INTERIM REPORT

LONG-TERM MONITORING OF OLD WORLD CLIMBING FERN (*LYGODIUM MICROPHYLLUM* (CAV.) R. BR.) IN SOUTHEASTERN FLORIDA

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SUMMARY

In the fall of 1998, the Institute for Regional Conservation (IRC) established frequency and cover plots in four habitats at three sites in southeastern Florida to monitor the spread of Old World climbing fern (*Lygodium microphyllum*), an invasive vine that threatens wetland and upland ecosystems in Florida. In the fall of 2000, IRC staff completed the first biennial re-monitoring of these plots.

Interim results indicate that the frequency of Old World climbing fern increased by 19%. This was not a statistically significant level, but a strong trend ($p = 0.058$). Significant change, however, was detected in increases of Old World climbing fern at A.R. Marshall Loxahatchee National Wildlife Refuge, where frequency increased from 53% to 70%. Our data indicate that Old World climbing fern is well established and rapidly spreading at Loxahatchee. Both tree islands and cypress in Loxahatchee experienced a significant increase in Old World climbing fern frequency.

Cover and relative cover of Old World climbing fern decreased in herb plots, but increased in both shrub and canopy plots. None of these changes were significant over the two-year period, suggesting that Old World climbing fern cover may increase relatively slowly over time.

INTRODUCTION

Old World climbing fern (*Lygodium microphyllum* (Cav.) R. Br.) is an herbaceous perennial fern in the Schizaceae. Unusual for ferns, this species, along with several others in the genus *Lygodium*, is a vine. Old World climbing fern is an invasive exotic in South Florida, and has been classified as a Category I invasive exotic plant species by the Florida Exotic Pest Plant Council (1999). It is one of several invasive exotic species that can spread into South Florida ecosystems without the assistance of relatively major disturbances.

Once established, Old World climbing fern has the potential to disrupt South Florida ecosystems. By the late 1970's, colonies as large as one-quarter mile long and 200 yards wide had been established in southeastern Florida (Nauman and Austin 1978). In 1993, a survey documented that the Old World climbing fern had impacted 1,233 acres at Jonathan Dickinson State Park (Roberts 1996). Old World climbing fern climbs and then blankets vegetation, much like kudzu (*Pueraria montana* var. *lobata*), air-potato (*Dioscorea* spp.), and skunkvine (*Paederia* spp.), causing severe damage to and ultimately mortality of canopy trees (Roberts 1996, Roberts 1997, personal observations

of the authors). It also causes fire to spread into the canopy of cypress and pine-dominated ecosystems, and facilitates spot-over fires (Roberts 1996, Roberts 1997). It is also of concern due to its potential impact to rare and listed plant species such as tropical curlygrass fern (*Actinostachys pennula*) at A. R. Marshall Loxahatchee National Wildlife Refuge.

Old World climbing fern is a native of Africa, India, Asia, Micronesia, Melanesia, and Australia (Serizawa 1975, Edie 1978, Singh and Panigrahi 1984, USDA 1999). It has been introduced into and is now well established in central and southern peninsular Florida. It has been naturalized in southeastern Florida since at least the mid-1960's (Beckner 1968); it apparently became first established in the upper Loxahatchee River area in southern Martin and northern Palm Beach counties (Nauman and Austin 1978). By the late 1970's, Old World climbing fern had been recorded for a number of sites in Martin and Palm Beach counties (Nauman and Austin 1978), but was still absent from other South Florida counties. By the early 1980's, Wunderlin (1982) considered it to be locally abundant in the southern half of central Florida. By the mid-1990's, Old World climbing fern had been recorded from nine counties in South Florida: Broward, Collier, Desoto, Highlands, Lee, Manatee, Martin, Palm Beach, and Polk (Wunderlin et al. 1996). Currently Old World climbing fern is known from at least 17 counties from Monroe County (in Everglades National Park) north to Brevard County (Wunderlin and Hansen 2000, Pernas 2000, Hazelton 2000). Data collected by the South Florida Water Management District shows an increase in estimated area of Old World climbing fern from 27,686 acres in 1993 to 107,000 acres in 1999 (Doren, in prep.).

