

Cordia bellonis
(no common name)

**5-Year Review:
Summary and Evaluation**

**U.S. Fish and Wildlife Service
Southeast Region
Caribbean Ecological Services Field Office
Boquerón, Puerto Rico**



**Flower of Cordia bellonis.
Photo by Omar Monsegur (USFWS)**

5-YEAR REVIEW
***Cordia bellonis* (no common name)**

I. GENERAL INFORMATION

- A. Methodology used to complete the review:** On September 27, 2006, the U.S. Fish and Wildlife Service (Service) published a notice in the *Federal Register* (71 FR 56545) announcing the 5-year review of the plant *C. bellonis*. The notice requested new information concerning the biology and status of the species and a 60-day public comment period was opened. No information was received from the public during that period.

This 5-year review was prepared by a Service biologist and summarizes the best available information that the Service has gathered on the species. The sources of information used for this review included the original listing rule for the species, its recovery plan, distribution and status reports on the plant, and published literature. The most updated information on the species consists of a master thesis by Sánchez-Cuervo (2006) and a recent research paper (2014) based on Sánchez-Cuervo work. Since this review was completed by some of the only known experts for the species, we did not seek additional peer review.

B. Reviewers

Lead Region: Kelly Bibb, Southeast Region, Atlanta, Georgia. (404) 679-7132.

Lead Field Office: Omar A. Monsegur Rivera, Caribbean Ecological Services Field Office, Boquerón, Puerto Rico, (787) 851-7297, extension 217.

C. Background

- 1. Federal Register Notice citation announcing initiation of this review:** September 27, 2006; 71 FR 56545
- 2. Species Status:**
As of the date of the publication of this 5-year review, we believe the status of *C. bellonis* is improving. The species is currently known from the Maricao, Susúa and Río Abajo Commonwealth Forests, and also extends along some localities within the northern moist karst region of Puerto Rico. The majority of the impacts to the species occur as part of trails and roads maintenance (particularly at the Maricao Commonwealth Forest). However, based on the latest assessments on the species' distribution, it is more common and

widespread within the Maricao and Río Abajo Commonwealth Forests than previously thought.

3. **Recovery Achieved** 3 (50-75 % of species' recovery objectives achieved).

4. **Listing History**

Original Listing

FR notice: 62 FR 1644

Date listed: January 10, 1997

Entity listed: species

Classification: endangered

5. **Review History:**

The January 10, 1997 final rule (62 FR 1644) and the Recovery Plan for *C. bellonis* approved and signed on October 1, 1999 (Service 1999) are the most recent comprehensive analyses of the species' status and are used as the reference point documents for this 5-year review.

At the time of listing, *C. bellonis* was known from three different locations: Maricao, Río Abajo, and Susúa Commonwealth Forests. Approximately 210 individuals were reported from these locations: 87 in Maricao, 118 in Río Abajo, and 5 in Susúa (Service 1999). The Recovery Plan for *C. bellonis* (Plan) includes the species' description and information about distribution and abundance, habitat, reproductive biology, and status of the species. Hence, the information included in the plan will not be repeated in this review. The Plan identifies habitat destruction and modification as the most significant factors affecting the numbers and distribution of the species.

Each year, the Service reviews and updates listed species information to benefit the required Recovery Report to Congress. Through 2013, we did a recovery data call that included showing status recommendations, such as "Stable" or "Improving" for this plant. We continue to show that species status recommendation as part in our 5-year reviews. The most recent evaluation for this plant was completed in 2016.

6. **Species' Recovery Priority Number at start of review (48 FR 43098):** 5

At the time of listing, *C. bellonis* was recognized as a species with high degree of threat and low recovery potential.

7. **Recovery Plan:**
Name of plan: Recovery Plan for *Cordia alliodora*
Date issued: October 1, 1999

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

The Endangered Species Act (Act) defines species to include any distinct population segment of any species of vertebrate wildlife. This definition limits listing as distinct population segments (DPS) only to vertebrate species of fish and wildlife. Because the DPS policy is not applicable to plant species, it is not further addressed in this review.

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? The species has an approved recovery plan establishing delisting as the recovery objective. However, we still need to determine if the establishment of new populations or enhancement of existing populations is needed for the recovery of the species. If these actions are needed, the Service needs to establish the number of individuals that comprise a sustainable population.

2. Adequacy of recovery criteria.

a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?

No. The plan does not include up-to-date information about the species' biology, distribution and abundance. Knowledge about the spatial distribution and biology for the species has increased substantially since the time of listing.

b. Are all the 5 listing factors that are relevant to the species addressed in the recovery criteria (and there is no new information to consider regarding existing or new threats?)

Yes. All listing factors that were considered threats at the time of listing are addressed in the recovery criteria.

3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information. For threats-related recovery criteria, please note which of the 5 listing factors are addressed by that criterion. If any of the 5 listing factors is not relevant to this species, please note that here.

The plan established two delisting criteria for *C. bellonis*:

1. A management plan that considers the protection and recovery of the species has been prepared and implemented for the Maricao, Susúa, and Río Abajo Commonwealth Forests.
2. New populations (the number of which should be determined following the appropriate studies) capable of self perpetuation have been established within the protected areas.

