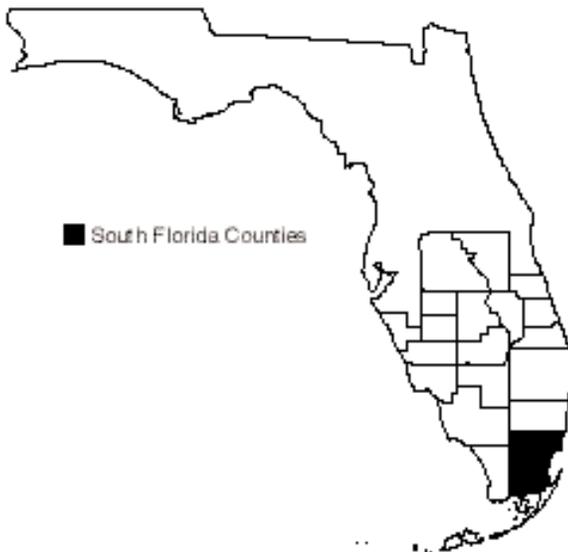

Deltoid Spurge

Chamaesyce deltoidea (Engelman ex Chapman) Small ssp. *deltoidea*

Federal Status:	Endangered (July 18, 1985)
Critical Habitat:	None Designated
Florida Status:	Endangered
Recovery Plan Status:	Revision (May 18, 1999)
Geographic Coverage:	Rangewide

Figure 1. County distribution of deltoid spurge.



Deltoid spurge is a prostrate, perennial herb belonging to the Euphorbiaceae or spurge family. This species is known from pine rocklands in Miami-Dade County, Florida. This plant was listed as a result of habitat destruction, which had reduced the deltoid spurge's range by 98 percent from urban expansion in the area. It requires relatively high light levels and little to no organic litter accumulation. Periodic fires are required to maintain a low litter level and an open understory. Habitat loss, fire suppression, and exotic plant invasions threaten the recovery of the deltoid spurge.

This account represents a revision of the existing recovery plan for the deltoid spurge (FWS 1988).

Description

Chamaesyce deltoidea ssp. *deltoidea* is a small, monoecious, prostrate to decumbent herb occurring in mats over exposed limestone. The stems are terete (circular although slightly oblong) in cross section, brown, and 0.3 to 0.6 mm in diameter. The leaves are smooth above to slightly hairy below, with an obtuse apex, cordate base, margins entire; stipules lacinate, brown to reddish brown with light tips, and smooth. The inflorescence is found singly, in leaf axils, with a short peduncle (1 mm long). The cyathium is 1.2 mm long, 1.0 mm wide and smooth (glabrous). It is green and ovate in shape with four glands and minute appendages. The fruit is a capsule, 1.0 mm long and 1.0 mm wide, and completely glabrous. The pedicel is also glabrous. It is fully exerted at maturity. There are three seeds, 1.0 mm long and 0.5 mm wide, ovate in shape and glabrous. The seeds are laterally four-ridged and yellowish-white (Remus 1979).

The leaves and stems of the subspecies *Chamaesyce deltoidea* ssp. *adhaerens* are appressed to the ground surface and the plants form mats. In some cases the stems will ascend and form tufts (Herndon 1993). The inflorescence is solitary, terminal, pedunculate (1.5 mm

long), and glabrous proximally to pilose distally. The main distinction between the two subspecies is their pubescence. The pubescence of the subspecies *C. deltoidea* ssp. *adhaerens* is appressed on the leaves and on the stems it is spreading or appressed (Herndon 1993). The pubescence for *C. deltoidea* ssp. *deltoidea* is sparse, appressed on the leaves and the stems are glabrous or thinly pubescent (Herndon 1993).

