magnitude than conventional herbicides (Boutin et al. 2000), yet little is known about their effects on nontarget plants in natural areas. The major advantage of ALS herbicides is their high specific activity to the ALS enzyme and low dosage application rate, which is often 100 times lower than conventional herbicides such as triclopyr and 2,4-D (Fairbrother and Kapustka 2001). Herbicides that inhibit ALS are applied at low rates up to 168 g a.i./ha compared to glyphosate and triclopyr, which are applied at rates of up to 2.3 kg a.i. and 2.7 kg a.i./ha, respectively. ALS-inhibiting herbicides are used for control of broadleaf plants and some grasses.

Old World climbing fern (*Lygodium microphyllum*) has become a serious invasive plant of mesic and hydric natural habitat in central and south Florida. Since its documentation in Florida natural areas 46 years ago (Beckner 1968), the range of Old World climbing fern had expanded to >48,800 ha in south Florida by 2003 (Ferriter and Pernas 2006), a rate of spread unprecedented in Florida for an invasive species. Management of Old World climbing fern during the 1990s was primarily with glyphosate, but limited control was achieved without repeated follow-up treatments. Metsulfuron methyl was reported to be effective for controlling Old World climbing fern (Hutchinson et al. 2006, Langeland and Link 2006). In 2003, a Special Local Needs Permit 24 (c) Label was approved for the use of metsulfuron methyl by public agencies to control Old World climbing fern in wetland and terrestrial habitats in Florida (DuPont 2003).

Some broadleaf wetland plants may be susceptible to metsulfuron methyl at very low rates of 0.045 and 0.45 g a.i./ha, well below the maximum rate of 2 g a.i./ha allowed on the label (Boutin et al. 2000). In Florida, metsulfuron methyl was applied at rates up to 168 g a.i./ha to control Old World climbing fern in marsh habitat. Treatments had no effect on maidencane (*Panicum hemitomon*) and saw grass (*Cladium jamaicense*), and ephemeral damage to buttonbush (*Cephalanthus occidentalis*; Langeland and Link 2006). Chiconela et al. (2004) reported that metsulfuron methyl significantly affect-

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ed pickerelweed (*Pontederia cordata*) and arrowhead (*Sagittaria lancifolia*), but had no significant effect on several species of grasses (*Panicum repens, Paspalum distichum,* and *Brachiaria mutica*) at rates up to 140 g a.i./ha and bulrush (*Scirpus validus*) at rates up to 70 g a.i./ha. However, the paucity of information on the effects of metsulfuron methyl on native wetlands in Florida warrants additional research.

A recent survey indicated that more land managers in south Florida are using metsulfuron methyl for control of Old World climbing fern (Hutchinson and Langeland 2006). As the use of this herbicide continues to increase in Florida, it is important to determine the effects of metsulfuron methyl on nontarget plants in areas where *L. microphyllum* exists. We investigated the effects of metsulfuron methyl on selected common native species that occur in or near areas where Old World climbing fern commonly invades.

MATERIALS AND METHODS

Bare root native plant species were purchased in June 2005 and April 2006 from a commercial grower in central Florida. Plants were potted in 1- or 2.5-L pots with a mixture of commercially purchased fertilizer and humus at a rate of 196 g Osmocote Pro (8 to 9 month release, 19-5-8) per 18 kg humus. The fertilizer was incorporated into the humus using an electric mixer. Plants were grown for four months prior to herbicide application on October 11, 2005, and July 3, 2006. All pots were submerged in 5 cm of water and maintained in 95-L plastic pools. Water was added as needed to the pools to maintain this depth. Plants were grown outdoors and exposed to ambient environmental conditions.

Swamp fern (*Blechnum serrulatum*, n = 11), sand cord grass (*Spartina bakeri*, n = 16), golden canna (*Canna flaccida*, n = 16), swamp lily (*Crinum americanum*, n = 16), soft rush (*Juncus effuses*, n = 16), lizard's tail (*Saururus cernuu*, n = 12), and fireflag (*Thalia geniculata*, n = 16) were evaluated for response to the commercial formulation of metsulfuron methyl (Escort XP) for five application rates in October 2005 and July 2006. Tested rates were 10.5, 21, 42, 84, and 168 g a.i./ha (0.25, 0.50, 1, 2, and 4 oz product/20 gal/ac) with 0.5% non-ionic surfactant (DyneAmic, Helena Chemical Co.). Plants were foliar sprayed with a CO_2 sprayer at 25 p.s.i. pressure. Untreated plants were included in each replication and were sprayed with water and 0.5% surfactant. Additionally, one experiment of the above treatments was conducted on buttonbush (n = 5) and cinnamon fern (*Osmunda cinnamomea*, n = 8) in 2006.