In its natural habitat, Old World climbing fern is found in mesic forest, rain forest, and open swampy areas, at altitudes from 0 to more than 1000 m; it appears to be more prevalent in open, and/or disturbed sites (Serizawa 1975, Edie 1978, Singh and Panigrahi 1984). While it was originally reported in South Florida only for wet, disturbed sites (Nauman and Austin 1978), it is now frequent in a number of mesic and wetland ecosystems including relatively undisturbed hammocks, cypress swamps, flatwoods, and bayheads (Nauman 1993, Wunderlin 1998, personal observations of the authors).

Little is known about the ecological requirements of Old World climbing fern in South Florida. The broad natural distribution of Old World climbing fern suggests that it can tolerate a wide range of climatic conditions. Although it has been primarily found in wetlands, it does show some ability to invade mesic soils. In South Florida, Old World climbing fern sporulates all year (Wunderlin 1998). Methods of dispersal are unclear, although spores may be spread accidentally by birds (Nauman and Austin 1978), and both water and wind dispersal appear likely.

Although the exact timing and method(s) of introduction in South Florida are not certain, it is known that Old World climbing fern is occasionally cultivated; the earliest know herbarium specimen was collected in a plant nursery in 1958 in southeastern Palm Beach County (Beckner 1968). It has been suggested that other occurrences of Old World climbing fern in South Florida have been established by direct human translocation (T. Pernas, pers. comm., 1998). Nevertheless, most new populations of Old World climbing

fern appear to become established without the assistance of humans. No significant predators or diseases affecting Old World climbing fern are known in Florida.

Research on Old World climbing fern has focused on different control measures using herbicides, fire, mechanical removal or trimming, and flooding (Roberts 1996, Roberts 1997, Stocker 1997). Since 1993, The South Florida Water Management District has conducted a biennial aerial survey for Old World climbing fern, which shows an increase in acreage from 1993 to 1999 (Pemberton and Ferriter 1998, Doren in prep.). Little is known, however, about the spread of Old World climbing fern in the early stages of establishment, how long it takes to form large monotypic stands, or how it affects native vegetation following establishment. We also do not know if Old World climbing fern establishment and growth occurs at different rates in different ecosystems and under different conditions. Finally, we do not know what the relationship is between the invasion of Old World climbing fern and other exotic plant species. The following study was designed to address these issues.

METHODS

Study Sites

Three sites in southeastern Florida were chosen for the establishment of long-term monitoring plots: A. R. Marshall Loxahatchee National Wildlife Refuge (Loxahatchee), J.W. Corbett Wildlife Management Area (Corbett), and Dupuis Management Area (Dupuis). Loxahatchee and Corbett are both in Palm Beach County, while Dupuis is located in both Martin and Palm Beach counties (Figures 1-4). Each was chosen because it met the following criteria: 1) it was known to contain Old World climbing fern; 2) it possessed at least two major habitats which contained Old World climbing fern; 3) it contained sufficient area of relatively undisturbed Old World climbing fern habitat with Old World climbing fern frequency not obviously greater than 10% and cover in the herb layer (< 1 m) not obviously greater than 1%; 4) it did not have an aggressive Old World climbing fern control program; and, 5) the site manager agreed not to conduct exotic species control treatments within the study areas for at least two years.

Habitats

Plots were established in cypress swamps at each site. In addition, plots were established in tree islands at Loxahatchee, in relatively undisturbed flatwoods at Corbett, and in recently roller-chopped flatwoods at Dupuis (Figure 5).

Three stations for each habitat were chosen at each site for the placement of plots. At each station, one series of randomly placed plots were placed to monitor frequency of Old World climbing fern and other exotic plant species, and one series of randomly-placed nested plots were established to monitor percent cover of Old World climbing fern and all associated exotic and native taxa.

