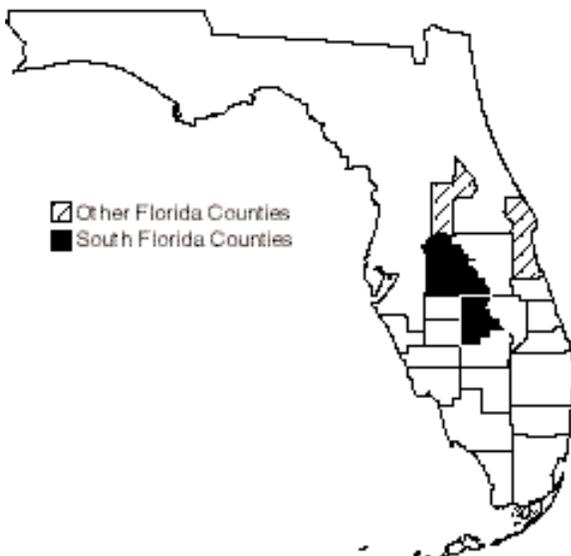

Carter's Mustard

Warea carteri Small

Federal Status:	Endangered: (January 21, 1987)
Critical Habitat:	None Designated
Florida Status:	Endangered
Recovery Plan Status:	Revision (May 18, 1999)
Geographic Coverage:	Rangewide

Figure 1. County distribution of Carter's mustard.



*W*area carteri is a fire-dependent annual herb occurring in xeric, shrub-dominated habitats on the Lake Wales Ridge of central Florida. One occurrence of *W. carteri* is also known from coastal scrub in Brevard County on Florida's Atlantic coast, but has not been relocated. The species occurred historically in the Miami metropolitan area, Miami-Dade County, and is extirpated from this county. The primary threats to *W. carteri* are habitat loss to citrus groves and residential developments, and long-term fire suppression, both of which cause local extirpations.

This account represents a revision of the existing recovery plan for Carter's mustard (FWS 1996).

Description

Warea carteri is an annual herb, 0.2 to 1.5 m tall with erect green stems. The plants usually have many slender, ascending branches forming an open, rounded crown. The leaves lack stipules and are arranged alternately on the stem. Lower leaves are lost by the time the plant flowers. Leaf size and shape varies with age and position on the plant. At the time of flowering, leaf petioles range from 0.8 to 3.9 mm with blades 1 to 3 cm long. Towards the tips of stems, the leaves are smaller and narrowly elliptical to almost linear, while closer to the bases of stems and branches, the leaves are larger and oblanceolate or spatulate. All leaves are rounded at the tip, their margins entire, and their bases attenuate to cuneate. The lower leaves can also be undulate, margined or lobed.

The many inflorescences of *W. carteri* are dense, rounded racemes with many flowers (60 or more). The flowers are radially symmetric, with four white linear-oblanceolate sepals, about 4.5 mm long, and curved toward the center of the flower at the tip. The four petals are white, about 6.0 mm long, with more than half their length in the form of a slender claw. The petal's blade is nearly round with irregular margins. The six spreading stamens are

irregularly subequal in length and arise from a nectar-producing floral disc. The ovary is superior, cylindrical, about 2.3 mm long, and raised on a slender stalk (gynophore) about 2 mm long. The sessile stigma has two lobes. *W. carteri* is protandrous: the anthers begin to dehisce within an hour or two after the flower has opened. The stigmas are receptive until 2 to 4 days afterwards, by which time the stamens on that flower have dropped.

Warea carteri's fruit is a silique, long, slender pod divided lengthwise by a partition (septum). The pod is flattened, cylindrical in cross-section and gently curved along its length, which is 4 to 6 cm long and 1.5 mm wide. The pod is borne on a gynophore, which is a stalk-bearing pistil 5 to 6 mm long, above a spreading pedicel, which is around 8.5 mm long. The pod carries numerous oblong seeds, each 1.5 mm long (Kral 1983). Fruits split apart passively to shed the seeds.

Taxonomy

Warea carteri was named by Small in 1909. A review of the genus by Channell and James in 1964 retained Small's treatment of the species. There are no scientific synonyms (Nauman 1980). Common names for the species include Carter's mustard, Carter's warea, and Carter-warea.

