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A Review of the Growth Habits and Restoration Issues for *Clitoria fragrans* and *Polygonella basiramia*

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Cover: *Clitoria fragrans* plant with a seed pod.

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Abstract: Military training activities, such as tracked vehicle operations and the use of high explosive ordnance, damage soils and vegetation. When federally listed threatened or endangered species are located in areas of destructive military activities, the military is required by law to consult with the U.S. Fish and Wildlife Service to determine the best course of action, which may be either to restrict the military mission or to obtain permission to "take" a limited number of individuals. At the Avon Park Air Force Range (APAFR), Florida, two listed endangered plant species, *Clitoria fragrans* Small and *Polygonella basiramia* (Small) Nesom and Bates, reside in such an area. It would benefit both the plants and the military mission if these two plants could be re-established elsewhere on APAFR property. This review examines what is known about the life history and ecology of *C. fragrans* and *P. basiramia* and examines options for restoration and maintenance of the two species. Most of the past research, and thus the literature found, relates to *P. basiramia* and very little to *C. fragrans*. Because *C. fragrans* produces very few seeds and little is known about its required habitat, we believe the best approach is to begin by studying the plant itself to see if the thick horizontal rhizomes (underground stems) on the plant can be used to propagate new plants. More is known concerning seed production and habitat for *P. basiramia,* and this information can be used as a starting point in developing a restoration program for this species. Preferably, restoration plots should be in oak stands with gaps cleared of competitive vegetation to simulate fire effects. Once the optimum timing and methods for collection are determined, seeds could be collected and propagated in both the field and greenhouse.

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Preface

This report was prepared by Antonio J. Palazzo, Susan E. Hardy, and Timothy J. Cary, all of the Biogeochemical Sciences Branch, U.S. Army Engineer Research and Development Center (ERDC), Cold Regions Research and Engineering Laboratory (CRREL), Hanover, New Hampshire, and by Dr. Terry Bashore, HQ Air Combat Command, Ranges, Airspace, and Airfield Operations Division (HQ ACC/A3AP), Langley Air Force Base, Virginia.

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1 Introduction

Military training activities, such as tracked vehicle operations and the use of high explosive ordnance, damage soils and vegetation. When federally listed threatened or endangered species are located in areas of destructive military activities, the military is required by law to consult with the U.S. Fish and Wildlife Service to determine the best course of action, which may be either to restrict the military mission or to obtain permission to "take" a limited number of individuals. At the Avon Park Air Force Range (APAFR), Florida, the Navy is proposing to construct targets and conduct live bombing using high explosive ordnance inside the impact area where *Clitoria fragrans* Small and *Polygonella basiramia* (Small) Nesom and Bates reside (Fig. 1). *C. fragrans* is listed as threatened in the U.S. and endangered in Florida, and *P. basiramia* is listed as endangered in both the U.S. and Florida. It would benefit both the plants and the military mission if the two plants could be re-established elsewhere on APAFR property.

Understanding life history traits and ecological attributes that limit species abundance and range is necessary in developing a restoration plan. This review examines the current limited knowledge about the life history and ecology of *C. fragrans* and *P. basiramia* and examines options for restoration and maintenance of the two species. Most of the past research, and thus the literature found, relates to *P. basiramia* and very little to *C. fragrans*.