Criterion 1 has been partially met. The Río Abajo Commonwealth Forest has an approved management plan that recognizes the presence of *C. bellonis* within the forest and highlights the conservation of this species. The Maricao and Susúa Commonwealth Forests do not have an approved management plan. Nonetheless, these forests are managed for conservation, and the prime habitat for *C. bellonis* is protected. Furthermore, Puerto Rico Department of Natural and Environmental Resources (PRDNER) listed *C. bellonis* as endangered, and included it as part of their list of critical elements. Thus, the species is supposed to receive special consideration when evaluating development actions within its suitable habitat. Nonetheless, further coordination between the PRDNER and the Service is needed to improve the long term monitoring of natural populations, and to develop guidelines on the management (propagation and reintroduction) of *C. bellonis*. Since the species is not consistently monitored, adverse impacts to the populations may occur due to forest management practices (e.g., opening of new trails and research projects).

Criterion 2 has not been met. Attempts to establish new populations have been conducted at the Río Abajo and Susúa Commonwealth Forests. However, the little information available indicates that the attempts to translocate material rescued from the right of way of highway PR-10 were unsuccessful. According to Sánchez-Cuervo et al. (2014), these efforts did not result in a self-sustainable population and the majority of the plant material did not survive. Additionally, despite the propagation potential of *C. bellonis*, it is important to determine the minimum number of individuals to establish self-sustainable populations based on the species dioecious reproductive biology (separate sexes), and better define the criteria for the selection of reintroduction sites.

C. Updated Information and Current Species Status

1. Biology and Habitat

- a. **Is there relevant new information regarding the species' abundance, population trends, demographic features, or demographic trends? Yes.**

Species abundance: Approximately 210 individuals of *C. bellonis* were reported at the time the recovery plan for the species was approved in 1999. In 2006, Sánchez-Cuervo studied some aspects of the population and reproductive ecology of *C. bellonis* in the Maricao Commonwealth Forest. Her research also included a population assessment of the known populations at the Río Abajo and Susúa Commonwealth Forests. Research localities were selected based on previous studied areas by Drs. Breckon and Kolterman from the University of Puerto Rico, Mayagüez Campus (UPRM; 1993, 1994, and 1996), and information obtained from herbarium vouchers kept at the UPRM herbarium (MAPR). Thus, Sánchez-Cuervo's research focused on historical sites. Population survey efforts conducted by Sánchez-Cuervo included approximately 300 hours, mainly concentrated in the Maricao Commonwealth Forest. These surveys were conducted between June and December, 2004; January-December, 2005; and February 2006. Approximately 226 individuals of *C. bellonis* were reported by Sánchez-Cuervo (2006) from the Maricao (192), Río Abajo (34) and Susúa (0) Commonwealth Forest. However, initial surveys under an ongoing project between the Service, PRDNER and the Royal Botanical Garden (KEW) to determine the population status of *C. bellonis* (Coop. Agreement F15AC01225) shows that as of the day of this review there are at least 275 detected individuals within the Maricao (255) and Río Abajo Commonwealth Forest (20), with further surveys planed along the northern karst and the Susúa Commonwealth Forest (Hamilton 2017).

As the sections below detail, here is a summary from each Commonwealth Forest:

Maricao	Rio Abajo	<u>Susúa</u>
2006 – 192 individuals	1994 – 118 individuals	1992 – 5 individuals
2016 – 255	2006 – 34 individuals	2006 – none found

individuals	2012 – none found	2014 – none found
2017 – further surveys to proceed and more individuals are expected to be found	2016 – 34 individuals 2017 - further surveys to proceed and more individuals are expected to be found	Further surveys to proceed soon in this forest

Maricao Commonwealth Forest:

According to the data collected by Sánchez-Cuervo (2006), the highest concentration of individuals of *C. bellonis* was found within the Maricao Commonwealth Forest. A total of 84 adults and 108 seedlings were found in five main areas within the Maricao Commonwealth Forest, ranging from a single individual to small groups. From these 192 individuals, approximately 158 were reported as new individuals (non-registered in previous surveys by Breckon and Kolterman): 14 males (8.8%), 8 females (5.06%), 28 non-reproductive (no flower production during the study period) adults (17.72%), and 108 seedlings (63.35%). However, the latest surveys under Coop. Agreement F15AC01225 (2016-2017) detected at least 255 plants (different size classes) at Maricao, with the caveat that surveys were limited to accessible areas, and there are several watersheds with pristine vegetation and suitable habitat that remains unexplored, and thus the number of individuals is expected to be greater (Hamilton 2017). Further surveys under this agreement are planned to target these areas that remain unexplored.

Río Abajo Commonwelath Forest:

Cordia bellonis was unknown from the Río Abajo Commonwealth Forest until it was found in 1994 during the construction of road PR-10. Approximately, 118 individuals were found in 12 localities along the project right of way at that time. Ninety-five (82%) of these individuals were removed and transferred to the PRDNER tree nursery at the Cambalache Commonwealth Forest for future reintroduction in suitable sites (Puerto Rico Highway Transportation Authority, 1995). In February 1997, sixteen additional plants were removed from the project area for future reintroduction at the project mitigation site within the Río Abajo Commonwealth Forest. From these 111 individuals, only 61 survived at the Cambalache nursery, and were later introduced in four locations within the mitigation site at the Río Abajo Commonwealth Forest during 2002 and 2003. Only 34 of these individuals of *C. bellonis* were observed by Sánchez-Cuervo (2006) during her visits to the Río Abajo Commonwealth Forest in August 2004, and July and November, 2005. According to Sánchez-Cuervo et al. (2014) during a subsequent follow-up assessment in 2102 to follow up on the status of individuals