Frequency Plots

At each station, twenty-five 5 m radius plots were established entirely within the habitat to be sampled. Presence or absence of Old World climbing fern and any other exotic plant species was recorded for each plot. A total of 450 radius plots were established for the study, 150 for each site, 225 for cypress swamps, and 75 each for tree islands, undisturbed flatwoods, and disturbed flatwoods. Plots were marked with PVC pipe driven directly into the soil, PVC pipe over rebar, or nails driven through two pieces of aluminum flashing (Figure 6).

Cover Plots

At each station, one 50 x 50 m canopy plot was established entirely within the habitat to be sampled; three 5 x 5 m shrub plots were nested within each canopy plot; and, three 1 x 1 m herb plots were nested within each shrub plot. The canopy layer was defined as > 3 m in height; the shrub layer was defined as > 1 m and <= 3 m in height; and, the herb layer was defined as <= 1 m in height. Cover of all species present in any layer was estimated using the Daubenmire cover scale (Mueller-Dombois and Ellenburg 1974). Corners of cover plots were marked as with frequency plots above. Herb plot boundaries were defined with a 1 x 1 m PVC square (Figure 7).

Data Collection

Initial data collection occurred during the fall of 1998. Interim data collection occurred in the fall of 2000. Subsequent data collection is planned for fall 2002 and, if funding permits, biennially thereafter.

Change in Plot Conditions

No major change was noted at any station at Loxahatchee. Two of the flatwoods stations burned, one undisturbed flatwoods station at Corbett (station 1), and one roller-chopped flatwoods site at Dupuis (station 3). Evidence of Brazilian-pepper (*Schinus terebinthifolius*) control was noted at station 2 at Dupuis.

Statistical Methods

Freidman ANOVA was used to determine if there were differences among sites in Old World climbing fern frequency and cover in 1998 and 2000. Chi-square tests were used to analyze frequency plot data to determine if there was a significant change in Old World climbing fern frequency between 1998 and 2000. Mann-Whitney U tests were used to analyze cover plot data between 1998 and 2000.

INTERIM RESULTS: FREQUENCY PLOTS

Frequency Plots: Old World Climbing Fern

There was no significant difference in Old World climbing fern frequency among sites in 1998 or 2000 ($p = 0.676$ and $p = 0.401$ respectively).

Frequency of Old World climbing fern for all study plots increased from 40.0% to 47.6% over the two-year sampling period, a 19% increase in frequency (Table 1). This was not a significant increase ($p = 0.058$), but a strong trend. In all, 12 stations experienced an increase in Old World climbing fern, 5 stations were unchanged, and 1 station experienced a decrease.

Frequency of Old World climbing fern increased at all sites. At Loxahatchee Old World climbing fern increased from 53.3% to 70.0%, which was a significant increase ($p = 0.002$). Old World climbing fern also increased at Corbett from 36.0 % to 40.7% and at Dupuis from 30.7% to 32.0%, but these changes were not significant.

Frequency of Old World climbing fern increased in cypress swamps from 32.9% to 40.4%, increased in tree islands from 77.3% to 96.0%, increased in undisturbed flatwoods from 20.0% to 25.3%, and decreased in roller-chopped flatwoods from 44.0% to 42.7%. Only the change in tree island frequency was significant ($p = 0.003$). However, when analyzed alone, the cypress swamps at Loxahatchee also experienced a significant increase from 29.3% to 44.0% ($p = 0.020$).

Frequency Plots: Other Exotics[1]

There was no significant difference in other exotic frequency among sites in 1998 or 2000 ($p = 0.154$ and $p = 0.280$ respectively).

Frequency of other exotics for all study plots increased from 44.9% to 46.9% over the two-year sampling period (Table 2). This was not a significant increase ($p = 0.974$). In all, 4 stations experienced an increase in Old World climbing fern, 10 stations were unchanged, and 4 stations experienced a decrease.