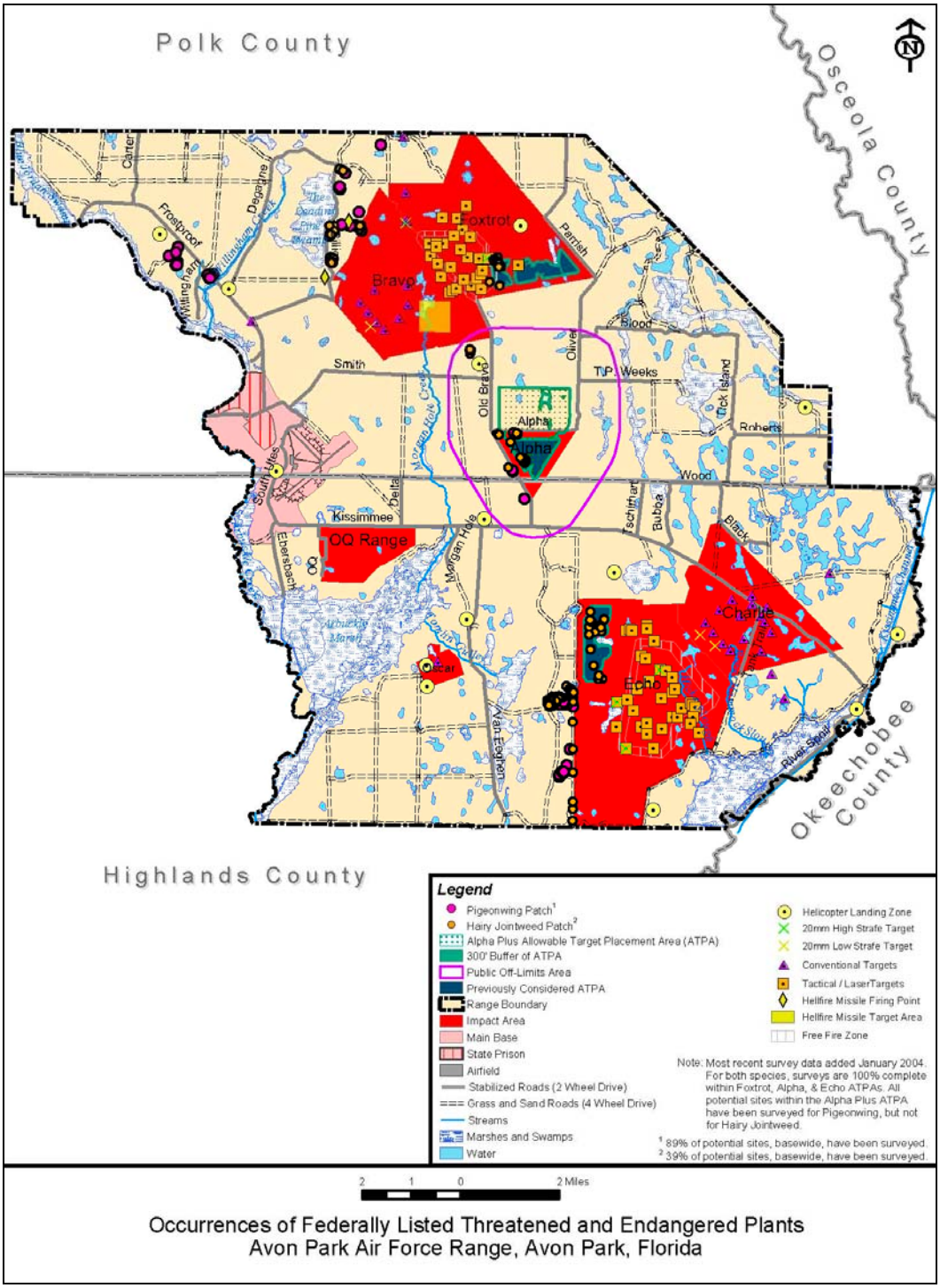

Figure 1. Alpha impact area on Avon Park Air Force Range, showing the locations of *Clitoria fragrans* (pigeon wing •) and *Polygonella basiramia* (wireweed or hairy jointweed •). Red indicates impact areas.

2 General Habitat

Both *P. basiramia* and *C. fragrans* are endemic to central Florida along the higher ridges and knolls in rosemary scrub at elevations of 40–50 m (Stout and Marion 1992). Florida rosemary scrub typically has low species diversity (Menges 1998). The habitat is a fire-maintained, shrubby association ranging from open communities dominated by Florida rosemary [*Ceratiola ericoides* (Empetraceae) Michx.] to dense stands of dwarf oaks (*Quercus* spp.) (Fig. 2); fires are caused by thunderstorm and human activity. The shrub matrix is interspersed with open sandy areas that contain a cover of herbs and lichens. Soil crusts are formed from various mixtures of algae, fungi, cyanobacteria, lichens, bacteria, and mosses. Crusts can have a critical role in stabilizing soils by maintaining plant nutrient cycling in soils. Both *P. basiramia* and *C. fragrans* occupy the open sandy spaces between shrubs and can be found in abundance along sandy fire lanes.

Figure 2. Typical habitat for *C. fragrans* and *P. basiramia* on Avon Park Air Force Range.

Gaps among dominant shrubs of rosemary scrub provide an important microhabitat for herbaceous plants and obligate seeders (those that can't reproduce vegetatively) (Menges and Hawkes 1998). Gaps persist between fires because of slow biomass recovery of Florida rosemary, an obligate seeder. Allelopathy by Florida rosemary may also play a role (Fisher et al. 1994). Most scrub species establish seedlings during winter. Fire kills seeds on the soil surface, but buried seeds that survive benefit from reduced litter depth and greater canopy openness (Carrington 1996).

Polygonella basiramia and *C. fragrans* are found on the Lake Wales Ridge, which is a 160-km-long narrow ridge in south-central Florida that runs through APAFR, and on the Bombing Range Ridge, which is a separate landform in APAFR. *P. basiramia* has also been found on the Lake Henry and Winter Haven Ridges (Christman and Judd 1990). Lake Wales Ridge soils are infertile, white sands and are largely well drained. The climate is humid and subtropical. Annual rainfall exceeds 1200 mm (47 in.), with the majority of rainfall occurring in June through September as a result of convective thunderstorms and tropical storm systems. Lightning is the primary ignition source, with 70–90 thunderstorm days annually.

Human activities have affected the Florida scrub habitat by causing habitat loss, habitat fragmentation, and fire suppression. On the Lake Wales Ridge about 85% of the original area of scrub has been lost (Christman and Judd 1990).

