DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

[Docket No. FWS–R4–ES–2015–0137]; [4500030113]

RIN 1018–AZ95

Endangered and Threatened Wildlife and Plants; Endangered Species Status for Chamaecrista lineata var. keyensis (Big Pine Partridge Pea), Chamaesyce deltoidea ssp. serpyllum (Wedge Spurge), and Linum arenicola (Sand Flax), and Threatened Species Status for Argythamnia blodgettii (Blodgett's Silverbush)

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Proposed rule.

SUMMARY: We, the U.S. Fish and Wildlife Service (Service or USFWS), propose to list four plants from south Florida under the Endangered Species Act of 1973, as amended (Act): *Chamaecrista lineata* var. *keyensis* (Big Pine partridge pea), *Chamaesyce deltoidea* ssp. *serpyllum* (wedge spurge), and *Linum arenicola* (sand flax) as endangered species, and *Argythamnia blodgettii* (Blodgett's silverbush) as a threatened species. If we finalize this rule as proposed, it would extend the Act's protections to these plants.

DATES: We will accept comments received or postmarked on or before November 30, 2015. Comments submitted electronically using the Federal eRulemaking Portal (see **ADDRESSES**, below) must be received by 11:59 p.m. Eastern Time on the closing date. We must receive requests for public hearings, in writing, at the address shown in **FOR FURTHER INFORMATION CONTACT** by November 13, 2015.

ADDRESSES: You may submit comments by one of the following methods:

(1) *Electronically:* Go to the Federal eRulemaking Portal: *http://www.regulations.gov.* In the Search box, enter FWS–R4–ES–2015–0137, which is the docket number for this rulemaking. Then, in the Search panel on the left side of the screen, under the Document Type heading, click on the Proposed Rules link to locate this document. You may submit a comment by clicking on ''Comment Now!''

(2) *By hard copy:* Submit by U.S. mail or hand-delivery to: Public Comments Processing, Attn: FWS–R4–ES–2015–0137; U.S. Fish and Wildlife Service, MS: BPHC, 5275 Leesburg Pike, Falls Church, VA 22041–3803.

We request that you send comments only by the methods described above. We will post all comments on *http://www.regulations.gov.* This generally means that we will post any personal information you provide us (see *Public Comments,* below, for more information).

FOR FURTHER INFORMATION CONTACT: Larry Williams, State Supervisor, U.S. Fish and Wildlife Service, South Florida Ecological Services Field Office, 1339 20th Street, Vero Beach, FL 32960; by telephone 772–562–3909; or by facsimile 772–562–4288. Persons who use a telecommunications device for the deaf (TDD) may call the Federal Information Relay Service (FIRS) at 800–877–8339.

SUPPLEMENTARY INFORMATION:

Executive Summary

Why we need to publish a rule. Under the Act, if we determine that a species is an endangered or threatened species throughout all or a significant portion of its range, we must publish a proposed rule to list the species in the **Federal Register** and make a determination on our proposal within 1 year. Listing a species as an endangered or threatened species can only be completed by issuing a rule.

This rule proposes the listing of *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum,* and *Linum arenicola* as endangered species, and *Argythamnia blodgettii* as a threatened species. The four plants are candidate species for which we have on file sufficient information on biological vulnerability and threats to support preparation of a listing proposal, but for which development of a listing rule has until now been precluded by other higher priority listing activities. This rule reassesses all available information regarding status of and threats to the four plants.

The basis for our action. Under the Act, we may determine that a species is an endangered or threatened species based on any of five factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence. We have determined that the threats to *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* consist primarily of habitat loss and modification through urban and agricultural development, and lack of adequate fire management (Factor A); and the proliferation of nonnative invasive plants, stochastic events (hurricanes and storm surge), maintenance practices used on roadsides and disturbed sites, and sea level rise (Factor E). Existing regulatory mechanisms have not been adequate to reduce or remove these threats (Factor D).

We will seek peer review. We will seek comments from independent specialists to ensure that our determinations are based on scientifically sound data, assumptions, and analyses. We will invite these peer reviewers to comment on this listing proposal.

Information Requested

Public Comments

We intend that any final action resulting from this proposed rule will be based on the best scientific and commercial data available and be as accurate and as effective as possible. Therefore, we request comments or information from other concerned governmental agencies, Native American tribes, the scientific community, industry, or any other interested parties concerning this proposed rule. We particularly seek comments concerning:

(1) The four plants' biology, range, and population trends, including:

(a) Biological or ecological requirements of these plants, including habitat requirements for establishment, growth, and reproduction;

(b) Genetics and taxonomy;

(c) Historical and current ranges, including distribution patterns;

(d) Historical and current population levels, and current and projected trends; and

(e) Past and ongoing conservation measures for the plants, their habitats, or both.

(2) Factors that may affect the continued existence of these plants, which may include habitat modification or destruction, overutilization, disease, predation, the inadequacy of existing regulatory mechanisms, or other natural or manmade factors.

(3) Biological, commercial trade, or other relevant data concerning any threats (or lack thereof) to these plants and existing regulations that may be addressing those threats.

(4) Current or planned activities in the areas occupied by these plants and possible impacts of these activities on these plants.

(5) Additional information concerning the biological or ecological requirements

of these plants, including pollination and pollinators.

(6) Scientific information or analysis informing whether these plants more closely meet the definition of endangered or of threatened under the Act.

Please include sufficient information with your submission (such as scientific journal articles or other publications) to allow us to verify any scientific or commercial information you include.

Please note that submissions merely stating support for or opposition to the action under consideration without providing supporting information, although noted, will not be considered in making a determination, as section 4(b)(1)(A) of the Act (16 U.S.C. 1531 *et seq.*) directs that determinations as to whether any species is an endangered or threatened species must be made ''solely on the basis of the best scientific and commercial data available.''

You may submit your comments and materials concerning this proposed rule by one of the methods listed in the **ADDRESSES** section. We request that you send comments only by the methods described in the **ADDRESSES** section.

If you submit information via *http://www.regulations.gov,* your entire submission—including any personal identifying information—will be posted on the Web site. If your submission is made via a hardcopy that includes personal identifying information, you may request at the top of your document that we withhold this information from public review. However, we cannot guarantee that we will be able to do so. We will post all hardcopy submissions on *http://www.regulations.gov.*

Comments and materials we receive, as well as supporting documentation we used in preparing this proposed rule, will be available for public inspection on *http://www.regulations.gov,* or by appointment, during normal business hours, at the U.S. Fish and Wildlife Service, South Florida Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

Public Hearing

Section 4(b)(5) of the Act provides for one or more public hearings on this proposal, if requested. Requests must be received within 45 days after the date of publication of this proposed rule in the **Federal Register**. Such requests must be sent to the address shown in the **FOR FURTHER INFORMATION CONTACT** section. We will schedule public hearings on this proposal, if any are requested, and announce the dates, times, and places of those hearings, as well as how to obtain reasonable accommodations, in the **Federal Register** and local newspapers at least 15 days before the hearing.

Peer Review

In accordance with our joint policy on peer review published in the **Federal Register** on July 1, 1994 (59 FR 34270), we will seek the expert opinions of at least three appropriate and independent specialists regarding this proposed rule. The purpose of peer review is to ensure that our listing determinations are based on scientifically sound data, assumptions, and analyses. The peer reviewers have expertise in the biology, habitat, and conservation status of these plants, which will inform our determinations. We invite comment from the peer reviewers during the public comment period.

Previous Federal Actions

On January 9, 1975, as directed by the Act, the Secretary for the Smithsonian Institution submitted a report to Congress on potential endangered and threatened plant species of the United States (Smithsonian 1975, entire). The report identified more than 3,000 plant species as potentially either endangered or threatened, including *Argythamnia blodgettii, Chamaecrista lineata* var. *keyensis* (under the former name *Cassia keyensis*), *Chamaesyce deltoidea* ssp. *serpyllum* (under the name *Chamaesyce* (*Euphorbia*) *deltoidea* ssp. *serpyllum*), and *Linum arenicola* (Smithsonian 1975, pp. 56, 58, 61, 81). On July 1, 1975, we published in the **Federal Register** (40 FR 27824) our notification that we considered this report to be a petition to list the identified plants as either endangered or threatened under the Act. The 1975 notice solicited information from Federal and State agencies, and the public, on the status of the species.

On December 15, 1980, we published in the **Federal Register** (45 FR 82480) our notice of review of plant taxa for listing as endangered or threatened species. In that document, *Argythamnia blodgettii, Chamaecrista lineata* var. *keyensis* (under the former name *Cassia keyensis*), *Chamaesyce deltoidea* ssp. *serpyllum* (under the former name *Euphorbia deltoidea* ssp. *serpyllum*), and *Linum arenicola* were identified as Category 1 species (taxa for which we had enough biological information to support listing as either endangered or threatened). As a result, we considered all four plants to be candidates for addition to the Federal List of Endangered and Threatened Plants. The 1980 notice solicited information from Federal and State agencies, and the public, on the status of the four plant species.

On November 28, 1983, we published a document in the **Federal Register** (48 FR 53640) assigning a listing priority number (LPN) to two of the four plant species in accordance with our Listing Priority Guidance (48 FR 43098; September 21, 1983). *Argythamnia blodgettii* and *Linum arenicola* were assigned an LPN of 2, which meant that information that the Service possessed indicated that proposing to list as endangered or threatened was possibly appropriate but we lacked substantial information on biological vulnerability and threat(s) to support a proposed listing.

On September 27, 1985, we published a document in the **Federal Register** (50 FR 39526) assigning LPNs to all four of the plant species in accordance with our Listing Priority Guidance (48 FR 43098; September 21, 1983). *Argythamnia blodgettii* and *Linum arenicola* both retained an LPN of 2, which meant that information that the Service possessed indicated that proposing to list as endangered or threatened was possibly appropriate but we lacked substantial information on biological vulnerability and threat(s) to support a proposed listing. *Chamaecrista lineata* var. *keyensis* (under the former name *Cassia keyensis*) and *Chamaesyce deltoidea* ssp. *serpyllum* (under the former name *Euphorbia deltoidea* ssp. *serpyllum*) were both assigned an LPN of 1, which meant the Service had on file substantial information on biological vulnerability and threat(s) to support the appropriateness of proposing to list as endangered or threatened. We recognized at that time that any proposed listing action may take ''some years'' because of the ''large number of taxa'' at issue.

The 1990 candidate notice of review (CNOR) published in the **Federal Register** on February 21, 1990 (55 FR 6184). In that CNOR, *Argythamnia blodgettii* and *Linum arenicola* both retained an LPN of 2, and *Chamaecrista lineata* var. *keyensis* and *Chamaesyce deltoidea* ssp. *serpyllum* both retained an LPN of 1. Candidate species are assigned LPNs based on immediacy and magnitude of threats, as well as taxonomic status. The lower the LPN, the higher priority that species is for us to determine appropriate action using our available resources. We determined at that time that proposing to list was warranted, but was precluded due to workloads and priorities.

All four plants remained on the candidate list in the 1993 CNOR (58 FR 51144; September 30, 1993), with *Argythamnia blodgettii* and *Linum arenicola* both retaining an LPN of 2, and *Chamaecrista lineata* var. *keyensis*

and *Chamaesyce deltoidea* ssp. *serpyllum* being assigned an LPN of 3C (taxa that have proven to be more abundant or widespread than previously believed and/or those that are not subject to any identifiable threat).

The 1999 CNOR (64 FR 57534; October 25, 1999) retained *Chamaecrista lineata* var. *keyensis* and *Chamaesyce deltoidea* ssp. *serpyllum* as candidates and assigned an LPN of 6 to both, retained *Linum arenicola* as a candidate and assigned an LPN of 2, and retained *Argythamnia blodgettii* as a candidate and assigned an LPN of 11.

Chamaecrista lineata var. *keyensis* and *Chamaesyce deltoidea* ssp. *serpyllum* remained on the candidate list from 2001 to 2006, with the LPN of 6 (66 FR 54808, October 30, 2001; 67 FR 40657, June 13, 2002; 69 FR 24876, May 4, 2004; 70 FR 24870, May 11, 2005; 71 FR 53756, September 12, 2006). In the December 6, 2007, CNOR (72 FR 69034), we changed the LPN of *Chamaecrista lineata* var. *keyensis* and *Chamaesyce deltoidea* ssp. *serpyllum* from a 6 to a 9 because the threats to the species were found to be of lower magnitude than previously known. *Chamaecrista lineata* var. *keyensis* and *Chamaesyce deltoidea* ssp. *serpyllum* remained on the candidate list as published in the CNORs from 2008 to 2014 with the LPN of 9 (73 FR 75176, December 10, 2008; 74 FR 57804, November 9, 2009; 75 FR 69222, November 10, 2010; 76 FR 66370, October 26, 2011; 77 FR 69994, November 21, 2012; 78 FR 70104, November 22, 2013; 79 FR 72450, December 5, 2014).

Linum arenicola remained on the candidate list from 2001 to 2009, with the LPN of 2 (66 FR 54808, October 30, 2001; 67 FR 40657, June 13, 2002; 69 FR 24876, May 4, 2004; 70 FR 24870, May 11, 2005; 71 FR 53756, September 12, 2006; 72 FR 69034, December 6, 2007; 73 FR 75176, December 10, 2008; 74 FR 57804, November 9, 2009). In the November 10, 2010, CNOR (75 FR 69222), we changed the LPN of *L. arenicola* from a 2 to a 5 because of the threats to the species were found to be of lower magnitude than previously known and new data showing a larger population. *L. arenicola* remained on the candidate list as published in the CNORs from 2011 to 2014 with the LPN of 5 (76 FR 66370, October 26, 2011; 77 FR 69994, November 21, 2012; 78 FR 70104, November 22, 2013; 79 FR 72450, December 5, 2014).

Argythamnia blodgettii remained on the candidate list from 2001 to 2014, with the LPN of 11 (66 FR 54808, October 30, 2001; 67 FR 40657, June 13, 2002; 69 FR 24876, May 4, 2004; 70 FR 24870, May 11, 2005; 71 FR 53756; September 12, 2006; 72 FR 69034, December 6, 2007; 73 FR 75176, December 10, 2008; 74 FR 57804, November 9, 2009; 75 FR 69222, November 10, 2010; 76 FR 66370, October 26, 2011; 77 FR 69994, November 21, 2012; 78 FR 70104, November 22, 2013; 79 FR 72450, December 5, 2014).

For all four of the plant species, the 2005 CNOR (70 FR 24870; May 11, 2005) included a ''warranted but precluded'' finding in response to a May 11, 2004, petition to list the species.

On May 10, 2011, as part of a settlement agreement with a plaintiff, the Service filed a proposed work plan with the U.S. District Court for the District of Columbia. The work plan would enable the agency to, over a period of 6 years, systematically review and address the needs of more than 250 species listed within the 2010 CNOR, including *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii,* to determine if these species should be added to the Federal Lists of Endangered and Threatened Wildlife and Plants. This work plan would enable the Service to again prioritize its workload based on the needs of candidate species, while also providing State wildlife agencies, stakeholders, and other partners clarity and certainty about when listing determinations will be made. On July 12, 2011, the Service reached an agreement with another plaintiff group and further strengthened the work plan, which would allow the agency to focus its resources on the species most in need of protection under the Act. These agreements were approved by the court on September 9, 2011. The four species are proposed for listing pursuant to these agreements.

Background

It is our intent to discuss below only those topics directly relevant to the listing of *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum,* and *Linum arenicola* as endangered, and *Argythamnia blodgettii* as threatened, in this proposed rule.

Chamaecrista lineata var. *keyensis* (Big Pine partridge pea)

Species Description

Chamaecrista lineata var. *keyensis* is a small, prostrate to ascending, perennial, herbaceous shrub that is 10–80 centimeters (cm) (3.9–31.5 inches (in)) tall, with yellow flowers and pinnately compound leaves (each leaf consists of a main stem with multiple leaflets lined up along on each side). It has one to several branched stems arising from a contorted rootstock. New branches are covered in soft, fuzzy hairs. The leaves are 1.7–4.0 cm (0.7–1.6 in) long, with 5 to 9 pairs of leaflets. Flowers consist of five sepals 9–20 mm (0.4–0.8 in) long that are fused together near their bases; five yellow petals 11–15 mm (0.4–0.6 in) long, with one slightly larger than the others; 10 reddish-purple stamens; and a single, elongate style. The fruit is an elongate pod, roughly similar to that of a pea, 33–45 mm (1.3–1.8 in) long and 4.5–5.0 mm (0.19–0.17 in) wide, with a soft fuzzy texture, which turns gray with age and eventually split open to release seeds (Irwin and Barneby 1982, p. 757; Small 1933, pp. 662–663).

Taxonomy

John Loomis Blodgett was the first to collect *Chamaecrista lineata* var. *keyensis,* sometime between 1838 and 1852, on Big Pine Key (Bradley and Gann 1999, p. 17). Pollard (1894, p. 217) assigned the plants on Big Pine Key to the existing taxon *Cassia grammica.* John K. Small (1903, p. 587; 1913, p. 58) followed this usage, but used the genus *Chamaecrista* (considered a subgenus within *Cassia* or a genus unto itself variously by many authors). In 1917, Pennell (p. 344) recognized the Big Pine Key plant as a distinct endemic species, naming it *Chamaecrista keyensis.* This name was retained by Small (1933, p. 663) in his Manual of the Southeastern Flora. In an exhaustive study of *Cassia* and *Chamaecrista,* Irwin and Barneby (1982, p. 757) assigned plants in Florida and parts of the West Indies to the existing taxon *Chamaecrista lineata,* and assigned the Big Pine Key plants to var. *keyensis,* retaining them as endemic to the Florida Keys. Isely (1990, p. 33), Wunderlin (1998, p. 348), and Wunderlin and Hansen (2003, p. 441) have followed this treatment. The online Atlas of Florida Vascular Plants (Wunderlin and Hansen 2014, p. 1) uses *Chamaecrista lineata* var. *keyensis.* The Integrated Taxonomic Information System (2015, p. 1) uses the name *Chamaecrista lineata* var. *keyensis* and indicates that this taxonomy is accepted. Based upon the best available scientific information, *Chamaecrista lineata* var. *keyensis* is a distinct taxon, endemic to the lower Keys in Monroe County, Florida. Synonyms are *Cassia keyensis* (Pennell) J.F. Macbr and *Chamaecrista keyensis* Pennell. *Chamaecrista lineata* var. *keyensis* is related to, and superficially resembles, *Chamaecrista fasciculata,* the partridge pea, a common species which occurs throughout Florida.

Climate

The climate of south Florida where *Chamaecrista lineata* var. *keyensis* occurs is classified as tropical savanna and is characterized by distinct wet and dry seasons and a monthly mean temperature above 18 degrees Celsius (°C) (64.4 degrees Fahrenheit (°F)) in every month of the year (Gabler *et al.* 1994, p. 211). Freezes can occur in the winter months, but are rare at this latitude in south Florida. Rainfall in the lower Keys, where *C. lineata* var. *keyensis* occurs exclusively, varies from an annual average of 89–102 cm (35–40 in). Approximately 75 percent of yearly rainfall occurs during the wet season from June through September (Snyder *et al.* 1990, p. 238).

Habitat

Chamaecrista lineata var. *keyensis* occurs in pine rocklands of the lower Florida Keys, and adjacent disturbed sites, including roadsides.

Pine Rocklands: Pine rocklands are a unique and highly imperiled ecosystem found on limestone substrates in south Florida and a few islands in the Bahamas. In Florida, pine rocklands are located on the Miami Rock Ridge in present day Miami and in Everglades National Park, in the Florida Keys, and in the Big Cypress Swamp. While all four plants in this proposed rule occur primarily in pine rocklands, they have not been recorded in the Big Cypress Swamp area. Pine rocklands differ to some degree between and within these areas with regard to substrate (*e.g.,* amount of exposed limestone, type of soil), elevation, hydrology, and species composition (both plant and animal).

Pine rocklands occur in a mosaic with primarily two other natural community types—rockland hammock and marl prairie. Pine rocklands grade into rockland hammock; pine rocklands have an open pine canopy, and rockland hammock has a closed, hardwood canopy. Marl prairies differ from pine rocklands in having no pines, an understory dominated by grasses and sedges, and a minimal cover of shrubs (FNAI 2010, p. 63).

The total remaining acreage of pine rocklands in Miami-Dade and Monroe Counties is now 8,981 hectares (ha) (22,079 acres (ac)) (approximately 8,140 ha (20,100 ac)) in Miami-Dade County, and 801 ha (1,979 ac) in the Florida Keys (Monroe County).

Pine rocklands are characterized by an open canopy of *Pinus elliottii* var. *densa* (South Florida slash pine) with a patchy understory of tropical and temperate shrubs and palms and a rich herbaceous layer of mostly perennial species, including numerous species endemic to South Florida. Outcrops of weathered oolitic (small, rounded particles or grains) limestone are common, and solution holes may be present. This subtropical, pyrogenic flatland can be mesic or xeric depending on landscape position and associated natural communities (FNAI 2010a, p. 1).

Pine rocklands occur on relatively flat, moderately to well-drained terrain from 2–7 meters (m) (6.5 to 23 feet (ft)) above sea level (FNAI 2010a, p. 2). The oolitic limestone is at or very near the surface, and there is very little soil development. Soils are generally composed of small accumulations of nutrient-poor sand, marl, clayey loam, and organic debris in depressions and crevices in the rock surface. Organic acids occasionally dissolve the surface limestone causing collapsed depressions in the surface rock called solution holes (FNAI 2010a, p. 1). Drainage varies according to the porosity of the limestone substrate, but is generally rapid. Consequently, most sites are wet for only short periods following heavy rains. During the rainy season, however, some sites may be shallowly inundated by slow-flowing surface water for up to 60 days each year (FNAI 2010a, p. 1).

Pine rocklands have an open canopy of South Florida slash pine, generally with multiple age classes. The diverse, open shrub and subcanopy layer is composed of more than 100 species of palms and hardwoods (FNAI 2010a, p. 1), most derived from the tropical flora of the West Indies (FNAI 2010a, p. 1). Many of these species vary in height depending on fire frequency, getting taller with time since fire. These may include *Serenoa repens* (saw palmetto), *Sabal palmetto* (cabbage palm), *Coccothrinax argentata* (silver palm), *Thrinax morrisii* (Key thatch palm), *Myrica cerifera* (wax myrtle), *Rapanea punctata* (myrsine), *Metopium toxiferum* (poisonwood), *Byrsonima lucida* (locustberry), *Dodonaea viscosa* (varnishleaf), *Tetrazygia bicolor* (tetrazygia), *Guettarda scabra* (rough velvetseed), *Ardisia escallonioides* (marlberry), *Psidium longipes* (longstalked stopper), *Sideroxylon salicifolium* (willow bustic), and *Rhus copallinum* (winged sumac). Short-statured shrubs may include *Quercus elliottii* (running oak), *Randia aculeata* (white indigoberry), *Crossopetalum ilicifolium* (Christmas berry), *Morinda royoc* (redgal), and *Chiococca alba* (snowberry).

