United States Department of Agriculture

Marketing and Regulatory Programs

Animal and Plant Health Inspection Service

Biological assessment for the proposed field release of a *Pseudophilothrips ichini* (Thysanoptera: Phlaeothripidae) for classical biological control of Brazilian peppertree, *Schinus terebinthifolia*, (Anacardiaceae) in the contiguous United States.

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Contents

I. POLICY

United States Department of Agriculture (USDA) Departmental Regulation, Fish and Wildlife Policy No. 9500-4, dated August 22, 1983 and updated April 28, 2008, sets forth the purpose, policy, and responsibilities of USDA with respect to fish and wildlife. Agencies of the USDA will not fund or take any action that is likely to jeopardize the continued existence of threatened or endangered species or destroy any habitat necessary for their conservation. The USDA will coordinate with the Secretaries of the Department of the Interior and the Department of Commerce in the administration of the Endangered Species Act (ESA) and animal and plant quarantine laws.

II. DESCRIPTION OF THE PROPOSED ACTION, *P. ICHINI* INFORMATION, AND HOST SPECIFICITY TESTING RESULTS

The purpose of this biological assessment (BA) is to assess the potential effects of the release of the thrips *Pseudophilothrips ichini* (Hood) (Thysanoptera: Phlaeothripidae), for classical biological control of Brazilian peppertree, *Schinus terebinthifolia* Raddi. (Sapindales: Anacardiaceae), in the contiguous United States, on species that are listed as endangered or threatened (listed), species proposed to be listed as endangered or threatened (proposed), and habitats designated or proposed to be designated as critical, in accordance with Section 7 of the ESA.

In the contiguous United States, there is one plant that is federally listed in the family Anacardiaceae (Michaux's sumac (*Rhus michauxii*)), the same family as the target weed. Based on the host specificity of *P. ichini* reported in testing, field observations, and in the scientific literature, APHIS has determined that environmental release of *P. ichini* may affect, but is not likely to adversely affect Michaux's sumac or the Everglade snail kite and its critical habitat. APHIS has also determined that *P. ichini* may affect beneficially, the Florida panther, Key deer, Florida scrub-jay, gopher tortoise, Bartram’s hairstreak butterfly and its critical habitat, Florida leafwing butterfly and its critical habitat, Miami blue butterfly, Schaus swallowtail butterfly, beach jacquemontia, Everglades bully, Florida pineland crabgrass, pineland sandmat, and Florida prairie-clover. The USDA, Animal and Plant Health Inspection Service (APHIS) is requesting concurrence from the U.S. Fish and Wildlife Service (FWS) on these determinations.

Proposed Action and Action Area

The USDA, APHIS, has the authority to regulate the release of biological control organisms in the United States under the Plant Protection Act of 2000. APHIS is proposing to issue permits for release of *P. ichini* into the contiguous United States. If approved by APHIS and participating states, releases will be made initially into the State of Florida. However, if *P. ichini* establishes, the insect could spread throughout the contiguous United States wherever host plants are available and the climate is suitable. Also, additional permits may be issued by APHIS after this initial release in Florida, such as Texas and California where Brazilian peppertree is a problem weed. Therefore, the action area is considered the contiguous United States. A permit is not

issued until APHIS conducts a National Environmental Policy Act (NEPA) evaluation for the release of *P. ichini*.

APHIS Process for Permitting of Weed Biological Control Organisms

A Plant Protection and Quarantine (PPQ) Form 526 permit is required for both the importation and the interstate movement of weed biological control organisms intended for environmental release. Organisms released for use as biological controls of weeds may be arthropods, nematodes, or microbial pathogens. Permits for importation of these organisms generally require them to be received and maintained in biocontainment facilities. APHIS also issues permits for first-time environmental release from containment of nonindigenous weed biological control organisms. Further, APHIS issues permits for interstate redistribution of approved weed biological control organisms. A PPQ Form 526 permit is not needed for interstate movement when pathogens used for weed biological control are listed as an active ingredient in an EPA-registered product.

Permits for first-time releases of nonindigenous weed biological control organisms are issued only after a scientific review of the potential effects of the release. RSPM No. 7, "Guidelines for Petition for First Release of Non-indigenous Phytophagous or Phytopathogenic Biological Control Agents" (NAPPO, 2015) describes the information that researchers must provide to APHIS before the release of new organisms can be permitted. Information requested includes aspects of the biology, regulatory status, distribution and economic impact of the target weed, and host specificity of the proposed biological control organism, its expected impact after release, and post-release monitoring plans.

For first-time releases of weed biological control organisms, an advisory group composed of Federal regulators and researchers (known as the Technical Advisory Group for Biological Control Agents of Weeds (TAG)) provides assistance to APHIS (https://www.aphis.usda.gov/aphis/ourfocus/planthealth/import-information/permits/regulated-organism-and-soil-permits/biological-control-organism-permits/sa_tag/ct_technical_advisory_group_biological_control_agents_weeds). The TAG evaluates the scientific information submitted by researchers requesting first-time environmental release of nonindigenous weed biological control organisms in the contiguous United States. The TAG makes recommendations to APHIS that are used as part of permitting decisions (7 CFR 330.202(a)). Once the TAG recommends release of an organism, APHIS proceeds with the preparation of an environmental evaluation of the release based on their assessment of those recommendations. For APHIS' approval of new organisms proposed for release in the United States or its territories, compliance with environmental statutes (such as NEPA and ESA) is required (7 CFR 372.5(b)(4)).

Interstate movement of weed biological control organisms for environmental release require permits from APHIS for the movement of the organism to the site of release. If the organism is widely established in the United States (within its potential range) and has not caused adverse effects, a permit may be issued for interstate movement for environmental release. If the requested organism is established only in part of its potential geographic range, permits may be

issued for release only in those States where establishment or prior releases are documented. If the organism is new to the requested destination State, a permit is not issued until an environmental evaluation is conducted.

PPQ 526 permits are issued by APHIS after the applicant/permit holder agrees to the required conditions for receiving the permit. Conditions included in permits for environmental release require verification of identity and purity of the organisms. For both importation and interstate movement of approved weed biological control organisms, permit conditions may require that the species are reared in laboratory colonies, or their identification is verified by a qualified person, and that the organisms are free from contaminant species, such as hyperparasites or propagative parts of noxious weeds. These conditions are to ensure that unwanted organisms, whether contaminants or misidentified biological control organisms, are not spread to the destination location to cause unintended consequences.

The following information regarding Brazilian peppertree, *P. ichini*, and the host specificity testing conducted is from two petitions submitted to the TAG (Wheeler et al., 2014; Overholt et al., 2015).

1. Nature of the Problem

1.1 History of introduction:

Brazilian peppertree is one of the worst invasive species in Florida (Schmitz et al., 1997). Rodgers et al. (2012) estimate that approximately 283,000 hectares of south and central Florida are invaded by Brazilian peppertree, and expenditures to control the tree by the South Florida Water Management District alone were approximately $1.7 million in 2011. In the same year, the Florida Fish and Wildlife Conservation Commission reported that nearly $7 million were spent by governmental agencies in Florida to control terrestrial invasive plants, including Brazilian peppertree (FWC, 2011). In the United States, this weed is present in Florida, Texas, California, Hawaii, Puerto Rico and the Virgin Islands (USDA/NRCS, 2002; EDDMapS, 2014), and in addition to Florida, is considered invasive in Hawaii (USFS, 2014), Texas (TexasInvasives.org, 2014) and California (Randall, 2000; Cal-IPC, 2014).

Brazilian peppertree is native to Brazil, Argentina, Paraguay, and Uruguay (Barkley, 1944; 1957; Ewel, 1986). Historical records indicate that it was found in Florida as early as the 1840s, although there is no information about the provenance of that early introduction (Barkley, 1944). Later, it was imported into Miami in 1898 (Morton, 1978), and into Punta Gorda on the west coast in 1926 (Nehrling, 1944). More recently, molecular studies identified two genetic lineages of Brazilian peppertree in Florida (referred to as haplotypes A and B), and since their arrival, they have extensively hybridized (Williams et al., 2005; 2007). There was a long lag period (50–60 years) between the time that Brazilian peppertree was first introduced into Florida, and the time it was recognized as invading natural ecosystems (Morton, 1978). Mukherjee et al. (2012) speculated that the extended lag period was due in part to genetic adaptations and rapid evolution that followed hybridization of the two genetic types that invaded the state, which may partially explain the aggressiveness of this species.

Brazilian peppertree has been nominated as one of the 100 worst invasive species worldwide by the Global Invasive Species Database (2014). In Florida, Brazilian peppertree is listed as a noxious weed (FLDACS, 1999), a prohibited plant (FLDEP, 1993), and is classified as a Category I invasive plant species by the Florida Exotic Plant Pest Council (FLEPPC, 2011). This weed invades disturbed sites such as canal banks, fallow farmlands, and also natural communities including pinelands, hardwood hammocks, and mangrove forests (Cuda et al., 2006). Several attributes may contribute to its invasiveness, including a large number of drupes produced per female plant, an effective mechanism of dispersal by birds (Panetta and McKee, 1997), tolerance to shade (Ewel, 1978), fire (Doren et al., 1991), and drought (Nilson and Muller, 1980a), allelopathic effects on neighboring plants (Gogue et al., 1974; Nilson and Muller, 1980b; Morgan and Overholt, 2005; Overholt et al., 2012), and tolerance to saline conditions (Ewe, 2001; Ewe and Sternberg, 2002). The invasion and displacement of native species by Brazilian peppertree poses a serious threat to biodiversity in many ecosystems in Florida (Morton, 1978; Cuda et al., 2006).

Chemical and mechanical control measures have been used with some success against this weed, but permanent maintenance programs are required to prevent regrowth, which are costly, labor intensive, and may be detrimental to native vegetation (Koepp, 1978; Doren and Jones, 1997).

1.2 Present distribution of Brazilian peppertree:

The genus *Schinus* is native to Argentina, southern Brazil, Uruguay, Paraguay, Chile, Bolivia, and Peru (Barkley, 1944). The center of origin for the genus *Schinus* is northern Argentina (Barkley, 1944). Brazilian peppertree is native to Brazil, Argentina, Paraguay, and Uruguay (Barkley, 1944; 1957; Ewel, 1986). Since the late 1800s, this species has been introduced as an ornamental plant into many tropical and subtropical regions including parts of Australia, New Zealand, the Bahamas, Bermuda, Fiji, Island of Mauritius, Kenya, Micronesia, New Caledonia, Reunion Island, South Africa, Asia, and Tahiti (Cuda et al., 2006; Scheffer and Grissell, 2003).

In the United States, Brazilian peppertree occurs in Florida, Texas, California, Hawaii, the Commonwealth of Puerto Rico, the U.S. Virgin Islands (EDDMapS, 2014) and Georgia (Gray et al., 2009) (Figure 1a). In Florida, Brazilian peppertree is widely distributed from Monroe County in the south to St. Johns and Levy Counties in the north (Figure 1b). In addition, it has recently been reported in Franklin County in the Panhandle (Wunderlin and Hansen, 2014) and Nassau County on the northeast coast (Salco, 2007). Brazilian peppertree is more abundant in south and central Florida due to its sensitivity to cold temperatures (Langeland and Burks, 1998). Ecological niche modeling suggests that cold tolerance may have increased since the introduction of Brazilian peppertree, which may explain the recent northward spread of this species (EDDmapS, 2014; Mukherjee et al., 2012).

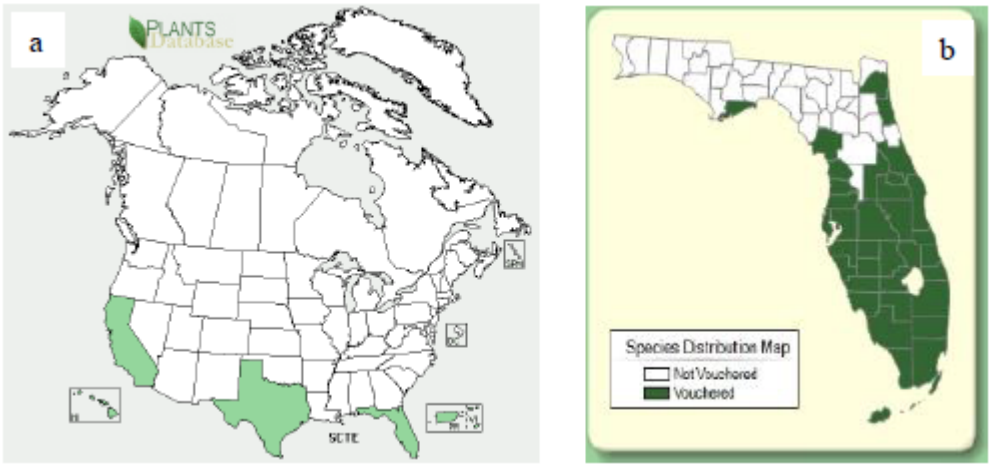

Figure 1. a) Distribution of Brazilian peppertree in the United States (source: USDA Plant Database http://plants.usda.gov), b) in Florida (source: Wunderlin and Hansen, 2014 http://www.florida.plantatlas.usf.edu)

1.3 Taxonomically Related Plants to Brazilian peppertree:

There are no native species in the genus *Schinus* in the United States, although four *Schinus* species have been introduced historically into the contiguous United States: 1) *Schinus longifolius* (Lindl.) Spreg. in Texas, 2) *Schinus molle* L. in California, Florida, and Texas, 3) *Schinus polygamus* (Cav.) Cabrera in California, and 4) *S. terebinthifolia* in California, Florida, and Texas (Bargeron and Swearingen, 2010). Even though Barkley (1944) reported specimens of *S. longifolius* in Texas, later surveys were unable to detect its presence. Similarly, *Schinus molle*, was recorded in a single collection in Central Florida from 1931 (UNC Herbarium), it should be considered an historic introduction which did not establish. *Schinus polygamus* is considered a weedy species in southern California but little is known about the extent of its invasive status (Cal-IPC, 2007). Of the four *Schinus* species that have been introduced, only *S. molle* in California has ornamental value. However, the California Exotic Pest Plant Council has listed this species as a 'limited' category invasive species (Cal-IPC, 2006). Therefore, in addition to *S. terebinthifolia*, only the congener *S. molle* was included in the host range testing.

1.4 Impacts of Brazilian peppertree:

1.4.1 Beneficial uses. Brazilian peppertree is considered a major nectar source for honey bees during the fall and winter months in Florida (Sanford, 1988). However, honey from Brazilian peppertree has a distinct taste and is not considered table grade (Sanford, 1988). Beekeepers consider Brazilian peppertree a primary nectar producer in the fall, but there are other plant species that bloom during that period providing alternate nectar sources for bee colonies in Florida (Sanford, 1988; Ellis and Nalen, 2013). The dried drupes of Brazilian peppertree are used as a spice for cooking and are sold in the United States and elsewhere (Habeck et al., 1994; Cuda et al., 2006). However, the ingestion of these drupes can be dangerous due to their toxic properties (Bell and Taylor, 1982). In South America, all parts of the tree have been used in

traditional herbal medicines since ancient times (Morton, 1978). For example, Brazilian peppertree can be used as a treatment for ulcers, respiratory problems, wounds, rheumatism, skin ailments, and arthritis among others (Campbell et al., 1980; Bennett and Habeck, 1991). However, the medicinal uses are not recommended because Brazilian peppertree extracts induced cell death in human prostate carcinoma cell lines (Queires et al., 2006). Finally, Brazilian peppertree wood has little commercial value because of its low quality, small trunk size, and difficulty of harvesting due to the clumped plant structure (Morton, 1978). It has been used in toothpicks, posts, railway ties, and construction (Morton, 1978).

1.4.2 Social and recreational impacts. Brazilian peppertree became popular in Florida during the Christmas holidays because of its green leaves and red drupes that resemble holly. This species was sold as an ornamental plant throughout the state until 1990 when the Florida legislature passed a state law prohibiting the sale, cultivation and transportation of Brazilian peppertree (Florida Statutes, Title XXXV, Chapter 581, Section 019, available at: http://www.leg.state.fl.us/Statutes/Index.cfm). In 1993, the Florida Administrative Code was amended and Brazilian peppertree was declared a prohibited species (FLDEP, 1993). There is no recreational or social value of this weed in Florida. In the native range, Brazilian peppertree is grown as an ornamental plant along road sides.

1.4.3 Impact on threatened and endangered species. Brazilian peppertree has invaded many habitats in the Everglades National Park including sawgrass marshes, hardwood hammocks, pine forests, and mangrove ecotones (Doren and Jones, 1997). The invasion of natural shoreline habitats and saline communities by this weed is threatening rare federal and/or state listed native plants (*Jacquemontia reclinata* House, *Remirea maritima* Aubl (Coile, 1998), and the endangered gopher tortoise (*Gopherus polyphemus* Daudin) (Doren and Jones, 1997).

1.4.4 Economic losses, including direct control costs. Brazilian peppertree is considered to be one of the most serious invasive plants in Florida (Schmitz et al., 1997). According to the Florida Fish and Wildlife Commission, the Uplands Program has expended over $108 million to treat invasive plants on over 1.6 million square acres from 1997 to 2010. Rodgers et al. (2012) estimated that approximately 283,000 hectares (ha) of south and central Florida are invaded by Brazilian peppertree, and control costs to the South Florida Water Management District are $1.7 million annually. Considering only herbicide applications, the cost to control Brazilian peppertree on 1,000 ha in 2002 was $0.5 million (Cuda et al., 2006).

Brazilian peppertree is particularly problematic on abandoned farm lands in The Hole-in-the-Donut (HID) in the Everglades National Park (Doren et al., 1990). Several methods were initially used to eliminate this weed including bulldozing, burning, mowing, and planting and seeding of native species, but all failed. However, the complete removal of disturbed substrate was successful and resulted in the recolonization of native vegetation (Doren et al., 1990; Dalrymple et al., 2003). Initial restoration efforts were completed at a cost of $640,000, however, it was estimated that it would cost an additional $20 million and take 20 years to restore the entire site (Doren et al., 1990). Finally, the wide distribution and continuous increase of Brazilian peppertree infestations coupled with its allergenic properties could negatively affect the multi-billion dollar tourist industry in Florida (Smith and Brown, 1994).

1.4.5 Health. Brazilian peppertree presents a health risk to humans. Like most members of the Anacardiaceae family, Brazilian peppertree contains active alkenyl phenols which can cause contact dermatitis and inflammation to sensitive individuals (Tomlinson, 1980). Close proximity to the plant may cause respiratory problems such as chest pains, acute headaches, eye irritation, and flu-like symptoms. People in direct contact with the plant sap may experience a rash followed by intense itching. Ingesting the bark, leaves, and drupes can be toxic to humans, mammals, and birds (Morton, 1978; Kinde et al., 2012).

1.4.6 Effects on native plant and animal populations. Brazilian peppertree invades a variety of native communities in Florida ranging from upland pinelands to mangrove forest (Cuda et al., 2006). Coastal mangrove forests are critically important ecosystems in Florida because of their high productivity, valued habitat to vertebrate and invertebrate species, and for shoreline protection and stabilization. This vital ecosystem is constantly being threatened by urbanization, climate change, and invasive species such as Brazilian peppertree (Armentano et al., 1995; Doren and Jones, 1997). There are few management options available because foliar herbicide applications are detrimental to mangrove species, and disturbance resulting from mechanical removal favors reestablishment of Brazilian peppertree (Doren and Jones, 1997).

Brazilian peppertree has invaded many habitats in the Everglades National Park including sawgrass marshes, hardwood hammocks, pine forests, and mangrove ecotones (Doren and Jones, 1997). Abandoned rock-plowed lands created better drained and aerated conditions conducive to mycorrhizal activity, which provided an advantage to mycorrhizal-dependent plants such as Brazilian peppertree (Sequiera et al., 1998). In addition to the weed's fast growth, its ability to tolerate root flooding and being less affected by seasonality may have conferred greater competitive advantage over native species (Ewe and Sternberg, 2002). Dense stands of Brazilian peppertree shade out and may kill food plants used by the white-tailed deer (*Odocoileus virginianus* (Zimmerman) in Florida Panther National Wildlife Reserve (Maffei, 1997). The decrease of the white-tailed deer may in turn affect the endangered Florida panther (*Felis concolor coryi* (Bangs)) because it serves as an important prey item. Brazilian peppertree is known to have toxic resins in the bark, leaves, and drupes which may be poisonous to some mammals and birds (Lloyd et al., 1977; Morton, 1978). Ingestion of the leaves and drupes can be fatal to grazing animals such as cattle and horses (Morton, 1978).

Brazilian peppertree also contributes to other invasive species problems, a phenomenon referred to as 'invasional meltdown' (Simberloff and Van Holle, 1999). For example, Brazilian peppertree leaf-litter provides a refuge for some exotic ants in the HID area of Everglades National Park (Clouse, 1999). Another invasive species, the black spiny-tailed iguana (*Ctenosaura similis* (Gray)), also benefits from this weed by using the plant for shelter and feeding on the drupes during the winter (Jackson and Jackson, 2007). In addition, Brazilian peppertree serves as an alternate host for the exotic root weevil, *Diaprepes abbreviatus* (Linnaeus), which is a serious pest of citrus in Florida and California (McCoy et al., 2003).

1.4.7 Impact of weed control on non-target plants. Chemical control is the most common method employed against Brazilian peppertree in Florida (Gioeli and Langeland, 1997; Randall, 2000;

Langeland and Stocker, 2001; Cuda et al., 2006). Even though successful control can be achieved, foliar and soil applications of herbicides have been reported to damage neighboring non-target plants (Laroche and Baker, 1994; Gioeli and Langeland, 1997). For example, Imazapyr is known to translocate through the soil causing leaf deformation in some native species.

Brazilian peppertree invades salt-tolerant communities such as mangrove forest along the shorelines in Florida (Doren and Jones, 1997). There are few management options available against Brazilian peppertree in these critically important habitats. Mangrove species are particularly vulnerable to foliar herbicide applications, and disturbance resulting from mechanical removal favors reestablishment of Brazilian peppertree (Doren and Jones, 1997).

1.4.8 Effects on ecosystem functions and ecological relationships. Invasive plant species, such as Brazilian peppertree, that displace native vegetation can alter the habitat and modify the plant composition resulting in a new community structure (Gordon, 1998). An example of this is the increased soil development and elevation resulting from Brazilian peppertree infestations in shallow soil systems (Gordon, 1998). In addition, Brazilian peppertree grows rapidly and dominates the understory of unburned pine rocklands. Dense stands of this weed retain high moisture and reduce fire frequency which in turn affects pines and herbaceous species (Wade et al., 1980; Gordon, 1998). For example, Brazilian peppertree comprised 40 percent of the trees of two meters (m) in height and 66 percent of trees taller than five m in areas of the Everglades where fire had been suppressed (Loope and Dunevitz, 1981).

The invasion of natural ecosystems by Brazilian peppertree has reduced the biological diversity of plants and animals (Morton, 1978; Bennett and Habeck, 1991; Ewel et al., 1982). Several native plant communities have been affected including saw-grass marshes, prairies, subtropical slash pine forests, tropical hardwood hammocks, mangrove forests, palmetto prairies, cypress savannas, and sand pine scrub oak (Loope and Dunevitz, 1981; Ewel et. al., 1982; Woodall, 1982; Doren and Jones, 1997). The production of allelopathic compounds by Brazilian peppertree may have facilitated its invasion of these habitats (Gogue et al., 1974; Nilson and Muller, 1980b; Morgan and Overholt, 2005; Overholt et al., 2012). Allelopathy is defined as the process by which plants release phytochemicals directly into their surrounding environment, inhibiting seed germination and seedling growth of neighboring species (Rice, 1995). According to Morgan and Overholt (2005), leaf extracts of Brazilian peppertree reduced germination and growth of two native species, *Bidens alba* L. and *Rivina humilis* L. Another study showed that drupes of Brazilian peppertree reduced growth, leaf production, and biomass of two Florida native mangrove species, the black mangrove (*Avicennia germinans* L.) and the red mangrove (*Rhizophora mangle* L.) (Donnelly et al., 2008).

1.5 Alternative Brazilian peppertree management options

Chemical, mechanical, and physical methods are employed to control Brazilian peppertree in Florida (Cuda et al., 2006). Mechanical methods, such as cutting, burning, and flooding, and herbicide application are commonly used in combination against this weed (Gioeli and Langeland, 1997; Langeland, 2001). For example, cut-stump treatments or basal bark applications of triclopyr can effectively control Brazilian peppertree (Langeland and Stocker,

2001). Physical control including soil removal, prescribed burning, and flooding can stress plants or even kill them (Randall, 2000). These different methods have been used with some success, but maintenance programs are required to prevent regrowth and non-target effects have been reported in some cases (Koepp, 1978; Laroche and Baker, 1994; Cuda et al., 2006). Management tactics should be followed by restoration seeding with native plants to prevent reestablishment of Brazilian peppertree or other invasive species (Cuda et al., 2006).

Chemical control is the most common and cost-effective method employed for controlling Brazilian peppertree in Florida (Gioeli and Langeland, 1997; Randall, 2000; Langeland and Stocker, 2001; Langeland, 2002). Foliar applications of triclopyr, glyphosate, or imazapyr are usually employed to control seedlings (Gioeli and Langeland, 1997), and only approved products such as glyphosate or imazapyr can be used in aquatic systems (Langeland and Stocker, 2001). However, higher amounts of herbicides are needed during foliar applications, and wind drift may damage nearby plants. Basal soil applications of both hexazinone and tebuthiuron resulted in 80-90 percent mortality of Brazilian peppertrees, but damage to adjacent non-target species was observed (Laroche and Baker, 1994). Basal bark applications of triclopyr ester were also effective, in particular during the fall when Brazilian peppertree plants are flowering, due to the high level of triclopyr translocation (Gioeli and Langeland, 1997). The down-side of basal applications is the difficulty for applicators to spray around the circumference of multiple stemmed trees while carrying a backpack sprayer. Cut-stump treatments are also employed by cutting the trunk with a saw or machete and treating the stumps with herbicide (Gioeli and Langeland, 1997). It is recommended to avoid doing cut-stumps treatments during Brazilian peppertree fruiting period (fall-winter) in order to avoid further spread of the seeds.

Mechanical control such as manual removal is often used to control Brazilian peppertree in low densities, and is particularly effective for small saplings. However, heavy equipment such as bulldozers, front end loaders, root rakes, and other specialized equipment are needed in order to remove larger plants (DiTomaso et al., 2013). When using heavy equipment, the entire root system has to be removed in order to prevent resprouting (Doren et al., 1990; Dalrymple et al., 2003). Soil disturbance during mechanical control may favor Brazilian peppertree recolonization and therefore, other methods of control and restoration should follow. Heavy equipment is not suitable for sensitive natural areas such as mangrove communities where alternative control measures are required.

Physical control has been also used to control Brazilian peppertree including soil removal, prescribed burning, and flooding (Randall, 2000). There have been mixed results from fire treatments; seed failed to germinate after burning but plants resprouted from the crowns and roots. Fire treatments were evaluated to control Brazilian peppertree infestations at the Everglades National Park, and repeated burning did not significantly decrease the rate of invasion which suggests that fire is not an appropriate management tool in this area (Doren et al., 1991). Brazilian peppertree seedlings are vulnerable to prolonged flooding (Ewel et al., 1982), while mature plants can survive long periods submerged and exhibit some tolerance to salinity (Ewe, 2001). The Sanibel Restoration Project illustrates the effects of flooding in managing Brazilian peppertree stands (Clark, 1999). A system of weirs was installed in 1995 at a cost of $4.5 million in order to maintain surface water at 3.2 feet above National Geodetic Vertical Datum (NGVD).

The return of the hydrology to historical levels has stressed and killed some Brazilian peppertree plants at transitional areas and tropical hardwood hammock ridges.

Several biological control agents of Brazilian peppertree were released in Hawaii in the 1950s and 1960s including *Episimus unguiculus* Clarke (= *E. utilis* Zimmerman) (Lepidoptera: Tortricidae), *Lithraeus atronotatus* Pic (Coleoptera: Bruchidae), and *Crasimorpha infuscate* Hodges (Lepidoptera: Gelechiidae) (Julien and Griffiths, 1999). Despite the successful establishment of two of these agents, little impact has been reported on Brazilian peppertree populations in Hawaii (Yoshioka and Markin, 1991; Julien and Griffiths, 1999). In Florida, biological control efforts have been ongoing since the 1980s (Bennett and Habeck, 1991; Habeck et al., 1994; Cuda et al., 2006), but no agents have yet been released. Research on a defoliating sawfly that was shown to be highly host specific to Brazilian peppertree (Medal et al., 1999), was halted after the larvae were found to contain compounds toxic to mammals (Dittrich et al., 2004), and possibly birds. Other candidate agents performed poorly on Florida Brazilian peppertree (Manrique et al., 2008) or were shown to feed on related non-target plants during quarantine studies (Wheeler et al., 2011; McKay et al., 2012, Manrique et al., 2014). Currently, the proposed field release of a leaf-galling psyllid, *Calophya latiforceps* (Hemiptera: Calophyidae) is under review by the United States Department of Agriculture and U.S. Fish and Wildlife Service.

2. Biological Control Agent Information

2.1 Taxonomy of *Pseudophilothrips ichini*

The thrips species, *Pseudophilothrips ichini* (Hood) was first recorded on leaves of Brazilian peppertree near Rio de Janeiro, Brazil and described by Hood in the genus *Liothrips* (Hood, 1949). It is assigned to the Phlaeothripidae family, in the Tubulifera suborder, of the Thysanoptera order (Borror et al., 1989). In Florida Brazilian peppertree is also attacked by another species of thrips, the red banded thrips *Selenothrips rubrocinctus* (Cassani, 1986). This species can be distinguished from the proposed biological control agent as the red banded thrips is assigned to the Terebrantia suborder and thus has the more rounded abdomenal tip.

Following the intial 1949 description of the *Liothrips ichini* thrips by Hood, it was later reassigned to a new genus *Pseudophilothrips* (Johansen, 1979). This new genus *Pseudophilothrips* represents a discrete New World, mainly Central and South American, lineage that was derived from the genus *Liothrips*. Prepared paratypes of *Pseudophilothrips ichini* are deposited in Departamento Entomologia, ESALQ/USP, Piracicaba; U.S. National Museum, Washington DC; Entomology Department, University of California, Riverside; Natural History Museum, London; Senckenberg Museum, Frankfurt; Australian National Insect Collection, Canberra. Additionally, voucher collections of these thrips are deposited in the Florida State Collection of Arthropods, Gainesville, FL. Our quarantine collections were identified morphologically by Dr. L. A. Mound, CSIRO Entomology, Canberra, Australia.

Individuals from *P. ichini* were characterized by molecular methods and these sequences are posted in National Center for Biotechnology Information, GenBank under accessions GU942812-GU942818. Briefly, to characterize these collections molecularly, a total of 589 thrips were

sequenced at 410 base pairs of the mitochondrial cytochrome oxidase I gene using primers LCO1490 and HC02190, C1-J-1718 and C1-N-2191. Thrips were collected from 207 individual Brazilian peppertrees with a median number of two thrips collected from a single tree. This analysis indicated that there were six *P. ichini* thrips haplotypes from Brazilian field samples. More detailed methods are provided in Mound et al. (2010). Collections in quarantine were identified by molecular methods by Dr. D.A. Williams, Department of Biology, Texas Christian University, Fort Worth, TX.

The *P. ichini* species was chosen as a potential biological control agent of Brazilian peppertree as it: 1) appears to have a high level of specificity for the target weed; 2) has wide environmental tolerance; and 3) field observations and laboratory research indicate feeding damage dramatically reduces growth and reproduction of the host.

2.2 Geographical Range of *Pseudophilothrips ichini*

The geographic range of the host and thrips was determined by frequent survey trips conducted by the researchers to Argentina, Brazil, Paraguay, and Uruguay during 2005 to 2014. These surveys were mostly concentrated in Brazil and ranged from Natal, Rio Grande do Norte, to Pelotas, Rio Grande do Sul states at the northern and the southern extremes of the known host plant range, respectively. Surveys also extended into Argentina, Paraguay, and Uruguay. These surveys covered the entire South American range of Brazilian peppertree.

