Paederia foetida

INTRODUCTORY

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FEIS ABBREVIATION:
PAEFOE

NRCS PLANT CODE [58]:
PAFO3

COMMON NAMES:
skunkvine
stinkvine
chicken excrement plant
flatulent vine

TAXONOMY:

The scientific name of skunkvine is *Paederia foetida* L. (Rubiaceae) [21,66]. Skunkvine belongs to the *Paederia* subgenus [40].

SYNONYMS:
Paederia scandens (Lour.) Merr. [60]

LIFE FORM:
Vine-liana

DISTRIBUTION AND OCCURRENCE

SPECIES: Paederia foetida

GENERAL DISTRIBUTION:
Skunkvine occurs as a nonnative species in Hawaii and the southeastern United States [62]. Its native Asian range extends from Japan through China to eastern India and south to the Philipines, Malaysia, and Indonesia [40]. In the United States, skunkvine has been reported outside of cultivation in North Carolina, South Carolina, Georgia, Florida, Louisiana, Texas, and Hawaii. Skunkvine occurs on the Hawaiian islands of Kauai, Oahu, Maui, and Hawaii [36]. In Florida, skunkvine populations occur from the northern counties of Suwannee and Gadsden south to Broward County [24]. Skunkvine is particularly abundant in Florida's Hernando and Pasco counties [11]. The current (2009) distribution and extent of skunkvine in Texas, Louisiana, Georgia, and the Carolinas is not well documented (review by [10]). Skunkvine populations are suspected in Mississippi and Alabama [36], although there were no reports of skunkvine in these states as of 2009. Plants Database provides a distribution map of skunkvine.

Introductions and local distribution changes: There were several skunkvine introductions made to the United States. It was first reported in Oahu, Hawaii, in 1854 [60]. The purpose of this introduction is unknown. Before 1897, skunkvine was introduced by the USDA as a potential fiber plant in Florida [25,32]. Based on early records and skunkvine's current distribution in Florida, the initial introduction site was likely a field station in Brooksville in west-central Florida [11,36]. Skunkvine was introduced in Florida again in 1916 and in 1932. The reasons for and fate of these introductions are unknown [32,36]. By 1903, skunkvine was collected from Seminole County, Florida [48], and before the second introduction of skunkvine in 1916, populations at Florida's Brooksville field station were considered "troublesome" [32]. By 1933, skunkvine was reported in thickets and fencerows in peninsular Florida (review by [25]). In 1968, skunkvine was spreading from a cultivation site in Darlington County, South Carolina [44]. It is likely that skunkvine was planted as an ornamental following its introduction to the United States [15], but reports and direct evidence of this are lacking. Skunkvine was first reported in Louisiana in 1983, when Thomas and McCoy [54] found large populations in the Jungle Botanical Gardens on Avery Island and also found plants growing over shrubs on the University of southwestern Louisiana campus in Lafayette Parish. In 1989 skunkvine was reported in Harris County, Texas [6], and an "extensive plant" was reported in Zoological Park in Randolph County, North Carolina, in 1998 [8].

Although not common at the most northern and southern portions of its US range [8,46], the extension of skunkvine's range into North Carolina and southern Florida is recent and suggests some long-distance dispersal mechanism. As of 1999, skunkvine's distribution in the Carolinas had not changed considerably [8]. On the Coastal Plain, skunkvine is generally limited to disturbed sites. Spread from cultivated sites has been limited (Radford and Weakly 1998 cited in [8]). In Florida, however, some reports indicate recent and fairly rapid southward spread. As of 1982, skunkvine was reported only as far south as Hillsborough County [65], but by 1996, skunkvine was reported as far south as Broward County, Florida [38]. Although surveys conducted in 1991 and 1995 in Broward County's Long Key Park did not report skunkvine, in a 1996 survey, it occupied over 6,810 feet² (633 m²) of the Park (Dehring 1999 cited in [38]).

HABITAT TYPES AND PLANT COMMUNITIES:

Asian habitats and plant communities: In its native Asian range, skunkvine occurs in a wide variety of habitats and plant communities but is most common in weedy, sunny, disturbed sites that include "waste" areas, roadsides, and fence lines. Skunkvine is also possible in the openings and at the edges of wet to dry forests and woodlands, in open montane vegetation, on sandy, rocky seacoasts, and in the cracks of rocks [40]. Based on the notes from herbarium records in Japan and Taiwan, skunkvine occupies secondary forests, shady forests, gaps in primary forests, grassy hillsides, river banks, canal banks, thickets, and roadsides [36].

North American habitats and plant communities: As in Asia, skunkvine is generally most common in disturbed areas but also occurs in undisturbed habitats and plant communities. In Hawaii, skunkvine is locally common in disturbed mesic forests, dry forests, alpine woodlands, and coastal areas [60]. It is reported in drainages and along streams in forests dominated by Indian walnut (*Aleurites moluccana*) and in alien wet forests dominated by nonnative species including mango (*Mangifera* spp.), common guava (*Psidium* spp.), and black bamboo (*Phyllostachys nigra*) [60]. In the southeastern United States, skunkvine occurs in xeric sandhill uplands, hammocks, floodplain forests and marshes, and mesic woodland and forested uplands [36]. In Florida skunkvine is common on disturbed sites [65,66] but has also established in undisturbed sandhill, hammock, floodplain, and upland vegetation [24]. In South Carolina, skunkvine is typically limited to disturbed areas of the Coastal Plain. In North Carolina, the only skunkvine population known as of 1999 grew adjacent to a deciduous hardwood forest [8].

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Paederia foetida

Skunkvine flowers from a plant in Makawao, Maui
Photo © Forest and Kim Starr

GENERAL BOTANICAL CHARACTERISTICS:

Botanical description: This description covers characteristics that may be relevant to fire ecology and is not meant for identification. Keys for identification are available (e.g., [60,65,66]).

As its common name suggests, skunkvine is a bad-smelling climber. It produces slender stems that may reach 30 feet (9 m) long. Stems are woody only at the base and twine to the right when supported [25,28,42,60]. Growth form and vine appearance are variable [36,40]. Leaves are evergreen in southern Florida but deciduous in central and northern Florida [36]. Skunkvines may grow prostrate or twine on other vegetation or supports. Ground-creeping vines form adventitious roots at the nodes [46,62]. Skunkvine generally produces opposite, heart-shaped leaves with pointed tips, entire margins, and long petioles [44]. Leaves are also possible in whorls of 3 [28]. Petioles commonly measure up to 2 inches (6 cm) long, and leaf blades are typically 2 to 5.5 inches (5-14 cm) long and up to 2 inches (5 cm) wide [60,62]. Sulfur compounds in the leaves and stems give skunkvine its smelly odor [25,37]. Skunkvine flowers occur in cymes that may form terminal panicles up to 12 inches (30 cm) long [60]. Flowers at the terminal end of the inflorescence open first. Flowers are short-lived, and stigmas are generally receptive for 2 days or less (see Pollination and breeding system) [41]. Skunkvine fruits are round, about the size of a large pea. The outer fruit covering becomes papery and falls away when seeds are mature [46,60]. Fruits contain 1 or 2 wingless seeds that are up to 5.5 mm long [26,62,66].

Skunkvine appears similar to sewer vine (*P. cruddasiana*) another nonnative vine that occurs in Florida, which can be distinguished from skunkvine by its oval fruits and winged seeds [25].

Raunkiaer [45] **life form:**
Phanerophyte
Chamaephyte

SEASONAL DEVELOPMENT:
In Florida, skunkvine flowers are possible from May to August during the wet summer season [26]. Fruits often persist through the winter [24].

