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Lygodium microphyllum (Old world climbing fern), *Lygodium japonicum* (Japanese climbing fern), and *Lygodium flexuosum*

Weed Risk Assessment

Left: *Lygodium microphyllum* on cypress trees (Peggy Greb, USDA Agricultural Research Service, Bugwood.org).
Right: *Lygodium japonicum* in pine forest (James H. Miller, USDA Forest Service, Bugwood.org).

Agency Contact:

United States Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Center for Plant Health Science and Technology
Plant Epidemiology and Risk Analysis Laboratory
1730 Varsity Drive, Suite 300
Raleigh, NC 27606

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1. Initiating Event

APHIS received an inquiry regarding market access for leaves of *Lygodium microphyllum* from China to be used in basket-weaving (Lehtonen, 2008). *Lygodium microphyllum* and its congener, *L. japonicum*, are already present in the United States, where they are listed as state noxious weeds in Florida and Alabama (NRCS, 2008). *Lygodium japonicum* is also used in Asian handcrafts (fern fronds) (Ferriter, 2001). Historically, this species has been confused with *L. microphyllum* (FDEP, N.D.; Pemberton and Ferriter, 1998). Because importation of *L. microphyllum* and *L. japonicum* may lead to the establishment of additional populations in the United States, Plant Protection and Quarantine (PPQ) requested that PERAL prepare a weed risk assessment to evaluate listing these species as Federal Noxious Weeds (Tasker, 2008). *L. flexuosum*, which is not in the United States, was also assessed because it is similar to these other two species, and may have similar impacts if introduced. We assessed all three species together in this document[1].

2. Plant Identity

Lygodium microphyllum (Cav.) R. Br.
Syn: *Lygodium scandens* auct. and *Ugena microphylla* Cavanilles

Lygodium japonicum (Thunb.) Sw.
Syn: *Ophioglossum japonicum* Thunb.

Lygodium flexuosum (L.) Sw.
Syn: *Ophioglossum flexuosum* L.
References: (ARS, 2008a)

3. Current PPQ Policy

None of these species is listed as a Federal Noxious Weed (queried April 29, 2008). PPQ issued a Federal Import Quarantine Order on May 30, 2008 to prevent the importation of *L. microphyllum* and *L. flexuosum*.

4. Data Sheet(s) and Other Risk Assessments

[1] The State of Florida requested that APHIS assess/list the entire genus of *Lygodium*. In this document, we only assessed species for which there was ample evidence of harm. A preliminary review of the literature indicated that of the approximately 25 species in the genus (Mabberley, 2008), only two other species have been considered weeds*: L. polymorphum* and *L. circinnatum* (Holm et al. 1979). Due to the limited amount of information available on these two species, they will be assessed separately after PPQ completes developing a predictive weed screening tool. No other species of *Lygodium* have been noted in the literature to be weeds.

PPQ has not formally evaluated these species. Gordon et al. (2008b) assessed *L. microphyllum* and *L. japonicum* in their test of the Australian weed risk assessment system in Florida. Because these two taxa are generally considered major invaders (e.g., Weber, 2003), numerous reports are available about them (e.g., Brandt and Black, 2001; ISSG, 2008; Masterson, 2007; Wu et al., 2006).

5. Pest Characterization

5.1. Distribution, Prevalence, and Potential Pathways of Entry

Lygodium microphyllum is native to tropical Africa, India, southeast Asia, Taiwan, and portions of Malaysia and northern Australia (ARS, 2008a; Langeland and Burks, 1998). The native range includes the following countries: Kenya, Tanzania, Uganda, Burundi, Cameroon, Gabon, Zaire, Cote D'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Nigeria, Senegal, Sierra Leone, Angola, Mozambique, Zambia, Zimbabwe, South Africa, China (Fujian, Guangdong, Guangxi, Yunnan), Japan (Ryukyu Islands), Taiwan, India, Thailand, Brunei, Indonesia, Malaysia, Papua New Guinea, Philippines, Australia, Micronesia, and Fiji (ARS, 2008a; Langeland and Burks, 1998; NTU, 2008).

Lygodium microphyllum is also currently established in the United States in twenty counties of peninsular Florida. The oldest known collection is from 1958 (Loxahatchee River area), but it had probably been in cultivation since at least the early 1950s (Nauman and Austin, 1978). It was probably introduced as an ornamental, as was its invasive congener, *L. japonicum* (Gordon and Thomas, 1997). A molecular study suggests that the U.S. population of *L. microphyllum* probably originated from Australia/Papua New Guinea (Goolsby et al., 2006). Where it occurs in natural areas, *L. microphyllum* is very abundant (Hutchinson et al., 2006). *Lygodium microphyllum* has not yet reached the limit of its potential geographic distribution in the United States (see geographic potential below and Figure 1).

Lygodium japonicum is native to tropical and temperate Asia, from Malaysia and Papua New Guinea northward to Taiwan, Japan, and Korea (ARS, 2008a). Its native range includes China, Japan, Korea, Bhutan, India, Nepal, Sri Lanka, Cambodia, Laos, Thailand, Vietnam, Indonesia, Malaysia, Papua New Guinea, and the Philippines (ARS, 2008a). It appeared in a U.S. nursery catalog as early as the 1880s and was probably introduced as an ornamental species at the same time (Pemberton and Ferriter, 1998). It has been established since at least

1937 (Soxman, 1939)[2]. It is also established in Puerto Rico and Hawaii (Liogier and Martorell, 2000; NRCS, 2008). *Lygodium japonicum* is relatively widespread in some states, but more regionalized or isolated in others (Figure 2) (NRCS, 2008). In the latter states, *L. japonicum* may not have reached the limit of its potential geographic distribution (USDA plant hardiness zone 8), and may spread further north (see geographic potential below). For example, researchers in Georgia report that after being present for some time, "…the population now seems to be spreading at an alarming rate" (Evans and Moorhead, 2005). Besides being spread through horticulture, it is readily wind-dispersed (Ferriter, 2001) and can spread in contaminated pine-straw and on field equipment (Miller, 2007).

Lygodium flexuosum is native to temperate and tropical Southeast Asia and Australia. It has been reported from Australia, China, India, Indonesia, Malaysia, Nepal, Papua New Guinea, the Philippines, Sri Lanka, and Thailand (ARS, 2008a; Dangol, 2005). Other than for biocontrol research at a quarantine facility in Gainesville (ARS, 2008b), we found no evidence of it being introduced to the United States.

Several species of *Lygodium*, including *L. microphyllum* and *L. japonicum*, are cultivated as ornamentals (Bailey and Bailey, 1976; Wiersema and Leon, 1999). *Lygodium flexuosum* is also likely to be cultivated, since one seed order company lists it in its online catalogue (Anonymous, 2008) and it is used in basket weaving (Anonymous, 2005). We found no evidence that any of these species have been domesticated or bred for any particular traits.

5.2. Weed Biology and Impact

All three species are ferns with a vine-like growth form. Fronds of *Lygodium japonicum* and *L. microphyllum* grow up to 30 feet long, capable of reaching into forest canopies (Ferriter, 2001; FNA Editorial Committee, 1993; Pemberton and Ferriter, 1998). They can blanket entire communities, shading out plants below, and, importantly, providing a means for fire to reach tree canopies (Ferriter, 2001; Munger, 2005; Pemberton and Ferriter, 1998). In the United States, they invade many different habitats, including wet (mesic) habitats, ditches, hammocks, pine forests, wetlands, and disturbed areas (Ferriter, 2001; ISSG, 2008). *Lygodium flexuosum* is a weed of rice fields and rubber, oil palm, and tea plantations, where it competes with plants and obstructs harvesting (PIC, 2008; Rajkhowa et al., 2005; Roder et al., 1995b; Roder et al., 1997). All three species are agricultural weeds in their native range (Holm et al., 1979).

[2] The USDA Plants Database currently indicates its presence in Pennsylvania (NRCS, 2008), but this report is going to be removed because the original reference is unverifiable and dubious (Skinner, 2008).

5.3. Current Response and Activities

Lygodium microphyllum and *L. japonicum* are state noxious weeds in Florida and Alabama; the other eight states with known populations of *L. japonicum* (Figure 2) do not list this species as a noxious weed (ADAI, 2008; Ferriter, 2001; NRCS, 2008). Outside of Florida, *L. japonicum* is controlled locally by various federal, state, or local agencies [e.g., Georgia (Evans et al., 2005), Texas (Korn et al., 2007; USDA-FS, 2007), and Mississippi River bottomland forests (Stanturf et al., 2004)]; however, the extent of local control is unknown. A survey of control measures for *L. microphyllum* in southern Florida highlighted the range of agencies managing it (Hutchinson and Langeland, 2006). To help coordinate control efforts, a detailed management plan for *L. microphyllum* was released two years ago (Hutchinson et al., 2006); a similar one is planned for *L. japonicum*. Both species are subject to intense monitoring and research (Carmichael and Platt, 2007; Clarke et al., 2007; Lott and Volin, 2003; Lott et al., 2003; Pemberton, 2003; Schmitz, 2007). In Florida, where both species are abundant (Wunderlin and Hansen, 2008), the Florida Department of Environmental Protection has spent approximately $15 million over the last ten years to control and study them (Sole, 2008).

5.4. Plant Protection Act's (PPA) Definition of Noxious Weed

To be listed as a Federal Noxious Weed, a plant must meet the definition of a Noxious Weed in the Plant Protection Act (7 U.S.C. § 7701-7786, 2000). The term "noxious weed means any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment" (7 U.S.C. § 7701-7786, 2000). APHIS lists in the Federal noxious weed regulations those species that are prohibited or restricted from entering the United States, or moving interstate, and for which authority exists under sections 412 and 414 of the PPA for APHIS to apply remedial measures.

Based on the information described above, all three species meet the PPA definition of noxious weed.

6. Risk Assessment

6.1. Establishment/Spread Potential

Lygodium microphyllum and *L. japonicum* have already demonstrated their ability to establish and spread beyond their native range, having

naturalized in other places outside of the United States (Liogier and Martorell, 2000; Pemberton and Ferriter, 1998; Randall, 2007). In the United States, they are considered invasive species that have rapidly spread across the region (Ferriter, 2001; Hutchinson et al., 2006; Pemberton and Ferriter, 1998; Volin et al., 2004; Wilson, 2002). For example, in Florida, *L. microphyllum* has increased in coverage nearly ten-fold in a decade (27,000 acres in 1993 vs. 120,000 acres in 2005; Hutchinson et al., 2006). And although *L. japonicum* has been established since at least 1937 in the United States (Soxman, 1939), it continues to spread "at an alarming rate" (Evans and Moorhead, 2005).

We assessed the establishment and spread potential of all three species using the 26 questions for this risk element listed in Appendices A & B. Although not necessary because they have already demonstrated their ability to spread, we did a full assessment on *L. microphyllum* and *L. japonicum* to evaluate which traits may have contributed to their invasiveness in the United States (Appendix A). On a scale of -22 to 28, where 28 represents a species scoring positively on all invasive traits, all three species scored relatively high (Table 1). *Lygodium flexuosum* scored somewhat lower (12) than *L. microphyllum* (18) and *L. japonicum* (17), primarily because of the first question about invasive status elsewhere (Appendix B).

Our review suggests that the following traits have contributed greatly to the establishment, naturalization, and spread of *L. microphyllum* and *L. japonicum* in the United States: 1) tolerance to a wide range of light conditions; 2) massive amounts of spore production; 3) long-distance wind dispersal of spores; 4) self-compatible gametophytes; 5) tolerance to fire; 6) relatively rapid growth rates and photosynthetic rates; and 7) regional spread via several pathways (FDEP, N.D.; Ferriter, 2001; Hutchinson et al., 2006; Hutchinson and Langeland, 2006; Lott and Volin, 2003; Lott et al., 2003; Masterson, 2007; Miller, 2007; Nauman and Austin, 1978; Pemberton and Ferriter, 1998; Volin et al., 2004). *Lygodium flexuosum* possesses many of these same traits.