In Bahia state the western range of the host extended to near Feira de Santana, and in Minas Gerais state, Brazilian peppertree populations extended west to Belo Horizonte then south to western Rio Grande do Sul and northeastern Argentina and eastern Paraguay. However, the thrips distribution did not entirely overlap that of the host. It was never found north of Sergipe or south of Santa Catarina states of Brazil. Furthermore, the thrips was never found west of Parana, Santa Catatina, or Rio Grande Do Sul states of Brazil in adjacent Argentina or Paraguay. As mentioned above, six thrips haplotypes were discovered in Brazil. Results presented here are only on the thrips haplotype number one collected near Ouro Preto, Minas Gerais, Brazil.

Thermal requirements and plant genotypes can be important factors in the establishment of newly introduced biological control agents (Ireson et al., 2008). Temperature-based physiological models indicated that *P. ichini* could establish throughout the invaded range in the United States (Manrique et al., 2014). Moreover, previous results indicated that the thrips species *P. ichini* had similar survival and development times when fed Brazilian peppertree leaves from the two parental types and their hybrid that are invasive in Florida and the one parental type invasive in Hawaii (Manrique et al., 2008).

2.3 Known Host Range (specificity)

The only known published report of the host range of *P. ichini* was from the original collection (originally described as *Liothrips ichini*) on leaves of *S. terebinthifolia* near Rio de Janeiro, Brazil (Hood, 1949; d'Araujo E Silva et al., 1968). Prior to the studies reported in this document, no formal quarantine host testing had been conducted on this thrips species. However, field host range was examined by the authors in its native range of Brazil during periodic surveys for prospective biological control agents. This effort focused, not only on the target weed, but on neighboring species, especially members of the Anacardiaceae that co-occur with Brazilian peppertree in its native range. These species include several South American endemic *Schinus* and *Lithrea* species, *Anacarium occidentale* (cashew), and the introduced *Mangifera indica* (mango). The *Schinus* species that overlap with Brazilian peppertree include *S. molle*, *S. lentiscifolius, S. longifolius, S. polygamus*, and *S. weinmannifolius* (JBRJ, 2011). The other species of the sympatric Anacardiaceae include *Lithrea molleoides*, and *L. brasiliensis*. A few other species, such as *Anacardium humile*, *Astronium glaziovii*, *Astronium gracile*, *Astronium graveolens, Myracrodruon urundeuva, Schinopsis brasiliensis, Tapirira guianenses,* and *Thrysodium spruceanum,* occur in the coastal region of Brazil (JBRJ, 2011), but were never found sympatric with Brazilian peppertree.

The results of this field host range assessment indicated a high degree of specificity where *P. ichini* was never found on any species other than the target weed. However, it needs to be mentioned that the areas where *P. ichini* occurs have few other natural populations of Anacardiaceae members. Although *S. molle* does not naturally occur in the area where thrips occur, ornamental plants were found and searched at four locations that also had thrips. These included four sites, one each in Parana, Minas Gerais, Rio de Janeiro, and Sao Paulo states. The plants were visually inspected and shaken to collect insects as described above but thrips were never found on *S. molle*. Similar searches resulted in finding thrips on *Lithrea* spp.; however these were a different species as revealed by both morphology and DNA analysis (Wheeler, unpublished data).

Currently, 13 species of *Pseudophilothrips* have been described and their host ranges, where known, are listed below from several different plant families (Table 1) (ThripsWiki, 2014). Only *P. ichini* and *P. gandolfoi* are known from host species of the Anacardiaceae. The host range of other thrips species of this genus are reported from members of the Sapindaceae, Lauraceae, and Araliaceae.

Table 1. Known members of the *Pseudophilothrips* genus, their distribution, and host.

- *P. adisi* (zur Strassen) Described from Manaus, Amazonas, Brazil from flower buds of *Paullinia cupana* Knuth (Sapindaceae)
- *P. amabilis* Johansen Described from Mexico, host unknown
- *P. avocadis* (Hood) Described from Panama from avocado, *Persea americana* Mill (Lauraceae)

- *P. didymopanicis* (Del-Claro & Mound) Described from Uberlandia, Brazil from *Didymopanax vinosum* Marchal and *D. macrocarpum* (Cham. Et Schltdl.) Seem. (Araliaceae)
- *P. fugitivus* Johansen Described from Mexico, host unknown
- *P. gandolfoi* Mound, Wheeler, & Williams Described from *Curitiba* Brazil from *Schinus terebinthifolia* Raddi leaves (Anacardiaceae)
- *P. ichini* (Hood) Described from Brazil from *Schinus terebinthifolia* Raddi leaves (Anacardiaceae)
- *P. moundi* Johansen from Mexico, host unknown
- *P. obscuricornis* (Priesner) Described from Paraguay, host unknown
- *P. perseae* (Watson) Described from Honduras from avocado *P. americana* (Lauraceae)
- *P. retanai* Soto Described from Costa Rica, host unknown
- *P. seticollis* (Karny) Described from Paraguay, host unknown
- *P. varicornis* (Hood) Described from Mexico from grass and weeds

2.6 Life History of *Pseudophilothrips ichini*

The life history stages of *P. ichini* include an egg, two larval stages, three pupal stages, and the adult (Fig. 2). The larval and adult stages only feed on the tips and leaves of Brazilian peppertree. The pupal stages are non-feeding, resting stages that occur in the soil, whereas all other stages occur on the plant. A freshly laid egg required on average (± SE) 5.5 (± 0.1) days to hatch. The first and second larval instars required 5.0 (± 0.3) days and 8.1 (±1.0) days, respectively, followed by the pupal stages which required 6.3 (± 0.2) days. Total development time at 27°C from egg hatch to adult emergence was 20.0 (± 1.4) days. Thrips can complete development at temperatures ranging from 20 to 30°C (Manrique et al., 2014), which coincides with temperatures found in Florida and Hawaii. Physiological models based on cold tolerance suggest that *P. ichini* may establish throughout the geographical range of Brazilian peppertree in the United States (Manrique et al., 2014).

Thrips population dynamics observed from Brazilian field surveys indicate that this species is present year round and its densities are influenced more by the availability of host flushing tips than by seasons. Thrips were present during every Brazilian survey (n = 19) conducted between 2005 and 2014, and these surveys occurred during every month of the year, except May. These field observations indicated that this thrips will typically be found feeding on the Brazilian peppertree expanded flush leaves produced periodically at branch tips. Adults colonize first by feeding on the flush leaves, followed by egg deposition on the leaves, and two larval stages which feed preferentially on the stems of the growing tip. Typically these attacked stems and tips produce leaves that are distorted and wrinkled eventually leading to death of the plant tip. Branches that had these dead tips were never seen flowering which precludes reproduction of the attacked tissues. If released in its invaded range, the thrips should have abundant food supply. Surveys conducted in south Florida indicated Brazilian peppertrees flush new leaves year round except late October and early November (Ewel et al., 1982). It is expected that *P. ichini* will reproduce year round especially in the weed's southern regions of the invaded range. With the short generation time (20 days), at least 12 generations per year are expected.

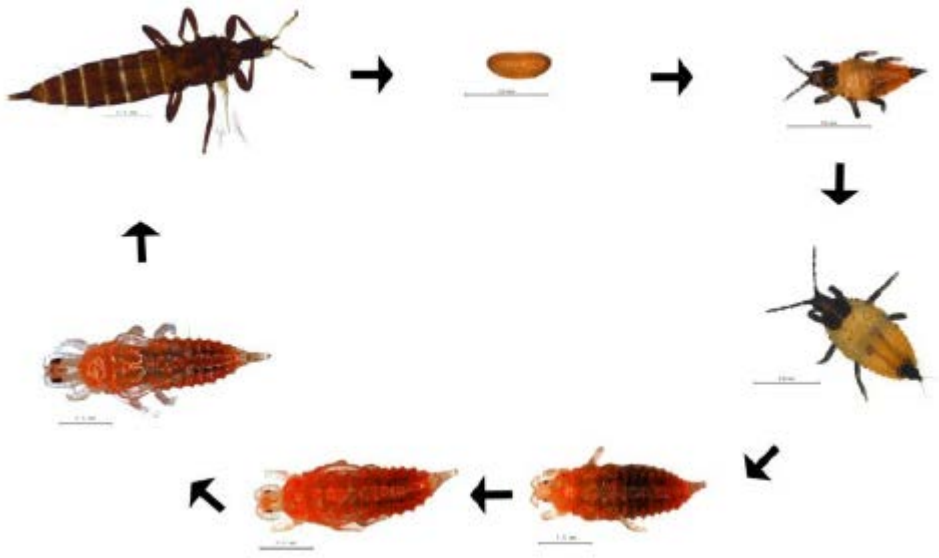

Figure 2. Life history stages of the thrips, *Pseudophilothrips ichini* reared on host leaves of *Schinus terebinthifolia* in quarantine USDA/ARS/IPRL (horizontal bar = 0.5 millimeter). (From: Wheeler et al., 2014)

Although many insect predators, including ants and spiders, were seen abundantly on the host in Brazil, no predation of any thrips life stage was observed during these surveys. Despite the thrips occasionally reaching high densities (e.g., > 100 adults/leaflet; Fig. 3), they may be protected from predators by defensive allomones as is known from other thrips species (Blum et al., 1992; Suzuki et al., 2004). These are characteristically produced in thrips when disturbed and can be recognized by the raised abdomen tip which secretes a droplet of repellent liquid. This same tip raising behavior was observed in *P. ichini*. The only observed natural enemies of these thrips were discovered during the initial field collection of larvae of *P. ichini*. A few (less than 5 percent) field collected individuals were attacked by a parasitoid, *Thripastichus* sp. (Hymenoptera: Eulophidae) (Determined by J. La Salle, CSIRO, Australia). These parasitoids were excluded during quarantine colonization and have not been seen since this initial collection from Brazil.

Figure 3. Adult thrips *Pseudophilothrips ichini* aggregation on flushing leaves of the host, *S. terebinthifolia* in Brazil killing growing tips and causing distortion of expanded leaves. (From: Wheeler et al., 2014)

2.7 Populations of the Agent Studied

The thrips *P. ichini* population introduced under quarantine for testing was originally field collected from Brazilian peppertree leaves in November 2007. The original collection occurred at a site (-20.36911 latitude; -43.56029 longitude; 1,329 meter elevation) near Ouro Preto, Minas Gerais state in Brazil. Of the six thrips DNA variants found, this collection was identified by molecular techniques as haplotype number one. Upon arrival in the United States, *P. ichini* collection was divided between two quarantines, the Invasive Plant Research Lab USDA/ARS in Ft. Lauderdale and the University of Florida, BCRCL in Ft. Pierce, FL. All laboratory studies were conducted at these two quarantines from this single introduction. The identity of these colonies was confirmed with genetic analysis (Williams, D. Texas Christian University, unpublished data). The thrips were collected from a haplotype A Brazilian peppertree plant, one of the two parental lines that are invasive in Florida and Hawaii (Williams et al., 2007). Extensive molecular analysis described above indicated this thrips was one of the two main haplotypes of this species found in Brazil and was collected throughout much of the native range of the host. This same thrips haplotype was also found in Sergipe, Bahia, Espirto Santo, Rio de Janeiro, Sao Paulo and Minas Gerais states. Sites ranged from sea level to 1,329 meters elevation, from 11.43° to 24.30° south latitude. Field observations reported here were conducted throughout this geographic range.

3. Host Specificity Testing

3.1 Test Plant List

Test plant lists are developed by researchers for determining the host specificity of biocontrol agents of weeds in North America. Test plant lists are usually developed on the basis of phylogenetic relationships between the target weed and other plant species (Wapshere, 1974). It is generally assumed that plant species more closely related to the target weed species are at greater risk of attack than more distantly related species.

The host specificity test strategy as described by Wapshere (1974) is "a centrifugal phylogenetic testing method which involves exposing to the organism a sequence of plants from those most closely related to the weed species, progressing to successively more and more distantly related plants until the host range has been adequately circumscribed." Researchers do not pursue release of biological control agents that do not demonstrate high host specificity to the target weed.

3.1.1 Test plant list. The strategy for developing this test plant list generally followed that recommended by Wapshere (1974) with modifications described in Briese and Walker (2008). A test plant list for Brazilian peppertree was compiled using North American, Caribbean, and Mexican flora. A plant list for this weed was previously submitted by other authors and approved by the Technical Advisory Group for Biological Control Agents of Weeds (TAG) which served as a template for the list included here. The TAG-reviewed plant list (TAG 03-05) included 90 species from 48 plant families. The test plant list for *P. ichini* generally followed this reviewed list with several improvements. One of the primary changes is in response to a recent critisism that previous scientists placed an overreliance on taxonomic nomenclature rather than actual genetic relationships (Briese and Walker, 2008). Increased safety in potential agent testing could be obtained by imposing greater emphasis on testing close phylogenetic relatives of the target weed. The researchers decreased emphasis on testing of unrelated species from families outside the Sapindales and focused more testing on close relatives. In total, 116 species from 45 plant families from 33 plant orders were tested. These included mostly members of the order Sapindales to which the family Anacardiaceae is assigned. The reserachers tested 23 species of the Anacardiaceae and 60 species of the families of the Sapindales. Due to their economic importance and occurrence in the invaded range, four known and one unknown mango variety and the primary cultivated pistachio variety were tested.

North American Test Plants by TAG Category

Category 1: Genetic types of the target weed species: Two genetic varieties of Brazilian peppertree and their intraspecific hybrid occur in Florida. These are referred to as A haplotype, B haplotype, and the hybrid (Williams et al., 2007). Only the A haplotype is known from Hawaii. Previous research showed that the different Brazilian peppertree varieties were nutritionally similar for *P. ichini*. When fed leaves from the two parental haplotypes (A and B) and hybrid, *P. ichini* had similar survival and development times (Manrique et al., 2008). Further research indicates that the thrips haplotype tested here (haplotype one from Ouro Preto) will have similar

fecundity when fed Brazilian peppertree leaves from haplotypes A and B and their hybrid (Manrique et al., 2014).

Category 2: Species in the same (or closely related) genus as the target weed, including environmentally and economically important species: The weed genus, *Schinus*, is endemic to South America and only *Schinus molle* has ornamental value in the United States. This species is an introduced ornamental in Arizona, California, Florida (one county reported from a 1931 collection), Hawaii, Texas (one county reported), and Puerto Rico (USDA/NRCS, 2002) (Bargeron and Swearingen, 2010) (Appendix 1). *Schinus molle* is common in California where it has unfortunately also naturalized in wild habitats and is now considered invasive (Nilsen and Muller, 1980; Howard and Minnich, 1989). Similarly, *S. molle* has naturalized in rangeland at Puu Anahulu on the big island of Hawaii (North Kona District). Two other congeners, *S. polygamus* and *S. longifolius*, are listed as introduced in California and Texas, respectively (USDA/NRCS, 2002). However *S. polygamus* is considered a weed in dry areas of southern California (Calflora.org, 2014).

Category 3: Species in other genera in the same family as the target weed, divided by subfamily and tribes, including environmentally and economically important species: Following recent molecular analysis, only two divisions of the Anacardiaceae have been established, the Anacardioideae and the Spondioideae (Pell et al., 2011). The Anacardioideae includes most of the genera that occur in North America and the species tested here. The Spondioideae includes a single genus, *Spondias* whose native range is the Caribbean, and two species occur occasionally as ornamentals in southwestern Florida. Of the Anacardioideae subfamily, members of the *Schinus* (target weed and one other species), *Anacardium* (1 species), *Cotinus* (2 species), *Mangifera* (1 species), *Metopium* (1 species), *Pistacia* (3 species), *Rhus* (6 species), and *Toxicodendron* (3 species) genera were tested (Appendix 1). Because of the possibility that *P. ichini* might migrate naturally to Caribbean areas, 3 endemic species of *Spondias* and the endemic *Comocladia dodonaea* were included. The only major economic crop grown in the United States from the Anacardiaceae includes pistacio, *P. vera*. Mango, *M. indica*, is also grown but has little commercial value. The primary variety of pistacio grown commercially in California (Kerman) and five varieties of mango (Carrie, Common, Haden, Ice Cream, and unidentified) were tested (Appendix 1).

Category 4: Threatened and endangered species in the same family as the target weed:
One member of the Anacardiaceae that occurs near the invaded range of the weed is federally listed as endangered (Coile and Garland, 2003). This species, *Rhus michauxii*, false poison sumac, historically occurred in the piedmont of the Carolinas, Georgia, and Florida where it occupied sandy or rocky openwoods (USDA/NRCS, 2002). At present *R. michauxii* occurs in northern Georgia, central counties of the Carolinas, and southern Virginia. The only reported occurrence of this species near the invaded range of Brazilian peppertree is Alachua county Florida where it was collected only once in 1961 from a single male clone (Florida Museum of Natural History, FLAS accession # 81935). This species is listed as endangered by the U.S. Fish and Wildlife Service, and is protected by the states of Florida, Georgia, and North Carolina. Other state listings include *Cotinus obovatus* (Tennessee) and *Toxicodendron vernix* (Kentucky). All three species, and other members of these genera, were tested here.

Category 5– North American or introduced species in other families that have some phylogenetic, morphological, or biochemical relationship to the target weed, including economically and environmentally important plants: Recent phylogenetic analyses are followed here and place the Anacardiaceae in the Sapindales order along with the families Aceraceae, Burseraceae, Hippocastanaceae, Meliaceae, Rutaceae, Sapindaceae, Simaroubaceae, Staphyleaceae, and Zygophyllaceae (USDA/NRCS, 2002; Stevens, 2011). Thirty-seven species from these families of the Sapindales order were tested (Appendix 1).

Category 6. North American or introduced species in other orders that have some phylogenetic, morphological, or biochemical relationship to the target weed, including economically and environmentally important plants: According to recent molecular phylogenies (Judd et al., 2002), the Sapindales order, is most closely related to several plant orders, among them are the plant orders Brassicales, Malvales, and Myrtales. Numerous members of these orders were tested as were more distantly related species (Appendix 1).

The chemical composition of Brazilian peppertree, including flavonoids and terpenoids, have been well characterized (Furth and Young, 1988; Wheeler et al., 2014). However, these do not represent chemical signatures unique to this species as these compounds occur broadly in many plant species. One exception is Spathulenol, which is repellent to several herbivore species. This compound also occurs in cotton (*Gossypium hirsutum*) which was tested here. Another group of compounds with more restricted phylogenetic distribution include the substituted catechols. Among these there are at least nine varieties of urushiols that are only known from Ginkgoaceae (*Ginkgo biloba*) and members of the Anacardiaceae family (Gross et al., 1975; Schotz, 2002). Species tested here that contain urushiols include *Ginkgo biloba, Comocladia dodonaea, Metopium toxiferum*, and *Toxicodendron* spp. Trace amounts of urushiols were also detected in Brazilian peppertree (Wheeler et al., 2014).

There is concern about possible spill over events that can occur when *P. ichini* populations build up and damage the weed to a point where the starving insects may temporarily feed on neighboring unrelated plants. Many of these species have significant economic or ecological value and were tested here as ‘safe-guard’ species. Consequently, numerous unrelated economic plants and ecologically dominant species were tested (Appendix 1).

Category 7: Any plant on which the biological control agent or its close relatives (within the same genus) have been previously recorded to feed and/or reproduce: The thrips, *P. ichini*, has not been previously recorded to feed or reproduce on other plant species. Hosts of most members of the genus *Pseudophilothrips* are unknown, however, species have been reported from ‘weeds and grass’, *Persea americana* (Lauraceae), flower buds of *Paullinia cupana* (Sapindaceae), *Didymopanax* spp. (Araliaceae) (Table 1; ThripsWiki, 2014). *Persea americana* (avocado) was tested; neither *Paulilinia* nor *Didymopanax* occur in the continental United States and so were not tested. However, other species of Sapindaceae were tested (Appendix 1).

3.1.2 Design.

1. Plant parts and growth stages tested – All tests were conducted on whole plants that were pruned and fertilized to stimulate the flush growth needed for thrips feeding and development. Plants were kept free of pests with periodic insecticide applications, however, no plants were used within 3 months of treatment.

2. Source populations of the test plants - Most test plants were obtained from plant nurseries. These included Pine Island Nursery (Miami, FL), Silent Native Nursery (Palmetto Bay, FL), Pine Ridge Gardens (London, AR) and seed catalog Sheffelds Seed Co (New York, NY). For species not available commercially, seeds were collected from local wild populations. The listed species, *Rhus michauxii*, was generously provided by Dr. J.L. Randall (University of North Carolina, Chapel Hill, NC). *Pistacia mexicana* seeds were generously provided by Mr. Jack Skiles (Langtry, TX) and Ms. Ann Vacek (USDA/Agricultural Research Service, Weslaco, TX). *Pistacia vera* seeds were donated by Mr. Craig Kallsen (Univ. California, Davis) and seedlings were provided by Mr. Lane Miller (S&J Ranch, Pinedale, CA). *Toxicodendron pubescens* were collected and provided by Dr. Richard Weaver (retired botanist, Department of Plant Industry, Gainesville, FL). *Comocladia dodonaea* plants were collected and provided by Mr. Tony Pernas (National Park Service, Homestead, FL). Plants from Hawaii were provided by Mr. Pat Conant (retired, HI Department of Agriculture, Hilo, HI) and Dr. Tracy Johnson (USDA/Forest Service, Volcano, HI). The Brazilian peppertree control plants were grown from locally collected seeds.

3. Numbers of replicates – In general, the number of replicates for no-choice tests was 10 for species of the closest relatives, such as species from the Anacardiaceae family; otherwise 4 replicates were included. In several examples, plants were difficult to obtain and grow and sufficient numbers for the desired replication were not achieved. Examples include the endangered plant species, *Rhus michauxii* (n=7), *Toxicodendron vernix* (n=6), and *Spondias mombin* (n=4). Only healthy plants with flushing growth were tested, which was a challenge for several species under subtropical south Florida growing conditions. Despite fewer than the target number of replicates, there was no variation in the thrips testing results with these species (see results). Moreover, other representative of these genera were tested with the target number of replicates. Although *Dodonaea viscosa* is assigned to the Sapindaceae and thus not a close relative, 10 replicates were included because of possible *P. ichini* feeding and development on this species. To confirm results obtained by each quarantine group, half the replicates of the Anacardiaceae were tested in each quarantine (Ft. Lauderdale and Ft. Pierce).

4. Number, stage, and age of individuals – In no choice and two choice tests, 20 adult thrips from the quarantine colony were introduced into vented cages with plants. These cages were constructed of clear Plexiglas®, measured 45 centimeters (cm) in height x 15 cm in diameter (Fig. 4), and were fitted with a mesh vent at the top and 2–3 vents (4 cm diameter) on the cylinder side. The open end of these cages fit tightly inside the upper rim of a 3.8 liter (1 gallon) pot. All experiments were conducted in quarantine greenhouses at 27 ± 2°C at 60–70 percent relative humidity (RH) under ambient photoperiod. All plants were watered as needed and inspected visually at least three times per week. To prevent the production of a second generation, adults were removed as soon as larvae were found on the plants. The total number of

F_1 adults produced was counted. Thus, data on *P. ichini* oviposition and completion of development on different test plant species was obtained.

5. Details of experimental setup – The protocol for host range tests can be divided into no-choice, choice and multiple generation tests. To predict the host range of *P. ichini*, the field host range observed in Brazil was supplemented with this series of tests. Here simultaneous no-choice starvation tests were conducted that extended for a complete generation of the thrips. These starvation no-choice tests are the most rigorous and conservative test design used to define a candidate's fundamental or physiological host range (Van Klinken and Heard, 2000; Schaffner, 2001). The primary criticism of these tests is that they potentially overlook candidates that would be safe to release (Cullen, 1990; Schaffner, 2001). Two choice tests were also conducted as they may complement the no-choice tests and are often considered to better simulate more natural conditions than no-choice tests (Harley, 1969). Choice tests may be accepted as better predictors of risk than other testing methods (Cullen, 1990). The two choice tests conducted were the 'normal choice tests' as they simultaneously exposed the target weed and a single test species (Schaffner, 2001). These tests were conducted during the candidate's most mobile life stage, the adult, where 'decisions' are made for oviposition. When F_1 offspring resulted from a no-choice test, the individuals were followed where possible, with multiple generation tests. These tests determined the number of generations a population of the agent could sustain solely on the non-target species.

Figure 4. Plexiglas cylinders (45 cm x 15 cm diameter) used to conduct no-choice tests for the thrips *Pseudophilothrips ichini*.

3.1.3 No-choice tests. No-choice tests assessed oviposition, completion of development, and reproduction on test plant species. Twenty thrips adults were introduced into the standard vented cage (Fig. 4) that contained either a single control or test plant. These P_1 adults were allowed to feed, mate and oviposit until second instar larvae were observed (~23 days), after which time the cage was removed and the P_1 adults were collected. The cage was replaced and the exposed plants were observed over the next 27 days (one generation plus a 7 day buffer) for the maturation of F_1 offspring. The number of F_1 adults were counted and the experiment was terminated.

3.1.4 Choice tests. If F_1 offspring were produced on a non-target species during no-choice tests, a choice test was conducted that included that non-target species and Brazilian peppertree. The choice tests were conducted by releasing 20 adult thrips into a medium size Plexiglas® cage (50 x 50 x 50 cm; Fig. 5) or a large fabric cage (100 x 100 x 100 cm). The thrips were allowed to feed and oviposit on either the target weed or the same species of non-target plant. The thrips adults were released on the base of the cage, between the weed and test plants. Cages were checked three times per week. When second instars were visible, the adults were removed and each plant was placed separately into the standard vented cage (Fig. 4). The exposed plants were left undisturbed for at least 27 days then the number of F_1 adults produced in each cage was counted and the experiment was terminated. This way preference of *P. ichini* could be determined and again (as in the no-choice tests) whether the test plant was a developmental host.

Figure 5. Plexiglas® cages (50 cm x 50 cm x 50 cm) used to conduct choice tests for *P. ichini*. This replicate contains one plant of the target, Brazilian peppertree and one plant of *Rhus sandwicensis*. When second instars were observed, the adults were removed and the plants were separated into individual cylindrical cages for emergence of F_1 adults.

3.1.5 Multiple generation tests. The protocol for multiple generation tests was to maintain F_1 adults produced during no-choice or choice tests to subsequent generations on the same test plant species. This was attempted by transferring whatever F_1 adults were produced to a fresh plant of the same species. We planned to transfer up to 20 F_1 adults to new cages (Fig. 4) that contained the same non-target species. If fewer than 20 F_1 adults were produced, transfers were made with what was available. Simultaneous controls were treated identically with 20 F_1 adults. To determine the feasibility of continuing a thrips population on each non-target, this process was to be repeated for three generations or until no futher F_1 adults were found. The plan was to compare the number of larvae and adults produced at each generation between the test plants and the Brazilian peppertree controls. Although this was the planned protocol for muliple generation tests, obtaining sufficient numbers of F_1 thrips from a non-target and additional plants to test them was often difficult. Most often too few F_1 adults were produced from these species (see results below). Additionally, for some species (e.g., *S. molle*) insufficient test plants were available to continue to the next generation.

3.1.6 Positive controls. Positive controls were used in all studies simulataneously with each test plant where thrips were fed Brazilian peppertree plants. These positive controls were included to ensure that lack of feeding and development on the test plant was not due to problems with insect quality or unfavorable conditions. Similar data were recorded on the control thrips for F_1 production on the target weed. If thrips failed to reproduce and fewer than 10 F_1 adults were observed on the control, experimental results were discarded and the test plants were re-evaluated.

3.1.7 Rationale for study design and execution. Thrips feed by puncturing the cell walls of healthy flushing plant tips with a mandible and subsequently suck the plant juices that leak from the wound (Kirk, 1995). Plants are known to respond to thrips damage by inducing anti-herbivore defenses that change host selection by thrips (Delphia et al., 2007). For these reasons, tests were conducted on whole, live plants, not bouquets or leaf disks (Palmer, 1999). The thrips are small (~3 mm in length) delicate arthropods that are easily lost or damaged by removing cages and handling. Once thrips adults were introduced into each cage, they were left undisturbed as much as possible to avoid false negative results where thrips mortality was caused by handling and not a lack of host plant suitability. A test was considered successful if at least 10 F_1 adults were produced on the Brazilian peppertree positive control plant.

All tests of the members of the Anacardiaceae were conducted independently at quarantine facilities at Ft. Lauderdale and Ft. Pierce. To detect laboratory-induced factors that could influence the results, half the replicated tests were conducted at each lab and their results were shared by the team members.

3.2 Discussion on Host Specificity

3.2.1 No-choice tests. The results of no-choice tests indicated that F_1 adults were produced on the congener of the target weed, *S. molle* (Table 2). Seven of nine (78 percent) of the replicate plants of this species were accepted by the thrips. The number of F_1 adults produced on *S. molle* averaged 20.3, whereas we obtained 124.9 F_1 adults on average from the Brazilian peppertree

control. F_1 adults were also found from eight other species of the Anacardiaceae and one species outside the family. These averages ranged from 0.4–5.5 thrips per plant. The percent of the replicate test plants accepted by the thrips ranged from 7–50 percent of the plants. The average number of F_1 adults produced when fed these test plants was generally less than 2, except for the 5.5 F_1 thrips produced on *R. sandwicensis*. Only one species outside the Anacardiaceae produced F_1 adults. This was *Dodonaea viscosa*, a member of the Sapindaceae, where 30 percent of the plants were accepted and an average of 2.8 F_1 adults was produced on the plants tested (Table 2). Overall, feeding damage on these non-target species was negligible compared to the target weed that had dried stems and damaged leaves by the end of the experiment.

Table 2. Results of no-choice tests. Number of F_1 adult offspring produced of the *Pseudophilothrips ichini* thrips candidate biological control agent of Brazilian peppertree. Twenty adult thrips were released in a cage with each test or control. Data were collected on the number of F_1 adult offspring produced in each cage.

