Monitoring Ground Treatments of Old World Climbing Fern (*Lygodium microphyllum*) on the Arthur R. Marshall Loxahatchee National Wildlife Refuge: A Follow-up Report

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Introduction

In 2003, Thomas and Brandt reported on monitoring of ground treatments of Old World climbing fern (*Lygodium microphyllum*) at Arthur R. Marshall Loxahatchee National Wildlife Refuge (hereafter Refuge). The study examined the effects of ground treatment on percent cover of *L. microphyllum* and native vegetation over 3 years post-treatment. This report provides additional information for tree islands monitored 3 and 4.5 years post-treatment.

The Refuge, a northern remnant of the greater Everglades, comprises around 59,894 ha and includes wet prairie, slough, sawgrass marsh and tree islands. Wet prairie and slough habitats are dominated by thousands of tree islands, a unique natural resource that is being degraded by heavy infestation of *L. microphyllum*. Based on Systematic Reconnaissance Flights, *L. microphyllum* is estimated to impact approximately 25,200 ha of the Refuge (Woodmansee 2005). The heaviest infestations of *L. microphyllum* primarily occur on tree islands in the north-central marsh interior.

Although various methods of treatment (e.g., aerial application) are currently being employed at the Refuge, *L. microphyllum* infestation remains a widespread problem and a serious threat to tree island health. Finding cost-effective and successful methods to control infestations of *L. microphyllum* and other invasive species is a high management priority. This report provides supplemental data on the effectiveness of ground treatments on *L. microphyllum*, including impacts to, and regrowth of, *L. microphyllum* and native plant species on tree islands over time following the initial treatment efforts that occurred in 1999.

Methods

The following methodology was summarized from Thomas and Brandt (2003). Treatments of *L. microphyllum* were performed by a contractor (Enviroglades, Inc.) during August – December 1999. Approximately 140 tree islands (125 ha) in the north-central interior of the Refuge, moderately to severely infested with *L. microphyllum*, underwent ground treatments. Treatments consisted of cutting the ascending portion of the fern at waist or knee level followed by a foliar spray application (5% solution of glyphosate plus surfactant in water) to the remaining portion of the *L. microphyllum* rooted in the ground, i.e., 'poodle cut' technique. Small infestations were simply foliar sprayed and left intact. To prevent additional spread of spores, the ascending portion of the fern biomass was left on site clinging to native vegetation. Re-treatments occurred during November 2000 – January 2001.

Ten of the treated tree islands were selected for study post-treatment and monitored until 2004. Tree islands were selected by generating random points on a grid map of the 125 ha area, and selecting the nearest treated tree island. A 4m x 5m quadrat was placed in the center of each island to collect data on percent coverage

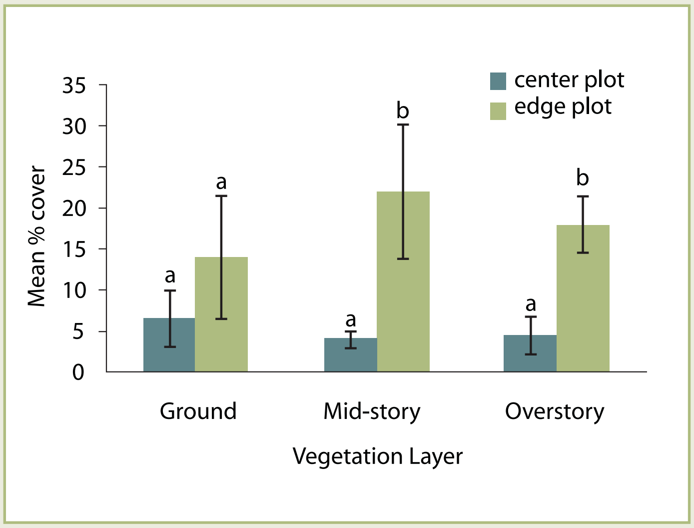

Figure 1. Mean (+ SE) percent cover of *L. microphyllum* in center plots versus edge plots on five tree islands on A.R.M. Loxahatchee NWR at 4.5 years post-treatment. Different letters indicate significant difference ($P < 0.10$) from Mann-Whitney U tests within ground, mid-story and overstory layers.