6.2. Potential Impacts: Production, Environmental, and Human/Social

Lygodium microphyllum and *L. japonicum* invade pristine habitats, disturbed areas, forest plantations, and rangelands (Ferriter, 2001; Handley, 2008; Miller, 2003; Pemberton and Ferriter, 1998; Rowe, 2008; USDA-FS, 2007). Their prolific growth shades underlying vegetation and promotes fire in plant canopies, thereby changing fire regime, altering habitat structure, reducing native plant diversity, and threatening rare species (Brandt and Black, 2001; Ferriter, 2001; Hutchinson et al., 2006; Pemberton and Ferriter, 1998). *Lygodium microphyllum* often creates a one-meter thick mat of live and dead fern

fronds (Pemberton and Ferriter, 1998). Treating *Lygodium* infestations in natural areas with herbicides and mechanical means can result in non-target impacts to native communities (Hutchinson et al., 2006; Hutchinson and Langeland, 2006). Control costs for *L. microphyllum* range between $1000 per ha in easily accessed areas to $3,750 per ha in more remote areas (2002 values; Masterson, 2007). We expect similar control costs for *L. japonicum*.

Lygodium microphyllum and *L. japonicum* are controlled by timber and agricultural managers (Carter-Finn et al., 2006; Ferriter, 2001; Hutchinson and Langeland, 2006), and are classified as agricultural weeds (Holm et al., 1979), which indicates they are harmful to wood production systems. *Lygodium japonicum* forms mats that smother shrubs and trees, and promotes fire in timber stands (Barnard and Loan, N.D.; Ferriter, 2001; Miller, 2003). Anecdotal evidence and personal communication with field biologists support these observations. For example, *L. microphyllum* grows from drainage ditches in Florida onto adjacent orchards (Nagid, 2008). Finally, *Lygodium* contaminates pine-straw and hay, leading to regulatory action against these products (ADAI, 2008) and potentially lower product value. Some interest exists for developing a certification program for *Lygodium*-free pine-straw (FFWCC, 2005).

Because *Lygodium microphyllum* and *L. japonicum* form impenetrable vine blankets that are unsightly and relatively useless to wildlife, they are likely harming outdoor recreational activities such as wildlife viewing and hunting (Handley, 2008; Rowe, 2008). A member of the Florida Cattlemen's Association reported that *Lygodium* invades forests that are adjacent to rangeland. These recreational activities are a significant source of revenue. For example, in 2006 across the United States, hunters spent $740 million on hunting leases, while wildlife watchers spent $45.7 billion on travel and equipment (USFWS, 2006). While these forests may or may not be used by cattle, the revenue obtained from hunting leases is a significant source of income for the Florida cattle industry (Handley, 2008).

Lygodium microphyllum and *L. japonicum* were assessed for their impact potential using the set of questions listed in Appendix A. The assessment indicated an overall moderate-high score of 3.0 and 3.2, respectively (Table 1). Both species have well-documented environmental effects.

We found less information about the impact and potential impact of *L. flexuosum* than for the other two species, so the uncertainty was greater. *Lygodium flexuosum* has never been taken out of its native range (except see ARS, 2008b), where it lives in association with its

coevolved pathogens and predators (e.g., Goolsby et al., 2003; Mound, 2002; Solis et al., 2005). Nevertheless, it is considered an agricultural weed in its native range (Holm et al., 1979), where it reduces rice yields (Roder et al., 1995a; Roder et al., 1995b), interferes with harvest operations in rubber tree and oil palm plantations (PIC, 2008), and may compete with tea plants for resources (Rajkhowa et al., 2005). In this assessment, *L. flexuosum* obtained a moderate score of 2.1 (Table 1), mostly due to impacts to production systems. Because its biology is similar to that of the other two *Lygodium* species, *L. flexuosum* is likely to similarly affect natural habitats and human environs if it establishes in the United States. *Lygodium flexuosum* ranked among the top 25 species not yet in cultivation with the potential to significantly affect agricultural and environmental ecosystems in the United States (Parker et al., 2007).

6.3. Geographic Potential

As discussed above (sects. 5.1, 6.1) all three *Lygodium* species have wide native distributions.

The distribution of *L. microphyllum* includes Plant Hardiness Zones 10-13, and it may potentially occur in zone 9 based on country-province level occurrences (e.g., Fujian, China; see Appendix A; Magarey et al., 2008). In Florida, *L. microphyllum* is killed back to the ground by frost, but it can regrow if its roots do not freeze (Pemberton and Ferriter, 1998). Because it grows in wet habitats, soil moisture protects the roots somewhat from freezing temperatures. We think this fern could grow in zone 9 (Pemberton and Ferriter, 1998). Thus, we think *L. microphyllum* could establish in all of Florida, and coastal regions of Texas, Louisiana, Alabama, and Mississippi. Approximately 9.9 percent of the total area of the United States occurs in Plant Hardiness Zones 9-13 (PERAL, 2008).

The tropical and subtropical distribution of *L. flexuosum* in Southeast Asia, suggests that it can also survive in Plant Hardiness Zones 9-13.

The distribution of *L. japonicum* indicates that it can survive in Plant Hardiness Zones 7-13. We estimate that *L. japonicum* could establish in about 39 percent of the United States (Appendix A). It may also survive in zone 6, based on its presence in Korea (see Appendix A; ARS, 2008a), but this occurrence has not been confirmed, and we did not consider it here. Experts recommend that gardeners in zone 6 mulch the plant after the first frost (Ferriter, 2001), suggesting that it may not be able to survive without human assistance in this zone.

6.4. Entry Potential

An international standard for pest risk assessment (ISPM #11)

recommends that assessments consider pest entry potential (IPPC, 2007). Because *L. microphyllum* and *L. japonicum* are already in the United States (Langeland and Burks, 1998), however, we do not need to consider their entry potential (IPPC, 2007: see ISPM #11 sect. 2.2.1). Overall, we estimate that the likelihood of entry for *Lygodium flexuosum* to be high (0.55; Table 1) because it is used in basket weaving (Anonymous, 2005) and is marketed on the internet (Anonymous, 2008). Of less importance is its potential ability to contaminate other pathways (Table 1).

Table 1. Summary of weed risk assessment results for three *Lygodium* species. See Appendix A for more details. Numbers in parentheses are mean uncertainty levels for that risk element. The scores for the four risk elements were not combined in any way; we used them to confirm the preponderance of the descriptive evidence given above.

Risk Element (score range)	**Scores (mean uncertainty[a])**		
	L. microphyllum	***L. japonicum***	***L. flexuosum***
Establishment/Spread Potential (-23 – 29)	18 (0.9)	17 (1.0)	12 (1.3)
Potential Effects (1 – 4)[b]	3.0 (1.5)	3.2 (1.5)	2.1 (2.1)
Environmental (0 – 1.2)	1.1 (1.3)	1.1 (1.4)	0.3 (2.5)
Human/Social (0 – 0.6)	0.3 (2.0)	0.3 (2.0)	0.0 (2.0)
Production (0 – 1.2)	0.6 (2.0)	0.8 (1.8)	0.8 (1.8)
Geographic Potential (0 – 1)	0.10 (1.2)	0.39 (1.3)	0.10 (1.0)
Entry Potential (0 – 1)	N/A	N/A	0.55 (1.7)

[a] Negligible = 0, Low = 1, Moderate = 2, High = 3

[b] The base score for potential effects is 1; the scores for the three sub-elements modify this value.

6.5. Weed Risk Potential

Lygodium microphyllum and *L. japonicum* have several traits that have contributed to their ability to establish, naturalize, and spread in the United States (*sensu* Richardson et al., 2000). Because they can form dense vine blankets and alter fire regime, they have a variety of environmental, aesthetic, and economic impacts. As such, they are considered significant invaders. The results of this assessment are consistent with another assessment that used the Australian weed risk assessment system to evaluate their invasiveness (Gordon et al., 2008b). Among a group of 205 species not in cultivation in the United States, *L. flexuosum* was one of the top 25 weeds that pose the greatest risk to the United States (Parker et al., 2007), supporting our recommendation below. Due to limited information on *L. flexuosum*, its assessment had higher uncertainty than that of the other two species (Table 1). Because it shares many of the same traits as *L. microphyllum* and *L. japonicum*, though, and because it is a "weed" in its native range, we expect it to behave similarly in the United States.

Lygodium microphyllum is in Florida, where it is a state noxious weed (NRCS, 2008) and under widespread control by local, state, and federal agencies (Hutchinson et al., 2006; Hutchinson and Langeland, 2006). It is also regulated in Alabama where program managers are trying to prevent its establishment in the state (ADAI, 2008). *Lygodium japonicum* occurs throughout the southeastern United States, but it has not yet reached the limit of its distribution and abundance. It also is a state noxious weed in Florida and Alabama and controlled by a wide variety of groups [e.g., Alabama (ADAI, 2008), Florida (Ferriter, 2001), Georgia (Evans et al., 2005), and Texas (Korn et al., 2007; USDA-FS, 2007)].

Lygodium flexuosum is not in the United States. It meets the definition of a noxious weed in the Plant Protection Act (7 U.S.C. § 7701-7786, 2000).

6.6. Recommendations

Based on their moderate to moderate high risk scores, we recommend that *Lygodium microphyllum* (Cavanilles) R. Brown, *Lygodium japonicum* (Thunb.) Sw., and *Lygodium flexuosum* (L.) Sw. be considered for listing as Federal Noxious Weeds under the authority granted to APHIS by the Plant Protection Act.

7. Contributors

USDA-APHIS-PPQ
Center for Plant Health Science and Technology
Plant Epidemiology and Risk Analysis Laboratory
Author: Anthony L. Koop (Botanist/Ecologist,)
Reviewers: Barney Caton (Ecologist), Larry Fowler (Botanist)
Editor: Ashley Jackson

USDA-APHIS-PPQ, Commodity Import Analysis & Operations
External reviewer: Polly Lehtonen (Senior Import Specialist)
External reviewer: Claudia Ferguson (Regulatory Policy Specialist)
External reviewer: Christa Speekmann (Import Specialist – AAAS Fellow)

USDA-APHIS-PPQ, Emergency and Domestic Programs
External reviewer: Al Tasker (National Weeds Program Manager)

8. Figures

Figure 1. County level distribution of *Lygodium microphyllum* in the lower 48 states.