Distribution

From what is known of the historic distribution of *W. carteri*, it occurred in scrubby flatwoods and sandhills of the Lake Wales Ridge in Highlands, Polk, and Lake counties, in South Florida slash pine forests of the Miami area in Miami-Dade County, and in coastal scrub in Brevard County. It has been found in yellow sand scrub at Lake Wales Ridge SF (C. Weekley, Lake Wales Ridge SF personal communication 1998).

The current known distribution of *W. carteri* includes Highlands, Polk, and Lake counties on the Lake Wales Ridge in central Florida. It may occur in Brevard County on Florida's Atlantic coast (Figure 1).

Habitat

The two largest populations of *W. carteri* on the Lake Wales Ridge occur at Archbold Biological Station and The Nature Conservancy's Tiger Creek Preserve. At Archbold Biological Station, *W. carteri* occurs in scrubby flatwoods and in turkey oak- and hickory-dominated sandhills, and is often found in the ecotone between these two vegetation types. Because sandhills occur on yellow sands, *W. carteri* is often found in or near yellow sands. Several populations of *W. carteri* at Archbold Biological Station are adjacent to roads, firelanes, or in areas with historic human disturbance. At Tiger Creek Preserve, *W. carteri* is found in degraded sandhill habitat where turkey oak is abundant, in scrubby flatwoods, and in xeric hammocks (E. Menges, Archbold Biological Station, personal communication 1995).

The collection of *W. carteri* made in Brevard County was in coastal scrub. In Miami-Dade County, *W. carteri* was found in South Florida slash pine

Carter's mustard.

Original photograph by Betty Wargo; original flower photograph by Steve Shirah.



(*Pinus elliotti* var. *densa*) flatwoods. Here it may have occupied some of the same sites as *Polygala smallii* (tiny polygala) and *Sabal miamiensis* (Miami palmetto), both of which occur in areas with a sandy surface rather than bare oolitic limestone.

Reproduction

Experiments have demonstrated that *Warea carteri* is self-pollinating, autogamous, and self-compatible (Evans *et al.*, in press). Autogamy and self-compatibility allow isolated or sparsely distributed individuals to reproduce. Natural levels of fruit- and seed-set are quite high, with a fruit-set of 62 percent, and seed-set of 50 percent (Evans *et al.* in press). Self-pollinated flowers showed significantly lower fruit- and seed-set, 41 percent fruit-set and 28 percent seed-set. This indicates that insect-mediated pollination is important in keeping fruit- and seed-set high, and individual fecundity high. Pollinators appear to be the limiting factor in fruit and seed production (Evans *et al.* in press). Because aboveground populations fluctuate wildly, autogamy helps ensure fecundity and may be a key life history trait (E. Menges, Archbold Biological Station, personal communication 1995).

Germination in *W. carteri* occurs in late winter through early spring (January-March). Flowering occurs in September and October. Fruiting occurs in October and November, and dispersal follows in November and early December (Kral 1983).

Preliminary observations of insect activity on *W. carteri* indicate it is a generalist with respect to pollination. A great diversity of insects visit the flowers, including native solitary bees, bumblebees, syrphids (known as hoverflies or bee-flies), wasps, flies, beetles, *etc.* Within-plant movements by

insects appear to predominate over among-plant movements. Because of this, and in combination with the close proximity of male and female flowers in an inflorescence, self-pollination probably is a regular method of reproduction in this species (Evans *et al.* in press).

There are no obvious specialized forms of seed dispersal in *W. carteri*. The siliques do not open explosively; rather, the external walls of the fruit peel away from the central septum as the fruit slowly dries, exposing the mature seeds inside. The seeds drop passively to the ground or they may be flung a bit further if the plant is brushed. It's not likely that seeds are moved by wind once they reach the ground. Collection or movement of seeds of *W. carteri* by ants or other animals has not been studied, but there are no obvious specialized structures on the seed that would encourage such movement.