REGENERATION PROCESSES:
Skunkvine reproduces vegetatively and from seed [15,26]; however, observations suggest that fruit production may be limited in some nonnative habitats [8,50]. On the island of Maui, skunkvine regeneration and spread are primarily vegetative, although maybe not exclusively so [49,50]. Vegetative spread from creeping stems can be extensive, and stem fragments are capable of rooting and producing new vines [28].

Pollination and breeding system: Skunkvine flowers are perfect, protandrous, and self incompatible [26,41,46]. In the greenhouse, skunkvine flowers protected from insects failed to produce fruit. When researchers artificially cross pollinated flowers, about 70% set fruit [41]. At field sites in Florida, no bagged flowers produced fruits, but more than 20% of unprotected flowers produced fruits [27].

Flowers are insect pollinated. Honeybees and other bees pollinated skunkvine flowers in Ogasawara Islands, Japan [1]. Butterflies were common pollinators in China, Malaysia, and Indonesia [41]. In Florida, 15 insect species visited skunkvine flowers; all insects were native to Florida, except European honey bees (*Apis mellifera*), which were most common on skunkvine flowers in an open field. Halictid bees were the most common visitors in the swamp forest and at a successional site where trees and shrubs were establishing. The number of insect visits/watch was significantly greater in the swamp forest than at the successional site ($P<0.05$). Skunkvine flowers produced up to 0.4 mm of nectar by volume, and sugar concentrations ranged from 20% to 35% [27].

Individual skunkvine flowers are short lived, and stigmas are receptive for a short period of time. However, skunkvine may produce many inflorescences each with multiple flowers, so plants may have open, receptive flowers for 6 weeks or more [41]. In Florida, skunkvine plants had multiple open flowers each day. Flowers generally opened before or at dawn and dropped petals by the next morning [27]. Once petals fall, stigmas are no longer receptive [41]. In Ogasawara Islands, Japan, skunkvine produced 11 to 100 flowers/inflorescence and 101 to 1,000 inflorescences/plant [1].

Seed production: In the United States, reports of skunkvine seed production are variable. As of 2003, skunkvine fruits had not been observed in Maui, Hawaii [50]. This lack of fruit production was likely the result of few and/or untimely observations and not environmental or pollinator issues [49]. As of 1976, reports and observations of skunkvine fruit or seed production in Florida were lacking [32]; however, in a study published in 2008, skunkvine plants in Florida produced ten or more fruit clusters, and each fruit cluster contained hundreds of berries (personal observation cited in [26]). An "extensive" skunkvine plant growing near Asheville, North Carolina, produced 24 panicles but just 2 berries [8].

In a Japanese black pine (*Pinus thunbergii*) stand on coastal sand dunes in central Japan, skunkvine averaged 114.9 fruits/plant, 1,900 fruits/ha, and 3,800 seeds/ha. On average, birds removed 66.9 fruits/plant [53].

Seed dispersal: Wind and animal dispersal of skunkvine seeds are likely in the United States. From experiments and calculations, researchers estimated that skunkvine seeds falling from 16 feet (5 m) above ground when horizontal winds were 5.9 feet (1.8 m)/s could travel 8.9 feet (2.7 m). Distances increased to 36 feet (10.9 m) and 72 feet (21.8 m) in winds of 23 feet (7 m)/s and 46 feet (14 m)/s, respectively [43].

Although direct evidence of animals dispersing skunkvine seeds in the United States is lacking, several sources indicate that animal dispersal is suspected ([3,28], review by [10]). Field studies in Japanese black pine stands in Japan showed that birds removed an average of 66.9 skunkvine fruits/plant. Brown-eared bulbuls, pale thrushes, dusky thrushes, and Japanese white-eyes were the most common dispersers. These birds consumed whole fruits but also dropped many fruits. During the study, there were 95 skunkvine seeds dropped beneath skunkvine plants, 71 beneath Japanese callicarpa (*Callicarpa japonica*), 35 beneath linden arrowwood (*Viburnum dilatatum*), and 32 beneath Japanese honeysuckle (*Lonicera japonica*). Researchers collected both fruits and exposed seeds. Exposed seeds were likely the result of defecation or regurgitation. Seed viability was not tested [53].

Seed banking: A field study conducted in west-central Florida suggests that skunkvine seed banks are short-lived. Researchers placed skunkvine fruits in mesh bags in 3 habitats: a mixed mesic forest dominated by sweetgum (*Liquidambar styraciflua*), southern magnolia (*Magnolia grandiflora*), and baldcypress (*Taxodium distichum*); the edge of the mixed forest; and an open grassland dominated by St Augustine grass (*Stenotaphrum secundatum*). Fruits were naturally buried over time by leaf litter and soil-disturbing animals. During the course of the study, 26% of seeds were damaged by weevils and weevil larvae. The number of viable seeds decreased significantly over time ($P<0.001$), but seeds survived longer in the forest interior than at the forest edge or in the grassland. After 1 year, 38% of seeds were viable in the interior, 2% at the edge, and 2% in the grassland. After 2 years, 4.7% of seeds were viable in interior, 0.4% at the edge, and 0% in the grassland. For all habitats, just 0.2% of skunkvine seeds were viable after 3 years. Researchers suggested that high temperature fluctuations and/or high light levels in the grasslands may have encouraged germination of skunkvine seeds. Canopy cover was 86% in the forest interior, 68% at the forest edge, and less than 1% in the grassland [26].

Germination: Few studies on skunkvine seed germination were available as of 2009, making it difficult to provide generalizations about germination requirements. Germination of seeds up to 2 years old was not affected by age, but germination was markedly reduced for many seeds over 2 years old. In Asia about 70% of skunkvine seeds collected from tetraploid plants germinated, but 40% or fewer of seeds from hexaploid plants germinated. Seeds were likely monitored at room temperature, but conditions were not reported [41]. Skunkvine seeds collected in November from floodplain grasslands in warm temperate Japan failed to germinate immediately after collection. Germination generally increased (maximum was 77%) with long moist chilling periods (up to 10 months). Germination maximums ranged from 18% to 30% for skunkvine seeds buried outdoors in mesh bags in 2 inches (5 cm) of soil. Buried seeds were

exposed to increasing or decreasing temperatures for 1 month before burial, and maximum germination occurred for seeds recovered in January. Duration of burial ranged from 3 to 18 months [61]. For skunkvine seeds collected from Florida in January, viability was low, 5.2%. Ten percent of skunkvine seeds collected from Brooksville, Florida, germinated after 13 days at 77 °F (25 °C) [52].

Seedling establishment and plant growth: Studies highlighting conditions most suitable for skunkvine seedling establishment and growth are lacking. A study along the Arakawa River floodplain near Urawa City, Japan, suggests that skunkvine seedlings establish on disturbed sites. There were 0.3 skunkvine seedlings/m² in moist tall grasslands that were burned each winter for 30 years. There were 1.8 skunkvine seedlings/m² on sites that were "cleared" in the winter for the last 6 years. Methods for clearing vegetation were not described. No skunkvine seeds were trapped on the burned site, but 16.7 skunkvine seed/m² were trapped on the cleared site [30].

During a recent expansion of skunkvine in Mead Gardens Park, Winter Park, Florida, park officials estimated that stems grew 2 to 3 inches (5-7.5 cm) per day. Skunkvine had almost completely covered 60-foot (18 m) magnolia (*Magnolia* spp.) trees. Rapid growth coincided with rainy weather [35].

Vegetative regeneration: Spread of skunkvine through vegetative growth is often extensive. Long stolons can allow skunkvine clones to form "impenetrable tangles" that may cover several acres [3,15,42]. A skunkvine plant growing near Asheville, North Carolina, produced stolons that were up to 13 feet (4 m) long [8]. Stolons that become detached from the parent plant continue to grow independently [41]. Stem fragments with a node are capable of producing new vines and likely play a role in dispersal [24,25,28].