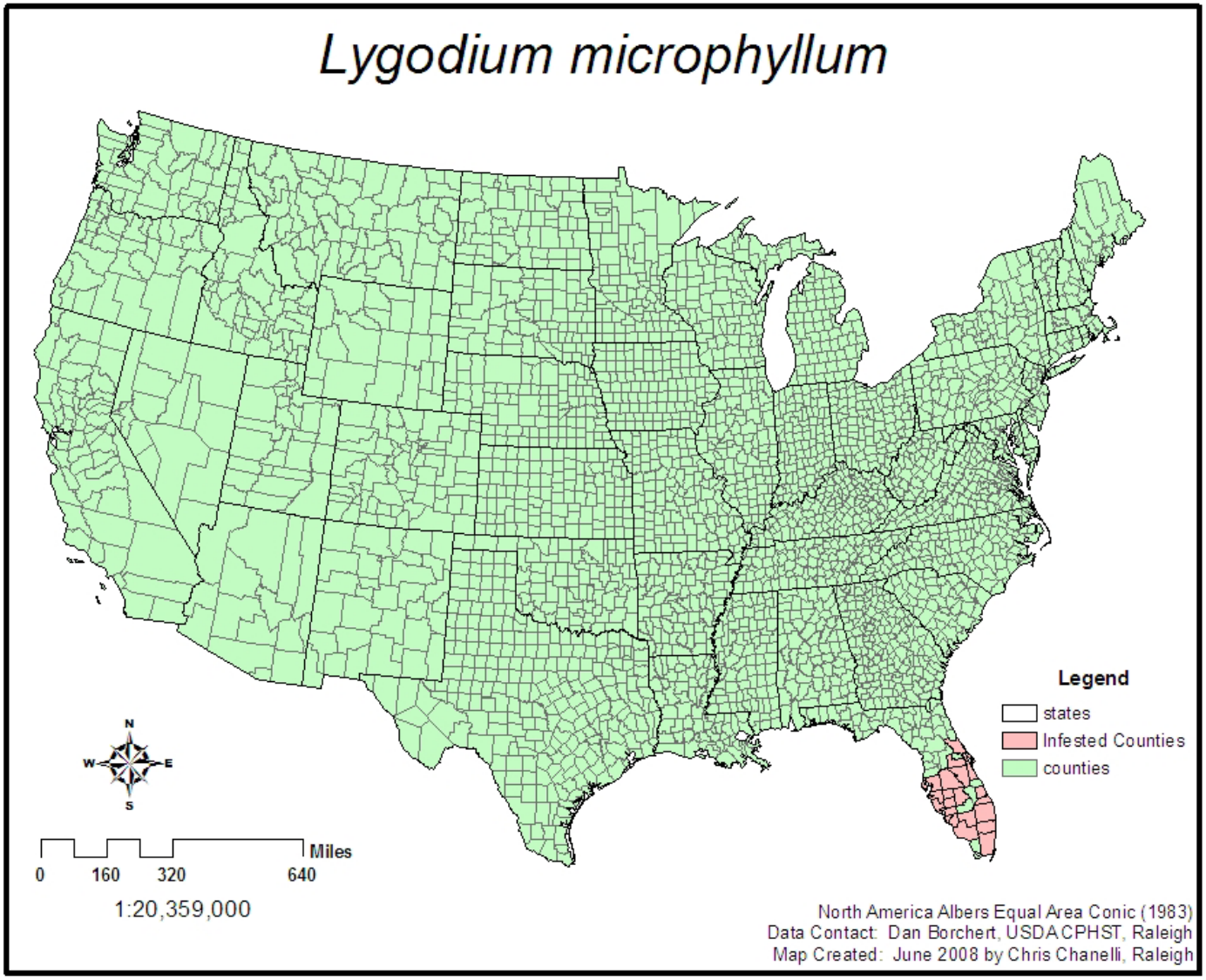
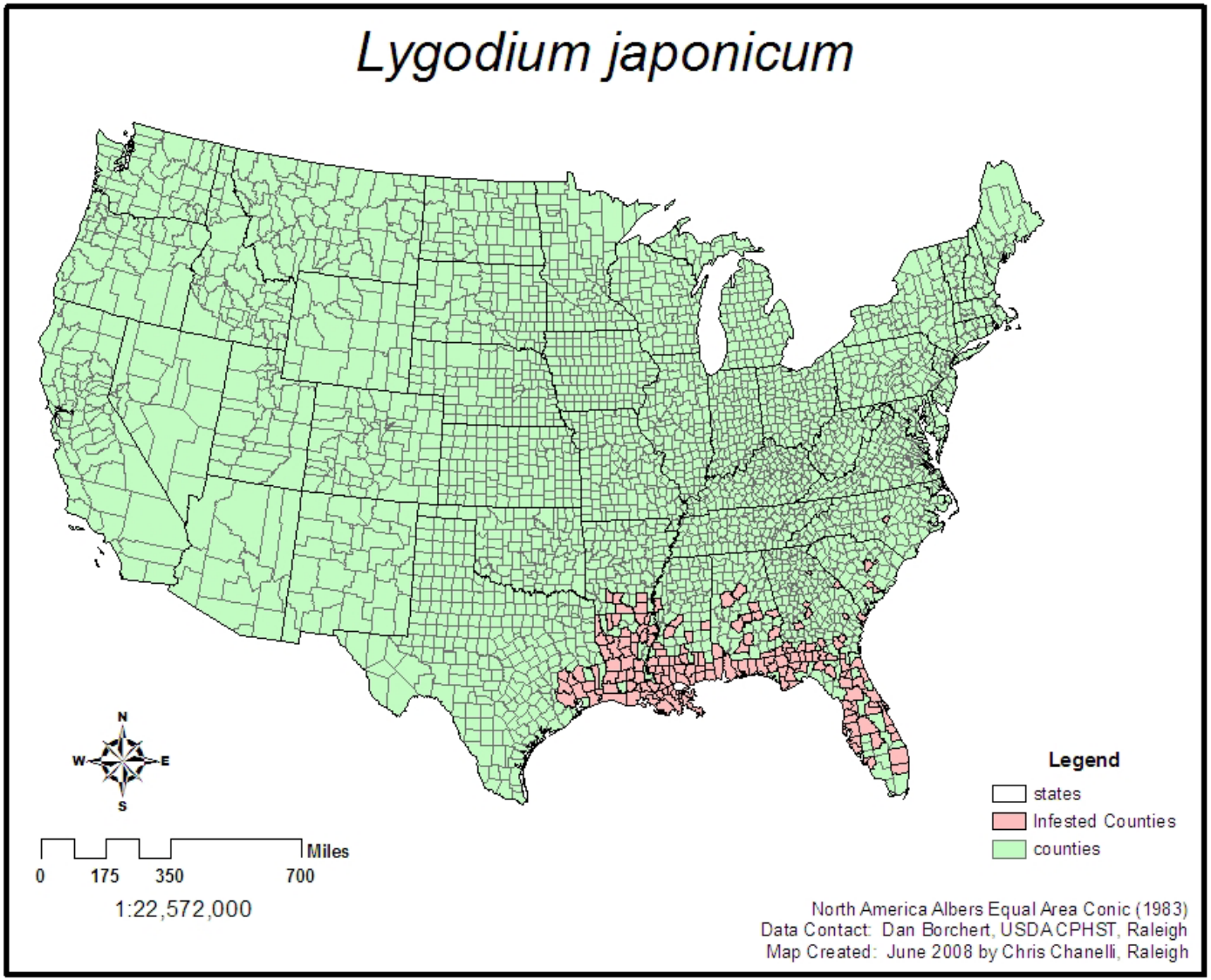


Figure 2. County level distribution of *Lygodium japonicum* in the lower 48 states.
Note, it is also present in Hawaii and Puerto Rico which are not shown.



9. References

7 U.S.C. § 7701-7786. 2000. Plant Protection Act, Title 7 United States Code § 7701-7786.

ADAI. 2008. Alabama Department of Agriculture and Industries: Administrative code. Alabama Department of Agriculture and Industries (ADAI). Last accessed April 28, 2008, http://www.alabamaadministrativecode.state.al.us/docs/agr/.

ALIPC. N.D. Alabama's ten worst invasive weeds. Alabama Invasive Plant Council (ALIPC), AL, U.S.A. 2 pp.

Amoroso, C. B., and V. B. Amoroso. 1998. Spore culture studies on some economic ferns of Mindanao, Philippines [Abstract]. Acta Horticulturae (461):231-235.

Anonymous. 2005. Jatujak weekend market. jj247.com, Bangkok, Thailand. Last accessed June 13, 2008, http://www.jj247.com/jatujak_about.html.

Anonymous. 2008. B & T world seeds, online catalogue. B & T World Seeds Company. Last accessed June 13, 2008, http://www.b-and-t-world-seeds.com/index.htm.

APHIS. 2006. A guide to the listing process for federal noxious weeds. Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine. http://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/listingguide.pdf.

ARS. 2008a. Germplasm Resources Information Network, online database. United States Department of Agriculture, Agricultural Research Service (ARS), National Germplasm Resources Laboratory. http://www.ars-grin.gov/cgi-bin/npgs/html/paper.pl. (Archived at PERAL).

ARS. 2008b. Research project: Natural enemies of weeds which are endemic to Australia and Southeast Asia, and invasive to the U.S.: 2006 annual report: 4d. progress report. Agricultural Research Service (ARS), U.S.A. Last accessed June 13, 2008, http://www.ars.usda.gov/research/projects/projects.htm?ACCN_NO=410266&showpars=true&fy=2006.

Bailey, L. H., and E. Z. Bailey. 1976. Hortus Third: A Concise Dictionary of Plants Cultivated in The United States and Canada (revised and expanded by The Staff of the Liberty Hyde Bailey Hortorium). Macmillan, New York, U.S.A. 1290 pp.

Banks, J. A. 1999. Gametophyte development in ferns. Annual Review of Plant Physiology and Plant Molecular Biology 50:163-186.

Barnard, E. L., and A. N. V. Loan. N.D. An assessment of Fusiform rust and selected non-native invasive pest plants in Longleaf and Slash pine plantations established with Florida Division of Forestry seedlings. Florida Department of Agriculture and Consumer Services, Division of Forestry, FL, U.S.A. 25 pp.

Brandt, L. A., and D. W. Black. 2001. Impacts of the introduced fern, *Lygodium microphyllum*, on the native vegetation of tree islands in the Arthur R. Marshall Loxahatchee National Wildlife Refuge [Abstract]. Florida Scientist 64(3):191-196.

Call, E. M., L. A. Brandt, and D. L. Deangelis. 2007. Old World Climbing Fern (*Lygodium microphyllum*) spore germination in natural substrates. Florida Scientist 70(1):55-61.

Carmichael, B. J., and W. J. Platt. 2007. Fire effects and soil disturbance: Investigating how Japanese climbing fern (*Lygodium japonicum*) responds in longleaf pine savannas. Oral presentation at Some Assembly Required: Preserving Nature in a Fragmented Landscape. Natural Areas Association 34th Annual Conference, Cleveland, Ohio. October 9-12, 2007.

Carter-Finn, K., A. W. Hodges, D. J. Lee, and M. T. Olexa. 2006. Management of *Melaleuca* by professional land managers in South Florida (FE671). Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL, U.S.A. 13 pp.

Clark, R. 2005. Pine straw contamination. Personal communication to D. Gordon on February 1, 2005, from Richard Clark (Florida Department of Agriculture and Consumer Services).

Clarke, T. C., K. G. Shetty, K. Jayachandran, and M. R. Norland. 2007. *Myrothecium verrucaria* - a potential biological control agent for the invasive 'old world climbing fern' (*Lygodium microphyllum*) [Abstract]. Biocontrol 52(3):399-411.

CPC. 2008. *Thalictrum cooleyi*. Center for Plant Conservation (CPC). Last accessed April 30, 2008, http://www.centerforplantconservation.org/asp/CPC_ViewProfile.asp?CPCNum=4264.

CU. 2008. Poisonous Plants Informational Database. Cornell University (CU). Last accessed April 28, 2008, http://www.ansci.cornell.edu/plants/.

Dahlan, I., M. D. Mahyuddin, Y. Yamada, and J. B. Liang. 1988. Voluntary dry-matter intake of grazing cattle under oil palm plantation [Abstract]. Pages 133-138 *in* Maximising livestock productivity. Proceedings of the 11th annual conference, Malaysian Society of Animal Production. Malaysian Society of Animal Production, Serdang, Malaysia.

Dangol, D. R. 2005. Species composition, distribution, life forms and folk nomenclature of forest and common land plants of western Chitwan, Nepal. Journal of the Institute of Agriculture and Animal Sciences 26:93-105.

DavesGarden. 2008. Plant files database. Dave's Garden. http://davesgarden.com/guides/pf/go/1764/. (Archived at PERAL).

DEWR. 2008. Flora of Australia Online. Australian Government, Department of Environment and Water Resources (DEWR). http://www.anbg.gov.au/abrs/online-resources/flora/main-query-styles.html. (Archived at PERAL).