Large fluctuations observed in above ground population size suggest the possibility that seed banking plays a significant role in *W. carteri*'s biology. Environmental cues necessary for germination were explored experimentally at Archbold Biological Station (E. Menges, Archbold Biological Station, personal communication 1995). Moisture and light were found to be necessary for germination. The use of an oak leachate did not significantly affect germination. Some seeds stored in dry, dark conditions for 2 years germinated, demonstrating the potential of *W. carteri*'s seeds to remain dormant at least that long. Fire-related cues such as heat do not stimulate germination, but germination does require light and seeds may remain dormant for more than 2 years (E. Menges, Archbold Biological Station, personal communication 1995).

Relationship to Other Species

Warea carteri typically occurs in dry oak sites where other scrub endemics are scarce (FWS 1996) and at the ecotone between scrub and high pineland with other plants: *Eriogonum longifolium* var. *gnaphalifolium* (scrub buckwheat) and *Prunus geniculata* (scrub plum) (K. DeLaney, Environmental Research Consultants, Inc., personal communication 1995). *W. carteri* does not seem to suffer badly from herbivory or predation by vertebrates or invertebrates, but a small percent of individuals do seem to suffer from the growth of a mold or fungus (M. Evans, Archbold Biological Station, personal communication 1995). There have not been any specific studies of *W. carteri*'s competitive relationships with other species. It is not clear whether the lack of above ground individuals in areas not recently burned is due to competition from other vegetation or if a direct effect of fire is necessary for germination (*i.e.* nutrient pulse, smoke, *etc.*). Although some persistent populations of *W. carteri* are found in openings in disturbed sites, populations in natural habitats following fire do not seem to be concentrated in openings between shrubs. In dense xeric hammocks though, they may prefer tree-canopy gaps (E. Menges, Archbold Biological Station, personal communication 1995).

Status and Trends

Warea carteri was listed as an endangered species in 1987 due to habitat loss (52 FR 2234). The primary threats to *W. carteri*'s persistence are habitat

destruction and fire suppression. On the Lake Wales Ridge, *W. carteri* is threatened primarily by the conversion of its habitat to citrus groves or residential subdivisions. In Highlands County, 64.2 percent of the xeric vegetation (sand pine scrub, scrubby flatwoods, and southern ridge sandhills) present before settlement was converted to other land uses by 1981. An additional 10.3 percent of the xeric vegetation was moderately altered, primarily by building roads to create residential subdivisions (Peroni and Abrahamson 1985). The situation is similar in Polk and Lake counties. Fire suppression has been in practice throughout *W. carteri*'s range for many decades. Fire suppression is a threat to this species because its demography and reproduction seem to be closely tied to fire.

The historical distribution of *W. carteri* includes the sites of at least 14 herbarium collections made in what is now the Miami urban area in Miami-Dade County, from 1878 to 1934. Nearly all of the suitable habitat for the plant in this area has been altered by urban growth. The remaining tracts of native vegetation have been searched carefully in recent years (D. Austin, Florida Atlantic University, personal communication 1995). The plant is almost certainly extirpated from the county (Nauman 1980).

Warea carteri has probably been extirpated from Brevard County as well as no specimens have been observed in recent years.

The status of the two largest populations of *W. carteri* in central Florida (at Archbold Biological Station and Tiger Creek Preserve) has been monitored for 6 years (M. Evans, Archbold Biological Station, personal communication 1995). Extreme fluctuations of population size are observed year to year. The data accumulated on population sizes indicate a strong relationship with fire. *W. carteri* seems to respond quickly, strongly, and positively to fire. Major population increases and the discovery of new populations consistently occur 1 year after fire, while major population crashes, including the appearance of no above ground individuals, occur 2 years after fire (Menges 1995).

The demography of *W. carteri* is being studied at Archbold Biological Station, Tiger Creek Preserve, and the Lake Placid Scrub (E. Menges, Archbold Biological Station, personal communication 1995). Dozens of local patches are known from Archbold Biological Station and Tiger Creek Preserve, although not all patches have aboveground plants in any given year. At both Archbold Biological Station and Tiger Creek Preserve, many *W. carteri* populations have behaved fairly predictably in response to fire. Populations either appear or boom the year following fire (11 of 16 instances of population doubling at Tiger Creek Preserve occurred the year after a fire). Population crashes occur in the second year (18 of 26 populations at Tiger Creek Preserve lost more than 50 percent 2 years post fire) (Menges 1995, Menges and Gordon 1996). Populations in sites that have experienced prolonged fire suppression usually persist only in very low above ground densities.