Spp Number	Species [1]	Replicate plants tested	Plants w/F1 thrips	F1 thrips produced		
				Mean	se	Range
1	*Schinus terebinthifolia*	80	80	124.9	10.3	12-388
2	*Schinus molle*	9	7	20.3	7.6	0-65
3	*Anacardium occidentale*	10	0	0	0	0
4	*Comocladia dodonaea*	10	0	0	0	0
5	*Cotinus coggygria*	14	1	0.4	0.4	0-6
6	*Cotinus obovatus*	10	0	0	0	0
	Malosma laurina	**4**	**2**	**2**	**1.1**	**0-5**
7	*Mangifera indica*	4	0	0	0	0
8	*Mangifera indica*-Carrie	4	0	0	0	0
9	*Mangifera indica*-Common	4	0	0	0	0
10	*Mangifera indica*-Haden	4	0	0	0	0
11	*Mangifera indica*-Ice Cream	4	0	0	0	0
12	*Metopium toxiferum*	10	3	1.4	0.9	0-10
13	*Pistacia chinensis*	10	2	0.2	0.1	0-1
14	*Pistacia mexicana*	9	0	0	0	0
15	*Pistacia vera*	10	3	0.8	0.6	0-7
16	*Rhus aromatica*	10	0	0	0	0
17	*Rhus copallinum*	10	0	0	0	0
18	***Rhus glabra***	**10**	**5**	**0.9**	**0.3**	**0-3**
19	*Rhus michauxii*	7	0	0	0	0
20	*Rhus sandwicensis*	10	1	5.5	3.3	0-33
21	*Rhus typhina*	10	3	2.9	2.6	0-26
22	*Toxicodendron pubescens*	11	0	0	0	0
23	*Toxicodendron radicans*	10	0	0	0	0
24	*Toxicodendron vernix*	6	0	0	0	0
25	*Spondias dulcis*	9	0	0	0	0
26	*Spondias mombin*	4	0	0	0	0
27	*Spondias purpurea*	10	0	0	0	0
28	*Acer rubrum*	4	0	0	0	0
29	*Acer saccharinum*	4	0	0	0	0
30	*Bursera simaruba*	4	0	0	0	0
31	*Aesculus pavia*	4	0	0	0	0
32	*Aglaia odorata*	2	0			
33	*Azadirachta indica*	4	0	0	0	0
34	*Entandrophragma caudatum*	4	0	0	0	0
35	*Khaya senegalensis*	4	0	0	0	0
36	*Lansium domesticum*	4	0	0	0	0
37	*Sandoricum koetjape*	4	0	0	0	0

38	*Swietenia macrophylla*	4	0	0	0	0

Spp Number	Species [1]	Replicate plants tested	Plants w/F1 thrips	F1 thrips produced		
				Mean	se	Range
39	*Swietenia mahagani*	4	0	0	0	0
40	*Toona ciliata*	4	0	0	0	0
41	*Casimiroa edulis* (Redlands)	4	0	0	0	0
42	*Citrofortunella microcarpa*	4	0	0	0	0
43	*Citrus x aurantifolia*	4	0	0	0	0
44	*Citrus x sinensis*	4	0	0	0	0
45	*Flindersia brayleyana*	4	0	0	0	0
46	*Fortunella japonica*	4	0	0	0	0
47	*Murraya exotica (=paniculata)*	4	0	0	0	0
48	*Zanthoxylum fagara* **	4	0	0	0	0
49	*Dimocarpus longan*/Biew Kieuw	4	0	0	0	0
50	*Dodonaea viscosa*	10	3	2.8	1.7	0-16
51	*Exothea paniculata*	4	0	0	0	0
52	*Filicium decipiens*	4	0	0	0	0
53	*Harpullia pendula*	4	0	0	0	0
54	*Hypelate trifoliata*	4	0	0	0	0
55	*Koelreuteria paniculata*	4	0	0	0	0
56	*Litchi chinensis* var. mauritius	7	0	0	0	0
57	*Majidea zanguebarica*	4	0	0	0	0
58	*Sapindus oahuensis*	2	0	0	0	0
59	*Sapindus saponaria*	4	0	0	0	0
60	*Leitneria floridana*	4	0	0	0	0
61	*Simarouba glauca*	4	0	0	0	0
62	*Staphylea trifolia*	4	0	0	0	0
63	*Guaiacum sanctum*	4	0	0	0	0
64	*Tribulus cistoides*	4	0	0	0	0
65	*Alocasia macrorrhizos*	4	0	0	0	0
66	*Daucus carota*	4	0	0	0	0
67	*Ilex cassine*	4	0	0	0	0
68	*Ambrosia trifida*	4	0	0	0	0
69	*Lactuca sativa*	4	0	0	0	0
70	*Solidago arguta*	4	0	0	0	0
71	*Brassica oleracea*	4	0	0	0	0
72	*Ananas comosus*	4	0	0	0	0
73	*Nyssa sylvatica*	4	0	0	0	0
74	*Oryza sativa*	4	0	0	0	0
75	*Saccharum officinarum*	4	0	0	0	0
76	*Zea mays*	4	0	0	0	0
77	*Sambucus nigra*	4	0	0	0	0
78	*Planchonella sandwicensis*	4	0	0	0	0
79	*Arctostaphylos densiflora*	4	0	0	0	0
80	*Ardisia escallonioides*	4	0	0	0	0
81	*Acacia koa*	4	0	0	0	0
82	*Arachis hypogaea*	4	0	0	0	0
83	*Phaseolus vulgaris*	4	0	0	0	0

84	*Sophora chrysophylla*	4	0	0	0	0

Spp Number	Species [1]	Replicate plants tested	Plants w/F1 thrips	F1 thrips produced		
				Mean	se	Range
85	*Alnus serrulata*	4	0	0	0	0
86	*Quercus virginiana*	4	0	0	0	0
87	*Ginkgo biloba*	4	0	0	0	0
88	*Hamamelis virginiana*	4	0	0	0	0
89	*Carya glabra*	4	0	0	0	0
90	*Clerodendrum sp.*	4	0	0	0	0
91	*Tectona grandis*	4	0	0	0	0
92	*Vitex sp.*	4	0	0	0	0
93	*Persea americana*	4	0	0	0	0
94	*Magnolia virginiana*	4	0	0	0	0
95	*Chamaesyce hypericifolia*	4	0	0	0	0
96	*Euphorbia pulcherrima*	4	0	0	0	0
97	*Hippomane mancinella*	4	0	0	0	0
98	*Manihot esculenta*	4	0	0	0	0
99	*Abelmoschus esculentus*	4	0	0	0	0
100	*Gossypium hirsutum*	4	0	0	0	0
101	*Hibiscus sp.*	4	0	0	0	0
102	*Morella (=Myrica) cerifera*	4	0	0	0	0
103	*Laguncularia racemosa*	5	0	0	0	0
104	*Eucalyptus camaldulensis*	4	0	0	0	0
105	*Eugenia axillaris*	4	0	0	0	0
106	*Eugenia uniflora*	4	0	0	0	0
107	*Metrosideros polymorpha*	4	0	0	0	0
108	*Macadamia integrifolia*	4	0	0	0	0
109	*Crataegus spathulata*	4	0	0	0	0
110	*Prunus caroliniana*	4	0	0	0	0
111	*Coffea arabica*	4	0	0	0	0
112	*Myoporum sandwicense*	4	0	0	0	0
113	*Ipomoea batatas*	4	0	0	0	0
114	*Capsicum annuum*	4	0	0	0	0
115	*Solanum lycopersicum*	4	0	0	0	0
116	*Solanum tuberosum*	3	0	0	0	0
117	*Gordonia lasianthus*	4	0	0	0	0
118	*Ulmus alata*	4	0	0	0	0
119	*Carica papaya*	4	0	0	0	0
120	*Musa acuminata*	4	0	0	0	0

3.2.2 Choice tests. Those test plant species that produced F_1 adults in the no-choice tests above were then tested in choice tests. When given a choice, thrips preferred to feed and lay eggs on the target weed, resulting in high numbers of offspring produced (Table 3). As is typically the case, choice tests indicated that the thrips host range was narrower when compared to no-choice tests. For example, nine test plant species produced progeny in no-choice tests while only four species produced progeny under choice testing (Tables 2 and 3). The number of F_1 thrips adults produced on these non-target species was significantly lower than on the target weed. For example, an average of two F_1 thrips (range 0–12) were produced on only one of the six *S. molle* plants tested. Only one F_1 thrips was produced on only one plant of *M. toxiferum*. Similarly, three F_1 thrips were produced on a single plant of *R. glabra* and 1–4 thrips were produced on 4 plants of *R. sandwicensis*. These results suggest that the test plant species lack the ovipositional cues used by ovipositing females and that these non-target species are generally inadequate nutritionally for completion of thrips development.

Table 3. Results of choice tests. Number of F_1 adult offspring produced of the *Pseudophilothrips ichini* thrips candidate biological control agent of Brazilian peppertree. Twenty adult thrips were released in a cage with both a test and a control plant. Data were collected on the number of F_1 adult offspring produced on each plant.

Species	Replicate plants tested	Test plants w/F1 thrips	F1 thrips produced		
			Mean number on St [1]	Mean number on NT [2]	Range number on NT
Schinus molle	6	1	72.3	2	0-12
Cotinus coggygria	8	0	71.0	0	0
Malosma laurina	4	0	61.5	0	0
Metopium toxiferum	9	1	67.4	0.1	0-1
Pistacia chinensis	9	0	69.6	0	0
Pistacia vera	5	0	57.4	0	0
Rhus glabra	11	1	60.4	0.3	0-3
Rhus sandwicensis	9	4	66.1	1.1	0-4
Rhus typhina	9	0	50.1	0	0
Dodonaea viscosa	10	0	51.1	0	0

[1] St: *Schinus terebinthifolia*

[2] NT: Non-target

3.2.3 Multiple generation tests. Multiple generation tests indicated that the *P. ichini* thrips sustained a population for more than one generation only on the two weedy exotic species, the Brazilian peppertree control and *S. molle* (Table 4). For the remaining non-target species, none supported development of thrips past the F_1 generation (Table 4). The number of multiple generation tests ranged from 1 to 8 for different species. However, F_1 adults were successfully produced on at most three replicate plants of *M. laurina*, *R. glabra*, *R. typhina*, and *D. viscosa*. A single F_1 replicate was obtained for the remainder of the species, except none were obtained for *C. coggygria*. The results indicate however, that no larvae or adults were produced from the F_1 generation. For example, as many as 63 larvae were produced on *D. viscosa* and these matured into 16 adults but the adults failed to produce another generation of thrips. Though fewer F_1 larvae were obtained, the same final result was found for the other species tested.

Table 4. Results of multiple generation tests. Number of F_1 larvae and adult offspring produced by the *Pseudophilothrips ichini* thrips candidate biological control agent of Brazilian peppertree. Twenty adult thrips were released in a cage with either a test or a control plant. As F_1 offspring were produced they were counted and the adults were carefully transferred to the same plant species and observed for continued larval and adult production. Data were collected on the number of F_1 adult offspring produced on each plant.

Species	Reps		F1 individuals		F2 individuals	
	Attempted	F1 produced	Mean adults	range	Mean adults	range
Brazilian peppertree	8	8	53.75	20-288	113	33-194
Schinus molle	4	4	34.8	0-125	32.6	0-135
Cotinus coggygria	8	0	0	0	0	0
Malosma laurina	4	1	1	0-6	0	0
Metopium toxiferum	2	1	4	0	0	0
Pistacia chinensis	1	1	1	0	0	0
Pistacia vera	4	1	2	0	0	0
Rhus glabra	6	3	3.7	1-8	0	0
Rhus sandwicensis	1	1*	1	0	0	0
Rhus typhina	6	3	6	1-15	0	0
Dodonaea viscosa	7	3	9.6	6-16	0	0

* Control thrips failed to produced F1 generation

3.3 Summary of Results

A total of 116 plant species (and 5 varieties of mango) were tested as potential hosts of the thrips, *P. ichini*. In no-choice and choice tests they demonstrated a high degree of specificity toward the target weed, Brazilian peppertree. There was minor use and a relatively small amount of reproduction in no-choice tests on several North American and Hawaiian plant species. However, significant F_1 thrips production was only found on the Brazilian congener *S. molle.* This species is an ornamental, close relative of the weed that has also become invasive in California and Hawaii (Nilsen and Muller, 1980; Howard and Minnich, 1989). Most (seven of nine) of the replicate plants of this species were suitable hosts. However, relative to the controls, the average number of F_1 offspring produced on *S. molle* (20.3 F_1 adults) was 16 percent of that on the Brazilian peppertree control plants (124.9 F_1 adults). Choice data indicated that one of the six *S. molle* plants tested produced F_1 adults, but as before, few (average of 2 adults) F_1 adults were produced.

In Brazil the distribution of *Schinus molle* and the thrips do not overlap. *Schinus molle* occurs in the southern state of Rio Grande do Sul, south of the thrips natural range. Climatic differences in these regions probably influence these distributions as *S. molle* is adapted to more temperate, arid conditions while the thrips occupies more subtropical and tropical regions. In its invaded range, Brazilian peppertree occurs in the southwestern corner of California near San Diego, and *S. molle* occurs from the San Francisco area south to San Diego. If permission is granted to release the thrips and it disperses naturally to California it could establish on the Brazilian peppertree plants near San Diego. In the San Diego area, spill over may occur from infested Brazilian peppertrees onto neighboring *S. molle* trees. Considering ornamental *S. molle* was not observed to be damaged by thrips in Brazil it seems unlikely that this will happen. However, the host specificity test results suggest some thrips feeding and development could occur on *S. molle*. Together, the Brazilian field observations and quarantine choice data suggest that *S. molle* is rarely selected by the thrips under more natural conditions and the no-choice starvation results indicate that when this species is used, it is a poor host.

The remaining plants that produced F_1 adults in no-choice tests included *Cotinus coggygria, Malosma laurina, Metopium toxiferum, Pistacia chinensis, Pistacia vera, Rhus glabra, Rhus sandwicensis, Rhus typhina,* and *Dodonea viscosa*. The average number of F_1 adult thrips produced was never higher than 5.5 on any non-target plant (*R. sandwicensis*), compared with the average 124.9 thrips produced per plant on the control. Multiple choice testing further narrowed the number of non-target species that were used by the thrips. In these cases, generally only a single plant replicate of *M. laurina, M. toxiferum* and *R. glabra* produced less than 4 F_1 adults compared with an average of 56.5 F_1 adults produced on Brazilian peppertree. The choice test results showed that under these conditions the most-used test plant, besides *S. molle,* was the Hawaiian *R. sandwicensis* where 4 out of 9 of the plants were used. However, these plants produced few thrips, less than 5 adults per plant. In choice tests, no F_1 adult thrips were produced on *C. coggygria, M. laurina, P. chinensis, P. vera, R. typhina* or *D. viscosa*. These results suggest that, although the host range of the thrips is restricted to Brazilian peppertree, a small amount of non-target feeding may occur. However, these non-target species cannot sustain more than one generation and thus slight damage might occur to these species in the form of spill over

from adjacent infestations on Brazilian peppertree. Of these plant species, such spill over will be restricted as the geographic distribution of only *D. viscosa*, *M. laurina*, *M. toxiferum*, and *R. sandwicensis* overlaps that of Brazilian peppertree. It must be noted that *R. sanwicensis* occurs on Hawaii, and *P. ichini* will not be released there.

3.4 Impacts to Brazilian Peppertree

Potential impacts of *P. ichini* on Brazilian peppertree are difficult to predict. Greenhouse studies showed that plant height and number of stems were reduced following thrips herbivory, and plants were not able to recover after 2.5 months (Manrique et al., 2014). In its native Brazil and in the laboratory environment, feeding leads to plant tips wilting followed by tip death. These damaged tips will not flower or produce fruit until the plant can direct resources again to produce fresh foliage. As Brazilian peppertree is not known to reproduce vegetatively, decreasing the sexual reproduction will reduce the number of seeds, and thus, seedlings produced. This same type of damage occurred with the successful release of the *Melaleuca quinquenervia* biological control agent *Oxyops vitiosa* where tip damage by the agent prevented the weed's ability to regenerate and reinvade (Center et al., 2012). The thrips may also increase the plant's susceptibility to disease and abiotic stresses.

4. Other Issues

4.1 Protocol for Releasing the Agent

Mass rearing of the agent will be conducted by Wheeler and colleagues (USDA/ARS), Overholt and colleagues (University of Florida). Field releases will be conducted throughout Florida in collaboration with extension agents and land managers. Several field sites will be established in the invaded area and post-monitoring of establishment and impact will be conducted (see below). Release strategies for recently introduced biological control agents consider whether it is best to make a few number of large agent releases or a large number of small agent releases. These decisions will be influenced by the number of agent individuals available and the number of prepared release sites (Grevstad, 1999). Previous research concluded that for a similar species, the gorse thrips, numerous relatively small releases of 250 adults per release was successful (Memmott et al., 1998). Initially, the researchers will follow this recommendation but leave open the possibility of adjusting this number as deemed appropriate. Other research has indicated that it may be important to consider a mixture of strategies during the initial release phase allowing time to learn and improve chances of finding the optimum approach (Shea and Possingham, 2000).

4.2 Post-release monitoring

Determination of the impact of a released biological control agent is time consuming and labor intensive. Several pre-release studies were conducted by the researchers in preparation for release of *P. ichini*. Long term, pre-release demographic studies were established in 2008 at six locations in Florida. At each site annual demographic data are being collected that include plant growth, survival, and reproduction of 80 plants. Following the tagging and initial description, plants have

been monitored yearly. Additional data collection includes litterfall that captures the normal foliar and reproductive output and senescence of the population. If approved, thrips will be released at all sites and their populations and impact will be monitored. These data represent pre-release characterizations needed to determine the impact of an agent on the weed population after release (Paynter, 2006; Raghu et al., 2006; Dauer et al., 2012; Evans et al., 2012).

A Brazilian peppertree garden was established at the location in Ft. Lauderdale, FL. Previous research investigated the residual control of systemic insecticides to protect Brazilian peppertrees from *P. ichini* thrips damage. To determine this, treated and untreated leaves at different time intervals post-application were fed to *P. ichini* thrips in quarantine to determine how long the insecticide remained effective. If granted a release permit, similar garden trees planted in 2008 at will be experimentally treated with the same methods and infested with thrips. By protecting Brazilian peppertrees against *P. ichini*, tree survival, reproduction, and growth with and without thrips will be compared.

Additionally, a common garden, field host range experiment was established at the USDA/ARS, Ft. Lauderdale location in 2011 consisting of related plant species of the Anacardiaceae that grow in South Florida. These include the species of Anacardiaceae *Anacardium occidentale*, *Comocladia dodonaea*, *Malosma laurina*, *Mangifera indica*, *Metopium toxiferum*, *Pistacia chinensis*, *Rhus copallinum*, *Spondias dulcis*, *S. purpurea*, *S. mombin*, and *Toxicodendron radicans*. Additionally, members of related plant families in the Sapindales order include *Citrus* spp. (Rutaceae), *Bursera simaruba* (Burseraceae), *Swietenia mahagoni* (Meliaceae), and *Dodonaea viscosa* (Sapindaceae). Plant species can be purchased and added to the garden if the need arises and a release date approaches. This garden is designed to confirm the results of quarantine specificity tests by defining the thrips ecological host range under multi-choice field conditions (Pratt et al., 2009).

III. LISTED SPECIES AND ASSESSMENTS

The following tables include all of the listed species and species proposed for listing that occur within the contiguous United States. Species where a "may affect, not likely to adversely affect" (MANLAA or May affect beneficially (MA – beneficial) determination were made are indicated in the following tables and then discussed further in Table 16.

Table 5. Mammals

Common Name	Scientific Name	Listing status	Critical Habitat (Y or N)	States of Occurrence	Impact/ Effect to Breeding (B), Feeding (F), Sheltering (S), Migration (M), and Nutrition (N)	Determination
Bat, Florida bonneted	*Eumops floridanus*	E	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Bat, gray	*Myotis grisescens*	E	N	AL, AR, FL, GA, IL, IN, KS, KY, MS, MO, NC, OK, TN, VA, WV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Bat, Indiana	*Myotis sodalis*	E	Y	AL, AR, FL, GA, IL, IN, IA, KY, MD, MI, MS, MO, NJ, NY, NC, OH, OK, PA, TN, VT, VA, WV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Bat, lesser long-nosed	*Leptonycteris curasoae yerbabuenae*	E	N	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Bat, Mexican long-nosed	*Leptonycteris nivalis*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Bat, Northern long-eared	*Myotis septentrionalis*	T	N	AL, AR, CT, DE, DC, GA, IL, IN, IA,	B=No F=No S=No	No Effect. This species will not interact with *P. ichini*.

				KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, MT, NE, NH, NJ, NY, NC, ND, OH, OK, PA, RI, SC, SD, TN, VT, VA, WV , WI, WY	M=No N=No	
Bat, Ozark big-eared	*Corynorhinus (=Plecotus) townsendii ingens*	E	Y	AR, MO, OK	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Bat, Virginia big-eared	*Corynorhinus (=Plecotus) townsendii virginianus*	E	Y	KY, NC, VA, WV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Bear, grizzly U.S.A., conterminous (lower 48) States, except where listed as an experimental population or delisted	*Ursus arctos horribilis*	T	N	ID, MT, WA, WY	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Caribou, woodland	*Rangifer tarandus caribou*	E	Y	ID, WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Deer, Columbian white-tailed	*Odocoileus virginianus leucurus*	T	N	OR, WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Deer, Key	*Odocoileus virginianus clavium*	E	N	FL	B=No F=Yes S=Yes M=No N=No L=All	MA - beneficial
Ferret, black-footed	*Mustela nigripes*	E, EXPN	N	AZ, CO, KS, MT, NE, NM, ND, SD, UT, WY	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Fox, San Joaquin kit	*Vulpes macrotis*	E	N	CA	B=No F=No	No Effect. This species will not interact with *P.*

	mutica				S=No M=No N=No	*ichini*.
Fox, Santa Catalina Island	*Urocyon littoralis catalinae*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Jaguar	*Panthera onca*	E	Y	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Jaguarundi, Gulf Coast	*Herpailurus (=Felis) yagouaroundi cacomitli*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Kangaroo rat, Fresno	*Dipodomys nitratoides exilis*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Kangaroo rat, giant	*Dipodomys ingens*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Kangaroo rat, Morro Bay	*Dipodomys heermanni morroensis*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Kangaroo rat, San Bernardino Merriam's	*Dipodomys merriami parvus*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Kangaroo rat, Stephens'	*Dipodomys stephensi (incl. D. cascus)*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Kangaroo rat, Tipton	*Dipodomys nitratoides nitratoides*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Lynx, Canada	*Lynx canadensis*	T	Y	CO, ID, ME, MI, MN, MT, NH, NM, NY, OR, UT, VT, WA, WI, WY	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.

Manatee, West Indian	*Trichechus manatus*	E	Y	AL, FL, GA, LA, MS, NC, SC, TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Mountain beaver, Point Arena	*Aplodontia rufa nigra*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Mouse, Alabama beach	*Peromyscus polionotus ammobates*	E	Y	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Mouse, Anastasia Island beach	*Peromyscus polionotus phasma*	E	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Mouse, Choctawhatchee beach	*Peromyscus polionotus allophrys*	E	Y	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Mouse, Key Largo cotton	*Peromyscus gossypinus allapaticola*	E	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Mouse, New Mexico meadow jumping	*Zapus hudsonius luteus*	E	Y	AZ, CO, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on crtical habitat.
Mouse, Pacific pocket	*Perognathus longimembris pacificus*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Mouse, Perdido Key beach	*Peromyscus polionotus trissyllepsis*	E	Y	AL, FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Mouse, Preble's meadow jumping	*Zapus hudsonius preblei*	T	Y	CO, WY	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on crtical habitat.
Mouse, salt marsh harvest	*Reithrodontomys raviventris*	E	N	CA	B=No F=No S=No M=No	No Effect. This species will not interact with *P. ichini*.

					N=No	
Mouse, southeastern beach	*Peromyscus polionotus niveiventris*	T	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Mouse, St. Andrew beach	*Peromyscus polionotus peninsularis*	E	Y	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Ocelot	*Leopardus (=Felis) pardalis*	E	N	AZ, TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Otter, southern sea	*Enhydra lutris nereis*	T	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Panther, Florida	*Puma (=Felis) concolor coryi*	E	N	FL	B=No F=Yes M=No S=No N=No L=All	MA - beneficial
Pocket gopher, Olympia	*Thomomys mazama pugetensis*	T	Y	WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Pocket gopher, Roy Prairie	*Thomomys mazama glacialis*	T	Y	WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Pocket gopher, Tenino	*Thomomys mazama tumuli*	T	Y	WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Pocket gopher, Yelm	*Thomomys mazama yelmensis*	T	Y	WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Prairie dog, Utah	*Cynomys parvidens*	T	N	UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Pronghorn, Sonoran	*Antilocapra americana*	E, EXPN	N	AZ	B=No F=No	No Effect. This species will not interact with *P.*

	sonoriensis				S=No M=No N=No	*ichini*.
Puma (=cougar), eastern	*Puma (=Felis) concolor couguar*	E	N	Likely extinct	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Rabbit, Lower Keys marsh	*Sylvilagus palustris hefneri*	E	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Rabbit, Pygmy (Columbia Basin DPS)	*Brachylagus idahoensis*	E	N	WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Rabbit, riparian brush	*Sylvilagus bachmani riparius*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Rat, rice	*Oryzomys palustris natator*	E	Y	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Sheep, Peninsular bighorn	*Ovis canadensis nelsoni*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Sheep, Sierra Nevada bighorn	*Ovis canadensis sierrae*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Shrew, Buena Vista Lake ornate	*Sorex ornatus relictus*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Squirrel, Carolina northern flying	*Glaucomys sabrinus coloratus*	E	N	NC, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Squirrel, Mount Graham red	*Tamiasciurus hudsonicus grahamensis*	E	N	AZ	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.

Squirrel, northern Idaho ground	*Spermophilus brunneus brunneus*	T	N	ID	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Vole, Amargosa	*Microtus californicus scirpensis*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Vole, Florida salt marsh	*Microtus pennsylvanicus dukecampbelli*	E	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Vole, Hualapai Mexican	*Microtus mexicanus hualpaiensis*	E	N	AZ	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Wolf, gray	*Canis lupus*	E, T, EXPN	Y	AL, AR, CA, CO, CT, DE, FL, GA, KS, KY, LA, MA, MD, ME, MN, MO, MS, NC, NE, NH, NJ, NV, NY, OK, PA, RI, SC, TN, TX, VA, VT and WV, AZ, IA, IN, IL, ND, NM, OH, OR, SD, UT, WA, WY	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Wolf, Mexican gray	*Canis lupus baileyi*	E, EXPN	N	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Wolf, red	*Canis rufus*	E, EXPN	N	FL, NC, SC, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Wolverine, North American (contiguous U.S. DPS)	*Gulo gulo luscus*	PT	N	CA, CO, ID, MT, NV, NM, OR, UT, WA, WY	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Woodrat, Key Largo	*Neotoma floridana smalli*	E	N	FL	B=No F=No S=No	No Effect. This species will not interact with *P. ichini*.

					M=No N=No	
Woodrat, riparian (=San Joaquin Valley)	*Neotoma fuscipes riparia*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.

*E=Endangered; T=Threatened; PE=Proposed Endangered; PT=Proposed Threatened; EXPN=Experimental Population

Mammal assessment (other than bat species):

Release of *P. ichini* will have no effect on any listed mammal species, except possibly the Florida panther and Key deer, which would benefit from reduction in Brazilian peppertree. Listed mammals in the United States are not known to use Brazilian peppertree, although Florida panthers have been observed in Brazilian pepper stands (Maehr, 1992). However, Brazilian pepper is likely to replace species used as food by white-tailed deer, which are important in the diet of Florida panthers (Maffei, 1994). Brazilian peppertree occurs on islands throughout the range of the Key deer, and can out-compete native vegetation in large areas, reducing the availability of deer forage and degrading deer habitat (FWS, 2010). Some mammals (raccoons) eat Brazilian peppertree fruits (Ewel et al., 1982), but it is not widely eaten and may be toxic to some animals (Morton, 1978; Williams, 1980). Although many animals may use Brazilian peppertree stands for cover, they are not considered optimal habitat for many native taxa (Meyer, 2011).

Any reduction of Brazilian peppertree by *P. ichini* is expected to happen gradually and should not affect other fauna, as it is not heavily used by native wildlife.

Pseudophilothrips ichini will have no effect on any designated critical habitat of these listed mammals in the United States because Brazilian peppertree is not a physical or biological feature essential to the conservation of any listed mammal.

Bat Assessment: Bats would not forage on *P. ichini* because the thrips are very tiny. Brazilian peppertree is not a physical or biological feature essential to the conservation of any listed bat. Release of *P. ichini* will have no effect on listed bats or their designated critical habitat in the United States.

Table 6. Birds

Common Name	Scientific Name	Listing status	Critical Habitat (Y or N)	States of Occurrence	Impact/ Effect to Breeding (B), Feeding (F), Sheltering (S), Migration (M), and Nutrition (N)	Determination
Albatross, short-tailed	*Phoebastria (=Diomedea)*	E	N	CA, OR, WA	B=No F=No	No Effect. This species will not

	albatrus				S=No M=No N=No	interact with *P. ichini.*
Bobwhite, masked (quail)	*Colinus virginianus ridgwayi*	E	N	AZ	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Caracara, Audubon's crested	*Polyborus plancus audubonii*	T	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Condor, California	*Gymnogyps californianus*	E, EXPN	Y	AZ, CA, UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Crane, Mississippi sandhill	*Grus canadensis pulla*	E	Y	MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Crane, whooping	*Grus americana*	E, EXPN	Y	CO, KS, MT, NE, ND, OK, SD, TX, AL, AR, GA, IL, IN, IA, KY, LA, MI, MN, MS, MO, NC, OH, SC, TN, VA, WI, WV, CO, ID, FL, NM, UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Cuckoo, yellow-billed (Western US DPS)	*Coccyzus americanus*	T	N (PCH)	AZ, CA, CO, MT, NV, NM, OR, TX, UT, WA, WY	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on proposed critical habitat.
Curlew, Eskimo	*Numenius borealis*	E	N	NE, OK, TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Falcon, northern aplomado	*Falco femoralis septentrionalis*	E, EXPN	N	TX, AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Flycatcher, southwestern willow	*Empidonax traillii extimus*	E	Y	AZ, CA, CO, NV, NM, TX, UT	B=No F=No S=No M=No	No Effect. This species will not interact with *P. ichini.* No effect

					N=No	on critical habitat.
Gnatcatcher, coastal California	*Polioptila californica californica*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Horned lark, streaked	*Eremophila alpestris strigata*	T	Y	OR, WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Kite, Everglade snail	*Rostrhamus sociabilis plumbeus*	E	Y	FL	B=Yes F=No S=Yes M=No N=Yes L=All	MANLAA
Knot, red	*Calidris canutus rufa*	T	N	AL, AR, CO, DE, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MI, MN, MS, MO, MT, NE, NJ, NY, NC, ND, OH, OK, PA, SC, SD, TN, TX, VA, WV, WS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Murrelet, marbled	*Brachyramphus marmoratus*	T	Y	CA, OR, WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Owl, Mexican spotted	*Strix occidentalis lucida*	T	Y	AZ, CO, NM, TX, UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Owl, northern spotted	*Strix occidentalis caurina*	T	Y	CA. OR. WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Parrot, thick-billed	*Rhynchopsitta pachyrhyncha*	E	N	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Plover, piping	*Charadrius melodus*	T	Y	AL, AR, CO, CT, FL, GA, IA, KS, LA, ME, MA, MN, MO, MT, NE, NH, NJ,	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.