Evans, C., and D. Moorhead. 2005. Georgia EPPC events highlight emerging threats. The University of Georgia and Georgia EPPC. Last accessed May 2, 2008, http://www.gaeppc.org/news/threats.html.

Evans, C. W., C. T. Bargeron, D. J. Moorhead, and G. K. Douce. 2005. Invasive weeds in Georgia: Japanese climbing fern, *Lygodium japonicum* (Thunb. ex Murr.) Sw. The Bugwood Network, The University of Georgia, GA, U.S.A. Last accessed May 2, 2008, http://www.gaeppc.org/weeds/climbingfern.html.

Fay, A. D. A. 1973. A natural *Lygodium* hybrid found in Trinidad. American Fern Journal 63(4):165.

FDEP. N.D. Weed alert: Japanese climbing fern (*Lygodium japonicum*). Florida Department of Environmental Protection (FDEP), Tallahassee, FL, U.S.A. 2 pp.

Ferriter, A. 2001. *Lygodium* management plan for Florida: A report from the Florida Exotic Pest Plant Council's *Lygodium* Task Force (first ed.). Florida Exotic Pest Plant Council, FL, U.S.A. 59 pp.

FFWCC. 2005. Florida's wildlife legacy initiative: Comprehensive wildlife conservation strategy. Florida Fish and Wildlife Conservation Commission (FFWCC), Tallahassee, Florida, U.S.A. 540 pp.

FNA Editorial Committee (ed.). 1993. Flora of North America (FNA, v. 2): Pteridophytes and Gymnosperms. Oxford University Press, New York, U.S.A.

Gardener, M., and M. Marrinan. 2004. Tropical Savannas Fire Response Database North Australian Land Manager. Last accessed June 13, 2008,

http://www.landmanager.org.au/view/327370/directory_of_fire_responses_of_plants_in_the_tropical_savannas_region_of_queensland.html.

Goolsby, J. A., P. J. De Barro, J. R. Makinson, R. W. Pemberton, D. M. Hartley, and D. R. Frohlich. 2006. Matching the origin of an invasive weed for selection of a herbivore haplotype for a biological control programme. Molecular Ecology 15:287-297.

Goolsby, J. A., A. D. Wright, and R. W. Pemberton. 2003. Exploratory surveys in Australia and Asia for natural enemies of Old World climbing fern, *Lygodium microphyllum*: Lygodiaceae. Biological Control 28:33-46.

Gordon, D. R., D. A. Onderdonk, A. M. Fox, and R. K. Stocker. 2008a. Consistent accuracy of the Australian weed risk assessment system across varied geographies. Diversity and Distributions: *Online Early Article*.

Gordon, D. R., D. A. Onderdonk, A. M. Fox, R. K. Stocker, and C. Gantz. 2008b. Predicting invasive plants in Florida using the Australian weed risk assessment. Invasive Plant Science and Management 1:178-195.

Gordon, D. R., and K. P. Thomas. 1997. Florida's invasion by nonindigenous plants: history, screening, and regulation. Pages 21-37 *in* D. Simberloff, D.C. Schmitz, and T.C. Brown, (ed.). Strangers in Paradise. Island Press, Washington, D.C.

Handley, J. 2008. Does *Lygodium* (*microphyllum* and/or *japonicum*) impact your industry? Personal communication to A. L. Koop on May 1, 2008, from Jim Handley (Florida Cattlemen's Association).

Heap, I. 2008. The international survey of herbicide resistant weeds. Weed Science Society of America. www.weedscience.com. (Archived at PERAL).

Holm, L. G., J. V. Pancho, J. P. Herberger, and D. L. Plucknett. 1979. A Geographical Atlas of World Weeds. Krieger Publishing Company, Malabar, Florida, U.S.A. 391 pp.

Hutchinson, J., A. Ferriter, K. Serbesoff-King, K. Langeland, and L. Rodgers. 2006. Old world climbing fern (*Lygodium microphyllum*) management plan for Florida (second edition). Florida Exotic Pest Plant Council, Lygodium Task Force, U.S.A. 115 pp.

Hutchinson, J. T., and K. A. Langeland. 2006. Survey of control measures on old world climbing fern (*Lygodium microphyllum*) in Southern Florida. Florida Scientist 69(4):217-223.

IPPC. 2007. International standards for phytosanitary measures: 1 - 27. International Plant Protection Convention (IPPC) and the Food and Agriculture Organization of the United Nations, Rome.

ISSG. 2008. Global Invasive Species Database. The World Conservation Union (IUCN), Invasive Species Specialist Group (ISSG). Last accessed April 15, 2008, http://www.issg.org/database/welcome/.

Korn, J., L. Temple, C. Texas Forest Service, TX., and W. 2007. Evaluating brush management practices for control of non-native, invasive species: Japanese climbing fern (*Lygodium japonicum*) and Chinese tallow (*Triadica sebifera*) at the W. Goodrich Jones State Forest, Conroe Texas. Oral presentation presented at the Texas Invasive Plant Conference, Lady Bird Johnson Wildflower Center, Austin, Texas. November 14 - 16, 2007.

Lal, N., and S. K. Roy. 1983. Contributions to the reproductive biology of the fern *Lygodium flexuosum* (L) SW. Current Science 52(11):560-562.

Langeland, K. A., and K. C. Burks. 1998. Identification and biology of non-native plants in Florida's natural areas. University of Florida, Gainesville, Florida.

Lehtonen, P. 2008. Florida DEP inquiry on *Lygodium*. Personal communication to K. Layman on April 22, 2008, from Al Tasker (PPQ Weeds Program Manager).

Lim, G., K. Lim, and K. Fook. 2001. New records of alternative host plants for oil palm nettle caterpillar *Setora nitens* Walker in Sabah, Malaysia [Abstract]. Pages 609-611 *in* Cutting-edge technologies for sustained competitiveness: Proceedings of the 2001 PIPOC International Palm Oil Congress, Agriculture Conference, Kuala Lumpur, Malaysia, 20-22 August 2001. Malaysian Palm Oil Board (MPOB), Kuala Lumpur.

Liogier, H. A., and L. F. Martorell. 2000. Flora of Puerto Rico and adjacent islands: a systematic synopsis (2nd ed.). Editorial de la Universidad the Puerto Rico, San Juan, Puerto Rico.

Lott, M. A., and J. C. Volin. 2003. The growth and physiological ecology of two invasive non-indigenous fern species, *Lygodium microphyllum* and *Lygodium japonicum*. Poster presented at the 88th Annual Meeting of The Ecological Society of America held jointly with the International Society for Ecological Modeling - North American Chapter, Savannah, Georgia August 3-8, 2003.

Lott, M. S., J. C. Volin, R. W. Pemberton, and D. E. Austin. 2003. The reproductive biology of the invasive ferns *Lygodium microphyllum* and *L. japonicum* (Schizaeaceae): Implications for invasive potential. American Journal of Botany 90(8): 1144-1152.

Mabberley, D. J. 2008. Mabberley's Plant-Book: A Portable Dictionary of Plants, their Classification and Uses (3rd edition). Cambridge University Press, New York, USA. 1021 pp.

Magarey, R. D., D. M. Borchert, and J. Schlegel. 2008. Global plant hardiness zones for phytosanitary risk analysis. Scientia Agricola [Manuscript in Review].

Masterson, J. 2007. *Lygodium microphyllum* (old world climbing fern). Smithsonian Marine Station. Last accessed March 31, 2008, http://www.sms.si.edu/IRLSpec/Lygodium_microphyllum.htm.

Miller, J. 2007. The Context of the South's Cogongrass Crisis. Pages 6-9 *in* N. J. Loewenstein and J. H. Miller, (eds.). Proceedings of the Regional Cogongrass Conference: A Cogongrass Management Guide: Confronting the Cogongrass Crisis Across the South, Mobile, Alabama.

Miller, J. H. 1995. Exotic plants in southern forests: their nature and control. Herbicide-resistant crops: a bitter or better harvest? Proceedings of the 48th annual meeting of the Southern Weed Science Society, Memphis, Tennessee, USA, 16-18 January 1995:120-126.

Miller, J. H. 2003. Nonnative invasive plants of southern forests (General Technical Report SRS-62). United States Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC, U.S.A. 93 pp.

Moore, W. 2008. Status of *Lygodium microphyllum* in Alabama. Personal communication to A. L. Koop on May 5, 2008, from William Moore (Alabama State Plant Health Director).

Mound, L. A. 2002. *Octothrips lygodii* sp. n. (Thysanoptera: Thripidae) damaging weedy *Lygodium* ferns in south-eastern Asia, with notes on other Thripidae reported from ferns. Australian Journal of Entomology 41:216-220.

Mueller, R. J. 1982. Shoot morphology of the climbing fern *Lygodium* (Schizaeaceae) - general organography, leaf initiation, and branching. Botanical Gazette 143(3):319-330.

Mueller, R. J. 1983. Indeterminate Growth and Ramification of the Climbing Leaves of *Lygodium-Japonicum* (Schizaeaceae). American Journal of Botany 70(5):682-690.

Munger, G. T. 2005. Fire Effects Information System: *Lygodium* spp. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Last accessed May 1, 2008, http://www.fs.fed.us/database/feis/.

Nagid, S. M. 2008. Looking for some specific information on *Lygodium microphyllum* and *L. japonicum*. Personal communication to A. L. Koop on May 5, 2008, from Stefanie M. Nagid (restoration ecologist, Florida Fish and Wildlife Conservation Commission).

Nauman, C. E., and D. F. Austin. 1978. Spread of the exotic fern *Lygodium microphyllum* in Florida. American Fern Journal 68(3):65-66.

NRCS. 2008. The PLANTS Database. United States Department of Agriculture, Natural Resources Conservation Service (NRCS), The National Plant Data Center. http://plants.usda.gov/cgi_bin/. (Archived at PERAL).

NTU. 2008. Flora of Taiwan Database. National Taiwan University (NTU) Herbarium. http://tai2.ntu.edu.tw/fotdv/fotmain.htm. (Archived at PERAL).

Page, S., and M. Olds (eds.). 2001. The Plant Book: The World of Plants in a Single Volume. Mynah, Hong Kong. 1020 pp.

Parker, C., B. P. Caton, and L. Fowler. 2007. Ranking nonindigenous weed species by their potential to invade the United States. Weed Science 55:386-397.

Pemberton, R. W. 2003. Northward range extension in Florida of the invasive fern *Lygodium microphyllum* (Lygodiaceae). SIDA Contributions to Botany 20(4):1759-1761.

Pemberton, R. W., and A. P. Ferriter. 1998. Old World climbing fern (*Lygodium microphyllum*), a dangerous invasive weed in Florida. American Fern Journal 88(4):165-175.

PERAL. 2008. Plant hardiness zones area and population analysis. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Center for Plant Health Science and Technology, Plant Epidemiology and Risk Analysis Laboratory (PERAL), Raleigh, U.S.A. 7 pp.

Pheloung, P. C., P. A. Williams, and S. R. Halloy. 1999. A Weed Risk Assessment Model for Use as a Biosecurity Tool Evaluating Plant Introductions. Journal of Environmental Management 57:239-251.

PIC. 2008. Weeds, pests and diseases. Paraquat Information Center (PIC). Last accessed April 12, 2008, http://www.paraquat.com/Default.aspx?tabid=968.

Rajkhowa, D. J., I. C. Barua, R. P. Bhuyan, and N. T. Yaduraju. 2005. Weed management in tea. National Research Centre for Weed Science, Jabalpur, India. 25 pp.

Randall, J. M. 2007. The introduced flora of Australia and its weed status. CRC for Australian Weed Management, Department of Agriculture and Food, Western Australia, Australia. 528 pp.