SITE CHARACTERISTICS:
Wide tolerance of climatic, hydrologic, and edaphic conditions is implied by the broad range of native and nonnative habitats occupied by skunkvine (see Habitat Types and Plant Communities) [24,36]. In its native and nonnative habitats, sites occupied by skunkvine may be disturbed or undisturbed, sunny or shady, dry or wet, and saline or salt free [15,24,40,66].

Climate: In the United States, skunkvine is most common in areas with tropical or subtropical climates, but based on its distribution in Japan, skunkvine could survive as far north as Delaware. In Japan, skunkvine reaches its northern limit in the Tohoku Region, where minimum temperatures generally range from -4 to 14 °F (-20 to -10 °C), which approximate the minimum temperatures just north of Delaware, Maryland, and the Virginias [37].

Climatic conditions for several native skunkvine habitats are provided as a potential guide for future US distributions. In Meghalaya, northeastern India, the climate is monsoonal with distinct wet-warm and cool-dry seasons. Annual precipitation averages 98 inches (2,500 mm), and average monthly temperatures are 37 to 72 °F (3-22 °C) [31]. On Miyakejima Island in the Pacific Ocean's western rim, the climate is warm temperate, and annual precipitation averages 110 inches (2,871 mm) [20]. In the Hitachi National Forest in central Japan, skunkvine occupies sites where the low monthly temperature averages 39 °F (3.8 °C); the high monthly temperature averages 77 °F (25 °C); and annual precipitation averages 59 inches (1,500 mm) [14].

By 1998, skunkvine populations in Florida had established above the frost line (Greger and Burks personal observations cited in [25]). In Hillsborough County, where skunkvine is most common, summers are warm, humid, and rainy, and winters are cool and dry. Annual precipitation averages 48 inches (1,219 mm), but over a 30-year period, precipitation averages ranged from 31 inches (799 mm) to 68 inches (1,720 mm). In August, the average maximum temperature is 90.3 °F (32.4 °C). Freezing temperatures are rare [33].

Elevation: In Asia, skunkvine is reported from sea level to 9,800 feet (3,000 m) [40], and in Hawaii, skunkvine occurs from sea level to 6,000 feet (1,830 m) [60]. Elevation ranges for skunkvine in the continental United States were not reported in the available literature (2009).

Soils: The variety of native and nonnative habitats and plant communities occupied by skunkvine suggests a wide tolerance of soil types and conditions, but detailed studies on the characteristics of invaded soils in the United States are lacking. In a subtropical forest in Meghalaya, northeastern India, skunkvine occurs in soils that are highly leached,

nutrient poor, and acidic (pH 5-5.7) [31]. Skunkvine is abundant in hydric hammocks in Hillsborough County, Florida, where the sandy soils are poorly drained. While soils are typically saturated, rarely are they flooded for prolonged periods [33]. In flooding experiments, skunkvine "vigor" decreased with flooding, and researchers reported "little healthy plant tissue" after 63 days of flooding. However, some pots contained live plant tissue after 192 days of flooding [52].

SUCCESSIONAL STATUS:
Skunkvine is not restricted to communities of a particular seral stage. It often occurs on highly disturbed sites [31,34] but can also persist in dense forests. In Hawaii, skunkvine occurs in forests where spreading Indian walnut crowns limit the understory to shade-tolerant species [60]. In Florida, skunkvine is especially common in hydric hammocks with dense canopies of laurel oak (*Quercus laurifolia*), sweetbay (*Magnolia virginiana*), and/or red maple (*Acer rubrum*) [33].

A review reports that skunkvine's growth habit and rate can disrupt natural forest succession in invaded areas of the United States. Rapid growth as a vine and as a ground cover allows skunkvine to form "dense curtains of intermingled stems" that can smother understory vegetation and damage or kill trees. If skunkvine causes mortality in the canopy, gaps created by tree fall are often occupied by skunkvine through rapid vegetative growth. Persistence of skunkvine can then prevent the establishment and growth of forest vegetation that would have regenerated in the absence of skunkvine [62].

Succession studies in skunkvine's native habitats suggest a high tolerance of disturbance and early-seral site conditions. On Miyakejima Island south of Tokyo, Japan, the frequency of skunkvine was 21% to 40% on 37-year-old basalt lava flows, 41% to 60% on 125-year-old flows. Skunkvine did not occur on volcanic flows over 800 years old [20]. In the Tama Hills of Tokyo, skunkvine had high indicator values in intensively managed habitats. On sites with annual shrub thinning and annual mowing, skunkvine's indicator value was 37. On sites with all trees and shrubs cut and mowing done biennially, skunkvine's indicator value was 21. The photosythetically active photon flux density at ground level was almost 30% on the annually mowed site and 80% on the biennially mowed site. Indicator values were calculated using relative abundance and relative frequency [34]. Regression analysis showed that skunkvine was highly positively correlated with scouring along floodplains of the Shinano River in Japan [18]. In Meghalaya, northeastern India, skunkvine was present in highly disturbed, moderately disturbed, and undisturbed areas of the subtropical Swer sacred grove. In undisturbed forests, canopy cover exceeded 40%, and there were 2,103 trees/ha. In highly disturbed forests, canopy cover was less than 10%, and there were 852 trees/ha. Primary disturbances included fuel wood collecting and domestic animal grazing. Skunkvine abundance was not reported [31].

In northern Honshu, Japan, skunkvine appeared within 4.5 years of grazing protection. On this island, sika deer graze heavily and lack local predators. In grazed areas, deer maintain Korean lawngrass (*Zoysia japonica*) stands at about 1.6 inches (4 cm) tall. When sites were protected from grazing for 4.5 years, Chinese silver grass (*Miscanthu sinensis*) was dominant and grew to about 70 inches (180 cm) tall [63]. Grazing preferences of the deer were not described; skunkvine's appearance could have been related to deer feeding habits or changes in edaphic conditions brought about by taller vegetation.

FIRE EFFECTS AND MANAGEMENT

SPECIES: Paederia foetida

FIRE EFFECTS:

Immediate fire effect on plant: Skunkvine is top-killed [14] if not entirely killed by fire [13].

Postfire regeneration strategy [51]:
Ground residual colonizer (on site, initial community)
Secondary colonizer (on- or off-site seed sources)

Fire adaptations and plant response to fire:
Fire adaptations: In the few studies (as of 2009) that report on the effects of fire on skunkvine, there are reports of mortality [13], sprouting [14], and seedling establishment soon after fire [30]. However, the limited number of fire studies and often incomplete descriptions of fire severity make predicting skunkvine's postfire survival and regeneration difficult.

Heat tolerance of skunkvine seeds was not reported in the available literature (2009). In the single study that reports skunkvine seedling establishment on burned sites, skunkvine seed rain was lacking, suggesting that seedlings established from soil-stored or off-site seed sources [30].

Plant response to fire: Studies described below suggest that skunkvine may be killed by fire, but generally skunkvine's absence from burned sites was short-lived. Reports of postfire sprouting by skunkvine came from a study that involved a single fire [14], while skunkvine seedling establishment was reported on repeatedly burned sites [30]. In the only US fire study, skunkvine abundance was reduced in the 1st postfire year after 1 and 3 consecutive fires, but the regeneration method was not described [13].

Five to six months following a March wildfire in a Japanese red pine (*Pinus densiflora*) forest in the Hitachi National Forest in central Japan, there were 0.06 skunvine sprouts/m². On burned plots, vegetation top-kill was 100%. Regeneration method was determined by excavating plants on burned sites. Skunkvine regenerated exclusively by sprouting; there were no seedlings [14].