Warea carteri is currently protected at Archbold Biological Station, Lake Placid Scrub, Tiger Creek Preserve, Lake Wales Ridge SF, Snell Creek and Horse Creek. Polk County. BLM is in contact with the SFWMD and FWS to determine the best course of action to pursue in order to protect and manage *W. carteri* at this site (S. Vogelpohl, BLM, personal communication 1998).

Management

The natural fire return interval in the various vegetation communities *W. carteri* inhabits ranges from every 2 to 6 years for turkey oak-dominated sandhill, to every 6 to 10 years in scrubby flatwoods, to every 10 to 20 years in hickory-dominated sandhill (Myers 1990). Through demographic monitoring of *W. carteri*, it is becoming clear that fire is an essential management tool to maintain large populations of this species. As with other rare species, habitat protection is a key element to preservation of *W. carteri*.

In the absence of fire, populations of *W. carteri* have survived in smaller numbers in areas of prior human disturbance, such as the margins of roads or firelanes. Several other Lake Wales Ridge endemics that are also federally listed appear to be favored by disturbance in this fashion including: *Eryngium cuneifolium* (snakeroot), *Polygonella myriophylla* (sand lace), *Prunus geniculata* (scrub plum), and *Conradina brevifolia* (short-leaved rosemary) (Johnson 1981), as well as *Polygonella basiramia* (wireweed) (Hawkes and Menges 1995) and *Dicerandra frutescens* (scrub mint) (Menges 1992).

Warea carteri is a locally abundant annual that may remain dormant as seed for several years, so a population may have a substantial number of growing, flowering plants only in the first year after a fire. Because this species is conspicuous only when in flower, monitoring and finding populations is difficult. As previously mentioned, fire management is a critical concern for this species. Long intervals between fires are likely to result in the real loss of viable seeds from the seed bank and declines in population sizes. The risk of extinction for this species is likely to be higher without proper fire management (E. Menges, Archbold Biological Station, personal communication 1995).

For management considerations, it is important to realize that at sites where *W. carteri* is known to occur, individual plants or all the plants at a site may not appear above ground in any given year. One year of searching is not enough to know whether a given site has *W. carteri*. This species is inconspicuous except during a brief flowering period lasting about a month. In addition, its remaining habitat on the Lake Wales Ridge has not been thoroughly surveyed. As a result, the present distributional records are likely incomplete (FWS 1996). The annual habit of *Warea carteri*, and its widely separated known localities, makes assessment of its status or planning its conservation more difficult than is the case for perennial herbs or shrubs.