previously surveyed on 2006, no individuals were found, leading them to suggest a complete extirpation of the species from the Río Abajo Commonwealth Forest. However, the latest information available to the Service indicates that the species may be more common and widespread within the Río Abajo Commonwealth Forest than previously thought. This species has been recently recorded in this forest by the Service at Los Puercos, Las Perdices, and Santa Rosa Power Station (O. Monsegur, Service, 2008-2015, pers. obs.). These observations included reproductive material (flowering plants) and several seedlings, and these records were not associated to previously known sites or the mitigation areas from the construction of road PR-10. Moreover, the recent surveys (2016-2017) under Coop. Agreement F15AC01225 recorded at least 20 plants (different size classes) at several sites within the Río Abajo Commonwealth Forest, thus confirming the species still occurs within this protected area (Hamilton 2017). One of the individuals was located at one of the reintroduction sites of material translocated from PR-10. As the case of the Maricao Commonwealth Forest, there is plenty of suitable habitat at the Río Abajo Commonwealth Forest that remains unexplored and further surveys are planned.

Susúa Commonwealth Forest:

The species was reported for the first time in the Susúa Commonwealth Forest in 1992 where a small population of 5 individuals was recorded (Breckon and Kolterman 1993). This area was also visited by Sánchez-Cuervo (2006) and (Sánchez-Cuervo et al. 2014) but no individuals of *C. bellonis* were found. Since these assessments were limited to the previously known locality, the Service cannot conclude the species is extirpated from the Susúa Commonwealth Forest. There is plenty of suitable habitat for the species within this forest, and the areas have not been properly surveyed. Habitat conditions at the northernmost boundaries of the Susúa Commonwealth Forest are similar to Maricao Forest, and surveys of suitable habitat are planned for 2017 under Coop. Agreement F15AC01225.

Population trends: As reported by Sánchez-Cuervo (2006), the number of populations of *C. bellonis* in historical areas (within these three Commonwealth Forests) showed a considerable overall reduction (68%) between 1990 and 2005. According to her population estimates, the Maricao population was reduced 61%. The adult population once reported along road PR-120 was reduced by 38%, and the one reported close to the Maricao fish hatchery was reduced by 91%. In addition, the individuals (21) once reported from

road PR-362, also in Maricao were not found. Other areas such as the trail to “Casa de Piedra” (2 plants), and the Maricao River area (11 plants) following the same route previously reported by Breckon and Kolterman (1993), were also visited but not found, except for one individual in the Maricao River location. Although Sánchez-Cuervo (2006) reported a population reduction in the Maricao Commonwealth Forest, her results indicate a reduction only from historical locations (traditional sites) previously reported by Breckon and Kolterman (1993). Breckon and Kolterman reported *C. bellonis* from 17 localities in three main areas within the forest. The data presented by Sánchez-Cuervo (2006) indicates that the species is currently present in 46 localities in 5 main areas of the forest, and thus it is more widespread within the forest. Nevertheless, it is important to highlight that this reduction from the historical sites may be the result of the biology of the species. *Cordia* species are considered early colonizers and gap species, so a reduction in the number of individuals may be anticipated as the vegetation develops and the canopy closes. Moreover, the scrambling growth form (vine growing over other trees) of *C. bellonis* makes it difficult to detect the species once it reaches the canopy. In fact, the ongoing surveys under Coop. Agreement F15AC01225 indicate that the species remains present at the areas surveyed by Sánchez-Cuervo over a decade ago (Hamilton 2017). As of the date of this review the Service has no evidence of a population decline or extirpation of natural populations within the last decade.

According to Sánchez-Cuervo (2006), population trend studies conducted in Río Abajo showed that, based on the amount of individuals (118) originally reported for this locality during the 1990s, *C. bellonis* has decreased by 71%, based on the amount of individuals (118) originally reported for the Río Abajo area during the 1990s. Sánchez-Cuervo (2006) found that the number of individuals transplanted to the mitigation areas in Río Abajo decreased by 44% when compared to the original amount of individuals (61) transplanted at Río Abajo Commonwealth Forest and the amount of plants (34) found by her in 4 locations during the study period. Moreover, a follow-up assessment of this area in 2012 resulted in no individuals found (Sánchez-Cuervo et al. 2014). The overall decline of this species in Río Abajo might be associated with the construction of highway PR-10, and the translocation of plant material originally located along the construction right-of-way. Nonetheless, Service biologist O. Monsegur documented seedlings of *C. bellonis* along the dirt road that goes from the entrance to the José Vivaldi aviary to the Santa Rosa power station within the Río Abajo Commonwealth Forest (O. Monsegur, Service, 2008-2015, pers. obs.). O. Monsegur also found several mature individuals in other areas of this forest that

harbors remnants of native vegetation (i.e., Las Perdices wetland and Los Puercos trail). The current surveys under Coop. Agreement F15AC01225 confirmed the observations by O. Monsegur (2008-2015), and also documented the species at one of the reintroduction sites from material transplanted due to construction of highway PR-10. The study by Sánchez-Cuervo (2006) does not account for several new localities discovered within the municipalities of Ciales and Utuado, expanding the range of the species outside the boundaries of the Río Abajo Commonwealth Forest. The mogotes (haystack hills) from Utuado to Ciales includes an outstanding amount of habitat for the species that remains unsurveyed for the species.