Plants were treated in October 2005 (experiment 1) and July 2006 (experiment 2). All plants were visually evaluated for necrosis every week based on survival along a scale of 0 (no injury) to 100 (plant death). Survival rates were calculated as number of plants with green foliage divided by total number of plants and expressed as a percent. Following treatment, plants in experiment 1 were monitored for 120 days then cut at soil level to monitor the potential for regrowth. At 90 days after initial cutting, plants in experiment 1 were cut at soil level and the removed plant material was placed in a dryer to determine dry weight biomass of regrowth. Following treatment, plants in experiment 2 were monitored for 45 days then cut at soil level to allow for regrowth. At 60 days after initial cutting, plants in experiment 2 were cut at soil level and placed in a dryer to determine dry weight biomass of regrowth. Height was measured from all live plants prior to final harvest. Data from experiments were not combined due to different treatment periods and because the sizes of the bare root plants differed between 2005 and 2006. Analysis of variance was used to determine differences between herbicide rates among species based on above ground dry weight biomass and height using SPSS statistical software (SPSS version 11.0.1, 2001). Comparisons with controls were made via a Dunnett's test (alpha = 0.05). A 50% inhibition of live plant tissue (I_{50} value) was calculated using nonlinear regression (SPSS version 11.0.1, 2001) to compare dry weights of surviving treated plants to rates of metsulfuron methyl.

RESULTS AND DISCUSSION

At 12 weeks post-treatment, there was 10% and 15 to 20% necrosis observed for soft rush and sand cord grass, respectively. There was 100% necrosis in all plant tissue for lizard's tail, fireflag, and golden canna between four and five weeks. Necrosis rates were intermediate for swamp lily with 30 to 35% necrosis for all rates of metsulfuron methyl at 12 weeks. Swamp fern and buttonbush showed increasing necrosis with increasing rates of metsulfuron methyl from 5 to 85% and 0 to 85%, respectively. Cinnamon fern exhibited 100% necrosis at all rates of metsulfuron methyl.

Survival was >87% for sand cord grass (I_{50} = 70.8 g a.i./ha) and soft rush (I_{50} = 775.0 g a.i./ha) at all rates of metsulfuron methyl, and minimal visual damage was observed at any application rate for these two species (Table 1). No significant differences were detected among dry weight biomass at any rate of metsulfuron methyl for sand cord grass during 2005 (P = 0.51) and 2006 (P = 0.15; Tables 2 and 3). No significant differences were detected for dry weight biomass of soft rush treated in 2005 ($P < 0.13$) and 2006 (P = 0.06). Mean regrowth height of soft rush at all rates was not significant during 2005 (P = 0.06) and 2006 (P = 0.05), but significant differences were detected for sand cord grass in 2005 ($P < 0.00$) and 2006 (P = 0.03; Tables 4 and 5). These differences are possibly due to shading effects or variable plant size during planting. There is no evidence in this study that metsulfuron methyl at any rate had any deleterious effects on sand cord grass or soft rush.

Survival rates were high for swamp lily (I_{50} = 148.8 g a.i./ha) at all rates except 84 g a.i./ha, which exhibited a 19% survival rate for plants treated in 2005 and 2006 (Table 1). Significant differences in dry weight biomass were detected among treatment rates during 2005 (P = <0.00) and 2006 (P = 0.00; Tables 2 and 3). Control plants had higher dry weight biomass, but results for treatment rates were variable. Some swamp lily treated with a higher rate of metsulfuron methyl had greater dry weight biomass than plants treated at a lower rate. Significant differences were also detected for the mean height of swamp lily during 2005 ($P < 0.00$) and 2006 ($P < 0.00$), but again results were variable with some plants treated at higher rates having greater mean height than plants treated at lower rates (Tables 4 and 5). Swamp lily exhibited spotted chlorosis at all rates except controls, but chlorosis was most prominent at 168 g a.i./ha.