Grasses, forbs, and ferns make up a diverse herbaceous layer ranging from mostly continuous in areas with more soil development and little exposed rock to sparse where more extensive outcroppings of rock occur. Typical herbaceous species may include *Andropogon* spp.; *Schizachyrium gracile, S. rhizomatum,* and *S. sanguineum* (bluestem grasses); *Aristida purpurascens* (arrowleaf threeawn); *Sorghastrum secundum* (lopsided indiangrass); *Muhlenbergia capillaris* (hairawn muhly); *Rhynchospora floridensis* (Florida white-top sedge); *Tragia saxicola* (pineland noseburn); *Echites umbellata* (devil's potato); *Croton linearis* (pineland croton); several species of *Chamaesyce* spp. (sandmats); *Chamaecrista fasciculata* (partridge pea); *Zamia pumila* (coontie); *Anemia adiantifolia* (maidenhair pineland fern); *Pteris bahamensis* (Bahama brake); and *Pteridium aquilinum* var. *caudatum* (lacy bracken) (FNAI 2010a, p. 1).

There are noticeable differences in species composition between the pine rocklands found in the Florida Keys and the mainland. The shrub layer in pine rocklands occurring in the northern end of the Miami Rock Ridge more closely resembles pine flatwoods as a result of the amount of sandy soils in this area, with species such as *Lyonia fruticosa* (staggerbush), *Quercus minima* (dwarf live oak), *Quercus pumila* (running oak), and *Vaccinium myrsinites* (shiny blueberry) becoming more common (Snyder *et al.* 1990, p. 255). Pine rocklands in the lower Florida Keys have a subcanopy composed of several palms such as *Thrinax morrisii, Thrinax radiata* (Florida thatch palm), and *Coccothrinax argentata,* and hardwoods such as *Byrsonima lucida* and *Psidium longipes* (Bradley 2006, p. 3). The diversity of the herbaceous layer decreases as the density of the shrub layer increases (*i.e.,* as understory openness decreases), and pine rocklands on the mainland have a more diverse herbaceous layer due to the presence of temperate species and some tropical species that do not occur in the Florida Keys (FNAI 2010, p. 63).

Pine rocklands are maintained by regular fire, and are susceptible to other natural disturbances such as hurricanes, frost events, and sea level rise (SLR) (Ross *et al.* 1994). Fires historically burned on an interval of approximately every 3 to 7 years, and were typically started by lightning strikes during the frequent summer thunderstorms (FNAI 2010a, p. 3). Mature South Florida slash pine is highly fire-resistant (Snyder *et al.* 1990, p. 259). Above-ground portions of hardwood shrubs are typically killed by fire, but often resprout below ground; palms typically produce new growth post-fire from their unaffected apical buds. The amount of woody understory growth is directly related to the length

of time since the last fire. Herbaceous diversity declines with time since last fire. The ecotone between pine rocklands and rockland hammock is abrupt when regular fire is present in the system. However, when fire is removed, the ecotone becomes more gradual and subtle as hardwoods encroach into the pineland (FNAI 2010a, p. 3). If fire is excluded for 20 to 30 years, hardwoods will come to dominate the community and hammock conditions will prevail, which further discourage fires from spreading except in drought conditions. Presently, prescribed fire must be periodically introduced into pine rocklands to sustain community structure, prevent invasion by woody species, maintain high herbaceous diversity (Loope and Dunevitz 1981, pp. 5–6; FNAI 2010a, p. 3), and prevent succession to rockland hammock.

Pine rocklands are also susceptible to natural disturbances such as hurricanes and other severe storms, during which trees may be killed, thereby helping to maintain the open canopy that is essential to pine rocklands plants. During such events, pine rocklands near the coast may be temporarily inundated by saltwater, which can also kill or damage vegetation (Snyder *et al.* 1990, p. 251). These sporadic but potentially major disturbances, along with burning, create the dynamic nature of the pine rocklands habitat. Some currently unsuitable areas may become open in the future, while areas currently open may develop more dense canopy over time, eventually rendering that portion of the pine rocklands unsuitable for pine rocklands endemic plants.

Within pine rocklands habitat, *Chamaecrista lineata* var. *keyensis* is associated with areas that have few hardwoods and overstory palms are abundant (Bradley and Gann 1999, p 17–18). *C. lineata* var. *keyensis* plants are often in a clumped distribution surrounded by large areas of bare, open rock that do not support plant growth (Bradley 2006, p. 3). *C. lineata* var. *keyensis* is widespread in pine rocklands of Big Pine Key, but more frequent in the northern part of the island (Bradley 2006, p. 13). It is also more frequent in the interior of pine rocklands than on coastal edges (Bradley 2006, p. 13; Bradley and Saha 2009, p. 9). *C. lineata* var. *keyensis* is more abundant in areas with relatively higher elevation (Bradley and Saha 2009, p. 26), low shrub density, and a diverse herb layer (Bradley 2006, p. 37).

Roadsides: Roadsides are a potentially important habitat for *Chamaecrista lineata* var. *keyensis* (Bradley 2006, p. 21). Where pine rocklands endemics such as *C. lineata* var. *keyensis* are found on road shoulders, the ground cover is dominated mostly by native herbs and grasses, and exotic lawn grasses have not been planted. Maintaining the roadsides in this condition through regular mowing, without planting sod, should continue to provide suitable habitat for *C. lineata* var. *keyensis* (Bradley 2006, p. 37).

Historical Range

Chamaecrista lineata var. *keyensis* is endemic to the lower Florida Keys in Monroe County, Florida. Historical records exist for occurrences on five islands: Big Pine Key, No Name Key, Ramrod Key, Cudjoe Key, and Sugarloaf Key (Hodges and Bradley 2006, pp. 20–21).

Current Range, Population Estimates, and Status

The current range of *Chamaecrista lineata* var. *keyensis* is Big Pine Key and Cudjoe Key. In 2007, Bradley and Saha (2009, pp. 9–11) surveyed Big Pine Key, Cudjoe Key, Little Pine Key, No Name Key, and Sugarloaf Key (the five islands in the Florida Keys containing pine rocklands) and observed *C. lineata* var. *keyensis* only on Big Pine Key and Cudjoe Key. It has not been reported from other islands for some time (Ramrod Key in 1911, No Name Key in 1916 (Hodges and Bradley 2006, p. 45), and Lower Sugarloaf Key in 2005 (Hodges and Bradley 2006, p. 21)). Accordingly, *C. lineata* var. *keyensis* is considered extirpated from Ramrod Key, No Name Key, and Lower Sugarloaf Key—3 of 5 (60 percent) of the islands where it was historically recorded (Bradley and Gann 1999, p. 18; Hodges and Bradley 2006, p. 21). Big Pine Key, Cudjoe Key, Little Pine Key, No Name Key, and Sugarloaf Key presently contain pine rocklands habitat. No pine rocklands currently exist on Ramrod Key.

Population data for *Chamaecrista lineata* var. *keyensis* have been collected periodically on Big Pine Key since 1955. Because of the size of Big Pine Key, sample study plots were used, as opposed to a complete search of all potential habitat. Multiple indicators show that the population on Big Pine Key has declined over the past 60 years (Bradley 2006, p. 35). Dickson (1955) and Alexander and Dickson (1972) reported densities of *C. lineata* var. *keyensis* from plots they established on Big Pine Key in 1951 and 1969, respectively. Dickson (1955) reports a mean density of 10,764 plants/ha (26,599 plants/ac). Alexander and Dickson (1972) report a mean density of 27,871 plants/ha (68,872 plants/ac). In 2005, Bradley (2006, p. 35) recorded 2,339 plants/ha (5,780 plants/ac), 23.4 percent and 9.0 percent of the 1955 and 1972 estimates, respectively. Hurricane Wilma, which passed over Big Pine Key on October 24, 2005, generated storm surge in the lower Keys of up to 10 feet (Bradley 2006, p. 11; Hodges 2010, p. 4). In 2007, density had dropped to 820 plant/ha (2,026 plants/ac) and had not fully rebounded after 9 years (Bradley *et al.* 2015, pp. 21–22). By 2013, density had fallen to 657 plants/ha (1,624 plants/ac) (Bradley *et al.* 2015, p. 21). In summary, the data from 2005 to 2013 demonstrate a 63.8 percent decline in the density of *C. lineata* var. *keyensis* on Big Pine Key (Bradley *et al.* 2015, p. 48).

A second indicator, the frequency which *Chamaecrista lineata* var. *keyensis* occurred in sample plots on Big Pine Key from data collected in 2005, 2007, and 2013, also show a decline. *Chamaecrista lineata* var. *keyensis* was present in 37 percent of plots in 2005, and 19 percent of plots in 2013, respectively. This represents a 49 percent reduction in the species frequency in study plots (Bradley *et al.* 2015, p. 48).

A third indicator, total population size for *Chamaecrista lineata* var. *keyensis* on publicly owned pine rocklands on Big Pine Key (478 ha (1,181 ac)), was estimated to be 866,659 plants in 2005 (pre-Hurricane Wilma), 391,944 in 2007 (2 years post-Wilma), and 313,914 in 2013 (8 years post-Wilma). This represents a population decrease of 64 percent (Bradley *et al.* 2015, p. 21).

The most recent estimate (2013) of the *Chamaecrista lineata* var. *keyensis* population on Big Pine Key is 313,914 plants (Bradley *et al.* 2015, p. 21). Since 82 percent of the pine rocklands on Big Pine Key are publicly owned, this estimate likely accounts for the majority of the population. The most recent estimate of the population on Cudjoe Key is 150 plants (Hodges and Bradley 2006, p. 21).

The decline in *Chamaecrista lineata* var. *keyensis* can be largely attributed to loss of pine rocklands habitat to development and modification of this habitat due to inadequate fire management. Folk (1991, p. 188) estimated that pine rocklands historically covered 1,049 ha (2,592 ac), about 44 percent of Big Pine Key. Pine rocklands now cover approximately 582 ha (1,438 ac) of Big Pine Key, 56 percent of the historical estimate by Folk (1991) (Bradley 2006, p. 4). Hurricanes and associated storm surge have also impacted population levels. These factors are discussed in detail below,

under Summary of Biological Status and Threats.

TABLE 1—SUMMARY OF THE STATUS AND TRENDS OF THE KNOWN OCCURRENCES OF CHAMAECRISTA LINEATA VAR. KEYENSIS

Population	Ownership	Most recent population estimate	Status	Trend
Big Pine Key	USFWS,[1] FWC[2] Monroe County, private.	313, 914 (2014)[4]	Extant[4]	Declining.[4]
Cudjoe Key	USFWS,[1] FWC[2]	150 (2005)[3]	Extant[3]	Insufficient data.
Lower Sugar Loaf Key	USFWS,[1] FWC[2], Monroe County.	3 (2005)[3]	Extirpated[3].	
No Name Key	unknown	no data (1916)[3]	Extirpated[3].	
Ramrod Key	unknown	no data (1911)[3]	Extirpated[3].	

[1] U.S. Fish and Wildlife Service.
[2] Florida Fish and Wildlife Conservation Commission.
[3] Hodges and Bradley 2006, p. 45.
[4] Bradley *et al.* 2015, p. 21.

Biology

The reproductive biology and relationship to fire of *Chamaecrista lineata* var. *keyensis* has received a considerable amount of study. Significant findings are summarized below.

Life History and Reproduction: Chamaecrista lineata var. *keyensis* is a perennial, but some stems will die back every year, and a small proportion of plants may go dormant for a year or more. Peak flowering and fruiting occurs in the summer from May to August, corresponding with increased rainfall during these months in the Florida Keys. Mature seedpods may contain 1 to 10 seeds. Seedlings may appear throughout the year, with a peak in the fall during September to October, immediately following seed dispersal. Seeds may persist in the soil seed bank for up to 3 years (Liu and Menges 2005, p. 1484).

Chamaecrista lineata var. *keyensis* flowers require insect visitation for pollination. The anthers (pollen-bearing structures) have small pores from which pollen escapes when a visiting insect's wings vibrate the structure, a phenomenon known as buzz-pollination. Though many types of insects visit *C. lineata* var. *keyensis* flowers, effective pollination can be performed only by buzz-pollinating bees. Of the numerous bee species that visit the flowers, only *Xylocopa micans* and *Melissodes* spp. bees have been observed performing effective buzz-pollination (Liu and Koptur 2003, pp. 1184–1186).

Chamaecrista lineata var. *keyensis* flowers are self-compatible (an individual can be fertilized with its own pollen), and seeds are generated both by self- and cross-pollination. However, seed set is higher when cross-pollination occurs. Seed germination rates are higher from cross-pollinated flowers, suggesting that inbreeding depression occurs in seeds produced through self-pollination (Liu and Koptur 2003, pp. 1184–1186). Taken together, these findings confirm that insect pollination is crucial to the plant's reproduction and progeny fitness.

Fire Ecology and Demography: Chamaecrista lineata var. *keyensis* grows in the understory of pine rocklands, a fire-dependent ecosystem. The seeds have a hard seed coat that may help them survive fire (Liu *et al.* 2005a, p. 216). Fire has important effects on survival and regeneration of *C. lineata* var. *keyensis.* Fire may immediately kill some of the plants, but populations rebound during the first and second years after fire. Three years post-fire, survival in burned areas can equal that of unburned areas, suggesting that *C. lineata* var. *keyensis* can recover completely after fire. Fire stimulates stem growth, fruiting, and seedling establishment. Fire seasonality may produce different responses in *C. lineata* var. *keyensis.* Overall, winter and early summer fires produce more favorable results compared with late summer fires (Liu and Menges 2005, p. 1848).

Demographic modeling by (Liu *et al.* 2005a, p. 210) found that fire return intervals of 5 to 7 years generated the lowest extinction and population decline probabilities for *Chamaecrista lineata* var. *keyensis,* regardless of burn season. Bradley and Saha (2009, p. 20) found that both fire frequency and time since the last fire had significant effects on the density of *C. lineata* var. *keyensis* in study plots. The highest densities were found in plots that were burned three or more times over a 45-year period from 1960 to 2005, and in plots that had burned recently, while lower densities were associated with plots that had not been burned in 45 years.

Liu *et al.* (2005b, p. 71) found that differences in fire intensity (as measured by maximum ground temperature) did not have a significant long-term effect on survival, growth, or seedling recruitment. However, the number of fruits produced and percentage of fruiting plants increased as fire intensity increased. This suggests that low-intensity fires associated with shorter fire return intervals (less than 3 years) may not provide the most favorable conditions for post-fire recovery.

Taken together, these results indicate that *Chamaecrista lineata* var. *keyensis* can tolerate and may benefit from periodic fire. As discussed above under ''Habitat,'' fire is a crucial element in maintaining the pine rocklands habitat. Periodic fires eliminate the shrub subcanopy, remove litter from the ground, recycle nutrients, and are necessary to prevent succession to a hardwood-dominated ecosystem (rockland hammock) that is unsuitable for *C. lineata* var. *keyensis* (Bradley and Gann 1999, pp. 17–18).

Chamaesyce deltoidea ssp. *serpyllum* (wedge spurge)

Species Description

Chamaesyce deltoidea ssp. *serpyllum* is a small, prostrate, perennial herb. The stems are slender and numerous, radiating out from the taproot. The leaves are 2 to 5 mm (0.08 to 0.19 in) long, more or less triangular, and covered with fine short fuzz, giving the plant a silvery appearance. The flowers are cyathia, the specialized inflorescences characteristic of the genus *Euphorbia* and its close relatives. The fruit is a capsule about 1.5 mm (0.06 in) wide (Small 1933, p. 795; Herndon 1993, p. 50).

Taxonomy

John K. Small collected plants on Big Pine Key and first described *Chamaesyce deltoidea* ssp. *serpyllum* as *C. serpyllum* (Small 1913, p. 81). Burch (1966, p.99) included *C. serpyllum* as a subspecies of *C. deltoidea,* assigning the currently accepted name *C. deltoidea* ssp. *serpyllum.* The online Atlas of Florida Vascular Plants uses the name *C. deltoidea* ssp. *serpyllum* (Wunderlin and Hansen 2008, p. 1), and the Integrated Taxonomic Information System (ITIS 2015, p. 1) indicates that its taxonomic status is accepted. We have carefully reviewed all taxonomic data to determine that *Chamaesyce deltoidea* (Engelm. ex Chapm.) Small ssp. *serpyllum* (Small) D.G. Burch is a valid taxon. Synonyms include *Chamaesyce serpyllum* Small; *Euphorbia deltoidea* Engelmann ex Chapman ssp. *serpyllum* (Small) Y. Yang; and *Chamaesyce serpyllum* Small, *Euphorbia deltoidea* Engelmann ex Chapman var. *serpyllum* (Small) Oudejans (Wunderlin and Hansen 2008, p. 3).

Climate

The climate of south Florida where *Chamaesyce deltoidea* ssp. *serpyllum* occurs is classified as tropical savanna, as described above for *Chamaecrista lineata* var. *keyensis*.

Habitat

Chamaesyce deltoidea ssp. *serpyllum* occurs in pine rocklands and adjacent disturbed sites on Big Pine Key, including roadsides. It most often grows directly from crevices in the oolitic limestone substrate (Bradley and Gann 1999, p. 31). Pine rocklands are described in detail for *Chamaecrista lineata* var. *keyensis,* above. Within pine rocklands, *Chamaesyce deltoidea* ssp. *serpyllum* is associated with areas of relatively higher elevation, extensive exposed rock substrate, where the understory is open, hardwood and palm density is low, and native herbaceous species cover and richness are high (Bradley and Saha 2009, p. 26; Ross and Ruiz 1996, p. 6; Bradley 2006, p. 27). Roadsides dominated mostly by native herbs and grasses where exotic lawn grasses are not established are a potentially important habitat for *C. deltoidea* ssp. *serpyllum* (Bradley 2006, p. 37).

Historical Range

Chamaesyce deltoidea ssp. *serpyllum* is historically known from only Big Pine Key in the Florida Keys in Monroe County, Florida.

Current Range, Population Estimates, and Status

The current range of *Chamaesyce deltoidea* ssp. *serpyllum* is on Big Pine Key. Small groups of plants are scattered widely across the island (Herndon 1993, in Bradley and Gann 1999, p. 31).

Population data for *Chamaesyce deltoidea* ssp. *serpyllum* have been collected on Big Pine Key periodically since 1996. Indicators show that the population on Big Pine Key has declined over the past 19 years. Using study plots across Big Pine Key, Ross and Ruiz (1996, p. 6) found *C. deltoidea* ssp. *serpyllum* was present in 22 percent of study plots in 1996. When sampled again by Bradley (2006, p. 11; Bradley *et al.* 2015, p. 21) in 2005, 2007, and 2013, the species was present in 7.4, 5.5, and 3.7 percent of study plots, respectively. This represents an 83 percent reduction of the species' frequency in study plots from 1996 to 2013, and a 50 percent reduction from 2005 to 2013. The decrease in frequency is attributed in large part to the total disappearance of the species from study plots in the southern portion of Big Pine Key after Hurricane Wilma in 2005 (Bradley *et al.* 2013, p. 24).

Total population size for *Chamaesyce deltoidea* ssp. *serpyllum* on publicly owned pine rocklands on Big Pine Key (478 ha (1,181 acres)) was estimated to be 352,993 plants in 2005 (pre-Hurricane Wilma), 343,255 in 2007 (post-Wilma), and 368,557 in 2013. This represents a slight (4.4 percent) increase in the known population size of from 2005 to 2013 (Bradley *et al.* 2013, p. 21). The slight increase in 2013 is due to the Blue Hole Fire in 2011. Prior to this fire, the species had not been detected in plots in the Blue Hole area of Big Pine Key, but was found in one plot after the 2011 fire. This single plot contained 134 plants, 17.3 percent of the plants recorded across all 646 plots in 2013. If this single plot is taken out of the analysis, density per plot would be 1.3, 10.3 percent lower than that recorded in 2005, and 18.6 percent lower than 2007 (Bradley *et al.* 2015, pp. 24–25; Bradley and Saha 2009, p. 12). Since 82 percent of the pine rocklands on Big Pine Key are publicly owned, this estimate likely accounts for the majority of the population. Taken together, the data suggest that the population declined significantly due to Hurricane Wilma but rebounded by 2013. However, the frequency of the plant in study plots has decreased from 1996 to 2013, suggesting that fewer areas now support the species. While there have been significant changes between sampling events, the 9-year pattern of total population size is stable (Bradley *et al.* 2015, pp. 21, 24, 49). At the same time, there has been a reduction in the species' range on Big Pine Key and frequency of the plant in study plots (Bradley *et al.* 2015, pp. 25, 49), suggesting that while there has been a small increase in the total number of plants, the area occupied by the plant is shrinking.

Table 2 summarizes the status and trends of the known occurrences of *Chamaesyce deltoidea* ssp. *serpyllum.*

TABLE 2—SUMMARY OF THE STATUS AND TRENDS OF THE KNOWN OCCURRENCES OF CHAMAESYCE DELTOIDEA SSP. SERPYLLUM

Population	Ownership	Most recent population estimate	Status	Trend
Big Pine Key	USFWS, FWC, private	368,557 [1]	Extant [1]	Declining.[1]

[1] Bradley *et al.* 2015, pp. 24–25.

Biology

Life History and Reproduction: Reproduction is sexual, and the plant produces seeds. No studies of reproductive biology or ecology have been conducted for *Chamaesyce deltoidea* ssp. *serpyllum.* Other species of *Chamaesyce* are completely reliant on insects for pollination and seed production, while others are capable of self-pollination. Pollinators may include bees, flies, ants, and wasps (Ehrenfeld 1976, pp. 406, 95–97).

Fire Ecology and Demography: The assemblage of endemic plants of the pine rocklands, which includes *Chamaesyce deltoidea* ssp. *serpyllum,* tends to be shade-intolerant and benefits from periodic burning to reduce competition from woody vegetation

(*e.g.,* shading, leaf litter accumulation) (Carlson *et al.* 1993, p. 922; Liu *et al.* 2005a, p. 210, Liu *et al.* 2005b, p. 71). *C. deltoidea* ssp. *serpyllum* is found more frequently in recently burned areas (Slapcinsky *et al.* 2010, p. 11). Populations of *C. deltoidea* ssp. *serpyllum* may decline without periodic fires, and fire has been shown to stimulate significant population growth (Slapcinsky and Gordon 2007, p. 5).