Vegetation layer	3 yr post-treatment min	max	M [a]	F [b]	4.5 yr post-treatment min	max	M	F
Lygodium microphyllum								
Ground	0	40	5	90	<5	30	<5	100
Mid-story	0	10	<5	60	0	10	5	70
Overstory	0	10	0	30	0	5	0	30
Native plant species								
Ground	13	73	30	---	10	85	26	---
Mid-story	<5	40	10	---	<5	33	24	---
Overstory	18	90	45	---	13	88	44	---

[a] median percent cover value for plant species in each layer
[b] F (percent frequency) = number of plots with *Lygodium* present in a layer / 10 plots

Table 1. Comparison of the range in percent cover, median percent cover and percent frequency of *L. microphyllum* and native species on 10 tree islands on A.R.M. Loxahatchee NWR. The table contains results for three vegetation layers at 3 and 4.5 years post-treatment.

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of live *L. microphyllum* and native vegetation in the ground (0-1 m), mid-story (1-2 m), and overstory layers (>2 m). Coverage for all plant species was visually estimated to the nearest 5%. The group of 10 islands was sampled twice annually for 4.5 years. This report, however, only examines data collected from 3 years post-treatment to 4.5 years post-treatment. For a summary of data collected prior to 3 years post-treatment, see Thomas and Brandt (2003).

At 3 years post-treatment, five additional sample plots were added near the edges of five of the 10 original islands that appeared to be experiencing significant regrowth of *L. microphyllum*. New quadrats on tree island edges were sampled twice annually for 1.5 years starting at 3 years post-treatment. *L. microphyllum* appears to establish at the edge and progress towards the center of tree islands. To examine this speculation, data from center plots were compared to data from edge plots using Mann-Whitney U tests on the five islands. Statistical analyses were conservatively evaluated at the $P = 0.10$ significance level due to small sample size.

Results and Discussion

For the 10 sample plots between 3 and 4.5 years post-treatment, percent frequency of *L. microphyllum* increased from 9/10 to 10/10 plots in the ground layer and 6/10 to 7/10 plots in the mid-story layer, but remained at 3/10 plots in the overstory (Table 1). By 4.5 years post-treatment, percent cover (median value) of *L. microphyllum* slightly decreased in the ground layer, slightly increased in the mid-story layer, and remained the same in the overstory layer (Table 1). Percent cover (median) of native species slightly decreased in the ground and overstory layers, but more than doubled in the mid-story layer (Table 1). Furthermore, the number of native plant species tended to increase in each vegetation layer by 4.5 years post-treatment. In general, from 3 years to 4.5 years post-treatment on the 10 study islands, the mean ± SE change in coverage of all vegetation layers combined was negative 6.5 ± 2.3% for *L. microphyllum* and positive 1.2 ± 7.9% for native plant species.

For comparison of mean cover of *L. microphyllum* between edge and center plots on five tree islands, infestation at 4.5 years post-treatment tended to be higher in edge plots than center plots (Figure 1). Cover of *L. microphyllum* in edge and center plots was not significantly different in the ground layer ($U = 13.5$, $P = 0.310$), but was significantly different in the mid-story ($U = 20.5$, $P = 0.095$) and in the overstory ($U = 25.0$, $P = 0.007$). Therefore, estimates of *L. microphyllum* cover in center plots are likely underestimating the degree of re-infestation on tree islands.