Randall, R. P. 2008. A Global Compendium of Weeds. Department of Agriculture of Western Australia. http://www.hear.org/gcw/. (Archived at PERAL).

Richardson, D. M., P. Pysek, M. Rejmanek, M. G. Barbour, F. D. Panetta, and C. J. West. 2000. Naturalization and invasion of alien plants: Concepts and definitions. Diversity and Distributions 6:93-107.

Ricketts, T. H., E. Dinerstein, D. M. Olson, C. J. Loucks, W. Elchbaum, D. DellaSala, K. Kavanagh, P. Hedao, P. T. Hurley, K. M. Carney, R. Abell, and S. Walters. 1999. Terrestrial Ecoregions of North America. Island Press, Washington D.C. 485 pp.

Roder, W., S. Phengchanh, B. Keoboualapha, and S. Maniphone. 1995a. *Chromolaena odorata* in slash-and-burn rice systems of Northern Laos. Agroforestry Systems 31:79-92.

Roder, W., S. Phengchanh, and B. Keoboulapha. 1995b. Relationships between soil, fallow period, weeds and rice yield in slash-and-burn systems of Laos. Plant and Soil 176(1):27-36.

Roder, W., S. Phengchanh, and B. Keobulapha. 1997. Weeds in slash-and-burn rice fields in northern Laos. Weed Science 37:111-119.

Rowe, R. 2008. Looking for some specific information on *Lygodium microphyllum* and *L. japonicum*. Personal communication to A. L. Koop on April 30, 2008, from Rosalind Rowe (Central Florida Invasive Plant Coordinator, The Nature Conservancy).

Schmitz, D. C. 2007. Florida's invasive plant research: Historical perspective and the present research program [Abstract]. Natural Areas Journal 27(3):251-253.

SFD. 2008. Fern Databank, online database. Sabah Forestry Department. http://www.forest.sabah.gov.my/default.asp. (Archived at PERAL).

Skinner, M. 2008. Can you tell me more about a certain record for *Lygodium japonicum*? Personal communication to A. L. Koop on May 2, 2008, from Mark Skinner (USDA, National Plant Data Center, botanist).

Sole, M. W. 2008. Request to list the genus *Lygodium* as a Federal Noxious Weed. Personal communication to D. Kaplan and A. Green on April 25, 2008, from Michael Sole (Florida Department of Environmental Protection).

Solis, M. A., U. Chattrukul, A. Winotai, S. Rimbut, A. Thagong, J. H. Goolsby, S. H. Yen, R. Pemberton, and T. Wright. 2005. *Siamusotima aranea*, a new stem-boring musotimine (Lepidoptera: Crambidae) from Thailand feeding on *Lygodium flexuosum* (Schizaeaceae). Annals of the Entomological Society of America 98(6):887-895.

Soxman, G. M. 1939. *Lygodium japonicum* in Texas. American Fern Journal 29(3):111-111.

Stanturf, J. A., W. H. Conner, E. S. Gardiner, C. J. Schweitzer, and A. W. Ezell. 2004. Recognizing and overcoming difficult site conditions for afforestation of bottomland hardwoods. Ecological Restoration 22(3):183-193.

Tasker, A. 2008. Adhoc project status of three weeds. Personal communication to A. L. Koop on April 18, 2008, from Al Tasker, PPQ National Weeds program manager.

Trivedi, B. S., and U. Kher. 1976. Ultrastructure of flagella of spermatozoids of *Lygodium flexuosum* (L.) SW. Current Science 45(9):317.

USDA-FS. 2007. The national forests and grasslands in Texas: Non-native invasive plant species project: Environmental assessment. United States Department of Agriculture (USDA), Forest Service (FS), Washington D.C. 70+ pp.

USDA. 2004. Weed-initiated pest risk assessment guidelines for qualitative assessments (v. 5.3). United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service. Last accessed June 8, 2004, http://www.aphis.usda.gov/ppq/weeds/weedsrisk99.html.

USFWS. 2006. National survey of fishing, hunting, and wildlife-associated recreation. United States Department of the Interior (DOI), U.S. Fish and Wildlife Service (USFWS), and U.S. Department of Commerce, U.S. Census Bureau. 168 pp.

Volin, J. C., M. S. Lott, J. D. Muss, and D. Owen. 2004. Predicting rapid invasion of the Florida Everglades by old world climbing fern (*Lygodium microphyllum*). Diversity and Distributions 10(5-6):439-446.

Wahab, H. A. 2001. Forages in oil palm and rubber plantations in Malaysia. S. G. Reynolds, (ed.). 7th Meeting of the Regional Working Group on Grazing and Feed Resources: Forage Development in Southeast Asia: Strategies and Impacts, Manado, Indonesia.

Weber, E. 2003. Invasive Plant Species of the World: A Reference Guide to Environmental Weeds. CABI Publishing, Wallingford, UK. 548 pp.

Wiersema, J. H., and B. Leon. 1999. World economic plants: A standard reference. CRC Press, Boca Raton, Florida, USA. 749 pp.

Wilson, K. A. 2002. Continued pteridophyte invasion of Hawaii. American Fern Journal 92(2):179-183.

Wu, Y. G., K. Rutchey, N. M. Wang, and J. Godin. 2006. The spatial pattern and dispersion of *Lygodium microphyllum* in the Everglades wetland ecosystem. Biological Invasions 8(7):1483-1493.

Wunderlin, R. P., and P. F. Hansen. 2008. Atlas of Florida Vascular Plants. University of South Florida, Department of Biology, Institute for Systematic Botany. http://www.plantatlas.usf.edu/browse.asp. (Archived at PERAL).

Appendix A.

Weed risk assessment of *Lygodium microphyllum* and *L. japonicum.* Note: The Plant Epidemiology and Risk Analysis Laboratory of APHIS is currently revising its weed risk assessment process. Many of the questions used below come from or have been adapted from the Australian weed risk assessment system (Pheloung et al., 1999) which has been tested over a wide range of geographies (e.g., Gordon et al., 2008a). Most of the remaining questions originated from the current USDA weed risk assessment system (USDA, 2004), and the IPPC's standard for pest risk assessment (IPPC, 2007; ISPM #11). Both *Lygodium* spp. were analyzed using this new approach. For each species, the result or letter response is shown, the associated score for that result, and the corresponding uncertainty level associated with the response. Generally, an uncertainty level of negligible is appropriate when there can be no doubt from the literature or when the question was answered by an expert. In contrast, high uncertainty corresponds to questions where the evidence is unclear or unavailable. Levels of low and moderate uncertainty fall in between. The score for each of the four risk elements were summed and summarized in Table 1.

Question	***Lygodium microphyllum***				***Lygodium japonicum***			
	Result/Score/ Uncertainty			**References & Notes**	**Result/Score/ Uncertainty**			**References & Notes**
Establishment/Spread Potential								
1. Select one: (A) Introduced elsewhere long ago (>75 years) but not escaped (-4 pts); (B) Introduced recently (<75 years) but not escaped (-2); (C) Never introduced elsewhere (0); (D) Escaped/Casual (1); (E) Naturalized (2); (F) Invasive (4).	f	4	negl	Naturalized in Jamaica and Guyana (Pemberton and Ferriter, 1998); however, in Florida, it is an invasive that has rapidly spread across the peninsula over the last few decades (Hutchinson et al., 2006; Pemberton and Ferriter, 1998).	f	4	negl	Naturalized in Puerto Rico (Liogier and Martorell, 2000) and Australia (Randall, 2007). Invasive in the southeastern United States (Ferriter, 2001) and in Hawaii (Wilson, 2002).
2. Is the species highly domesticated? (y=-3; n=0, ?=_)	n	0	mod	There is no evidence that this species has been domesticated.	n	0	mod	Used as an ornamental (DavesGarden, 2008), but no evidence of domestication and reduced invasiveness.
3. Adaptive potential. (A) Individual plants demonstrated to be phenotypically plastic/variable when exposed to different environmental conditions (2); (B) Populations exhibit phenotypic or	a	2	mod	One report states that it is phenotypically plastic (Hutchinson et al., 2006). Also, in Florida, "it is common in bald cypress stands, but also infests pine flatwoods, wet prairies, saw	c	1	mod	Tolerates sun to shade (FDEP, N.D.). From habitat descriptions, it appears to invade moist to mesic uplands (Ferriter, 2001).

Question	*Lygodium microphyllum*			*Lygodium japonicum*			
	Result/Score/ Uncertainty		**References & Notes**	**Result/Score/ Uncertainty**			**References & Notes**
genetic variation (among population variation) (1); (C) Plants reported to grow in diverse habitats or across a wide/broad range of environmental gradients (e.g., wet to dry, nutrient poor to rich, sun to shade, fresh to salt, hot to cold, etc.) (1); (D) Plants are not known to be variable or genetically diverse, or plants are restricted to a narrow environmental range (-1); (E) Unknown (0 pts).			grass marshes, mangrove communities, Everglades tree islands, and disturbed areas" (Pemberton and Ferriter, 1998).				
4. **[Answer only if question 1 is A, B, or C].** Consider invasive/weed status of congeners. (A) Plant has no invasive/weedy congeners (0 pts); (B) Plant has a few (1-4) invasive/weedy congeners (1); (C) Plant has many (5 or more) invasive/weedy congeners (2).	N/A			N/A			
5. Propagule pressure. Is the species widely cultivated/popular/useful such that its introduction and cultivation will increase establishment? (y=1, n=0, ?=_)	n	0	low	Although this species was once cultivated in North America (Bailey and Bailey, 1976), there is no evidence suggesting it is still cultivated.	n	0	mod	Only three nurseries listed under Plant Information online, one under Plant Find, and one under Dave's Garden.
6. Shade tolerant at some stage of life cycle? (y=1, n=0, ?=_)	y	1	negl	Shade tolerance is believed to be one of the main reasons it is invasive in Florida (Volin et al., 2004).	y	1	low	Tolerates shade (FDEP, N.D.).

Question	*Lygodium microphyllum*				*Lygodium japonicum*			
	Result/Score/ Uncertainty			References & Notes	Result/Score/ Uncertainty			References & Notes
7. Climbing or smothering growth habit? (y=1, n=0, ?=_)	y	1	negl	(Pemberton and Ferriter, 1998)	y	1	negl	Plant is a vine (Langeland and Burks, 1998; Mueller, 1983).
8. Aquatic? (y=5, n=0, ?=_)	n	0	low	Terrestrial (FNA Editorial Committee, 1993).	n	0	low	Terrestrial (Langeland and Burks, 1998).
9. Grass? (y=1, n=0)	n	0	negl	Plant is a fern (NRCS, 2008).	n	0	negl	Not a grass (FNA Editorial Committee, 1993).
10. Nitrogen-fixing woody plant? (y=1, n=0, ?=_)	n	0	mod	No evidence.	n	0	mod	No evidence.
11. Geophyte (herbaceous with underground storage organs)? (y=1, n=0, ?=_).	y	1	low	Plants with rhizomes (Miller, 2003).	y	1	low	Plants with rhizomes (Hutchinson et al., 2006).
12. Produces viable seed or spores? (y=1, ?=0, n=-1)	y	1	negl	(Call et al., 2007)	y	1	low	Plants reproduce sexually via spores (Ferriter, 2001).
13. Self-compatible or apomictic? (y=1, ?=0, n=-1)	y	1	negl	(Lott et al., 2003)	y	1	negl	Experiences intragametophytic selfing (Lott et al., 2003)
14. Requires specialist pollinators? (y=-1, n=0, ?=_)	n	0	negl	Plant is a fern; does not use pollinators (Lott et al., 2003).	n	0	negl	Plant is a fern; does not use pollinators (Lott et al., 2003)
15. Unpalatable to grazing animals? (y=1, ?=0, n=-1)	?	0	high	While one study reports cattle eating an unknown *Lygodium* species, this study is insufficient to determine the overall palatability of *Lygodium* (Dahlan et al., 1988).	?	0	high	While one study reports cattle eating an unknown *Lygodium* species, this study is insufficient to determine the overall palatability of *Lygodium* (Dahlan et al., 1988).
16. Reproduction by vegetative fragmentation? (y=1, ?=0, n=-1)	y	1	low	Produces a short-creeping rhizome (Weber, 2003).	y	1	low	Produces a short-creeping rhizome (Weber, 2003).
17. Minimum generative time (A) 1 year or less (1 pt), (B) 2 or 3 years (0), (C) >3 years (-1pt); Unknown (?)=_.	b	0	mod	The gametophytic generation becomes sexually mature in about 5 weeks (Lott et al., 2003). Plants produce spores in 2-5 years	?		high	Unknown. No data available.