Linum arenicola (sand flax)

Species Description

Linum arenicola is a small, perennial herb that is 35 to 53 cm (14 to 21 in) tall with yellow flowers that are similar in appearance those of a buttercup (*Ranunculus* spp.). When not in flower, it resembles a short, wiry grass. Plants have one to several stems arising from their base. Leaves are linear in shape, 7–10 millimeters (mm) (0.3–0.4 in) long, 0.6–1 mm (0.02–0.04 in) wide, and arranged alternately along stems, and they have glands scattered along their edges. Flowers are produced on stems consisting of a few slender, spreading branches. The individual flowers are on small stalks 2 mm (0.08 in) long or shorter. The flowers have five yellow, egg-shaped petals that are 4.5–5.5 mm (0.18–0.22 in) long, and five green, lance-shaped to egg-shaped sepals that are 2.4–3.2 mm (0.09–0.13 in) long. The fruit is a woody capsule, 2.1–2.5 mm (0.08–0.1 in) long, 2–2.3 mm (0.08–0.09 in) diameter, which dries and splits into 10 segments. The seeds are ovate, 1.2–1.4 mm (0.05–0.06 in) long, and 0.7- 0.8 mm (0.027–0.031 in) wide (Rogers 1963, pp. 103–104).

Taxonomy

Linum arenicola was first described by Small in 1907 as *Cathartolinum arenicola* from plants he collected in Miami-Dade County in 1904. This treatment was consistently followed by Small (1913a, p. 69; 1913b, p. 96; 1933, p. 752). In 1931, Winkler included *Cathartolinum* within the genus *Linum,* renaming the plants *Linum arenicola* (Winkler 1931, p. 30). Others have followed this treatment, including Rogers (1963, p. 103), Long and Lakela (1971, p. 505), Robertson (1971, p. 649), Wunderlin (1998, p. 100), and Wunderlin & Hansen (2003, p. 100) (Hodges and Bradley 2006, p. 37).

Synonyms include *Cathartolinum arenicola* Small (Wunderlin and Hansen 2004, p. 5). The Integrated Taxonomic Information System (2015, p. 1) uses the name *Linum arenicola* and indicates that this species' taxonomic standing is accepted. The online Atlas of Florida Vascular Plants (Wunderlin and Hansen 2008, p. 1) uses the name *L. arenicola.* There is consensus that *L. arenicola* is a distinct taxon. We have carefully reviewed the available taxonomic information to reach the conclusion that the species is a valid taxon.

Climate

The climate of south Florida where *Linum arenicola* occurs is classified as tropical savanna, as described above for *Chamaecrista lineata* var. *keyensis* and *Chamaesyce deltoidea* ssp. *serpyllum.*

Rainfall within the range of *Linum arenicola* varies from an annual average of 153–165 cm (60–65 in) in the northern portion of the Miami Rock Ridge to an average of 89–102 cm (35–40 in) in the lower Florida Keys (Snyder *et al.* 1990, p. 238).

Habitat

Pine Rocklands: *Linum arenicola* occurs in pine rocklands, disturbed pine rocklands, dry marl prairie, and disturbed areas on rocky soils adjacent to these habitats (Bradley and Gann 1999, p. 61; Hodges and Bradley 2006, p. 37). *L. arenicola* grows in thin soil over limestone or in small soil patches caught in surface irregularities of exposed limestone (Kernan and Bradley, 1996, p. 2). Sites most likely to support *L. arenicola* have a grass- and herb-dominated understory, abundant pine regeneration, and high cover of exposed rock (Ross and Ruiz 1996, pp. 5–6). The pine rocklands and marl prairies where this species occurs require periodic fire to maintain an open, shrub-free subcanopy, and to reduce litter levels (Bradley and Saha 2009, p. 4). Pine rocklands habitat is described in detail for *Chamaecrista lineata* var. *keyensis,* above.

Roadsides and Other Disturbed Sites: While pine rocklands historically were the primary habitat of *Linum arenicola,* the species is currently rare in relatively undisturbed pine rocklands, with the exception of plants on Big Pine Key. Several occurrences are in scraped (scarified) pine rocklands remnants that are dominated by native pine rocklands species, but have little or no pine canopy or subcanopy (Bradley and Van Der Heiden 2013, pp. 9–12). Two populations in Miami-Dade County occur entirely on levees composed of crushed oolitic limestone that are surrounded by sawgrass marsh (Bradley and Gann 1999, p. 61; Bradley and Van Der Heiden 2013, pp. 7–9). Roadsides and other disturbed sites are important habitat for *L. arenicola* because they imitate upland herbaceous habitat (Hodges and Bradley 2006, p. 40). The most robust roadside populations occur in areas adjacent to pine rocklands or rockland hammocks (Hodges 2010, p. 3). Where *L. arenicola* is found on roadsides, the ground cover is dominated mostly by native herbs and grasses where exotic lawn grasses have not been planted (Bradley 2006, p. 37). Infrequent mowing of some roadsides, and of disturbed sites such as Homestead Air Reserve Base (HARB) and U.S. Special Operations Command South Headquarters (SOCSOUTH), a unified command of all four services in the Department of Defense (DOD) has likely allowed the species to persist by preventing these sites from being taken over by hardwoods.

Because *Linum arenicola* seems to only rarely occur within intact pine rocklands, but more frequently adjacent to this habitat, developing conservation and management plans for this species is exceptionally difficult. Its persistence on roadsides is not fully understood. *L. arenicola* was at one time more common in pine rocklands in Miami-Dade County, but a lack of periodic fires in most pine rocklands fragments over the last century have pushed this species into more sunny, artificial environments (Bradley and Gann 1999, p. 61). It is also possible that the species has evolved to persist along roadsides as fire regimes and natural areas were altered and destroyed over the last century (Hodges and Bradley 2006, p. 41).

Dry Marl Prairie: Marl prairie is a sparsely vegetated, grass-dominated community found on marl substrates in South Florida. Marls are fine, white, calcareous muds formed from calcite precipitated by a mixture of green algae, blue green algae, and diatoms, known as periphyton. It is seasonally inundated (2 to 4 months) to a shallow depth averaging about 20 cm (8 in). Marl prairie is a diverse community that may contain over 100 species. Marl prairie normally dries out during the winter and is subject to fires at the end of the dry season (FNAI 2010, p. 1). Occurrences reported from marl prairie are at sites that have been artificially drained (Bradley and Van Der Heiden 2013, p. 11), or are scraped pine rocklands that function more like marl prairie (Kernan and Bradley 1996, p. 11). As with roadside populations of *Linum arenicola,* it is possible that dry marl prairies have become refugia for the species as fire regimes and natural areas were altered and destroyed over the last century. Accordingly, the Service does not consider marl prairie to be a primary habitat for *L. arenicola.*

Historical Range

The historical range of *Linum arenicola* consists of central and southern Miami-Dade County and

Monroe County in the lower Florida Keys (Bradley and Gann 1999, p. 61). In Miami-Dade County, records for the species were widespread from the Coconut Grove area to the southern part of the County, close to what is now the main entrance to Everglades National Park and Turkey Point (Bradley and Gann 1999, p. 61). In the Florida Keys (Monroe County), there are records of the species from Big Pine Key, Ramrod Key, Upper and Lower Sugarloaf Keys, Park Key, Boca Chica Key, Middle Torch Key (Bradley and Gann 1999, p. 61), and Big Torch Key (Hodges 2010, p. 10).

Current Range, Population Estimates, and Status

The current range of *Linum arenicola* consists of eight extant populations in Miami-Dade County and four extant populations in the Florida Keys (see Table 3, below). In Miami-Dade County, the current distribution of *Linum arenicola* is from just north of SW 184 Street (in the Richmond Pinelands), south to the intersection of Card Sound Road and the C–102 canal, and west to SW 264 Street and 177 Avenue (Everglades Archery Range at Camp Owaissa Bauer). This distance is approximately 30 km (19 mi) north to south, and 14 km (9 mi) east to west. In the Florida Keys (Monroe County), the current distribution of *L. arenicola* includes four islands: Big Pine Key, Upper and Lower Sugarloaf Keys, and Big Torch Key.

Multiple surveys have been conducted for *Linum arenicola* in Miami-Dade and Monroe Counties over the past 30 years. However, most surveys only cover one county and not the other. The large area of potential habitat and scarcity and diminutive size of *L. arenicola* make thorough surveys for this species difficult (Hodges and Bradley 2006, p. 37).

Based on a compilation of all survey work through 2013, including Austin (1980), Kernan and Bradley (1996, pp.1–30), Bradley and Gann (1999, pp. 61–65), Hodges and Bradley (2006, pp. 37–41), Bradley and Saha (2009, p. 10), Bradley (2009, p. 3), Hodges (2010, pp. 4–5, 15), Bradley and van der Heiden (2013, pp. 6–12,19), and Bradley *et al.* (2015, pp. 28–29), of 26 historical population records for *Linum arenicola,* 12 populations are extant and 14 are extirpated (see Table 3), a loss of roughly 54 percent of known populations, from the early 1900s to the present.

Table 3 summarizes the status and trends of the known occurrences of *Linum arenicola*.

TABLE 3—SUMMARY OF THE STATUS AND TRENDS OF THE KNOWN OCCURRENCES OF LINUM ARENICOLA

Population	Ownership	Most recent population estimate	County	Trend
		Extant 12 records		
Big Pine Key	USFWS, FWC, TNC[12], Private.	2,676 (2007)[1]	Monroe	declining.
Upper Sugarloaf Key	FDOT[13], USFWS	73 (2010)[2]	Monroe	insufficient data.
Lower Sugarloaf Key	FDOT[13], USFWS	531 (2010)[2]	Monroe	stable.
Big Torch Key	FDOT[13], Private	1 (2010)[2]	Monroe	declining.
Richmond Pineland	Private	56 (2014)[5]	Miami-Dade	insufficient data.
Martinez Pineland	Miami-Dade County	100–200 (2013)[6]	Miami-Dade	insufficient data.
Everglades Archery Range (Camp Owaissa Bauer).	Miami-Dade County	23 (2012)[7]	Miami-Dade	insufficient data.
HAFB[15] 1—S of Naizare BLVD.	DOD[14], Miami-Dade County.	24,000 (2013)[7]	Miami-Dade	stable.
SOCSOUTH (HAFB 2—NW side of Bikini BLVD).	DOD[14] (leased from Miami-Dade County).	74,000 (2009)[7 10]	Miami-Dade	stable.
HARB (SW 288 St. and 132 Ave).	DOD[14]	37 (2011)[7]	Miami-Dade	insufficient data.
C–102 Canal SW 248 St. to U.S. 1.	SFWMD[11]	1,000–10,000 (2013)[7]	Miami-Dade	insufficient data.
L–31E canal, from SW 328 St. to Card Sound Road.	SFWMD[11]	Plants occur along 14 km (8.7 mi) of levee (2013)[7].	Miami-Dade	insufficient data.
		Extirpated 14 records		
Middle Torch Key	FWC, FDOT[13]	3 (2005)[3]	Monroe.	
Ramrod Key	FDOT[13]	110 (1979)[4]	Monroe.	
Park Key	FDOT[13]	unknown (1961)[3]	Monroe.	
Boca Chica	DOD[14], other (unknown)	unknown (1912)[3]	Monroe.	
Camp Jackson	unknown	unknown (1907)[9]	Miami-Dade.	
Big Hammock Prairie	unknown	unknown (1911)[9]	Miami-Dade.	
Camp Owaissa Bauer	Miami-Dade County	10 (1983)[7]	Miami-Dade.	
Allapatah Drive and Old Cutler Road.	Private	256 (1996)[8]	Miami-Dade.	
Bauer Drive (Country Ridge Estates).	Miami-Dade County	8 (1996)[8]	Miami-Dade.	
Silver Green Cemetery	Private	47 (1996)[8]	Miami-Dade.	
Palmetto Bay Village Center.	Private	12 (1996)[8]	Miami-Dade.	
HAFB (Community Partnership Drive).	DOD[14], Miami-Dade County.	unknown (2010)[7]	Miami-Dade.	
Coco Plum Circle (corner of Robles Street & Vista Mar Street).	Private	75 (1996)[8]	Miami-Dade.	

TABLE 3—SUMMARY OF THE STATUS AND TRENDS OF THE KNOWN OCCURRENCES OF LINUM ARENICOLA—Continued

Population	Ownership	Most recent population estimate	County	Trend
George Avery Pineland Preserve.	Private	"small colony" (2002) [7]	Miami-Dade.	

[1] Bradley and Saha 2009, p. 10
[2] Hodges 2010, p. 10
[3] Hodges and Bradley 2006, pp. 39–48
[4] Austin *et al.* 1980 in FNAI
[5] FTBG 2014, p. 2
[6] Possely 2014, pers. comm.
[7] Bradley and Van Der Heiden 2013, pp. 6–11
[8] Kernan and Bradley 1996, p. 9
[9] Bradley and Gann 1999, p. 65
[10] Bradley 2009, p. 3
[11] South Florida Water Management District (SFWMD)
[12] The Nature Conservancy (TNC)
[13] Florida Department of Transportation (FDOT)
[14] Department of Defense (DOD)
[15] Homestead Air Force Base (HAFB; decommissioned)

Based on the data presented in Table 3, reliable population trends can be derived from past surveys for 5 of the 12 extant populations. Populations on Big Pine Key and Big Torch Key have shown clear declines. Three populations appear to be stable (data suggest they have not declined appreciably). Data are insufficient to determine trends for the remaining seven populations. The data also show that 5 of the 12 extant populations are rather small, having fewer than 100 plants.

Miami-Dade County: The first survey for *Linum arenicola,* conducted in 1980 in Miami-Dade County, reported two extant and eight extirpated populations, but population sizes were not reported (Austin *et al.,* 1980, p. 3). A 1996 survey conducted in Miami-Dade County reported seven populations, representing about 1,000 plants (Kernan and Bradley 1996, p. 5). A 1999 status survey reported five extant populations and seven extirpated populations in Miami-Dade County (Bradley and Gann 1999, p. 65).

A comprehensive field survey of *Linum arenicola* sites in Miami-Dade was conducted in 2013 (Bradley and van der Heiden 2013, p. 4). *L. arenicola* populations were found at six sites, containing an estimated total of 107,060 plants. Populations ranged in size from 23 plants to 74,000 plants, with a median population size of approximately 4,500. All but one of the Miami-Dade *L. arenicola* populations occur on public lands, but only the Martinez Pineland site is managed for conservation. The remaining sites are owned by the DOD (military bases), State of Florida (canal banks; SFWMD), and Miami-Dade County (a public archery range). A seventh small population located in 2014 at the Richmond pinelands is located on private land that is currently slated for development (Fairchild Tropical Botanic Garden (FTBG) 2014, p. 2). The largest *Linum arenicola* population in Miami-Dade County, estimated at 74,000 plants in 2009 (Bradley 2009, p. 3), is located on property owned by the Miami-Dade County Homeless Trust and leased to Special Operations Command South (SOCSOUTH; a DOD facility).

In Miami-Dade County, of 18 records for *Linum arenicola,* 8 populations are extant, while 10 are extirpated, a loss of roughly 56 percent of known populations. The loss of these populations corresponds to a contraction of the species' historical range in Miami-Dade County by approximately 20 km (12 mi) at its northern extent (40 percent reduction in north to south range), and approximately 15 km (9 mi) of its east to west extent (50 percent reduction in east to west range).

Monroe County (Florida Keys): A 1999 status survey reported four *Linum arenicola* populations in Monroe County (Bradley and Gann 1999, p. 65). In 2006, Hodges and Bradley (2006, pp. 37–41) conducted the first comprehensive survey of the distribution and abundance of *L. arenicola* in the Florida Keys, including extant occurrences, historical records, and exploratory surveys of potential habitat. Four extant populations were observed (Big Pine Key, Big Torch Key, Middle Torch Key, and Lower Sugarloaf Key) and three historical populations were confirmed extirpated (Boca Chica Key, Ramrod Key, and Park Key). The surveys did not find *L. arenicola* in potential habitat on No Name Key, Little Torch Key, or Upper Sugarloaf Key (Hodges and Bradley 2006, pp. 37, 48). However, in 2010, Hodges (2010, p. 10) resurveyed Upper Sugarloaf and rediscovered the population.

Linum arenicola is extirpated from 4 of 8 (50 percent) of the islands that once supported it. Its historical range spanned approximately 36 km (22 mi) from northeast to southwest. The loss of populations on Boca Chica, Park, Middle Torch, and Ramrod Keys represents a 14-km (9-mi) loss of the western extent of the species' range, corresponding to a 39 percent contraction of the species' historical range.

The total population of *Linum arenicola* in Monroe County is estimated at 2,676 plants in pine rocklands on Big Pine Key (Bradley and Saha 2009, p. 10), and 100 to 1,000 plants across the remainder of the Florida Keys (Hodges and Bradley 2006, pp. 37, 48; Hodges 2010, p. 10).

The largest population in Monroe County is located on Big Pine Key within the National Key Deer Refuge (NKDR) and surrounding lands, where there are approximately 478 ha (1,181 ac) of publicly owned pine rocklands (Gann *et al.* 2002, p. 806; Bradley 2006, p. 4; Hodges and Bradley 2006, pp. 37–38). It is also the best studied population. On Big Pine Key, *Linum arenicola* occurs at the Terrestris Preserve, which is owned by TNC; this occurrence is included within the Big Pine Key site in Table 3.

Linum arenicola on Big Pine Key has been surveyed multiple times since 1996, with the most recent being 2014. Because of the size of Big Pine Key, sample study plots were utilized for these surveys, as opposed to a complete search of all potential habitats. Ross and Ruiz (1996, p. 5) found the species in 11 percent of their study plots. Subsequent surveys in 2005, 2007, and 2013 have found *L. arenicola* to be extremely rare, being recorded in 4.1, 2.0, and 1.4

percent of study plots, respectively, representing an 87 percent reduction from 1996 to 2013 (Bradley *et al.* 2015, pp. 28–29).

The decline in the Big Pine Key population of *Linum arenicola* from 2005 to 2007 can be largely attributed to the effects of Hurricane Wilma (Bradley 2006, p. 11; Hodges 2010, p. 4). Prior to Wilma, there was a maximum of 56,404 individuals of *L. arenicola* in the 478 ha (1,181 ac) of publicly owned pine rocklands on Big Pine Key (Bradley 2006, p. 19). As of 2007, there were just 2,676 plants, representing a 95 percent decline (Bradley and Saha 2009, p. 10). Significantly, the species virtually disappeared from the southern half of Big Pine Key after Hurricane Wilma (Bradley and Saha 2009, p. 10).

Historically, the population has declined due to habitat loss and fire suppression. Approximately half of the historical pine rocklands on Big Pine Key have been lost (Bradley 2006, p. 35). Long-term ecological changes associated with fire suppression, land clearing, SLR, changes in hydrology, fluctuations in Key deer (*Odocoileus virginianus clavium*) densities, and invasion of exotic plants likely have impacted the population sizes of this species (Bradley 2006, p. 2; Bradley and Saha 2009, p. 2).

The population on Big Torch Key also declined after Hurricane Wilma, but this decline may have been due to herbicide applications or frequent mowing associated with road shoulder maintenance (Hodges 2010, p. 4).

Biology

Life History and Reproduction: Little is known about the life history of *Linum arenicola,* including pollination biology, seed production, or dispersal. Reproduction is sexual, with new plants generated from seeds. The species produces flowers from February to September, with a peak around March and April. *L. arenicola* population demographics or longevity have not been studied (Bradley and Gann, 1999, p. 65; Hodges and Bradley 2006, p. 41; Hodges 2007, p. 2).

Fire Ecology and Demography: There have been no studies of *Linum arenicola* population demographics or relationship to fire, though historical declines have been partially attributed to habitat loss from fire suppression or inadequate fire management.

Argythamnia blodgettii (Blodgett's silverbush)

Species Description

Argythamnia blodgettii, in the Euphorbia family, is an erect, perennial shrub or herb, 10 to 60 cm (4 to 24 in) tall, with a woody base and small, green flowers. The stems and leaves are covered with small hairs. The leaves, arranged alternately along the stems, are 1.5 to 4.0 cm (0.6 to 1.6 in) long, have smooth (or rarely toothed) edges, are oval or elliptic in shape, and often are colored a distinctive, metallic bluish green. The plants have separate male and female flowers. Staminate (male) flowers have a calyx 7 to 8 mm (0.27 to 0.31 in) wide, consisting of 4 to 5 lance-shaped sepals that are larger than the petals. The petals are broadly elliptic and shorter than the sepals. There are 10 stamens. Pistillate (female) flowers have 4 to 5 sepals that are 5 to 6 mm (0.19 to 0.24 in) long, lance-shaped, and often more narrow than those of male flowers. The petals are broadly elliptic, shorter than the sepals. The fruit is a woody capsule 4 to 5 mm (0.16 to 0.19 in) wide, which contains the seeds (Adapted from Small 1933, pp. 784–785; Bradley and Gann 1999, p. 2).

Taxonomy

Botanist John Torrey first described the species in Chapman (1884, p. 100) as *Aphora blodgettii,* reporting it for South Florida. In an 1896 (p. 100) revision of the genus, Pax placed it in the genus *Ditaxis.* In 1897 (p. 100), Chapman placed it in the genus *Argythamnia.* In 1903, Small placed it again in the genus *Ditaxis.* In 1914, Pax (p. 100) placed it in synonymy under *Ditaxis fendleri,* a plant of Colombia, Venezuela, Curacao, and Trinidad. Small (1933, pp. 784–785) retained it as *Ditaxis blodgettii,* treating it as a southern Florida endemic. Subsequent authors (Webster 1967, p. 100; Long and Lakela 1971, p. 558; Wunderlin 1998, p. 100; Wunderlin and Hansen 2003, p. 100) have retained it as a southern Florida endemic *Argythamnia blodgettii* (from Hodges and Bradley 2006, p. 10).

The Integrated Taxonomic Information System (2015, p. 1) uses the name *Argythamnia blodgettii* and indicates that this species' taxonomic standing is accepted. The online Atlas of Florida Vascular Plants (Wunderlin and Hansen 2008, p. 1) uses the name *A. blodgettii.* In summary, there is consensus that *A. blodgettii* is a distinct taxon. We have carefully reviewed the available taxonomic information to reach the conclusion that the species is a valid taxon. Synonyms include *Aphora blodgettii* Torr. ex Chapm.; *Ditaxis blodgettii* (Torr. ex Chapm.) Pax; *Argyrothamnia blodgettii* (Torr. ex Chapm.) Chapm.; and *Ditaxis fendleri* Pax, not (Müll. Arg.) Pax and K. Hoof.

Climate

The climate of south Florida where *Argythamnia blodgettii* occurs is classified as tropical savanna, as described above for *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum,* and *Linum arenicola.*

Rainfall within the range of *Argythamnia blodgettii* varies from an annual average of 153–165 cm (60–65 in) in the northern portion of the Miami Rock Ridge to an average of 89–102 cm (35–40 in) in the lower Florida Keys (Snyder *et al.* 1990, p. 238).