3 *Clitoria fragrans* Description and Ecology

Clitoria fragrans is an erect perennial herb belonging to the pea family (Fig. 3–5). One of about 35 species in the *Clitoria* genus (USDA 2007), *C. fragrans* is limited mainly to the rapidly disappearing scrub habitat of the Lake Wales Ridge in Highlands and Polk counties of Florida (Fantz 1977, Wunderlin et al. 1980, Christman 1988, USFWS 1999) (Fig. 6). It is 15–100 cm tall with one or a few erect, purplish, waxy stems growing from a thick horizontal root that may be more than 2 m long. The stems are wiry (1–2 mm thick) and somewhat zigzagged. The leaves are alternate with three leathery, narrowly oblong leaflets, 2–5 cm long; the upper surface is dark green with conspicuous veins, and the lower surface is pale green and waxy. The leaflet tip is rounded with a minute bristle (USFWS 1999, Fantz 1977).

Clitoria fragrans has two types of flowers: chasmogamous (showy, insect pollinated) and cleistogamous (small, lacking petals, self-pollinating). The chasmogamous flowers (Fig. 7) are borne from May to June, and the less common cleistogamous flowers appear later in the summer into September (USFWS 1993). The pale-purple, inverted chasmogamous flowers make the plant easy to recognize (Fantz 1979). The chasmogamous flowers have a typical zygomorphic pea family arrangement, with a large 3.5- to 5-cm-long wing petal and a small white keel petal forming a boat-shaped enclosure for the anthers and stigma (Fantz 1977, Isely 1990). However, the flower is inverted (resupinate) so that the anthers and stigma touch the backs of visiting insects. The common name, pigeon wings, refers to the wing-like petals of the chasmogamous flowers (Fantz 1979). Cross-fertilization of the cleistogamous flowers is prevented because the flowers do not open (Fantz 1979). Both flower types produce viscous seeds of approximately the same size that disperse ballistically (Lewis and Stout 2005) (Fig. 8). The seed pod is borne on a stipe (stalk) that projects from the dried calyx (Fantz 1977, Isely 1990).

Similar Species

The only other member of the genus native to Florida, *C. mariana*, has similar flowers but is a trailing vine with tendrils and oval or lance-shaped leaves. *C. fragrans* is easily distinguished by its purplish and glaucous

stems, non-twining habit, narrower and more acute (pointed) leaflets, smaller flowers, and long-stipitate fruits (Fantz 1977).