				NM, NY, NC, ND, OK, RI, SC, SD, TX, VA		
Plover, piping (Great Lakes watershed)	*Charadrius melodus*	E	N	IL, IN, MI, MN, OH, PA, WI	B=No F=No S=No M=No N=No L=All	No Effect. This species will not interact with *P. ichini.*
Plover, western snowy	*Charadrius alexandrinus nivosus*	T	Y	CA, OR, WA	B=Yes F=No S=Yes M=No N=No L=All	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Prairie-chicken, Attwater's greater	*Tympanuchus cupido attwateri*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Prairie-chicken, lesser	*Tympanuchus pallidicinctus*	T	N	CO, KS, NM, OK, TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Rail, California clapper	*Rallus longirostris obsoletus*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Rail, light-footed clapper	*Rallus longirostris levipes*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Rail, Yuma clapper	*Rallus longirostris yumanensis*	E	N	AZ, CA, NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Sage-grouse, Gunnison	*Centrocercus minimus*	T	Y	CO, UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Scrub-jay, Florida	*Aphelocoma coerulescens*	T	N	FL	B=Yes F=Yes S=Yes M=No N=Yes	MA- beneficial
Shrike, San Clemente loggerhead	*Lanius ludovicianus mearnsi*	E	N	CA	B=No F=No S=No M=No	No Effect. This species will not interact with *P. ichini.*

					N=No	
Sparrow, Cape Sable seaside	*Ammodramus maritimus mirabilis*	E	Y	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sparrow, Florida grasshopper	*Ammodramus savannarum floridanus*	E	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Sparrow, San Clemente sage	*Amphispiza belli clementeae*	T	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Stork, wood	*Mycteria americana*	T	N	AL, FL, GA, MS, NC, SC	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Tern, California least	*Sterna antillarum browni*	E	N	AZ, CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Tern, least	*Sterna antillarum*	E	N	AR, CO, IA, IL, IN, KS, KY, LA, MS, MO, MT, ND, NE, NM, OK, SD, TN, TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Tern, roseate (northeastern U.S. nesting pop.)	*Sterna dougallii dougallii*	E	N	CT, ME, MA, NH, NJ, NY, NC, RI, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Tern, roseate (Western Hemisphere)	*Sterna dougallii dougallii*	T	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Towhee, Inyo California	*Pipilo crissalis eremophilus*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Vireo, black-capped	*Vireo atricapilla*	E	N	OK, TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Vireo, least Bell's	*Vireo bellii pusillus*	E	Y	CA	B=No F=No S=No	No Effect. This species will not interact with *P.*

					M=No N=No	*ichini*.No effect on critical habitat.
Warbler, Kirtland's	*Setophaga kirtlandii (= Dendroica kirtlandii)*	E	N	FL, MI, SC, WI	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Warbler (=wood), Bachman's	*Vermivora bachmanii*	E	N	FL, SC	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Warbler (=wood), golden-cheeked	*Dendroica chrysoparia*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Woodpecker, ivory-billed	*Campephilus principalis*	E	N	AR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Woodpecker, red-cockaded	*Picoides borealis*	E	N	AL, AR, FL, GA, LA, MS, MO, NC, OK, SC, TX, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*

Bird Assessment: Birds eat Brazilian pepper drupes (Ewel et al., 1982), a mechanism for dispersal of Brazilian peppertree (Panetta and McKee, 1997). However, ingesting drupes can be toxic to birds (Kinde et al., 2012). Curnutt (1989) reported six bird species nesting in Brazilian pepper in Everglades National Park. Red-winged blackbird, common yellowthroat, and eastern towhee densities were higher in a Brazilian pepper stand than densities previously reported for pineland or forest-edge habitats (Curnutt, 1989). A short-term investigation of breeding birds in a Brazilian pepper stand found total bird density and diversity less than those typically found in other habitats, although difference in methodology between studies may explain some of this discrepancy (Curnutt, 1989). The invasion of some scrub habitat within Indian River, St. Lucie, and Martin counties by exotic plants and animals, including Brazilian peppertree, has degraded scrub-jay habitat locally (USFWS, 2007). The Everglade snail kite is known to nest in Brazilian peppertree (Takekawa and Beissinger, 1989), but nests in many other tree species as well.

Any reduction of Brazilian peppertree by *P. ichini* is expected to happen gradually and should not affect other fauna, as it is not heavily used by wildlife.

P. ichini will not be toxic to birds that might forage on it. In a search of the literature, there is no reference indicating that these thrips are toxic (Wheeler et al., 2014).

Release of *P. ichini* will have no effect on any birds because they would have no interaction with it, but release of *P. ichini* may be beneficial to the scrub jay because Brazilian peppertree has

degraded its habitat. Release of *P. ichini* will have no effect on the designated critical habitat of listed birds in the United States. Brazilian peppertree is not a physical or biological feature essential to the conservation of any listed bird.

Table 7. Reptiles

Common Name	Scientific Name	Listing status	Critical Habitat (Y or N)	States of Occurrence	Impact/ Effect to Breeding (B), Feeding (F), Sheltering (S), Migration (M), and Nutrition (N)	Determination
Crocodile, American	*Crocodylus acutus*	T	Y	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Gartersnake, northern Mexican	*Thamnophis eques megalops*	T	N (PCH)	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on proposed critical habitat.
Lizard, blunt-nosed leopard	*Gambelia silus*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Lizard, Coachella Valley fringe-toed	*Uma inornata*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pinesnake, Louisiana	*Pituophis ruthveni*	PT	N	LA, TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Rattlesnake, Eastern massasauga,	*Sistrurus catenatus*	T	N	IL, IN, IA, MI, MN, NY, OH, PA, WI	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Rattlesnake, New Mexican ridge-nosed	*Crotalus willardi obscurus*	T	Y	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sea turtle, green (Breeding colony in FL)	*Chelonia mydas*	E	Y	FL	B=No F=No S=No	No Effect. This species will not interact with *P.*

					M=No N=No	*ichini.* No effect on critical habitat.
Sea turtle, green	*Chelonia mydas*	T	Y	AL, CA, CT, DE, GA, LA, ME, MD, MA, MS, NH, NJ, NY, NC, OR, RI, SC, TX, VA, WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sea turtle, hawksbill	*Eretmochelys imbricata*	E	Y	AL, CT, DE, FL, GA, LA, ME, MD, MA, MS, NH, NJ, NY, NC, RI, SC, TX, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sea turtle, Kemp's ridley	*Lepidochelys kempii*	E	N	AL, CT, DE, FL, GA, LA, MD, MA, MS, NJ, NY, NC, RI, SC. TX, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Sea turtle, leatherback	*Dermochelys coriacea*	E	Y	AL, CA, CT, DE, FL, GA, LA, ME, MD, MA, MS, NH, NJ, NY, NC, OR, RI, SC, TX, VA, WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sea turtle, loggerhead (North Pacific Ocean DPS)	*Caretta caretta*	E	N	OR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Sea turtle, loggerhead (Northwest Atlantic Ocean DPS)	*Caretta caretta*	T	Y	AL, FL, GA, LA, MS, NC, SC, TX, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sea turtle, olive ridley	*Lepidochelys olivacea*	T	N	CA, OR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Skink, bluetail mole	*Eumeces egregius lividus*	T	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Skink, sand	*Neoseps reynoldsi*	T	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Snake, Atlantic salt marsh	*Nerodia clarkii taeniata*	T	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*

Snake, black pine	*Pituophis melanoleucus lodingi*	T	N (PCH)	AL, MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on proposed critical habitat.
Snake, copperbelly water	*Nerodia erythrogaster neglecta*	T	N	IN, MI, OH	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Snake, eastern indigo	*Drymarchon corais couperi*	T	N	AL, FL, GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Snake, giant garter	*Thamnophis gigas*	T	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Snake, narrow-headed garter	*Thamnophis rufipunctatus*	T	N (PCH)	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on proposed critical habitat.
Snake, San Francisco garter	*Thamnophis sirtalis tetrataenia*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Tortoise, desert	*Gopherus agassizii*	T	Y	AZ, CA, UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Tortoise, gopher	*Gopherus polyphemus*	T	N	AL, FL, GA, SC	B=No F=No S=No M=No N=No	MA - beneficial
Turtle, Alabama red-belly	*Pseudemys alabamensis*	E	N	AL, MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Turtle, bog (=Muhlenberg)	*Clemmys muhlenbergii*	T	N	CT, DE, MD, MA, NJ, NY, PA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Turtle, flattened musk	*Sternotherus depressus*	T	N	AL	B=No F=No	No Effect. This species will not

					S=No M=No N=No	interact with *P. ichini.*
Turtle, Plymouth Redbelly	*Pseudemys rubriventris bangsi*	E	Y	MA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Turtle, ringed map	*Graptemys oculifera*	T	N	LA, MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Turtle, Sonoyta mud	*Kinosternon sonoriense longifemorale*	PE	N	AZ	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Turtle, yellow-blotched map	*Graptemys flavimaculata*	T	N	MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Whipsnake (=striped racer), Alameda	*Masticophis lateralis euryxanthus*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.

Reptile Assessment: Release of *P. ichini* will have no effect on any listed reptiles, except for the gopher tortoise. In the Everglades National Park, the nesting habitat of the gopher tortoise is being encroached upon by Brazilian peppertree (Doren and Jones, 1997), although Brazilian peppertree leaves and berries are secondary or seasonal food for gopher tortoises (Ashton and Ashton, 2008). A positive correlation between gopher tortoise density and grass basal cover implies that dense stands of Brazilian peppertree, with their low herbaceous cover (Doren and Whiteaker, 1990) and potential to negatively impact important gopher tortoise forage species (Ashton and Ashton, 2008), are poor habitat for gopher tortoises (Meyer, 2011). Therefore, removal of Brazilian peppertree from the habitat of the desert tortoise may be beneficial to it. No other listed reptiles are known to use Brazilian peppertree. Any reduction of Brazilian peppertree via *P. ichini* is expected to happen gradually and should not directly affect listed reptiles.

P. ichini will not be toxic to reptiles that might forage on it. In a search of the literature, there is no reference indicating that these thrips are toxic (Wheeler et al., 2014).

Release of *P. ichini* will have no effect on the designated critical habitat of listed reptiles in the United States. Brazilian peppertree is not a physical or biological feature essential to the conservation of any listed reptile.

Table 8. Amphibians

Common Name	Scientific Name	Listing status	Critical Habitat (Y or N)	States of Occurrence	Impact/ Effect to Breeding (B), Feeding (F), Sheltering (S), Migration (M), and Nutrition (N)	Determination
Frog, California red-legged	*Rana draytonii*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Frog, Chiricahua leopard	*Rana chiricahuensis*	T	Y	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Frog, dusky gopher	*Rana sevosa*	E	Y	MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Frog, mountain yellow-legged (Northern California DPS)	*Rana muscosa*	E	Y	CA, NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Frog, mountain yellow-legged (Southern California DPS)	*Rana muscosa*	E	Y	CA, NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Frog, Oregon spotted	*Rana pretiosa*	T	Y	CA, OR, WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Frog, Sierra Nevada Yellow-legged	*Rana sierrae*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Hellbender, Ozark	*Cryptobranchus alleganiensis bishopi*	E	N	AR, MO	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Salamander, Austin blind	*Eurycea waterlooensis*	E	Y	TX	B=No F=No	No Effect. This species will not

					S=No M=No N=No	interact with *P. ichini.* No effect on critical habitat.
Salamander, Barton Springs	*Eurycea sosorum*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Salamander, California tiger (Santa Barbara County)	*Ambystoma californiense*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Salamander, California tiger (Sonoma County)	*Ambystoma californiense*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Salamander, California tiger (Central CA DPS)	*Ambystoma californiense*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Salamander, Cheat Mountain	*Plethodon nettingi*	T	N	VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Salamander, desert slender	*Batrachoseps aridus*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Salamander, frosted flatwoods	*Ambystoma cingulatum*	T	Y	FL, GA, SC	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Salamander, Georgetown	*Eurycea naufragia*	T	N (PCH)	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on proposed critical habitat.
Salamander, Jemez Mountains	*Plethodon neomexicanus*	E	Y	NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Salamander, Jollyville Plateau	*Eurycea tonkawae*	T	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.

Salamander, Red Hills	*Phaeognathus hubrichti*	T	N	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Salamander, reticulated flatwoods	*Ambystoma bishopi*	E	Y	FL, GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Salamander, Salado	*Eurycea chisholmensis*	T	N (PCH)	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on proposed critical habitat.
Salamander, San Marcos	*Eurycea nana*	T	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Salamander, Santa Cruz long-toed	*Ambystoma macrodactylum croceum*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Salamander, Shenandoah	*Plethodon shenandoah*	E	N	VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Salamander, Sonora tiger	*Ambystoma tigrinum stebbinsi*	E	N	AZ	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Salamander, Texas blind	*Typhlomolge rathbuni*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Toad, arroyo (=arroyo southwestern)	*Anaxyrus californicus*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Toad, Houston	*Bufo houstonensis*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Toad, Wyoming	*Anaxyrus baxteri*	E	N	WY	B=No F=No S=No	No Effect. This species will not interact with *P.*

					M=No N=No	*ichini.*
Toad, Yosemite	*Anaxyrus canorus*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Waterdog, black warrior	*Necturus alabamensis*	PE	N (PCH)	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on proposed critical habitat.

Amphibian Assessment: Release of *P. ichini* will have no effect on any listed amphibians. Listed amphibians are not known to use Brazilian peppertree. Some amphibian species, including the Florida chorus frog, were rarely or never captured in previously farmed areas in the Everglades, which are commonly dominated by Brazilian pepper (Meyer, 2011). Any reduction of Brazilian peppertree due to *P. ichini* is expected to happen gradually. Thus, bank erosion from the biocontrol of Brazilian peppertree is not expected.

P. ichini will not be toxic to amphibians that might forage on it. In a search of the literature, there is no reference indicating that these thrips are toxic (Wheeler et al., 2014).

Release of *P. ichini* will have no effect on the designated critical habitat of listed amphibians in the United States. Brazilian peppertree is not a physical or biological feature essential to the conservation of any listed amphibian.

Table 9. Fish

Common Name	Scientific Name	Listing status	Critical Habitat (Y or N)	States of Occurrence	Impact/ Effect to Breeding (B), Feeding (F), Sheltering (S), Migration (M), and Nutrition (N)	Determination
Catfish, Yaqui	*Ictalurus pricei*	T	Y	AZ	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Cavefish, Alabama	*Speoplatyrhinus poulsoni*	E	Y	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Cavefish, Ozark	*Amblyopsis rosae*	T	N	AR, MO,	B=No	No Effect. This

				OK	F=No S=No M=No N=No	species will not interact with *P. ichini.*
Chub, bonytail	*Gila elegans*	E	Y	AZ, CA, CO, NV, UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Chub, Borax Lake	*Gila boraxobius*	E	Y	OR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Chub, Chihuahua	*Gila nigrescens*	T	N	NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Chub, Gila	*Gila intermedia*	E	Y	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Chub, headwater	*Gila nigra*	PT	N	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Chub, humpback	*Gila cypha*	E	Y	AZ, CO, UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Chub, Hutton tui	*Gila bicolor ssp.*	T	N	OR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Chub, Owens Tui	*Gila bicolor ssp. snyderi*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Chub, Pahranagat roundtail	*Gila robusta jordani*	E	N	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*

Chub, roundtail (Lower Colorado River DPS)	*Gila robusta*	PT	N	AZ, CO, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Chub, slender	*Erimystax cahni*	T, EXPN	Y	TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Chub, Sonora	*Gila ditaenia*	T	Y	AZ	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Chub, spotfin	*Erimonax monachus*	T, EXPN	Y	AL, NC, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Chub, Virgin River	*Gila seminuda (=robusta)*	E	Y	AZ, NV, UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Chub, Yaqui	*Gila purpurea*	E	Y	AZ	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Cui-ui	*Chasmistes cujus*	E	N	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Dace, Ash Meadows speckled	*Rhinichthys osculus nevadensis*	E	Y	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Dace, blackside	*Phoxinus cumberlandensis*	T	N	KY, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Dace, Clover Valley speckled	*Rhinichthys osculus oligoporus*	E	N	NV	B=No F=No S=No	No Effect. This species will not interact with *P.*

					M=No N=No	*ichini.*
Dace, desert	*Eremichthys acros*	T	Y	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Dace, Foskett speckled	*Rhinichthys osculus ssp.*	T	N	OR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Dace, Independence Valley speckled	*Rhinichthys osculus lethoporus*	E	N	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Dace, Kendall Warm Springs	*Rhinichthys osculus thermalis*	E	N	WY	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Dace, Laurel	*Chrosomus saylori*	E	Y	TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Dace, Moapa	*Moapa coriacea*	E	N	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Darter, amber	*Percina antesella*	E	Y	GA, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Darter, bayou	*Etheostoma rubrum*	T	N	MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Darter, bluemask (=jewel)	*Etheostoma sp.*	E	N	TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Darter, boulder	*Etheostoma wapiti*	E, EXPN	N	AL, TN	B=No F=No S=No M=No	No Effect. This species will not interact with *P. ichini.*

					N=No	
Darter, Cherokee	*Etheostoma scotti*	T	N	GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Darter, Cumberland	*Etheostoma susanae*	E	Y	KY, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Darter, diamond	*Crystallaria cincotta*	E	Y	WV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Darter, duskytail	*Etheostoma percnurum*	E, EXPN	N	KY, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Darter, Etowah	*Etheostoma etowahae*	E	N	GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Darter, fountain	*Etheostoma fonticola*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Darter, goldline	*Percina aurolineata*	T	N	AL, GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Darter, Kentucky arrow	*Etheostoma spilotum*	T	Y	KY	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Darter, leopard	*Percina pantherina*	T	Y	AR, OK	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Darter, Maryland	*Etheostoma sellare*	E	Y	MD	B=No	No Effect. This

					F=No S=No M=No N=No	species will not interact with *P. ichini.* No effect on critical habitat.
Darter, Niangua	*Etheostoma nianguae*	T	Y	MO	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Darter, Okaloosa	*Etheostoma okaloosae*	T	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Darter, pearl	*Percina aurora*	PT	N	MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Darter, relict	*Etheostoma chienense*	E	N	KY	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Darter, rush	*Etheostoma phytophilum*	E	Y	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Darter, slackwater	*Etheostoma boschungi*	T	Y	AL, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Darter, snail	*Percina tanasi*	T	Y	AL, GA, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Darter, vermilion	*Etheostoma chermocki*	E	Y	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Darter, watercress	*Etheostoma nuchale*	E	N	AL	B=No F=No S=No M=No	No Effect. This species will not interact with *P. ichini.*

					N=No	
Darter, yellowcheek	*Etheostoma moorei*	E	Y	AR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Gambusia, Big Bend	*Gambusia gaigei*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Gambusia, Clear Creek	*Gambusia heterochir*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Gambusia, Pecos	*Gambusia nobilis*	E	N	NM, TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Gambusia, San Marcos	*Gambusia georgei*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Goby, tidewater	*Eucyclogobius newberryi*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Logperch, Conasauga	*Percina jenkinsi*	E	Y	GA, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Logperch, Roanoke	*Percina rex*	E	N	NC, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Madtom, chucky	*Noturus crypticus*	E	Y	TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Madtom, Neosho	*Noturus placidus*	T	N	KS, MO, OK	B=No F=No S=No	No Effect. This species will not interact with *P.*

					M=No N=No	*ichini.*
Madtom, pygmy	*Noturus stanauli*	E, EXPN	N	TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Madtom, Scioto	*Noturus trautmani*	E	N	OH	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Madtom, smoky	*Noturus baileyi*	E, EXPN	Y	TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Madtom, yellowfin	*Noturus flavipinnis*	T, EXPN	Y	TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Minnow, Devils River	*Dionda diaboli*	T	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Minnow, Guadalupe roundnose	*Dionda nigrotaeniata*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Minnow, loach	*Tiaroga cobitis*	E	Y	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Minnow, Rio Grande Silvery	*Hybognathus amarus*	E, EXPN	Y	NM, TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pikeminnow (=squawfish), Colorado	*Ptychocheilus lucius*	E, EXPN	Y	AZ, CA, CO, NM, UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Poolfish,	*Empetrichthys*	E	N	NV	B=No	No Effect. This

Pahrump	*latos*				F=No S=No M=No N=No	species will not interact with *P. ichini.*
Pupfish, Ash Meadows Amargosa	*Cyprinodon nevadensis mionectes*	E	Y	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pupfish, Comanche Springs	*Cyprinodon elegans*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pupfish, desert	*Cyprinodon macularius*	E	Y	AZ, CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pupfish, Devils Hole	*Cyprinodon diabolis*	E	N	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pupfish, Leon Springs	*Cyprinodon bovinus*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pupfish, Owens	*Cyprinodon radiosus*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pupfish, Warm Springs	*Cyprinodon nevadensis pectoralis*	E	N	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Salmon, Atlantic (Gulf of Maine DPS)	*Salmo salar*	E	Y	ME	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sculpin, Grotto	*Cottus specus*	E	Y	MO	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.

Sculpin, pygmy	*Cottus paulus (=pygmaeus)*	T	Y	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Shiner, Arkansas River	*Notropis girardi*	T	Y	AR, KS, NM, OK, TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Shiner, beautiful	*Cyprinella formosa*	T	Y	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Shiner, blue	*Cyprinella caerulea*	T	N	AL, GA, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Shiner, Cahaba	*Notropis cahabae*	E	N	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Shiner, Cape Fear	*Notropis mekistocholas*	E	Y	NC	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Shiner, palezone	*Notropis albizonatus*	E	N	AL, KY	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Shiner, Pecos bluntnose	*Notropis simus pecosensis*	T	N	NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Shiner, sharpnose	*Notropis oxyrhynchus*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Shiner, smalleye	*Notropis buccula*	E	Y	TX	B=No F=No S=No M=No	No Effect. This species will not interact with *P. ichini.* No effect

					N=No	on critical habitat.
Shiner, Topeka	*Notropis topeka (=tristis)*	E, EXPN	Y	IA, KS, MN, MO, NE, SD	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Silverside, Waccamaw	*Menidia extensa*	T	Y	NC	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Smelt, delta	*Hypomesus transpacificus*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Spikedace	*Meda fulgida*	E	Y	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Spinedace, Big Spring	*Lepidomeda mollispinis pratensis*	T	Y	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Spinedace, Little Colorado	*Lepidomeda vittata*	T	Y	AZ	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Spinedace, White River	*Lepidomeda albivallis*	E	Y	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Springfish, Hiko White River	*Crenichthys baileyi grandis*	E	Y	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Springfish, Railroad Valley	*Crenichthys nevadae*	T	Y	NV	B=No F=No S=No M=No	No Effect. This species will not interact with *P. ichini.* No effect

					N=No	on critical habitat.
Springfish, White River	*Crenichthys baileyi baileyi*	E	Y	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Stickleback, unarmored threespine	*Gasterosteus aculeatus williamsoni*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Sturgeon, Alabama	*Scaphirhynchus suttkusi*	E	Y	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sturgeon (Gulf subspecies), Atlantic	*Acipenser oxyrinchus (=oxyrhynchus) desotoi*	T	Y	AL, FL, LA, MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sturgeon, pallid	*Scaphirhynchus albus*	E	N	AR, IL, IA, KS, KY, LA, MS, MO, MT, NE, ND, SD, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Sturgeon, white	*Acipenser transmontanus*	E	Y	ID, MT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sucker, June	*Chasmistes liorus*	E	Y	UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sucker, Lost River	*Deltistes luxatus*	E	Y	CA, OR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sucker, razorback	*Xyrauchen texanus*	E	Y	AZ, CA, CO, NV, NM, UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical

						habitat.
Sucker, Santa Ana	*Catostomus santaanae*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sucker, shortnose	*Chasmistes brevirostris*	E	Y	CA, OR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sucker, Warner	*Catostomus warnerensis*	T	Y	CA, NV, OR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Sucker, Zuni bluehead	*Catostomus discobolus yarrowi*	E	N (PCH)	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on proposed critical habitat.
Sunfish, spring pygmy	*Elassoma alabamae*	T	N	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Topminnow, Gila (incl. Yaqui)	*Poeciliopsis occidentalis*	E	N	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Trout, Apache	*Oncorhynchus apache*	T	N	AZ	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Trout, bull	*Salvelinus confluentus*	T, EXPN	Y	ID, MT, NV, OR, WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Trout, Gila	*Oncorhynchus gilae*	T	N	AZ, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Trout, Greenback Cutthroat	*Oncorhynchus clarki stomias*	T	N	CO, UT	B=No F=No S=No	No Effect. This species will not interact with *P.*

					M=No N=No	*ichini.*
Trout, Lahontan cutthroat	*Oncorhynchus clarkii henshawi*	T	N	CA, NV, OR, UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Trout, Little Kern golden	*Oncorhynchus aguabonita whitei*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Trout, Paiute cutthroat	*Oncorhynchus clarkii seleniris*	T	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Tui chub, Mohave	*Gila bicolor ssp. mohavensis*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Woundfin	*Plagopterus argentissimus*	E, EXPN	Y	AZ, NV, NM, UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.

Fish Assessment: Release of *P. ichini* will have no effect on any listed fish. Fish would not be exposed to it. Any reduction of Brazilian peppertree due to *P. ichini* is expected to happen gradually. Thus, bank erosion from the biocontrol of Brazilian peppertree is not expected.

Release of *P. ichini* will have no effect on the designated critical habitat of listed fish in the United States. Brazilian peppertree is not a physical or biological feature essential to the conservation of any listed fish.

Table 10. Mussels

Common Name	**Scientific Name**	**Listing status**	**Critical Habitat (Y or N)**	**States of Occurrence**	**Impact/ Effect to Breeding (B), Feeding (F), Sheltering (S), Migration (M), and Nutrition (N)**	**Determination**
Acornshell, southern	*Epioblasma othcaloogensis*	E	Y	AL, TN	B=No F=No S=No M=No	No Effect. This species will not interact with *P. ichini.* No effect

					N=No	on critical habitat.
Bankclimber, purple (mussel)	*Elliptoideus sloatianus*	T	Y	AL, FL, GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Bean, Choctaw	*Villosa choctawensis*	E	Y	AL, FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Bean, Cumberland (pearlymussel)	*Villosa trabalis*	E, EXPN	N	AL, KY, NC, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Bean, purple	*Villosa perpurpurea*	E	Y	TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Bean, rayed	*Villosa fabalis*	E	N	IN, MI, NY, OH, PA, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Blossom, green (pearlymussel)	*Epioblasma torulosa gubernaculum*	E	N	TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Blossom, tubercled (pearlymussel)	*Epioblasma torulosa torulosa*	E, EXPN	N	KY, TN, WV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Blossom, turgid (pearlymussel)	*Epioblasma turgidula*	E, EXPN	N	AL, AR, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Blossom, yellow (pearlymussel)	*Epioblasma florentina florentina*	E, EXPN	N	AL, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Catspaw, white (pearlymussel)	*Epioblasma obliquata perobliqua*	E	N	IN, OH	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Clubshell	*Pleurobema clava*	E, EXPN	N	IL, IN, KY, MI, NY, OH, PA,	B=No F=No S=No	No Effect. This species will not interact with *P.*

				TN, WV	M=No N=No	*ichini.*
Clubshell, black	*Pleurobema curtum*	E	N	MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Clubshell, ovate	*Pleurobema perovatum*	E	Y	AL, MS, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Clubshell, southern	*Pleurobema decisum*	E	Y	AL, GA, MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Combshell, Cumberlandian	*Epioblasma brevidens*	E, EXPN	Y	AL, KY. MS, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Combshell, southern	*Epioblasma penita*	E	N	AL, MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Combshell, upland	*Epioblasma metastriata*	E	Y	AL, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Ebonyshell, round	*Fusconaia rotulata*	E	Y	AL, FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Elktoe, Appalachian	*Alasmidonta raveneliana*	E	Y	NC, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Elktoe, Cumberland	*Alasmidonta atropurpurea*	E	Y	KY, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Fanshell	*Cyprogenia stegaria*	E, EXPN	N	AL, IL, IN, KY, OH, TN, VA, WV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Fatmucket, Arkansas	*Lampsilis powellii*	T	N	AR	B=No F=No	No Effect. This species will not

					S=No M=No N=No	interact with *P. ichini.*
Heelsplitter, Alabama (=inflated)	*Potamilus inflatus*	T	N	AL, LA, MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Heelsplitter, Carolina	*Lasmigona decorata*	E	Y	NC, SC	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Higgins eye (pearlymussel)	*Lampsilis higginsii*	E	N	IL, IA, MN, MS, SD, WI	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Hornshell, Texas	*Popenaias popeii*	PE	N	TX, NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Kidneyshell, fluted	*Ptychobranchus subtentum*	E	Y	KY, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Kidneyshell, southern	*Ptychobranchus jonesi*	E	Y	AL, FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Kidneyshell, triangular	*Ptychobranchus greenii*	E	Y	AL, GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Lampmussel, Alabama	*Lampsilis virescens*	E, EXPN	N	AL, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Lilliput, pale (pearlymussel)	*Toxolasma cylindrellus*	E	N	AL, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Mapleleaf, winged	*Quadrula fragosa*	E, EXPN	N	AR, MN, MO, OK, WI	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Moccasinshell,	*Medionidus*	T	Y	AL, GA, MS	B=No	No Effect. This

Alabama	*acutissimus*				F=No S=No M=No N=No	species will not interact with *P. ichini.* No effect on critical habitat.
Moccasinshell, Coosa	*Medionidus parvulus*	E	Y	AL, GA, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Moccasinshell, Gulf	*Medionidus penicillatus*	E	Y	AL, FL, GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Moccasinshell, Ochlockonee	*Medionidus simpsonianus*	E	Y	FL, GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Moccasinshell, Suwanee	*Medionidus walkeri*	T	N	FL, GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Monkeyface, Appalachian (pearlymussel)	*Quadrula sparsa*	E, EXPN	N	TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Monkeyface, Cumberland (pearlymussel)	*Quadrula intermedia*	E, EXPN	N	AL, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Mucket, Neosho	*Lampsilis rafinesqueana*	E	Y	AR, KS, MO, OK	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Mucket, orangenacre	*Lampsilis perovalis*	T	Y	AL, MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Mucket, pink (pearlymussel)	*Lampsilis abrupta*	E	N	AL, AR, IL, KY, LA, MO, OH, TN, VA, WV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Mussel, oyster	*Epioblasma capsaeformis*	E, EXPN	Y	AL, KY, NC, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.

Mussel, scaleshell	*Leptodea leptodon*	E	N	AR, IL, MO, NE, OK, SD	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Mussel, sheepnose	*Plethobasus cyphyus*	E	N	AL, IL, IN, IA, KY, MN, MS, MO, OH, PA, TN, VA, WV, WI	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Mussel, snuffbox	*Epioblasma triquetra*	E	N	AL, AR, MN, MS, MO, OH, PA, VA, WV, WI	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pearlshell, Alabama	*Margaritifera marrianae*	E	Y	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pearlshell, Louisiana	*Margaritifera hembeli*	T	N	LA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pearlymussel, birdwing	*Lemiox rimosus*	E, EXPN	N	AL, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pearlymussel, cracking	*Hemistena lata*	E, EXPN	N	AL, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pearlymussel, Curtis	*Epioblasma florentina curtisii*	E	N	AR, MO	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pearlymussel, dromedary	*Dromus dromas*	E, EXPN	N	AL, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pearlymussel, littlewing	*Pegias fabula*	E	N	AL, KY, NC, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pearlymussel, slabside	*Pleuronaia dolabelloides*	E	Y	AL, KY, MS, TN, VA	B=No F=No	No Effect. This species will not

					S=No M=No N=No	interact with *P. ichini.* No effect on critical habitat.
Pigtoe, Cumberland	*Pleurobema gibberum*	E	N	TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pigtoe, dark	*Pleurobema furvum*	E	Y	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pigtoe, finerayed	*Fusconaia cuneolus*	E, EXPN	N	AL, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pigtoe, flat	*Pleurobema marshalli*	E	N	AL, MS	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pigtoe, fuzzy	*Pleurobema strodeanum*	T	Y	AL, FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pigtoe, Georgia	*Pleurobema hanleyianum*	E	Y	AL, GA, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pigtoe, heavy	*Pleurobema taitianum*	E	N	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pigtoe, narrow	*Fusconaia escambia*	T	Y	AL, FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pigtoe, oval	*Pleurobema pyriforme*	E	Y	AL, FL, GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pigtoe, rough	*Pleurobema plenum*	E, EXPN	N	AL, IN, KY, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pigtoe, shiny	*Fusconaia cor*	E,	N	AL, TN, VA	B=No	No Effect. This

		EXPN			F=No S=No M=No N=No	species will not interact with *P. ichini.*
Pigtoe, southern	*Pleurobema georgianum*	E	Y	AL, GA, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pigtoe, tapered	*Fusconaia burkei*	T	Y	AL, FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pimpleback, orangefoot (pearlymussel)	*Plethobasus cooperianus*	E, EXPN	N	AL, IL, KY, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pocketbook, fat	*Potamilus capax*	E	N	AR, IL, IN, KY, LA, MS, MO	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pocketbook, finelined	*Lampsilis altilis*	T	Y	AL, GA, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pocketbook, Ouachita rock	*Arkansia wheeleri*	E	N	AR, OK	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pocketbook, shinyrayed	*Lampsilis subangulata*	E	Y	AL, FL, GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Pocketbook, speckled	*Lampsilis streckeri*	E	N	AR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Purple Cat's paw (=Purple Cat's paw pearlymussel)	*Epioblasma obliquata obliquata*	E, EXPN	N	AL, KY, OH	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Rabbitsfoot	*Quadrula cylindrica cylindrica*	T	Y	AL, AR, IL, IN, KS, KY, LA, MS, MO, OH, OK, PA, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.