Habitat

Argythamnia blodgettii grows in pine rocklands, in sunny gaps or edges of rockland hammock and coastal berm, and on roadsides (Bradley and Gann 1999, p. 3). It grows from crevices on oolitic limestone or on sand. The pine rocklands habitat where it occurs requires periodic fire to maintain an open, sunny understory with a minimum amount of hardwoods. Bradley and Gann (1999, p. 3) indicated that this species does tolerate some degree of human-induced disturbance. It can often be found along disturbed edges of pine rocklands, rockland hammock, and coastal berm, or in completely scarified pine rocklands (Bradley and Gann, 1999, p. 3). Pine rocklands are described in detail for *Chamaecrista lineata* var. *keyensis,* above.

Coastal Berm: Coastal berms are landscape features found along low-energy coastlines in south Florida and the Florida Keys. Coastal berm is a short forest or shrub thicket found on long, narrow, storm-deposited ridges of loose sediment formed by a mixture of coarse shell fragments, pieces of coralline algae, and other coastal debris. These ridges parallel the shore and may be found on the seaward edge or landward edge of the mangroves or farther inland depending on the height of the storm surge that formed them. They range in height from 0.30 to 3.05 m (1 to 10 ft). Structure and composition of the vegetation is variable depending on height and time since the last storm event. The most stable berms may share some tree species with rockland hammocks, but generally have a greater proportion of shrubs and herbs. Tree species may include *Bursera simaruba* (gumbo limbo), *Coccoloba uvifera* (seagrape), *Coccothrinax argentata* (silver palm), *Guapira discolor* (blolly), *Drypetes diversifolia* (milkbark), *Genipa clusiifolia* (seven year apple), and *Metopium toxiferum* (poisonwood). Characteristic tall shrub and short tree

species include *Eugenia foetida* (Spanish stopper), *Ximenia americana* (hog plum), *Randia aculeata* (white indigoberry), *Pithecellobium keyense* (Florida Keys blackbead), and *Sideroxylon celastrinum* (saffron plum). Short shrubs and herbs include *Hymenocallis latifolia* (perfumed spiderlily), *Capparis flexuosa* (bayleaf capertree), *Lantana involucrata* (buttonsage), and *Rivina humilis* (rougeplant). More seaward berms or those more recently affected by storm deposition may support a suite of plants similar to beaches, including shoreline *Sesuvium portulacastrum* (sea purslane), *Distichlis spicata* (saltgrass), and *Sporobolus virginicus* (seashore dropseed), or scattered to dense shrub thickets with *Conocarpus erectus* (buttonwood*),* stunted *Avicennia germinans* (black mangrove), *Rhizophora mangle* (red mangrove), *Laguncularia racemosa* (white mangrove), *Suriana maritima* (bay cedar), *Manilkara jaimiqui* (wild dilly), *Jacquinia keyensis* (joewood), and *Borrichia frutescens* (bushy seaside oxeye) (Florida Natural Areas Inventory (FNAI) 2010a, p. 1).

Coastal berms are deposited by storm waves along low-energy coasts. Their distance inland depends on the height of the storm surge. Tall berms may be the product of repeated storm deposition. Coastal berms that are deposited far enough inland and remain long-undisturbed may in time succeed to hammock. This is a structurally variable community that may appear in various stages of succession following storm disturbance, from scattered herbaceous beach colonizing plants to a dense stand of tall shrubs (FNAI 2010a, p. 2).

Rockland Hammock: Rockland hammock is a species-rich, tropical hardwood forest on upland sites in areas where limestone is very near the surface and often exposed. The forest floor is largely covered by leaf litter with varying amounts of exposed limestone and has few herbaceous species. Rockland hammocks typically have larger, more mature trees in the interior, while the margins can be almost impenetrable in places with dense growth of smaller shrubs, trees, and vines. Typical canopy and subcanopy species include *Bursera simaruba, Lysiloma latisiliquum* (false tamarind), *Coccoloba diversifolia* (pigeon plum), *Sideroxylon foetidissimum* (false mastic), *Ficus aurea* (strangler fig), *Piscidia piscipula* (Jamaican dogwood), *Ocotea coriacea* (lancewood), *Drypetes diversifolia, Simarouba glauca* (paradisetree), *Sideroxylon salicifolium* (willow bustic), *Krugiodendron ferreum* (black ironwood), *Exothea paniculata* (inkwood), *Metopium toxiferum,* and *Swietenia mahagoni* (West Indies mahogany). Mature hammocks may be open beneath a tall, well-defined canopy and subcanopy. More commonly, in less mature or disturbed hammocks, dense woody vegetation of varying heights from canopy to short shrubs is often present. Species that generally make up the shrub layers within rockland hammock include several species of *Eugenia* (stoppers), *Thrinax morrisii* and *T. radiata* (thatch palms), *Amyris elemifera* (sea torchwood), *Ardisia escallonioides* (marlberry), *Psychotria nervosa* (wild coffee), *Chrysophyllum oliviforme* (satinleaf), *Sabal palmetto* (cabbage palm), *Guaiacum sanctum* (lignum-vitae), *Ximenia americana, Colubrina elliptica* (soldierwood), *Pithecellobium unguis-cati* and *Pithecellobium keyense, Coccoloba uvifera,* and *Colubrina arborescens* (greenheart). Vines can be common and include *Toxicodendron radicans* (eastern poison ivy), *Smilax auriculata* (earleaf greenbrier), *Smilax havanensis* (Everglades greenbrier), *Parthenocissus quinquefolia* (Virginia creeper), *Hippocratea volubilis* (medicine vine), and *Morinda royoc* (redgal). The typically sparse short shrub layer may include *Zamia pumila* (coontie) and *Acanthocereus tetragonus* (triangle cactus). Herbaceous species are occasionally present and generally sparse in coverage. Characteristic species include *Lasiacis divaricata* (smallcane), *Oplismenus hirtellus* (basketgrass), and many species of ferns (FNAI 2010e, p. 1).

Rockland hammock occurs on a thin layer of highly organic soil covering limestone on high ground that does not regularly flood, but it is often dependent upon a high water table to keep humidity levels high. Rockland hammocks are frequently located near wetlands; in the Everglades, they can occur on organic matter that accumulates on top of the underlying limestone; in the Keys, they occur inland from tidal flats (FNAI 2010e, p. 1).

Rockland hammock is susceptible to fire, frost, canopy disruption, and ground water reduction. Rockland hammock can be the advanced successional stage of pine rocklands, especially in cases where rockland hammock is adjacent to pine rocklands. In such cases, when fire is excluded from pine rocklands for 15 to 25 years, it can succeed to rockland hammock vegetation. Historically, rockland hammocks in south Florida evolved with fire in the landscape. Fire most often extinguished near the edges when it encountered the hammock's moist microclimate and litter layer. However, rockland hammocks are susceptible to damage from fire during extreme drought or when the water table is lowered. In these cases, fire can cause tree mortality and consume the organic soil layer (FNAI 2010e, p. 2).

Rockland hammocks are also sensitive to the strong winds and storm surge associated with infrequent hurricanes. Canopy damage often occurs, which causes a change in the microclimate of the hammock. Decreased relative humidity and drier soils can leave rockland hammocks more susceptible to fire. Rockland hammock can transition into glades marsh, mangrove swamp, salt marsh, coastal rock barren, pine rocklands, maritime hammock, or marl prairie (FNAI 2010e, p. 2).

The sparsely vegetated edges or interior portions laid open by canopy disruption are the areas of rockland hammock that have light levels sufficient to support *Argythamnia blodgettii.* However, the dynamic nature of the habitat means that areas not currently open may become open in the future as a result of canopy disruption from hurricanes, while areas currently open may develop more dense canopy over time, eventually rendering that portion of the hammock unsuitable for *A. blodgettii.*

Historical Range

Argythamnia blodgettii historically occurred from central and southern Miami-Dade County from Brickell Hammock to Long Pine Key in Everglades National Park, and in Monroe County throughout the Florida Keys from Totten Key south to Key West (Bradley and Gann 1999, p. 2).

Current Range, Population Estimates, and Status

Argythamnia blodgettii is currently known from central Miami-Dade County from Coral Gables and southern Miami-Dade County to Long Pine Key in Everglades National Park, and the Florida Keys from nine islands, from Windley Key (Bradley and Gann 1999, p. 3) southwest to Boca Chica Key (Hodges and Bradley 2006, pp. 10, 43).

Previous status surveys of *Argythamnia blodgettii* include Bradley and Gann (1999, pp. 2–6) and Hodges and Bradley (2006, pp. 11–20, 43). Bradley and Gann (1999, p. 3) reported 18 extant occurrences of *A. blodgettii* in 1999 (4 in Monroe County, 14 in Miami-Dade County), representing approximately 10,000 plants. Hodges and Bradley (2006, pp. 11–20, 43) verified that *A. blodgettii* is extant on nine islands in the Florida Keys

(Monroe County), and has an estimated population of between 10,000 and 100,000 plants (Hodges and Bradley, p. 2). The FNAI element tracking summary data indicated a total of 31 element occurrence records in 2 counties, with 24 occurrences in management areas (FNAI 2008, p. 1). There is insufficient data available to identify trends in any populations of *A. blodgettii.*

Although we do not know the total extent of the former range of *Argythamnia blodgettii,* approximately 12 miles (19 kilometers) of the species' range has been lost near the northern end of the range in Miami-Dade County and 43 miles (69 kilometers) has been lost in Monroe County on the southern edge of the species' range (Bradley and Gann 1999, p. 3).

Miami-Dade County: According to data from the Institute for Regional Conservation (IRC), the estimated population of *Argythamnia blodgettii* in Miami-Dade County is 375 to 13,650 plants (*i.e.,* total of low and high estimates) (K. Bradley 2007, pers. comm.); however, this may be an overestimate of the actual population size because it was based upon a log10 scale. In Everglades National Park (ENP), the current estimated population size is 2,000 plants (J. Sadle 2015, pers. comm.).

Based on the data presented below in Table 4, there are 31 records for *Argythamnia blodgettii* in Miami-Dade County. Six populations are extant, 11 are extirpated, and the status of 14 is uncertain because they have not been surveyed in 15 years or more.

Monroe County: In the Keys, *Argythamnia blodgettii* is extant on nine islands, with three others of uncertain status (Hodges and Bradley 2006, p. 43). The largest population surveyed is on Big Munson Island and is estimated to be 8,000 to 9,000 plants (Hodges and Bradley 2006, p. 17). On Big Pine Key, a population of *A. blodgettii* estimated at 2,200 plants is found scattered across the island. Occurrences are known from the Koehn's subdivision, Long Beach, Cactus Hammock, and Watson Hammock. Sizable populations also occur at Key West Naval Air Station on Boca Chica Key. The total population size in the Florida Keys is estimated to be approximately 13,200 plants (Hodges and Bradley 2006, pp. 10–13, 17).

Argythamnia blodgettii is extirpated from 3 of 16 (23 percent) of the islands that once supported it. Based on the data presented in Table 4, there are 18 records for *A. blodgettii* in Monroe County. Eleven populations are extant, three are extirpated, and the status of four is uncertain because they have not been surveyed in 15 years or more.

TABLE 4—SUMMARY OF THE STATUS AND TRENDS OF THE KNOWN OCCURRENCES OF ARGYTHAMNIA BLODGETTII

Population	Ownership	Most recent population estimate	County	Trend
		Extant 17 records		
Plantation Key, Snake Creek Hammock.	FWC	101–1,000 (2005)[2]	Monroe	Insufficient data.
Lower Matecumbe Key—Klopp Tract.	FDEP[6]	11–100 (2000)[2]	Monroe	Insufficient data.
Lignumvitae Key	FDEP[6]	101–1,000 (2005)[2]	Monroe	Insufficient data.
Big Munson Island	Private (Boy Scouts of America).	1,001–10,000 (2005)[2]	Monroe	Insufficient data.
North Key Largo	DOD, FDOT	No estimate (2005)[8]	Monroe	Insufficient Data.
Key Largo—Dove Creek Hammock.	FWC, FDOT	11–100 (2005)[2]	Monroe	Insufficient data.
Vaca Key (Marathon)—Blue Heron Hammock.	FWC, FDOT	11–100 (2005)[2]	Monroe	Insufficient data.
Windley Key—State Park	FDEP[6]	11–100 (2005)[2]	Monroe	Insufficient data.
Boca Chica KWNAS[7] Runway 25.	DOD	1,001–10,000 (2004)[2]	Monroe	Insufficient data.
Boca Chica Key KWNAS[7] Weapons Hammock.	DOD	200 (2004)[2]	Monroe	Insufficient data.
Big Pine Key	USFWS, FWC, private	~2,200 (2005)[2]	Monroe	Insufficient data.
ENP Long Pine Key Deer Hammock area (Pine Block A), Turkey Hammock area (Pine Block B), Pine Block E.	NPS[5]	2,000 (2015)[4]	Miami-Dade	Insufficient data.
Camp Choee	Private (Girl Scout Council of Tropical Florida).	3 (2005)[3]	Miami-Dade	Insufficient data.
Crandon Park—Key Biscayne.	Miami Dade Parks and Recreation.	4 (2005)[3]	Miami-Dade	Insufficient data.
Martinez Pineland/Larry and Penny Thompson Park.	Miami Dade Parks and Recreation.	6 (2005)[3]	Miami-Dade	Insufficient data.
Tropical Park Pineland	Miami Dade Parks and Recreation.	20 (2005)[3]	Miami-Dade	Insufficient data.
Boystown Pineland	Private	No estimate (2005)[3]	Miami-Dade	Insufficient data.
		Uncertain 18 records		
Crawl Key, Forestiera Hammock.	Private	10 (1982)[3]	Monroe	Insufficient data.
Long Key State Park	FDEP	No estimate (1999)[2]	Monroe	Insufficient data.
Stock Island	Private	No estimate (1981)[2]	Monroe	Insufficient data.
Boot Key	Private	11–100 (1998)[2]	Monroe	Insufficient data.
Deering Estate	State of Florida	11–100 (1991)[1]	Miami-Dade	Insufficient data.

TABLE 4—SUMMARY OF THE STATUS AND TRENDS OF THE KNOWN OCCURRENCES OF ARGYTHAMNIA BLODGETTII—Continued

Population	Ownership	Most recent population estimate	County	Trend
Castellow Hammock	Miami Dade Parks and Recreation.	11–100 (1991) [1]	Miami-Dade	Insufficient data.
Owaissa Bauer County Park.	Miami Dade Parks and Recreation.	101–1,000 (1991) [1]	Miami-Dade	Insufficient data.
Pine Ridge Sanctuary	Private	2–10 (1992) [1]	Miami-Dade	Insufficient data.
County Ridge Estates	Private	11–100 (1999) [1]	Miami-Dade	Insufficient data.
Epmore Drive pineland	Private	2–10 (1999) [1]	Miami-Dade	Insufficient data.
Gifford Arboretum Pineland	Private	2–10 (1999) [1]	Miami-Dade	Insufficient data.
Ned Glenn Nature Preserve.	Miami Dade Parks and Recreation.	11–100 (1999) [1]	Miami-Dade	Insufficient data.
Natural Forest Community #317.	Private	2–10 (1999) [1]	Miami-Dade	Insufficient data.
Old Dixie pineland	Private	11–100 (1999) [1]	Miami-Dade	Insufficient data.
Owaissa Bauer Addition #1	Miami Dade Parks and Recreation.	11–100 (1991) [1]	Miami-Dade	Insufficient data.
SW 184th St. and 83rd Ave..	Private	11–100 (1999) [1]	Miami-Dade	Insufficient data.
Castellow #33	Private	12 (1995) [3]	Miami-Dade	Insufficient data.
Castellow #31	Private	30–50 (1995) [3]	Miami-Dade	Insufficient data.
Extirpated 14 records				
Upper Matecumbe Key	unknown	No estimate (1967) [3]	Monroe.	
Totten Key	NPS	No estimate (1904) [1]	Monroe.	
Key West	City of Key West	No estimate (1965) [1]	Monroe.	
Fuch's Hammock	Miami-Dade County	No estimate (1991) [1]	Miami-Dade.	
Brickell Hammock	unknown	Extirpated 1937 [1]	Miami-Dade.	
Carribean Park	Miami-Dade County	Extirpated 1998 [1]	Miami-Dade.	
Coconut Grove	Miami-Dade County	Extirpated 1901 [1]	Miami-Dade.	
Coral Gables area	unknown	Extirpated 1967 [1]	Miami-Dade.	
Miller and 72nd Ave	unknown	Extirpated 1975 [1]	Miami-Dade.	
Orchid Jungle	Miami-Dade County	Extirpated 1930 [1]	Miami-Dade.	
Palms Woodlawn Cemetery.	Private	Extirpated 1992 [1]	Miami-Dade.	
South of Miami River	unknown	Extirpated 1913 [1]	Miami-Dade.	
Bauer Drive Pineland	Private	No estimate (1985) [3]	Miami-Dade.	
Naranja	Private	No estimate (1974) [3]	Miami-Dade.	

[1] Bradley and Gann 1999, p. 6.
[2] Hodges and Bradley 2006, pp. 10–17.
[3] FNAI 2011.
[4] Sadle 2015, pers. comm., p. 1.
[5] National Park Service (NPS).
[6] Florida Department of Environmental Protection (FDEP).
[7] Key West Naval Air Station (KWNAS).
[8] Henize and Hipes 2005, p. 25.

Biology

Life History and Reproduction: Reproductive biology of *Argythamnia blodgettii* has not been studied. Reproduction is sexual and flowering and fruiting apparently takes place throughout the year (Bradley and Gann 1999, p. 3).

Fire Ecology and Demography: The fire ecology and demography of *Argythamnia blodgettii* have not been studied. Populations of *A. blodgettii* can be ephemeral (Hodges and Bradley 2006, p. 14).

Summary of Biological Status and Threats

The Act directs us to determine whether any species is an endangered species or a threatened species because of any one of five factors affecting its continued existence. In this section, we summarize the biological condition of each of the plant species and its resources, and the factors affecting them, to assess the species' overall viability and the risks to that viability.

Factor A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

Chamaecrista lineata var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* have experienced substantial destruction, modification, and curtailment of their habitats and ranges (see Background, above). Specific threats to these plants included in this factor include habitat loss, fragmentation, and modification caused by development (*i.e.,* conversion to both urban and agricultural land uses) and inadequate fire management. Each of these threats and its specific effects on these plants are discussed in detail below.

Human Population Growth, Development, and Agricultural Conversion

The modification and destruction of the habitats that support *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* has been extreme in most areas of Miami-Dade and Monroe Counties, thereby reducing these plants' current ranges and abundance in Florida. The

pine rocklands community of south Florida, in which all four plants primarily occur, is critically imperiled locally and globally (FNAI 2012, p. 27). Destruction of pine rocklands and rockland hammocks has occurred since the beginning of the 1900s. Extensive land clearing for human population growth, development, and agriculture in Miami-Dade and Monroe Counties has altered, degraded, or destroyed thousands of acres of these once abundant ecosystems.

In Miami-Dade County, development and agriculture have reduced pine rocklands habitat by 90 percent in mainland south Florida. Pine rocklands habitat decreased from approximately 74,000 ha (183,000 ac) in the early 1900s, to only 8,140 ha (20,100 ac) in 1996 (Kernan and Bradley 1996, p. 2). The largest remaining intact pine rocklands (approximately 2,313 ha (5,716 ac)) is Long Pine Key in ENP. Outside of ENP, only about 1 percent of the pine rocklands on the Miami Rock Ridge have escaped clearing, and much of what is left are small remnants scattered throughout the Miami metropolitan area, isolated from other natural areas (Herndon 1998, p. 1).

Similarly, most of the pine rocklands in the Florida Keys (Monroe County) have been impacted (Hodges and Bradley 2006, p. 6). Pine rocklands historically covered 1,049 ha (2,592 ac) of Big Pine Key (Folk 1991, p. 188), the largest area of pine rocklands in the Florida Keys. Pine rocklands now cover approximately 582 ha (1,438 ac) of the island, a reduction of 56 percent (Bradley and Saha 2009, p. 3). There were no estimates of pine rocklands area on the other islands historically, but each contained much smaller amounts of the habitat than Big Pine Key. Remaining pine rocklands on Cudjoe Key cover 72 ha (178 ac), Little Pine has 53 ha (131 ac), No Name has 56 ha (138 ac), and Sugarloaf has 38 ha (94 ac). The total area of remaining pine rocklands in the Florida Keys is approximately 801 ha (1,979 ac). Currently, about 478 ha (1,181 ac) (82 percent) of the pine rocklands on Big Pine Key, and most of the pine rocklands on these other islands, are protected within the National Key Deer Refuge and properties owned by the Nature Conservancy, the State of Florida, and Monroe County (Bradley and Saha 2009, pp. 3–4). Based on the data presented above, the total remaining acreage of pine rocklands in Miami-Dade and Monroe Counties is now 8,981 ha (22,079 ac) (approximately 8,140 ha (20,100 ac) in Miami-Dade County, and 801 ha (1,979 ac) in the Florida Keys (Monroe County)).

The marl prairies that also support *Linum arenicola* have similarly been destroyed by the rapid development of Miami-Dade and Monroe Counties. At least some of the occurrences reported from this habitat may be the result of colonization that occurred after they were artificially dried-out due to local or regional drainage.

Likewise, habitat modification and destruction from residential and commercial development have severely impacted rockland hammocks, and coastal berm, that support *Argythamnia blodgettii.* Rockland hammocks were once abundant in Miami-Dade and Monroe Counties but are now considered imperiled locally and globally (FNAI 2010x, pp. 24–26). The tremendous development and agricultural pressures in south Florida have resulted in significant reductions of rockland hammock, which is also susceptible to fire, frost, hurricane damage, and groundwater reduction (Phillips 1940, p. 167; Snyder *et al.* 1990, pp. 271–272; FNAI 2010, pp. 24–26).

Pine rocklands, rockland hammock, marl prairie, and coastal habitats on private land remain vulnerable to development, which could lead to the loss of populations of these four species. As noted earlier, all four plants have been impacted by development. The sites of Small's 1907 and 1911 *L. arenicola* collections in Miami-Dade County are now agricultural fields (Kernan and Bradley 1996, p. 4). A pine rocklands site that supported *L. arenicola* on Vistalmar Street in Coral Gables (Miami-Dade County) was cleared and developed in 2005, as the Cocoplum housing development. A second pine rocklands site that supported *L. arenicola,* located on private land on Old Cutler Road, was developed into the Palmetto Bay Village Center. *L. arenicola* has not been observed at either site since they were developed. A former marl prairie site supporting a sizable population of *L. arenicola* near Old Cutler Road and Allapatah Drive (SW 112 Ave3.) in Miami-Dade County was extirpated when the site was developed in the 1990s (Bradley and van der Heiden 2013, pp. 6–12, 19). The Boca Chica Key population of *L. arenicola* was also likely lost due to development (Hodges and Bradley 2006, p. 48).