TABLE 1. COMBINED SURVIVAL RATE (%) AND I_{50} VALUES FOR EXPERIMENTS CONDUCTED IN 2005 AND 2006 OF PLANTS TREATED WITH VARIOUS RATES OF METSULFURON METHYL.

Species	I_{50} Value (g a.i./ha)	Survival Rate (%) Rate (g a.i./ha)					
		0	10.5	21	42	84	168
Sand cord grass (n = 16)	70.8	87.5	100.0	100.0	100.0	93.8	100.0
Soft rush (n = 16)	775.0	100.0	100.0	100.0	100.0	100.0	100.0
Swamp lily (n = 16)	148.8	100.0	87.5	75.0	81.3	18.8	75.0
Swamp fern (n = 11)	0.7	90.9	45.5	9.1	9.1	0.0	0.0
Lizard's tail (n = 12)	0.3	100.0	0.0	0.0	0.0	0.0	0.0
Golden canna (n = 16)	0.3	100.0	0.0	0.0	0.0	0.0	0.0
Fireflag (n = 16)	0.3	100.0	0.0	0.0	0.0	0.0	0.0
Buttonbush (n = 5)	34.6	80.0	60.0	80.0	100.0	80.0	80.0
Cinnamon fern (n = 8)	0.3	75.0	0.0	0.0	0.0	0.0	0.0

Buttonbush survival rates (I_{50} = 34.6 g a.i./ha) ranged from 60 to 100% and no significant differences were detected for dry weight regrowth (P = 0.64) or mean height (P = 0.33; Tables 1, 3, and 5). Following treatment, buttonbush exhibited 50% necrosis and leaf loss within 35 days post-treatment for all herbicide treated plants except controls. Buttonbush treated at all herbicide rates survived by coppice sprouting. Regrowth rates of buttonbush were hindered by whitetail deer herbivory. Langeland and Link (2006) reported that no permanent damage occurred on buttonbush treated with metsulfuron methyl up to 168 g a.i./ha. Aerial treatment of Old World climbing fern in January 2005 with metsulfuron methyl at 84 g a.i./ha resulted in no damage to dormant buttonbush; evaluation in June 2005 documented robust leaf flush (Hutchinson and Langeland, unpubl. data).

Swamp fern survival rate (I_{50} = 0.7 g a.i./ha) was 45% at 10.5 g a.i./ha, but <10% at higher treatment rates (Table 1). Survival rates for swamp fern controls averaged 91%. Dry weight biomass among swamp fern treatments was significant in 2005 (P < 0.00) and 2006 (P = 0.04), with control plants having significantly greater dry weight biomass than all treatment rates (Tables 2 and 3). Significant differences were also detected for the mean height of swamp ferns treated in 2005 (P < 0.00) and 2006 (P = 0.00) with control plants having much greater mean height (Tables 4 and 5). The survival rate of cinnamon fern (I_{50} = 0.3 g a.i./ha) was zero for all treatment rates. Significant differences were detected between controls and treated plants for dry weight biomass (P = 0.01) and mean height (P < 0.00; Tables 3 and 5). Complete necrosis of cinnamon fern was observed at less than five weeks post-treatment for all plants except in controls. Swamp, cinnamon, and several other species of ferns are very common in areas where Old World climbing fern has invaded. Managers using metsulfuron methyl to treat Old World climbing fern should use caution in areas where high concentrations of native ferns are present. Ground treatments can limit nontarget damage to native ferns, while broadcast aerial application will likely cause substantial damage to native ferns.

Survival rates for lizard's tail (I_{50} = 0.3 g a.i./ha), golden canna (I_{50} = 0.3 g a.i./ha), and fireflag (I_{50} = 0.3 g a.i./ha) were 0% for all treatment rates, with controls having 100% survival rates (Table 1). Significant differences were detected among controls and treatments for dry weight biomass for lizard's tail during 2005 (P < 0.00) and 2006 (P < 0.00), golden canna during 2005 (P < 0.00) and 2006 (P < 0.00), and fireflag during 2005 (P < 0.00) and 2006 (P < 0.00; Tables 2 and 3). Complete necrosis was observed on lizard's tail and golden canna for all treatment rates less than five weeks post-treatment. Fireflag exhibited complete necrosis at all rates less than nine weeks post-treatment.

Metsulfuron methyl applied at rates up to 168 g a.i./ha had minimal effect on sand cord grass and soft rush, but severely affected lizard's tail, golden canna, fireflag, and ferns.