There were 0.3 skunkvine seedlings/m² in annually winter burned grasslands along the Arakawa River floodplain near Urawa City, Japan. Moist, tall grasslands were burned almost every year for the last 30 years. Seedlings were likely counted in the first postfire year, although the precise time since fire was not reported. Skunkvine seeds were not trapped in the annually burned area but were trapped in an unburned plot that had been cleared of vegetation in the winter for the last 6 years [30]. A lack of skunkvine seed rain in the burned plot suggested that reproductively mature skunkvine plants were absent from the burned plot and that seedlings established from soil-stored or off-site seed sources. In another study of floodplain vegetation along Japan's Shinano River, regression analyses showed that skunkvine was negatively correlated with burning and was rare on annually burned sites [18].

Skunkvine density was reduced by 95% after the 1st prescribed fire in sandhills vegetation on the Janet Butterfield Brooks Preserve in Hernando County, Florida. Before any fires, there were 15 skunkvine stems/tree on control plots and 13.2 skunkvine stems/tree on plots to be burned. In the 1st postfire month after the 1st prescribed fire in March, researchers found no surviving skunkvine stems. One year following the fire, the density of skunkvine stems on burned plots was 0.61 stems/tree, significantly lower than the prefire density ($P<0.05$). Density decreased by 33% on unburned plots. Researchers did not speculate on the reason for density decreases on unburned plots. The density of skunkvine 1 year after the 2nd prescribed fire was 0.14 stems/tree. After 3 years without fire, the density of skunkvine was 2.82 stems/tree on burned and 5.5 stems/tree on unburned plots. Researchers suggested that smoldering in the substantial duff layer where much of the skunkvine stem occurred may have been the reason for high skunkvine mortality. In areas lacking a thick litter layer, fire-caused mortality of skunkvine may be lower than in this study [13].

FUELS AND FIRE REGIMES:
Skunkvine occurs in a variety of habitats (see Habitat Types and Plant Communities). Changes in the

fire frequency or fire severity in plant communities invaded by skunkvine were not described in the available literature (2009). However, because skunkvine often grows into tree canopies (reviews by [10,50,62]) the chance of crown fires could increase in areas with skunkvine, altering the fire behavior in areas adapted to primarily surface fires. In sandhills vegetation in Hernando County, Florida, researchers reported that prescribed fires laddered into tree canopies because of nonnative vines. Researchers reported that of the monitored trees with nonnative vines, 13 hardwoods and 1 longleaf pine (*Pinus palustris*) died on the burned plots, while just 2 hardwoods died on the unburned plots [13].

Skunkvine in Camden County, Georgia, observed by an adjacent property owner for 3 to 5 years prior to the photo date.
Photo © David J. Moorhead, University of Georgia, Bugwood.org

Through severe shading or excessive weight, skunkvine may increase the abundance of fuels by causing stem breakage or mortality in shrub and tree populations (review by [10]). An increase in the abundance of dead material on a site could lead to an increase in the fire frequency, intensity, or severity on an invaded site. Although these changes in fire regimes and behavior are speculative, they highlight the need for more information about how skunkvine may affect the fire ecology of invaded habitats.

For more information on the aggressive growth of skunkvine and its effect on associated vegetation, see Impacts. See the Fire Regime Table for more information on fire regimes in plant communities where skunkvine may occur.

FIRE MANAGEMENT CONSIDERATIONS:

Preventing postfire establishment and spread: Skunkvine is common on disturbed sites [28], and seedling establishment has been reported on burned plots [30]. These findings suggest that burned areas should be monitored closely for skunkvine establishment. Because skunkvine seed may be dispersed by birds or other animals, a large distance between burned areas and established populations may not exclude them as potential establishment sites.

Preventing the establishment of invasive plants in weed-free burned areas is the most effective and least costly management method. This may be accomplished through early detection and eradication, careful monitoring and follow-up, and limiting invasive plant seed dispersal into burned areas. General recommendations for preventing postfire establishment and spread of invasive plants include:

- Incorporate cost of weed prevention and management into fire rehabilitation plans
- Acquire restoration funding

- Include weed prevention education in fire training
- Minimize soil disturbance and vegetation removal during fire suppression and rehabilitation activities
- Minimize the use of retardants that may alter soil nutrient availability, such as those containing nitrogen and phosphorus
- Avoid areas dominated by high priority invasive plants when locating firelines, monitoring camps, staging areas, and helibases
- Clean equipment and vehicles prior to entering burned areas
- Regulate or prevent human and livestock entry into burned areas until desirable site vegetation has recovered sufficiently to resist invasion by undesirable vegetation
- Monitor burned areas and areas of significant disturbance or traffic from management activity
- Detect weeds early and eradicate before vegetative spread and/or seed dispersal
- Eradicate small patches and contain or control large infestations within or adjacent to the burned area
- Reestablish vegetation on bare ground as soon as possible
- Avoid use of fertilizers in postfire rehabilitation and restoration
- Use only certified weed-free seed mixes when revegetation is necessary

For more detailed information on these topics see the following publications: [2,4,12,57].

Use of prescribed fire as a control agent: Prescribed fire in sandhill vegetation in Florida reduced the density of skunkvine dramatically in the 1st postfire year after a single fire. Density of skunkvine was lower on burned than unburned plots for up to 3 years after 3 consecutive prescribed fires [13], suggesting that fire may be used to control skunkvine. However, in the absence of fire, skunkvine populations were recovering. It is likely that successful skunkvine management will require more than fire alone to eliminate skunkvine populations, because studies report skunkvine occurrence on repeatedly burned sites [13,30].

Altered fuel characteristics: Because skunkvine utilizes other vegetation for structural support, it can damage or kill this vegetation as well as provide ladder fuels into the canopy. This topic is discussed in Fuels and Fire Regimes.

MANAGEMENT CONSIDERATIONS

SPECIES: Paederia foetida

FEDERAL LEGAL STATUS:
None

OTHER STATUS:
Information on state-level noxious weed status of plants in the United States is available at Plants Database.

IMPORTANCE TO WILDLIFE AND LIVESTOCK:
Birds consume and disperse skunkvine seeds in Japan [53] and are suspected to do the same in the United States (see Seed dispersal). In Citrus County, Florida, cattle grazed skunkvine, but grazing effects were not examined (review by [10]).

OTHER USES:

Several medicinal uses of skunkvine are reported in the literature, although their effectiveness has been poorly researched. Skunkvine is said to have diuretic and emetic properties but is most commonly described in the literature as a treatment for rheumatism (review by [39]). Other ailments reportedly treated with skunkvine include: headaches, fevers, toothaches, herpes, chest pains, stomach discomforts, hemorrhoids, juandice, spleen inflammation, low fertility, menopausal symptoms, skin ulcers, and snake bites (reviews by [10,39,46]).

IMPACTS AND CONTROL:

Impacts: Although quantitative studies on the ecological and economic impacts of skunkvine on invaded habitats are lacking, anecdotal and visual evidence of skunkvine's impact on native plants and vegetation structure is abundant. As of 2005, the Florida Exotic Pest Plant Council listed skunkvine as a Category 1 invasive species based on documented ecological damage. In Florida, skunkvine has altered native plant communities by displacing native species and/or by changing community structure or ecological functions [9]. In Mead Gardens Park in Winter Park, Florida, skunkvine had been established for years, but in 1992, park officials reported that in several months of rainy weather it increased in size and came to occupy 6 acres (2.4 ha) of the 55-acre (22 ha) Park [35].

Skunkvine growing in Keaukaha, Hawaii

Skunkvine has invaded many habitat types and is not restricted to disturbed areas [24]. As of 1996, skunkvine was reported in natural areas of Florida's Hillsborough, Hernando, Pasco, Citrus, Marion, Sumter, Lake, Orange, and Polk counties (Florida Exotic Pest Plant Council 1996 cited in [25]). There have also been recent expansions of skunkvine's nonnative range to the north and south (see Local distibution changes).