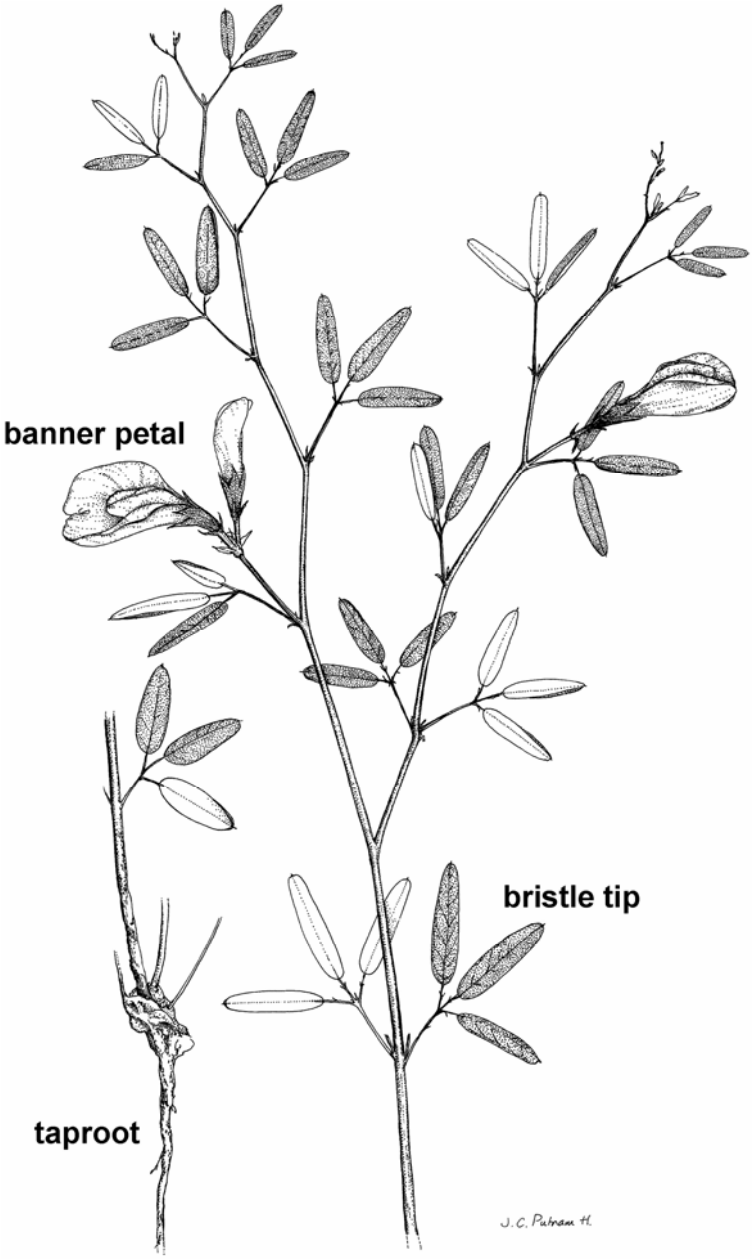

Figure 3. Drawing of *C. fragrans.* (From Chafin 2000; Copyright Florida Natural Areas Inventory, used by permission.)

Figure 4. Photo of *C. fragrans*. (From Wunderlin and Hansen 2007; used by permission.)

Figure 5. *C. fragrans* in grass on the Avon Park Air Force Range.

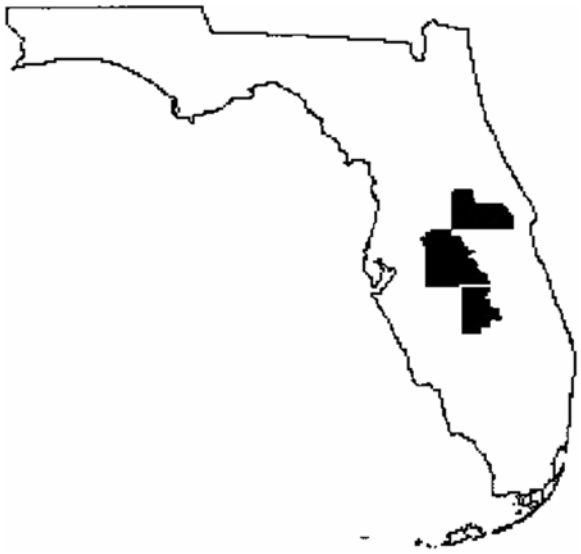

Figure 6. Florida counties where *C. fragrans* is found. (After USFWS 1999.)

Figure 7. Chasmogamous flower on *C. fragrans*. (From Wunderlin and Hansen 2007; used by permission.)

Figure 8. Seed pod of *C. fragrans*.

Distribution and Habitat

Clitoria fragrans is distributed along the Lake Wales Ridge in Highlands and Polk Counties, Florida (Fantz 1977, Wunderlin et al. 1980, Christman 1988, USFWS 1999) (Fig. 6). *C. fragrans* occurs in scrub vegetation, turkey oak barrens, and at least at the edges of high pine (Christman and Judd 1990). There is disagreement about the plant's preference for white or yellow sand soils. It occurs in turkey oak barrens and scrub hickory, which occur on yellow sand soils, and it appears to have habitat preferences similar to *Eriogonum longifolium* Nutt. var. *gnaphalifolium* Gandog. (scrub or longleaf buckwheat) and *Polygala lewtonii* Small (Lewton's polygala), which tend to occur on yellow sand. However, Fantz (1979) considers it a species of white sand soils, and it has been seen in white sand scrub at Carter Creek and Highlands County and on both white and yellow sands on Lake Wales Ridge (USFWS 1999).

The destruction of habitat for citrus groves and residential areas along the Lake Wales Ridge is the main threat to this species (USFWS 1996). The plant was probably never abundant even before its habitat was reduced in size (USFWS 1999). In southern Osceola County, it occurs in a region of large ranches, where scrub is quite likely to remain intact, according to range conservationists with the Natural Resources Conservation Service (USFWS Red Book).

At APAFR, there are 57 sites of various sizes identified as potential habitat for *C. fragrans* based on mapped soil series polygons (Orzell 2004) (Fig. 1). As of 7 January 2004, 51 of the 57 sites had been surveyed.

Population and Ecological Dynamics

Lewis and Stout (2005) studied the life history and local distribution of *C. fragrans* at APAFR for three years, providing the first quantitative data on these characteristics for this species. They examined uniquely marked individuals on seven permanent transects at APAFR weekly from March until September or October. They found that the frequency and survivorship of the two flower types, seed production and predation, and yearly survival of individuals vary with the season and frequency of fire events. Cleistogamous flowers are more frequent in the annual flowering cycle; however, chasmogamous flowers may increase in frequency following a fire event. Plants in long-unburned sites may only rarely pro-

duce cleistogamous flowers. Survival data from Lewis and Stout (2005) support the observation that *C. fragrans* is a long-lived perennial with modest levels of recruitment.