TABLE 2. ABOVE GROUND DRY WEIGHT BIOMASS (G) OF NATIVE WETLAND SPECIES AFTER APPLICATION OF VARIOUS RATES OF METSULFURON METHYL DURING OCTOBER 2005. MEAN DRY WEIGHT REPRESENTS WEIGHT 120 DAYS POST-TREATMENT AND AN ADDITIONAL 90 DAYS AFTER PLANTS WERE CUT AT BASE.

Rates (g a.i/ha)	Species (mean g dry mass/container)*						
	Sand Cord Grass	Soft Rush	Swamp Lily	Swamp Fern	Lizard's Tail	Golden Canna	Fireflag
0	105.0[a]	8.4[a]	5.4[a]	2.9[a]	29.3[a]	135.7[a]	63.5[a]
10.5	94.6[a]	8.8[a]	2.6[a]	0.1[b]	0.0[b]	0.0[b]	0.0[b]
21	104.7[a]	9.1[a]	1.4[b]	0.1[b]	0.0[b]	0.0[b]	0.0[b]
42	94.1[a]	5.9[a]	4.3[a]	0.1[b]	0.0[b]	0.0[b]	0.0[b]
84	111.5[a]	8.1[a]	0.6[b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]
168	85.5[a]	8.1[a]	1.2[b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]

*Values within a column followed by the same letter are not significantly different based on Dunnett's test (alpha = 0.05).

TABLE 3. ABOVE GROUND DRY WEIGHT BIOMASS (G) OF NATIVE WETLAND SPECIES AFTER APPLICATION OF VARIOUS RATES OF METSULFURON METHYL DURING JULY 2006. MEAN DRY WEIGHT REPRESENTS WEIGHT 45 DAYS POST-TREATMENT AND AN ADDITIONAL 60 DAYS AFTER PLANTS WERE CUT AT BASE.

Rates (g a.i/ha)	Species (mean g dry mass/container)*								
	Sand Cord Grass	Soft Rush	Swamp Lily	Swamp Fern	Lizard's Tail	Golden Canna	Fireflag	Buttonbush	Cinnamon Fern
0	11.2[a]	10.4[a]	4.3[a, b]	3.2[a]	9.7[a]	24.0[a]	62.2[a]	1.7[a]	1.3[a]
10.5	19.8[a]	11.5[a]	3.5[a, b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	1.1[a]	0.0[b]
21	13.6[a]	12.6[a]	3.5[a, b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	0.7[a]	0.0[b]
42	15.8[a]	18.9[a]	2.5[b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	1.0[a]	0.0[b]
84	18.8[a]	13.8[a]	0.6[b, c]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	0.9[a]	0.0[b]
168	11.9[a]	16.8[a]	3.3[a, b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	1.1[a]	0.0[b]

*Values within a column followed by the same letter are not significantly different based on Dunnett's test (alpha = 0.05).

Several native or non-native grasses found in Florida were tolerant of metsulfuron methyl at rates up to 140 g a.i./ha (Chiconela et al. 2004). Langeland and Link (2006) reported no observable effects for maidencane and sawgrass treated with metsulfuron methyl at rates up to 168 g a.i./ha. With the exception of swamp lily and buttonbush, metsulfuron methyl was highly lethal to the ferns and broadleaf plants in this study. Low rates of metsulfuron methyl at <10% maximum label rate damaged broadleaf species such as *Mimulus ringens* and *Bidens cernua* (Boutin et al. 2000).

Brandt (2004) reported that metsulfuron methyl applied aerially at rates of 42 and 84 g a.i./ha resulted in less nontarget damage than glyphosate to control Old World climbing fern over tree islands in the Loxahatchee National Wildlife Refuge. In another study, variable nontarget effects were observed 10 months after aerial application of metsulfuron methyl (42 and 84 g a.i./ha) and glyphosate (2.3 and 4.6 l a.e./ha) on 45 tree islands heavily infested with Old World climbing fern in A.R.M. Loxahatchee National Wildlife Refuge (Hutchinson and Langeland, pers. observ.). Tree islands treated with metsulfuron methyl exhibited minimal damage to buttonbush, Dahoon holly (*Ilex cassine*), wax myrtle (*Myrica cerifera*), and swamp bay (*Persea palustris*), while understory plants (primarily swamp fern and cinnamon fern) suffered high mortality. Tree islands treated with glyphosate suffered high canopy damage to shrubs and trees, but less mortality was observed to understory plants. Metsulfuron methyl aerially sprayed at 84 g a.i./ha in the western Everglades to control Old World climbing fern resulted in high mortality of cabbage palms (*Sabal palmetto*; Taylor 2004).