Frequency of other exotics increased at all sites. At Loxahatchee other exotics increased from 50.0% to 50.7%, at Corbett exotics cover increased from 12.7% to 14.7%, and at Dupuis it increased from 72.0% to 75.3%. None of these changes were significant.

Frequency of other exotics increased in cypress swamps from 58.7% to 59.5%, increased in tree islands from 0.0% to 1.3%, decreased in undisturbed flatwoods from 5.3% to 4.0%, and increased in roller-chopped flatwoods from 88.0% to 97.3%. None of these changes were significant.

[1] *Urena lobata* and *Salvinia minima*, both now considered as exotics, were not considered as exotics in 1998 and therefore are not included in frequency data.

The total number of exotic taxa within the frequency plots decreased from 31 in 1998 to 28 in 2000 (Table 3). This was not a significant change. In addition, no significant change was noted in exotics diversity within different sites or different habitats between 1998 and 2000.

INTERIM RESULTS: COVER PLOTS[2]

Herb Plots: Old World Climbing Fern

There was no significant difference in Old World climbing fern cover among sites in 1998 or 2000 ($p = 0.939$ and $p = 0.368$ respectively).

Percent cover of Old World climbing fern for all study plots decreased from 1.5% to 0.5% over the two-year sampling period (Table 4). This was not a significant decrease ($p = 0.542$). In all, 3 stations experienced an increase in Old World climbing fern, 11 stations were unchanged, and 4 stations experienced a decrease.

Percent cover decreased at Loxahatchee from 3.1% to 1.1%, decreased at Corbett from 1.4 % to 0.3%, and remained unchanged at Dupuis at 0.1%. None of these changes were significant.

Percent cover increased in roller-chopped flatwoods from 0.0% to 0.1%, and decreased in cypress swamps from 0.8% to 0.2%, in tree islands from 6.2% to 2.2%, and in undisturbed flatwoods from 0.6% to 0.2%. None of these changes were significant.

Shrub Plots: Old World Climbing Fern

There was no significant difference in Old World climbing fern cover among sites in 1998 or 2000 ($p = 0.319$ and $p = 0.538$ respectively).

Percent cover of Old World climbing fern for all study plots increased from 1.6% to 2.9% over the two-year sampling period (Table 5). This was not a significant increase ($p = 0.257$). In all, 6 stations experienced an increase in Old World climbing fern, 11 stations were unchanged, and 1 station experienced a decrease.

Percent cover increased at all sites. Old World climbing fern at Loxahatchee increased from 3.7% to 5.1%, at Corbett from 1.1 % to 3.2%, and at Dupuis from 0.1% to 0.4%, none of which were significant.

Percent cover increased in cypress swamps from 0.8% to 2.2%, increased in tree islands from 7.3% to 9.8%, and increased in roller-chopped flatwoods 0.0% to 0.8%, but remained the same in undisturbed flatwoods at 0.3%. None of these changed were significant.

[2] Totals may exceed 100% due to overlap in cover. *Urena lobata* and *Salvinia minima* are included in cover plot data.

Canopy Plots: Old World Climbing Fern

There was a significant difference in Old World climbing fern cover among sites in 1998, but not in 2000 ($p = 0.022$ and $p = 0.099$ respectively), an affect caused by the absence of any Old World climbing fern in the canopy at Dupuis in 1998.

Percent cover of Old World climbing fern for all study plots increased from 1.0% to 2.8% over the two-year sampling period (Table 6). This was not a significant increase ($p = 0.220$). In all, 6 stations experienced an increase in Old World climbing fern, 11 stations were unchanged, and 1 station experienced a decrease.

Percent cover increased at all sites. Old World climbing fern at Loxahatchee increased from 2.1% to 4.7%, at Corbett from 0.8 % to 3.0%, and at Dupuis from 0.0% to 0.8%. None of these changes were significant.

Percent cover increased in cypress swamps from 1.4% to 3.1%, in tree islands from 1.7% to 6.8%, and in roller-chopped flatwoods from 0.0% to 0.8%. No Old World climbing fern was observed in the canopy of undisturbed flatwoods plots. None of these changes were significant.