Taxonomy

Deltoid spurge was first described as *Euphorbia deltoidea* by Engelman (Chapman 1883). In 1903, Small transferred the species to the genus *Chamaesyce*, a natural genus distinguished from *Euphorbia* by having the main stem abortive just above the cotyledons, making the aerial portion of *Chamaesyce* homologous to the inflorescence of *Euphorbia* subgenus *Esula* (Webster 1967). Burch (1966) treated *C. deltoidea* as a complex of three taxa endemic to South Florida: *C. deltoidea*, *C. adhaerens* Small, and *C. serphyllum* Small, treating deltoid spurge as *C. deltoidea* (Engelman ex Chapman) Small subsp. *deltoidea* var. *deltoidea* without comment. In Herndon's (1993) revision of the *C. deltoidea* complex, he recognized four subspecies endemic to South Florida: ssp. *deltoidea*, ssp. *adhaerens*, ssp. *pinetorum*, and ssp. *serphyllum*. The taxonomy of this complex is difficult and some follow Burch's 1966 treatment and others follow Herndon's 1993 treatment. The final rule as listed in the Federal Register applies to the taxa *deltoidea* and *adhaerens*, which are restricted to Miami-Dade County, Florida. According to this, all members of the *C. deltoidea* complex that are restricted to Miami-Dade County are considered endangered species by the FWS. For purposes of clarity, Herndon's treatment will be used for this recovery plan.

Synonyms: *Euphorbia deltoidea* Engelman ex Chapman; *Chamaesyce deltoidea* (Engelman ex Chapman) Small ssp. *deltoidea* var. *deltoidea*; *Chamaesyce adhaerens* Small; *Chamaesyce deltoidea* (Engelm. ex Chapman) ssp. *deltoidea* var. *adhaerens* (Small) Burch.

Distribution

Deltoid spurge is a Miami-Dade County endemic that was historically known to occur in pine rocklands from the Goulds area north to the center of the city of Miami (Figure 1). The northern portion of its range has been completely modified by urban expansion. The deltoid spurge is now known only from south Miami to the Homestead area (DERM 1994).

The deltoid spurge is the most northerly member of the *C. deltoidea* complex; the other member of the species complex, *C. deltoidea* ssp. *adhaerens*, occurs in the southern Biscayne pine rocklands, in the area known as the Redlands of Miami-Dade County (Herndon 1993).

Habitat

The deltoid spurge tends to occur in areas with an open shrub canopy, exposed limestone (oolite), and minimal litter (pine needles, leaves, and other organic

Deltoid spurge. *Original photograph by Joy Kline.*



materials). It is most often found growing at the edges of sand pockets with plants growing both in sand (sometimes in association with the endangered *Polygala smallii*) and on oolitic limestone. The soils in which it grows are classified as Opalocka-Rock Outcrop soils. The subspecies *C. deltoidea* ssp. *adhaerens* occurs in fine, reddish sandy loam over limestone. Dense colonies are sometimes found in pinelands that have undergone a slight mechanical disturbance, where little or no topsoil is formed and where productivity is low. The shrub canopy in this disturbed habitat is often poorly developed providing high light levels and low organic litter accumulation rates. The pine rocklands are often considered a fire subclimax, and are maintained with periodic fires (3 to 7 years). These periodic fires keep the shrub canopy down and eliminate the litter accumulations.

Reproduction

Studies into the life history of the deltoid spurge have only recently begun and little is known about its reproduction. It is a perennial that flowers from April through November, peaking in July. Its extensive root system gives evidence that it is a long-lived plant (DERM 1994).

The reproductive ecology in *Chamaesyce* has been poorly studied but it is known to be highly variable (Ehrenfeld 1976, 1979; Webster 1967). Some species are completely reliant on insects for pollination and seed production while others are self-pollinating. Pollinators may include bees, flies, ants, and wasps (Ehrenfeld 1979). Seed capsules of many *Euphorbiaceae* are explosively dehiscent, ejecting seeds a short distance from the parent plant. The seeds of some species are dispersed by ants (Pemberton 1988).

Relationship to Other Species

The pine rocklands where the deltooid spurge occur, are characterized by a canopy of slash pine (*Pinus elliottii* var. *densa*), a shrub canopy of saw palmetto (*Serenoa repens*), wax myrtle (*Myrica cerifera*), poisonwood (*Metopium toxiferum*), willow bastic (*Sideroxylon salicifolium*), and dozens of other shrub species. Common herbaceous associates include *Schizachyrium sanguineum* var. *sanguineum*, *Schizachyrium gracile*, *Aster adnatus*, and *Acalypha chamaedrifolia*.