Regarding the *C. bellonis* population originally reported for the Susúa Commonwealth Forest, Sánchez-Cuervo (2006) reported it as extirpated. However, she limited her surveys to the historically known population, and thus her study does not account as a comprehensive survey of the species suitable habitat at Susúa.

As stated above, the Service currently has an ongoing project in collaboration with the PRDNER and KEW to determine the population status and for gene bank development of *C. bellonis* (Coop. Agreement F15AC01225). Under this project, the species has been relocated along the traditional sites surveyed by Sánchez-Cuervo (2006), and further new localities have been identified at the Maricao and Río Abajo Commonwealth Forest, showing the species is more common than originally anticipated and that populations are stable (Hamilton 2017). This project also partners with the PR Parrot project at the Maricao Commonwealth Forest, and monitoring (2012-present) of the individuals along “Los Viveros Trail” show a stable population with evidence of natural recruitment.

Demographic features: Studies on the population structure conducted by Sánchez-Cuervo (2006) indicate that from the 226 individuals reported for the Maricao (192) and Río Abajo (34) forests, 9.73% were females, 13.27% males, 29.20% non-reproductive, and 47.78% were seedlings. Specific distribution in Maricao was reported as 10.93% (21) females, 15.62% (30) males, 17.18% non-reproductive individuals, and 56.25% seedlings. Sánchez-Cuervo (2006) determined that the proportion of sexes was not significantly different from 1:1. However, she assumed that this proportion could change if sexes of non-reproductive individuals are determined. According to an analysis of the spatial distribution of sexes, there is no evidence indicating that sexes are spatially distributed (distribution coefficient $S=0.0047$) (Sánchez-Cuervo, 2006).

Only one female was found in the Río Abajo Commonwealth Forest by Sánchez-Cuervo (2006). At the time of her study, the rest of the population (33) was composed of non-reproductive individuals and no seedlings were observed. However, as mentioned above, the Service documented several seedlings and adult individuals in the Río Abajo Commonwealth Forest, indicating that natural recruitment is occurring (O. Monsegur, Service, 2008-2015, pers. obs.). Recent surveys (2016-2017) by the Service, PRDNER and KEW (Coop. Agreement F15AC01225) also recorded juvenile plants along “Las Perdices Trail” showing further evidence of natural recruitment (Hamilton 2017).

Sánchez-Cuervo (2006) also made observations on mortality of seedlings found under the canopy of *C. bellonis* female plants from June 2004 to February 2006 at the Maricao Commonwealth Forest. The amount of seedlings recorded for this area (108) varied due to mortality events. In June 2004, 59 seedlings were found. This amount increased in April 2005 when 49 additional seedlings were observed, but only 19 survived (Sánchez-Cuervo 2006). Data on the recruitment of new plants was also collected during this period. According to Sánchez-Cuervo (2006), recruitment does not occur every year. She noted that no recruitment occurred in February 2004 in known localities compared to 2005. The recruitment period occurred during the short dry season and the beginning of the rainy season. According to her observations, recruitment occurs in one or two months around the fructification period (February) suggesting a short latency period.

Seedling mortality was high (46%) due to natural causes (31%) and to human-induced disturbance (16%), as well. Between April and August 2005 (rainy season), the mortality rate was low compared to observations made in February 2006 (dry season) when the highest seedling mortality rate was registered (Sánchez-Cuervo 2006). Thus, seedling mortality is likely the result of water stress during droughts. Although germination season seems to be adequate, a lot of seeds did not germinate due to desiccation (or hydrologic stress). This finding is consistent with the observation by Service biologist O. Monsegur (2012), who found a germination success of less than 5% under nursery conditions.

Species phenology: Phenology studies were also conducted by Sánchez-Cuervo (2006) in reproductive individuals of the Maricao population. Observations were made from August 2004 to February 2005, and from August through November 2005. Information regarding the amount of individuals with buds and flowers, in addition to data collected regarding the amount or number of plants

with mature and/or immature fruits, was collected during this period. In general, the flowering period of *C. bellonis* occurs during the rainy season. According to Sánchez-Cuervo's observations, phenology behavior was very similar between years 2005 and 2004 with a slight difference in the amount of individuals with buds, flowers, and immature fruits for the same seasons. No information regarding flower production in each sex was recorded due to the amount and size of the flowers and the height of the branches.

The fructification period was recorded from the end of the rainy season and continues until the dry season (September-February). Immature fruits were synchronic from October to December and mature fruits from November to January. Sánchez-Cuervo (2006) was not able to quantify the amount of flowers and fruits per plant, however, she indicated that fruit production was minimal compared to flower production. Observations made on female individuals indicate that fruits in *C. bellonis* plants mature unequally. Female plants were seen with mature and immature fruits at the same time, and all fruits were single seeded. No evidence of fructification was observed in any male individuals (Sánchez-Cuervo 2006).