Question	*Lygodium microphyllum*				*Lygodium japonicum*			
	Result/Score/ Uncertainty			References & Notes	Result/Score/ Uncertainty			References & Notes
				(Gardener and Marrinan, 2004)				
18. Evidence that a persistent propagule bank (e.g., seed bank) is formed (>1yr)? (y=1, ?=0, n=-1)	y	1	mod	*Lygodium* spp. spores can remain viable for years (Hutchinson et al., 2006).	y	1	mod	*Lygodium* spp. spores can remain viable for years (Hutchinson et al., 2006). "Spores of the *Lygodium* genus have very thick walls, giving these propagules long environmental viability" (Ferriter, 2001).
19. Well controlled by herbicides or other cultural / management techniques? (y=-1, ?=0, n=1)	n	1	mod	"Many herbicides have activity against Old World climbing fern, however results are inconsistent. Herbicide performance can be affected by variables such as weather conditions, site conditions, application technique, etc" (Hutchinson et al., 2006).	n	1	mod	Although various herbicides show activity against *L. japonicum*, long-term control is very variable, and overall success is inconsistent. "All Garlon 3A, Garlon 4, and Pathfinder II plots had almost 100 percent regrowth within 8 months. The Rodeo plot had approximately 5 percent regrowth *of L. japonicum* and growth of native species" (Ferriter, 2001).
20. Tolerates/benefits from mutilation, cultivation, or fire? (y=1, ?=0, n=-1)	y	1	low	Plant tolerates fires, returning to pre-burn coverage within two years (Hutchinson et al., 2006). Furthermore, fire may help to spread spores (Hutchinson and Langeland, 2006).	y	1	mod	Anecdotal comments and observations suggest that it tolerates fire (Munger, 2005).
21. Is resistant to some herbicides	n	0	low	No *Lygodium* species is listed as	n	0	low	No *Lygodium* species is listed

Question	*Lygodium microphyllum*				*Lygodium japonicum*			
	Result/Score/ Uncertainty			**References & Notes**	**Result/Score/ Uncertainty**			**References & Notes**
or has potential to acquire herbicide resistance (e.g., related to genetically modified crop it can outcross to, congener of weeds which have developed herbicide resistance)? (y=1, n=0, ?=_)				having developed herbicide resistance (Heap, 2008).				as having developed herbicide resistance (Heap, 2008).
22. Hybridizes naturally? (y=1, ?=0, n=-1)	n	-1	low	There doesn't appear to be any evidence of this species hybridizing. A quick search showed only one hybridization event in *Lygodium* (Fay, 1973).	n	-1	low	There doesn't appear to be any evidence of this species hybridizing. A quick search showed only one hybridization event in *Lygodium* (Fay, 1973).
23. Propagules likely to be dispersed unintentionally by people? (y=1, ?=0, n=-1)	y	1	low	Control operators may disperse from site to site, but this may be an insignificant risk compared to the plant's natural capacity to spread (Hutchinson et al., 2006).	y	1	low	Contaminates pine-straw and equipment (Ferriter, 2001; Miller, 2007). Spores contaminate clothing (ISSG, 2008).
24. Propagules dispersed intentionally by people? (y=1, ?=0, n=-1)	y	1	low	Even though it does not appear to be cultivated still, as an ornamental species it is likely to be dispersed intentionally by some (Bailey and Bailey, 1976).	y	1	negl	Imported in the 1880s as an ornamental (Pemberton and Ferriter, 1998) and currently featured in gardening books (Bailey and Bailey, 1976; Page and Olds, 2001). This species is still cultivated, grown and sold (DavesGarden, 2008).
25. Propagules adapted for either wind, water, or animal (internal or external) dispersal? (y=1, ?=0, n=-1)	y	1	negl	Wind-dispersed (Wu et al., 2006).	y	1	negl	Spores are wind-dispersed (Miller, 2007). Spores cling to animal fur (ISSG, 2008).
26. Prolific seed/spore production	y	1	negl	As a fern, this question gets an	y	1	low	As a fern, this question gets an

Question	*Lygodium microphyllum*				*Lygodium japonicum*			
	Result/Score/ Uncertainty			References & Notes	Result/Score/ Uncertainty			References & Notes
(see scoring guide)? (y=1, ?=0, n=-1)				automatic yes. But one study estimated about 15,000 spores per square cm of fertile pinnae (Volin et al., 2004).				automatic yes. One study estimated bout 15,000 spores per square cm of fertile pinnae on *L. microphyllum* (Volin et al., 2004); thus, *L. japonicum* is probably very similar.
Impact Potential								
27. Is there evidence or strong reason to believe it impacts ecosystem processes and system-wide parameters that affect other species (e.g., changes fire regime, nutrient cycling, water availability, community light levels, etc.)? (y=0.2, n=0)	y	0.2	low	Changes fire regime and community light levels (Hutchinson et al., 2006).	y	0.2	low	Forms sun-blocking walls (Langeland and Burks, 1998). Alters fire regime (Ferriter, 2001).
28. Does it change community structure by creating, modifying, or eliminating vegetation layers? (y=0.2, n=0)	y	0.2	low	Creates an impermeable mat over all vegetation, including the canopy (Brandt and Black, 2001).	y	0.2	low	Can form large vine mats in native range (Ferriter, 2001). Covers native plants in Florida (ALIPC, N.D.; Langeland and Burks, 1998).
29. Does the invasive/weedy taxon change community composition by reducing or eliminating native species or promoting other invasive species? (y=0.2, n=0)	y	0.2	low	Reduces native species abundance (Brandt and Black, 2001; Pemberton, 2003).	y	0.2	low	Smothers and displaces native species (ALIPC, N.D.; Langeland and Burks, 1998).
30. Does it impact or is it likely to impact any particular native plant species significantly more so than others (e.g., through competition,	y	0.1	high	*L. microphyllum* is a host for *Octothrips lygodii*, which thus far appears to only affect *Lygodium* hosts (Mound, 2002). *L.*	y	0.1	high	*L. japonicum* is a host for *Octothrips lygodii*, which thus far appears to only affect *Lygodium* hosts (Mound,

Question	*Lygodium microphyllum*				*Lygodium japonicum*			
	Result/Score/ Uncertainty			**References & Notes**	**Result/Score/ Uncertainty**			**References & Notes**
parasitism, hybridization, or alternate host for pest or disease)? (y=0.1, n=0)				*microphyllum* in the U.S. may provide a pathway for the entry and establishment of the thrips, which could impact the native *L. palmatum*.				2002). *L. japonicum* in the U.S. may provide a pathway for the entry and establishment of the thrips, which could impact the native *L. palmatum*.
31. Consider the potential distribution of the invasive plant in the United States and the potential habitats it may invade. Is it likely to affect any federal Threatened and Endangered plant species? (y=0.1, n=0)	y	0.1	low	*Cucurbita okeechobeensis* (Hutchinson et al., 2006).	y	0.1	mod	Is a threat to at least three Florida T&E species (Ferriter, 2001). It may also threaten U.S.-listed Threatened and Endangered species such as *Thalictrum cooleyi,* which occurs in similar mesic habitats as *Lygodium* (CPC, 2008)
32. Consider the potential distribution of the invasive plant in the United States and the potential habitats it may invade. Is it likely to affect any globally outstanding ecoregions as defined by Ricketts et al. (1999)? (y=0.1, n=0)	y	0.1	low	It has invaded southern and central Florida (Hutchinson et al., 2006).	y	0.1	low	It has invaded the southeastern United States (NRCS, 2008), which contain several globally outstanding ecoregions (Ricketts et al., 1999).
33. Allelopathic? (y=0.1, n=0)	n	0	mod	There is no evidence that it is allelopathic.	n	0	mod	There is no evidence that it is allelopathic.
34. Is this plant directly targeted/controlled by managers in conservation areas? (y=0.2, n=0)	y	0.2	negl	(Hutchinson et al., 2006)	y	0.2	negl	(Ferriter, 2001)
35. Produces a human allergen or toxin, or is otherwise physically harmful? (y=0.1, n=0)	n	0	mod	No evidence.	n	0	mod	No evidence.
36. Produces spines, thorns, burrs,	n	0	mod	No evidence.	n	0	mod	No evidence.

Question	*Lygodium microphyllum*				*Lygodium japonicum*			
	Result/Score/ Uncertainty			References & Notes	Result/Score/ Uncertainty			References & Notes
or other undesirable trait (e.g., foul smell, stains property)? (y=0.1, n=0)								
37. Does it hinder or otherwise affect processes and aspects generally deemed important for human civilization or safety (e.g., vines on power lines, shrubs or trees on utility right-of-ways, growth in urban structures, destabilizes coastal dunes)? (y=0.1, n=0)	y	0.1	mod	It is being managed and cleared on a major highway in Florida (Florida Turnpike) (Hutchinson et al., 2006).	y	0.1	mod	"*Lygodium* [*japonicum*] then occurred in about 10 locations along the park drive and in an equal number of locations along powerline rights-of-way" (Ferriter, 2001). Moderate uncertainty because there was no mention of degree of impact.
38. Changes or limits recreational use of an area (e.g., hinders navigation in bodies of water, hunting/fishing, impedes scenic vistas)? (y=0.1, n=0)	y	0.1	mod	May impact hunting leases on private lands (Handley, 2008; Rowe, 2008). "*Lygodium* poses an unknown economic threat to the tourism industry through its degradation of natural resources in Florida's parks and recreation areas" (Ferriter, 2001).	y	0.1	low	"Access to lands is denied" (ALIPC, N.D.). May impact hunting leases on private lands (Handley, 2008; Rowe, 2008). "Lygodium poses an unknown economic threat to the tourism industry through its degradation of natural resources in Florida's parks and recreation areas" (Ferriter, 2001).
39. Outcompetes, replaces or otherwise affects desirable plants and vegetation (e.g., gardens, lawns, street trees)? (y=0.1, n=0)	n	0	mod	No evidence.	y	0.1	high	"In 2000, plants were found in Kaneohe, volunteering in gardens among cultivated and native plants" (Wilson, 2002). High uncertainty because there is no real evidence that it impacts these features.