4 *Polygonella basiramia* Description and Ecology

Polygonella basiramia is a short-lived, perennial, taprooted herb that flowers one or more years and does not often live beyond the third year (Hawkes and Menges 1995). It is one of only about four distinct species in the *Polygonella* genus; its range is limited to Highlands and Polk Counties in south Florida (USFWS 1999) (Fig. 9). Common names for *P. basiramia* are Florida jointweed, hairy jointweed, and wireweed. The upright plant consists of basal compressed stems that develop 1 to 46 slender, flowering, spike-like panicles as tall as 80 cm (Fig. 10). Stems range in color from green to dark red, with the red often associated with older vegetative parts more exposed to sunlight (Hawkes and Menges 1995). Stems appear jointed; the sheaths at stem nodes (ocrea) bear two or more long bristles. The vegetative parts of the plant consist entirely of basal compressed stems with narrow, alternate leaves.

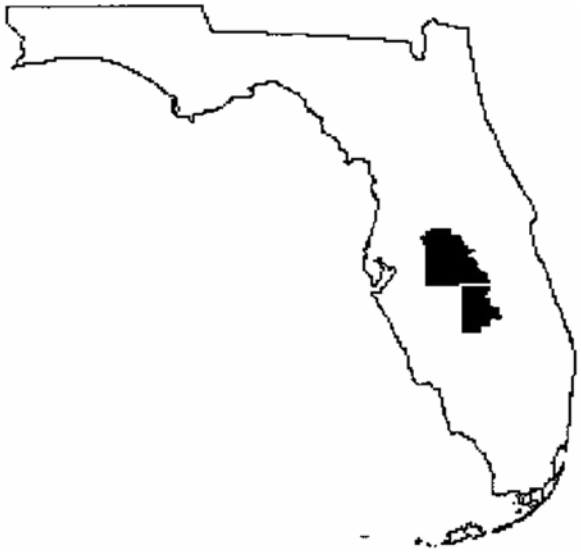

Figure 9. Florida counties where *P. basiramia* is found. (After USFWS 1999.)

The plants have either pistillate (female) flowers or hermaphroditic (bisexual) flowers. The flowers are apetalous with five small, white to pale pink sepals, pink pistils, and black anthers (Fig. 10–11). Flowers are arranged in elongate clusters, often with many clusters per plant.

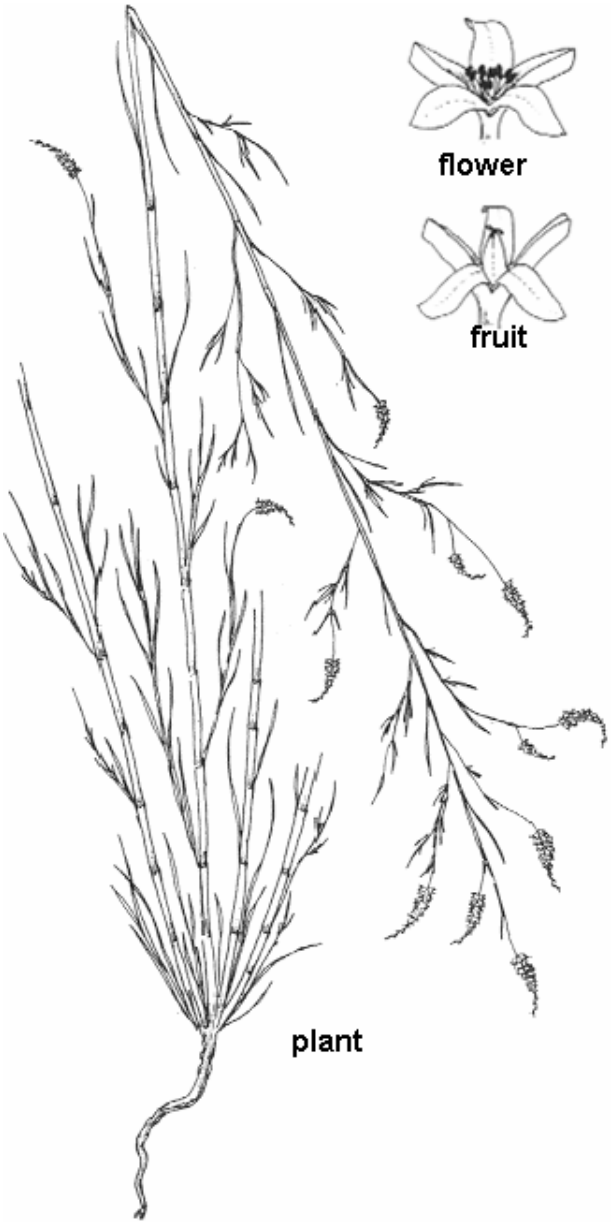

Figure 10. Drawing of *P. basiramia*. (From USFWS 1999; original drawing by Anna-Lisa King.)

Flowering occurs from the top of each spiked stem downward, so that flowers and seeds are present at the same time. The fruits are three-sided achenes 1–3 mm long (Fig. 11). Hawkes and Menges (1995) reported that female plants produce more seeds than hermaphrodites. The mean seed production per stem was 217.8 for females and only 32.1 for hermaphrodites.