Status and Trends

The subspecies *C. deltoidea* ssp. *deltoidea* is the most numerous of the deltooid spurge complex. In a 1994 report, Miami-Dade County DERM estimated the population size to be 10,000 individuals. *C. deltoidea* ssp. *deltoidea* is known from 19 sites, including the Richmond pine rocklands (DERM 1994). Twelve of these sites are in public ownership. The primary threat to this subspecies is poor management of the publicly owned sites. Although exotics were removed from over 800 acres of pine rocklands since 1994, active fire management still needs improvement. In addition, monitoring of these sites has not documented any population trends.

The subspecies *C. deltoidea* ssp. *adhaerens* is the rarest of the deltooid spurge complex. There are 12 sites known and only six are on protected lands (K. Bradley, Institute for Regional Conservation, personal communication 1996). Some management is in place at the protected sites. Goulds and Black Creek Forest are being managed. Also extensive management of the Camp Owaissa Bauer pineland began in 1998 under a state pollution recovery trust fund (J. Maguire, 1998). Along with the loss of pine rocklands to development many of the small fragments have been degraded as a result of fire suppression and the associated hardwood succession and organic litter accumulation.

Several exotic plants are significant problems in pine rocklands. Burma-reed (*Neyraudia reynaudiana*) is the most problematic. This large, fire-adapted exotic grass is now present in almost every pine rockland fragment in Miami-Dade County and forms dense stands in deltooid spurge habitat. Brazilian pepper (*Schinus terebinthifolius*), earleaf acacia (*Acacia auriculiformis*), natalgrass (*Rhynchelytrum repens*), and molasses grass (*Melinis minutiflora*) are also significant problems.

Management

The pine rocklands of Miami-Dade County have evolved and adapted to frequent fires (Snyder *et al.* 1990). In two to three decades of fire suppression these areas mature into tropical hammocks with a few pines in the canopy (Snyder *et al.* 1990). A fundamental question about the fire ecology of pine rocklands is how frequently they should burn and during what season. Snyder *et al.* (1990) inferred the historic burn regimes by looking at the time it takes for the herbaceous layer to be excluded from an area by shading (maximum time between fire) and the point when enough fuel is available to carry a fire (minimum time between fires).

The minimum fire regime they found was 2 to 3 years and the maximum was 15 years. This wide range in fire frequencies would result in different forest structures and dynamics. This would lead us to believe that a mosaic of burns should be used in the management of pine rocklands.

Presently, the recommended burn regime is 3 to 7 years with summer fires generally preferred to winter. Summer fires are preferred since most lightning strikes (the historical cause of fires) occur in the summer months. In areas where fires have been suppressed for many years, the reintroduction of fire may have to be done in step-wise fashion. In some areas it may include winter burns, or the manual removal of some fuel to prevent a hot fire. Any prescribed fire management should include a monitoring program to determine the effectiveness of the prescription. Monitoring should include the species distribution (presence/absence), quantitative assessment of abundance or condition, and demographic information on individual plants (Menges and Gordon 1996). There should also be a component to the monitoring that captures the health of the community and species that occur in association with the deltoid spurge (*C. Kernan*, Fairchild Tropical Garden, personal communication 1996).

Invasive exotic species, especially *Schinus terebinthifolius*, and *Neyraudia reynaudiana*, threaten the deltoid spurge and other rare pine rockland plants. The control of exotic species in the pine rocklands is a very important part of habitat maintenance, although it can be very costly once exotics are established in an area. In most cases the control of exotics includes the use of manual labor, herbicides, and prescribed fire. In heavily infested areas removal is labor intensive, with a field crew pulling the plants by hand or cutting. Prescribed fire and herbicide treatments are then used to control the exotic plants. Once an area is cleared of exotics, proper management can reduce the costs of control and maintain the site relatively exotic free.

The management for pine rocklands in Miami-Dade County is complicated because most of the remaining habitat occurs in small fragmented areas bordered by urban development. Areas surrounding the managed pine rockland that have exotic species can act as a seed source for exotics to continue to invade the pine rocklands. To effectively control invasive exotics, an active strategy is needed. This should include a multilingual outreach program in Miami-Dade County stressing the importance of invasive exotic control in areas surrounding managed pine rockland areas.