Herb Plots: Other Exotics

There was a significant difference in other exotics cover among sites in 1998 but not in 2000 ($p = 0.042$ and $p = 0.135$ respectively), which was due to a number of factors including high levels of water spangles (*Salvinia minima*) in 1998.

Percent cover of other exotics for all study plots decreased from 21.0% to 16.4% over the two-year sampling period (Table 7). This was not a significant change ($p = 0.358$). In all, 5 stations experienced an increase in exotics, 4 stations were unchanged, and 9 stations experienced a decrease.

Percent cover decreased at Loxahatchee from 34.8% to 19.5%, decreased at Corbett from 1.6 % to 0.6%, but increased at Dupuis from 26.6% to 29.1%. None of these changes were significant.

Percent cover decreased in cypress swamps from 24.4% to 12.5%, decreased in tree islands from 8.1% to 3.8%, decreased in undisturbed flatwoods from 0.9% to 0.6%, but increased in roller-chopped flatwoods from 43.8% to 56.5%. None of these changes were significant.

Shrub Plots: Other Exotics

There was no significant difference in other exotics cover among sites in 1998 or 2000 ($p = 0.060$ and $p = 0.143$ respectively).

Percent cover of other exotics for all study plots increased from 4.9% to 5.0% over the two-year sampling period (Table 8). This was not a significant increase ($p = 0.271$). In all, 5 stations experienced an increase in exotics, 10 stations were unchanged, and 3 stations experienced a decrease.

At Loxahatchee exotics cover decreased from 13.7% to 8.7%, at Corbett cover increased from 0.0% to 0.1%, and at Dupuis cover increased from 1.0 to 6.2 %. None of these changes were significant.

Percent cover decreased in cypress swamps from 9.8% to 6.0%, and increased in roller-chopped flatwoods from 0.0% to 11.8%. The change in roller-chopped flatwoods was significant ($p = 0.370$). No exotics other than Old World climbing fern were recorded in trees islands or undisturbed flatwoods in 1998 or 2000.

Canopy Plots: Other Exotics

There was not a significant difference in other exotics cover among sites in 1998 but there was in 2000 ($p = 0.060$ and $p = 0.024$ respectively).

Percent cover of other exotics for all study plots increased from 2.1% to 7.1% over the two-year sampling period (Table 9). This was not a significant increase ($p = 0.763$). In all, 5 stations experienced an increase in exotics, 12 stations were unchanged, and 1 station experienced a decrease.

At Loxahatchee exotics cover increased from 4.7% to 17.3%, and at Dupuis cover increased from 1.7% to 3.8%. Neither of these changes was significant. No exotics were recorded in the canopy at Corbett in 1998 or 2000.

Percent cover increased in cypress swamps from 4.2% to 13.8%, and in tree islands from 0.0% to 0.8%. Neither of these changes was significant. No exotics other than Old World climbing fern were recorded in undisturbed flatwoods or roller-chopped flatwoods in 1998 or 2000.

Herb Plots: Natives

There was a significant difference in native cover among sites in 1998 and 2000 ($p = 0.042$ and $p = 0.030$ respectively).

Percent cover of natives for all study plots decreased from 82.7% to 58.8% over the two-year sampling period (Table 10). This was not a significant change ($p = 0.235$). In all, 4 stations experienced an increase in natives and 14 stations experienced a decrease.

Percent cover of natives decreased at all sites. Native cover decreased at Loxahatchee from 70.1% to 44.7%, decreased at Corbett from 116.5% to 80.0%, and decreased at Dupuis from 61.6% to 51.8%.

Percent cover decreased in cypress swamps from 78.4% to 44.5%, decreased in tree islands 85.1% to 59.0%, and decreased in undisturbed flatwoods from 143.0% to 108.3%. Changes in cypress swamps and tree islands were both significant ($p = 0.047$ and $p = 0.050$), but only marginally. Native cover increased in roller-chopped flatwoods from 33.2% to 52.1%, but this change was not significant.