Sánchez-Cuervo (2006) also conducted diurnal and nocturnal observations during the flowering period from August to November 2004 in 3 females and 6 males to document the presence of floral visitors or pollinators. She documented 4 species of insects visiting the flowers. The most frequent visitor was a moth from the Noctuidae family (Lepidoptera), and the second most abundant species of visitor was the honey bee (*Apis mellifera* L. (Hymenoptera: Apidae)). Other two species from the Syrphidae (fly) and Pompilidae (wasp) families were also recorded. Sánchez-Cuervo (2006) also collected some specimens of the visitors to determine the presence of pollen in their bodies. Since no pollen from *C. bellonis* was detected on any insect part, it was not possible to determine the presence of a "true" pollinator for the species. These visitors caused no harm to the floral parts and there was no preference to visit either male or female plants.

Sánchez-Cuervo (2006) conducted diurnal and nocturnal observations in Maricao during the fructification period of November 2005 to determine the potential seed dispersal agents for *C. bellonis*. Her observations indicated that the majority of the fruits matured in the plant until the pericarpus (wall of the ripened fruit) was colonized or invaded by fungus and fell directly on the floor. The majority of seedlings observed were found under the canopy of female plants. According to Sánchez-Cuervo (2006), seed dispersal could be carried out by birds because of the pericarpus morphology and color of the fruit.

Sánchez-Cuervo (2006) carried out germination experiments to determine light conditions, percent of viability and mortality, and average monthly growth of seeds. A total of 60 pre-treated seeds were collected from 6 female individuals and planted in different shade conditions in January 2005. No germination occurred after three months. Further efforts were made, but no seed germinated during her experiments. Failure was attributed to two possible factors: inadequacy of substrate for planting, and low viability of seeds. Further germination trials by Service biologist O. Monsegur (2012) suggest it is very likely that the species shows a low seed viability, or may require seed scarification to germinate.

Data to obtain information on average monthly growth was collected by Sánchez-Cuervo (2006) from 40 seedlings which germinated approximately in February and March 2005 after the previous fructification season (September 2004-February 2005). Seedlings grew an average of 0.46 cm from April to May and presented an average height of 3.23 cm at the beginning of the observation period (April 2005). The highest growth rate (0.83) and an average height (5.44 cm) were recorded in October, during the rainy season. Data from material germinated at the tree nursery of the Cabo Rojo National Wildlife Refuge indicated that individuals may develop into reproductive plants in less than 2 years if maintained under nursery conditions (O. Monsegur, Service, 2012, pers. obs.).

b. Is there relevant new information regarding the species' genetics, genetic variation, or trends in genetic variation (e.g. loss of genetic variation, genetic drift, inbreeding, etc.)?

There is no new information on the genetics, genetic variation, or trends in genetic variation of *C. bellonis*.

c. Is there relevant new information regarding taxonomic classification or changes in nomenclature?

Cordia bellonis was traditionally lumped into the genus *Cordia*, a group of approximately 250 or more species of trees and shrubs of tropical and subtropical regions. However, recent taxonomical treatments recognized *Varronia* as a monophyletic group based on vegetative, floral, and pollen morphology (Miller and Gottschling 2007). *Varronia* comprises multi-stemmed shrubs with condensed inflorescence and evenly serrate leaves (Sánchez de Stapf 2010). *Varronia* is currently represented in the West Indies by about 66 valid species (Acevedo-Rodríguez and Strong 2012). Axelrod (2011) recognized seven species found in Puerto Rico, with *V. bellonis* and

V. wagnerorum being endemic to the Island, and *V. rupicola* extending to the island of Anegada, in British Virgin Islands. For the purposes of this document, we will continue using the name (*C. bellonis*) as it was published at the time of listing.

- d. **Is there relevant new information regarding the species' spatial distribution, trends in spatial distribution, or historic range (e.g. corrections to the historical range, change in distribution of the species within its historic range, etc.)? Yes.**

At the time of listing, the species was known from three localities: Maricao, Río Abajo, and Susúa Commonwealth Forests. Sánchez-Cuervo (2006) studies were conducted in these three historical locations. Within these areas, the species remains segregated, finding solitary individuals in some localities and aggregates of plants comprised by no more than eleven individuals in other areas, but according to Sánchez-Cuervo (2006) observations during her visits to the Susúa Commonwealth Forest, the population (5 plants) once reported in 1992 was not present. Moreover, Sánchez-Cuervo et al. (2014) also suggested the species may be extirpated from the reintroduction sites at Río Abajo Commonwealth Forest. However, in the case of Río Abajo, the species have recently been recorded by the Service in nontraditional sites (i.e., Los Puercos trail, Las Perdices trail, and Santa Rosa Power Station). Moreover, recent surveys (2016-2017) under the ongoing collaboration between the Service, PRDNER and KEW identify further new localities at the Maricao and Río Abajo Commonwealth Forest (Coop. Agreement F15AC01225) (Hamilton 2017). The initial findings from this effort indicate the species is more common and widespread within these forests, but the scrambling growth form of the species requires greater efforts to detect the individuals.

Moreover, the latest available information to the Service from herbarium collections (MAPR, SJ and UPRRP) shows that the species has been collected in the municipality of Ciales and Utuado within similar habitat to the Río Abajo Commonwealth Forest. Both sites occur on moist limestone substrate along the northern karst region, expanding the species range outside the boundaries of the Río Abajo Commonwealth Forest. It is important to mention that botanical exploration at these new sites has been minimal, and there is a large amount of habitat that needs to be surveyed. Thus, the species is more widespread along the northern karst region of Puerto Rico.