Literature Cited

- Abrahamson, W.G., A.E. Johnson, J.N. Layne, and P.A. Peroni. 1984. Vegetation of the Archbold Biological Station, Florida: an example of the southern Lake Wales Ridge. *Florida Scientist* 47:209-250.
- Austin, D. 1995. FWS Multi-Species Recovery Team meeting. December 6-8, 1995.
- Channel, R.B., and C.W. James. 1964. Nomenclature and taxonomic corrections in *Warea* (Cruciferae). *Rhodora* 66(765):18-26.
- DeLaney, K. 1995. FWS Multi-Species Recovery Team meeting. December 6-8, 1995.
- Evans, M.E.K., E.S. Menges, and D.R. Gordon. In press. Breeding system of *Warea carteri*: implications for conservation. *Conservation Biology*.
- Evans, M. 1995. FWS Multi-Species Recovery Team meeting. December 6-8, 1995.
- Hawkes, C., 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.
- Johnson, A.F. 1981. Scrub endemics of the Central Ridge, Florida. Unpublished report to U.S. Fish and Wildlife Service; Jacksonville, Florida.
- Kral, R. 1983. *Warea carteri* Small. A report on some rare, threatened, or endangered forest-related vascular plants of the South. U.S. Department of Agriculture, Forest Service technical publication R8-TP2; Atlanta, Georgia.
- Menges, E.S. 1992. Habitat preferences and response to disturbance for *Dicerandra frutescens*, a Lake Wales Ridge (Florida) endemic plant. *Bulletin of the Torrey Botanical Club* 199(3):308-313.
- Menges, E.S., and D.R. Gordon. 1996. Three levels of monitoring intensity for rare plant species. *Natural Areas Journal* 16:227-237.
- Menges, E.S. 1995. Monitoring report for *Warea carteri*. Unpublished document. The Nature Conservancy, Florida Chapter. On file at the U.S. Fish and Wildlife Service; Vero Beach, Florida.
- Menges, E. 1995. FWS Multi-Species Recovery Team meeting. December 6-8, 1995.
- Myers, R. 1990. Scrub and high pine. Pages 150-193 in R. Meyers and J. Ewel eds. *Ecosystems of Florida*. University of Central Florida Press; Orlando, Florida.
- Nauman, C.E. 1980. Status report on *Warea carteri* Small. Pages 743-756 in D. Austin. *Flora and Fauna of South Florida*. Unpublished report to U.S. Fish and Wildlife Service; Jacksonville, Florida.
- Peroni, P.A., and W.G. Abrahamson. 1985. A rapid method for determining losses of native vegetation. *Natural Areas Journal* 5:20-24.
- Small, J.K. 1909. Additions to the flora of peninsular Florida. *Bulletin of the Torrey Botanical Club* 36:159.
- U.S. Fish and Wildlife Service [FWS]. 1996. Recovery plan for nineteen Florida scrub and high pineland species (revised). U.S. Fish and Wildlife Service; Atlanta, Georgia.
- Vogelpohl, S. 1998. Comments on draft species accounts. January 16.
- Weekley, C. 1998. Comments on draft species account. January 28.

Recovery for the Carter's Mustard

Warea carteri Small

Recovery Objective: STABILIZE, then reclassify to threatened.

Recovery Criteria

Warea carteri may be considered stabilized when existing populations, within the historic range of *W. carteri*, are adequately protected from further habitat loss, degradation, and fire suppression. These sites must also be managed to maintain scrubby flatwoods and turkey oak dominated high pine to support *W. carteri*.

Once the existing populations are stabilized, *W. carteri* may be considered for reclassification. Reclassification will be considered when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations required to assure 95 percent probability of persistence for 100 years; when these populations, within the historic range of *W. carteri* are adequately protected from further habitat loss, degradation, and fire suppression; when these sites are managed to maintain the scrubby flatwoods and turkey oak dominated high pine to support *W. carteri*; and when monitoring programs demonstrate these sites support sufficient population sizes, are distributed throughout the historic range, and are sexually reproducing at sufficient rates to maintain the population.

This recovery objective is an interim goal because of the limited data on the biology, ecology, and management needs of this species. The recovery objective will be reassessed annually based on new research, management, and monitoring information. Reclassification criteria may be refined if new information identifies ways of re-establishing populations of this species to expand its current distribution within its historic range.

Species-level Recovery Actions

- S1. Determine current distribution of *W. carteri*.** Some portions of *W. carteri*'s range have been well surveyed, yet a total distribution has not been ascertained for this species. A thorough survey is needed to determine the distribution for this species.
 - S1.1. Conduct surveys for additional populations of *W. carteri*.** The distribution of this species may be among the hardest to ascertain. *Warea carteri*'s sparse and patchy occurrence make surveying very difficult. In addition, the seed bank must be considered for this species. Plants may occur for only a few years following a burn, not to return until another disturbance.
 - S1.1.1. Survey scrub habitat in the coastal counties.** Adequate survey work has not been conducted off the Lake Wales Ridge. Given that this species has historically been found in both Miami-Dade and Brevard counties, more thorough survey work is warranted to determine its distribution.