Rabbitsfoot, rough	*Quadrula cylindrica strigillata*	E	Y	TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Riffleshell, northern	*Epioblasma torulosa rangiana*	E	N	IN, KY, MI, OH, PA, WV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Riffleshell, tan	*Epioblasma florentina walkeri (=E. walkeri)*	E	N	KY, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Ring pink (mussel)	*Obovaria retusa*	E, EXPN	N	AL, KY, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Sandshell, Southern	*Hamiota australis*	T	Y	AL, FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Slabshell, Chipola	*Elliptio chipolaensis*	T	Y	AL, FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Spectaclecase (mussel)	*Cumberlandia monodonta*	E	N	AL, AR, IL, IA, KS, KY, MN, MO, TN, VA, WV, WI	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Spinymussel, Altamaha	*Elliptio spinosa*	E	Y	GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Spinymussel, James	*Pleurobema collina*	E	N	NC, VA, WV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Spinymussel, Tar River	*Elliptio steinstansana*	E	N	NC	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Stirrupshell	*Quadrula stapes*	E	N	AL, MS	B=No F=No S=No M=No	No Effect. This species will not interact with *P. ichini.*

					N=No	
Threeridge, fat (mussel)	*Amblema neislerii*	E	Y	FL, GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Wartyback, white (pearlymussel)	*Plethobasus cicatricosus*	E, EXPN	N	AL, KY, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Wedgemussel, dwarf	*Alasmidonta heterodon*	E	N	CT, MD, MA, NH, NJ, NY, NC, PA, VY, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*

Mussel Assessment: Release of *P. ichini* will have no effect on any listed mussel. Mussels would not be exposed to it. Any reduction of Brazilian peppertree due to *P. ichini* is expected to happen gradually. Thus, bank erosion from the biocontrol of Brazilian peppertree is not expected.

Release of *P. ichini* will have no effect on the designated critical habitat of listed mussels in the United States. Brazilian peppertree is not a physical or biological feature essential to the conservation of any listed mussel.

Table 11. Snails

Common Name	Scientific Name	Listing status	Critical Habitat (Y or N)	States of Occurrence	Impact/ Effect to Breeding (B), Feeding (F), Sheltering (S), Migration (M), and Nutrition (N)	Determination
Ambersnail, Kanab	*Oxyloma haydeni kanabensis*	E	N	AZ, UT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Campeloma, slender	*Campeloma decampi*	E	N	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Cavesnail, Tumbling Creek	*Antrobia culveri*	E	Y	MO	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Elimia, lacy	*Elimia crenatella*	T	N	AL	B=No	No Effect. This

(snail)					F=No S=No M=No N=No	species will not interact with *P. ichini.*
globe, noonday	*Patera clarki nantahala*	T	N	NC	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Hornsnail, rough	*Pleurocera foremani*	E	Y	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Limpet, Banbury Springs	*Lanx sp.*	E	N	ID	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Lioplax, cylindrical (snail)	*Lioplax cyclostomaformis*	E	N	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Marstonia, royal (snail)	*Pyrgulopsis ogmorhaphe*	E	N	TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Pebblesnail, flat	*Lepyrium showalteri*	E	N	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Riversnail, Anthony's	*Athearnia anthonyi*	E, EXPN	N	AL, TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Rocksnail, interrupted	*Leptoxis foremani*	E	Y	AL, GA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Rocksnail, painted	*Leptoxis taeniata*	T	N	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Rocksnail, plicate	*Leptoxis plicata*	E	N	AL	B=No F=No S=No	No Effect. This species will not interact with *P.*

					M=No N=No	*ichini.*
Rocksnail, round	*Leptoxis ampla*	T	N	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Snail, armored	*Pyrgulopsis (=Marstonia) pachyta*	E	N	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Snail, Bliss Rapids	*Taylorconcha serpenticola*	T	N	ID	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Snail, Chittenango ovate amber	*Succinea chittenangoensis*	T	N	NY	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Snail, flat-spired three-toothed	*Triodopsis platysayoides*	T	N	WV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Snail, Iowa Pleistocene	*Discus macclintocki*	E	N	IL, IA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Snail, Morro shoulderband (=Banded dune)	*Helminthoglypta walkeriana*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Snail, painted snake coiled forest	*Anguispira picta*	T	N	TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Snail, Pecos assiminea	*Assiminea pecos*	E	Y	NM, TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Snail, Snake River physa	*Physa natricina*	E	N	ID	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*

Snail, Stock Island tree	*Orthalicus reses (not incl. nesodryas)*	T	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Snail, tulotoma	*Tulotoma magnifica*	T	N	AL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Snail, Virginia fringed mountain	*Polygyriscus virginianus*	E	N	VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Springsnail, Alamosa	*Tryonia alamosae*	E	N	NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Springsnail, Bruneau Hot	*Pyrgulopsis bruneauensis*	E	N	ID	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Springsnail, Chupadera	*Pyrgulopsis chupaderae*	E	Y	NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Springsnail, Koster's	*Juturnia kosteri*	E	Y	NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Springsnail, Phantom	*Pyrgulopsis texana*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Springsnail, Roswell	*Pyrgulopsis roswellensis*	E	Y	NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
springsnail, San Bernardino	*Pyrgulopsis bernardina*	T	Y	AZ	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical

						habitat.
Springsnail, Socorro	*Pyrgulopsis neomexicana*	E	N	NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Springsnail, Three Forks	*Pyrgulopsis trivialis*	E	Y	AZ	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Tryonia, Diamond	*Pseudotryonia adamantina*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Tryonia, Gonzales	*Tryonia circumstriata (=stocktonensis)*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Tryonia, Phantom	*Tryonia cheatumi*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.

Snail Assessment: Snail species would not be exposed to *P. ichini.* Any reduction of Brazilian peppertree due to *P. ichini* is expected to happen gradually, and should not affect other fauna.

Release of *P. ichini* will have no direct effect on the designated critical habitat of listed snails in the United States. Brazilian peppertree is not a physical or biological feature essential to the conservation of any listed snail.

Table 12. Insects

Common Name	Scientific Name	Listing status	Critical Habitat (Y or N)	States of Occurrence	Impact/ Effect to Breeding (B), Feeding (F), Sheltering (S), Migration (M), Nutrition (N), and Lifestage (L)	Determination
Beetle, American burying	*Nicrophorus americanus*	E, EXPN	N	AR, KS, MA, MO, NE, OH,	B=No F=No S=No	No Effect. This species will not interact with *P.*

				OK, RI, SD, TX	M=No N=No	*ichini.*
Beetle, Casey's June	*Dinacoma caseyi*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Beetle, Coffin Cave mold	*Batrisodes texanus*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Beetle, Comal Springs dryopid	*Stygoparnus comalensis*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Beetle, Comal Springs riffle	*Heterelmis comalensis*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Beetle, delta green ground	*Elaphrus viridis*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Beetle, Helotes mold	*Batrisodes venyivi*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Beetle, Hungerford's crawling water	*Brychius hungerfordi*	E	N	MI	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Beetle, Kretschmarr Cave mold	*Texamaurops reddelli*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Beetle, Mount Hermon June	*Polyphylla barbata*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Beetle, [no	*Rhadine exilis*	E	Y	TX	B=No	No Effect. This

common name]					F=No S=No M=No N=No	species will not interact with *P. ichini.* No effect on critical habitat.
Beetle, [no common name]	*Rhadine infernalis*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Beetle, Tooth Cave ground	*Rhadine persephone*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Beetle, valley elderberry longhorn	*Desmocerus californicus dimorphus*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Bumble bee, rusty patched	*Bombus affinis*	E	N	IL, IN, IA, ME, MD, MA, MN, NC, OH, PA, TN VA, WI.	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P, ichini.*
Butterfly, Bartram's hairstreak	*Strymon acis bartrami*	E	Y	FL	B=Yes F=Yes S=Yes M=No N=No L=All	MA - beneficial
Butterfly, bay checkerspot	*Euphydryas editha bayensis*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Butterfly, Behren's silverspot	*Speyeria zerene behrensii*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Butterfly, callippe silverspot	*Speyeria callippe callippe*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Butterfly, El Segundo blue	*Euphilotes battoides allyni*	E	N	CA	B=No F=No S=No M=No	No Effect. This species will not interact with *P. ichini.*

					N=No	
Butterfly, Fender's blue	*Icaricia icarioides fenderi*	E	Y	OR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Butterfly, Florida leafwing	*Anaea troglodyta floridalis*	E	Y	FL	B=Yes F=Yes S=Yes M=No N=No L=All	MA - beneficial
Butterfly, Karner blue	*Lycaeides melissa samuelis*	E	N	IL, IN, MI, MN, NH, NY, OH, WI	B=No F=Yes S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Butterfly, Lange's metalmark	*Apodemia mormo langei*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Butterfly, lotis blue	*Lycaeides argyrognomon lotis*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Butterfly, Miami Blue	*Cyclargus (=Hemiargus) thomasi bethunebakeri*	E	N	FL	B=Yes F=Yes S=Yes M=No N=No L=All	MA - beneficial
Butterfly, mission blue	*Icaricia icarioides missionensis*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Butterfly, Mitchell's satyr	*Neonympha mitchellii mitchellii*	E	N	AL, IN, MI, MS, OH, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Butterfly, Mount Charleston blue	*Plebejus shasta charlestonensis*	E	Y	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Butterfly, Myrtle's silverspot	*Speyeria zerene myrtleae*	E	N	CA	B=No F=No S=No M=No	No Effect. This species will not interact with *P. ichini.*

					N=No	
Butterfly, Oregon silverspot	*Speyeria zerene hippolyta*	T	Y	CA, OR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Butterfly, Palos Verdes blue	*Glaucopsyche lygdamus palosverdesensis*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Butterfly, Quino checkerspot	*Euphydryas editha quino (=E. e. wrighti)*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Butterfly, Saint Francis' satyr	*Neonympha mitchellii francisci*	E	N	NC	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Butterfly, San Bruno elfin	*Callophrys mossii bayensis*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Butterfly, Schaus swallowtail	*Heraclides aristodemus ponceanus*	E	N	FL	B=Yes F=Yes S=Yes M=Yes N=No L=All	MA- beneficial
Butterfly, Smith's blue	*Euphilotes enoptes smithi*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Butterfly, Uncompahgre fritillary	*Boloria acrocnema*	E	N	CO	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Checkerspot, Taylor's (=whulge)	*Euphydryas editha taylori*	E	Y	OR, WA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Dragonfly, Hine's emerald	*Somatochlora hineana*	E	Y	IL, MI, MO, WI	B=No F=No	No Effect. This species will not

					S=No M=No N=No	interact with *P. ichini*. No effect on critical habitat.
Fly, Delhi Sands flower-loving	*Rhaphiomidas terminatus abdominalis*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Grasshopper, Zayante band-winged	*Trimerotropis infantilis*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Moth, Kern primrose sphinx	*Euproserpinus euterpe*	T	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Naucorid, Ash Meadows	*Ambrysus amargosus*	T	Y	NV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Skipper, Carson wandering	*Pseudocopaeodes eunus obscurus*	E	N	NV, CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Skipper, Dakota	*Hesperia dacotae*	T	Y	IA, MN, ND, SD	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Skipper, Laguna Mountains	*Pyrgus ruralis lagunae*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Skipperling, Poweshiek	*Oarisma poweshiek*	E	Y	IA, MI, MN, ND, SD, WI	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Skipper, Pawnee montane	*Hesperia leonardus montana*	T	Y	CO	B=No F=No S=No M=No	No Effect. This species will not interact with *P. ichini*. No effect

					N=No	on critical habitat.
Stonefly, meltwater lednian	*Lednia tumana*	PT	N	MT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Stonefly, western glacier	*Zapada glacier*	PT	N	MT	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Tiger beetle, Miami	*Cicindelidia floridana*	E	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Tiger beetle, Northeastern beach	*Cicindela dorsalis dorsalis*	T	N	MD, MA, NJ, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Tiger beetle, Ohlone	*Cicindela ohlone*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Tiger beetle, Puritan	*Cicindela puritana*	T	N	CT, MD, MA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Tiger beetle, Salt Creek	*Cicindela nevadica lincolniana*	E	Y	NE	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.

Insect Assessment: Insects are known to eat Brazilian peppertree leaves, seeds, and nectar (Hight et al., 2002; Workman, 1978; Yoshioka and Markin, 1991). Insects pollinate Brazilian pepper flowers (Meyer, 2011). However, no listed insect species are specifically known to utilize Brazilian peppertree, and no direct effect is expected to them from release of *P. ichini.* Gould and Hammer (1999) indicate that butterflies native to pineland and hammock communities are threatened by the spread of Brazilian pepper due to replacement of host plants. Therefore, release of *P. ichini* may affect beneficially the Bartram's hairstreak, Miami blue, Florida leafwing, and Schaus swallowtail butterflies and their designated critical habitats. Reduction of Brazilian peppertree due to *P. ichini* is expected to happen gradually, and effects to insects would also be gradual.

P. ichini will not be toxic to other insects that might forage on it. In a search of the literature, there is no reference indicating that these thrips are toxic (Wheeler et al., 2014).

Release of *P. ichini* will have no direct effect on the designated critical habitat of listed insects in the United States, other than possibly beneficially affecting the critical habitat of the Florida leafwing and Bartram's hairstreak. Brazilian peppertree is not a physical or biological feature essential to the conservation of any listed insect.

Table 13. Arachnids

Common Name	Scientific Name	Listing status	Critical Habitat (Y or N)	States of Occurrence	Impact/ Effect to Breeding (B), Feeding (F), Sheltering (S), Migration (M), and Nutrition (N)	Determination
Harvestman, Bee Creek Cave	*Texella reddelli*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Harvestman, Bone Cave	*Texella reyesi*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Harvestman, Cokendolpher Cave	*Texella cokendolpheri*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Meshweaver, Braken Bat Cave	*Cicurina venii*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Meshweaver, Government Canyon Bat Cave	*Cicurina vespera*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Meshweaver, Madla's Cave	*Cicurina madla*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Meshweaver,	*Cicurina*	E	Y	TX	B=No	No Effect. This

Robber Baron Cave	*baronia*				F=No S=No M=No N=No	species will not interact with *P. ichini.* No effect on critical habitat.
Pseudoscorpion, Tooth Cave	*Tartarocreagris texana*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Spider, Government Canyon Bat Cave	*Neoleptoneta microps*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Spider, spruce-fir moss	*Microhexura montivaga*	E	Y	NC, TN, VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Spider, Tooth Cave	*Leptoneta myopica*	E	N	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*

Arachnid Assessment: Listed arachnids are not expected to interact with *P. ichini.* None of the cave-dwelling organisms would encounter *P. ichini*. The spruce-fir moss spider is found only in bryophyte mats on sheltered, well-shaded rock outcrops and Brazilian peppertree is not part of this habitat. Release of *P. ichini* would have no effect on listed arachnids.

P. ichini will not be toxic to arachnids that might forage on it. In a search of the literature, there is no reference indicating that these thrips are toxic (Wheeler et al., 2014).

Release of *P. ichini* will have no direct effect on the designated critical habitat of listed arachnids in the United States. Brazilian peppertree is not a physical or biological feature essential to the conservation of any listed arachnid.

Table 14. Crustaceans

Common Name	Scientific Name	Listing status	Critical Habitat (Y or N)	States of Occurrence	Impact/ Effect to Breeding (B), Feeding (F), Sheltering (S), Migration (M), and Nutrition (N)	Determination
Amphipod,	*Gammarus*	E	Y	TX	B=No	No Effect. This species

diminutive	*hyalleloides*				F=No S=No M=No N=No	will not interact with *P. ichini*. No effect on critical habitat.
Amphipod, Hay's Spring	*Stygobromus hayi*	E	N	DC, MD	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Amphipod, Illinois cave	*Gammarus acherondytes*	E	N	IL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Amphipod, Kenk's	*Stygobromus kenki*	PE	N	DC	B=No F=No S=No M=No N=No	No effect. This species will not interact with *P. ichini*.
Amphipod, Noel's	*Gammarus desperatus*	E	Y	NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Amphipod, Peck's cave	*Stygobromus (=Stygonectes) pecki*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Amphipod, Pecos	*Gammarus pecos*	E	Y	TX	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Crayfish, Big Sandy	*Cambarus callainus*	E	N	KY, VA, WV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Crayfish, cave	*Cambarus aculabrum*	E	N	AR, MO	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Crayfish, cave	*Cambarus zophonastes*	E	N	AR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Crayfish, Guyandotte River	*Cambarus veteranus*	E	N	WV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.

Crayfish, Nashville	*Orconectes shoupi*	E	N	TN	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Crayfish, Shasta	*Pacifastacus fortis*	E	N	CA, OR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Fairy shrimp, Conservancy	*Branchinecta conservatio*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Fairy shrimp, longhorn	*Branchinecta longiantenna*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Fairy shrimp, Riverside	*Streptocephalus woottoni*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Fairy shrimp, San Diego	*Branchinecta sandiegonensis*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Fairy shrimp, vernal pool	*Branchinecta lynchi*	T	Y	CA, OR	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*. No effect on critical habitat.
Isopod, Lee County cave	*Lirceus usdagalun*	E	N	VA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Isopod, Madison Cave	*Antrolana lira*	T	N	VA, WV	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Isopod, Socorro	*Thermosphaeroma thermophilus*	E	N	NM	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini*.
Shrimp, Alabama cave	*Palaemonias alabamae*	E	N	AL	B=No F=No S=No M=No	No Effect. This species will not interact with *P. ichini*.

					N=No	
Shrimp, California freshwater	*Syncaris pacifica*	E	N	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Shrimp, Kentucky cave	*Palaemonias ganteri*	E	Y	KY	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.
Shrimp, Squirrel Chimney Cave	*Palaemonetes cummingi*	T	N	FL	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.*
Tadpole shrimp, vernal pool	*Lepidurus packardi*	E	Y	CA	B=No F=No S=No M=No N=No	No Effect. This species will not interact with *P. ichini.* No effect on critical habitat.

Crustacean Assessment: No listed crustaceans would encounter or prey upon *P. ichini*. Release of *P. ichini* will have no effect on any listed crustacean. Any reduction of Brazilian peppertree due to *P. ichini* is expected to happen gradually. Thus, bank erosion from the biocontrol of Brazilian peppertree is not expected.

Release of *P. ichini* will have no effect on the designated critical habitat of listed crustaceans in the United States. Brazilian peppertree is not a physical or biological feature essential to the conservation of any listed crustacean.

Table 15. Plants

Common Name	Scientific Name	Listing status	Critical Habitat (Y or N)	States of Occurrence	Effect Determination
Cypress, Gowen	*Cupressus goveniana ssp. goveniana*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cypress, Santa Cruz	*Hesperocyparis =Cupressus abramsiana*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Torreya, Florida	*Torreya taxifolia*	E	N	FL, GA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Fern, Alabama streak-sorus	*Thelypteris pilosa var. alabamensis*	T	N	AL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Fern, American hart's-tongue	*Asplenium scolopendrium var. americanum*	T	N	AL, MI, NY, TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*

Fern, Florida bristle	*Trichomanes punctatum ssp. floridanum*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Quillwort, Louisiana	*Isoetes louisianensis*	E	N	AL, LA, MS	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Quillwort, mat-forming	*Isoetes tegetiformans*	E	N	GA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cladonia, Florida perforate	*Cladonia perforata*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Lichen, rock gnome	*Gymnoderma lineare*	E	N	NC, SC, TN, VA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Allocarya, Calistoga	*Plagiobothrys strictus*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Alopecurus, Sonoma	*Alopecurus aequalis var. sonomensis*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Amaranth, seabeach	*Amaranthus pumilus*	T	N	DE, NJ, NY, NC, SC, VA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Ambrosia, San Diego	*Ambrosia pumila*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Ambrosia, south Texas	*Ambrosia cheiranthifolia*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Amole, purple	*Chlorogalum purpureum*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Amphianthus, little	*Amphianthus pusillus*	T	N	AL, GA, SC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Arrowhead, bunched	*Sagittaria fasciculata*	E	N	NC, SC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Aster, decurrent false	*Boltonia decurrens*	T	N	IL, MO	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Aster, Florida golden	*Chrysopsis floridana*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Aster, Ruth's golden	*Pityopsis ruthii*	E	N	TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Avens, spreading	*Geum radiatum*	E	N	NC, TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*

Ayenia, Texas	*Ayenia limitaris*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Baccharis, Encinitas	*Baccharis vanessae*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Barberry, island	*Berberis pinnata ssp. insularis*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Barberry, Nevin's	*Berberis nevinii*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Beaked-rush, Knieskern's	*Rhynchospora knieskernii*	T	N	DE, NJ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Beardtongue, Parachute	*Penstemon debilis*	T	Y	CO	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Beardtongue, Penland	*Penstemon penlandii*	E	N	CO	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Beargrass, Britton's	*Nolina brittoniana*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bear-poppy, Dwarf	*Arctomecon humilis*	E	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Beauty, Harper's	*Harperocallis flava*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bedstraw, El Dorado	*Galium californicum ssp. sierrae*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bedstraw, island	*Galium buxifolium*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bellflower, Brooksville	*Campanula robinsiae*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Birch, Virginia round-leaf	*Betula uber*	T	N	VA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bird's beak, palmate-bracted	*Cordylanthus palmatus*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bird's-beak, Pennell's	*Cordylanthus tenuis ssp. capillaris*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bird's-beak, salt marsh	*Cordylanthus maritimus ssp. maritimus*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*

Bird's-beak, soft	*Cordylanthus mollis ssp. mollis*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Birds-in-a-nest, white	*Macbridea alba*	T	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bittercress, small-anthered	*Cardamine micranthera*	E	N	NC, VA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bladderpod, Dudley Bluffs	*Lesquerella congesta*	T	N	CO	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bladderpod, kodachrome	*Lesquerella tumulosa*	E	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bladderpod, lyrate	*Lesquerella lyrata*	T	N	AL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bladderpod, Missouri	*Physaria filiformis*	T	N	AR, MO	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bladderpod, San Bernardino Mountains	*Lesquerella kingii ssp. bernardina*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Bladderpod, Short's	*Physaria globosa*	E	Y	IN, KY, TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Bladderpod, Spring Creek	*Lesquerella perforata*	E	N	TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bladderpod, white	*Lesquerella pallida*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bladderpod, White Bluffs	*Physaria douglasii ssp. tuplashensis*	T	Y	WA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Bladderpod, Zapata	*Lesquerella thamnophila*	E	Y	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Blazingstar, Ash Meadows	*Mentzelia leucophylla*	T	Y	NV	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Blazingstar, Heller's	*Liatris helleri*	T	N	NC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Blazingstar, scrub	*Liatris ohlingerae*	E	N	FL	No Effect. This species is not related to the target weed and would not be

					targeted by *P. ichini.*
Bluecurls, Hidden Lake	*Trichostema austromontanum ssp. compactum*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bluegrass, Napa	*Poa napensis*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bluegrass, San Bernardino	*Poa atropurpurea*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Blue-star, Kearney's	*Amsonia kearneyana*	E	N	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bluet, Roan Mountain	*Hedyotis purpurea var. montana*	E	N	NC, TN, VA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bonamia, Florida	*Bonamia grandiflora*	T	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Brickell-bush, Florida	*Brickellia mosieri*	E	Y	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Brodiaea, Chinese Camp	*Brodiaea pallida*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Brodiaea, thread-leaved	*Brodiaea filifolia*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Buckwheat, cushenbury	*Eriogonum ovalifolium var. vineum*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Buckwheat, Ione (incl. Irish Hill)	*Eriogonum apricum (incl. var. prostratum)*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Buckwheat, scrub	*Eriogonum longifolium var. gnaphalifolium*	T	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Buckwheat, steamboat	*Eriogonum ovalifolium var. williamsiae*	E	N	NV	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Buckwheat, Umtanum Desert	*Eriogonum codium*	T	Y	WA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Bully, Everglades	*Sideroxylon reclinatum* ssp. *austrofloridense*	PT	N	FL	MA - beneficial
Bulrush, Northeastern	*Scirpus ancistrochaetus*	E	N	MD, MA, NH, NY,	No Effect. This species is not related to the target weed and would not be

				PA, VT, VA, WV	targeted by *P. ichini.*
Bush-clover, prairie	*Lespedeza leptostachya*	T	N	IL, IA, MN, WI	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bush-mallow, San Clemente Island	*Malacothamnus clementinus*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Bush-mallow, Santa Cruz Island	*Malacothamnus fasciculatus var. nesioticus*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Buttercup, autumn	*Ranunculus aestivalis (=acriformis)*	E	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Butterfly plant, Colorado	*Gaura neomexicana var. coloradensis*	T	Y	CO, NE, WY	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Butterweed, Layne's	*Senecio layneae*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Butterwort, Godfrey's	*Pinguicula ionantha*	T	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Button-celery, San Diego	*Eryngium aristulatum var. parishii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Button, Mohr's Barbara	*Marshallia mohrii*	T	N	AL, GA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Acuña	*Echinomastus erectocentrus var. acunensis*	E	N (PCH)	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on proposed critical habitat.
Cactus, Arizona hedgehog	*Echinocereus triglochidiatus var. arizonicus*	E	N	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Bakersfield	*Opuntia treleasei*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, black lace	*Echinocereus reichenbachii var. albertii*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Brady pincushion	*Pediocactus bradyi*	E	N	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Chisos Mountain hedgehog	*Echinocereus chisoensis var. chisoensis*	T	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Cochise pincushion	*Coryphantha robbinsiorum*	T	N	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Colorado	*Sclerocactus*	T	N	CO	No Effect. This species is not related

hookless	*glaucus*				to the target weed and would not be targeted by *P. ichini.*
Cactus, Fickeisen plains	*Pediocactus peeblesianus fickeiseniae*	E	N (PCH)	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on proposed critical habitat.
Cactus, Florida semaphore	*Consolea corallicola*	E	Y	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Cactus, Key tree	*Pilosocereus robinii*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Knowlton's	*Pediocactus knowltonii*	E	N	CO, NM	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Kuenzler hedgehog	*Echinocereus fendleri var. kuenzleri*	E	N	NM	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Lee pincushion	*Coryphantha sneedii var. leei*	T	N	NM	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Lloyd's Mariposa	*Echinomastus mariposensis*	T	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Mesa Verde	*Sclerocactus mesae-verdae*	T	N	CO, NM	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Nellie cory	*Coryphantha minima*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Nichol's Turk's head	*Echinocactus horizonthalonius var. nicholii*	E	N	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Pariette	*Sclerocactus brevispinus*	T	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Peebles Navajo	*Pediocactus peeblesianus var. peeblesianus*	E	N	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Pima pineapple	*Coryphantha scheeri var. robustispina*	E	N	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, San Rafael	*Pediocactus despainii*	E	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Siler pincushion	*Pediocactus (=Echinocactus,=Utahia) sileri*	T	N	AZ, UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Sneed pincushion	*Coryphantha sneedii var. sneedii*	E	N	NM, TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, star	*Astrophytum*	E	N	TX	No Effect. This species is not related

	asterias				to the target weed and would not be targeted by *P. ichini.*
Cactus, Tobusch fishhook	*Sclerocactus brevihamatus ssp. tobuschii*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Uinta Basin hookless	*Sclerocactus wetlandicus*	T	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Winkler	*Pediocactus winkleri*	T	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cactus, Wright fishhook	*Sclerocactus wrightiae*	E	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Campion, fringed	*Silene polypetala*	E	N	FL, GA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Catchfly, Spalding's	*Silene spaldingii*	T	N	ID, MT, OR, WA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cat's-eye, Terlingua Creek	*Cryptantha crassipes*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Ceanothus, coyote	*Ceanothus ferrisae*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Ceanothus, Pine Hill	*Ceanothus roderickii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Ceanothus, Vail Lake	*Ceanothus ophiochilus*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Centaury, spring-loving	*Centaurium namophilum*	T	Y	CA, NV	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Chaffseed, American	*Schwalbea americana*	E	N	AL, FL, GA, LA, MS, NJ, NC, SC, VA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Checker-mallow, Keck's	*Sidalcea keckii*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Checker-mallow, Kenwood Marsh	*Sidalcea oregana ssp. valida*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Checker-mallow, Nelson's	*Sidalcea nelsoniana*	T	N	OR, WA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Checker-mallow, pedate	*Sidalcea pedata*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*

Checkermallow, Wenatchee Mountains	*Sidalcea oregana var. calva*	E	Y	WA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Clarkia, Pismo	*Clarkia speciosa ssp. immaculata*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Clarkia, Presidio	*Clarkia franciscana*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Clarkia, Springville	*Clarkia springvillensis*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Clarkia, Vine Hill	*Clarkia imbricata*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cliff-rose, Arizona	*Purshia (=Cowania) subintegra*	E	N	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Clover, Monterey	*Trifolium trichocalyx*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Clover, running buffalo	*Trifolium stoloniferum*	E	N	AR, IN, KY, MO, OH, WV	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Clover, showy Indian	*Trifolium amoenum*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Coneflower, smooth	*Echinacea laevigata*	E	N	GA, NC, SC, VA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Cory cactus, bunched	*Coryphantha ramillosa*	T	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Crabgrass, Florida pineland	*Digitaria pauciflora*	PT	N	FL	MA - beneficial
Crownbeard, big-leaved	*Verbesina dissita*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Crownscale, San Jacinto Valley	*Atriplex coronata var. notatior*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Cycladenia, Jones	*Cycladenia humilis var. jonesii*	T	N	AZ, UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Daisy, Lakeside	*Hymenoxys herbacea*	T	N	IL, MI, OH	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Daisy, Parish's	*Erigeron parishii*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.