Bradley and Gann (1999, p. 6) list 12 populations of *Argythamnia blodgettii* in Miami-Dade County that were lost when the site that supported them was developed. An *A. blodgettii* population on Key West was likely lost due to the near complete urbanization of the island (Hodges and Bradley 2006, p. 43). Any development related to the Boy Scout camp on Big Munson Island is a potential threat to the largest population *A. blodgettii.*

The largest *Linum arenicola* population in Miami-Dade County is located on property owned by the Miami-Dade County Homeless Trust. SOCSOUTH, a unified command of all four services of DOD, has entered into a 50-year agreement with Miami-Dade County to lease this 90-ac (36.4-ha) area, where they are building a permanent headquarters on approximately 28 ac (11.3 ha) (DOD 2009, p. 1). As stated above, the population of *L. arenicola* is spread across the site and was estimated at 74,000 plants in 2009 (Bradley 2009, p. 3). In consultation with the Service, the DOD developed a plan that avoided the majority of the population with accompanying protection and management of approximately 57,725 individuals of sand flax (about 78 percent of the estimated onsite population) (Service 2011, p. 13). The plan will manage 5.95 ha (14.7 ac) of habitat, though most of it is scraped, and only a small portion has a pine canopy (Van der Heiden and Johnson 2013, p. 2). An additional 1.3 ha (3.2 ac) is being managed and supports 13,184 individuals of sand flax (about 18 percent of the estimated onsite population) (Service 2011, p. 13).

Currently there are plans to develop 55 ha (137 ac) of the largest remaining parcel of pine rocklands habitat in Miami-Dade County, the Richmond pine rocklands, with a shopping center and residential construction (RAM 2014, p. 2). Bradley and Gann (1999, p. 4) called the 345-ha (853-ac) Richmond pine rocklands, ''the largest and most important area of pine rockland in Miami-Dade County outside of Everglades National Park.'' Populations of *Argythamnia blodgettii* and *Linum arenicola,* along with numerous federally listed species, occur there. The Miami-Dade County Department of Environmental Resources Management (DERM) has completed a management plan for portions of the Richmond pine rocklands under a grant from the Service and is leading the restoration and management of the Richmond pine rocklands (Bradley and Gann 1999, p. 4). The developer has proposed to enter into a habitat conservation plan in conjunction with their plans to develop their portion of the site and was required by Miami-Dade County Natural Forest Community (NFC) regulations to set aside and manage 15 ha (39 ac) of pine rocklands and 2 ha (4 ac) of rockland hammock. A second project that would result in the loss of pine rocklands habitat is also planned for the

Richmond pine rocklands. It includes expanding the Miami Zoo complex to develop an amusement park and large retail mall.

Approximately 25 percent of extant *Linum arenicola* occurrences (3 of 12 sites), and 44 percent of extant *Argythamnia blodgettii* occurrences (13 of 34 sites), are located on private land; no extant populations of *Chamaecrista lineata* var. *keyensis* or *Chamaesyce deltoidea* ssp. *serpyllum* are located entirely on private land. It is possible that the plants on private lands will be lost from most of these sites in the future with increased pressure from development and the other threats described below. *Argythamnia blodgettii* is the only one of the four plants species which occurs in ENP, where a population of over 2,000 plants is stable and prescribed fire and other management activities that benefit *A. blodgettii* are conducted on a regular basis.

Most pine rocklands and rockland hammock habitat is now limited to public conservation lands, where future development and habitat alteration are less likely than on private lands. However, public lands could be sold off (or leased) in the future and become more likely to be developed or altered in a way that negatively impacts the habitat. For example, at the SOCSOUTH site noted above (leased to DOD by Miami-Dade County), ongoing development of headquarters buildings SOCSOUTH has resulted in the loss of *L. arenicola* and pine rocklands habitat (Bradley and van der Heiden 2013, pp. 8–10). Construction of visitor facilities such as parking lots, roads, trails, and buildings can result in habitat loss on public lands that are set aside as preserves or parks.

Roadside populations of *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* are vulnerable to habitat loss and modification stemming from infrastructure projects such as road widening, and installation of underground cable, sewer, and water lines. The Lower Sugarloaf Key population of *Linum arenicola* was impacted by repaving of the road, which placed asphalt on top of and adjacent to the population (Hodges and Bradley 2006, p. 41).

Although no entire populations of *Chamaecrista lineata* var. *keyensis* or *Chamaesyce deltoidea* ssp. *serpyllum* have been extirpated by habitat loss due to development, the size and extent of these populations have been reduced on Big Pine Key (and surrounding islands for *Chamecrista lineata* var. *keyensis*). The total area of pine rockland on Big Pine Key has decreased by 56 percent from 1955 to the present (Bradley and Saha 2009, p. 3).

The human population within Miami-Dade County is currently greater than 2.4 million people, and is expected to grow to more than 4 million by 2060, an annual increase of roughly 30,000 people (Zwick and Carr 2006, p. 20). Overall, the human population in Monroe County is expected to increase from 79,589 to more than 92,287 people by 2060 (Zwick and Carr 2006, p. 21). All vacant land in the Florida Keys is projected to be developed by then, including lands currently inaccessible for development, such as islands not attached to the Overseas Highway (U.S. 1) (Zwick and Carr 2006, p. 14). However, in an effort to address the impact of development on federally listed species, Monroe County implemented a habitat conservation plan (HCP) for Big Pine and No Name Keys in 2006. In order to fulfill the HCP's mitigation requirements, the County has been actively acquiring parcels of high-quality pine rocklands, such as The Nature Conservancy's 20-acre Terrestris Tract on Big Pine Key, and managing them for conservation. Although the HCP has helped to limit the impact of development, land development pressure and habitat losses may resume when the HCP expires in 2023. If the HCP is not renewed, residential or commercial development could increase to pre-HCP levels.

While Miami-Dade and Monroe County both have developed a network of public conservation lands that include pine rocklands, rockland hammocks, marl prairies, and coastal habitats, much of the remaining habitat occurs on private lands as well as publicly owned lands not managed for conservation. Species occurrences and suitable habitat remaining on these lands are threatened by habitat loss and degradation, and threats are expected to accelerate with increased development. Further losses will seriously affect the four plant species' ability to persist in the wild and decrease the possibility of their recovery or recolonization.

Habitat Fragmentation

The remaining pine rocklands in the Miami metropolitan area are severely fragmented and isolated from each other by vast areas of development. Remaining pine rockland areas in the Florida Keys are fragmented and are located on small islands separated by ocean. Habitat fragmentation reduces the size of plant populations and increases spatial isolation of remnants. Barrios *et al.* (2011, p. 1062) investigated the effects of fragmentation on a pine rocklands plant, *Angadenia berteroi* (pineland golden trumpet), which is recognized by the State of Florida as threatened, and found that abundance and fragment size were positively related. Possley *et al.* (2008, p. 385) studied the effects of fragment size on species composition in south Florida pine rocklands, and found that plant species richness and fragment size were positively correlated (although some small fragments supported nearly as many species as the largest fragment). Composition of fragmented habitat typically differs from that of intact forests; as isolation and edge effects increase, there is increased abundance of disturbance-adapted species (weedy species, nonnative invasive species) and lower rates of pollination and propagule dispersal (Laurence and Bierregaard 1997, pp. 347–350; Noss and Csuti 1997, pp. 284–299). The degree to which fragmentation threatens the dispersal abilities of *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* is unknown. In the historical landscape, where pine rocklands occurred within a mosaic of wetlands, water may have acted as a dispersal vector for all pine rocklands seeds. In the current, fragmented landscape, this type of dispersal would no longer be possible for any of the Miami-Dade populations. While additional dispersal vectors may include animals and (in certain locations) mowing equipment, it is likely that fragmentation has effectively reduced these plants' ability to disperse and exchange genetic material.

While pollination research has not been conducted for *Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii,* research regarding other species and ecosystems, including *Chamaecrista lineata* var. *keyensis* (discussed below), provides valuable information regarding potential effects of fragmentation on these plants. Effects of fragmentation on pollinators may include changes to the pollinator community as a result of limitation of pollinator-required resources (*e.g.,* reduced availability of rendezvous plants, nesting and roosting sites, and nectar/pollen); these changes may include changes to pollinator community composition, species abundance and diversity, and pollinator behavior (Rathcke and Jules 1993, pp. 273–275; Kremen and Ricketts 2000, p. 1227; Harris and Johnson 2004, pp. 30–33). As a result, plants in fragmented habitats may experience lower visitation rates, which in turn may result in

reduced seed production of the pollinated plant (which may lead to reduced seedling recruitment), reduced pollen dispersal, increased inbreeding, reduced genetic variability, and ultimately reduced population viability (Rathcke and Jules 1993, p. 275; Goverde *et al.* 2002, pp. 297–298; Harris and Johnson 2004, pp. 33–34).

In addition to affecting pollination, fragmentation of natural habitats often alters other ecosystems' functions and disturbance regimes. Fragmentation results in an increased proportion of ''edge'' habitat, which in turn has a variety of effects, including changes in microclimate and community structure at various distances from the edge (Margules and Pressey 2000, p. 248), altered spatial distribution of fire (greater fire frequency in areas nearer the edge) (Cochrane 2001, pp. 1518–1519), and increased pressure from nonnative, invasive plants and animals that may out-compete or disturb native plant populations. Liu and Koptur (2003, p. 1184) reported decreases in *Chamaecrista lineata* var. *keyensis's* seed production in urban areas of Big Pine Key due to increased seed predation, compared with areas away from development.

The effects of fragmentation on fire go beyond edge effects and include reduced likelihood and extent of fires, and altered behavior and characteristics (*e.g.,* intensity) of those fires that do occur. Habitat fragmentation encourages the suppression of naturally occurring fires, and has prevented fire from moving across the landscape in a natural way, resulting in an increased amount of habitat suffering from these negative impacts. High fragmentation of small habitat patches within an urban matrix discourages the use of prescribed fire as well due to logistical difficulties (see ''Fire Management,'' below). Forest fragments in urban settings are also subject to increased likelihood of certain types of human-related disturbance, such as the dumping of trash (Chavez and Tynon 2000, p. 405). The many effects of habitat fragmentation may work in concert to threaten the local persistence of a species; when a species' range of occurrence is limited, threats to local persistence increase extinction risk.

Fire Management

One of the primary threats to *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* is habitat modification and degradation through inadequate fire management, which includes both the lack of prescribed fire and suppression of natural fires. Where the term ''fire-suppressed'' is used below, it describes degraded pine rocklands conditions resulting from a lack of adequate fire (natural or prescribed) in the landscape. Historically, frequent (approximately twice per decade), lightning-induced fires were a vital component in maintaining native vegetation and ecosystem functioning within south Florida pine rocklands (see Background, above). A period of just 10 years without fire may result in a marked decrease in the number of herbaceous species due to the effects of shading and litter accumulation (FNAI 2010, p. 63). Exclusion of fire for approximately 25 years will likely result in gradual hammock development over that time period, leaving a system that is very fire-resistant if additional pre-fire management (*e.g.,* mechanical hardwood removal) is not undertaken.

Today, natural fires are unlikely to occur or are likely to be suppressed in the remaining, highly fragmented pine rocklands habitat. The suppression of natural fires has reduced the size of the areas that burn, and habitat fragmentation has prevented fire from moving across the landscape in a natural way. Without fire, successional climax from pine rocklands to rockland hammock is rapid, and displacement of native species by invasive, nonnative plants often occurs. Understory plants such as *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola, and Argythamnia blodgettii* are shaded out by hardwoods and nonnatives alike. Shading may also be caused by a fire-suppressed pine canopy that has evaded the natural thinning effects that fire has on seedlings and smaller trees. Whether the dense canopy is composed of pine, hardwoods, nonnatives, or a combination, seed germination and establishment are inhibited in fire-suppressed habitat due to accumulated leaf litter, which also changes soil moisture and nutrient availability (Hiers *et al.* 2007, pp. 811–812). This alteration to microhabitat can also inhibit seedling establishment as well as negatively influence flower and fruit production (Wendelberger and Maschinski 2009, pp. 849–851), thereby reducing sexual reproduction in fire-adapted species such as *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, L. arenicola,* and *A. blodgettii* (Geiger 2002, pp. 78–79, 81–83).

After an extended period of inadequate fire management in pine rocklands, it becomes necessary to control invading native hardwoods mechanically, as excess growth of native hardwoods would result in a hot fire, which can kill mature pines. Mechanical treatments cannot entirely replace fire because pine trees, understory shrubs, grasses, and herbs all contribute to an ever-increasing layer of leaf litter, covering herbs and preventing germination, as discussed above. Leaf litter will continue to accumulate even if hardwoods are removed mechanically. In addition, the ashes left by fires provide important post-fire nutrient cycling, which is not provided via mechanical removal.

Federal (Service, NPS), State (FDEP, FWC), and County land managers (Miami-Dade DERM), and nonprofit organizations (IRC) implement prescribed fire on public and private lands within the ranges of these four plants. While management of some County conservation lands includes regular burning, other lands remain severely fire-suppressed. Even in areas under active management, some portions are typically fire-suppressed.

Miami-Dade County: Implementation of a prescribed fire program in Miami-Dade County has been hampered by a shortage of resources, as well as by logistical difficulties and public concern related to burning next to residential areas. Many homes have been built in a mosaic of pine rocklands, so the use of prescribed fire in many places has become complicated because of potential danger to structures and smoke generated from the burns. Nonprofit organizations such as IRC have similar difficulties in conducting prescribed burns due to difficulties with permitting and obtaining the necessary permissions as well as hazard insurance limitations (Gann 2013a, pers. comm.). Few private landowners have the means or desire to implement prescribed fire on their property, and doing so in a fragmented urban environment is logistically difficult and may be costly.

All occurrences of *Linum arenicola* and *Argythamnia blodgettii* in Miami-Dade County are affected by some degree of inadequate fire management of pine rocklands and marl prairie habitat, with the primary threat being the modification and loss of habitat due to an increase in shrub and hardwood dominance, eliminating suitable conditions for the four plants, and eventual succession to rockland hammock.

In Miami-Dade County, *Linum arenicola* occurred along the south edge of Bauer Drive on the northern border of a pine rockland owned by Miami-Dade County. The property is occupied by a communications tower, and is not a managed preserve. Kernan and Bradley (1996) reported eight plants. At the time

(1992 through 1996), the road shoulder was dominated by native grasses. Since then, native canopy hardwoods have invaded the site and eliminated the sunny conditions required by *L. arenicola.* It has not been seen since, despite multiple surveys between 1997 and 2012, and is considered to be extirpated. *L. arenicola* was discovered at Camp Owaissa Bauer by George N. Avery in 1983. Since that time, the pine rocklands habitat where he found the plants in the park suffered extremely heavy hardwood recruitment due to fire suppression. Despite recent hardwood control and reintroduction of fire, no plants have been relocated. At the Martinez pineland, a population of *L. arenicola* in a marl prairie that became overgrown due to lack of fire has not been observed since 2011. Plants may reappear at this site if prescribed fire is implemented and viable seeds remain in the soil (Bradley and van der Heiden 2013, pp. 8–11). Bradley and Gann (1999, pp. 71–72) suggested that the lack of fires in most forest fragments in Miami-Dade County during the last century may be one of the reasons why *L. arenicola* occurs primarily in disturbed areas.

Monroe County (Florida Keys): Fire management of pine rocklands of the lower Florida Keys, most of which are within NKDR, is hampered by a shortage of resources, technical challenges, and expense of conducting prescribed fire in a matrix of public and private ownership. Residential and commercial properties are embedded within or in close proximity to pine rocklands habitat (Snyder *et al.* 2005, p. 2; C. Anderson 2012a, pers. comm.). As a result, hand or mechanical vegetation management may be necessary at select locations on Big Pine Key (Emmel *et al.* 1995, p. 11; Minno 2009, pers. comm.; Service 2010, pp. 1–68) to maintain or restore pine rocklands. Mechanical treatments may be less beneficial than fire because they do not quickly convert debris to nutrients, and remaining leaf litter may suppress seedling development; fire has also been found to stimulate seedling germination (C. Anderson 2010, pers. comm.). Because mechanical treatments may not provide the same ecological benefits as fire, NKDR continues to focus efforts on conducting prescribed fire where possible (C. Anderson 2012a, pers. comm.). However, the majority of pine rocklands within NKDR are several years behind the ideal fire return interval (5–7 years) suggested for this ecosystem (Synder *et al.* 2005, p. 2; Bradley and Saha 2011, pp. 1–16). Tree ring and sediment data show that pine rocklands in the lower Keys have burned at least every 5 years and sometimes up to three times per decade historically (Albritton 2009, p. 123; Horn *et al.* 2013, pp. 1–67; Harley 2012, pp. 1–246). From 1985 to 1992, prescribed burns were conducted in the NKDR mainly for fuel reduction. There was no prescribed burning by Service staff in the NKDR from 1992–1997, in part because not enough was known about the ecological effects of prescribed fire in this system (Snyder *et al.* 1990, p. 2).

All occurrences of *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* in the Florida Keys are affected by some degree of inadequate fire management of pine rocklands habitat, with the primary threat being the modification and loss of habitat due to an increase in shrub and hardwood dominance, eliminating suitable conditions for the four plants, and eventual succession to rockland hammock.

Prescribed fire management over the past decade has not been sufficient to reverse long-term declines in *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum,* or *Linum arenicola* on Big Pine Key. Prescribed fire activity on Big Pine Key and adjacent islands within NKDR appears to be insufficient to prevent loss of pine rocklands habitat (Carlson *et al.* 1993, p. 914; Bergh and Wisby 1996, pp. 1–2; O'Brien 1998, p. 209; Bradley and Saha 2009, pp. 28–29; Bradley *et al.* 2011, pp. 1–16). As a result, many of the pine rocklands across NKDR are being compromised by succession to rockland hammock (Bradley and Saha 2009, pp. 28–29; Bradley *et al.* 2011, pp. 1–16).

Conservation Efforts To Reduce the Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

Miami-Dade County Environmentally Endangered Lands (EEL) Covenant Program: In 1979, Miami-Dade County enacted the Environmentally Endangered Lands (EEL) Covenant Program, which reduces taxes for private landowners of natural forest communities (NFCs; pine rocklands and tropical hardwood hammocks) who agree not to develop their property and manage it for a period of 10 years, with the option to renew for additional 10-year periods (Service 1999, p. 3–177). Although these temporary conservation easements provide valuable protection for their duration, they are not considered under Factor D, below, because they are voluntary agreements and not regulatory in nature. Miami-Dade County currently has approximately 59 pine rocklands properties enrolled in this program, preserving 69.4 ha (172 ac) of pine rocklands habitat (Johnson 2012, pers. comm.). The program also has approximately 21 rockland hammocks properties enrolled in this program, preserving 20.64 ha (51 ac) of rockland hammock habitat (Joyner 2013b, pers. comm.). The vast majority of these properties are small, and many are in need of habitat management such as prescribed fire and removal of nonnative, invasive plants. Thus, while EEL covenant lands have the potential to provide valuable habitat for these plants and reduce threats in the near term, the actual effect of these conservation lands is largely determined by whether individual land owners follow prescribed EEL management plans and NFC regulations (see ''Local'' under Factor D discussion, below).

Fee Title Properties: In 1990, Miami-Dade County voters approved a 2-year property tax to fund the acquisition, protection, and maintenance of natural areas by the EEL Program. The EEL Program purchases and manages natural lands for preservation. Land uses deemed incompatible with the protection of the natural resources are prohibited by current regulations; however, the County Commission ultimately controls what may happen with any County property, and land use changes may occur over time (Gil 2013b, pers. comm.). To date, the Miami-Dade County EEL Program has acquired a total of approximately 313 ha (775 ac) of pine rocklands, and 95 ha (236 ac) of rockland hammocks (Guerra 2015, pers. comm.; Gil 2013b, pers. comm.). The EEL Program also manages approximately 314 ha (777 ac) of pine rocklands, and 639 ha (1,578 ac) of tropical hardwood and rockland hammocks owned by the Miami-Dade County Parks, Recreation and Open Spaces Department, including some of the largest remaining areas of pine rocklands habitat on the Miami Rock Ridge outside of ENP (*e.g.,* Larry and Penny Thompson Park, Zoo Miami pinelands, Navy Wells Pineland Preserve), and some of the largest remaining areas of tropical hardwood and rockland hammocks (*e.g.,* Matheson Hammock Park, Castellow Hammock Park, Deering Estate Park and Preserves).

Conservation efforts in Miami's EEL Preserves have been underway for many years. In Miami-Dade County, conservation lands are and have been monitored by FTBG and IRC, in coordination with the EEL Program, to assess habitat status and determine any

changes that may pose a threat to or alter the abundance of these species. Impacts to habitat (*e.g.,* canopy) via nonnative species and natural stochastic events are monitored and actively managed in areas where the taxon is known to occur. These programs are long-term and ongoing in Miami-Dade County; however, programs are limited by the availability of annual funding.

Since 2005, the Service has funded IRC to facilitate restoration and management of privately owned pine rocklands habitats in Miami-Dade County. These programs included prescribed burns, nonnative plant control, light debris removal, hardwood management, reintroduction of pines where needed, and development of management plans. One of these programs, called the Pine Rockland Initiative, includes 10-year cooperative agreements between participating landowners and the Service/IRC to ensure restored areas will be managed appropriately during that time. Although most of these objectives have been achieved, IRC has not been able to conduct the desired prescribed burns, due to logistical difficulties as discussed earlier (see ''Fire Management,'' above).

Connect to Protect Program: Fairchild Tropical Botanic Garden (FTBG), with the support of various Federal, State, and local agencies and nonprofit organizations, has established the ''Connect to Protect Network.'' The objective of this program is to encourage widespread participation of citizens to create corridors of healthy pine rocklands by planting stepping stone gardens and rights-of-way with native pine rocklands species, and restoring isolated pine rocklands fragments. By doing this, FTBG hopes to increase the probability that pollination and seed dispersal vectors can find and transport seeds and pollen across developed areas that separate pine rocklands fragments to improve gene flow between fragmented plant populations and increase the likelihood that these plants will persist over the long term. Although these projects may serve as valuable components toward the conservation of pine rocklands species and habitat, they are dependent on continual funding, as well as participation from private landowners, both of which may vary through time.

National Wildlife Refuges: The National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. 668dd note) and the Fish and Wildlife Service Manual (601 FW 3, 602 FW 3) require maintaining biological integrity and diversity, require comprehensive conservation planning for each refuge, and set standards to ensure that all uses of refuges are compatible with their purposes and the Refuge System's wildlife conservation mission. The comprehensive conservation plans (CCP) address conservation of fish, wildlife, and plant resources and their related habitats, while providing opportunities for compatible wildlife-dependent recreation uses. An overriding consideration reflected in these plans is that fish and wildlife conservation has first priority in refuge management, and that public use be allowed and encouraged as long as it is compatible with, or does not detract from, the Refuge System mission and refuge purpose(s). The CCP for the Lower Florida Keys National Wildlife Refuges (NKDR, Key West National Wildlife Refuge, and Great White Heron National Wildlife Refuge) provides a description of the environment and priority resource issues that were considered in developing the objectives and strategies that guide management over the next 15 years. The CCP promotes the enhancement of wildlife populations by maintaining and enhancing a diversity and abundance of habitats for native plants and animals, especially imperiled species that are found only in the Florida Keys. The CCP also provides for obtaining baseline data and monitoring indicator species to detect changes in ecosystem diversity and integrity related to climate change. The CCP provides specifically for maintaining and expanding populations of candidate plant species, including *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii,* all four of which are found in this refuge complex.