- S1.1.2. Continue surveys in Polk and Highlands counties.** This species is found sparsely in scrub and high pine, as well as hammock. During surveys, this species could be overlooked. Many sites may still be unfound. September is the best month in which to conduct surveys.
- S1.1.3. Continue surveys on protected lands.** New sites for listed species are still being found on protected lands. This survey work should be continued to catalog all existing protected sites and new sites as they are purchased.
- S1.2. Maintain distribution of known populations and suitable habitat in GIS database.** Use GIS to map existing populations and to assess the species' status and trends over time. The database should contain information on locations, population sizes, and status. This information should also be used for project review, in land acquisition activities, and to coordinate updates with the Florida Natural Areas Inventory database. Currently, the Lake Wales Ridge Ecosystem Working Group and Archbold Biological Station are proposing to map the entire central ridge. This information would show potential habitat for scrub endemics based on their habitat needs.
- S2. Protect and enhance existing populations.** Much of the native xeric uplands on the Lake Wales Ridge and surrounding counties has been converted to agriculture or urban development. The remaining habitat is fragmented into small parcels and in many cases, isolated. For this reason, existing populations are in need of protection from a variety of threats.
- S2.1. Protect privately-owned habitat through acquisition, conservation easements, or agreements with landowners.**
- S2.2. Protect populations on public lands.** Develop management guidelines that allow for a fire regime that includes a mosaic of successional stages. This species can probably survive with fire regimes in the 3 to 20 year range.
- S2.3. Use local or regional planning to protect habitat.** Utilize available regional and county planning processes to encourage protection of suitable habitat unoccupied and occupied both of *W. carteri*.
- S2.4. Conserve germ plasm.** The seed for this species is not presently in long-term storage.
- S2.5. Enforce available protective measures.** Use local, State and Federal regulations to protect this species from overcollecting and damage from off-road vehicle use. Regulations should also be used to protect xeric vegetative communities where *W. carteri* lives.
- S2.5.1. Initiate section 7 consultation when applicable.** Initiate section 7 consultations when Federal activities may affect this species.
- S2.5.2. Enforce take and trade prohibitions.** This species is protected by take provisions of the ESA (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction; maliciously damaging or destroying any such species on any such area; or removing, cutting or digging up any such species), by the Preservation of Native Flora of Florida Act, and by the Florida State Parkrules regarding removal of plants from State lands.

- S3. Conduct research on life history characteristics of *W. carteri*.** Much of the basic biology and ecology of this species remains poorly understood. To effectively recover this species' more specific biological information is needed.
- S3.1. Continue research to determine demographic information, such as numbers of sites and populations, numbers of individuals in a population, recruitment, long-term seed bank, germination, seedling mortality, dispersal, growth, survival, and mortality.**
- S3.2. Once demographic data are known, conduct population viability and risk assessment** analysis to determine the numbers of plants, sites, subpopulations and populations, and spatial distributions needed to ensure persistence of the species.
- S3.3. Conduct research to assess management requirements of *W. carteri*.** Determine which natural populations can be increased by habitat management. Monitoring information on the localities of *W. carteri* sites will identify factors contributing to any declines at these sites. Monitoring of populations should be in reference to various habitat management practices. Site-specific management guidelines should be provided to land managers .Close coordination among land managers is essential to develop adaptive management techniques.
- S4. Monitor existing populations of *W. carteri*.**
- S4.1. Develop monitoring protocol to assess population trends for *W. carteri*.**
- S4.1.1. Monitor to detect changes in demographic characteristics, such as reproduction, recruitment, growth, long-term seed bank, germination, seedling mortality, dispersal, survival and mortality.** Also monitor for pollinators, herbivory, disease, and injury.
- S4.1.2. Monitor the effects of various land management actions on *W. carteri*.** Assess any changes in demographic characteristics of *W. carteri* in response to land management activities, such as prescribed fire, exotic plant control, *etc.*
- S4.2. Develop a quantitative description of the population structure of *W. carteri*.** This description will provide a baseline for monitoring population dynamics in response to natural environmental changes and management treatments. Data recorded should include morphology, survivorship, mortality, and reproduction for individual plants. Data about each plant's microsite (vegetation cover, litter depth, substrate, and closest neighbors) should also be recorded. Data about survivorship and mortality should only be taken for a given year or for the seed bank since this species is a seed bank annual.
- S5. Provide public information about *W. carteri*.** It is important for the recovery of this species that governmental agencies, conservation organizations, and private landowners be appropriately informed about this species.
- S5.1. Public outreach efforts must also continue to address the increasing concern that horticultural demand for this and other rare species may not benefit conservation of threatened and endangered species.** Public education should identify that commercial production and horticultural uses of endangered species provide little benefit to species, since the recovery of *W. carteri* and other rare species requires a self-sustaining, secure, number of natural populations.