Figure 11. Photo of *P. basiramia.* (From USFWS 1999; original photograph by Steven Shirah.) This plant produces up to 30 flowering stalks, each of which produces numerous white to pink flowers from the top downwards.

Polygonella basiramia seedlings germinate in the winter and spring. Achenes do not fall far from the plant, and most fall by mid-January (Hawkes and Menges 1995). Plants overwinter as rosettes. Soil crust organisms may provide a sealed surface layer for seed germination and are a source of nitrogen for adult vascular plants like *P. basiramia*.

Similar Species

Polygonella basiramia may be distinguished from *P. ciliata* by growth form and filaments of the stamens. *P. basiramia* branches at ground level, while *P. ciliata* branches 10–50 cm above ground. Both species have basally dilated filaments with an additional bilateral flange; in *P. basiramia* the flanges surround the ovary in an undefined mass, but in *P. ciliata* the flanges are sharply defined (Nesom and Bates 1984).

Distribution and Habitat

The habitat and life cycle requirements of *P. basiramia* have been more widely studied than those of *C. fragrans*. *P. basiramia* is nearly restricted to the Florida scrub community of south-central Florida (Menges 1998, USFWS 1999) (Fig. 9). It is commonly found in rosemary scrub, where the shrub matrix is interspersed with open sandy areas that contain a cover of

herbs and lichens. *P. basiramia* occupies open spaces between shrubs and can be found in abundance along sandy fire lanes.

The 2004 survey of this species on APAFR found about 149 potential habitat sites (Orzell 2004). The impact areas contain about 30% (15,285 plants) of the plants at APAFR.

Population and Ecological Dynamics

Polygonella basiramia appears to do better in open gaps. Menges and Hawkes (Hawkes and Menges 1995, Menges and Hawkes 1998) found that *P. basiramia* density and fecundity increase with gap area and were highest along fire lanes where the soil crust had been disturbed by chopping. Boyle (2005) found that the species within gaps increases in larger, less-isolated gaps and that the probability of extinction decreases with increasing gap area.

Hawkes and Menges (1995) found open space (bare sand) in rosemary scrub to be a good indicator of *P. basiramia* density, with the density ranging from 0.000 to 0.085 plants per m^2. Along fire lanes where open sand is abundant, densities were much higher, with a mean of 8.1 plants per m^2. Open rosemary scrub decreases from nearly 100% after a fire to approximately 30% four years after a fire. Open sand was found to be the only variable having a significant positive relationship with both plant density and seed production, which suggested that the lack of interspecific competition in open sand gaps helped define its microhabitat (Hawkes and Menges 1995).

Maliakal-Witt et al. (2005) characterized microhabitats of *P. basiramia*, a rosemary shrub specialist, and compared it to two habitat-generalists, *Polygonella robusta* [(Small) Nesom and Bates] and *Lechea deckertii* (Small). Plants of *P. basiramia* occurred in microhabitats with significantly more bare sand than plants of habitat-generalist species. Seedlings of *P. basiramia* also grew larger in bare sand microhabitats.

Boyle et al. (2003) stated that fires create open sand gaps within a shrub matrix that support *P. basiramia* and also kill established competitive plants, but there is no known relationship between fire intervals and *P. basiramia* density. *P. basiramia* is an obligate seeder often not present in the first few years after fire. Menges (1999) found that *P. basiramia*

appears to recover from fire by dispersing seeds into burned sites from individuals occurring in unburned adjacent patches; its seeds do not occur in seed banks, and population recovery is delayed on burned sites. Seedlings require about one year to mature and set seed, so populations would not recover if fires occur at intervals insufficient for sprouting and maturity (Menges 1999).

Quintata-Ascencio and Menges (2000) found that when they transplanted this species into burned patches, the transplants generally had higher survival, larger biomass, and greater reproductive output than transplants into long-unburned patches.

5 Restoration and Management

Understanding life history traits and ecological attributes that limit species abundance and range is necessary for improved land management and species restoration. Especially for *C. fragrans,* information is scarce on community responses to nutrient cycling and below-ground competition, and there is only sketchy information on fire intervals. Unanswered land management questions will be crucial to conserving the biodiversity and ecological integrity of the remnant scrub (Menges 1998).

Nearly all the rare plants found in the Florida scrub depend on openings or gaps in the vegetation with exposed mineral soil and little or no litter accumulation for recruitment or long-term survival (Stout 2001). Both *P. basiramia* and *C. fragrans* can be considered habitat specialists in that they grow in a single, specific habitat type (Maliakal-Witt et al. 2005). Habitat specialization is widely cited as being highly associated with rarity, but the mechanistic basis of habitat specificity is often not well understood (Maliakal-Witt et al. 2005).