Department of Defense Lands: The Sikes Act requires the DOD to develop and implement integrated natural resources management plans (INRMPs) for military installations across the United States (see also Factor D discussion, below). INRMPs are prepared in cooperation with the Service and State fish and wildlife agencies to ensure proper consideration of fish, wildlife, and habitat needs. The DOD has an approved INRMP for KWNAS on Boca Chica Key that includes measures that will protect and enhance *Argythamnia blodgettii* habitat, including nonnative species control (DOD 2014, p. 69). Furthermore, DOD is currently preparing an INRMP for HARB and SOCSOUTH. A previous biological opinion (Service 2011, entire) required SOCSOUTH to protect and manage 7.4 ha (18.3 ac) of pine rocklands habitat and 70,909 individuals of *Linum arenicola* (approximately 96 percent of the estimated onsite population) based on 2009 survey data. A conservation easement was established over the protected areas, and DOD has provided funds for management of the site, including fencing and nonnative species control.

Summary of Factor A

We have identified a number of threats to the habitat of *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* that have operated in the past, are impacting these species now, and will continue to impact them in the future. Habitat loss, fragmentation, and degradation, and associated pressures from increased human population, are major threats; these threats are expected to continue, placing these plants at greater risk. All four plants may be impacted when pine rocklands are converted to other uses or when lack of fire causes the conversion to hardwood hammocks or other unsuitable habitat conditions. Any populations of these species found on private property could be destroyed by development; the limited pine rocklands, rockland hammock, and coastal berm habitat on public lands can also be affected by development of recreational facilities or infrastructure projects. Although efforts are being made to conserve publicly and privately owned natural areas and apply prescribed fire, the long-term effects of large-scale and wide-ranging habitat modification, destruction, and curtailment will last into the future, while ongoing habitat loss due to population growth, development, and agricultural conversion continues to pose a threat. Therefore, based on the best information available, we have determined that the threats to the four plants from habitat destruction, modification, or curtailment are occurring throughout the entire range of the species and are expected to continue into the future.

Factor B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The best available data do not indicate that overutilization for commercial, recreational, scientific, or educational purposes is a threat to *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* or *Argythamnia blodgettii.* Threats to these plants related to other aspects of recreation and similar human activities (*i.e.,* not related to overutilization) are discussed under Factor E.

Factor C. Disease or Predation

No diseases or incidences of predation have been reported for *Chamaesyce deltoidea* ssp. *serpyllum* or *Argythamnia blodgettii.*

Key deer are known to occasional browse plants indiscriminately, including *Chamaecrista lineata* var. *keyensis* and *Linum arenicola.* Key deer do not appear to feed on *Argythamnia blodgettii,* probably due to potential toxicity (Hodges and Bradley 2006, p. 19).

Seed predation by an insect occurs in *Chamaecrista lineata* var. *keyensis,* and seems to be exacerbated by habitat fragmentation. Individuals at the urban edge suffer higher insect seed predation than those inside the forest (Liu and Koptur 2003, p. 1184).

While seed predation and occasional Key deer browsing may be a stressor, they do not appear to rise to the level of threat at this time. Therefore, the best available data do not indicate that disease or predation is a threat to *Chamaecrista lineata* var. *keyensis* or *Linum arenicola.*

Factor D. The Inadequacy of Existing Regulatory Mechanisms

Under this factor, we examine whether threats to these plants are discussed under the other factors are continuing due to an inadequacy of an existing regulatory mechanism. Section 4(b)(1)(A) of the Act requires the Service to take into account ''those efforts, if any, being made by any State or foreign nation, or any political subdivision of a State or foreign nation, to protect such species.'' In relation to Factor D under the Act, we interpret this language to require the Service to consider relevant Federal, State, and tribal laws, regulations, and other such mechanisms that may minimize any of the threats we describe in threat analyses under the other four factors, or otherwise enhance conservation of the species. We give strongest weight to statutes and their implementing regulations and to management direction that stems from those laws and regulations. An example would be State governmental actions enforced under a State statute or constitution or Federal action under statute.

Having evaluated the impact of the threats as mitigated by any such conservation efforts, we analyze under Factor D the extent to which existing regulatory mechanisms are inadequate to address the specific threats to the species. Regulatory mechanisms, if they exist, may reduce or eliminate the impacts from one or more identified threats. In this section, we review existing Federal, State, and local regulatory mechanisms to determine whether they effectively reduce or remove threats to *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii.*

Federal

As Federal candidate species, the four plant species are afforded some protection through sections 7 and 10 of the Act and associated policies and guidelines. Service policy requires candidate species be treated as proposed species for purposes of intra-Service consultations and conferences where the Service's actions may affect candidate species. Other Federal action agencies (*e.g.,* NPS) are to consider the potential effects (*e.g.,* prescribed fire, pesticide treatments) to these plants and their habitat during the consultation and conference process. Applicants and Federal action agencies are encouraged to consider candidate species when seeking incidental take for other listed species and when developing habitat conservation plans. However, candidate species do not receive the same level of protection that a listed species would under the Act.

Populations of *Argythamnia blodgettii* within ENP are protected by NPS regulations at 36 CFR 2.1, which prohibit visitors from harming or removing plants, listed or otherwise, from ENP. However, the regulations do not address actions taken by NPS that cause habitat loss or modification.

Populations of the four plants within Florida Keys Wildlife Refuge Complex benefit from the National Wildlife Refuge System Improvement Act of 1997 and the Fish and Wildlife Service Manual (601 FW 3, 602 FW 3), which require the Service to maintain biological integrity and diversity, require comprehensive conservation planning for each refuge, and set standards to ensure that all uses of refuges are compatible with their purposes and the Refuge System's wildlife conservation mission. The CCP for a refuge addresses conservation of fish, wildlife, and plant resources and their related habitats, while providing opportunities for compatible wildlife-dependent recreation uses. An overriding consideration reflected in these plans is that fish and wildlife conservation has first priority in refuge management, and that public use be allowed and encouraged as long as it is compatible with, or does not detract from, the Refuge System mission and refuge purpose(s).

The CCP for the Lower Florida Keys National Wildlife Refuges (National Key Deer Refuge, Key West National Wildlife Refuge, and Great White Heron National Wildlife Refuge) and the CCP for the Crocodile Lake National Wildlife Refuge provide for *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* as described above. *Linum arenicola* occurs on DOD lands at HARB and SOCSOUTH. *L. arenicola* and *A. blodgettii* occur on Federal lands within the Richmond Pinelands Complex, including lands owned by the U.S. Coast Guard and the National Oceanic and Atmospheric Association (NOAA; small portion of Martinez Pineland).

As discussed under Factor A, above, the DOD has an approved INRMP for KWNAS on Boca Chica Key that includes measures that will protect and enhance *Argythamnia blodgettii* habitat, including nonnative species control (DOD 2014, p. 69). Furthermore, DOD is currently preparing an INRMP for HARB and SOCSOUTH. A 2011 Service biological opinion requires SOCSOUTH to protect and manage 7.4 ha (18.3 ac) of pine rocklands habitat and 70,909 individuals of *Linum arenicola* (approximately 96 percent of the estimated onsite population) based on 2009 survey data. A conservation easement was established over the protected areas, and DOD has provided funds for management of the site, including fencing and nonnative species control.

Populations of the four plants that occur on State- or County-owned properties and development of these areas will likely require no Federal permit or other authorization. Therefore, projects that affect them on State- and County-owned lands do not have Federal oversight, such as complying with the National Environmental Policy Act (NEPA) (42 U.S.C. 4321 *et seq.*), unless the project has a Federal nexus (Federal funding, permits, or other authorizations). Therefore, the four plants have no direct Federal regulatory protection in these areas.

State

Chamaecrista lineata var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* are listed on the Regulated Plant Index (Index) as endangered under chapter 5B–40, Florida Administrative Code. This listing provides little or no habitat protection beyond the State's development of a regional impact process, which discloses impacts from projects, but provides no regulatory protection for State-listed plants on private lands.

Florida Statutes 581.185 sections (3)(a) and (3)(b) prohibit any person from willfully destroying or harvesting any species listed as endangered or threatened on the Index, or growing such a plant on the private land of another, or on any public land, without first obtaining the written permission of the landowner and a permit from the Florida Department of Plant Industry. The statute further provides that any person willfully destroying or harvesting; transporting, carrying, or conveying on any public road or highway; or selling or offering for sale any plant listed in the Index as endangered must have a permit from the State at all times when engaged in any such activities. Further, Florida Statutes 581.185 section (10) provides for consultation similar to section 7 of the Act for listed species, by requiring the Department of Transportation to notify the FDACS and the Endangered Plant Advisory Council of planned highway construction at the time bids are first advertised, to facilitate evaluation of the project for listed plant populations, and to provide ''for the appropriate disposal of such plants'' (*i.e.,* transplanting).

However, this statute provides no substantive protection of habitat or protection of potentially suitable habitat at this time. Florida Statutes 581.185 section (8) waives State regulation for certain classes of activities for all species on the Index, including the clearing or removal of regulated plants for agricultural, forestry, mining, construction (residential, commercial, or infrastructure), and fire-control activities by a private landowner or his or her agent.

Local

In 1984, section 24–49 of the Code of Miami-Dade County established regulation of County-designated NFCs. These regulations were placed on specific properties throughout the County by an act of the Board of County Commissioners in an effort to protect environmentally sensitive forest lands. The Miami-Dade County Department of Regulatory and Economic Resources (RER) has regulatory authority over these County-designated NFCs and is charged with enforcing regulations that provide partial protection of remaining upland forested areas designated as NFC on the Miami Rock Ridge. NFC regulations are designed to prevent clearing or destruction of native vegetation within preserved areas. Miami-Dade County Code typically allows up to 20 percent of pine rocklands designated as NFC to be developed, and requires that the remaining 80 percent be placed under a perpetual covenant. The code requires that no more than 10 percent of a rockland hammock designated as NFC may be developed for properties greater than 5 acres and that the remaining 90 percent be placed under a perpetual covenant for preservation purposes (Joyner 2013a, 2014, pers. comm.; Lima 2014, pers. comm.). However, for properties less than 5 acres, up to one-half an acre may be cleared if the request is deemed a reasonable use of property; this allowance often may be greater than 20 percent (for pine rocklands) or 10 percent (for rockland hammock) of the property (Lima 2014, pers. comm.). NFC landowners are also required to obtain an NFC permit for any work, including removal of nonnatives within the boundaries of the NFC on their property. When RER discovers unpermitted work, it takes appropriate enforcement action and seeks restoration when possible. The NFC program is responsible for ensuring that NFC permits are issued in accordance with the limitations and requirements of the county code and that appropriate NFC preserves are established and maintained in conjunction with the issuance of an NFC permit when development occurs. The NFC program currently regulates approximately 600 pine rocklands or pine rocklands/hammock properties, comprising approximately 1,200 ha (3,000 ac) of habitat (Joyner 2013, pers. comm.).

Although the NFC program is designed to protect rare and important upland (non-wetlands) habitats in south Florida, it is a regulatory strategy with limitations. For example, in certain circumstances where landowners can demonstrate that limiting development to 20 percent (for pine rocklands) or 10 percent (for rockland hammock) does not allow for ''reasonable use'' of the property, additional development may be approved. Furthermore, Miami-Dade County Code provides for up to 100 percent of the NFC to be developed in limited circumstances for parcels less than 2.02 ha (5 ac) in size and only requires coordination with landowners if they plan to develop property or perform work within the NFC designated area. Therefore, many of the existing private forested NFC parcels remain fragmented, without management obligations or preserve designation, as development has not been proposed at a level that would trigger the NFC regulatory requirements. Often, nonnative vegetation over time begins to dominate and degrade the undeveloped and unmanaged NFC landscape until it no longer meets the legal threshold of an NFC, which applies only to land dominated by native vegetation. When development of such degraded NFCs is proposed, Miami-Dade County Code requires delisting of the degraded areas as part of the development process. Property previously designated as NFC is removed from the list even before development is initiated because of the abundance of nonnative species, making it no longer considered to be jurisdictional or subject to the NFC protection requirements of Miami-Dade County Code (Grossenbacher 2013, pers. comm.).

Summary of Factor D

Currently, *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* are found on Federal, State, and County lands; however, there is no regulatory mechanism in place that provides substantive protection of habitat or protection of potentially suitable habitat at this time. NPS and USFWS Refuge regulations provide protection at ENP and the Florida Keys Wildife Refuge Complex, respectively. The Act provides some protection for candidate species on NWRs and during intra-Service section 7 consultations. State regulations provide protection against trade, but allow private landowners or their agents to clear or remove species on the Florida Regulated Plant Index. State Park regulations provide protection for plants within Florida State Parks. The NFC program in Miami is designed to protect rare and important upland (non-wetlands) habitats in south Florida; however, this regulatory strategy has several limitations (as described above) that reduce its ability to protect the four plants and their habitats.

Although many populations of the four plants are afforded some level of protection because they are on public conservation lands, existing regulatory mechanisms have not led to a reduction or removal of threats posed to these plants by a wide array of sources (see discussions under Factor A, above, and Factor E, below).

Factor E. Other Natural or Manmade Factors Affecting Its Continued Existence

Other natural or manmade factors affect *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* to varying degrees. Specific threats to these plants included in this factor consist of the spread of nonnative, invasive plants;

potentially incompatible management practices (such as mowing and herbicide use); direct impacts to plants from recreation and other human activities; small population size and isolation; effects of pesticide spraying on pollinators; climate change and sea level rise (SLR); and risks from environmental stochasticity (extreme weather) on these small populations. Each of these threats and its specific effect on these plants is discussed in detail below.

Nonnative Plant Species

Nonnative, invasive plants compete with native plants for space, light, water, and nutrients, and make habitat conditions unsuitable for *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii,* which prefer open conditions. Bradley and Gann (1999, pp. 13, 71–72) indicated that the control of nonnative plants is one of the most important conservation actions for these plants and a critical part of habitat maintenance.

Nonnative plants have significantly affected pine rocklands, and threaten all occurrences of these four species to some degree (Bradley 2006, pp. 25–26; Bradley and Gann 1999, pp. 18–19; Bradley and Saha 2009, p. 25; Bradley and van der Heiden 2013, pp. 12–16). As a result of human activities, at least 277 taxa of nonnative plants have invaded pine rocklands throughout south Florida (Service 1999, p. 3–175). *Neyraudia neyraudia* (Burma reed) and *Schinus terebinthifolius* (Brazilian pepper) threaten all four species (Bradley and Gann 1999, pp. 13, 72). *S. terebinthifolius,* a nonnative tree, is the most widespread and one of the most invasive species. It forms dense thickets of tangled, woody stems that completely shade out and displace native vegetation (Loflin 1991, p. 19; Langeland and Craddock Burks 1998, p. 54). *Acacia auriculiformis* (earleaf acacia), *Rhynchelytrum repens* (natal grass), *Lantana camara* (shrub verbena), and *Albizia lebbeck* (tongue tree) are some of the other nonnative species in pine rocklands. More species of nonnative plants could become problems in the future, such as *Lygodium microphyllum* (Old World climbing fern), which is a serious threat throughout south Florida. Nonnative plants in pine rocklands can also affect the characteristics of a fire when it does occur. Historically, pine rocklands had an open, low understory where natural fires remained patchy with low temperature intensity, thus sparing many native plants such as *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii.* Dense infestations of *Neyraudia neyraudia* and *Schinus terebinthifolius* cause higher fire temperatures and longer burning periods. With the presence of invasive, nonnative species, it is uncertain how fire, even under a managed situation, will affect these plants.

At least 162 nonnative plant species are known to invade rockland hammocks; impacts are particularly severe on the Miami Rock Ridge (Service 1999, pp. 3–135). Nonnative plant species have significantly affected rockland hammocks where *Argythamnia blodgettii* occurs and are considered one of the threats to the species (Snyder *et al.* 1990, p. 273; Hodges and Bradley 2006, p. 14). In many Miami-Dade County parks, nonnative plant species comprise 50 percent of the flora in hammock fragments (Service 1999, pp. 3–135). Horvitz (*et al.* 1998, p. 968) suggests the displacement of native species by nonnative species in conservation and preserve areas is a complex problem with serious impacts to biodiversity conservation, as management in these areas generally does not protect native species and ecological processes, as intended. Problematic nonnative, invasive plants associated with rockland hammocks include *Leucaena leucocephala* (lead tree), *Schinus terebinthifolius, Bischofia javanica* (bishop wood), *Syngonium podophyllum* (American evergreen), *Jasminum fluminense* (Brazilian jasmine), *Rubus niveus* (mysore raspberry), *Thelypteris opulenta* (jeweled maiden fern), *Nephrolepis multiflora* (Asian swordfern), *Schefflera actinophylla* (octopus tree), *Jasminum dichotomum* (Gold Coast jasmine), *Epipremnum pinnatum* (centipede tongavine), and *Nephrolepis cordifolia* (narrow swordfern) (Possley 2013h–i, pers. comm.).

Management of nonnative, invasive plants in pine rocklands and rockland hammocks in Miami-Dade County is further complicated because the vast majority of pine rocklands and rockland hammocks are small, fragmented areas bordered by urban development. In the Florida Keys, larger fragments are interspersed with development. Developed or unmanaged areas that contain nonnative species can act as a seed source for nonnatives, allowing them to continue to invade managed pine rocklands or rockland hammocks (Bradley and Gann 1999, p. 13).

Nonnative plant species are also a concern on private lands, where often these species are not controlled due to associated costs, lack of interest, or lack of knowledge of detrimental impacts to the ecosystem. Undiscovered populations of the four plants on private lands could certainly be at risk. Overall, active management is necessary to control for nonnative species and to protect unique and rare habitats where the four plants occur (Snyder *et al.* 1990, p. 273).

Management of Roadsides and Disturbed Areas

All four plants occur in disturbed areas such as roadsides and areas that formerly were pine rocklands. *Linum arenicola* is particularly vulnerable to management practices in these areas because nearly all populations of the species are currently found on disturbed sites. The large *L. arenicola* population at HARB and SOCSOUTH is located largely in areas that are regularly mowed. Similarly, the small population of *L. arenicola* at the Everglades Archery Range, which is owned by Miami-Dade County and managed as a part of Camp Owaissa Bauer, is growing along the edges of the unimproved perimeter road that is regularly mowed. Finally, the two populations of *L. arenicola* on canal banks are subject to mowing, herbicide treatments, and revegetation efforts (sodding) (Bradley and van der Heiden 2013, pp. 8–10). The population of *Argythamnia blodgettii* at Lignumvitae Key Botanical State Park grows around the perimeter of the large lawn around the residence. Maintenance activities and encroachment of exotic lawn grasses are potential threats to this population (Hodges and Bradley 2006, p. 14). At Windley Key State Park, *A. blodgettii* grows in two quarry bottoms. In the first, larger quarry, to the east of the visitor center, plants apparently persist only in natural areas not being mowed. However, the majority of the plants are in the farthest quarry, which is not mowed (Hodges and Bradley 2006, p. 15).

While no studies have investigated the effect of mowing on the four plants, research has been conducted on the federally endangered *Linum carteri* var. *carteri* (Carter's small-flowered flax, a close relative of *Linum arenicola* that also occurs in pine rocklands and disturbed sites). The study found significantly higher densities of plants at the mown sites where competition with other plants is decreased (Maschinski and Walters 2007, p. 56). However, plants growing on mown sites were shorter, which may affect fruiting magnitude. While mowing did not usually kill adult plants, if mowing occurred prior to plants reaching reproductive status, it could delay

reproduction (Maschinski and Walters 2007, pp. 56–57). If such mowing occurs repeatedly, reproduction of those plants would be entirely eliminated. If, instead, mowing occurs at least 3 weeks after flowering, there would be a higher probability of adults setting fruit prior to mowing; mowing may then act as a positive disturbance by both scattering seeds and reducing competition (Maschinski and Walters 2007, p. 57). The exact impacts of mowing thus depend on the timing of the mowing event, rainfall prior to and following mowing, and the numbers of plants in the population that have reached a reproductive state.

Herbicide applications, the installation of sod, and dumping may affect populations of the four plants that occur on roadsides, canals banks, and other disturbed sites. Signs of herbicide application were noted at the site of the Big Torch Key roadside population of *Linum arenicola* in 2010 (Hodges 2010, p. 2). At the L–31 E canal site, plants of *L. arenicola* were lost on the levee close to Card Sound Road due to the installation of Bahia grass (*Paspalum conjugatum*) sod in recent years, an activity associated with the installation of new culverts. If similar projects are planned, other erosion control measures should be investigated that do not pose a threat to *L. arenicola* (Bradley and Van Der Heiden 2013, p. 10). Illegal dumping of storm-generated trash after Hurricane Wilma had a large impact on roadside populations of plants in the lower Florida Keys (Hodges and Bradley 2006, pp. 11–12, 19, 39).

All populations of the four plants that occur on disturbed sites are vulnerable to regular maintenance activities such as mowing and herbicide applications, and dumping. This includes portions of all populations of *Chamaecrista lineata* var. *keyensis* and *Chamaesyce deltoidea* ssp. *serpyllum,* 10 of 12 *Linum arenicola* populations, and 5 of 34 *Argythamnia blodgettii* populations. All roadside populations are also vulnerable to infrastructure projects such as road widening and installation of underground cable, sewer, and water lines.

Pesticide Effects on Pollinators

Another possible anthropogenic threat to the four plants is current application of insecticides throughout these plants' ranges to control mosquito populations. Currently, an aerial insecticide (1,2-dibromo-2,2-dichloroethyl dimethyl phosphate) and ground insecticide (Permethrin) are applied sometimes as frequently as daily in May through November in many parts of south Florida. Nontarget effects of mosquito control may include the loss of pollinating insects upon which certain plants depend.

Koptur and Liu (2003, p. 1184) reported a decrease in *Chamaecrista lineata* var. *keyensis* pollinator activity following mosquito spraying on Big Pine Key. Mosquito spraying is common on Big Pine Key, and its suppression of pollinator populations may have a long-term impact on reproduction rates. Similar problems with mosquito spraying and effects of forest fragmentation and proximity to homes and business may also be impacting *Chamaesyce deltoidea* ssp. *serpyllum* and *Linum arenicola* (Bradley 2006, p. 36).