Dense shading by extensive skunkvine clones as well as the weight of multiple climbing stems can eventually damage or kill herbaceous vegetation, shrubs, and trees, creating canopy gaps. In these gaps, skunkvine establishment and growth can be rapid, limiting the recruitment of shrub and tree seedlings and saplings and preventing normal forest regeneration (reviews by [10,62]). In the Jungle Botanical Gardens in Iberia Parish, Louisiana, Thomas and McCoy [54] found large skunkvine populations and likened their growth to that of Japanese honeysuckle (*Lonicera japonica*) and Japanese climbing fern (*Lygodium japonicum*), two other nonnative species that have negatively impacted wildland habitats. Near Asheville, North Carolina, a recently discovered skunkvine clone was climbing over shrubs, into low tree branches, and along the ground for lengths of up to 13 feet (4 m). The clone had established beneath an American beech (*Fagus grandifolia*) planted about 6 years earlier. The researcher speculated that skunkvine seed was a contaminant in the tree's root ball or was dispersed by a migratory bird [8]. In Florida, observations suggest that dense skunkvine growth has reduced the density and cover of native herbaceous species [13], and skunkvine has smothered and killed portions of one of the few remaining populations of Cooley's water willow (*Justicia cooleyi*), a federal endangered species (Bowman and Martin 1995 personal communiciations cited in [25]). In wet disturbed lowland sites of Hilo, Hawaii, and on the island of Maui, skunkvine growth is dense and often forms blankets over other vegetation. On Maui, skunkvine reaches at least 33 feet (10 m) into tree canopies [50].

In Hawaii, skunkvine is linked to economic impacts in ornamental plant nurseries. When skunkvine invades fields used

to propagate ornamental plants, control is difficult. Because nontarget effects must be minimized, the number of potential control methods is reduced and often the labor and economic costs associated with control are increased [36].

Control: Control of nonnative invasive species is most effective when it employs a long-term, ecosystem-wide strategy rather than a tactical approach focused on an individual species [29]. When targeting a nonnative species for control, the potential for other invasive species to fill their void must be considered, regardless of the control method used [5].

Fire: For information on the use of prescribed fire to control this species, see Fire Management Considerations.

Prevention: It is commonly argued that the most cost-efficient and effective method of managing invasive species is by preventing their establishment and spread through the maintenance of "healthy" natural communities [29,47,56] and by continual monitoring [19]. Maintaining the integrity of the native plant community and mitigating the factors that enhance ecosystem invasibility are likely to be more effective than managing solely to control the invader [17].

Weed prevention and control can be incorporated into many types of management plans, including those for logging and site preparation, grazing allotments, recreation management, research projects, road building and maintenance, and fire management [57]. See the Guide to noxious weed prevention practices [57] for specific guidelines in preventing the spread of weed seeds and propagules under different management conditions.

Physical or mechanical control: Hand-pulling and cutting the stems of established skunkvines rarely provides effective control [24]. Seedlings and small plants may be easily pulled by hand, but cutting and pulling established stems promotes sprouting (review by [62]). In Florida, skunkvine was sprouting 2 weeks after hand-pulling [52]. Stems within a skunkvine clone found near Asheboro, North Carolina, were pulled or cut in October 1998. Skunkvine sprouts occurred by mid-April 1999 [8]. Researchers recommend careful disposal of cut or pulled stems to limit the number of fruits, seeds, and stem fragments left on the treated site [24]. During seed bank studies conducted in Florida, a fraction of skunkvinve seeds remained viable for at least 3 years, suggesting that treated sites should be monitored for seedlings for at least 4 years [26].

Biological control: There has been testing on a Japanese flea beetle (*Trachyaphthona sordida*) that appears to be a skunkvinve specialist [37]. As of 2009, no biological controls had been released.

Many factors must be considered and evaluated before biological controls are released. Refer to these sources: [59,64] and the Weed control methods handbook [55] for background information and important considerations for developing and implementing biological control programs.

Chemical control: Sprouting is common after herbicide treatments on skunkvine [28]. A single herbicide application does not control skunkvine [24]. When skunkvine is growing over or in desirable native vegetation, vines should be pulled off of this vegetation before herbicides are applied. Herbicides are considered most effective if applied while skunkvine is actively growing in the spring or summer [28].

A review recommends cutting skunkvine stems and then applying herbicides to cut bases and prostrate stems. This method should increase the effectivness of herbicides and minimize nontarget effects [10], but treated sites should probably be monitored for seedling establishment for at least 4 years [26].

While herbicides are effective in gaining initial control of a new invasion or a severe infestation, rarely do they provide a complete or long-term weed management solution [7]. See the Weed control methods handbook [55] for considerations on the use of herbicides in natural areas and detailed information on specific chemicals.

Integrated management: No information is available on this topic.

APPENDIX: FIRE REGIME TABLE

SPECIES: Paederia foetida

The following table provides fire regime information that may be relevant to skunkvine habitats. Follow the links in the table to documents that provide more detailed information on these fire regimes.

Fire regime information on vegetation communities in which skunkvine may occur. This information is taken from the LANDFIRE Rapid Assessment Vegetation Models [23], which were developed by local experts using available literature, local data, and/or expert opinion. This table summarizes fire regime characteristics for each plant community listed. The PDF file linked from each plant community name describes the model and synthesizes the knowledge available on vegetation composition, structure, and dynamics in that community. Cells are blank where information is not available in the Rapid Assessment Vegetation Model.

South-central US Southern Appalachians Southeast

South-central US

- South-central US Grassland
- South-central US Woodland
- South-central US Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
South-central US Grassland					
Southern shortgrass or mixed-grass prairie	Replacement	100%	8	1	10
Southern tallgrass prairie	Replacement	91%	5		
	Mixed	9%	50		
Oak savanna	Replacement	3%	100	5	110
	Mixed	5%	60	5	250
	Surface or low	93%	3	1	4
South-central US Woodland					
Oak-hickory savanna	Replacement	1%	227		
	Surface or low	99%	3.2		
Oak woodland-shrubland-grassland mosaic	Replacement	11%	50		
	Mixed	56%	10		
	Surface or low	33%	17		
	Replacement	3%	150	100	300

Interior Highlands oak-hickory-pine	Surface or low	97%	4	2	10
Pine bluestem	Replacement	4%	100		
	Surface or low	96%	4		
South-central US Forested					
Interior Highlands dry-mesic forest and woodland	Replacement	7%	250	50	300
	Mixed	18%	90	20	150
	Surface or low	75%	22	5	35
Gulf Coastal Plain pine flatwoods	Replacement	2%	190		
	Mixed	3%	170		
	Surface or low	95%	5		
West Gulf Coastal plain pine (uplands and flatwoods)	Replacement	4%	100	50	200
	Mixed	4%	100	50	
	Surface or low	93%	4	4	10
West Gulf Coastal Plain pine-hardwood woodland or forest upland	Replacement	3%	100	20	200
	Mixed	3%	100	25	
	Surface or low	94%	3	3	5
Southern floodplain	Replacement	42%	140		
	Surface or low	58%	100		
Southern floodplain (rare fire)	Replacement	42%	≥1,000		
	Surface or low	58%	714		

Southern Appalachians

- Southern Appalachians Grassland
- Southern Appalachians Woodland
- Southern Appalachians Forested

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Southern Appalachians Grassland					
Eastern prairie-woodland mosaic	Replacement	50%	10		
	Mixed	1%	900		
	Surface or low	50%	10		