Shrub Plots: Natives

There was a significant difference in native cover among sites in 1998, but not in 2000 ($p = 0.030$ and $p = 0.223$ respectively).

Percent cover of natives for all study plots increased from 58.8% to 81.9% over the two-year sampling period (Table 11). This was a significant change ($p = 0.034$). All stations experienced an increase in native cover.

Cover of natives increased at all sites. Cover increased at Loxahatchee from 93.0.% to 110.9%, increased at Corbett from 50.0% to 81.4%, and increased at Dupuis from 33.4% to 53.5%. None of these changes were significant.

Percent cover increased in cypress swamps from 65.1% to 79.5%, increased in tree islands 123.3% to 145.4%, increased in undisturbed flatwoods from 33.7% to 60.7%, and increased in roller-chopped flatwoods from 0.5% to 46.9%. Changes in cypress swamps and roller-chopped flatwoods were both significant ($p = 0.31$ and $p = 0.046$).

Canopy Plots: Natives

There was not a significant difference in native cover among sites in 1998 or 2000 ($p = 0.607$ and $p = 0.200$ respectively).

Percent cover of natives for all study plots increased from 106.9% to 107.8% over the two-year sampling period (Table 12). This was not a significant change ($p = 0.887$). In all, 4 stations experienced an increase in natives, 9 stations were unchanged, and 5 stations experienced a decrease.

Cover of natives increased at Loxahatchee from 173.9% to 176.8%, decreased at Corbett from 125.2% to 124.8%, and increased at Dupuis from 128.7% to 129.8%. None of these changes were significant.

Percent cover increased in cypress swamps from 143.7% to 145.2%, remained the same in tree islands at 122.0%, decreased in undisturbed flatwoods from 57.2% to 56.3%, and increased in roller-chopped flatwoods from 31.5% to 33.2%. None of these changes are significant.

Relative Cover: Old World Climbing Fern

Relative cover of Old World climbing fern decreased in herb plots over the two-year sampling period from 1.6% to 1.3%, increased in shrub plots from 1.7% to 7.1%, and increased in canopy plots from 1.2% to 2.3% (Table 13). None of these changes were significant.

Relative Cover: Exotics, Excluding Old World Climbing Fern

Average relative cover of other exotics decreased in herb plots over the two-year sampling period from 21.1% to 18.2%, decreased in shrub plots from 11.4% to 7.8%, and increased in canopy plots from 1.4% to 4.1% (Table 14). None of these changes were significant.

DISCUSSION

Interim results indicate that the frequency of Old World climbing fern is increasing, not at a statistically significant level, but with a strong trend. Significant change, however, was detected in increases of Old World climbing fern at A.R. Marshall Loxahatchee National Wildlife Refuge, where frequency increased from 53% to 70%. Loxahatchee had the highest frequency of the three sites in 1998, although the difference between Loxahatchee and the other sites was not significant. Our results indicate that Old World climbing fern is well established and rapidly spreading at Loxahatchee. Both tree islands and cypress swamps in Loxahatchee experienced a significant increase in Old World climbing fern frequency.

Cover of Old World climbing fern decreased in herb plots, but increased in both shrub and canopy plots. None of these changes were significant over the two-year period, suggesting that Old World climbing fern cover may increase relatively slowly over time.

Relative cover of Old World climbing fern followed the same trend as with cover, again with no significant results. Loss of native cover in the herb layer can be attributed to a number of factors including drier conditions in cypress swamps and tree islands, some suppression of herbs in undisturbed flatwoods due to lack of fire, and the temporary loss of perennial grass cover following a prescribed fire in undisturbed flatwoods. The increase in the shrub layer can be attributed to more flowering of tall herbs, including grasses, throughout all of the sites.

It is also worth noting that roller-chopped flatwoods, all of which had been chopped in the year prior to the establishment of the plots, experienced a large increase in exotics cover in both the herb and shrub layers.

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