- e. **Is there a relevant new information addressing habitat or ecosystem condition (e.g. amount, distribution, and suitability of the habitat or ecosystem)? Yes.**

Some ecological characteristics of female plants in the Maricao population were studied by Sánchez-Cuervo (2006). Soil samples under the canopy of female plants with and without seedlings were taken to determine the occurrence of any factor that may influence the presence/absence of seedlings and its survival. Soils were analyzed for organic matter, phosphorus content, and pH. The results showed no significant differences in soil content and pH. These results seem to indicate that none of these factors determine seedling establishment.

Soil samples under the canopy of female plants of *C. bellonis* were also analyzed for seed bank formation. Observations made indicate that this species do not form seed banks possibly due to soil depth (low profile). Soil type may also influence the establishment of seed banks under *C. bellonis* plants. Seed producers were found in serpentine soils and Nipe and Rosario soil series. These soils are characterized by their clay-like and sticky texture, which can make the seed emergence to the soil surface difficult. However, seedbank formation may not be discarded as it has been documented for other related species such as *V. rupicola*, and this may represent a strategy to colonize areas or colonize gaps when conditions are favorable.

f. Is there any other relevant information on species?

Additional studies on population structure and population size included the estimation of basal diameter of plants. Reproductive adults registered a larger size distribution (1.3-2.85 cm). Data collected to compare basal diameter showed no significant differences among sexes, although according to Sánchez-Cuervo (2006) observations, male plants tend to have a smaller basal diameter if compared to female plants. Basal diameter measurements were significantly different among non-reproductive and reproductive individuals. Sánchez-Cuervo (2006) was not able to determine age at first maturity through size distribution. However, at Maricao reproductive plants were recorded from 0.5 cm basal diameter. Nonetheless, recent observations by Service biologist O. Monsegur indicate that material propagated and maintained under nursery conditions at the Cabo Rojo National Wildlife Refuge may reach reproductive size within two years. This observation is consistent with the reproductive biology of an early colonizer or gap adapted species.

2. Five Factor Analysis

(a) Present or threatened destruction, modification, or curtailment of its habitat or range:

When the species was listed in 1997, destruction and modification of its habitat was identified by the Service as the most significant factor affecting the amount and distribution of *C. bellonis*. The species' rarity and restricted distribution makes it vulnerable to habitat destruction and modification. In general, the species is adapted to survive in secondary successions and other zones directly or indirectly altered by human activities like fire or tree felling. *Cordia bellonis* grows on road edges and trails, in open, exposed areas since the light exposure seems to be an important factor for the flower production of the species (Sánchez-Cuervo 2006), and all available information indicates the species is a gap colonizer. The species' location along road margins makes it vulnerable to impacts associated to road management activities. According to Sánchez-Cuervo (2006), during 2004 and 2005, road maintenance activities were performed at least six times in the Maricao forest, notably affecting the individuals closer to road edges. These were reproductive individuals and seedlings. Sánchez-Cuervo (2006) indicated that 46% of these *C. bellonis* individuals were at risk of being totally eliminated due to their proximity to road edges and trails, 35% were exposed to cutting of some branches, while 19% did not present any risk at all.

Nonetheless, the latest surveys (2016-2017) by the Service, PRDNER and KEW (Coop. Agreement F15AC01225) have detected the species along multiple areas along PR-120 at the Maricao Commonwealth Forest (Hamilton 2017). These initial findings indicate the species has not been extirpated from the areas surveyed by Sánchez-Cuervo (2006), and the Service is developing a comprehensive assessment of the species and implementing a long term monitoring project. Moreover, there is an outstanding amount of habitat that remains unexplored and undisturbed, and the Service has recently identified new localities of *C. bellonis* within remote and inaccessible remnants of pristine habitat (not associated to disturbed sites or roads) in the Maricao (i.e., Maricao and Bonelli Rivers Watersheds) and Río Abajo (i.e., Las Perdices and Los Puercos Trail) Commonwealth Forests. Thus, at present time the Service considers the habitat modification as a low and non-imminent threat.

(b) Overutilization for commercial, recreational, scientific or educational purposes:

At the time of listing, taking for these purposes were not documented as a factor responsible for the decline of the species. Based on the best available information, we continue to consider that the species is not threatened by this factor.

(c) Disease or predation:

At the time of listing, disease or predation were not considered a threat to *C. bellonis*. Based on the best available information, we continue to consider that the species is not threatened by this factor.

(d) Inadequacy of existing regulatory mechanisms:

At the time of listing *C. bellonis* was not on the list of species protected by the Commonwealth of Puerto Rico. The inadequacy of existing regulatory mechanism was considered as a threat.

The Maricao, Río Abajo and Susúa Commonwealth Forests are protected by Law No.133 (12 L.P.R.A. sec. 191) 1975, as amended, known as *Ley de Bosques de Puerto Rico* (Forest Law of Puerto Rico), as amended in 2000. Section 8 (A) of Law No. 133, prohibits cutting, killing, destroying, uprooting, extracting, or in any way hurting any tree or vegetation within a Commonwealth forest without authorization from the Secretary of the PRDNER. These forests are also designated as Critical Wildlife Areas (CWA) by the Commonwealth of Puerto Rico. The CWA designation constitutes a special recognition by the local government with the purpose of providing information to Commonwealth and Federal agencies about the conservation importance and needs of CWAs, and assisting permitting agencies in precluding negative impacts as a result of permit approvals or endorsements (PRDNER 2005).