Conclusions

It appears that ground treatment on tree islands is effective in controlling *L. microphyllum* to a certain degree and that the native plant community on these treated islands is recovering over a 4.5 year period. Infestation levels showed greater increase in edge plots than in center plots, possibly due to quantity and availability of sunlight for growth or spore germination. Future monitoring should take into account the spatial patterns of re-infestation. Tracking infestation in the mid-story and overstory is most critical because spore dispersion (mainly by wind) occurs primarily at these heights (Lott et al. 2003). A critical point for re-treating islands is when *L. microphyllum* reaches 25-30% cover in the mid-story (near the island edge) to limit potential spread of spores and to suppress infestations to manageable levels. Using center plots as estimates, *L. microphyllum* cover was not > 25% in the mid-story or overstory layers by 4.5 years post-treatment on any island (10 plots). However, using edge plot estimates, four of five islands had > 25% cover of *L. microphyllum* in one of these two layers. Extrapolated to the total islands treated (*n* = 140), this would account for approximately 112 islands (80%) having > 25% cover of *L. microphyllum* on the island edge in either the mid-story or overstory by 4.5 years post-treatment. Based on the above conclusions, it is recommended that tree islands be re-treated prior to 4.5 years post-treatment to limit re-infestation extent.

Despite the apparent short-term effectiveness of ground treatments, it is an expensive and time-consuming method (Thomas and Brandt 2003), especially in a large area that has limited access like the Refuge. It may not be feasible, therefore, to employ ground treatments as the primary method across the extent of the Refuge. It is likely more cost-effective to supplement ground treatments with aerial treatments in identified locations throughout the Refuge, as long as non-target damage is not considered severe. Aerial application could be principally utilized in areas that are not readily accessible by airboat or where ground treatments were deemed not to be cost effective. Initial aerial treatments should be followed-up with ground treatments for long-term control of *L. microphyllum* infestations. Inspections of current control methods using aerial-ground combination and ongoing research on an array of treatment types at the Refuge will help provide the information necessary to make effective management decisions in controlling *L. microphyllum* on tree islands.

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Additional Report of *Lygodium microphyllum* Mats as a Potential Problem for Wildlife

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Anyone who has attempted to walk through a dense rachis mat of Lygodium fern (*Lygodium microphyllum*) knows it can be very difficult, even when using a chainsaw to cut a trail. Darby and McKercher (*Wildland Weeds*, Fall 2002) suggested that heavy infestations of Old World climbing fern could be dangerous to wildlife after the discovery of white-tail deer bones entangled in the rachis mat of the fern. In September 2006, while conducting herbicide trials on Old World climbing fern in a maple swamp at the Lakeland Wastewater Facility (Polk County), I discovered the empty shell of a male painted turtle (*Chrysemys* spp.). There was no sign of predation on the shell. Old World climbing fern coverage along the area where the turtle was found was >95%, indicating its movement may have been fatally hindered by the rachis mat.

The turtle apparently had been crawling underneath the fern canopy along a small wildlife trail towards a small wetland about 5 m away when it became entangled in the rachis mat. Multiple rachis stems ascending from rhizomes could easily entangle a turtle's legs, neck, carapace, plastron or a combination of these, resulting in death from exhaustion or starvation. Areas within 15-20 m to the north and south of the site did not contain any Old World climbing fern and were dominated by clumping ferns such as cinnamon *(Osmunda cinnamomea)* and royal *(Osmunda regalis)*, with many open areas in which a turtle could easily traverse.

Areas with heavy infestations of Old World climbing fern frequently have well-defined wildlife trails and tunnels utilized by wild hogs, raccoons, and possibly small mammals (Daniel W. Clark, M. S. Thesis, Univ. of Florida, 2002). While large mammals can probably forage or move about in heavy infestations of Old World climbing fern when not threatened by predators or fast moving fires, it is unlikely that slower moving, less mobile species such as turtles could navigate through the thick rachis mat. Additionally, the extremely high temperatures of fires involving Old World climbing fern could result in increased mortality as wildlife becomes trapped in the rachis as they attempt to flee or seek refuge in burrows, wetlands, etc. Other possible effects include the alteration of habits and movement patterns due to the almost impenetrable rachis, and a decrease in wildlife utility due to the competitive displacement of native plant and animal species used for food and habitat.

Though observations are limited, this and Darby and McKercher's report offer some evidence that Old World climbing fern can potentially result in wildlife mortality. No other documentation is known. However, knowing the difficulty humans have in walking through Old World climbing fern, it is likely that, at a minimum, heavy infestations of the fern have a deleterious effect on the movements of some species of wildlife.

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