The Richmond pine rocklands, owned mostly by Federal and county agencies, is the largest and most important area of pine rockland in Miami-Dade County outside of Everglades NP (J. Maguire, Miami-Dade County DERM, personal communication, 1995). This 10 km² area contains 345 ha of pine rockland forest and has populations of two listed plants (*C. deltoidea* ssp. *deltoidea* and *Polygala smallii*). The Miami-Dade County DERM has completed a management plan for the Richmond pine rocklands under a grant from the FWS. The restoration and management of the Richmond pine rocklands is being lead by the Miami-Dade County Park and Recreation Department's Natural Areas Management Section and DERM. They have been replanting pines lost as a result of Hurricane Andrew, cutting and applying herbicide treatments to exotic plants, and using prescribed fire where possible. In areas where management has been completed, the restoration has been successful.

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Recovery for the Deltoid Spurge

Chamaesyce deltoidea (Engelman ex Chapman) Small ssp.
deltoidea

Recovery Objective: STABILIZE then reclassify to threatened.

Recovery Criteria

Chamaesyce deltoidea ssp. *deltoidea* may be considered stabilized when existing populations, within the historic range of *C. deltoidea* ssp. *deltoidea*, are adequately protected from further habitat loss, degradation, exotic plant invasion, and fire suppression. These sites must also be managed to maintain pine rocklands to support *C. deltoidea* ssp. *deltoidea*.

Once the existing populations are stabilized, *C. deltoidea* ssp. *deltoidea* may be considered for reclassification to threatened. Reclassification will be considered when: enough demographic data are available to determine the appropriate numbers of self-sustaining populations required to ensure 20 to 90 percent probability of persistence for 100 years; when these populations, within the historic range of *C. deltoidea* ssp. *deltoidea* are adequately protected from further habitat loss, degradation, exotic plant invasion, and fire suppression; when these sites are managed to maintain the pine rocklands to support *C. deltoidea* ssp. *deltoidea*; and when monitoring programs demonstrate that populations of *C. deltoidea* ssp. *deltoidea* on these sites support sufficient population sizes, are distributed throughout the historic range, and are sexually or vegetatively 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 distribution within its historic range.

Species-level Recovery Actions

- S1. Conduct surveys to determine distribution of pine rockland plants.** Pine rockland plants were thoroughly surveyed in Miami-Dade County; however, the status of *C. deltoidea* is not known over its entire range.
 - S1.1. Inventory known populations.** Conduct thorough ground surveys to determine the distribution of *C. deltoidea*. Collect and archive herbarium voucher specimens for all populations. Initiate a quarterly monitoring program. Use existing standardized monitoring protocols developed by the Florida Natural Areas Inventory to record baseline data regarding the biology and ecology of *C. deltoidea*.
 - S1.2. Resurvey historic locations.** Conduct thorough ground surveys to locate unrecorded individuals and populations of *C. deltoidea*.

- S1.3. Map distribution of known populations and suitable habitat.** Map populations, including obtaining GPS coordinates and developing GIS coverages.
- S2. Protect and enhance existing populations.** It is imperative for the recovery of pine rockland plants that additional populations not be lost.
- S2.1. Augment natural populations of listed pine rockland plants, where appropriate.** *Ex situ* collections exist for many rare pine rockland species. These collections should be used to cultivate pine rockland plants and augment sparse populations in protected areas. These experiments with reintroductions will be useful in the future, and could be essential for the recovery of pine rockland plant species. The principles of restoration genetics should be understood and applied when carrying out this task.
- S2.1.1. Continue work with *ex situ* propagation and seed banks.** Seeds should continue to be banked for all the listed species possible, and should be identified precisely as to collection location. A genetically representative *ex situ* conservation collection does not exist for *C. deltoidea*. Initiate work with *ex situ* propagation and seed storage banks. Identify seed storage potential and methods. Identify germination and propagation protocols.
- S2.1.2. Identify potential reintroduction sites and reintroduce *C. deltoidea*, where appropriate.** Sites identified as suitable for reintroduction within the known historic range of *C. deltoidea* should be surveyed and prepared to receive plants. Study the feasibility of translocating propagules into historically appropriate and protected natural habitats. Federal lands under proper management regimes may be good recipient sites. Use reintroduction protocols established by the conservation community.
- S2.1.3. Monitor the experimental outplantings.** Monitoring of reintroduced plants is essential for assessing the success of recovery efforts. Growth and survivorship should be measured.
- S2.2. Enforce available protective legislation.** State, Federal, and local regulations should be used to protect the pine rockland ecosystem and the listed plants.
- S2.2.1. Initiate section 7 consultation when applicable.** section 7 of the Endangered Species Act applies to Federal activities which might impact listed species, especially on Federal lands (Everglades NP).
- S2.2.2. Encourage implementation of management plans.** Federal agencies are obligated under section 7(a)(1) of the ESA to perform positive conservation programs for the benefit of listed species. The implementation of management plans to benefit pine rocklands in Everglades NP and southern Miami-Dade County are positive conservation programs.
- S2.2.3. Continue to enforce take and trade prohibitions.** The listed pine rockland plants are protected by take and trade restrictions of the ESA, the Preservation of Native Flora Act, and the regulations of Everglades NP. Since these are inconspicuous plants, take and trade are nonexistent or uncommon.