In 1999, the Commonwealth of Puerto Rico approved Law No. 241, known as *Nueva Ley de Vida Silvestre de Puerto Rico* (New Wildlife Law of Puerto Rico). The purpose of this law is to protect, conserve, and enhance both native and migratory wildlife species, declare as the property of Puerto Rico all wildlife species (including plants) within its jurisdiction, regulate permits, hunting activities, and exotic species, among other activities. This law also has provisions to protect habitat for all wildlife species. In 2004, the PRDNER approved Regulation 6766, *Reglamento para Regir el Manejo de las Especies Vulnerables y en Peligro de Extinción en el Estado Libre Asociado de Puerto Rico* (Regulation 6766 to Govern the Management of Threatened and Endangered Species in the Commonwealth of Puerto Rico). Article 2.06 of this regulation prohibits collecting, cutting, and removing, among other activities, listed plant individuals within the jurisdiction of Puerto Rico. *Cordia bellonis* was listed under Regulation 6766 as critically endangered.

The habitat of *C. bellonis* extends to private lands. The protection of this species within private properties continues to be a challenge as accidental damage or extirpation of individuals of federally listed species has

occurred due to lack of knowledge of the species by private landowners. However, at present we are unaware of any ongoing damage to *C. bellonis* in private properties. Therefore, based on the existence of Commonwealth and Federal laws and regulations protecting listed species, we believe the inadequacy of existing regulatory mechanisms is not a current threat to the species.

(e) Other natural or manmade factors affecting its continued existence:

Human-Induced Fires. Fire is not a natural event in subtropical dry or moist forests of Puerto Rico. The vegetation in the Caribbean is not adapted to fires, as this disturbance does not naturally occur on these islands, and in the case of Puerto Rico, it is usually associated with human activities (Brandeis and Woodall 2008, Santiago-García et al. 2008). Human-induced fires could modify the landscape by promoting non-native trees and grasses, and by diminishing the seed bank of native species (Brandeis and Woodall 2008). In some cases, fires may maintain extensive areas of young forest and grasslands, slowing the recovery (natural regeneration) of ecosystems, and therefore, impairing the delivery of ecosystem services (Brandeis and Woodall 2008). Furthermore, the presence of non-native grasses may increase the amount of fuel and the intensity of fires. Damage caused by fires to the ecosystems, particularly to juvenile plants and natural recruitment, might be irreversible.

The limited number of known populations and the low number of individuals per population makes some populations of *C. bellonis* vulnerable to human induced fires. However, this is only considered a threat along the drier southern slopes of the Maricao Commonwealth Forest (municipalities of San German and Sabana Grande), where scattered populations may occur. These areas have not been adequately surveyed for the species due the remoteness and inaccessibility of the habitat, and thus may harbor undetected populations of *C. bellonis*. In fact, in March 2005, Sánchez-Cuervo (2006) reported various wildland fires in the Maricao Commonwealth Forest. These fires did not directly affect any of the known *C. bellonis* populations because fires occurred in drier and lower southern slopes of the forest far away from the currently known populations (historically known sites). However, Sánchez-Cuervo (2006) indicated that road widening has occurred in areas where this species has been reported to transport equipment and personnel to the areas affected by fires. Based on the above information, the Service considers human-induced fires as a low and non-imminent threat to *C. bellonis*.

Hurricanes, Flooding, Landslides and Climate Change. As an endemic to the Caribbean, *C. bellonis* should be well adapted to tropical

storms disturbance. However, the low number of individuals per population poses a threat to the species by making it more susceptible to stochastic events such as hurricanes. Moreover, climate change is expected to increase the frequency and strength of tropical storms (Hopkinson et al. 2008). Vulnerability to climate change impacts is a function of sensitivity to those changes (e.g., changes rain regime and moisture availability), exposure to those changes, and adaptive capacity (e.g., capacity to colonize further available habitat) (Glick et al. 2011).

It was reported by Sánchez-Cuervo (2006) that the majority of *C. bellonis* individuals (10 of 11) previously reported by Breckon and Kolterman (1993) growing along the margins of the Río Maricao were extirpated by flooding events during Hurricane Georges (1998). Further monitoring by Service biologist O. Monsegur along this area has detected only a few individuals along the river margins. Moreover, natural landslides are common within serpentine soils along the Maricao and Susúa Commonwealth Forests, and it is expected that the frequency of this disturbance increases as a result of severe rain events. Thus, individuals of *C. bellonis* growing in steep slopes and low profile soils may be affected by landslides during heavy rain events.

Despite the low number of known populations and individuals, the Service considers hurricanes and landslides as a low and non-imminent threat to the species.

Reproductive Biology. As previously discussed *C. bellonis* is a dioecious species (having male and female plants apart). Therefore, distance between plants of *C. bellonis* and low number of individuals per population could be a limiting factor for the species. Sánchez-Cuervo (2006) observed that three female plants did not produce any fruits during 2004 and 2005. She noticed that one of these females was located 42.5 meters away from the closest male plant within the same area. Another plant was located 940.8 meters away from the closest male plant along that same road. In general, 47% of the females are located more than 100 meters away from their closest male plant and 52% are located less than 100 meters away from its closest male individual (range = 3.5-940.8m, median = 186.4m, s.d. = 241.7). The distance between plants, in terms of dispersal of the species' genetic material, is likely to be more important as a limiting factor than fruit dispersal (Breckon and Kolterman, 1993). Pollen flow, must necessarily involve two different plants and probably occurs only over a relatively short distances. Therefore, the distance between individuals may pose a threat to the species especially due to the dioecious breeding system of *C. bellonis*. In the case of isolated individuals, these would be incapable of reproducing and may be considered as functionally extinct populations. The above highlights the threats to the species by habitat fragmentation and the lack of

connectivity between populations. Since the majority of the species' habitat remains undisturbed and further populations have been discovered, the Service considers the species reproductive biology as a moderate and non-imminent threat to the species.