TABLE 4. HEIGHT OF NATIVE WETLAND SPECIES AFTER APPLICATION OF VARIOUS RATES OF METSULFURON METHYL DURING OCTOBER 2005. MEAN HEIGHT REPRESENTS HEIGHT 120 DAYS POST-TREATMENT AND AN ADDITIONAL 90 DAYS AFTER PLANTS WERE CUT AT BASE.

Rates (g a.i/ha)	Mean height (cm)*						
	Sand Cord Grass	Soft Rush	Swamp Lily	Swamp Fern	Lizard's Tail	Golden Canna	Fireflag
0	128.6[a, b]	66.2[a]	47.9[a, b]	47.2[a]	89.0[a]	119.3[a]	106.2[a]
10.5	124.9[a, b]	64.2[a]	28.0[a, b, c]	1.5[b]	0.0[b]	0.0[b]	0.0[b]
21	122.5[b]	74.9[a]	19.0[a, b, c]	0.4[b]	0.0[b]	0.0[b]	0.0[b]
42	115.0[b]	65.2[a]	40.2[a, b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]
84	133.9[a]	65.0[a]	5.6[c]	0.0[b]	0.0[b]	0.0[b]	0.0[b]
168	125.7[a, b]	70.3[a]	15.7[b, c]	0.0[b]	0.0[b]	0.0[b]	0.0[b]

*Values within a column followed by the same letter are not significantly different based on Dunnett's test (alpha = 0.05).

TABLE 5. HEIGHT OF NATIVE WETLAND SPECIES AFTER APPLICATION OF VARIOUS RATES OF METSULFURON METHYL DURING JULY 2006. MEAN HEIGHT REPRESENTS HEIGHT 45 DAYS POST-TREATMENT AND AN ADDITIONAL 60 DAYS AFTER PLANTS WERE CUT AT BASE.

Rates (g a.i/ha)	Mean height (cm)*								
	Sand Cord Grass	Soft Rush	Swamp Lily	Swamp Fern	Lizard's Tail	Golden Canna	Fireflag	Buttonbush	Cinnamon Fern
0	63.6[a, b]	95.7[a]	45.0[a]	24.1[a]	46.4[a]	75.0[a]	112.1[a]	16.4[a]	18.4[a]
10.5	101.3[a]	86.7[a]	47.1[a]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	11.9[a]	0.0[b]
21	91.9[a]	98.4[a]	46.5[a]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	10.8[a]	0.0[b]
42	94.9[a]	100.5[a]	32.3[a, b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	18.5[a]	0.0[b]
84	80.4[a, b]	89.2[a]	9.4[b]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	10.0[a]	0.0[b]
168	75.9[b]	92.3[a]	41.6[a]	0.0[b]	0.0[b]	0.0[b]	0.0[b]	7.5[a]	0.0[b]

*Values within a column followed by the same letter are not significantly different based on Dunnett's test (alpha = 0.05)

The results of this study are consistent with those of Langeland and Link (2006), where selective control of Old World climbing fern was achieved with ground application of metsulfuron methyl over habitat dominated by grasses and sedges. We observed no effects on sand cord grass and soft rush from metsulfuron methyl at twice the maximum label rate. However, some degree of mortality can be expected to occur on certain types of herbaceous plants and ferns during aerial application of metsulfuron methyl. Applicators or managers using metsulfuron methyl to control Old World climbing fern in areas with high densities of sensitive, nontarget plants must take into account that substantial nontarget damage will occur. In natural areas invaded by Old World climbing fern that have high densities of herbaceous plants and ferns, ground treatment and directed spraying of Old World climbing fern with metsulfuron methyl can be used to minimize nontarget damage. Boutin et al. (2000) notes that many plants not listed on the label could be affected by metsulfuron methyl and suggests that drift may be more damaging to nontarget plants than target species. As the use of metsulfuron methyl to control Old World climbing fern increases in Florida, this herbicide has the potential to impact some nontarget plants in natural communities of Florida and should be used with caution in areas where sensitive plants are known to occur.

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