Question	*Lygodium microphyllum*				*Lygodium japonicum*			
	Result/Score/ Uncertainty			References & Notes	Result/Score/ Uncertainty			References & Notes
40. Is this plant widely targeted/controlled by citizens or other groups or agencies in urban/suburban areas? (y=0.1, n=0)	y	0.1	mod	Along major highways in Florida (Hutchinson et al., 2006).	n	0	mod	No evidence.
41. Reduces crop/product yield (e.g., by parasitism, competition, or by harboring other pests)? (y=0.2, n=0)	n	0	mod	No evidence.	y	0.2	mod	"*L. japonicum* poses a serious economic risk to pine plantations through its spread and intensification of fire" (Ferriter, 2001). "Scattered in open timber stands and plantations, but can increase in cover to form mats, smothering shrubs and trees." (Miller, 2003). Present in timber stands (Barnard and Loan, N.D.).
42. Lowers commodity value (e.g., by increasing costs of production, lowering market prices, or other)? (y=0.2, n=0)	y	0.2	mod	*L. microphyllum* grows in wet ditches along orchards (e.g., citrus); it can grow over and onto the trees, thereby requiring treatment (Nagid, 2008).	y	0.2	low	Treatment of *L. japonicum* in pine plantations will increase control costs, particularly to avoid contaminated pine straw (Nagid, 2008). There is a movement to certify plantations that are *Lygodium* free (FFWCC, 2005).
43. Results in a loss of markets (foreign or domestic) due to the presence of a new quarantine pest? (y=0.2, n=0)	y	0.2	mod	*L. microphyllum* is a state noxious weed in Alabama where it is regulated, including in nursery stock and hay (ADAI, 2008).	y	0.2	low	Regulated in Florida and Alabama (NRCS, 2008). Because it contaminates pine-straw bales (Ferriter, 2001), it may result in a loss of domestic and or foreign markets, or at least requirement of risk

Question	*Lygodium microphyllum*				*Lygodium japonicum*			
	Result/Score/ Uncertainty			**References & Notes**	**Result/Score/ Uncertainty**			**References & Notes**
								management programs (e.g. Clark, 2005).
44. Reduces the quality or availability of irrigation, or strongly competes with plants for water? (y=0.1, n=0).	n	0	mod	No evidence.	n	0	mod	No evidence.
45. Toxic to animals, including livestock/range animals and poultry (y=0.1, n=0)?	n	0	mod	No evidence (CU, 2008).	n	0	mod	No evidence (CU, 2008).
46. Host for recognized pests and pathogens? (y=0.1, n=0, ?=_)	?		high	Unknown.	?		high	Unknown.
47. Parasitic? (y=0.1, n=0)	n	0	low	Not described as a parasitic plant (FNA Editorial Committee, 1993).	n	0	low	Not described as a parasitic plant (FNA Editorial Committee, 1993).
48. Is this plant directly controlled or managed in some fashion in any production system (e.g., agriculture, forestry, horticulture, aquaculture, etc.)? (y=0.2, n=0)	y	0.2	mod	See Table 4: "Land area infested with and treated for invasive species by professional managers" (Carter-Finn et al., 2006). Assigning moderate uncertainty because the reference was not directly about *Lygodium*.	y	0.2	mod	"Foresters in north central Florida report that neither prescribed burns nor application of herbicide containing the active ingredient 2,4-D, or combinations, were effective for controlling it in pine plantations" (Ferriter, 2001). Assigned moderate uncertainty, because it doesn't appear to be a problem all the time, at least during dry springs (Ferriter, 2001).
Entry Potential								
49. Plant already here? (y=1, n=0).	y	1	negl	(Wunderlin and Hansen, 2008)	y	1	negl	(Miller, 1995)

Question	*Lygodium microphyllum*		*Lygodium japonicum*	
	Result/Score/ Uncertainty	**References & Notes**	**Result/Score/ Uncertainty**	**References & Notes**
STOP IF YES				
50. Plant proposed for entry, or entry is imminent? (y=1, n=0) **STOP IF YES**	N/A		N/A	
51. Plant under cultivation or sold/traded elsewhere? (y=0.25, n=0) **[Skip #54 if yes. Skip #53 if no.]**	N/A		N/A	
52. Plant currently marketed on the internet or traded by growers elsewhere? (enter 2 for yes, or 1 for no)	N/A		N/A	
53. Plant not under cultivation but deemed important? (y=0.05, n=0)	N/A	Used in its native range (Hutchinson et al., 2006).	N/A	
54. Natural dispersal? (y=.05, n=0)	N/A		N/A	
55. Plant present in Canada, Mexico, Central America, the Caribbean or China? Note doubles likelihood of all contaminating pathways (enter 2 for yes, or 1 for no)	N/A	(Hutchinson et al., 2006)	N/A	
56. Q56 (contaminants of fruits and vegetables for consumption)? (y=0.01, n=0)	N/A		N/A	
57. Q37 (contaminants in plants for planting, including aquarium plants and products)? (y=0.04, n=0)	N/A		N/A	

Question	*Lygodium microphyllum*			*Lygodium japonicum*			
	Result/Score/ Uncertainty		**References & Notes**	**Result/Score/ Uncertainty**			**References & Notes**
58. Bird seed, or seeds for planting (contaminants in grain, flower seed packets, etc.)? (y=0.04, n=0)	N/A			N/A			
59. Ballast water? (y=0.03, n=0)	N/A			N/A			
60. Military vehicles or other equipment? (y=0.02, n=0)	N/A			N/A			
61. Imported landscape products (e.g., pine-straw, hydro mulch, etc.) (y=0.02, n=0)?	N/A			N/A			
62. Other (specify) (A) 0.01, (B) 0.02, (C) 0.03, (D) 0.04	N/A			N/A			
Geographic Potential (USDA Plant Hardiness Zones)[3]							
Zone 1 (0.056)	n	0	low	n	0	low	
Zone 2 (0.037)	n	0	low	n	0	low	
Zone 3 (0.058)	n	0	low	n	0	low	
Zone 4 (0.129)	n	0	low	n	0	low	
Zone 5 (0.133)	n	0	low	n	0	mod	
Zone 6 (0.192)	n	0	low	n	0	high	Korea (ARS, 2008a). Gardeners in Zone 6 are recommended to mulch after first frost (Ferriter, 2001). Because it may be unlikely to survive without human assistance, answering no, but with high uncertainty.

[3] Numbers in parentheses represent the proportion of the United States (lower 48 states, Alaska, Hawaii, and Puerto Rico) in that plant hardiness zone. All numbers sum to 1.

Question	*Lygodium microphyllum*				*Lygodium japonicum*			
	Result/Score/ Uncertainty			References & Notes	Result/Score/ Uncertainty			References & Notes
Zone 7 (0.152)	n	0	low		y	0.152	mod	Korea (ARS, 2008a). Reported to be in Korea (ARS, 2008a), but no documentation in which location. Zone 7 is the warmest zone in Korea (Magarey et al., 2008).
Zone 8 (0.143)	n	0	low		y	0.143	low	Western Japan (ARS, 2008a); southern Arkansas (NRCS, 2008); (DavesGarden, 2008)
Zone 9 (0.089)	y	0.089	mod	South Africa, China (ARS, 2008a). Orlando, Florida (Pemberton, 2003)	y	0.089	low	Taiwan (NTU, 2008); (DavesGarden, 2008)
Zone 10 (0.009)	y	0.009	low	Angola, Mozambique, Zambia, Zimbabwe, China, Florida (ARS, 2008a)	y	0.009	low	Taiwan (NTU, 2008); (DavesGarden, 2008)
Zone 11 (0.001)	y	0.001	low	Angola, Mozambique, Zambia, Zimbabwe, Florida (ARS, 2008a)	y	0.001	low	Taiwan (NTU, 2008); (DavesGarden, 2008)
Zone 12 (0.0003)	y	0.0003	low	Australia, Tanzania (ARS, 2008a)	y	0.0003	low	Hawaii (Wilson, 2002); Malaysia, Papua New Guinea (ARS, 2008a)
Zone 13 (0.0004)	y	0.0004	mod	Kenya, Uganda (ARS, 2008a)	y	0.0004	low	Hawaii (Wilson, 2002); Malaysia, Papua New Guinea (ARS, 2008a)

Appendix B.

Weed risk assessment of *Lygodium flexuosum.* See Appendix A table heading for additional information.

Question	***Lygodium flexuosum***			
	Result/Score/ Uncertainty			**References & Notes**
Establishment/Spread Potential				
1. Select one: (A) Introduced elsewhere long ago (>75 years) but not escaped (-4 pts); (B) Introduced recently (<75 years) but not escaped (-2); (C) Never introduced elsewhere (0); (D) Escaped/Casual (1); (E) Naturalized (2); (F) Invasive (4).	c	0	mod	No evidence that it has been moved outside of its naturalized range, other than for research under quarantine conditions (ARS, 2008b).
2. Is the species highly domesticated? (y=-3; n=0, ?=_)	n	0	mod	No evidence.
3. Adaptive potential. (A) Individual plants demonstrated to be phenotypically plastic/variable when exposed to different environmental conditions (2); (B) Populations exhibit phenotypic or genetic variation (among population variation) (1); (C) Plants reported to grow in diverse habitats or across a wide/broad range of environmental gradients (e.g., wet to dry, nutrient poor to rich, sun to shade, fresh to salt, hot to cold, etc.) (1); (D) Plants are not known to be variable or genetically diverse, or plants are restricted to a narrow environmental range (-1); (E) Unknown (0 pts).	c	1	low	"Climbs trees and scrambles in open places in rainforest and on cliffs and banks" (DEWR, 2008). Grows in deciduous forests and mixed forests (SFD, 2008).
4. **[Answer only if question 1 is A, B, or C].** Consider invasive/weed status of congeners. (A) Plant has no invasive/weedy congeners (0 pts); (B) Plant has a few (1-4) invasive/weedy congeners (1); (C) Plant has many (5 or more) invasive/weedy congeners (2).	b	1	negl	*Lygodium japonicum* and *L. microphyllum* are invasive weeds in the United States (Ferriter, 2001). *L. circinnatum* and *L. polymorphum* are considered weeds by others (Holm et al., 1979; Randall, 2008), but evidence is less clear.
5. Propagule pressure. Is the species widely cultivated/popular/useful such that its introduction and cultivation will increase establishment? (y=1, n=0, ?=_)	n	0	low	No nurseries appear to currently carry it (query: Plant Find and Plant Information Online). Basic horticultural information unavailable (query: Dave's Garden).
6. Shade tolerant at some stage of life cycle? (y=1, n=0, ?=_)	y	1	low	Requires partial to full shade (DavesGarden, 2008). Found in mature shaded areas in plantations (PIC, 2008).
7. Climbing or smothering growth habit? (y=1, n=0, ?=_)	y	1	negl	(DEWR, 2008)

Question	*Lygodium flexuosum*			
	Result/Score/ Uncertainty			References & Notes
8. Aquatic? (y=5, n=0, ?=_)	n	0	negl	(DEWR, 2008)
9. Grass? (y=1, n=0)	n	0	negl	Plant is a terrestrial fern.
10. Nitrogen-fixing woody plant? (y=1, n=0, ?=_)	n	0	mod	No evidence that it fixes nitrogen.
11. Geophyte (herbaceous with underground storage organs)? (y=1, n=0, ?=_).	y	1	low	The genus *Lygodium* produces rhizomes (Mueller, 1982).
12. Produces viable seed or spores? (y=1, ?=0, n=-1)	y	1	negl	Spores have a high rate of germination (94%-95%) (Amoroso and Amoroso, 1998).
13. Self-compatible or apomictic? (y=1, ?=0, n=-1)	y	1	low	Capable of intragametophytic selfing (Lal and Roy, 1983).
14. Requires specialist pollinators? (y=-1, n=0, ?=_)	n	0	negl	Plant is a fern.
15. Unpalatable to grazing animals? (y=1, ?=0, n=-1)	?	0	high	In oil and rubber plantations in Malaysia, it is grazed on last, after all other palatable species (Wahab, 2001).
16. Reproduction by vegetative fragmentation? (y=1, ?=0, n=-1)	y	1	high	Plants produce rhizomes (DEWR, 2008), which are assumed to result in vegetative reproduction.
17. Minimum generative time (A) 1 year or less (1 pt), (B) 2 or 3 years (0), (C) >3 years (-1pt); Unknown (?)=_.	b	0	mod	Plants produce spores in 2-5 years (Gardener and Marrinan, 2004). Spores producing the gametophyte generation germinate within a few days (Trivedi and Kher, 1976).
18. Evidence that a persistent propagule bank (e.g., seed bank) is formed (>1yr)? (y=1, ?=0, n=-1)	y	1	mod	*Lygodium* spp. spores can remain viable for years (Hutchinson et al., 2006). "Spores of the *Lygodium* genus have very thick walls, giving these propagules long environmental viability" (Ferriter, 2001). Fern spores can remain dormant for years (Banks, 1999). Moderate uncertainty because decision was based on genus level information.
19. Well controlled by herbicides or other cultural / management techniques? (y=-1, ?=0, n=1)	?	0	high	Unknown, but paraquat is specifically recommended for ferns (PIC, 2008).
20. Tolerates/benefits from mutilation, cultivation or fire? (y=1,	?	0	high	