Specialists may be dependent on particular microhabitat conditions that are characteristic of their preferred habitat (Menges 1998). Fire and other disturbances that create open patches are likely candidates influencing the survival of the two species in question. The short-term effects of fire on seed dormancy, germination, and establishment promote emergence because of changes in soil structure, nutrient levels, or allelochemicals (Quintata-Ascencio and Menges 2000). We propose a study to determine what these characteristics are and then use them to propagate new plants.

Clitoria fragrans

None of the sites that the Navy plans to disturb at APAFR contain *C. fragrans* (Orzell 2004), although there is one population called Alpha Road just northwest of the Navy area that could potentially be affected. The Alpha Road population contains 246 of the 2419 identified plants at AFAFR (Orzell 2004). The potential for damage depends on how the new site is prepared and used.

We need to learn more about the best methods to restore this species in other locations. Stout (2001) stated that the seed bank for *C. fragrans* is unknown. There is disagreement on its soil preference (yellow or white sand), and there is no information available on the pollination vector, fertilization rate, seed production, or germination rates for the species. The Multi-Species Recovery Plan for South Florida (USFWS 1999) recommends studying the response of *C. fragrans* to various land management practices such as prescribed fire regimes, vegetative thinning, and control of exotic/invasive vegetation.

During our October 2005 visit, we observed that the plant produces only a few seeds. The number of seed pods on observed plants ranged from zero to three, and there are only three seeds per pod. Therefore, collecting sufficient seeds to develop an extensive restoration program may be difficult.

Because little is known about the required habitat for restoration and because few seeds are produced, we feel that the best place to start is with the plant itself. The plant contains thick horizontal rhizomes (underground stems) that are locally called xylopodium. For our initial plan, we hope to use these plant parts to propagate new plants. Once permits are obtained, we could collect the rhizomes on site and plant them in the field and in the greenhouse.

Polygonella basiramia

More is known concerning seed production and habitat for *P. basiramia,* and this information can be used as a starting point in developing a restoration program. The female *P. basiramia* plants appear to produce many small seeds. Much is known about this plant's growth habits, especially its preference for large, open sand areas, and the literature shows that others have been successful in transplanting this species (Quintata-Ascencio and Menges 2000). Preferably, restoration plots should be in oaks, with the gaps cleared of competitive vegetation to simulate fire effects. Our plan is to determine the best time to collect seeds and then try to propagate them in both the field and the greenhouse.

P. basiramia appears to require, or be able to respond to, both small-scale disturbances, such as animal paths and burrow mounds that disrupt soil crust and create space, and large-scale natural disturbance, such as fires.

In cases where fire is not an option, mechanical disturbance can have some benefits by providing openings.

Preliminary ideas on a restoration plan for this species should consider collecting seed from the plant. The female plants are good seed producers, but we will need to determine when and how to collect seeds. The seeds are tiny, which may make collection difficult since the seed will shatter and be lost if collection is not done at the appropriate time. Collecting soils surrounding plants to obtain dormant seeds has not been successful to date.

References

Boyle, O.D. 2005. Metapopulation ecology and genetics of the Florida scrub endemic *Polygonella basiramia*. Presented at 2005 Archbold Research Symposium, 11-12 January, Lake Placid, FL.

Boyle, O.D., E.S. Menges, and D.M. Waller. 2003. Dances with fire: Tracking metapopulation dynamics of *Polygonella basiramia* in Florida scrub (USA). *Folia Geobotanica* 38: 252–262.

Carrington, M.E. 1996. Postfire recruitment in Florida sand pine scrub in comparison with California chaparral. Ph.D. dissertation, University of Florida, Gainesville.

Chafin, L.G. 2000. *Field guide to the rare plants of Florida*. Tallahassee, Florida: Florida Natural Areas Inventory.

Christman, S. 1988. Endemism and Florida's interior sand pine scrub. Final project report, Project No. GFC-84-101. Submitted to Florida Game and Fresh Water Fish Commission, Tallahassee.

Christman, S.P., and W.S. Judd. 1990. Notes on plants endemic to Florida scrub. *Florida Scientist* 53: 52–73.

Fantz, P.R. 1977. A monograph of the genus *Clitoria* (Leguminosae: Glycineae). Ph.D. dissertation, University of Florida, Gainesville. University Microfilms Order No. 7806693, p. 696–705.

Fantz, P.R. 1979. Pigeon-wing. In *Rare and endangered biota of Florida*, vol. 5, *Plants*, ed. D.B. Ward, 77-79. Gainesville, FL: University Presses of Florida.

Fisher, N.H., G.B. Williamson, J.D. Weidenhamer, and D.R. Richardson. 1994. In search of allelopathy in the Florida scrub; the role of terpenoids. *Journal of Chemical Ecology* 20: 1355–1380.

Hawkes, C.V., and E.S. Menges. 1995. Density and seed production of a Florida endemic, *Polygonella basiramia*, in relation to time since fire and open sand. *American Midland Naturalist* 133: 138–148.