Environmental Stochasticity

Endemic species whose populations exhibit a high degree of isolation and narrow geographic distribution, such as *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii,* are extremely susceptible to extinction from both random and nonrandom catastrophic natural or human-caused events. Of the four species, *Argythamnia blodgettii* is probably less vulnerable because of the larger number of sites where it occurs throughout Miami-Dade and Monroe Counties. Small populations of species, without positive growth rates, are considered to have a high extinction risk from site-specific demographic and environmental stochasticity (Lande 1993, pp. 911–927).

The climate of south Florida is driven by a combination of local, regional, and global weather events and oscillations. There are three main ''seasons'': (1) The wet season, which is hot, rainy, and humid from June through October; (2) the official hurricane season that extends one month beyond the wet season (June 1 through November 30), with peak season being August and September; and (3) the dry season, which is drier and cooler, from November through May. In the dry season, periodic surges of cool and dry continental air masses influence the weather with short-duration rain events followed by long periods of dry weather.

Florida is considered the most vulnerable State in the United States to hurricanes and tropical storms (Florida Climate Center, *http://coaps.fsu.edu/climate_center*). Based on data gathered from 1856 to 2008, Klotzbach and Gray (2009, p. 28) calculated the climatological probabilities for each State being impacted by a hurricane or major hurricane in all years over the 152-year timespan. Of the coastal States analyzed, Florida had the highest climatological probabilities, with a 51 percent probability of a hurricane (Category 1 or 2) and a 21 percent probability of a major hurricane (Category 3 or higher). From 1856 to 2008, Florida experienced 109 hurricanes, 36 of which were considered major hurricanes. Given the few isolated populations and restricted range of the four plants in locations prone to storm influences (*i.e.,* Miami-Dade and Monroe Counties), they are at substantial risk from hurricanes, storm surges, and other extreme weather events.

Hurricanes, storm surge, and extreme high tide events are natural events that can pose a threat to the four plants. Hurricanes and tropical storms can modify habitat (*e.g.,* through storm surge) and have the potential to destroy entire populations. Climate change may lead to increased frequency and duration of severe storms (Golladay *et al.* 2004, p. 504; McLaughlin *et al.* 2002, p. 6074; Cook *et al.* 2004, p. 1015). The four plants experienced these disturbances historically, but had the benefit of more abundant and contiguous habitat to buffer them from extirpations. With most of the historical habitat having been destroyed or modified, the few remaining populations of these plants could face local extirpations due to stochastic events.

The Florida Keys were impacted by three hurricanes in 2005: Katrina on August 26, Rita on September 20, and Wilma on October 24. Hurricane Wilma had the largest impact, with storm surges flooding much of the landmass of the Keys. In some places this water impounded and sat for days. The vegetation in many areas was top-killed due to salt water inundation (Hodges and Bradley 2006, p. 9). Flooding kills plants that do not have adaptations to tolerate anoxic soil conditions that persist after flooding; the flooding and resulting high salinities might also impact soil seed banks of the four plants (Bradley and Saha 2009, pp. 27–28). After hurricane Wilma, the herb layer in pine rocklands in close proximity to the coast was brown with few plants having live material above ground (Bradley 2006, p. 11). Subsequent surveys found no *Linum arenicola* and little *Chamaecrista lineata* var. *keyensis* or *Chamaesyce deltoidea* ssp. *serpyllum* in areas where they previously occurred. Not only did the storm surge kill the vegetation, but many of the roadside areas were heavily disturbed by dumping and removal of storm debris (Bradley 2006, p. 37). Estimates of the population sizes pre- and post-Wilma were calculated for *Chamaesyce*

deltoidea ssp. *serpyllum* and *Chamaecrista lineata* var. *keyensis.* Each declined in the months following the storm, by 41.2 percent and 48.0 percent, respectively (Bradley and Saha 2009, p. 2). *L. arenicola* was not found at all in surveys 8 to 9 weeks after the hurricane (Bradley 2006, p. 36). The Middle Torch Key population was extirpated after Hurricane Wilma, and the population on Big Torch Key declined drastically, with only one individual located. Both of these areas were heavily affected by storm surges during Hurricane Wilma (Hodges 2010, p. 2). As of 2013, populations of *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum,* and *L. arenicola* in the Florida Keys have not returned to pre-Hurricane Wilma levels (Bradley *et al.* 2015, pp. 21, 25, 29).

Some climate change models predict increased frequency and duration of severe storms, including hurricanes and tropical storms (McLaughlin *et al.* 2002, p. 6074; Cook *et al.* 2004, p. 1015; Golladay *et al.* 2004, p. 504). Other models predict hurricane and tropical storm frequencies in the Atlantic are expected to decrease between 10 and 30 percent by 2100 (Knutson *et al.* 2008, pp. 1–21). For those models that predict fewer hurricanes, predictions of hurricane wind speeds are expected to increase by 5 to 10 percent due to an increase in available energy for intense storms. Increases in hurricane winds can elevate the chances of damage to existing canopy and increase storm surge heights.

All populations of the four plants are vulnerable to hurricane wind damage. Populations close to the coast and all populations of the four plants in the Florida Keys are vulnerable to inundation by storm surge. Historically, the four plant species may have benefitted from more abundant and contiguous habitat to buffer them from storm events. The small size of many populations of these plants makes them especially vulnerable, in which the loss of even a few individuals could reduce the viability of a single population. The destruction and modification of native habitat, combined with small population size, has likely contributed over time to the stress, decline, and, in some instances, extirpation of populations or local occurrences due to stochastic events.

Due to the small size of some existing populations of *Chamaecrista lineata* var. *keyensis, Linum arenicola,* and *Argythamnia blodgettii* (see below) and the narrow geographic range of all four plant species, their overall resilience to these factors is likely low. These factors, combined with additional stress from habitat loss and modification (*e.g.,* inadequate fire management) may increase the inherent risk of stochastic events that impact these plants. For these reasons, all four plants are at risk of extirpation during extreme stochastic events. Of the four species, *Argythamnia blodgettii* is probably less vulnerable because of the larger number of sites where it occurs throughout Miami-Dade and Monroe Counties.

Small Population Size and Isolation

Endemic species whose populations exhibit a high degree of isolation are extremely susceptible to extinction from both random and nonrandom catastrophic natural or human-caused events. Species that are restricted to geographically limited areas are inherently more vulnerable to extinction than widespread species because of the increased risk of genetic bottlenecks, random demographic fluctuations, climate change, and localized catastrophes such as hurricanes and disease outbreaks (Mangel and Tier 1994, p. 607; Pimm *et al.* 1998, p. 757). These problems are further magnified when populations are few and restricted to a very small geographic area, and when the number of individuals is very small. Populations with these characteristics face an increased likelihood of stochastic extinction due to changes in demography, the environment, genetics, or other factors (Gilpin and Soule 1986, pp. 24–34). Small, isolated populations often exhibit reduced levels of genetic variability, which diminishes the species' capacity to adapt and respond to environmental changes, thereby decreasing the probability of long-term persistence (*e.g.,* Barrett and Kohn 1991, p. 4; Newman and Pilson 1997, p. 361). Very small plant populations may experience reduced reproductive vigor due to ineffective pollination or inbreeding depression. Isolated individuals have difficulty achieving natural pollen exchange, which limits the production of viable seed. The problems associated with small population size and vulnerability to random demographic fluctuations or natural catastrophes are further magnified by synergistic interactions with other threats, such as those discussed above (see Factors A and C).

Chamaecrista lineata var. *keyensis* and *Chamaesyce deltoidea* ssp. *serpyllum* both have large populations on Big Pine Key. The other extant occurrence of *Chamaecrista lineata* var. *keyensis* in the Florida Keys, on Cudjoe Key, is small. Five out of 12 extant *Linum arenicola* populations, and 20 of 34 *Argythamnia blodgettii* populations have fewer than 100 individuals. These small populations are at risk of adverse effects from reduced genetic variation, an increased risk of inbreeding depression, and reduced reproductive output. Many of these populations are small and isolated from each other, decreasing the likelihood that they could be naturally reestablished in the event that extinction from one location would occur. *Argythamnia blodgettii* is the only one of the four plants species which occurs in ENP, where a population of over 2,000 plants is stable and prescribed fire and other management activities that benefit *A. blodgettii* are conducted on a regular basis.

Climate Change and Sea Level Rise

Climatic changes, including sea level rise (SLR), are occurring in the State of Florida and are impacting associated plants, animals, and habitats. Our analyses under the Act include consideration of ongoing and projected changes in climate. The term ''climate,'' as defined by the Intergovernmental Panel on Climate Change (IPCC), refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2013, p. 1450). The term ''climate change'' thus refers to a change in the mean or variability of one or more measures of climate (*e.g.,* temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2013, p. 1450). A recent compilation of climate change and its effects is available from reports of the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2013, entire).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions. (For these and other examples, see IPCC 2007a, p. 30; Solomon *et al.* 2007, pp. 35–54, 82–85). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is ''very likely'' (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere

as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2007a, pp. 5–6 and figures SPM.3 and SPM.4; Solomon *et al.* 2007, pp. 21–35). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011, p. 4), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (*e.g.,* Meehl *et al.* 2007, entire; Ganguly *et al.* 2009, pp. 11555, 15558; Prinn *et al.* 2011, pp. 527, 529). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (IPCC 2007a, pp. 44–45; Meehl *et al.* 2007, pp. 760–764, 797–811; Ganguly *et al.* 2009, pp. 15555–15558; Prinn *et al.* 2011, pp. 527, 529). (See IPCC 2007b, p. 8, for a summary of other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation. Also see IPCC 2011 (entire) for a summary of observations and projections of extreme climate events.)

Various changes in climate may have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as interactions of climate with other variables (*e.g.,* habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19). Identifying likely effects often involves aspects of climate change vulnerability analysis. Vulnerability refers to the degree to which a species (or system) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the type, magnitude, and rate of climate change and variation to which a species is exposed, its sensitivity, and its adaptive capacity (IPCC 2007a, p. 89; see also Glick *et al.* 2011, pp. 19–22). There is no single method for conducting such analyses that applies to all situations (Glick *et al.* 2011, p. 3). We use our expert judgment and appropriate analytical approaches to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

As is the case with all stressors that we assess, even if we conclude that a species is currently affected or is likely to be affected in a negative way by one or more climate-related impacts, it does not necessarily follow that the species meets the definition of an ''endangered species'' or a ''threatened species'' under the Act. If a species is listed as endangered or threatened, knowledge regarding the vulnerability of the species to, and known or anticipated impacts from, climate-associated changes in environmental conditions can be used to help devise appropriate strategies for its recovery.

Global climate projections are informative, and, in some cases, the only or the best scientific information available for us to use. However, projected changes in climate and related impacts can vary substantially across and within different regions of the world (*e.g.,* IPCC 2007a, pp. 8–12). Therefore, we use ''downscaled'' projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (see Glick *et al.* 2011, pp. 58–61, for a discussion of downscaling).

With regard to our analysis for *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii,* downscaled projections suggest that SLR is the largest climate-driven challenge to low-lying coastal areas in the subtropical ecoregion of southern Florida (U.S. Climate Change Science Program (USCCSP) 2008, pp. 5–31, 5–32). All populations of the four plants occur at elevations from 2.83–4.14 m (9.29–13.57 ft) above sea level, making these plants highly susceptible to increased storm surges and related impacts associated with SLR.

We acknowledge that the drivers of SLR (especially contributions of melting glaciers) are not completely understood, and there is uncertainty with regard to the rate and amount of SLR. This uncertainty increases as projections are made further into the future. For this reason, we examine threats to the species within the range of projections found in recent climate change literature.

The long-term record at Key West shows that sea level rose on average 0.229 cm (0.090 in) annually between 1913 and 2013 (National Oceanographic and Atmospheric Administration (NOAA) 2013, p. 1). This equates to approximately 22.9 cm (9.02 in) over the last 100 years. IPCC (2008, p. 28) emphasized it is very likely that the average rate of SLR during the 21st century will exceed the historical rate. The IPCC Special Report on Emission Scenarios (2000, entire) presented a range of scenarios based on the computed amount of change in the climate system due to various potential amounts of anthropogenic greenhouse gases and aerosols in 2100. Each scenario describes a future world with varying levels of atmospheric pollution leading to corresponding levels of global warming and corresponding levels of SLR. The IPCC Synthesis Report (2007, entire) provided an integrated view of climate change and presented updated projections of future climate change and related impacts under different scenarios.

Subsequent to the 2007 IPCC Report, the scientific community has continued to model SLR. Recent peer-reviewed publications indicate a movement toward increased acceleration of SLR. Observed SLR rates are already trending along the higher end of the 2007 IPCC estimates, and it is now widely held that SLR will exceed the levels projected by the IPCC (Rahmstorf *et al.* 2012, p. 1; Grinsted *et al.* 2010, p. 470). Taken together, these studies support the use of higher end estimates now prevalent in the scientific literature. Recent studies have estimated global mean SLR of 1.0–2.0 m (3.3–6.6 ft) by 2100 as follows: 0.75–1.90 m (2.50–6.20 ft; Vermeer and Rahmstorf 2009, p. 21530); 0.8–2.0 m (2.6–6.6 ft; Pfeffer *et al.* 2008, p. 1342); 0.9–1.3 m (3.0–4.3 ft; Grinsted *et al.* 2010, pp. 469–470); 0.6–1.6 m (2.0–5.2 ft; Jevrejeva *et al.* 2010, p. 4); and 0.5–1.4 m (1.6–4.6 ft; National Research Council 2012, p. 2).

Other processes expected to be affected by projected warming include temperatures, rainfall (amount, seasonal timing, and distribution), and storms (frequency and intensity) (see ''Environmental Stochasticity'', above). Models where sea surface temperatures are increasing also show a higher probability of more intense storms (Maschinski *et al.* 2011, p. 148). The

Massachusetts Institute of Technology (MIT) modeled several scenarios combining various levels of SLR, temperature change, and precipitation differences with human population growth, policy assumptions, and conservation funding changes. All of the scenarios, from small climate change shifts to major changes, indicate significant effects on coastal Miami-Dade County. The Science and Technology Committee of the Miami-Dade County Climate Change Task Force (Wanless *et al.* 2008, p. 1) recognizes that significant SLR is a serious concern for Miami-Dade County in the near future. In a January 2008 statement, the committee warned that sea level is expected to rise at least 0.9–1.5 m (3.0–5.0 ft) within this century (Wanless *et al.* 2008, p. 3). With a 0.9–1.2 m (3.0–4.0 ft) rise in sea level (above baseline) in Miami-Dade County, spring high tides would be at about 1.83–2.13 m (6.0–7.0 ft); freshwater resources would be gone; the Everglades would be inundated on the west side of Miami-Dade County; the barrier islands would be largely inundated; storm surges would be devastating to coastal habitat and associated species; and landfill sites would be exposed to erosion, contaminating marine and coastal environments. Freshwater and coastal mangrove wetlands will be unable to keep up with or offset SLR of 0.61 m (2.0 ft) per century or greater. With a 1.52 m (5.0 ft) rise, Miami-Dade County will be extremely diminished (Wanless *et al.* 2008, pp. 3–4).

SLR projections from various scenarios have been downscaled by TNC (2011; entire) and Zhang *et al.* (2011; entire) for the Florida Keys. Using the IPCC best-case, low pollution scenario, a rise of 18 cm (7 in) (a rate close to the historical average reported above) would result in the inundation of 23,796 ha (58,800 acres) or 38.2 percent of the Florida Keys upland area by the year 2100 (TNC 2011, p. 25). Under the IPCC worst-case, high pollution scenario, a rise of 59 cm (23.2 in) would result in the inundation of 46,539 ha (115,000 acres) or 74.7 percent of the Florida Keys upland area by the year 2100 (TNC 2011, p. 25). Using Rahmstorf *et al.*'s (2007; p. 368) SLR projections of 100 to 140 cm, 80.5 to 92.2 percent of the Florida Keys land area would be inundated by 2100. The Zhang *et al.* (2011, p. 136) study models SLR up to 1.8 m (5.9 ft) for the Florida Keys, which would inundate 93.6 percent of the current land area of the Keys.

Prior to inundations from SLR, there will likely be habitat transitions related to climate change, including changes to hydrology and increasing vulnerability to storm surge. Hydrology has a strong influence on plant distribution in coastal areas (IPCC 2008, p. 57). Such communities typically grade from salt to brackish to freshwater species. From the 1930s to 1950s, increased salinity contributed to the decline of cabbage palm forests in southwest Florida (Williams *et al.* 1999, pp. 2056–2059), expansion of mangroves into adjacent marshes in the Everglades (Ross *et al.* 2000, pp. 101, 111), and loss of pine rocklands in the Keys (Ross *et al.* 1994, pp. 144, 151–155). In Florida, pine rocklands transition into rockland hammocks, and, as such, these habitat types are closely associated in the landscape. A study conducted in one pine rocklands location on Sugar Loaf Key (with an average elevation of 0.89 m (2.90 ft)) found an approximately 65 percent reduction in an area occupied by South Florida slash pine over a 70-year period, with pine mortality and subsequent increased proportions of halophytic (salt-loving) plants occurring earlier at the lower elevations (Ross *et al.* 1994, pp. 149–152). During this same time span, local sea level had risen by 15 cm (6 in), and Ross *et al.* (1994, p. 152) found evidence of groundwater and soil water salinization. Extrapolating this situation to hardwood hammocks is not straightforward, but it suggests that changes in rockland hammock species composition may not be an issue in the immediate future (5–10 years); however, over the long term (within the next 10–50 years), it may be an issue if current projections of SLR occur and freshwater inputs are not sufficient to maintain high humidities and prevent changes in existing canopy species through salinization (Saha *et al.* 2011, pp. 22–25). Ross *et al.* (2009, pp. 471–478) suggested that interactions between SLR and pulse disturbances (*e.g.,* storm surges) can cause vegetation to change sooner than projected based on sea level alone.

Impacts from climate change including regional SLR have been studied for coastal hammocks but not rockland hammock habitat. Saha (*et al.* 2011, pp. 24–25) conducted a risk assessment on rare plant species in ENP and found that impacts from SLR have significant effects on imperiled taxa. This study also predicted a decline in the extent of coastal hammocks with initial SLR, coupled with a reduction in freshwater recharge volume and an increase in pore water (water filling spaces between grains of sediment) salinity, which will push hardwood species to the edge of their drought (freshwater shortage and physiological) tolerance, jeopardizing critically imperiled or endemic species, or both, with possible extirpation. In south Florida, SLR of 1–2 m (3.3–6.6 ft) is estimated by 2100, which is on the higher end of global estimates for SLR. These projected increases in sea level pose a threat to coastal plant communities and habitats from mangroves at sea level to salinity-intolerant, coastal rockland hammocks where elevations are generally less than 2.00 m (6.1 ft) above sea level (Saha *et al.* 2011, p. 2). Loss or degradation of these habitats can be a direct result of SLR or in combination of several other factors, including diversion of freshwater flow, hurricanes, and exotic plant species infestations, which can ultimately pose a threat to rare plant populations (Saha *et al.* 2011, p. 24).

Habitats for these species are restricted to relatively immobile geologic features separated by large expanses of flooded, inhospitable wetland or ocean, leading us to conclude that these habitats will likely not be able to migrate as sea level rises (Saha *et al.* 2011, pp. 103–104). Because of the extreme fragmentation of remaining habitat and isolation of remaining populations, and the accelerating rate at which SLR is projected to occur (Grinsted *et al.* 2010, p. 470), it will be particularly difficult for these species to disperse to suitable habitat once existing sites that support them are lost to SLR. Patterns of development will also likely be significant factors influencing whether natural communities can move and persist (IPCC 2008, p. 57; CCSP 2008, pp. 7–6). The plant species face significant risks from coastal squeeze that occurs when habitat is pressed between rising sea levels and coastal development that prevents landward migration of species. The ultimate effect of these impacts is likely to result in reductions in reproduction and survival, and corresponding decreases in population numbers.

Saha (*et al.* 2011, p. 4) suggested that the rising water table accompanying SLR will shrink the vadose zone (the area which extends from the top of the ground surface to the water table); increase salinity in the bottom portion of the freshwater lens, thereby increasing brackishness of plant-available water; and influence tree species composition of coastal hardwood hammocks based upon species-level tolerance to salinity or drought or both. Evidence of population declines and shifts in rare plant communities, along with multi-trophic effects, already have been documented on the low-elevation islands of the

Florida Keys (Maschinski *et al.* 2011, p. 148).

Direct losses to extant populations of all four plants are expected due to habitat loss and modification from SLR by 2100. We analyzed existing sites that support populations of the four plants using the National Oceanic and Atmospheric Administration (NOAA) Sea Level Rise and Coastal Impacts viewer. Below we discuss general implications of sea level rise within the range of projections discussed above on the current distribution of these species. The NOAA tool uses 1-foot increments, so the analysis is based on 0.91 m (3 ft) and 1.8 m (6 ft).

Chamaecrista lineata var. *keyensis:* A 0.91-m (3-ft) rise would inundate most areas of Big Pine Key, and all areas of Cudjoe Key, that support *Chamaecrista lineata* var. *keyensis,* and reduce both Keys to several much smaller islands. The remaining uplands on these islands would likely transition to buttonwoods and saltmarshes, and would be extremely vulnerable to storm surge. This will further reduce and fragment these populations. A 1.8-m (6-ft) rise would completely inundate all areas that support *C. lineata* var. *keyensis* and eliminate all pine rocklands habitat within the historic range of the species.

Chamaesyce deltoidea var. *serpyllum:* A 0.91-m (3-ft) rise would inundate most areas of Big Pine Key that support *Chamaesyce deltoidea* var. *serpyllum,* and reduce the Key to three to five much smaller islands. The remaining uplands would likely transition to buttonwoods and saltmarshes, and would be extremely vulnerable to storm surge. This will further reduce and fragment the population. A 1.8-m (6-ft) rise would completely inundate all areas that support *C. deltoidea* var. *serpyllum* and eliminate all pine rocklands habitat within the historic range of the species.

Linum arenicola: In Miami-Dade County, a 0.91-m (3-ft) rise would inundate the area that supports a large extant population of *Linum arenicola* along L–31E canal. While other areas that support the species are located in higher elevation areas along the coastal ridge, changes in the salinity of the water table and soils, along with additional vegetation shifts in the region, are likely. Remaining uplands may transition to wetter, more salt-tolerant plant communities. This will further reduce and fragment the populations. A 1.8-m (6-ft) rise would inundate portions of the largest known population (HARB), as well the population along L–31E canal. The areas that support *Linum arenicola* at the Martinez and Richmond pinelands to the north would not be inundated, but pine rocklands in these areas may be reduced through transition to wetter, more salt-tolerant plant communities, as discussed above.