- S5.2 Private land owners should also be made aware of the rarity of *W. carteri* and its specialized habitat needs.** Conservation easements, habitat management plans, and other methods of protecting and enhancing scrub habitat should be developed with private land owners as a means of increasing the number of protected and managed populations of *W. carteri*.

Habitat-level Recovery Actions

- H1. Prevent degradation of existing habitat.** Extensive habitat loss, degradation, and fragmentation have already occurred throughout the range of this species. Both urbanization and fire suppression have decreased the available habitat. To date, there are six protected sites for *W. carteri* in Polk and Highlands counties.
- H1.1. Secure habitat through acquisition, landowner agreements, and conservation easements.** With so little xeric scrub habitat left, any method of securing protected populations should be sought.
- H1.2. Manage and enhance habitat.** Manage habitat to maintain *W. carteri* populations by providing proper management of habitat, including prescribed fire.
- H1.2.1. Conduct prescribed burns.** Fire is a necessary and integral characteristic of the scrub community. A variable interval in fire return and in season is important to mimic the natural fire regime. In addition, spatial variation in fire intensity and unburned patches is necessary to construct a natural fire landscape. Scrub is naturally made up of islands of suitable and unsuitable habitat. To repeat this landscape pattern, sites should be burned as a mosaic when possible to allow for variation. This species can live in a range of burn regimes with burn cycles from 3 to 20 years.
- H1.2.2. Control and eliminate exotic and invasive plants and animals.** Exotic plant and animal species are not yet a major threat in Florida scrub as compared to other communities in South Florida. However, in isolated areas, exotic species are becoming established. Without control, exotic and invasive plants may become a threat to the survival and recovery of *W. carteri*.
- H1.2.3. Control access to areas where listed plants are growing.** Collection, trampling, and off-road vehicles can severely threaten individual populations.
- H2. Restore areas to suitable habitat.** Native habitats that have been disturbed or that have experienced a long history of fire suppression may be good candidates for future reserves.
- H2.1. Restore natural fire regime.** Long periods without fire can change the species composition and the ability of the site to carry fire. Rehabilitation of a site may be a lengthy process, but with fewer and fewer sites remaining, these sites may become more valuable for future recovery. On these sites a seed bank may exist that could include *W. carteri*.
- H2.2. Enhance sites with native plant species.** Because of lack of habitat management and long periods without fire, certain native plant species that were present historically may now be absent from the natural composition of the community. *Warea carteri*, as well as other species of rare scrub plants should be reintroduced,

if natural colonization is not possible. Wiregrass and longleaf pine should also be reintroduced to sandhill sites in locations where these species have been displaced by hardwood hammock species (C. Weekley, Lake Wales Ridge SF, personal communication 1998).

- H3. Conduct habitat-level research projects.** Study the response of *W. carteri* to various land management practices, such as prescribed fire regimes, vegetative thinning, and control of exotic and invasive vegetation. More information is needed on the response to management activities for this species.
- H4. Monitor habitat and ecological processes.** Monitor the effects of land management actions, such as prescribed fire, exotic plant control, etc., on the habitats where *W. carteri* occurs.
- H5. Provide public information about scrub and its unique biota.** Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without these successful efforts, the Lake Wales Ridge National Wildlife Refuge would not have been created. Florida's system of biological preserves depends on a broad base of public understanding and support for its funding and future success. In addition to past and ongoing educational efforts by The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, future efforts by these organizations, and the Florida Park Service, the Florida Division of Forestry, the South Florida Water Management District, the Florida Native Plant Society, and local garden clubs are crucial in increasing public appreciation of scrub and high pine communities, and their associated plant species. The Arbuckle Appreciation Day sponsored by the Florida Division of Forestry has been especially successful in disseminating knowledge about these unique communities.