Southern Appalachians Woodland					
Appalachian shortleaf pine	Replacement	4%	125		
	Mixed	4%	155		
	Surface or low	92%	6		
Southern Appalachians Forested					
Bottomland hardwood forest	Replacement	25%	435	200	≥1,000
	Mixed	24%	455	150	500
	Surface or low	51%	210	50	250
Mixed mesophytic hardwood	Replacement	11%	665		
	Mixed	10%	715		
	Surface or low	79%	90		
Appalachian oak-hickory-pine	Replacement	3%	180	30	500
	Mixed	8%	65	15	150
	Surface or low	89%	6	3	10
Oak (eastern dry-xeric)	Replacement	6%	128	50	100
	Mixed	16%	50	20	30
	Surface or low	78%	10	1	10
Appalachian Virginia pine	Replacement	20%	110	25	125
	Mixed	15%	145		
	Surface or low	64%	35	10	40
Appalachian oak forest (dry-mesic)	Replacement	6%	220		
	Mixed	15%	90		
	Surface or low	79%	17		
Southern Appalachian high-elevation forest	Replacement	59%	525		
	Mixed	41%	770		

Southeast

- Southeast Grassland
- Southeast Shrubland
- Southeast Woodland
- Southeast Forested

Vegetation Community (Potential Natural	Fire	Fire regime characteristics			
		Percent	Mean	Minimum	Maximum

Vegetation Group)	severity*	of fires	interval (years)	interval (years)	interval (years)
Southeast Grassland					
Floodplain marsh	Replacement	100%	4	3	30
Pond cypress savanna	Replacement	17%	120		
	Mixed	27%	75		
	Surface or low	57%	35		
Southern tidal brackish to freshwater marsh	Replacement	100%	5		
Gulf Coast wet pine savanna	Replacement	2%	165	10	500
	Mixed	1%	500		
	Surface or low	98%	3	1	10
Southeast Shrubland					
Pocosin	Replacement	1%	>1,000	30	>1,000
	Mixed	99%	12	3	20
Southeast Woodland					
Longleaf pine/bluestem	Replacement	3%	130		
	Surface or low	97%	4	1	5
Longleaf pine (mesic uplands)	Replacement	3%	110	40	200
	Surface or low	97%	3	1	5
Longleaf pine-Sandhills prairie	Replacement	3%	130	25	500
	Surface or low	97%	4	1	10
Pond pine	Replacement	64%	7	5	500
	Mixed	25%	18	8	150
	Surface or low	10%	43	2	50
South Florida slash pine flatwoods	Replacement	6%	50	50	90
	Surface or low	94%	3	1	6
Atlantic wet pine savanna	Replacement	4%	100		
	Mixed	2%	175		
	Surface or	94%	4		

	low				
Southeast Forested					
Sand pine scrub	Replacement	90%	45	10	100
	Mixed	10%	400	60	
Coastal Plain pine-oak-hickory	Replacement	4%	200		
	Mixed	7%	100		
	Surface or low	89%	8		
Maritime forest	Replacement	18%	40		500
	Mixed	2%	310	100	500
	Surface or low	80%	9	3	50
Mesic-dry flatwoods	Replacement	3%	65	5	150
	Surface or low	97%	2	1	8
South Florida coastal prairie-mangrove swamp	Replacement	76%	25		
	Mixed	24%	80		
Southern floodplain	Replacement	7%	900		
	Surface or low	93%	63		

*Fire Severities—
Replacement: Any fire that causes greater than 75% top removal of a vegetation-fuel type, resulting in general replacement of existing vegetation; may or may not cause a lethal effect on the plants.
Mixed: Any fire burning more than 5% of an area that does not qualify as a replacement, surface, or low-severity fire; includes mosaic and other fires that are intermediate in effects.
Surface or low: Any fire that causes less than 25% upper layer replacement and/or removal in a vegetation-fuel class but burns 5% or more of the area [16,22].

Paederia foetida: REFERENCES

1. Abe, Tetsuto. 2006. Threatened pollination systems in native flora of the Ogasawara (Bonin) Islands. Annals of Botany. 98: 317-334. [75795]

2. Asher, Jerry; Dewey, Steven; Olivarez, Jim; Johnson, Curt. 1998. Minimizing weed spread following wildland fires. Proceedings, Western Society of Weed Science. 51: 49. [40409]

3. Austin, Daniel F. 1999. Displacement of native ecosystems by invasive alien plants--the Florida experience, or how to destroy an ecosystem. In: Jones, David T.; Gamble, Brandon W., eds. Florida's garden of good and evil: Proceedings of the 1998 joint symposium of the Florida Exotic Pest Plant Council and the Florida Native Plant Society; 1998 June 3-7; Palm Beach Gardens, FL. West Palm Beach, FL: South Florida Water Management District: 1-21. [53996]

4. Brooks, Matthew L. 2008. Effects of fire suppression and postfire management activities on plant invasions. In: Zouhar, Kristin; Smith, Jane Kapler; Sutherland, Steve; Brooks, Matthew L., eds. Wildland fire in ecosystems: Fire and nonnative invasive plants. Gen. Tech. Rep. RMRS-GTR-42-vol. 6. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 269-280. [70909]

5. Brooks, Matthew L.; Pyke, David A. 2001. Invasive plants and fire in the deserts of North America. In: Galley, Krista E. M.; Wilson, Tyrone P., eds. Proceedings of the invasive species workshop: The role of fire in the control and spread of invasive species; Fire conference 2000: 1st national congress on fire ecology, prevention, and management; 2000 November 27 - December 1; San Diego, CA. Misc. Publ. No. 11. Tallahassee, FL: Tall Timbers Research Station: 1-14. [40491]

6. Brown, Larry E. 1992. Cayratia japonica (Vitaceae) and Paederia foetida (Rubiaceae) adventive in Texas. Phytologia. 72(1): 45-47. [75796]

7. Bussan, Alvin J.; Dyer, William E. 1999. Herbicides and rangeland. In: Sheley, Roger L.; Petroff, Janet K., eds. Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press: 116-132. [35716]

8. Diamond, Pete. 1999. Paederia foetida (Rubiaceae), new to the flora of North Carolina. SIDA. 18(4): 1273-1276. [75923]

9. Florida Exotic Pest Plant Council. 2005. List of Florida's invasive species, [Online]. Florida Exotic Pest Plant Council (Producer) Available: http://www.fleppc.org/list/05List.htm [2005, November 1]. [54964]

10. Gann, George; Gordon, Doria R. 1998. Paederia foetida (skunk vine) and P. cruddasiana (sewer vine): threats and management strategies. Natural Areas Journal. 18(2): 169-174. [75819]

11. Garland, Mark A. 2004. Noxious weed list: Plants in chapter 5B-57.007, Florida Administrative Code, [Online]. In: Noxious weed information. Florida Department of Agriculture and Consumer Services, Division of Plant Industry (Producer). Available: http://www.doacs.state.fl.us/pi/enpp/botany/images/noxiousweedtable1.pdf [2005, November 1]. [54963]

12. Goodwin, Kim; Sheley, Roger; Clark, Janet. 2002. Integrated noxious weed management after wildfires. EB-160. Bozeman, MT: Montana State University, Extension Service. 46 p. Available online: http://www.montana.edu/wwwpb/pubs/eb160.html [2003, October 1]. [45303]

13. Gordon, Doria R.; Gann, George D.; Morrison, Steve C.; Fisher, Jill H. 1999. Using fire to control skunk vine (Paederia foetida L.) in an invaded sandhill. In: Jones, David T.; Gamble, Brandon W., eds. Florida's garden of good and evil: Proceedings of the 1998 joint symposium of the Florida Exotic Pest Plant Council and the Florida Native Plant Society; 1998 June 3-7; Palm Beach Gardens, FL. West Palm Beach, FL: South Florida Water Management District: 275-283. [54034]