Daisy, Willamette	*Erigeron decumbens var. decumbens*	E	Y	OR	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Dawn-flower, Texas prairie	*Hymenoxys texana*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Desert-parsley, Bradshaw's	*Lomatium bradshawii*	E	N	OR, WA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Dogweed, ashy	*Thymophylla tephroleuca*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Dropwort, Canby's	*Oxypolis canbyi*	E	N	DE, GA, MD, NC, SC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Dudleya, Conejo	*Dudleya abramsii ssp. parva*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Dudleya, marcescent	*Dudleya cymosa ssp. marcescens*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Dudleya, Santa Clara Valley	*Dudleya setchellii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Dudleya, Santa Cruz Island	*Dudleya nesiotica*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Dudleya, Verity's	*Dudleya verityi*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Dudleya, Santa Monica Mountains	*Dudleya cymosa ssp. ovatifolia*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Dwarf-flax, Marin	*Hesperolinon congestum*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Evening-primrose, Antioch Dunes	*Oenothera deltoides ssp. howellii*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Evening-primrose, Eureka Valley	*Oenothera avita ssp. eurekensis*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Evening-primrose, San Benito	*Camissonia benitensis*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Fescue, Guadalupe	*Festuca ligulata*	PE	N (PCH)	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on proposed critical habitat.
Fiddleneck, large-flowered	*Amsinckia grandiflora*	E	Y	CA	No Effect. This species is not related to the target weed and would not be

					targeted by *P. ichini.* No effect on critical habitat.
Flannelbush, Mexican	*Fremontodendron mexicanum*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Flannelbush, Pine Hill	*Fremontodendron californicum ssp. decumbens*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Flax, Carter's small-flowered	*Linum carteri carteri*	E	Y	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Flax, sand	*Linum arenicola*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Fleabane, Zuni	*Erigeron rhizomatus*	T	N	AZ, NM	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Four-o'clock, MacFarlane's	*Mirabilis macfarlanei*	T	N	ID, OR	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Fringepod, Santa Cruz Island	*Thysanocarpus conchuliferus*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Fringe-tree, pygmy	*Chionanthus pygmaeus*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Fritillary, Gentner's	*Fritillaria gentneri*	E	N	CA, OR	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Gerardia, sandplain	*Agalinis acuta*	E	N	CT, MD, MA, NY, RI	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Gilia, Hoffmann's slender-flowered	*Gilia tenuiflora ssp. hoffmannii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Gilia, Monterey	*Gilia tenuiflora ssp. arenaria*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Gladecress, Fleshy-fruit	*Leavenworthia crassa*	E	Y	AL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Glade cress, Kentucky	*Leavenworthia exigua laciniata*	T	Y	KY	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Gladecress, Texas golden	*Leavenworthia texana*	E	Y	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Goldenrod, Blue	*Solidago*	T	N	NC, TN	No Effect. This species is not related

Ridge	*spithamaea*				to the target weed and would not be targeted by *P. ichini.*
Goldenrod, Houghton's	*Solidago houghtonii*	T	N	MI, NY	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Goldenrod, Short's	*Solidago shortii*	E	N	IN, KY	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Goldfields, Burke's	*Lasthenia burkei*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Goldfields, Contra Costa	*Lasthenia conjugens*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Gooseberry, Miccosukee	*Ribes echinellum*	T	N	FL, SC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Gourd, Okeechobee	*Cucurbita okeechobeensis ssp. okeechobeensis*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Grass, Colusa	*Neostapfia colusana*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Grass, Eureka Dune	*Swallenia alexandrae*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Grass, Solano	*Tuctoria mucronata*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Grass, Tennessee yellow-eyed	*Xyris tennesseensis*	E	N	AL, GA, TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Ground-plum, Guthrie's (=Pyne's)	*Astragalus bibullatus*	E	N	TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Gumplant, Ash Meadows	*Grindelia fraxinipratensis*	T	Y	CA, NV	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Harebells, Avon Park	*Crotalaria avonensis*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Harperella	*Ptilimnium nodosum*	E	N	AL, AR, GA, MD, NC, OK, SC, VA, WV	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Heartleaf, dwarf-flowered	*Hexastylis naniflora*	T	N	NC, SC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*

Heather, mountain golden	*Hudsonia montana*	T	Y	NC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Howellia, water	*Howellia aquatilis*	T	N	CA, MT, OR, WA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Hypericum, highlands scrub	*Hypericum cumulicola*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Indian paintbrush, San Clemente Island	*Castilleja grisea*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Ipomopsis, Holy Ghost	*Ipomopsis sancti-spiritus*	E	N	NM	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Iris, dwarf lake	*Iris lacustris*	T	N	MI, WI	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Irisette, white	*Sisyrinchium dichotomum*	E	N	NC, SC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Ivesia, Ash Meadows	*Ivesia kingii var. eremica*	T	Y	CA, NV	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Ivesia, Webber	*Ivesia webberi*	T	Y	CA, NV	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Jacquemontia, beach	*Jacquemontia reclinata*	E	N	FL	MA - beneficial
Jewelflower, California	*Caulanthus californicus*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Jewelflower, Metcalf Canyon	*Streptanthus albidus ssp. albidus*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Jewelflower, Tiburon	*Streptanthus niger*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Joint-vetch, Sensitive	*Aeschynomene virginica*	T	N	MD, NJ, NC, VA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Ladies'-tresses, Canelo Hills	*Spiranthes delitescens*	E	N	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Ladies'-tresses, Navasota	*Spiranthes parksii*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Ladies'-tresses, Ute	*Spiranthes diluvialis*	T	N	CO, ID, MT, NE, NV, UT, WA,	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*

				WY	
Larkspur, Baker's	*Delphinium bakeri*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Larkspur, San Clemente Island	*Delphinium variegatum ssp. kinkiense*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Larkspur, yellow	*Delphinium luteum*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Layia, beach	*Layia carnosa*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Lead-plant, Crenulate	*Amorpha crenulata*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Leather flower, Alabama	*Clematis socialis*	E	N	AL, GA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Leather flower, Morefield's	*Clematis morefieldii*	E	N	AL, TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Lessingia, San Francisco	*Lessingia germanorum (=L.g. var. germanorum)*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Lily, Minnesota dwarf trout	*Erythronium propullans*	E	N	MN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Lily, Pitkin Marsh	*Lilium pardalinum ssp. pitkinense*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Lily, Western	*Lilium occidentale*	E	N	CA, OR	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Liveforever, Laguna Beach	*Dudleya stolonifera*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Liveforever, Santa Barbara Island	*Dudleya traskiae*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Locoweed, Fassett's	*Oxytropis campestris var. chartacea*	T	N	WI	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Lomatium, Cook's	*Lomatium cookii*	E	Y	OR	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Loosestrife, rough-leaved	*Lysimachia asperulaefolia*	E	N	NC, SC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Lotus, San Clemente	*Acmispon*	T	N	CA	No Effect. This species is not related

Island	*dendroideus var. traskiae (=Lotus d. ssp. traskiae)*				to the target weed and would not be targeted by *P. ichini.*
Lousewort, Furbish	*Pedicularis furbishiae*	E	N	ME	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Lupine, clover	*Lupinus tidestromii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Lupine, Kincaid's	*Lupinus sulphureus ssp. kincaidii*	T	Y	OR, WA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Lupine, Nipomo Mesa	*Lupinus nipomensis*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Lupine, scrub	*Lupinus aridorum*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Malacothrix, island	*Malacothrix squalida*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Malacothrix, Santa Cruz Island	*Malacothrix indecora*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Mallow, Gierisch	*Sphaeralcea gierischii*	E	Y	AZ, UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Mallow, Kern	*Eremalche kernensis*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Mallow, Peter's Mountain	*Iliamna corei*	E	N	VA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Manioc, Walker's	*Manihot walkerae*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Manzanita, Del Mar	*Arctostaphylos glandulosa ssp. crassifolia*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Manzanita, Franciscan	*Arctostaphylos franciscana*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Manzanita, Ione	*Arctostaphylos myrtifolia*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Manzanita, Morro	*Arctostaphylos morroensis*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Manzanita, pallid	*Arctostaphylos pallida*	T	N	CA	No Effect. This species is not related to the target weed and would not be

					targeted by *P. ichini.*
Manzanita, Presidio	*Arctostaphylos hookeri var. ravenii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Manzanita, Santa Rosa Island	*Arctostaphylos confertiflora*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Mariposa lily, Tiburon	*Calochortus tiburonensis*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Meadowfoam, Butte County	*Limnanthes floccosa ssp. californica*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Meadowfoam, large-flowered woolly	*Limnanthes floccosa ssp. grandiflora*	E	Y	OR	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Meadowfoam, Sebastopol	*Limnanthes vinculans*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Meadowrue, Cooley's	*Thalictrum cooleyi*	E	N	FL, GA, NC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Mesa-mint, Otay	*Pogogyne nudiuscula*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Mesa-mint, San Diego	*Pogogyne abramsii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Milkpea, Small's	*Galactia smallii*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Milk-vetch, Applegate's	*Astragalus applegatei*	E	N	CA, OR	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Milk-vetch, Ash meadows	*Astragalus phoenix*	T	Y	CA, NV	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Milk-vetch, Braunton's	*Astragalus brauntonii*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Milk-vetch, Clara Hunt's	*Astragalus clarianus*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Milk-vetch, Coachella Valley	*Astragalus lentiginosus var. coachellae*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Milk-vetch, coastal dunes	*Astragalus tener var. titi*	E	N	CA	No Effect. This species is not related to the target weed and would not be

					targeted by *P. ichini.*
Milk-vetch, Cushenbury	*Astragalus albens*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Milk-vetch, Deseret	*Astragalus desereticus*	T	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Milk-vetch, Fish Slough	*Astragalus lentiginosus var. piscinensis*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Milk-vetch, heliotrope	*Astragalus montii*	T	Y	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Milk-vetch, Holmgren	*Astragalus holmgreniorum*	E	Y	AZ, UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Milk-vetch, Jesup's	*Astragalus robbinsii var. jesupi*	E	N	NH, VT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Milk-vetch, Lane Mountain	*Astragalus jaegerianus*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Milk-vetch, Mancos	*Astragalus humillimus*	E	N	CO, NM	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Milkvetch, Osterhout	*Astragalus osterhoutii*	E	N	CO	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Milk-vetch, Peirson's	*Astragalus magdalenae var. peirsonii*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Milk-vetch, Sentry	*Astragalus cremnophylax var. cremnophylax*	E	N	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Milk-vetch, Shivwits	*Astragalus ampullarioides*	E	Y	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Milk-vetch, triple-ribbed	*Astragalus tricarinatus*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Milk-vetch, Ventura Marsh	*Astragalus pycnostachyus var. lanosissimus*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Milkweed, Mead's	*Asclepias meadii*	T	N	IL, IN, IA, KS, MO, WI	No Effect. This species is not related to the target weed and would not be

					targeted by *P. ichini.*
Milkweed, Welsh's	*Asclepias welshii*	T	Y	AZ, UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Mint, Garrett's	*Dicerandra christmanii*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Mint, Lakela's	*Dicerandra immaculata*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Mint, longspurred	*Dicerandra cornutissima*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Mint, scrub	*Dicerandra frutescens*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Monardella, willowy	*Monardella viminea*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Monkey-flower, Michigan	*Mimulus michiganensis*	E	N	MI	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Monkeyflower, Vandenberg	*Mimulus fremontii var. vandenbergensis*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Monkshood, northern wild	*Aconitum noveboracense*	T	N	IA, NY, OH, WI	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Morning-glory, Stebbins'	*Calystegia stebbinsii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Mountain balm, Indian Knob	*Eriodictyon altissimum*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Mountain-mahogany, Catalina Island	*Cercocarpus traskiae*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Mustard, Carter's	*Warea carteri*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Mustard, Penland alpine fen	*Eutrema penlandii*	T	N	CO	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Mustard, slender-petaled	*Thelypodium stenopetalum*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Navarretia, few-flowered	*Navarretia leucocephala ssp. pauciflora (=N. pauciflora)*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*

Navarretia, many-flowered	*Navarretia leucocephala ssp. plieantha*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Navarretia, spreading	*Navarretia fossalis*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Niterwort, Amargosa	*Nitrophila mohavensis*	E	Y	NV	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
No common name	*Geocarpon minimum*	T	N	AR, LA, MO, TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Oak, Hinckley	*Quercus hinckleyi*	T	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Onion, Munz's	*Allium munzii*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Orchid, eastern prairie fringed	*Platanthera leucophaea*	T	N	IL, IN, IA, ME, MI, MO, OH, OK, VA, WI	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Orchid, western prairie fringed	*Platanthera praeclara*	T	N	IA, KS, MN, MO, NE, ND, OK, SD	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Orchid, white fringeless	*Platanthera integrilabia*	T	N	AL, KY, GA, MS, SC, TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Orcutt grass, California	*Orcuttia californica*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Orcutt grass, hairy	*Orcuttia pilosa*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Orcutt grass, Sacramento	*Orcuttia viscida*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Orcutt grass, San Joaquin	*Orcuttia inaequalis*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Orcutt grass, slender	*Orcuttia tenuis*	T	Y	CA, NV, OR	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Owl's-clover, fleshy	*Castilleja campestris ssp. succulenta*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on

					critical habitat.
Oxytheca, cushenbury	*Oxytheca parishii var. goodmaniana*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Paintbrush, ash-grey	*Castilleja cinerea*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Paintbrush, golden	*Castilleja levisecta*	T	N	OR, WA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Paintbrush, soft-leaved	*Castilleja mollis*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Paintbrush, Tiburon	*Castilleja affinis ssp. neglecta*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Partridge pea, Big Pine	*Chamaecrista lineata keyensis*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Pawpaw, beautiful	*Deeringothamnus pulchellus*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Pawpaw, four-petal	*Asimina tetramera*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Pawpaw, Rugel's	*Deeringothamnus rugelii*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Penny-cress, Kneeland Prairie	*Thlaspi californicum*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Pennyroyal, Todsen's	*Hedeoma todsenii*	E	Y	NM	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Penstemon, blowout	*Penstemon haydenii*	E	N	NE, WY	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Pentachaeta, Lyon's	*Pentachaeta lyonii*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Pentachaeta, white-rayed	*Pentachaeta bellidiflora*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Peppergrass, slickspot	*Lepidium papilliferum*	T	N (PCH)	ID	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on proposed critical habitat.
Phacelia, clay	*Phacelia argillacea*	E	N	UT	No Effect. This species is not related

					to the target weed and would not be targeted by *P. ichini.*
Phacelia, DeBeque	*Phacelia submutica*	T	Y	CO	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect to critical habitat.
Phacelia, island	*Phacelia insularis ssp. insularis*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Phacelia, North Park	*Phacelia formosula*	E	N	CO	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Phlox, Texas trailing	*Phlox nivalis ssp. texensis*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Phlox, Yreka	*Phlox hirsuta*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Pigeon wings	*Clitoria fragrans*	T	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Pinkroot, gentian	*Spigelia gentianoides*	E	N	AL, FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Pink, swamp	*Helonias bullata*	T	N	DE, GA, MD, NJ, NC, SC, VA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Piperia, Yadon's	*Piperia yadonii*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect to critical habitat.
Pitaya, Davis' green	*Echinocereus viridiflorus var. davisii*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Pitcher-plant, Alabama canebrake	*Sarracenia rubra ssp. alabamensis*	E	N	AL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Pitcher-plant, green	*Sarracenia oreophila*	E	N	AL, GA, NC, TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Pitcher-plant, mountain sweet	*Sarracenia rubra ssp. jonesii*	E	N	NC, SC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Plum, scrub	*Prunus geniculata*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Pogonia, small whorled	*Isotria medeoloides*	T	N	CT, DE, GA, IL, ME, MA, MI, MO, NH, NJ, NY, NC, OH, PA, RI, SC, TN,	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*

				VA, WV	
Polygala, Lewton's	*Polygala lewtonii*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Polygala, tiny	*Polygala smallii*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Polygonum, Scotts Valley	*Polygonum hickmanii*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Pondberry	*Lindera melissifolia*	E	N	AL, AR, GA, MS, MO, NC, SC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Pondweed, Little Aguja (=Creek)	*Potamogeton clystocarpus*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Popcornflower, rough	*Plagiobothrys hirtus*	E	N	OR	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Poppy-mallow, Texas	*Callirhoe scabriuscula*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Poppy, Sacramento prickly	*Argemone pleiacantha ssp. pinnatisecta*	E	N	NM	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Potato-bean, Price's	*Apios priceana*	T	N	AL, IL, KY, MS, TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Potentilla, Hickman's	*Potentilla hickmanii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Prairie-clover, Florida	*Dalea carthagenesis* var. *floridana*	PE	N	FL	MA - beneficial
Prairie-clover, leafy	*Dalea foliosa*	E	N	AL, IL, TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Prickly-apple, aboriginal	*Harrisia (=Cereus) aboriginum (=gracilis)*	E	Y	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Prickly-apple, fragrant	*Cereus eriophorus var. fragrans*	E	N	FL	No Effect on plant. This species is not related to the target weed and would not be targeted by *P. ichini*.
Primrose, Maguire	*Primula maguirei*	T	N	UT	No Effect on plant. This species is not related to the target weed and would not be targeted by *P. ichini*.
Pussypaws, Mariposa	*Calyptridium pulchellum*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Ragwort, San Francisco Peaks	*Packera franciscana*	T	Y	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on

					critical habitat.
Rattleweed, hairy	*Baptisia arachnifera*	E	N	GA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Reed-mustard, Barneby	*Schoenocrambe barnebyi*	E	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Reed-mustard, clay	*Schoenocrambe argillacea*	T	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Reed-mustard, shrubby	*Schoenocrambe suffrutescens*	E	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Rhododendron, Chapman	*Rhododendron chapmanii*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Ridge-cress, Barneby	*Lepidium barnebyanum*	E	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Rock-cress, Braun's	*Arabis perstellata*	E	Y	KY, TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Rockcress, Georgia	*Arabis georgiana*	T	Y	AL, GA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Rock-cress, Hoffmann's	*Arabis hoffmannii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Rock-cress, McDonald's	*Arabis macdonaldiana*	E	N	CA, OR	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Rockcress, Santa Cruz Island	*Sibara filifolia*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Rock-cress, Shale barren	*Arabis serotina*	E	N	VA, WV	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Rose-mallow, Neches River	*Hibiscus dasycalyx*	T	Y	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Rosemary, Apalachicola	*Conradina glabra*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Rosemary, Cumberland	*Conradina verticillata*	T	N	KY, TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Rosemary, Etonia	*Conradina etonia*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Rosemary, short-	*Conradina*	E	N	FL	No Effect. This species is not related

leaved	*brevifolia*				to the target weed and would not be targeted by *P. ichini.*
Roseroot, Leedy's	*Rhodiola integrifolia ssp. leedyi*	T	N	MN, NY, SD	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Rush-pea, slender	*Hoffmannseggia tenella*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Rush-rose, island	*Helianthemum greenei*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Sandlace	*Polygonella myriophylla*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Sandmat, pineland	*Chamaesyce deltoidea pinetorum*	PT	N	FL	MA - beneficial
Sand-verbena, large-fruited	*Abronia macrocarpa*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Sandwort, Bear Valley	*Arenaria ursina*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Sandwort, Cumberland	*Arenaria cumberlandensis*	E	N	KY, TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Sandwort, Marsh	*Arenaria paludicola*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Seablite, California	*Suaeda californica*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Sedge, golden	*Carex lutea*	E	Y	NC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Sedge, Navajo	*Carex specuicola*	T	Y	AZ, UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Sedge, white	*Carex albida*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Silverbush, Blodgett's	*Argythamnia blodgettii*	T	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Skullcap, Florida	*Scutellaria floridana*	T	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Skullcap, large-flowered	*Scutellaria montana*	T	N	GA, TN	No Effect. This species is not related to the target weed and would not be

					targeted by *P. ichini.*
Skyrocket, Pagosa	*Ipomopsis polyantha*	E	Y	CO	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Snakeroot	*Eryngium cuneifolium*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Sneezeweed, Virginia	*Helenium virginicum*	T	N	MO, VA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Snowbells, Texas	*Styrax texanus*	E	N	TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Spineflower, Ben Lomond	*Chorizanthe pungens var. hartwegiana*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Spineflower, Howell's	*Chorizanthe howellii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Spineflower, Monterey	*Chorizanthe pungens var. pungens*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Spineflower, Orcutt's	*Chorizanthe orcuttiana*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Spineflower, Robust	*Chorizanthe robusta var. robusta*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Spineflower, San Fernando Valley	*Chorizanthe parryi var. fernandina*	PT	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Spineflower, Scotts Valley	*Chorizanthe robusta var. hartwegii*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Spineflower, slender-horned	*Dodecahema leptoceras*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Spineflower, Sonoma	*Chorizanthe valida*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Spiraea, Virginia	*Spiraea virginiana*	T	N	GA, KY, NC, OH, TN, VA, WV	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Spurge, deltoid	*Chamaesyce deltoidea ssp. deltoidea*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Spurge, Garber's	*Chamaesyce garberi*	T	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*

Spurge, Hoover's	*Chamaesyce hooveri*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Spurge, telephus	*Euphorbia telephioides*	T	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Spurge, wedge	*Chamaesyce deltoidea serpyllum*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Stickseed, showy	*Hackelia venusta*	E	N	WA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Stonecrop, Lake County	*Parvisedum leiocarpum*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Sumac, Michaux's	*Rhus michauxii*	E	N	GA, NC, SC, VA	MANLAA
Sunburst, Hartweg's golden	*Pseudobahia bahiifolia*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Sunburst, San Joaquin adobe	*Pseudobahia peirsonii*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Sunflower, Pecos (=puzzle, =paradox)	*Helianthus paradoxus*	T	Y	NM, TX	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Sunflower, San Mateo woolly	*Eriophyllum latilobum*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Sunflower, Schweinitz's	*Helianthus schweinitzii*	E	N	NC, SC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Sunflower, whorled	*Helianthus verticillatus*	E	Y	AL, GA, TN	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Sunray, Ash Meadows	*Enceliopsis nudicaulis var. corrugata*	T	Y	CA, NV	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Sunshine, Sonoma	*Blennosperma bakeri*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Taraxacum, California	*Taraxacum californicum*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Tarplant, Gaviota	*Deinandra increscens ssp. villosa*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.

Tarplant, Otay	*Deinandra (=Hemizonia) conjugens*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Tarplant, Santa Cruz	*Holocarpha macradenia*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Thelypody, Howell's spectacular	*Thelypodium howellii spectabilis*	T	N	OR	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Thistle, Chorro Creek bog	*Cirsium fontinale var. obispoense*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Thistle, fountain	*Cirsium fontinale var. fontinale*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Thistle, La Graciosa	*Cirsium loncholepis*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Thistle, Loch Lomond coyote	*Eryngium constancei*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Thistle, Pitcher's	*Cirsium pitcheri*	T	N	IL, IN, MI, WI	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Thistle, Sacramento Mountains	*Cirsium vinaceum*	T	N	NM	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Thistle, Suisun	*Cirsium hydrophilum var. hydrophilum*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Thornmint, San Diego	*Acanthomintha ilicifolia*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Thornmint, San Mateo	*Acanthomintha obovata ssp. duttonii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Thoroughwort, Cape Sable	*Chromolaena frustrata*	E	Y	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Townsendia, Last Chance	*Townsendia aprica*	T	N	UT	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Trillium, persistent	*Trillium persistens*	E	N	GA, SC	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Trillium, relict	*Trillium reliquum*	E	N	AL, GA, SC	No Effect. This species is not related to the target weed and would not be

					targeted by *P. ichini.*
Tuctoria, Greene's	*Tuctoria greenei*	E	Y	CA, OR	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Twinpod, Dudley Bluffs	*Physaria obcordata*	T	N	CO	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Vervain, Red Hills	*Verbena californica*	T	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Wallflower, Ben Lomond	*Erysimum teretifolium*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Wallflower, Contra Costa	*Erysimum capitatum var. angustatum*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Wallflower, Menzies'	*Erysimum menziesii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Warea, wide-leaf	*Warea amplexifolia*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Watercress, Gambel's	*Rorippa gambellii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Water-plantain, Kral's	*Sagittaria secundifolia*	T	N	AL, GA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Water-umbel, Huachuca	*Lilaeopsis schaffneriana var. recurva*	E	Y	AZ	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Water-willow, Cooley's	*Justicia cooleyi*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Whitlow-wort, papery	*Paronychia chartacea*	T	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Wild buckwheat, clay-loving	*Eriogonum pelinophilum*	E	Y	CO	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Wild-buckwheat, gypsum	*Eriogonum gypsophilum*	T	Y	NM	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Wild-buckwheat, southern mountain	*Eriogonum kennedyi var. austromontanum*	T	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Wild-rice, Texas	*Zizania texana*	E	Y	TX	No Effect. This species is not related

					to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Wire-lettuce, Malheur	*Stephanomeria malheurensis*	E	Y	OR	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Wireweed	*Polygonella basiramia*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Woodland-star, San Clemente Island	*Lithophragma maximum*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Woolly-star, Santa Ana River	*Eriastrum densifolium ssp. sanctorum*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Wooly-threads, San Joaquin	*Monolopia (=Lembertia) congdonii*	E	N	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*
Yellowhead, desert	*Yermo xanthocephalus*	T	Y	WY	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Yerba santa, Lompoc	*Eriodictyon capitatum*	E	Y	CA	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.* No effect on critical habitat.
Ziziphus, Florida	*Ziziphus celata*	E	N	FL	No Effect. This species is not related to the target weed and would not be targeted by *P. ichini.*

Plant Assessment:

There is one listed plant in the contiguous United States that belongs to the family Anacardiaceae, the same family as the target weed. The species is discussed below and in Table 16.

Michaux's Sumac, *Rhus michauxii* (From: U.S. Fish and Wildlife Service, 2015 https://www.fws.gov/raleigh/species/es_michauxs_sumac.html)

Federal Status: Endangered, listed September 28, 1989

Description: Michaux's sumac is a rhizomatous, densely hairy shrub, with erect stems from 1–3 feet (ft) (30.5–91 cm) in height. It belongs to the cashew family (Anacardiaceae).
The compound leaves contain evenly serrated, oblong to lanceolate, acuminate leaflets. Most plants are unisexual; however, more recent observations have revealed plants with both male and female flowers on one plant. The flowers are small, borne in a terminal, erect, dense cluster, and colored greenish yellow to white. Flowering usually occurs from June to July; while the fruit, a red drupe, is produced through the months of August to October.

Habitat: Michaux's sumac grows in sandy or rocky open woods in association with basic soils. Apparently, this plant survives best in areas where some form of disturbance has provided an open area.

Distribution: Michaux's sumac is endemic to the coastal plain and piedmont of Virginia, North Carolina, South Carolina, Georgia, and Florida (Figure 6). The largest population known is located at Fort Pickett in Virginia, but the most populations are located in the North Carolina piedmont and sandhills.

Threats: Perhaps the most crucial factor endangering this species is its low reproductive capacity. A low percentage of the plant's remaining populations have both male and female plants. The plant is also threatened by fire suppression and habitat destruction due to residential and industrial development. Michaux's sumac populations have been destroyed by residential and commercial development, conversion of a site to a pine plantation, the construction of a water tower, highways and herbicides used for power line maintenance.

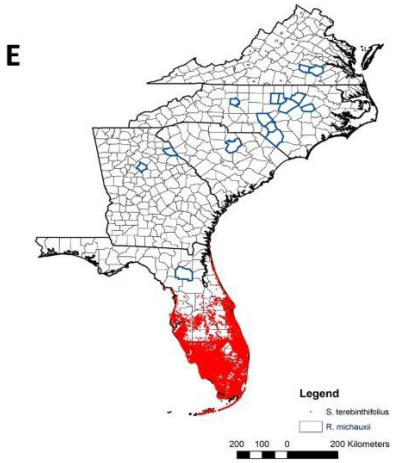

Figure 6. Distribution map of *S. terebinthifolia* in the Southeastern United States (red dots; Bargeron and Swearingen, 2010) and the distribution of *Rhus michauxii* (blue outlined areas) (From: Wheeler et al., 2014).

Assessment: *Pseudophilothrips ichini* could potentially feed on this plant, affecting its survival and reproduction because it belongs in the same family as Brazilian peppertree (Anacardiaceae). In host specificity tests using Michaux's sumac, no eggs were laid on any test plants, plants were not damaged, and there was no development of *P. ichini*. Therefore, APHIS has determined that release of *P. ichini* may affect, but is not likely to adversely affect Michaux's sumac.

Table 16. Agency May Affect, Not likely to Adversely Affect Determination and Conservation Measures.

Common Name	Stage	Determination	Impact/Effects	Conservation measure
Florida scrub-jay	B=Yes F=Yes	MA - beneficial	The invasion of some scrub habitat within Indian River, St. Lucie, and Martin counties by exotic	None

	S=Yes M=No N=Yes L=All		plants and animals, including Brazilian peppertree, has degraded scrub-jay habitat locally (USFWS, 2007). Removal of Brazilian peppertree from the habitat of the scrub jay may be beneficial to it.	
Everglade snail kite	B=Yes F=No S=Yes M=No N=Yes L=All	MANLAA	The Everglade snail kite is known to nest in Brazilian peppertree (Takekawa and Beissinger, 1989), but nests in many other tree species as well. Removal of Brazilian peppertree by *P. ichini* would be gradual and its impact would be insignificant to the snail kite.	None
Florida panther	B=No F=Yes M=No S=No N=No L=All	MA - beneficial	Brazilian pepper is likely to replace species used as food by white-tailed deer, which are important in the diet of Florida panthers (Maffei, 1994). Removal of Brazilian peppertree from the habitat of the Florida panther via *P. ichini* may be beneficial to it.	None
Key deer	B=No F=Yes S=Yes M=No N=No L=All	MA- beneficial	Brazilian peppertree occurs on islands throughout the range of the Key deer, and can out-compete native vegetation in large areas, reducing the availability of deer forage and degrading deer habitat (USFWS, 2010). Removal of Brazilian peppertree from the habitat of the Key deer may be beneficial to it.	None
Gopher tortoise	B=Yes F=Yes S=Yes M=No N=Yes L=All	MA - beneficial	In the Everglades National Park, the nesting habitat of the gopher tortoise is being encroached upon by Brazilian peppertree (Doren and Jones, 1997), although Brazilian peppertree leaves and berries are secondary or seasonal food for gopher tortoises (Ashton and Ashton, 2008). Release of *P. ichini* may affect beneficially the gopher tortoise.	None
Bartram's hairstreak butterfly	B=Yes F=Yes	MA - beneficial	Gould and Hammer (1999) assert that butterflies native to pineland and hammock communities	None

	S=Yes M=No N=No L=All		are threatened by the spread of Brazilian pepper due to replacement of host plants. Release of *P. ichini* may affect beneficially the Bartram's hairstreak butterfly and its designated critical habitat.	
Florida leafwing butterfly	B=Yes F=Yes S=Yes M=No N=No L=All	MA - beneficial	Gould and Hammer (1999) assert that butterflies native to pineland and hammock communities are threatened by the spread of Brazilian pepper due to replacement of host plants. Release of *P. ichini* may affect beneficially the Florida leafwing butterfly and its designated critical habitat.	None
Miami blue butterfly	B=Yes F=Yes S=Yes M=No N=No L=All	MA - beneficial	Gould and Hammer (1999) assert that butterflies native to pineland and hammock communities are threatened by the spread of Brazilian pepper due to replacement of host plants. Release of *P. ichini* may affect beneficially the Miami blue butterfly.	None
Schaus swallowtail butterfly	B=Yes F=Yes S=Yes M=No N=No L=All	MA - beneficial	Gould and Hammer (1999) assert that butterflies native to pineland and hammock communities are threatened by the spread of Brazilian pepper due to replacement of host plants. Release of *P. ichini* may affect beneficially the Schaus swallowtail butterfly.	None
Beach jacquemontia		MA - beneficial	The beach jacquemontia is adversely affected by Brazilian peppertree invasion (FLEPPC, 2006). Release of *P. ichini* may affect beneficially the beach jacquemontia.	None
Everglades bully		MA - beneficial	The Everglades bully is adversely affected by Brailian peppertree invasion (USDOI, FWS, 2016). Release of *P. ichini* may affect beneficially the Everglades bully.	None
Florida pineland crabgrass		MA - beneficial	Florida pineland crabgrass is adversely affected by Brazilian peppertree invasion (USDOI, FWS, 2016). Release of *P. ichini* may affect beneficially the Florida pineland crabgrass.	None
Pineland sandmat		MA - beneficial	Pineland sandmat is adversely affected by Brazilian peppertree invasion (USDOI, FWS, 2016). Release of *P. ichini* may affect beneficially pineland sandmat.	None
Florida prairie-clover		MA - beneficial	Florida prairie-clover is adversely affected by Brazilian peppertree invasion (USDOI, FWS, 2016). Release of *P. ichini* may affect beneficially Florida prairie-clover.	None

Michaux's sumac		MANLAA	*Pseudophilothrips ichini* could potentially feed on this plant, affecting its survival and reproduction because it belongs in the same family as Brazilian peppertree (Anacardiaceae). Host specificity test results indicated that Michaux's sumac did not support development of *P. ichini* (see Table 2). Therefore, APHIS has determined that release of *P. ichini* may affect, but is not likely to adversely affect Michaux's sumac.	Monitor for non-target impacts at initial release sites.

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Appendix 1. North American and Caribbean species of Sapindales and other test plants that are native or introduced and were tested against the thrips Pseudophilothrips ichini, prospective biological control agents of Brazilian peppertree. Listed Anacardiaceae species compiled from Pell et al. (2011). The remaining species names and their distributions from USDA/NRCS (2002) and Wunderlin and Hansen (2008).