In the Florida Keys, a 0.91-m (3-ft) rise would inundate most areas of Big Pine Key and Lower Sugarloaf Key, and all of the areas on Upper Sugarloaf Key and Big Torch Key, that support *Linum arenicola,* and reduce these Keys to numerous much smaller islands. The remaining uplands on these small islands would likely transition to buttonwoods and saltmarshes, and would be extremely vulnerable to further losses due to storm surge. This would further reduce and fragment the populations. A 1.8-m (6-ft) rise would completely inundate all areas that support *Linum arenicola* in the Florida Keys and eliminate all pine rocklands habitat within the historic range of the species in Monroe County.

Argythamnia blodgettii: In Miami-Dade County, a 0.91-m (3-ft) rise would not inundate any extant populations of *Argythamnia blodgettii* because these habitats are located in higher elevation areas along the coastal ridge. However, changes in the salinity of the water table and soils, along with additional vegetation shifts in the region, are likely. Remaining uplands may likely transition to wetter, more salt-tolerant plant communities. This will further reduce and fragment the populations. A 1.8-m (6-ft) rise would inundate portions of Crandon Park, making it unsuitable for *A. blodgettii.* Other areas that support *A. blodgettii,* including the Martinez and Richmond pinelands to the north, and Long Pine Key in ENP, would not be inundated, but habitats in these areas may be reduced through transition to wetter, more salt-tolerant plant communities, as discussed above.

In the Florida Keys, a 0.91-m (3-ft) rise would reduce the area of islands in the upper Keys, but extant populations on Key Largo, Windley Key, and Lignumvitae Key are less vulnerable than the Middle and Lower Keys, which are at lower elevations. Lower Matecumbe Key, Plantation Key, Vaca Key, Big Pine Key, and Big Munson Island would be fragmented and reduced to numerous much smaller islands. The remaining uplands on these small islands would likely transition to buttonwoods and saltmarshes, and would be extremely vulnerable further losses to storm surge. This would further reduce and fragment the populations. A 1.8-m (6-ft) rise would completely inundate all areas that support *Argythamnia blodgettii* south of Lignumvitae Key. Key Largo, Windley Key, and Lignumvitae Key are the only existing areas supporting extant populations that could continue to support a population given a 1.8-m (5.9-ft) sea level rise.

Conservation Efforts To Reduce Other Natural or Manmade Factors Affecting Its Continued Existence

NPS, the Service, Miami-Dade County, and the State of Florida have ongoing nonnative plant management programs to reduce threats on public lands, as funding and resources allow. In Miami-Dade County, nonnative, invasive plant management is very active, with a goal to treat all publicly owned properties at least once a year and more often in many cases. IRC and FTBG conduct research and monitoring in various natural areas within Miami-Dade County and the Florida Keys for various endangered plant species and nonnative, invasive species.

Summary of Factor E

We have analyzed threats from other natural or manmade factors including: nonnative, invasive plants; management practices used on roadsides and disturbed sites (such as mowing, sodding, and herbicide use); pesticide spraying and its effects on pollinators; environmental stochasticity; effects from small population size and isolation; and the effects of climate change, including SLR. The related risks from hurricanes and storm surge act together to impact populations of all four plants. Some of these threats (*e.g.,* nonnative species) may be reduced on public lands due to active programs by Federal, State, and county land managers. Many of the remaining populations of these plants are small and geographically isolated, and genetic variability is likely low, increasing the inherent risk due to overall low resilience of these plants.

Cumulative Effects of Threats

When two or more threats affect populations of the four plants, the effects of those threats could interact or become compounded, producing a cumulative adverse effect that is greater than the impact of either threat alone. The most obvious cases in which cumulative adverse effects would be significant are those in which small populations (Factor E) are affected by threats that result in destruction or modification of habitat (Factor A). The limited distributions and small population sizes of many populations of the four plants make them extremely susceptible to the detrimental effects of further habitat modification, degradation, and loss, as well as other anthropogenic threats. Mechanisms

leading to the decline of the four plants, as discussed above, range from local (*e.g.,* agriculture) to regional (*e.g.,* development, fragmentation, nonnative species) to global influences (*e.g.,* climate change, SLR). The synergistic effects of threats, such as impacts from hurricanes on a species with a limited distribution and small populations, make it difficult to predict population viability. While these stressors may act in isolation, it is more probable that many stressors are acting simultaneously (or in combination) on populations of these four plants, making them more vulnerable.

Proposed Determination

We have carefully assessed the best scientific and commercial data available regarding the past, present, and future threats to *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii.* Numerous populations of all four plants have been extirpated from these species' historical ranges, and the primary threats of habitat destruction and modification resulting from human population growth and development, agricultural conversion, and inadequate fire management (Factor A); competition from nonnative, invasive species (Factor E); changes in climatic conditions, including SLR (Factor E); and natural stochastic events (Factor E) remain threats for existing populations. Existing regulatory mechanisms have not led to a reduction or removal of threats posed to the four plants from these factors (see Factor D discussion, above). These threats are ongoing, rangewide, and expected to continue in the future. A significant percentage of populations of *Chamaecrista lineata* var. *keyensis, Linum arenicola,* and *Argythamnia blodgettii* are relatively small and isolated from one another, and their ability to recolonize suitable habitat is unlikely without human intervention, if at all. The threats have had and will continue to have substantial adverse effects on the four plants and their habitats. Although attempts are ongoing to alleviate or minimize some of these threats at certain locations, all populations appear to be impacted by one or more threats.

The Act defines an endangered species as ''any species which is in danger of extinction throughout all or a significant portion of its range'' and a threatened species as ''any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.''

As described in detail above, *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum,* and *Linum arenicola* are currently at risk throughout all of their range due to the immediacy, severity, significance, timing, and scope of those threats. Impacts from these threats are ongoing and increasing; singly or in combination, these threats place these three plants in danger of extinction. The risk of extinction is high because the populations are small, are isolated, and have limited to no potential for recolonization. Numerous threats are currently ongoing and are likely to continue in the foreseeable future, at a high intensity and across the entire range of these plants. Furthermore, natural stochastic events and changes in climatic conditions pose a threat to the persistence of these plants, especially in light of the fact these events cannot be controlled and mitigation measures have yet to be addressed. Individually and collectively, all these threats can contribute to the local extirpation and potential extinction of these plant species. Because these threats are placing them in danger of extinction throughout their ranges, we have determined that each of these three plants meets the definition of an endangered species. Therefore, on the basis of the best available scientific and commercial information, we propose to list *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum,* and *Linum arenicola* as endangered species in accordance with sections 3(6) and 4(a)(1) of the Act. We find that threatened species status is not appropriate for *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum,* and *Linum arenicola* because of the contracted range of each species and because the threats are occurring rangewide, are ongoing, and are expected to continue into the future.

Throughout its range, *Argythamnia blodgettii* faces threats similar to the other three plant species that are the subjects of this proposed rule. However, we find that endangered species status is not appropriate for *A. blodgettii.* While we have evidence of threats under Factors A, D, and E affecting the species, insufficient data are available to identify the trends in extant populations. Six populations are extant, 11 are extirpated, and we are uncertain of the status of 14 populations that have not been surveyed in 15 years or more. Additionally, data show that the threat of habitat loss from sea level rise is not as severe for this species. Also, *A. blodgettii* is likely less vulnerable because of the larger number of sites where it occurs throughout Miami-Dade and Monroe Counties. Further, *A. blodgettii* is the only one of the four plants species that occurs in ENP, where a population of over 2,000 plants is stable and prescribed fire and other management activities that benefit *A. blodgettii* are conducted on a regular basis. Therefore, based on the best available information, we find that *A. blodgettii* is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range, and we propose to list the species as a threatened species in accordance with sections 3(20) and 4(a)(1) of the Act.

Significant Portion of the Range

Under the Act and our implementing regulations, a species may warrant listing if it is endangered or threatened throughout all or a significant portion of its range. The threats to the survival of *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* occur throughout these species' ranges and are not restricted to any particular significant portion of those ranges. Accordingly, our assessment and proposed determination applies to each of the four plants throughout its entire range. Because we have determined that *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum,* and *Linum arenicola* meet the definition of endangered species, and *Argythamnia blodgettii* meets the definition of a threatened species, throughout their ranges, no portion of their ranges can be ''significant'' for purposes of the definitions of ''endangered species'' and ''threatened species.'' See the Service's SPR Policy (79 FR 37578, July 1, 2014).

Available Conservation Measures

Conservation measures provided to species listed as endangered or threatened under the Act include recognition, recovery actions, requirements for Federal protection, and prohibitions against certain practices. Recognition through listing results in public awareness, and conservation by Federal, State, Tribal, and local agencies; private organizations; and individuals. The Act encourages cooperation with the States and other countries and calls for recovery actions to be carried out for listed species. The protection required by Federal agencies and the prohibitions against certain activities are discussed, in part, below.

The primary purpose of the Act is the conservation of endangered and threatened species and the ecosystems upon which they depend. The ultimate

goal of such conservation efforts is the recovery of these listed species, so that they no longer need the protective measures of the Act. Subsection 4(f) of the Act calls for the Service to develop and implement recovery plans for the conservation of endangered and threatened species. The recovery planning process involves the identification of actions that are necessary to halt or reverse the species' decline by addressing the threats to its survival and recovery. The goal of this process is to restore listed species to a point where they are secure, self-sustaining, and functioning components of their ecosystems.

Recovery planning includes the development of a recovery outline shortly after a species is listed and preparation of a draft and final recovery plan. The recovery outline guides the immediate implementation of urgent recovery actions and describes the process to be used to develop a recovery plan. Revisions of the plan may be done to address continuing or new threats to the species, as new substantive information becomes available. The recovery plan also identifies recovery criteria for review of when a species may be ready for downlisting or delisting, and methods for monitoring recovery progress. Recovery plans also establish a framework for agencies to coordinate their recovery efforts and provide estimates of the cost of implementing recovery tasks. Recovery teams (composed of species experts, Federal and State agencies, nongovernmental organizations, and stakeholders) are often established to develop recovery plans. If these four plant species are listed, a recovery outline, draft recovery plan, and the final recovery plan will be available on our Web site (*http://www.fws.gov/endangered*), or from our South Florida Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

Implementation of recovery actions generally requires the participation of a broad range of partners, including other Federal agencies, States, Tribes, nongovernmental organizations, businesses, and private landowners. Examples of recovery actions include habitat restoration (*e.g.,* restoration of native vegetation), research, captive propagation and reintroduction, and outreach and education. The recovery of many listed species cannot be accomplished solely on Federal lands because their range may occur primarily or solely on non-Federal lands. To achieve recovery of these species requires cooperative conservation efforts on private, State, and Tribal lands. If these four plant species are listed, funding for recovery actions will be available from a variety of sources, including Federal budgets, State programs, and cost share grants for non-Federal landowners, the academic community, and nongovernmental organizations. In addition, pursuant to section 6 of the Act, the State of Florida would be eligible for Federal funds to implement management actions that promote the protection or recovery of the four plants. Information on our grant programs that are available to aid species recovery can be found at: *http://www.fws.gov/grants.*

Although *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* are only proposed for listing under the Act at this time, please let us know if you are interested in participating in recovery efforts for this species. Additionally, we invite you to submit any new information on these plants whenever it becomes available and any information you may have for recovery planning purposes (see **FOR FURTHER INFORMATION CONTACT**).

Section 7(a) of the Act requires Federal agencies to evaluate their actions with respect to any species that is proposed or listed as an endangered or threatened species and with respect to its critical habitat, if any is designated. Regulations implementing this interagency cooperation provision of the Act are codified at 50 CFR part 402. Section 7(a)(4) of the Act requires Federal agencies to confer with the Service on any action that is likely to jeopardize the continued existence of a species proposed for listing or result in destruction or adverse modification of proposed critical habitat, if designated. If a species is listed subsequently, section 7(a)(2) of the Act requires Federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of the species or destroy or adversely modify its critical habitat. If a Federal action may affect a listed species or its critical habitat, if designated, the responsible Federal agency must enter into consultation with the Service.

Federal agency actions within the species' habitat that may require conference or consultation or both as described in the preceding paragraph include management and any other landscape-altering activities on Federal lands administered by the Service, NPS, and Department of Defense; issuance of section 404 Clean Water Act permits by the U.S. Army Corps of Engineers; construction and management of gas pipeline and power line rights-of-way by the Federal Energy Regulatory Commission; construction and maintenance of roads or highways by the Federal Highway Administration; and disaster relief efforts conducted by the Federal Emergency Management Agency.

With respect to endangered plants, prohibitions outlined at 50 CFR 17.61 make it illegal for any person subject to the jurisdiction of the United States to import or export, transport in interstate or foreign commerce in the course of a commercial activity, sell or offer for sale in interstate or foreign commerce, or to remove and reduce to possession any such plant species from areas under Federal jurisdiction. In addition, for endangered plants, the Act prohibits malicious damage or destruction of any such species on any area under Federal jurisdiction, and the removal, cutting, digging up, or damaging or destroying of any such species on any other area in knowing violation of any State law or regulation, or in the course of any violation of a State criminal trespass law. Exceptions to these prohibitions are outlined in 50 CFR 17.62. With respect to threatened plants, 50 CFR 17.71 provides that, with certain exceptions, all of the prohibitions outlined at 50 CFR 17.61 for endangered plants also apply to threatened plants. Permit exceptions to the prohibitions for threatened plants are outlined in 50 CFR 17.72.

Preservation of native flora of Florida through Florida Statutes 581.185, sections (3)(a) and (3)(b), provide limited protection to species listed in the State of Florida Regulated Plant Index including *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii,* as described under the Factor D discussion, above. Federal listing would increase protection for these plants by making violations of section 3 of the Florida Statute punishable as a Federal offense under section 9 of the Act. This would provide increased protection from unauthorized collecting and vandalism for the plants on State and private lands, where they might not otherwise be protected by the Act, and would increase the severity of the penalty for unauthorized collection, vandalism, or trade in these plants.

The Service acknowledges that it cannot fully address some of the natural threats facing *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii,* (*e.g.,* hurricanes, storm surge) or even some of the other significant, long-term threats (*e.g.,* climatic changes, SLR). However,

through listing, we could provide protection to the known populations and any new population of these plants that may be discovered (see discussion below). With listing, we could also influence Federal actions that may potentially impact these plants (see discussion below); this is especially valuable if these plants are found at additional locations. With listing, we would also be better able to deter illicit collection and trade.

We may issue permits to carry out otherwise prohibited activities involving endangered or threatened plants under certain circumstances. Regulations governing permits for endangered plants are codified at 50 CFR 17.62, and for threatened plants at 50 CFR 17.72. With regard to endangered plants, the Service may issue a permit authorizing any activity otherwise prohibited by 50 CFR 17.61 for scientific purposes or for enhancing the propagation or survival of endangered plants.

It is our policy, as published in the **Federal Register** on July 1, 1994 (59 FR 34272), to identify to the maximum extent practicable at the time a species is proposed for listing or listed, those activities that would or would not constitute a violation of section 9 of the Act. The intent of this policy is to increase public awareness of the effect of a proposed listing on proposed and ongoing activities within the range of species proposed for listing. Based on the best available information, the following actions would be unlikely to result in a violation of section 9, if these activities were carried out in accordance with existing regulations and permit requirements; this list is not comprehensive:

(1) Import any such species into, or export any of the four plant species from, the United States.

(2) Remove and reduce to possession any of the four plant species from areas under Federal jurisdiction; maliciously damage or destroy any of the four plant species on any such area; or remove, cut, dig up, or damage or destroy any of the four plant species on any other area in knowing violation of any law or regulation of any State or in the course of any violation of a State criminal trespass law.

(3) Deliver, receive, carry, transport, or ship in interstate or foreign commerce, by any means whatsoever and in the course of a commercial activity, any of the four plant species.

(4) Sell or offer for sale in interstate or foreign commerce any of the four plant species.

(5) Introduce any nonnative wildlife or plant species to the State of Florida that compete with or prey upon *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* or *Argythamnia blodgettii*.

(6) Release any unauthorized biological control agents that attack any life stage of *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* or *Argythamnia blodgettii*.

(7) Manipulate or modify, without authorization, the habitat of *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* or *Argythamnia blodgettii* on Federal lands.

Questions regarding whether specific activities would constitute a violation of section 9 of the Act should be directed to the Field Supervisor of the Service's South Florida Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**). Requests for copies of regulations regarding listed species and inquiries about prohibitions and permits should be addressed to the U.S. Fish and Wildlife Service, Ecological Services Division, Endangered Species Permits, 1875 Century Boulevard, Atlanta, GA 30345 (phone 404–679–7140; fax 404–679–7081).

If *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* are listed under the Act, the State of Florida's Endangered Species Act (Florida Statutes 581.185) is automatically invoked, which would also prohibit take of these plants and encourage conservation by State government agencies. Further, the State may enter into agreements with Federal agencies to administer and manage any area required for the conservation, management, enhancement, or protection of endangered species (Florida Statutes 581.185). Funds for these activities could be made available under section 6 of the Act (Cooperation with the States). Thus, the Federal protection afforded to these plants by listing them as endangered species would be reinforced and supplemented by protection under State law.

Activities that the Service believes could potentially harm these four plants include, but are not limited to:

(1) Actions that would significantly alter the hydrology or substrate, such as ditching or filling. Such activities may include, but are not limited to, road construction or maintenance, and residential, commercial, or recreational development.

(2) Actions that would significantly alter vegetation structure or composition, such as clearing vegetation for construction of residences, facilities, trails, and roads.

(3) Actions that would introduce nonnative species that would significantly alter vegetation structure or composition. Such activities may include, but are not limited to, residential and commercial development, and road construction.

(4) Application of herbicides, or release of contaminants, in areas where these plants occur. Such activities may include, but are not limited to, natural resource management, management of right of ways, residential and commercial development, and road construction.

Critical Habitat

Section 3(5)(A) of the Act defines critical habitat as ''(i) the specific areas within the geographical area occupied by the species, at the time it is listed * * * on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed upon a determination by the Secretary that such areas are essential for the conservation of the species. Section 3(3) of the Act defines conservation as to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to the Act are no longer necessary.''

Section 4(a)(3) of the Act, as amended, and implementing regulations (50 CFR 424.12), require that, to the maximum extent prudent and determinable, the Secretary will designate critical habitat at the time the species is determined to be an endangered or threatened species. Our regulations (50 CFR 424.12(a)(1)) state that the designation of critical habitat is not prudent when one or both of the following situations exist:

(1) The species is threatened by taking or other human activity, and identification of critical habitat can be expected to increase the degree of threat to the species, or

(2) Such designation of critical habitat would not be beneficial to the species.

There is currently no imminent threat of take attributed to collection or vandalism under Factor B for these species, and identification and mapping of critical habitat is not expected to initiate any such threat. Therefore, in the absence of finding that the designation of critical habitat would increase threats to a species, if there are

any benefits to a critical habitat designation, a finding that designation is prudent is warranted. Here, the potential benefits of designation include: (1) Triggering consultation under section 7 of the Act, in new areas for actions in which there may be a Federal nexus where it would not otherwise occur because, for example, it is unoccupied; (2) focusing conservation activities on the most essential features and areas; (3) providing educational benefits to State or county governments or private entities; and (4) preventing people from causing inadvertent harm to these species.

Because we have determined that the designation of critical habitat will not likely increase the degree of threat to the species and may provide some measure of benefit, we determine that designation of critical habitat is prudent for *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii*.

Our regulations (50 CFR 424.12(a)(2)) further state that critical habitat is not determinable when one or both of the following situations exists: (1) Information sufficient to perform required analysis of the impacts of the designation is lacking; or (2) the biological needs of the species are not sufficiently well known to permit identification of an area as critical habitat. On the basis of a review of available information, we find that critical habitat for *Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum, Linum arenicola,* and *Argythamnia blodgettii* is not determinable because the specific information sufficient to perform the required analysis of the impacts of the designation is currently lacking.

Required Determinations

Clarity of the Rule

We are required by Executive Orders 12866 and 12988 and by the Presidential Memorandum of June 1, 1998, to write all rules in plain language. This means that each rule we publish must:

(1) Be logically organized;

(2) Use the active voice to address readers directly;

(3) Use clear language rather than jargon;

(4) Be divided into short sections and sentences; and

(5) Use lists and tables wherever possible.

If you feel that we have not met these requirements, send us comments by one of the methods listed in the **ADDRESSES** section. To better help us revise the rule, your comments should be as specific as possible. For example, you should tell us the numbers of the sections or paragraphs that are unclearly written, which sections or sentences are too long, the sections where you feel lists or tables would be useful, etc.

National Environmental Policy Act (42 U.S.C. 4321 et seq.)

We have determined that environmental assessments and environmental impact statements, as defined under the authority of the National Environmental Policy Act, need not be prepared in connection with listing a species as an endangered or threatened species under the Act. We published a notice outlining our reasons for this determination in the **Federal Register** on October 25, 1983 (48 FR 49244).

References Cited

A complete list of references cited in this rulemaking is available on the Internet at *http://www.regulations.gov* and upon request from the South Florida Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

Authors

The primary authors of this proposed rule are the staff members of the South Florida Ecological Services Field Office.

List of Subjects in 50 CFR Part 17

Endangered and threatened species, Exports, Imports, Reporting and recordkeeping requirements, Transportation.

Proposed Regulation Promulgation

Accordingly, we propose to amend part 17, subchapter B of chapter I, title 50 of the Code of Federal Regulations, as set forth below:

PART 17—[AMENDED]

■ 1. The authority citation for part 17 continues to read as follows:

Authority: 16 U.S.C. 1361–1407; 1531–1544; and 4201–4245, unless otherwise noted.

■ 2. Amend § 17.12(h) by adding entries for *Argythamnia blodgettii, Chamaecrista lineata* var. *keyensis, Chamaesyce deltoidea* ssp. *serpyllum,* and *Linum arenicola,* in alphabetical order under FLOWERING PLANTS, to the List of Endangered and Threatened Plants to read as set forth below:

§ 17.12 Endangered and threatened plants.

* * * * *

(h) * * *

Species		Historic range	Family	Status	When listed	Critical habitat	Special rules
Scientific name	Common name						
FLOWERING PLANTS							
*	* *	*	*		*		*
Argythamnia blodgettii	Blodgett's silverbush	U.S.A. (FL)	Euphorbiaceae.	T		NA	NA
*	* *	*	*		*		*
Chamaecrista lineata var. *keyensis*.	Big Pine partridge pea	U.S.A. (FL)	Fabaceae	E		NA	NA
*	* *	*	*		*		*
Chamaesyce deltoidea ssp. *serpyllum*.	Wedge spurge	U.S.A. (FL)	Euphorbiaceae.	E		NA	NA
*	* *	*	*		*		*
Linum arenicola	Sand flax	U.S.A. (FL)	Linaceae	E		NA	NA
*	* *	*	*		*		*

* * * * *

Dated: September 9, 2015.

Stephen Guertin,

Acting Director, U.S. Fish and Wildlife Service.

[FR Doc. 2015–24291 Filed 9–28–15; 8:45 am]

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