14. Goto, Yoshiaki; Yoshitake, Takashi; Okano, Michiaki; Shimada, Kazunori. 1996. Seedling regeneration and vegetative resprouting after fires in Pinus densiflora forests. Vegetatio. 122(2): 157-165. [75829]

15. Hall, David. 1993. Skunk vine time. Resource Management Notes. 5(1): 11-12. [75931]

16. Hann, Wendel; Havlina, Doug; Shlisky, Ayn; [and others]. 2008. Interagency fire regime condition class guidebook. Version 1.3, [Online]. In: Interagency fire regime condition class website. U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior; The Nature Conservancy; Systems for Environmental Management (Producer). 119 p. Available: http://frames.nbii.gov/frcc/documents/FRCC_Guidebook_2008.07.10.pdf [2008, September 03]. [70966]

17. Hobbs, Richard J.; Humphries, Stella E. 1995. An integrated approach to the ecology and management

of plant invasions. Conservation Biology. 9(4): 761-770. [44463]

18. Ishida, Shinya; Nakashizuka, Tohru; Gonda, Yutaka; Kamitani, Tomohiko. 2008. Effects of flooding and artificial burning disturbances on plant species composition in a downstream riverside floodplain. Ecological Research. 23(4): 745-755. [75801]

19. Johnson, Douglas E. 1999. Surveying, mapping, and monitoring noxious weeds on rangelands. In: Sheley, Roger L.; Petroff, Janet K., eds. Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press: 19-36. [35707]

20. Kamijo, Takashi; Kitayama, Kanehiro; Sugawara, Aya; Urushimichi, Shinya; Sasai, Kanako. 2002. Primary succession of the warm-temperate broad-leaved forest on a volcanic island, Miyake-Jima, Japan. Folia Geobotanica. 37(1): 71-89, 91. [75832]

21. Kartesz, John T. 1999. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland. 1st ed. In: Kartesz, John T.; Meacham, Christopher A. Synthesis of the North American flora (Windows Version 1.0), [CD-ROM]. Chapel Hill, NC: North Carolina Botanical Garden (Producer). In cooperation with: The Nature Conservancy; U.S. Department of Agriculture, Natural Resources Conservation Service; U.S. Department of the Interior, Fish and Wildlife Service. [36715]

22. LANDFIRE Rapid Assessment. 2005. Reference condition modeling manual (Version 2.1), [Online]. In: LANDFIRE. Cooperative Agreement 04-CA-11132543-189. Boulder, CO: The Nature Conservancy; U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior (Producers). 72 p. Available: http://www.landfire.gov/downloadfile.php?file=RA_Modeling_Manual_v2_1.pdf [2007, May 24]. [66741]

23. LANDFIRE Rapid Assessment. 2007. Rapid assessment reference condition models, [Online]. In: LANDFIRE. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Lab; U.S. Geological Survey; The Nature Conservancy (Producers). Available: http://www.landfire.gov/models_EW.php [2008, April 18] [66533]

24. Langeland, K. A.; Stocker, R. K.; Brazis, D. M. 2006 [Revised]. Natural area weeds: Skunkvine (Paederia foetida). Publication No. SS-AGR-80. Gainesville, FL: University of Florida, Institute of Food and Agricultural Sciences, Florida Cooperative Extension Service. 4 p. Available online: http://edis.ifas.ufl.edu/WG208 [2009, September 30]. [75958]

25. Langeland, Kenneth A.; Burks, K. Craddock, eds. 1998. Identification and biology of non-native plants in Florida's natural areas. Gainesville, FL: University of Florida. 165 p. [72429]

26. Liu, Hong; Pemberton, Robert W. 2008. Differential soil seed bank longevity of Paederia foetida L., an invasive woody vine, across three habitats in Florida. Journal of the Torrey Botanical Society. 135(4): 491. [75803]

27. Liu, Hong; Pemberton, Robert W.; Stiling, Peter. 2006. Native and introduced pollinators promote a self-incompatible invasive woody vine (Paederia foetida L.) in Florida. Journal of the Torrey Botanical Society. 133(2): 304. [75804]

28. MacDonald, Gregory E.; Ferrell, Jay; Sellers, Brent; Langeland, Ken; Duperron-Bond, Ona Tina; Ketterer-Guest, Eileen. 2008. Skunkvine--Paederia foetida (L.) Rubiaceae, [Online]. In: Plant info and images--Invasive plant management plans. In: Center for Aquatic and Invasive Plants. Gainesville, FL: University of Florida, Institute of Food and Agricultural Sciences, Center for Aquatic and Invasive Plants (Producer). Available: http://plants.ifas.ufl.edu/node/303 [2009, October 28]. [75966]

29. Mack, Richard N.; Simberloff, Daniel; Lonsdale, W. Mark; Evans, Harry; Clout, Michael; Bazzaz,

Fakhri A. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. Ecological Applications. 10(3): 689-710. [48324]

30. Masuda, M.; Washitani, I. 1990. A comparative ecology of the seasonal schedules for 'reproduction by seeds' in a moist tall grassland community. Functional Ecology. 4(2): 169-182. [75827]

31. Mishra, B. P.; Tripathi, O. P.; Tripathi, R. S.; Pandey, H. N. 2004. Effects of anthropogenic disturbance on plant diversity and community structure of a sacred grove in Meghalaya, northeast India. Biodiversity and Conservation. 13(2): 421-436. [75805]

32. Morton, Julia F. 1976. Pestiferous spread of many ornamental and fruit species in South Florida. Proceedings of the Florida State Horticultural Society. 89: 348-353. [75932]

33. Myers, James H.; Wunderlin, Richard P. 2003. Vascular flora of Little Manatee River State Park, Hillsborough County, Florida. Castanea. 68(1): 56-74. [75824]

34. Okubo, Satoru; Kamiyama, Asako; Kitagawa, Yoshiko; Yamada, Susumu; Palijon, Armando; Takeuchi, Kazuhiko. 2005. Management and micro-scale landform determine the ground flora of secondary woodlands and their verges in the Tama Hills of Tokyo, Japan. Biodiversity and Conservation. 14(9): 2137-2157. [75807]

35. Pankowski, Karen. 1992. Fast-growing vine at root of park's troubles. The Orlando Sentinel. October 19; Sec. Local and state: D.1. Available online: http://pqasb.pqarchiver.com/orlandosentinel/access/78488335.html?dids=78488335:78488335&FMT=ABS&FMTS=ABS:FT&date=Oct+10%2C+1992&author=Karen+Pankowski+Of+The+Sentinel+Staff&pub=Orlando+Sentinel&edition=&startpage=D.1&desc=FAST-GROWING+VINE+AT+ROOT+OF+PARK %27S+TROUBLES [2009, November 18]. [75929]

36. Pemberton, R. W.; Pratt, P. D. 2002. Skunk vine. In: Van Driesche, Roy; Lyon, Suzanne; Blossey, Bernd; Hoddle, Mark; Reardon, Richard, tech. coord. Biological control of invasive plants in the eastern United States. USDA Forest Service Publication FHTET-2002-04. [Washington, DC]: U.S. Department of Agriculture, Forest Service: 373-383. Available online: http://www.invasive.org/eastern/biocontrol/27SkunkVine.html [2005, August 12]. [54260]

37. Pratt, P. D.; Pemberton, R. W. 2004. Skunk vine. In: Coombs, Eric M.; Clark, Janet K.; Piper, Gary L.; Cofrancesco, Alfred F., Jr., eds. Biological control of invasive plants in the United States. Corvallis, OR: Oregon State University Press: 449. [53108]

38. Pratt, Paul D.; Pemberton, Robert W. 2001. Geographic expansion of the invasive weed Paederia foetida into tropical South Florida. Castanea. 66(3): 307. [75809]