Spp	Order	Family	Sub-Family	Species [1]	Authority	Common Name	Distribution [2]	Status [3]	Listed species US T/E [4]	Listed species State T/E [5,6,7]
Category 1: Genetic types of the target weed species										
1	Sapindales	Anacardiaceae	Anacardioideae	*Schinus terebinthifolia*	Raddi	Brazilian Peppertree	CA, FL, HI, TX, PR, VI	I		
	Three invasive genotypes of *S. terebinthifolia*, A, B, and hybrid were found to be suitable hosts of *P. ichini* (Manrique et al. 2008).									
Category 2: Species in the same (or closely related) genus as the target weed, including environmentally and economically important										
2	Sapindales	Anacardiaceae	Anacardioideae	*Schinus molle*	L.	Peruvian Peppertree	AZ, CA, FL, HI, TX, PR	I		
Category 3: Species in other genera in the same family as the target weed, divided by Subfamily and tribes, including environmentally and economically important										
3	Sapindales	Anacardiaceae	Anacardioideae	*Anacardium occidentale*	L.	Cashew	PR, VI	I		
4	Sapindales	Anacardiaceae	Anacardioideae	*Comocladia dodonaea*	(L.) Urb.	Poison ash	PR, VI	N		
5	Sapindales	Anacardiaceae	Anacardioideae	*Cotinus coggygria*	Scop.	Eurasian Smoketree	NE-US, UT	I		
6	Sapindales	Anacardiaceae	Anacardioideae	*Malosma laurina*	(Nutt.) Nutt. Ex Abrahms	Laurel sumac	CA	N		
7	Sapindales	Anacardiaceae	Anacardioideae	*Mangifera indica*	L.	Mango	FL, HI, PR, VI	I		
8	Sapindales	Anacardiaceae	Anacardioideae	*Mangifera indica*-Carrie	L.	Mango	FL, HI, PR, VI	I		
9	Sapindales	Anacardiaceae	Anacardioideae	*Mangifera indica*-Common	L.	Mango	FL, HI, PR, VI	I		
10	Sapindales	Anacardiaceae	Anacardioideae	*Mangifera indica*-Haden	L.	Mango	FL, HI, PR, VI	I		
11	Sapindales	Anacardiaceae	Anacardioideae	*Mangifera indica*-Ice Cream	L.	Mango	FL, HI, PR, VI	I		
12	Sapindales	Anacardiaceae	Anacardioideae	*Metopium toxiferum*	(L.) Krug & Urb.	Poisonwood	FL, PR	N		
13	Sapindales	Anacardiaceae	Anacardioideae	*Pistacia chinensis*	Bunge	Chinese Pistacio	SE-US, TX, CA	I		
14	Sapindales	Anacardiaceae	Anacardioideae	*Pistacia mexicana*	Kunth	American Pistacio	TX	N		
15	Sapindales	Anacardiaceae	Anacardioideae	*Pistacia vera*-Kerman	L.	Pistacio nut	CA	I		
16	Sapindales	Anacardiaceae	Anacardioideae	*Rhus aromatica*	Aiton	Fragrant Sumac	NW-FL, E-US	N		
17	Sapindales	Anacardiaceae	Anacardioideae	*Rhus copallina*	L.	Winged Sumac	E-US	N		

Spp	Order	Family	Sub-Family	Species [1]	Authority	Common Name	Distribution [2]	Status [3]	Listed species US T/E [4]	Listed species State T/E [5,6,7]
Category 3 (continued)										
18	Sapindales	Anacardiaceae	Anacardioideae	*Rhus glabra*	L.	Smooth Sumac	US, NW-FL	N		
20	Sapindales	Anacardiaceae	Anacardioideae	*Rhus sandwicensis*	A. Gray	Neneleau	HI	N		
21	Sapindales	Anacardiaceae	Anacardioideae	*Rhus typhina*	L.	Staghorn sumac	SE-US, not FL	N		
22	Sapindales	Anacardiaceae	Anacardioideae	*Toxicodendron pubescens*	Mill.	Atlantic Poison Oak	NW-FL, E-US	N		
23	Sapindales	Anacardiaceae	Anacardioideae	*Toxicodendron radicans*	(L.) Kuntze	Eastern Poison Ivy	E-US	N		
25	Sapindales	Anacardiaceae	Spondioideae	*Spondias dulcis*	Parkinson	Jewish plum	PR	N		
26	Sapindales	Anacardiaceae	Spondioideae	*Spondias mombin*	L.	Yellow Mombin	PR,VI	N		
27	Sapindales	Anacardiaceae	Spondioideae	*Spondias purpurea*	L.	Purple Mombin	FL, PR, VI	I		
Category 4: Threatened and endangered species in the same family as the target weed										
6	Sapindales	Anacardiaceae	Anacardioideae	*Cotinus obovatus*	Raf	American Smoketree	SE-US, not FL	N		Protected in TN
19	Sapindales	Anacardiaceae	Anacardioideae	*Rhus michauxii*	Sarg.	Michauxii's Sumac	SE-US [7]	N	Endang-ered	Protected in FL, GA, NC
24	Sapindales	Anacardiaceae	Anacardioideae	*Toxicodendron vernix*	(L.) Kuntze	Poison Sumac	E-US, TX	N		Endangered in KY
Category 5– North American or introduced species in other families that have some phylogenetic, morphological, or biochemical relationship to the target weed, economically and environmentally important plants										
28	Sapindales	Aceraceae	N/A	*Acer rubrum*	L.	Red maple	E-US	N		
29	Sapindales	Aceraceae	N/A	*Acer saccharinum*	L.	Silver Maple	US & Canada	N		
30	Sapindales	Burseraceae	N/A	*Bursera simaruba*	(L.) Sarg.	Gumbo limbo	FL, PR,VI	N		
31	Sapindales	Hippocastanaceae	N/A	*Aesculus pavia*	L.	Red Buckeye	E-US	N		
32	Sapindales	Meliaceae	N/A	*Aglaia odorata*	Lour.	Chinese Perfume Plant	HI	I		
33	Sapindales	Meliaceae	N/A	*Azadirachta indica*	A. Juss.	Neem	HI, PR	I		
34	Sapindales	Meliaceae	N/A	*Entandrophragma caudatum*	Sprague	Mountain Mahogany	HI	I		
35	Sapindales	Meliaceae	N/A	*Khaya senegalensis*	(Desr.) A. Juss.	African mahogany	FL, HI, PR	I		
36	Sapindales	Meliaceae	N/A	*Lansium domesticum*	Correa	Langsat	HI	I		
37	Sapindales	Meliaceae	N/A	*Sandoricum koetjape*	(Burm. f.) Merr.	Santol	HI	I		
38	Sapindales	Meliaceae	N/A	*Swietenia macrophylla*	King	Big-leaf Mahogany	HI	I		

Spp	Order	Family	Sub-Family	Species [1]	Authority	Common Name	Distribution [2]	Status [3]	Listed species US T/E [4]	Listed species State T/E [5,6,7]
Category 5 (continued)										
39	Sapindales	Meliaceae	N/A	*Swietenia mahagani*	(L.) Jacq.	West Indian Mahogany	FL, HI, PR,VI	N/I		
40	Sapindales	Meliaceae	N/A	*Toona ciliata*	Roem.	Australian Red Cedar	HI,PR	I		
41	Sapindales	Rutaceae	N/A	*Casimiroa edulis* (Redlands)	Llave & Lex.	White Sapote	HI	I		
42	Sapindales	Rutaceae	N/A	*Citrofortunella microcarpa*	(Bunge) Wijnands	Calamondin	Hi	I		
43	Sapindales	Rutaceae	N/A	*Citrus x aurantifolia*	Swingle	Key Lime	FL,PR,VI	I		
44	Sapindales	Rutaceae	N/A	*Citrus x sinensis*	(L.) Osbeck	Sweet orange	FL,LA,PR,VI	I		
45	Sapindales	Rutaceae	N/A	*Flindersia brayleyana*	F. Muell.	Queensland Maple	HI	I		
46	Sapindales	Rutaceae	N/A	*Fortunella japonica*	(Thunb.) Swingle	Kumquat	CA,HI	I		
47	Sapindales	Rutaceae	N/A	*Murraya exotica (=paniculata)*	L.	Orange Jessamine	FL, HI, PR,VI	I		
48	Sapindales	Rutaceae	N/A	*Zanthoxylum fagara* [9]	(L.) Sarg.	Lime Pricklyash	FL,HI, TX	I		
49	Sapindales	Sapindaceae	N/A	*Dimocarpus longan*/Biew Kieuw	Lour.	Longan	FL,HI	I		
50	Sapindales	Sapindaceae	N/A	*Dodonaea viscosa*	(L.) Jacq.	Hopbrush	AZ, FL, HI,TX, PR,VI	N/I		
51	Sapindales	Sapindaceae	N/A	*Exothea paniculata*	(Juss.) Radlk.	Inkwood	FL, HI,PR,VI	N/I		
52	Sapindales	Sapindaceae	N/A	*Filicium decipiens*	(Wight & Arn.) Thwaites	Japanese Fern Tree	HI	I		
53	Sapindales	Sapindaceae	N/A	*Harpullia pendula*	Planch. Ex F.Muell.	Tulipwood	HI	I		
54	Sapindales	Sapindaceae	N/A	*Hypelate trifoliata*	Sw.	White Ironwood	FL,PR,VI	N		
55	Sapindales	Sapindaceae	N/A	*Koelreuteria paniculata*	Laxm.	Goldenrain Tree	E-US, HI	I		
56	Sapindales	Sapindaceae	N/A	*Litchi chinensis* var. mauritius	Sonn.	Lychee	FL, HI	I		
57	Sapindales	Sapindaceae	N/A	*Majidea zanguebarica*	J.Kirk	Mgambo Tree	HI	I		
58	Sapindales	Sapindaceae	N/A	*Sapindus oahuensis*	Hillebr. Ex Radlk.	Lonomea	HI	N		
59	Sapindales	Sapindaceae	N/A	*Sapindus saponaria*	L.	Soapberry	SE-US, HI	N		
60	Sapindales	Simaroubaceae	N/A	*Leitneria floridana*	Chapm.	Corkwood	SE-US, HI	N		
61	Sapindales	Simaroubaceae	N/A	*Simarouba glauca*	DC.	Paradise Tree	FL	N		
62	Sapindales	Staphyleaceae	N/A	*Staphylea trifolia*	L.	American bladdernut	E-US	N		
63	Sapindales	Zygophyllaceae	N/A	*Guaiacum sanctum*	L.	Lignum-vitae	FL,PR	N		
64	Sapindales	Zygophyllaceae	N/A	*Tribulus cistoides*	L.	Jamaican Feverplant	S-US,HI,PR,VI	I		

Spp	Order	Family	Sub-Family	Species [1]	Authority	Common Name	Distribution [2]	Status [3]	Listed species US T/E [4]	Listed species State T/E [5,6,7]
Category 6. North American or introduced species in other orders that have some phylogenetic, morphological, or biochemical relationship to the target weed, economically and environmentally important plants										
65	Alismatales	Araceae	N/A	*Alocasia macrorrhizos*	(L.) G.Don	Giant taro	FL, HI, TX,PR	I		
66	Apiales	Apiaceae	N/A	*Daucus carota*	L	Carrot	US	I		
67	Aquifoliales	Aquifoliaceae	N/A	*Ilex cassine*	L	Dahoon Holly	SE-US	N		
68	Asterales	Asteraceae	N/A	*Ambrosia trifida*	L	Giant Ragweed	US & Canada	N		
69	Asterales	Asteraceae	N/A	*Lactuca sativa*	L	Head Lettuce	US	I		
70	Asterales	Asteraceae	N/A	*Solidago arguta*	Aiton	Goldenrod	E-US	N		
71	Brasicales	Brassicaceae	N/A	*Brassica oleracea*	L	Califlower	US	I		
72	Bromeliales	Bromeliaceae	N/A	*Ananas comosus*	(L.) Merr.	Pineapple	FL, PR	I		
73	Cornales	Cornaceae	N/A	*Nyssa sylvatica*	Marshall	Blackgum	E-US	N		
74	Cyperales	Poaceae	N/A	*Oryza sativa*	L	Rice	FL,PR,VI	I		
75	Cyperales	Poaceae	N/A	*Saccharum officinarum*	L	Sugarcane	SE-US	I		
76	Cyperales	Poaceae	N/A	*Zea mays*	L	Corn	US,PR,VI	I		
77	Dipsacales	Adoxaceae	N/A	*Sambucus nigra*	L	Elderberry	US & Canada	N/I		
78	Ebenales	Sapotaceae	N/A	*Planchonella sandwicensis*	(A. Gray) Baehni & O. Deg.	'ala'a	HI	N		
79	Ericales	Ericaceae	N/A	*Arctostaphylos densiflora*	M.S. Baker	Manzanita	CA	N		
80	Ericales	Primulaceae	N/A	*Ardisia escallonioides*	Schltdl. & Cham.	Marlberry	FL	N		
81	Fabales	Fabaceae	N/A	*Acacia koa*	A. Gray	Koa	HI	N		
82	Fabales	Fabaceae	N/A	*Arachis hypogaea*	L	Peanut	SE-US	I		
83	Fabales	Fabaceae	N/A	*Phaseolus vulgaris*	L	Pinto bean	US	I		
84	Fabales	Fabaceae	N/A	*Sophora chrysophylla*	(Salisb.) Seem.	Mamane	HI	N		
85	Fagales	Betulaceae	N/A	*Alnus serrulata*	(Aiton) Willd.	Hazel Alder	E-US	N		
86	Fagales	Fagaceae	N/A	*Quercus virginiana*	Mill.	Live oak	SE-US	N		
87	Ginkgoales	Ginkgoaceae	N/A	*Ginkgo biloba*	L	Maidenhair tree	E-US	I		
88	Hamamelidales	Hamamelidaceae	N/A	*Hamamelis virginiana*	L.	Witch hazel	E-US	N		
89	Juglandales	Juglandaceae	N/A	*Carya glabra*	(Mill.) Sweet	Pignut hickory	E-US	N		
90	Lamiales	Verbenaceae	N/A	*Clerodendrum sp.*	N/A	Glorybower	SE-US	I		
91	Lamiales	Verbenaceae	N/A	*Tectona grandis*	L. f.	Teak	HI, PR,VI,	I		
92	Lamiales	Verbenaceae	N/A	*Vitex sp.*	N/A	Chastetree	S-US	I		

94	Magnoliales	Magnoliaceae	N/A	*Magnolia virginiana*	L.	Sweetbay	SE-US	N		
95	Malpighiales	Euphorbiaceae [10]	N/A	*Chamaesyce hypericifolia*	(L.) Millsp.	Graceful Sandmat	HI, S-US,PR, VI	N/I		
			N/A							
			N/A						Listed species	
									US	State
Spp	Order	Family	Sub-Family	Species [1]	Authority	Common Name	Distribution [2]	Status [3]	T/E [4]	T/E [5&7]
Category 6 (continued)										
96	Malpighiales	Euphorbiaceae	N/A	*Euphorbia pulcherrima*	Willd. ex Klotzsch	Poinsettia	HI, PR	I		
97	Malpighiales	Euphorbiaceae	N/A	*Hippomane mancinella*	L.	Manchineel	FL, PR, VI	N		Protected in FL
98	Malpighiales	Euphorbiaceae	N/A	*Manihot esculenta*	Crantz	Cassava	SE-US	I		
99	Malvales	Malvaceae	N/A	*Abelmoschus esculentus*	(L.) Moench	Okra	E-US, PR, VI	I		
100	Malvales	Malvaceae	N/A	*Gossypium hirsutum*	L.	Cotton	S-US, HI, PR,VI	N/I		
101	Malvales	Malvaceae	N/A	*Hibiscus sp.*		Hibiscus				
102	Myricales	Malvaceae	N/A	*Morella (=Myrica) cerifera*	(L.) Small	Wax myrtle	SE-US	N		
103	Myrtales	Combretaceae	N/A	*Laguncularia racemosa*	(L.) C.F. Gaertn.	White Mangrove	FL, PR, VI	N		
104	Myrtales	Myrtaceae	N/A	*Eucalyptus camaldulensis*	Dehnh.	Red Gum	CA, FL, HI, PR, VI,	I		
105	Myrtales	Myrtaceae	N/A	*Eugenia axillaris*	(Sw.) Willd.	White Stopper	FL,PR,VI	N		
106	Myrtales	Myrtaceae	N/A	*Eugenia uniflora*	L.	Surinam cherry	FL, HI, PR,VI	I		
107	Myrtales	Myrtaceae	N/A	*Metrosideros polymorpha*	Gaudich.	Ohi'a lehua	HI	N		
108	Proteales	Proteaceae	N/A	*Macadamia integrifolia*	Maiden & Betche	Macadamia nut	PR	I		
109	Rosales	Rosaceae	N/A	*Crataegus spathulata*	Michx.	Hawthorn	SE-US	N		
110	Rosales	Rosaceae	N/A	*Prunus caroliniana*	Aiton	Cherry laurel	SE-US	N		
111	Rubiales	Rubiaceae	N/A	*Coffea arabica*	L.	Arabian coffee	HI, PR,VI	I		
112	Scrophulariales	Myoporaceae	N/A	*Myoporum sandwicense*	(A. DC.) A. Gray	Naio	HI	N		
113	Solanales	Convolvulaceae	N/A	*Ipomoea batatas*	(L.) Lam.	Sweet potato	US,HI,PR,VI	I		
114	Solanales	Solanaceae	N/A	*Capsicum annuum*	L.	Bell Pepper	S-US, HI, PR,VI	I		
115	Solanales	Solanaceae	N/A	*Solanum lycopersicum*	L.	Tomato	US, HI, PR,VI,	I		
116	Solanales	Solanaceae	N/A	*Solanum tuberosum*	L.	Potato	US, HI, PR	I		
117	Theales	Theaceae	N/A	*Gordonia lasianthus*	(L.) Ellis	Loblolly bay	SE-US	N		
118	Urticales	Ulmaceae	N/A	*Ulmus alata*	Michx.	Florida elm	SE-US	N		
119	Violales	Caricaceae	N/A	*Carica papaya*	L.	Papaya	FL, HI, PR, VI	I		
120	Zingiberales	Musaceae	N/A	*Musa acuminata*	Colla	Edible Banana	FL	I		
Category 7: Any plant on which the biological control agent or its close relatives (within the same genus) have been previously recorded to feed and/or reproduce										
93	Laurales	Lauraceae	N/A	*Persea americana*	Mill.	Avocado	FL, HI, PR,VI	I		

[1] Species names follow Pell et al (2011) USDA/NRCS (2002) and Wunderlin and Hansen (2008)

[2] Distributions from USDA/NRCS (2002) and from personal observations.

[3] I: Introduced; N: Native

[4] Federal endangered plant list from USFWS Endangered Species Program (2006). (Accessed 15 Apr 2014) (http://ecos.fws.gov/)

[5] Florida state endangered plant list from Coile and Garland (2004); Nongame and Rare Species Program: Federal/State Threatened and Endangered Species (Accessed 15 Apr 2013). Texas Parks and Wildlife Department, Texas. www.tpwd.state.tx.us/huntwild/wild/wildlife_diversity/texas_rare_species/listed_species/

[6] Tennessee Natural Heritage Program (2002). Rare plant list (20 October 2002). Department of Environment and Conservation, Tennessee.

[7] Kentucky State Nature Preserves Commission (2000). Endangered, threatened, and special concern species (20 October 2002). Kentucky State Nature Preserves Commission, Kentucky.

[8] *Rhus michauxii* collected only once, from Alachua Co, FL in 1961 from a male clone plant.

[9] Several Hawaiian species of *Zanthoxylum* are listed as federally endangered. We test here, *Z. fagara*, a surrogate of these species.

[10] We place the Euphorbiaceae in the Malpigiales after APG III (2009) instead of Euphorbiales as in USDA/NRCS (2002)

Appendix 2. Quarantine host range testing of *Pseudophilothrips ichini*, a potential biological control agent of Brazilian peppertree, *Schinus terebinthifolia*, in North America and Hawaii (Wheeler et al., 2016).

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SPECIAL ISSUE – IMPROVING PEST CONTROL: MASS REARING AND FIELD PERFORMANCE

Quarantine host range testing of *Pseudophilothrips ichini*, a potential biological control agent of Brazilian peppertree, *Schinus terebinthifolia*, in North America and Hawaii

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Abstract

Brazilian peppertree, *Schinus terebinthifolia* Raddi (Anacardiaceae), is an invasive weed of natural and agricultural areas of Florida, Hawaii, and Texas (USA). Biological control presents an environmentally safe and cost-effective control method for invasive populations of this weed. Though many potential agents have been tested for specificity, nearly all have been rejected due to a broad host range. However, one species, a thrips *Pseudophilothrips ichini* (Hood) (Thysanoptera: Phlaeothripidae), shows promise from field observations and quarantine host range tests. A series of no-choice, choice, and multiple-generation tests was conducted on 127 plant taxa (including five mango and four pistachio varieties) from 45 families and 33 orders. In no-choice starvation tests, the thrips fed and produced offspring on the target weed (124 F_1 adults per plant), whereas no or few (<4 F_1 adults per plant) were obtained on non-target species. The primary exception was another exotic invasive tree *Schinus molle* L., on which an average 20 F_1 thrips adults were produced. No-choice tests indicated that small numbers of F_1 offspring were produced on nine other non-target plant species. The numbers of F_1 offspring produced on these plants were <3% of those produced on the target weed. In choice tests, on average two or fewer F_1 adults were produced on four non-target species tested, compared with 64 F_1 adults on the target weed. Multiple-generation tests indicated that three generations of thrips were maintained only on the target weed and *S. molle* with no differences between these two plant species or across generations. Thus, this thrips species has a narrow host range that includes the two invasive *Schinus* spp. tested here. If released, the thrips *P. ichini* will constitute safe and potentially effective biological control of Brazilian peppertree in North America and Hawaii.

Introduction

Brazilian peppertree, *Schinus terebinthifolia* Raddi (Anacardiaceae), native to South America, is one of the most aggressive and widespread invasive species in Florida, Hawaii, and Texas (USA) (Ewel, 1986; Rodgers et al., 2014). This species constitutes a threat to natural areas, agriculture, and cattle production (Morton, 1978; Ewel, 1986; Yoshioka & Markin, 1991). Brazilian peppertree, also known as Christmas berry in Hawaii, has successfully colonized most of the Florida peninsula, covering more than 280 000 ha (700 000 acres), with thick monospecific stands that eliminate understory plant growth (Ferriter, 1997; Schmitz et al., 1997). In Hawaii, surveys conducted in the early 1990s estimated that 50 000 ha were moderately to heavily infested by this noxious weed (Yoshioka & Markin, 1991). In Texas, Brazilian peppertree occurs along

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the Gulf Coast, from Galveston south to Brownsville, where it is considered one of the greatest threats to native plant and animal biodiversity (www.texasinvasives.org, accessed 12 April 2016). The US Fish and Wildlife Service (1998) identified Brazilian peppertree as one of the most significant non-indigenous species currently impacting federally listed threatened and endangered native plants throughout the Hawaiian islands. Brazilian peppertree produces allelopathic compounds that suppress the growth of native plant species (Gogue et al., 1974; Morgan & Overholt, 2005). Moreover, this species causes allergic reactions and respiratory illness in sensitive people due to volatiles released by the leaves, flowers, and fruits (Morton, 1978; Stahl et al., 1983). Ingestion of the leaves and fruits can have narcotic and toxic effects in grazing animals and birds (Campello & Marsaioli, 1974; Morton, 1978). Chemical and mechanical control measures are costly, and maintenance programs are required to prevent regrowth (Doren & Jones, 1997; Rodgers et al., 2012). Classical biological control may provide an ecologically sound, cost-effective, and sustainable management solution to protect native plants in the invaded range.

Brazilian peppertree is a Neotropical species whose native range extends along the South American Atlantic coast of Brazil and Uruguay, west to northeastern Argentina and adjacent Paraguay (Barkley, 1957; Wheeler et al., 2016b) (Figure 1). This species has been introduced to many countries around the world as an ornamental plant, and has become naturalized in subtropical areas of both the northern and southern hemispheres (Ewel et al., 1982;

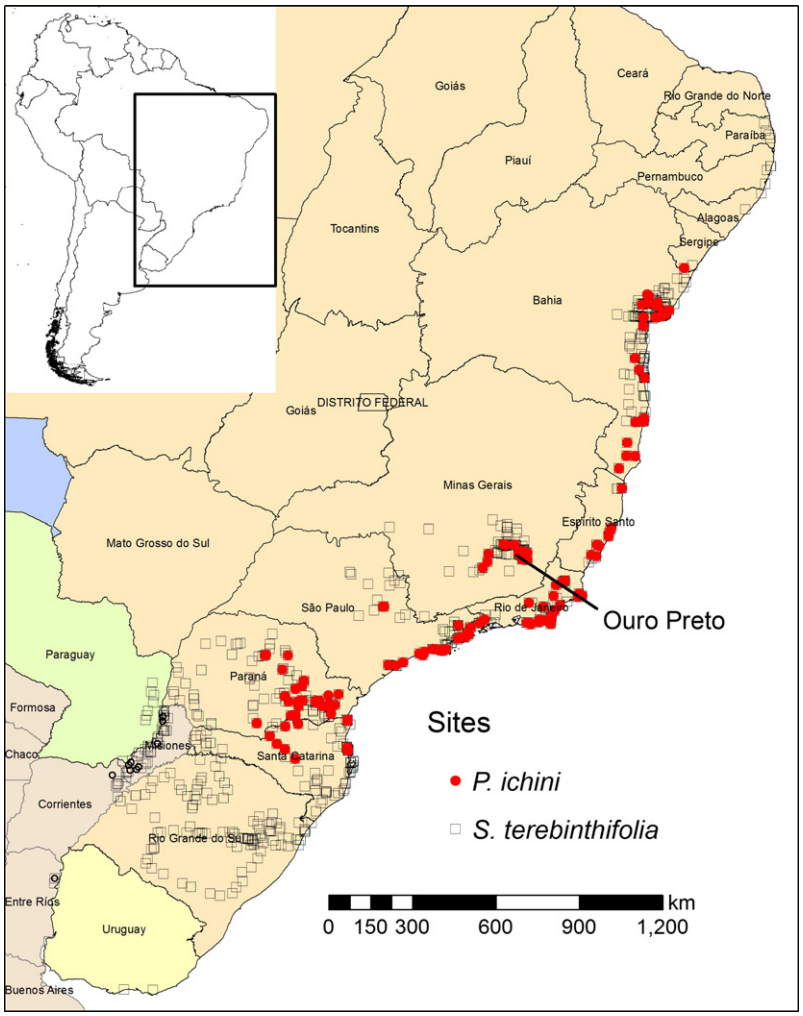

Figure 1 Geographic distribution of the host *Schinus terebinthifolia* (open black squares) and the *Pseudophilothrips ichini* (red dots) thrips in Brazil and adjacent Argentina, Paraguay, and Uruguay. The thrips was found mostly throughout the distribution of the host. However, no thrips were found north of Sergipe or south of Santa Catarina states in Brazil. The thrips collection from near Ouro Preto was tested in quarantine for specificity. [Colour figure can be viewed at wileyonlinelibrary.com]

Panetta & McKee, 1997; Henderson, 2001). The distribution of this species appears to be restricted by winter freezes (Barkley, 1957; Mukherjee et al., 2012). Currently, Brazilian peppertree occurs in the USA in Alabama, California, Florida, Georgia, Hawaii, and Texas (USDA/NRCS, 2016). On the Hawaiian Islands, it occurs on Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii (Wagner et al., 1990; Staples & Herbst, 2005). This weed also occurs in Puerto Rico and the Virgin Islands (USDA/NRCS, 2016). Historical records from Florida reveal two separate introductions as an ornamental plant (Morton, 1978). These introductions occurred between 1898 and 1926 near Miami on the east coast, and near Punta Gorda on the west coast of Florida (Williams et al., 2005). Recent genetic analysis indicates that these introductions are distinct haplotypes, originated from different source areas in Brazil, and have since hybridized extensively throughout Florida (Williams et al., 2007; Mukherjee et al., 2012).

Biological control research against Brazilian peppertree began in Hawaii in 1954, continued between 1960 and 1961 (Yoshioka & Markin, 1991), and has been conducted in Florida more recently (Hight et al., 2002; Wheeler et al., 2016a). Three biological control agents were released in Hawaii, a bruchid seed feeder, *Lithraeus atronotatus* Pic, a tortricid leaf folder, *Episimus unguiculus* Clarke, and a gelechiid stem galler, *Crasimorpha infuscata* Hodges (Davis & Krauss, 1962; Krauss, 1962, 1963; Yoshioka & Markin, 1991). Despite the establishment of the first two species in Hawaii, their feeding has not sufficiently reduced the weed problem (Yoshioka & Markin, 1991; Julien & Griffiths, 1998; Hight et al., 2002).

The thrips *Pseudophilothrips ichini* (Hood) (Thysanoptera: Phlaeothripidae) was first recorded on leaves of *S. terebinthifolia* near Rio de Janeiro, Brazil, and described in the genus *Liothrips* (Hood, 1949). This thrips species has been proposed as a classical biological control agent of *S. terebinthifolia* in Florida and Hawaii (Wheeler et al., 2016a). Since its initial description, several members of the *Liothrips* genus have been reassigned to the *Pseudophilothrips* genus (Johansen, 1979). Previous collections of Brazilian thrips occurred from locations near Curitiba, Parana, Brazil, and were incorrectly identified as *P. ichini* (Garcia, 1977; Hight et al., 2002; Cuda et al., 2008, 2009). More recent research determined that this was a different species (i.e., *Pseudophilothrips gandolfoi* Mound et al.), and the identity of these two species was clarified with molecular and morphological techniques (Mound et al., 2010). The name *P. ichini* is applied herein. In its native range of eastern Brazil, *P. ichini* has a wide distribution, but does not entirely overlap that of its host, nor does if co-ocur with *P. gandolfoi* (Mound et al., 2010; Wheeler et al., 2016b). The results of South American field host range tests of *P. ichini* indicated a high degree of specificity, as this thrips was never found on any species other than the target weed Brazilian peppertree (Wheeler et al., 2016b). Our goal in this study was to examine the host range of *P. ichini* to determine its suitability for field release as a classical biological control agent of Brazilian peppertree.

Materials and methods

Plants

The development of the test plant list generally followed the recommendations made by Wapshere (1974), with modifications described in Briese & Walker (2008). A test plant list for this target weed was compiled using North American, Hawaiian, Caribbean, and Mexican flora. To more accurately predict host range, we focused testing on relatives with increased emphasis on closely related species.

Schinus terebinthifolia is assigned to the moderately sized family Anacardiaceae in the order Sapindales. Numerous plant species assigned to families in the Sapindales were tested here for specificity. This order also includes families such as the Burseraceae (torchwood), Meliaceae (mahogany), Rutaceae (citrus), Sapindaceae (soapberry), and Simaroubaceae (tree of heaven) (Stevens, 2011). In order to include related plant species, we tested members of these plant families and members of the Aceraceae, Hippocastanaceae, Staphyleaceae, and Zygophyllaceae, as these families have historically been included with the Sapindales (USDA/NRCS, 2016).

The native geographic range of few of the Anacardiaceae species overlap that of the target weed (Wunderlin & Hansen, 2008; USDA/NRCS, 2016). Those native, taxonomically related species that are sympatric with the weed include *Metopium toxiferum* (L.) Krug & Urb., *Rhus copallina* L., *Rhus sandwicensis* A. Gray (Hawaii only), *Toxicodendron radicans* (L.) Kuntze, *Toxicodendron vernix* (L.) Kuntze, *Spondias dulcis* Parkinson, and *Spondias mombin* L. (both co-occur in Puerto Rico and the Virgin Islands). Related native species with near or minimal overlap with the weed include *Cotinus obovatus* Raf, *Pistacia mexicana* Kunth, *Rhus aromatica* Aiton, *Rhus glabra* L., *Rhus michauxii* Sarg., *Rhus typhina* L., and *Toxicodendron pubescens* Mill. Related introduced species that are sympatric include *Anacardium occidentale* L., *Mangifera indica* L., *Schinus molle* L., *Pistacia chinensis* Bunge, and *Spondias purpurea* L. Related species that are introduced with near or minimal overlap with the weed include *Pistacia vera* L.