- S3. Collect biological information important to species recovery.** Additional information on the ecology and life history of pine rockland plants needs to be collected. The size and viability of known populations of *C. deltoidea* needs to be evaluated.
- S3.1. Investigate the reproductive biology of *C. deltoidea*.** A better understanding of the genetics and reproduction of this species is needed.
- S3.2. Identify demographics and gene flow in *C. deltoidea*.** Determine the size and viability of all populations. Conduct studies to document the genetic variation within and between populations.
- S3.3. Study the response of *C. deltoidea* to habitat management treatments.** Study the fire ecology of *C. deltoidea*.
- S3.4. Characterize the habitat and identify suitable sites for experimental outplantings.** Apply and modify, if need be, reintroduction protocols established by the conservation community.
- S4. Monitor *C. deltoidea* populations.** Use existing standardized monitoring protocols developed by the Florida Natural Areas Inventory to record baseline data regarding the biology and ecology of *C. deltoidea*. Determine the effects of management actions on *C. deltoidea*. Initiate quarterly monitoring programs.
- S4.1. Collect existing and historical data and place in a central location.** Contact former researchers for historical data, gather information from herbaria and museums, and contact all present researchers to compile data and place in GIS database in the FWS South Florida Ecosystem Office. This location will allow all researchers access to both historic and current data, and provide the FWS with a means to monitor the success of recovery tasks.
- S4.2. Convene a meeting of all researchers.** A meeting of current pine rockland researchers and land managers would enable the FWS to locate information sources, and begin the process of compiling those data. The meeting would also afford cooperators an opportunity to discuss monitoring and management procedures and set realistic species level-goals.
- S4.3. Monitor status and success of all populations and change management practices if so indicated.** Because of the varying vegetation conditions and fire history, different management may be required at different pine rockland sites. Different prescribed burn intervals may be necessary for best results. Intervals should be adjusted over the years to promote pine re-establishment and hardwood reduction.
- S4.4. Monitor reintroduction success and modify procedures as necessary.** Plant reintroductions should be monitored to determine the success of the procedure. The goal of reintroduction should be to establish a viable population. Management of the reintroduction sites should be modified as necessary to improve results.
- S5. Continue implementation of the fire education program and modify as necessary any fire management education program that has been developed.** Future modifications to this program may include tri-lingual distribution (Spanish, English, and Haitian Creole).