39. Puff, Christian. 1991. Medicinal uses of Paederia L. (Rubiaceae-Paederieae). In: Puff, Christian, ed. The genus Paederia L. (Rubiaceae-Paederieae): a multidisciplinary study. Opera Botanica Belgica--Volume 3. Meise, Belgium: National Botanic Garden of Belgium: 159-164. [76287]

40. Puff, Christian. 1991. Revision of the genus Paederia L. (Rubiaceae-Paederieae) in Asia. In: Puff, Christian, ed. The genus Paederia L. (Rubiaceae-Paederieae): a multidisciplinary study. Opera Botanica Belgica--Volume 3. Meise, Belgium: National Botanic Garden of Belgium: 207-289. [76291]

41. Puff, Christian. 1991. Selected aspects of the reproductive biology of Paederia L. (Rubiaceae-Paederieae). In: Puff, Christian, ed. The genus Paederia L. (Rubiaceae-Paederieae): a multidisciplinary study. Opera Botanica Belgica--Volume 3. Meise, Belgium: National Botanic Garden of Belgium: 167-178. [76288]

42. Puff, Christian; Igersheim, Anton. 1991. Growth form, stems, and leaves of Paederia L. (Rubiaceae-Paederieae). In: Puff, Christian, ed. The genus Paederia L. (Rubiaceae-Paederieae): a multidisciplinary study. Opera Botanica Belgica--Volume 3. Meise, Belgium: National Botanic Garden of Belgium: 19-33. [75930]

43. Puff, Christian; Werbowsky, Ira. 1991. Size, shape, weight, fall behaviour and dispersal potential of the anemochorous diaspores of the genus Paederia L. (Rubiaceae-Paederieae). In: Puff, Christian, ed. The genus Paederia L. (Rubiaceae-Paederieae): a multidisciplinary study. Opera Botanica Belgica--Volume 3. Meise, Belgium: National Botanic Garden of Belgium: 179-192. [76289]

44. Radford, Albert E.; Ahles, Harry E.; Bell, C. Ritchie. 1968. Manual of the vascular flora of the Carolinas. Chapel Hill, NC: The University of North Carolina Press. 1183 p. [7606]

45. Raunkiaer, C. 1934. The life forms of plants and statistical plant geography. Oxford: Clarendon Press. 632 p. [2843]

46. Rogers, George K. 2005. The genera of Rubiaceae in the southeastern United States--Part II. Subfamily Rubioideae, and subfamily Cinchonoideae revisited (Chiococca, Erithalis, and Guettarda). Harvard Papers in Botany. 10(1): 1-45. [75811]

47. Sheley, Roger; Manoukian, Mark; Marks, Gerald. 1999. Preventing noxious weed invasion. In: Sheley, Roger L.; Petroff, Janet K., eds. Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press: 69-72. [35711]

48. Small, John K. 1910. Additions to the flora of peninsular Florida. II. Naturalized species. Bulletin of the Torrey Botanical Club. 37(10): 513-518. [75831]

49. Starr, Forest. 2009. [Email to Corey L. Gucker]. October 19. Regarding fruit production by Paederia foetida in Hawaii. Makawao, HI: U.S. Geological Survey, Pacific Island Ecosystems Research Center, Haleakala Field Station. On file with: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT; FEIS files. [76558]

50. Starr, Forest; Starr, Kim; Loope, Lloyd. 2003. Paederia foetida--Maile pilau, Rubiaceae. In: Plants of Hawaii--Reports. In: Hawaiian Ecosystems at Risk (HEAR) project. Honolulu, HI: United States Geological Survey, Biological Resource Division, Pacific Island Ecosystems Research Center (Producer). Available: http://www.hear.org/starr/hiplants/reports/pdf/paederia_foetida.pdf [2009, October 5]. [76009]

51. Stickney, Peter F. 1989. Seral origin of species comprising secondary plant succession in Northern Rocky Mountain forests. FEIS workshop: Postfire regeneration. Unpublished draft on file at: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Fire Sciences Laboratory, Missoula, MT. 10 p. [20090]

52. Stocker, Randall K.; Brazis, Dorothy. 1999. Current control technology for the control of skunk vine (Paederia foetida). Final Report #34. Gainesville, FL: University of Florida, Institute of Food and Agricultural Sciences, Center of Aquatic and Invasive Plants; Agronomy Department. 51 p. [75964]

53. Takahashi, Kazuaki; Kamitani, Tomohiko. 2004. Factors affecting seed rain beneath fleshy-fruited plants. Plant Ecology. 174(2): 247-256. [75826]

54. Thomas, R. Dale; McCoy, John W. 1986. Paederia foetida L., Cois lacryma-jobi L., and Hedychium coronatum Koenig from Iberia Parish, Louisiana. Phytologia. 61(3): 142. [75815]

55. Tu, Mandy; Hurd, Callie; Randall, John M., eds. 2001. Weed control methods handbook: tools and techniques for use in natural areas. Davis, CA: The Nature Conservancy. 194 p. [37787]

56. Tyser, Robin W.; Worley, Christopher A. 1992. Alien flora in grasslands adjacent to road and trail corridors in Glacier National Park, Montana (U.S.A.). Conservation Biology. 6(2): 253-262. [19435]

57. U.S. Department of Agriculture, Forest Service. 2001. Guide to noxious weed prevention practices. Washington, DC: U.S. Department of Agriculture, Forest Service. 25 p. Available online: http://www.fs.fed.us/rangelands/ftp/invasives/documents/Guideto NoxWeedPrevPractices_07052001.pdf [2005, October 25]. [37889]

58. U.S. Department of Agriculture, Natural Resources Conservation Service. 2009. PLANTS Database, [Online]. Available: http://plants.usda.gov/. [34262]

59. Van Driesche, Roy; Lyon, Suzanne; Blossey, Bernd; Hoddle, Mark; Reardon, Richard, tech. coords. 2002. Biological control of invasive plants in the eastern United States. USDA Forest Service Publication FHTET-2002-04. [Washington, DC]: U.S. Department of Agriculture, Forest Service. 413 p. Available online: http://www.invasive.org/eastern/biocontrol/index.html [2005, August 12]. [54194]

60. Wagner, Warren L.; Herbst, Derral R.; Sohmer, S. H., eds. 1999. Manual of the flowering plants of Hawai'i. Revised edition: Volume 1. Bishop Museum Special Publication 97. Honolulu, HI: University of Hawai'i Press; Bishop Museum Press. 988 p. [70167]

61. Washitani, I.; Masuda, M. 1990. A comparative study of the germination characteristics of seeds from a moist tall grassland community. Functional Ecology. 4(4): 543-557. [75825]

62. Weber, Ewald. 2003. Invasive plant species of the world: a reference guide to environmental weeds. Cambridge, MA: CABI Publishing. 548 p. [71904]

63. Werger, Marinus J. A.; Hirose, Tadaki; During, Heinjo J.; Heil, Gerrit W.; Hikosaka, Kouki; Ito, Takehiko; Nachinshonhor, U. G.; Nagamatsu, Dai; Shibasaki, Katsuhiko; Takatsuki, Seiki; van Rheenen, Jan W.; Anten, Niels P. R. 2002. Light partitioning among species and species replacement in early successional grasslands. Journal of Vegetation Science. 13(5): 615-626. [75817]

64. Wilson, Linda M.; McCaffrey, Joseph P. 1999. Biological control of noxious rangeland weeds. In: Sheley, Roger L.; Petroff, Janet K., eds. Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press: 97-115. [35715]

65. Wunderlin, Richard P. 1982. Guide to the vascular plants of central Florida. Tampa, FL: University Presses of Florida. 472 p. [13125]

66. Wunderlin, Richard P.; Hansen, Bruce F. 2003. Guide to the vascular plants of Florida. 2nd edition. Gainesville, FL: The University of Florida Press. 787 p. [69433]

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