Question	*Lygodium flexuosum*			
	Result/Score/ Uncertainty			References & Notes
?=0, n=-1)				
21. Is resistant to some herbicides or has potential to acquire herbicide resistance (e.g., related to genetically modified crop it can outcross to, congener of weeds which have developed herbicide resistance)? (y=1, n=0, ?=_)	n	0	low	No *Lygodium* species is listed as having developed herbicide resistance (Heap, 2008).
22. Hybridizes naturally? (y=1, ?=0, n=-1)	n	-1	low	There doesn't appear to be any evidence of this species hybridizing. A quick search showed only 1 hybridization event in *Lygodium* (Fay, 1973).
23. Propagules likely to be dispersed unintentionally by people? (y=1, ?=0, n=-1)	y	1	high	*L. microphyllum* and *L. japonicum* can be dispersed unintentionally by people (Hutchinson et al., 2006; Miller, 2007). It is reasonable to assume the same will be true for *L. flexuosum*.
24. Propagules dispersed intentionally by people? (y=1, ?=0, n=-1)	y	1	mod	Marketed on the internet (Anonymous, 2008).
25. Propagules adapted for either wind, water, or animal (internal or external) dispersal? (y=1, ?=0, n=-1)	y	1	negl	Ferns produce wind-dispersed spores.
26. Prolific seed/spore production (see scoring guide)? (y=1, ?=0, n=-1)	y	1	negl	As a fern, this question gets an automatic yes. One study estimated bout 15,000 spores per square cm of fertile pinnae on *L. microphyllum* (Volin et al., 2004); *L. flexuosum* is probably very similar.
Impact Potential				
27. Is there evidence or strong reason to believe it impacts ecosystem processes and system-wide parameters that affect other species (e.g., changes fire regime, nutrient cycling, water availability, community light levels, etc.)? (y=0.2, n=0)	?		high	No information available from native or introduced range outside of U.S. However, *L. microphyllum*, which has a similar growth form, changes fire regime and community light levels in Florida (Hutchinson et al., 2006).
28. Does it change community structure by creating, modifying, or eliminating vegetation layers? (y=0.2, n=0)	?		high	No information available from native or introduced range outside of U.S. However, *L. microphyllum*, which has a similar growth form, creates an impermeable mat

Question	*Lygodium flexuosum*			
	Result/Score/ Uncertainty			References & Notes
				over all vegetation, including the canopy (Brandt and Black, 2001).
29. Does the invasive/weedy taxon change community composition by reducing or eliminating native species or promoting other invasive species? (y=0.2, n=0)	?		high	No information available from native or introduced range outside of U.S. However, *L. microphyllum,* which has a similar growth form, reduces native species abundance (Brandt and Black, 2001; Pemberton, 2003)
30. Does it impact or is it likely to impact any particular native plant species significantly more so than others (e.g., through competition, parasitism, hybridization, or alternate host for pest or disease)? (y=0.1, n=0)	y	0.1	high	*L. flexuosum* is a host for *Octothrips lygodii*, which thus far, appears to only affect *Lygodium* hosts (Mound, 2002). Establishment of *L. flexuosum* in the U.S. may provide a pathway for the entry and establishment of the thrips, which could impact the native *L. palmatum*.
31. Consider the potential distribution of the invasive plant in the United States and the potential habitats it may invade. Is it likely to affect any federal Threatened and Endangered plant species? (y=0.1, n=0)	y	0.1	mod	It may threaten US listed Threatened and Endangered species such as *Thalictrum cooleyi* which occurs in similar mesic habitats as *Lygodium* (CPC, 2008).
32. Consider the potential distribution of the invasive plant in the United States and the potential habitats it may invade. Is it likely to affect any globally outstanding ecoregions as defined by Ricketts et al. (1999)? (y=0.1, n=0)	y	0.1	low	Based upon its potential distribution in plant hardiness zones 9 and higher, it can impact the southeastern U.S. which contains several globally outstanding ecoregions (Ricketts et al., 1999).
33. Allelopathic? (y=0.1, n=0)	n	0	mod	No evidence.
34. Is this plant directly targeted/controlled by managers in conservation areas? (y=0.2, n=0)	n	0	high	No evidence that it has been introduced elsewhere and subject to control.
35. Produces a human allergen or toxin, or is otherwise physically harmful? (y=0.1, n=0)	n	0	mod	No evidence.
36. Produces spines, thorns, burrs, or other undesirable trait (e.g., foul smell, stains property)? (y=0.1, n=0)	n	0	mod	No evidence.
37. Does it hinder or otherwise affect processes and aspects generally deemed important for human civilization or safety (e.g., vines on power lines, shrubs or trees on utility right-of-	n	0	mod	No evidence.

Question	*Lygodium flexuosum*			
	Result/Score/ Uncertainty			**References & Notes**
ways, growth in urban structures, destabilizes coastal dunes)? (y=0.1, n=0)				
38. Changes or limits recreational use of an area (e.g., hinders navigation in bodies of water, hunting/fishing, impedes scenic vistas)? (y=0.1, n=0)	n	0	mod	No evidence.
39. Outcompetes, replaces or otherwise affects desirable plants and vegetation (e.g., gardens, lawns, street trees)? (y=0.1, n=0)	n	0	mod	No evidence.
40. Is this plant widely targeted/controlled by citizens or other groups or agencies in urban/suburban areas? (y=0.1, n=0)	n	0	mod	No evidence.
41. Reduces crop/product yield (e.g., by parasitism, competition, or by harboring other pests)? (y=0.2, n=0)	y	0.2	low	Considered a primary constraint to rice production and reduces rice yield (Roder et al., 1995b; Roder et al., 1997).
42. Lowers commodity value (e.g., by increasing costs of production, lowering market prices, or other)? (y=0.2, n=0)	y	0.2	low	Weeding in rice fields increases cost of production; weeding is labor intensive (Roder et al., 1995b; Roder et al., 1997). Interferes with harvest in tree plantations (PIC, 2008)
43. Results in a loss of markets (foreign or domestic) due to the presence of a new quarantine pest? (y=0.2, n=0)	y	0.2	high	Unknown. But *L. japonicum* and *L. microphyllum* are regulated in Florida and Alabama (NRCS, 2008). Because *L. japonicum* contaminates pine straw bales (Ferriter, 2001), it may result in a loss of domestic and/or foreign markets, or at least requirement of risk management programs (e.g., Clark, 2005).
44. Reduces the quality or availability of irrigation, or strongly competes with plants for water? (y=0.1, n=0).	?		high	
45. Toxic to animals, including livestock/range animals and poultry (y=0.1, n=0)?	n	0	mod	No evidence (CU, 2008).
46. Host for recognized pests and pathogens? (y=0.1, n=0, ?=_)	?		high	
47. Parasitic? (y=0.1, n=0)	n	0	low	Not described as a parasitic plant.

Question	*Lygodium flexuosum*			
	Result/Score/ Uncertainty			References & Notes
48. Is this plant directly controlled or managed in some fashion in any production system (e.g., agriculture, forestry, horticulture, aquaculture, etc.)? (y=0.2, n=0)	y	0.2	negl	Controlled in rice fields (Roder et al., 1995b; Roder et al., 1997) and tree plantations (PIC, 2008). It, among other weeds, is controlled in tea plantations, where it is considered a high to significant weed (Rajkhowa et al., 2005).
Entry Potential				
49. Plant already here? (y=1, n=0). **STOP IF YES**	n	0	low	Not listed in the USDA Plants Database. Imported by USDA-ARS to study impact of potential biological control agents for *Lygodium microphyllum* (ARS, 2008b).
50. Plant proposed for entry, or entry is imminent? (y=1, n=0) **STOP IF YES**	n	0	low	
51. Plant under cultivation or sold/traded elsewhere? (y=0.25, n=0) **[Skip #54 if yes. Skip #53 if no.]**	y	0.5	low	Listed in a seed company catalogue, but may not be readily available (Anonymous, 2008). Plant used in handcrafts (Anonymous, 2005).
52. Plant currently marketed on the internet or traded by growers elsewhere? (enter 2 for yes, or 1 for no)	2		negl	(Anonymous, 2008).
53. Plant not under cultivation but deemed important? (y=0.05, n=0)		N/A		
54. Natural dispersal? (y=.05, n=0)	n	0	negl	Not present in surrounding regions.
55. Plant present in Canada, Mexico, Central America, the Caribbean or China. Note doubles likelihood of all contaminating pathways? (enter 2 for yes, or 1 for no)	1		negl	Not present in surrounding regions.
56. Q56 (contaminants of fruits and vegetables for consumption)? (y=0.01, n=0)	y	0.01	mod	"Creepers like *Mikania* [and *Lygodium flexuosum*] contaminate plucked shoots" of tea in India (Rajkhowa et al., 2005). It is likely spores may be present on the contaminants.
57. Q37 (contaminants in plants for planting, including aquarium plants and products)? (y=0.04, n=0)	?	0	high	Unknown, but spores could readily contaminate any Q37 material.

Question	*Lygodium flexuosum*			
	Result/Score/ Uncertainty			References & Notes
58. Bird seed, or seeds for planting (contaminants in grain, flower seed packets, etc.)? (y=0.04, n=0)	?	0	high	Unknown, but spores could readily contaminate this material.
59. Ballast water? (y=0.03, n=0)	n	0	mod	No evidence, but considered unlikely.
60. Military vehicles or other equipment? (y=0.02, n=0)	y	0.02	high	Unknown for *L. flexuosum*, but *L. japonicum* contaminates equipment (Miller, 2007).
61. Imported landscape products (e.g., pine-straw, hydro mulch, etc.) (y=0.02, n=0)?	y	0.02	high	Unknown for *L. flexuosum*, but "*L. japonicum* has also been identified as a contaminant in pine straw bales" (Clark, 2005; Ferriter, 2001).
62. Other (specify) (A) 0.01, (B) 0.02, (C) 0.03, (D) 0.04	?	0.00	high	
Geographic Potential (USDA Plant Hardiness Zones)[4]				
Zone 1 (0.056)	n	0	low	
Zone 2 (0.037)	n	0	low	
Zone 3 (0.058)	n	0	low	
Zone 4 (0.129)	n	0	low	
Zone 5 (0.133)	n	0	low	
Zone 6 (0.192)	n	0	low	
Zone 7 (0.152)	n	0	low	
Zone 8 (0.143)	n	0	high	Temperate and subtropical China: Guangdong, Guangzi, and Guizhou provinces (ARS, 2008a).
Zone 9 (0.089)	y	0.089	mod	
Zone 10 (0.009)	y	0.009	low	
Zone 11 (0.001)	y	0.001	negl	In northern Australia (DEWR, 2008).
Zone 12 (0.0003)	y	0.0003	negl	In northern Australia (DEWR, 2008).
Zone 13 (0.0004)	y	0.0004	negl	Sir Lanka (ARS, 2008a); Malaysia (Lim et al., 2001).

[4] Numbers in parentheses are the proportion of area of the United States (lower 48 states, Alaska, Hawaii, and Puerto Rico) in that plant hardiness zone. All numbers sum to 1.