Habitat-level Recovery Actions

- H1. Continue to protect pine rockland plant habitat in order to prevent degradation.** The decline of the five listed pine rockland plants is due to alteration of pine rocklands in South Florida.
- H1.1. Protect pine rockland habitat. Acquisition of remaining private sites** may be the only effective way to protect or conserve pine rockland habitat. Miami-Dade County's Environmentally Endangered Lands program and the State of Florida's CARL program have acquired over 182.25 ha of pine rocklands since 1990. It should be noted that public lands may still be subject to development for recreational, maintenance, or other purposes. Such disturbances, unless carefully planned, may directly destroy pine rocklands and may secondarily result in exotic plant infestations as well as destructive human uses.
- H1.2. Protect or acquire privately owned sites.** Less-than-fee-simple acquisition should be used, where appropriate, as an alternative means of protecting pine rockland habitat. Covenants, as provided for under Miami-Dade County regulations, provide tax incentives for private landowners to protect pine rockland sites. A site owned by Florida Power and Light Company may be maintained through cooperation with that utility. This avenue of protection should also be pursued with the railroad company that owns pine rockland habitat that supports other listed species. Miami-Dade County DERM is developing a private lands management and grant program for pine rockland protection and restoration and this program should be implemented as soon as possible.
- H1.3. Develop and implement best management practices for pine rocklands.** This would include development of fire management strategies that would best benefit pine rockland species. Without active fire and exotic plant management, pine rocklands will continue to disappear or degrade. Because of the restricted nature of pine rocklands, intensive management may be necessary at many of the remaining sites.
- H1.4. Continue to expand prescribed burns.** Fire should be conducted at appropriate times of year to lower fuel loads. Growing season burns should be employed most often after fuel levels are under control. Special consideration must be included when planning prescribed fire for pine rocklands invaded by Burma reed or Cogon grass (*Imperata cylindrica*). Incorporate appropriate actions to minimize additional Burma reed or Cogon grass infestations in these areas. Due to the highly urbanized lands surrounding some of the pine rockland sites, burning involves risks of smoke damage and annoyance, or worse, losing control of the fire. The Florida Division of Forestry has expertise in carrying out controlled burns in Miami-Dade County and should be contacted to assist with burns. Miami-Dade County DERM is developing a private lands management and grant program for pine rockland protection and restoration and this program should be implemented as soon as possible.
- H1.5. Implement additional management to meet habitat needs.**
- H1.5.1. Eliminate human-caused degradation.** Preventing trash dumping or other destructive human activities in pine rocklands is important. In order to accomplish this task, fencing and access restrictions may be necessary.

H1.5.2. Control invasive plant species, particularly exotics. Burma reed, Cogon grass, and persistent hardwoods need to be controlled and may require special techniques including herbicide, fire, mechanical, and hand clearing at most sites. Other management needs indicated by ongoing research should also be implemented.

H2. Restore areas to suitable habitat.

H2.1. Eliminate physical degradation of habitat and restore to optimal conditions. Physical degradation of pine rocklands continues to occur. Hurricane Andrew, in 1992, killed most of the adult pines in southern Miami-Dade County. The adult pines on Long Pine Key in Everglades NP were not as severely damaged (Herndon, 1998). The continued degradation of these areas should be curtailed and restoration of uneven-aged pine stands undertaken. Tubeling or direct seeding experiments may be used to accomplish this task. In order to use direct seeding techniques, collection of local pine seeds must continue.

H2.2. Continue to refine management practices for pine rocklands. Management plans for sites including *C. deltoidea* should be implemented and modified as necessary for the benefit of this species.

H2.3. Continue to conduct prescribed burns. Prescribed burns should be conducted at sites where *C. deltoidea* occurs at appropriate time of the year to lower fuel loads. Growing season burns should then be employed after fuel loads are under control. The response to *C. deltoidea* to prescribed burns should be studied.

H3. Conduct habitat-related research.

H3.1. Continue to investigate and refine the habitat needs of each species. The habitat needs of these species have been studied, but are still not completely understood. The pollination, germination, and growth requirements have not been fully investigated. Research should address how light levels affect survival, and how fire management affects light levels, reproduction, and regeneration of these species.

H3.2. Investigate fire history and incorporate into management strategies. Look at fire history for pine rocklands in Miami-Dade County and Everglades NP, incorporate into GIS database and analyze relative to healthy populations. This exercise will provide adequate information on fire history and intervals in urbanized and non-urbanized settings to enable assessment of the appropriateness of proposed management regimes.

H3.3. Monitor sites with *C. deltoidea* ssp. *deltoidea* to determine success. A protocol developed by Fairchild Tropical Garden for monitoring pine rockland plant communities should be implemented at sites where *C. deltoidea* ssp. *deltoidea* occur.

H3.4. Develop a GIS database on the five listed pine rockland species and their habitats. Distribute the database to researchers, land managers, and conservationists.

H3.2.1. Assess the availability of GIS data. Create coverage of population locations, acquire recent imageries of the sites, and distribute the coverages to researchers, land managers, and conservationists.