Isely, D. 1990. *Vascular flora of the southeastern United States*. vol. 3, part2. *Leguminosae (Fabaceae)*. Chapel Hill, NC: University of North Carolina Press.

Lewis, M., and J. Stout. 2005. Survival and reproductive effort of *Clitoria fragrans* relative to fire history. Abstracts, Ecological Society of America meeting, Montreal, Quebec, Canada, August, 2005. http://abstracts.co.allenpress.com/pweb/esa2005/category/?ID=45239.

Maliakal-Witt, S., E.S. Menges, and J.S. Denslow. 2005. Microhabitat distribution of two Florida scrub endemic plants in comparison to their habitat-generalist congeners. *American Journal of Botany* 92: 411–421.

Menges, E.S. 1999. Ecology and conservation of Florida scrub. In *Savannas, barrens, and rock outcrop plant communities of North America*, ed. R.C. Anderson, J.S. Fralish, and J.M. Baskin, 7–22. Cambridge, England: Cambridge University Press.

Menges, E.S., and C.V. Hawkes. 1998. Interactive effects of fire and microhabitat on plants of Florida scrub. *Ecological Applications*, 8: 935–946.

Nesom, G.L., and V.M. Bates. 1984. Reevaluations of intraspecific taxonomy in *Polygonella* (Polygonaceae). *Brittonica* 36: 37–44.

Orzell, S.L. 2004. Status of plants of federal concern on Avon Park Force Range (APAFR), Florida within/near Navy Allowable Target Areas (ATA's). Unpublished APAFR report.

Quintata-Ascencio, P.F., and E.S. Menges. 2000. Competitive abilities of three narrowly endemic plant species in experimental neighborhoods along a fire gradient. *American Journal of Botany* 87: 690–699.

Stout, I.J. 2001. Rare plants of the Florida scrub, USA. *Natural Areas Journal* 21: 50–60.

Stout, I.J., and W.R. Marion 1992. Pine flatwoods and zeric pine forests of the Southern (lower) Coastal Plain. In *Biodiversity of the southeastern United States: Lowland terrestrial communities*, ed. W.H. Martin, S.G. Boyce, and A.C. Echternacht, 373–446. New York: John Wiley and Sons.

USDA, ARS, National Genetic Resources Program. 2007. *Germplasm Resources Information Network - (GRIN)* (Online Database). National Germplasm Resources Laboratory, Beltsville, Maryland. http://www.ars-grin.gov/cgi-bin/npgs/html/index.pl (02 April 2007).

U.S. Fish and Wildlife Service. 1993. Final rule: Endangered or threatened status for seven central Florida plants. *Federal Register* 58(79): 25746–24755. Published April 27.

U.S. Fish and Wildlife Service. 1999. Multi-species recovery plan for south Florida (revised). U.S. Fish and Wildlife Service, Atlanta, Georgia (p. 4-901 to 4-910 and 4-1149-4 to 1162).

U.S. Fish and Wildlife Service. 1996. *Endangered and threatened species of the southeastern United States (The Red Book)*. U.S. Fish and Wildlife Service, FWS Region 4.

Wunderlin, R.P., and B.F. Hansen. 2007. *Atlas of Florida vascular plants*. Tampa, Florida: Institute for Systematic Botany, University of South Florida.

Wunderlin, R.P., D. Richardson, and B. Hansen. 1980. Status report on *Clitoria fragrans*. Unpublished report, U.S. Fish and Wildlife Service, Vero Beach, FL.

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14. ABSTRACT

Military training activities, such as tracked vehicle operations and the use of high explosive ordnance, damage soils and vegetation. When federally listed threatened or endangered species are located in areas of destructive military activities, the military is required by law to consult with the U.S. Fish and Wildlife Service to determine the best course of action, which may be either to restrict the military mission or to obtain permission to "take" a limited number of individuals. At the Avon Park Air Force Range (APAFR), Florida, two listed endangered plant species, *Clitoria fragrans* Small and *Polygonella basiramia* (Small) Nesom and Bates, reside in such an area. It would benefit both the plants and the military mission if these two plants could be re-established elsewhere on APAFR property. This review examines what is known about the life history and ecology of *C. fragrans* and *P. basiramia* and examines options for restoration and maintenance of the two species. Most of the past research, and thus the literature found, relates to *P. basiramia* and very little to *C. fragrans*. Because *C. fragrans* produces very few seeds and little is known about its required habitat, we believe the best approach is to begin by studying the plant itself to see if the thick horizontal rhizomes (underground stems) on the plant can be used to propagate new plants. More is known concerning seed production and habitat for *P. basiramia*, and this information can be used as a starting point in developing a restoration program for this species. Preferably, restoration plots should be in oak stands with gaps cleared of competitive vegetation to simulate fire effects. Once the optimum timing and methods for collection are determined, seeds could be collected and propagated in both the field and greenhouse.

15. SUBJECT TERMS

Clitoria fragrans
Endangered species
Military training
Polygonella basiramia

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