The *Schinus* genus is endemic to South America, where ca. 30 species are known to occur from Ecuador to Patagonia (Pell et al., 2011). There are no native species in the

genus *Schinus* in the USA, although four *Schinus* species have been introduced historically: (1) *Schinus longifolius* (Lindl.) Speg. in Texas, (2) *S. molle* in California, Florida, and Texas, (3) *Schinus polygamus* (Cav.) Cabrera in California, and (4) *S. terebinthifolia* in California, Florida, Hawaii, and Texas (Bargeron & Swearingen, 2010). Even though Barkley (1944) reported specimens of *S. longifolius* in Texas, later surveys were unable to detect its presence. Similarly, *S. molle* was recorded in a single collection in Central Florida from 1931 (Herbarium UNC, 2016); however, it should be considered an historic introduction which did not establish. Both *S. molle* and *S. polygamus* are considered weedy species in southern California (Cal IPC, 2016). Of the four *Schinus* species that have been introduced, only *S. molle* in California has ornamental value. However, the California Exotic Pest Plant Council has listed this species as a 'limited' category invasive species (Cal IPC, 2016). Therefore, in addition to *S. terebinthifolia*, only the congener *S. molle* was included in the host range testing.

In the USA, the most important agricultural commodity in the Anacardiaceae is pistachio (*P. vera*) which is cultivated primarily in California (99% of the USA acreage; www.americanpistachios.org). California pistachio production is dominated by one cultivar, i.e., *P. vera* cv. Kerman (Roitman et al., 2011), which, when irrigated, can grow in climates with long, dry, and hot summers; low humidity; and cool winters. We tested the *P. vera* cvs Kerman, Lost Hills, and Randy, and the rootstock, UCB1, a hybrid of *P. atlantica* Desf. and *P. integerrima* JL Stewart ex Brandis. In addition, the related introduced species *P. chinensis*, *P. atlantica*, and *P. integerrima*, and the native *P. mexicana* were tested. Other cultivated members of the Anacardiaceae include mango, *M. indica*, and cashew, *A. occidentale*, although fruits of both are mostly imported in the USA (Evans, 2008; McLaughlin et al., 2013). However, they are cultivated to a limited extent in South Florida, Hawaii, Puerto Rico, and the Virgin Islands (USDA/NRCS, 2016). We tested the mango varieties Carrie, Common, Haden, and Ice Cream. The tested cashew was an unnamed variety.

Insects

The thrips *P. ichini* population introduced under quarantine for testing was field-collected from Brazilian peppertree leaves in November 2007. The collection occurred at a site (−20.36911 latitude, −43.56029 longitude; 1 329 m a.s.l.) near Ouro Preto, MG, Brazil. Upon arrival in the USA, this thrips collection was divided between two quarantine laboratories, the Invasive Plant Research Laboratory, USDA/ARS in Ft Lauderdale, FL, and the University of Florida, Biological Control Research and Containment Laboratory in Ft Pierce, FL. All laboratory studies were conducted at these two quarantine facilities from this single introduction. The identity of these colonies was confirmed with genetic analysis (D Williams, Texas Christian University, Ft Worth, TX, USA, unpubl.). The thrips were collected from a haplotype A Brazilian peppertree plant, one of the two parental lines that are invasive in Florida and Hawaii (Williams et al., 2007).

All thrips were reared on whole Brazilian peppertree plants that were initially grown in outdoor gardens and fertilized with both liquid (30N-10P-10K; 2.5 g per 3.8 l; Miracle-Gro for acidophilic plants, Marysville, OH, USA) and slow-release (14N-14P-16K; Multicote 4, Matam, Israel) fertilizers applied (30–60 g per pot) every 3–4 months. Plants were pruned periodically to stimulate the flush growth needed for *P. ichini* feeding and development. Plants were kept free of pests with occasional insecticide applications (29.6 ml per 3.8 l water, acephate 9.4% active ingredient; Ortho Systemic Insect Killer, Scotts Miracle Gro, Marysville, OH, USA); however, no plants were used within 3 months of treatment. When prepared, plants were moved into quarantine greenhouses to feed thrips colonies. Colony thrips were routinely reared on live Brazilian peppertree plants inside vented acrylic cylindrical cages (45 cm long × 15 cm diameter). The vent at the top of the cylinder was sealed with expanding foam to prevent thrips escape (Jones et al., 2010). The thrips were allowed to complete their entire life cycle inside these cylinders.

Quarantine host range tests

In total, we tested 127 taxa in quarantine from 45 plant families from 33 plant orders. These included mostly members of the order Sapindales. We tested 26 species of the Anacardiaceae and 64 species of the other families of the Sapindales. Our protocol for host range tests was divided into no-choice, choice, and multiple-generation tests. To predict the host range of the thrips *P. ichini*, we supplemented the field host range observed in Brazil (Wheeler et al., 2016b) with this series of tests conducted inside quarantine. Simultaneous no-choice starvation tests that extended for one complete generation of the thrips were conducted. These no-choice starvation tests are the most rigorous and conservative test design used to define a candidate's fundamental or physiological host range (Van Klinken, 2000; Schaffner, 2001). When we obtained F_1 adults on a non-target species, we then subjected the thrips to a choice test of that species and Brazilian peppertree. The choice tests conducted here were the 'normal choice tests' as they simultaneously exposed the target weed and a single test species (Schaffner, 2001). These tests were conducted during the thrips' most mobile life stage, i.e., the

adult stage, in which decisions are made for oviposition. Moreover, when F_1 offspring resulted from a no-choice test, we also conducted multiple-generation tests on those plant species. These tests determined whether the thrips could sustain up to three generations solely on the non-target species.

No-choice tests

These tests assessed immature development and reproduction of *P. ichini* on test plant species including the target weed. Twenty thrips adults were introduced into the standard vented cages (described above) that contained either a single Brazilian peppertree (control) or a non-target plant. These P_1 adults were allowed to feed, mate, and oviposit until second instars were observed (ca. 23 days), after which time the cage was removed and the P_1 adults were collected. The cage was replaced and the exposed plants were observed over the next 27 days (one generation + a 7-day buffer) for the maturation of F_1 offspring. The F_1 adults were counted and the experiment was terminated. Replicates generally ranged from four to 14 for the non-target species; fewer replicates were included for several species that were difficult to obtain.

Choice tests

If F_1 offspring were produced on a non-target species during no-choice tests, we conducted a choice test that included that non-target species and the weed Brazilian peppertree. The choice tests were conducted by releasing 20 adult thrips into a Plexiglas cage (50 × 50 × 50 cm) or a large fabric cage (1 × 1 × 1 m). The thrips were allowed to feed and oviposit on either the Brazilian peppertree or the non-target plant. The thrips adults were transferred to a plastic vial and released inside each cage. A leaf of each plant species was inserted into each vial to facilitate thrips transfer. Cages were checked 3× per week. When second instars were visible, the adults were removed and each plant was placed separately into a standard vented cage. The plants were left undisturbed for at least 27 days, after which the F_1 adults produced on each plant were counted and the experiment was terminated. In this way, we could determine preference of the thrips and, as in the no-choice tests, whether the test plant was suitable for development. Replicate numbers ranged from four to nine.

Multiple-generation tests

Similar to the adult choice tests above, we conducted multiple-generation tests on those species that produced F_1 adults of *P. ichini* during no-choice tests. This was accomplished by transferring 20 F_1 adults to a fresh plant of the same species. If fewer than 20 F_1 adults were produced, transfers were made with available individuals. Simultaneous controls were treated identically, with 20 F_1 adults fed Brazilian peppertree plants. To determine the feasibility of continued thrips populations on each non-target species, this process was repeated for three generations, or until fewer than two F_1 adults were found, as no subsequent generation could be produced under such conditions. Furthermore, we compared the number of adults produced at each generation between the test plants and the Brazilian peppertree controls. Four to five replicates were included for these multiple-generation tests.

Statistical analysis

Prior to statistical analysis of all data, results were checked for agreement with the assumptions of ANOVA and log (x + 1) transformed as appropriate. The number of F_1 adults produced from the no-choice tests was analyzed by one-way ANOVA for those plant species that produced offspring and means were compared with a Tukey's honestly significant difference test (HSD; $\alpha = 0.05$). The number of F_1 adults produced in the choice test on each non-target species was compared with that of the corresponding control plant with individual ANOVAs. Data for the multiple-generation tests were analyzed by a repeated measures ANOVA (SAS Institute, 2014).

Results

No-choice tests

The results of no-choice tests indicated that F_1 adults of *P. ichini* were produced on the congener of the target weed, *S. molle*, and nine other species (Table 1). The mean (± SEM) number of F_1 adults per plant produced on *S. molle* was 20.3 ± 7.6, whereas we obtained significantly more from the Brazilian peppertree control (124.0 ± 9.1). The average number produced on the other non-target plants – *C. coggygria*, *Malosma laurina* (Nutt.), *M. toxiferum*, *P. chinensis*, *R. glabra*, *R. sandwicensis*, and *R. typhina* – ranged from 0.2–3.3 F_1 adults per plant. We also obtained adults from two of the *P. vera* cultivars (Kerman and Lost Hills) and from UCB1, a hybrid rootstock of *P. atlantica* and *P. integerrima*. Development on these pistachio taxa averaged <1 F_1 adult per plant. F_1 adults were produced on only one species outside the Anacardiaceae, *Dodonaea viscosa* Jacq. (2.8 ± 1.7 per plant) (Table 1).

Choice tests

The 10 plant species that produced F_1 adults of *P. ichini* in the no-choice tests above were then tested in adult choice tests. When given a choice, thrips overwhelmingly completed development on the target weed, resulting in the production of significantly greater numbers of F_1 offspring

Table 1 F1 production (mean number of F1 adult progeny per plant ± SEM) of *Pseudophilothrips ichini* in no-choice tests on a range of native and introduced plants belonging to seven species categories derived from USDA/APHIS/TAG (2003). The list of Anacardiaceae species was compiled from Pell et al. (2011), the remaining species names from plants.usda.gov (2015)

	Species	Common name	Status	n	Mean ± SEM
Category 1 – Genetic types of the target weed species found in North America and Hawaii					
Sapindales					
Anacardiaceae	*Schinus terebinthifolia* Raddi	Brazilian peppertree	Invasive	99	124.0 ± 9.1a
Category 2 – North American and Hawaii species in the same genus as the target weed					
Sapindales					
Anacardiaceae	*Schinus molle* L.	Peruvian peppertree	Invasive	9	20.3 ± 7.6b
Category 3 – North American and Hawaii species in other genera in the same family as the target weed					
Sapindales					
Anacardiaceae	*Anacardium occidentale* L.	Cashew	Cultivated	10	0
	Cotinus coggygria Scop.	Eurasian smoketree	Introduced	14	0.4 ± 0.4b
	Cotinus obovatus Raf	American smoketree	Native	10	0
	Malosma laurina (Nutt.)	Laurel sumac	Native	4	1.25 ± 1b
	Mangifera indica L.	Mango	Cultivated	4	0
	M. indica cv. Carrie	Mango	Cultivated	4	0
	M. indica cv. Common	Mango	Cultivated	4	0
	M. indica cv. Haden	Mango	Cultivated	4	0
	M. indica cv. Ice cream	Mango	Cultivated	4	0
	Metopium toxiferum (L.) Krug & Urb.	Poisonwood	Native	10	1.4 ± 1.0b
	Pistacia atlantica Desf.	Mt Atlas mastic tree	Cultivated	5	0
	Pistacia chinensis Bunge	Chinese pistacio	Cultivated	10	0.2 ± 0.1b
	Pistacia integerrima J.L. Stewart ex Brandis	Zebrawood	Cultivated	3	0
	Pistacia mexicana Kunth	American pistacio	Native	9	0
	Pistacia vera L. cv. Lost hills	Pistacio nut	Cultivated	2	0.4 ± 0.3b
	P. vera cv. Kerman	Pistacio nut	Cultivated	12	0.8 ± 0.6b
	P. vera cv. Randy	Pistacio nut	Cultivated	3	0
	P. vera cv. UCB1	Pistacio nut	Cultivated	5	0.4 ± 0.4b
	Rhus aromatica Aiton	Fragrant sumac	Native	10	0
	Rhus copallina L.	Winged sumac	Native	10	0
	Rhus sandwicensis A. Gray	Neneleau	Native	10	3.3 ± 3.3b
	Rhus typhina L.	Staghorn sumac	Native	9	3.2 ± 2.9b
	Toxicodendron pubescens Mill.	Atlantic poison oak	Native	11	0
	Toxicodendron radicans (L.) Kuntze	Eastern poison ivy	Native	10	0
	Spondias dulcis Parkinson	Jewish plum	Introduced	10	0
	Spondias mombin L.	Yellow mombin	Introduced	4	0
	Spondias purpurea L.	Purple mombin	Introduced	10	0
Category 4 – Threatened and endangered species in the same of closely related families to the target weed					
Sapindales					
Anacardiaceae	*Rhus michauxii* Sarg.	Michauxii's sumac	Native	7	0
	Toxicodendron vernix (L.) Kuntze	Poison sumac	Native	6	0
	Comocladia dodonaea (L.) Urb.	Poison ash	Native	10	0
	Rhus glabra L.	Smooth sumac	Native	10	0.9 ± 0.4b
Hippocastanaceae	*Aesculus pavia* L.	Red buckeye	Native	4	0
Meliaceae	*Swietenia mahagani* (L.) Jacq.	West Indian mahogany	Native	4	0
Sapindaceae	*Dodonaea eleganoides* Rudolphi ex Ledeb. & Alderst	Smallfruit	Native	10	0
	Hypelate trifoliata Sw.	White ironwood	Native	4	0
Simaroubaceae	*Leitneria floridana* Chapm.	Corkwood	Native	4	0
Staphyleaceae	*Staphylea trifolia* L.	American bladdernut	Native	4	0

Table 1 Continued

	Species	Common name	Status	n	Mean ± SEM
Zygophyllaceae	*Guaiacum sanctum* L.	Lignum-vitae	Native	4	0
Magnoliales					
Magnoliaceae	*Magnolia virginiana* L.	Sweetbay	Native	4	0
Malpighiales					
Euphorbiaceae	*Hippomane mancinella* L.	Manchineel	Native	4	0
Category 5 – North American and Hawaii species in other families in the same order that have some phylogenetic, morphological, or biochemical similarities to the target weed					
Sapindales					
Aceraceae	*Acer rubrum* L.	Red maple	Native	4	0
	Acer saccharinum L.	Silver maple	Native	4	0
Burseraceae	*Bursera simaruba* (L.) Sarg.	Gumbo limbo	Native	4	0
Meliaceae	*Aglaia odorata* Lour.	Chinese perfume plant	Introduced	4	0
	Azadirachta indica A. Juss.	Neem	Cultivated	4	0
	Entandrophragma caudatum Sprague	Mountain mahogany	Introduced	4	0
	Khaya senegalensis (Desr.) A. Juss.	African mahogany	Introduced	4	0
	Lansium domesticum Correa	Langsat	Cultivated	4	0
	Sandoricum koetjape (Burm. f.) Merr.	Santol	Introduced	4	0
	Swietenia macrophylla King	Big-leaf Mahogany	Introduced	4	0
	Toona ciliata Roem.	Australian red cedar	Introduced	4	0
Rutaceae	*Casimiroa edulis* Llave & Lex.	White sapote	Introduced	4	0
	Citrofortunella microcarpa (Bunge) Wijnands	Calamondin	Introduced	4	0
	Citrus × *aurantifolia* Swingle	Key lime	Cultivated	4	0
	Citrus × *sinensis* (L.) Osbeck	Sweet orange	Cultivated	4	0
	Flindersia brayleyana F. Muell.	Queensland maple	Introduced	4	0
	Fortunella japonica (Thunb.) Swingle	Kumquat	Introduced	4	0
	Murraya exotica (= *paniculata*) L.	Orange jessamine	Introduced	4	0
	Zanthoxylum fagara (L.) Sarg.	Lime pricklyash	Introduced	4	0
Sapindaceae	*Dimocarpus longan* Lour.	Longan	Cultivated	4	0
	Dodonaea viscosa Jacq.	Hopbrush	Native/introduced	10	2.8 ± 1.7b
	Exothea paniculata (Juss.) Radlk.	Inkwood	Native/introduced	4	0
	Filicium decipiens (Wight & Arn.) Thwaites	Japanese fern tree	Introduced	4	0
	Harpullia pendula Planch. ex F.Muell.	Tulipwood	Introduced	4	0
	Koelreuteria paniculata Laxm.	Goldenrain tree	Invasive	4	0
	Litchi chinensis var. mauritius Sonn.	Lychee	Cultivated	7	0
	Majidea zanguebarica J. Kirk	Mgambo tree	Introduced	4	0
	Sapindus oahuensis Hillebr. ex Radlk.	Lonomea	Native	2	0
	Sapindus saponaria L.	Soapberry	Native	4	0
Simaroubaceae	*Simarouba glauca* DC.	Paradise tree	Native	4	0
Zygophyllaceae	*Tribulus cistoides* L.	Jamacan feverplant	Invasive	4	0
Category 6 – North American and Hawaii species in other orders that have some phylogenetic, morphological, or biochemical similarities to the target weed					
Aquifoliales					
Aquifoliaceae	*Ilex cassine* L.	Dahoon holly	Native	4	0
Asterales					
Asteraceae	*Ambrosia trifida* L.	Giant ragweed	Native	4	0
	Solidago arguta Aiton	Goldenrod	Native	4	0
Cornales					
Cornaceae	*Nyssa sylvatica* Marshall	Blackgum	Native	4	0

Table 1 Continued

	Species	Common name	Status	n	Mean ± SEM
Dipsacales					
Adoxaceae	*Sambucus nigra* L.	Elderberry	Native/introduced	4	0
Ebenales					
Sapotaceae	*Planchonella sandwicensis* (A. Gray) Baehni & O. Deg.	‘ala’a	Native	4	0
Ericales					
Ericaceae	*Arctostaphylos densiflora* M.S. Baker	Manzanita	Native	4	0
Primulaceae	*Ardisia escallonioides* Schitdl. & Cham.	Marlberry	Native	4	0
Fabales					
Fabaceae	*Acacia koa* A. Gray	Koa	Native	4	0
	Sophora chrysophylla (Salisb.) Seem.	Mamane	Native	4	0
Fagales					
Betulaceae	*Alnus serrulata* (Aiton) Willd.	Hazel alder	Native	4	0
Fagales					
Fagaceae	*Quercus virginiana* Mill.	Live oak	Native	4	0
Hamamelidales					
Hamamelidaceae	*Hamamelis virginiana* L.	Witch hazel	Native	4	0
Juglandales					
Juglandaceae	*Carya glabra* (Mill.) Sweet	Pignut hickory	Native	4	0
Lamiales					
Verbenaceae	*Clerodendrum* sp.	Glorybower	Introduced	4	0
	Vitex sp.	Chastetree	Introduced	4	0
Malpighiales					
Euphorbiaceae	*Chamaesyce hypericifolia* (L.) Millsp.	Graceful sandmat	Native/introduced	4	0
Myricales					
Malvaceae	*Morella* (= *Myrica*) *cerifera* (L.) Small	Wax myrtle	Native	4	0
Myrtales					
Combretaceae	*Laguncularia racemosa* (L.) C.F. Gaertn.	White mangrove	Native	5	0
Myrtales					
Myrtaceae	*Eugenia axillaris* (Sw.) Willd.	White stopper	Native	4	0
	Metrosideros polymorpha Gaudich.	Ohi’a lehua	Native	4	0
Rosales					
Rosaceae	*Crataegus spathulata* Michx.	Hawthorn	Native	4	0
	Prunus caroliniana Aiton	Cherry laurel	Native	4	0
Scrophulariales					
Myoporaceae	*Myoporum sandwicense* (A. DC.) A. Gray	Naio	Native	4	0
Theales					
Theaceae	*Gordonia lasianthus* (L.) Ellis	Loblolly bay	Native	4	0
Urticales					
Ulmaceae	*Ulmus alata* Michx.	Florida elm	Native	4	0
Category 7 – Plants not closely related to the target weed, which have agricultural significance and are grown in the same range as the weed in North America and Hawaii					
Alismatales					
Araceae	*Alocasia macrorrhizos* (L.) G. Don	Giant taro	Cultivated	4	0
Apiales					
Apiaceae	*Daucus carota* L.	Carrot	Cultivated	4	0
Asterales					
Asteraceae	*Lactuca sativa* L.	Head lettuce	Cultivated	4	0
Brassicales					
Brassicaceae	*Brassica oleracea* L.	Cauliflower	Cultivated	4	0
Bromeliales					
Bromeliaceae	*Ananas comosus* (L.) Merr.	Pineapple	Cultivated	4	0

Table 1 Continued

	Species	Common name	Status	n	Mean ± SEM
Cyperales					
Poaceae	*Oryza sativa* L.	Rice	Cultivated	4	0
	Saccharum officinarum L.	Sugarcane	Cultivated	4	0
	Zea mays L.	Corn	Cultivated	4	0
Fabales					
Fabaceae	*Arachis hypogaea* L.	Peanuts	Cultivated	4	0
	Phaseolus vulgaris L.	Pinto bean	Cultivated	4	0
Ginkgoales					
Ginkgoaceae	*Ginkgo biloba* L.	Maidenhair tree	Introduced	4	0
Lamiales					
Verbenaceae	*Tectona grandis* L. f.	Teak	Introduced	4	0
Laurales					
Lauraceae	*Persea americana* Mill.	Avocado	Cultivated	4	0
Malpighiales					
Euphorbiaceae	*Euphorbia pulcherrima* Willd. ex Klotzsch	Poinsettia	Cultivated	4	0
	Manihot esculenta Crantz	Cassava	Cultivated	4	0
Malvales					
Malvaceae	*Abelmoschus esculentus* (L.) Moench	Okra	Cultivated	4	0
	Gossypium hirsutum L.	Cotton	Native/introduced	4	0
	Hibiscus spec.	Hibiscus	Cultivated	4	0
Myrtales					
Myrtaceae	*Eucalyptus camaldulensis* Dehnh.	Red gum	Introduced	4	0
	Eugenia uniflora L.	Surinam cherry	Introduced	4	0
Proteales					
Proteaceae	*Macadamia integrifolia* Maiden & Betche	Macadamia nut	Cultivated	4	0
Rubiales					
Rubiaceae	*Coffea arabica* L.	Arabian coffee	Cultivated	4	0
Solanales					
Convolvulaceae	*Ipomoea batatas* (L.) Lam.	Sweet potato	Cultivated	4	0
Solanaceae	*Capsicum annuum* L.	Bell pepper	Cultivated	4	0
	Solanum lycopersicum L.	Tomato	Cultivated	4	0
	Solanum tuberosum L.	Potato	Cultivated	4	0
Violales					
Caricaceae	*Carica papaya* L.	Papaya	Cultivated	4	0
Zingiberales					
Musaceae	*Musa acuminata* Colla	Edible banana	Cultivated	4	0

Means followed by the same letter are not significantly different (Tukey's HSD: $P>0.05$). Only those plants that had F_1 thrips were included in analysis.

(71.0 ± 15.3 F_1 adults per plant; Table 2). The choice tests indicated that the thrips host range was narrower compared to no-choice tests. For example, 10 test plant species – *S. molle*, *C. coggygria*, *M. laurina*, *M. toxiferum*, *P. chinensis*, *P. vera*, *R. glabra*, *R. sandwicensis*, *R. typhina*, and *D. viscosa* – produced F_1 progeny in no-choice tests, whereas only four species produced progeny under choice testing (*S. molle*, *M. toxiferum*, *R. glabra*, and *R. sandwicensis*) (Table 2). In all comparisons, the number of F_1 thrips adults produced on these non-target species (<3 F_1 adults per plant) was significantly lower than on the target weed.

Multiple-generation tests

The multiple-generation tests indicated that the *P. ichini* thrips sustained a population for three generations only on the two weedy exotic species, *S. terebinthifolia* and *S. molle* (Figure 2). Regardless of generation, nearly 1.5× as many thrips were produced on the target weed than on *S. molle* (54.5 ± 4.8 vs. 33.2 ± 6.3 F_1 adults per plant);

Table 2 Mean numbers of *Pseudophilothrips ichini* thrips (F1 adult progeny per plant) produced in adult choice tests on *Schinus terebinthifolia* vs. a range of non-target species, analysed by individual one-way ANOVAs

Species	Repetitions	F1 thrips produced on		F	d.f.	P
		Schinus terebinthifolia	Non-target			
Schinus molle	6	72.3	2	26.66	1,10	0.0004
Cotinus coggygria	8	71.0	0	342.06	1,14	<0.0001
Malosma laurina	4	61.5	0	67.07	1,6	0.0002
Metopium toxiferum	9	67.4	0.1	438.87	1,16	<0.0001
Pistacia chinensis	9	69.6	0	418.7	1,16	<0.0001
Pistacia vera	5	57.4	0	582.74	1,8	<0.0001
Rhus glabra	9	64.4	0.2	193.77	1,16	<0.0001
Rhus sandwicensis	9	66.1	1.1	82.05	1,16	<0.0001
Rhus typhina	9	50.1	0	664.12	1,16	<0.0001
Dodonaea viscosa	5	57.0	0	106.65	1,8	<0.0001

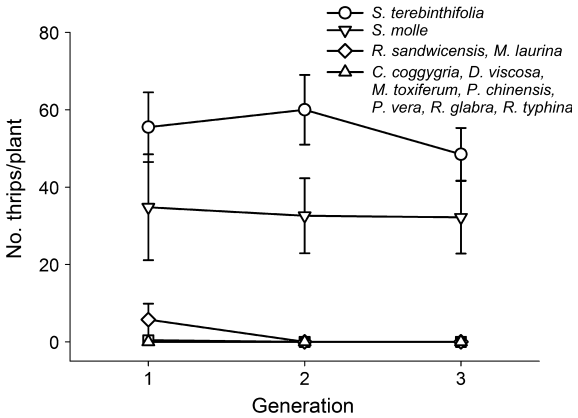

Figure 2 Mean (± SEM) number of thrips produced when fed the weeds *Schinus terebinthifolia* and *S. molle* compared with various non-target species: *Cotinus coggygria*, *Malosma laurina*, *Metopium toxiferum*, *Pistacia chinensis*, *P. vera*, *Rhus glabra*, *R. sandwicensis*, *R. typhina*, and *Dodonea viscosa*. The thrips reproduced and continued to feed and develop to the third generation only on the weedy invasives *S. terebinthifolia* and *S. molle*. No significant differences were found in the number of thrips produced on *S. terebinthifolia* and *S. molle* regardless of generation.

still, this difference was not significant ($F_{1,16} = 2.24$, $P = 0.15$). Moreover, the number of thrips produced over the three generations did not change significantly for either *S. terebinthifolia* or *S. molle* ($F_{2,27} = 0.14$, $P>0.8$). During the first generation, an average of 0.4 ± 0.4 F_1 adults per plant was produced on *R. glabra*, 5.8 ± 4.1 on *R. sandwicensis*, 3.5 ± 2.6 on *M. laurina*, and no adults were produced on the remaining species (Figure 2). No F_2 or F_3 adults were produced on these non-target species.

Discussion

Extensive host range testing is required during the selection of biological control agents and rigorous protocols are followed in order to ensure the safety of these programs (Schaffner, 2001). This study examined the host range of the thrips *P. ichini*, a promising agent of the invasive Brazilian peppertree. A total of 127 plant taxa (including five varieties of mango and four varieties of pistachio) were tested as potential hosts. No-choice, choice, and multiple-generation tests demonstrated specificity toward the target weed, Brazilian peppertree. There was minor use and a relatively small amount of reproduction in no-choice tests on several North American and one Hawaiian plant species. However, substantial (>10% of the control) F_1 thrips production was only found on the South American congener *S. molle*. This species is a weedy ornamental plant, and a close relative of the weed that has also become invasive in California and Hawaii (Nilsen & Muller, 1980; Howard & Minnich, 1989; Wagner et al., 1990). Relative to the controls, the average number of F_1 offspring produced on *S. molle* (20.3 F_1 adults per plant) was 16% of that on the Brazilian peppertree control plants (124.0 F_1 adults). Additional studies indicated that, when given a choice between Brazilian peppertree and *S. molle*, *P. ichini* thrips produced few adults on *S. molle* (2 F_1 adults) compared with 72.3 F_1 adults on Brazilian peppertree. When forced to feed on *S. molle* in no-choice multiple-generation tests, the thrips were able to sustain a population for three generations, with similar population size to that of thrips reared on Brazilian peppertree.

In Brazil, the distributions of *S. molle* and the thrips do not overlap, as *S. molle* occurs in the southern state of Rio Grande do Sul, which is south of the

thrips natural range (Wheeler et al., 2016b). Climatic differences in these regions probably influence these distributions, as *S. molle* is adapted to more temperate, arid conditions, whereas the thrips occupies more subtropical and tropical regions (Silva-Luz & Pirani, 2016). In its invaded range, Brazilian peppertree occurs in the southwestern corner of California near San Diego, and *S. molle* occurs from the San Francisco area south to San Diego (USDA/NRCS, 2016). If the thrips is released and it disperses to California, it could establish on the Brazilian peppertree plants near San Diego. In this area, spillover may occur from infested Brazilian peppertrees onto neighboring *S. molle* trees. Any spillover will be temporary, as our results suggest few thrips individuals selected *S. molle* plants. Additionally, considering the lack of *P. ichini* presence and damage on *S. molle* in Brazil (Wheeler et al., 2016b), it seems unlikely that this non-target will be damaged. However, our results suggest that some thrips feeding and development could occur on *S. molle*. Together, the Brazilian field observations and quarantine choice data suggest that *S. molle* is rarely selected by the thrips under more natural conditions and the no-choice starvation results indicate that when this species is used, it is a relatively poor host.

The remaining plants that produced F_1 adults in no-choice tests included *C. coggygria*, *D. viscosa*, *M. laurina*, *M. toxiferum*, *P. chinensis*, *P. vera*, *R. glabra*, *R. sandwicensis*, and *R. typhina*. The average number of F_1 adult thrips per plant was never higher than 3.3 on any non-target plant, compared with the average of 124.0 thrips produced per plant on Brazilian peppertree. The primary criticism of these no-choice tests is that they potentially result in false positives, and that they reject candidates that would be safe to release (Cullen, 1990; Schaffner, 2001). Choice tests may complement the no-choice tests, and are often considered to better simulate more natural conditions (Harley, 1969). Choice tests may be accepted as better predictors of risk than other testing methods (Cullen, 1990). Results from choice testing further narrowed the number of non-target species that were used by the thrips. In these cases, although an overall average of 63.9 F_1 adults were produced on Brazilian peppertree, an average of less than 2 F_1 adults was produced on *M. toxiferum*, *R. glabra*, and *R. sandwicensis*, suggesting that a small amount of non-target feeding may occur. However, these non-target species cannot sustain more than one generation, and thus slight damage, if any, will occur on these species in the form of spillover from adjacent infestations on Brazilian peppertree. Of these plant species, such spillover will be restricted, as only the geographic distributions of *D. viscosa*, *M. laurina*, *M. toxiferum*, and *R. sandwicensis* overlap that of Brazilian peppertree.

In summary, the proposed biological control candidate, the thrips *P. ichini*, will have no or little negative impact on the native and economically important flora of the infested range of Brazilian peppertree while severely decreasing the weed's ability to regenerate and spread. Thrips feeding had a detrimental effect on its host plant, resulting in death of growing tips, thereby preventing damaged tissues from flowering and fruiting (Wheeler et al., 2016b), and reducing plant height and growth rates of Brazilian peppertree over time (Manrique et al., 2014). Our results from a series of no-choice, choice, and multiple-generation tests showed that the thrips *P. ichini* is suitably host-specific to the target weed. If approved, this will be the first and fourth biological control agent released against Brazilian peppertree in the continental USA and Hawaii respectively. This thrips will constitute a safe and effective component in an integrated control program of Brazilian peppertree.

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