3. Synthesis

At the time of listing, *C. bellonis* was known from three different localities: Maricao, Susúa and the Río Abajo Commonwealth Forests. Approximately 210 individuals were reported from these forests: 87 in Maricao, 118 in Río Abajo, and 5 in Susúa. Sánchez-Cuervo (2006) updated population estimates in these areas and provided new relevant information about population structure, mortality and recruitment, phenology, floral visitors, seed dispersal agents, germination and average monthly growth of seedlings. According to her findings, the species may be extirpated from the Susúa Commonwealth Forest, and some historical locations in the Río Abajo and Maricao Commonwealth Forests were not located during her research. She reported 192 individuals in Maricao and 34 individuals in Río Abajo, for a total of 226 individuals in these two forests. Of the 192 individuals in Maricao, 158 were new or not previously reported, the majority of which were seedlings. It is important to highlight that Sánchez-Cuervo's (2006) research targeted historical populations previously reported by Breckon and Kolterman (UPRM). However, as mentioned earlier the initial surveys under the ongoing project between the Service, PRDNER and the Royal Botanical Garden to determine the population status of *C. bellonis* (Coop. Agreement F15AC01225) has identified at least 275 individuals of *C. bellonis* within the Maricao (255) and Río Abajo Commonwealth Forest (20), with further surveys planned along the northern karst and the Susúa Commonwealth Forest (Hamilton 2017). According to the latest information available to the Service the species is more widely distributed throughout the Maricao and Río Abajo Commonwealth Forests, and probably in the upper watershed of Río Loco in the Susúa Commonwealth Forest (Hamilton 2017). Service staff has also identified new populations within nontraditional sites at the Río Abajo Commonwealth Forest. Moreover, the distribution of the species in northern Puerto Rico has expanded, and now extends to the municipalities of Ciales and Utuado. Both in Maricao and Río Abajo forests, there is clear evidence of natural recruitment of the species, and different size classes (seedling, juveniles and adults) are present.

Destruction and modification of habitat continue to be a threat to the species. Sánchez-Cuervo's suggested that 46% of *C. bellonis* individuals are at risk to be totally eliminated due to its proximity to road edges and trails, and 35% are exposed to be affected by the cutting of branches. However, this threat is limited to historical localities located along road

and trails subject to maintenance within the Maricao Commonwealth Forest. Even so, the Service is not aware of a substantial decline in the number of individuals due to habitat modification. For example, monitoring of individuals over a period of 5 year (2012-2016) along “Los Viveros Trail” in the Maricao Commonwealth Forest showed no evidence of population decline or extirpation of the approximately 40 individuals known along the trail, and there is evidence of recruitment of new individuals. Moreover, these sites has been reevaluated as part of the ongoing monitoring (2016-2017), and confirming this population is stable (Hamilton 2017). These surveys have relocated the majority of the populations at the sites surveyed by Sánchez-Cuervo (2006) along PR-120, and found no extirpation has been recorded at these sites (Hamilton 2017).

Another factor that may pose a threat to *C. bellonis* is the distance between individuals because of the plant dioecious breeding system in which isolated individuals would be incapable of sexual reproduction. Distance between plants may limit the exchange of genetic material and pollen transfer. Nonetheless, as previously mentioned, recent surveys and observations indicate the species is more widespread and common within its habitat, and there is plenty of suitable habitat that may harbor undetected populations, and provides for the recovery of the species. Thus, the Service considers all the above mentioned threats as low and non-imminent. The Service is currently conducting a comprehensive survey of the species prime habitat in collaboration with other partners (PRDNER and KEW) in order to identify new populations and update the species distribution and abundance. Monitoring of the populations since 2010 has not recorded any population decline or unusual mortality of individuals at the known populations in the Maricao Commonwealth Forest, and the species has been located at several new localities within the Rio Abajo Commonwealth Forest.

III. RESULTS

A. Recommended Classification:

- ☒ Yes, downlisting to Threatened.
- ☐ Yes, uplisting to Endangered.
- ☐ Yes, delist.
- ☐ No, no change is needed.

As mentioned in this review, the species appears to be more widespread within its habitat. The prime habitat for *C. bellonis* is already protected, and is one of the best remnants of native vegetation in Puerto Rico. It is important to highlight that this species survived the almost entire deforestation of Puerto Rico with less than 6% of

remaining forested by the 1930s, compared to the current trend of over 50% of the island covered by forest. The original low number of individuals and mortality associated to habitat disturbance appear to be a bias toward a convenience sampling along roads and trails. The prime habitat for the species occurs on steep topography and inaccessible sites. The Service is currently conducting a thorough sampling of the habitat to update the species distribution and abundance, and collecting samples for a population genetic study. The ongoing research includes the development of a habitat suitability model to determine the extant amount of suitable habitat and to identify areas that need to be surveyed. Based on the low and non-imminent threats and the above mentioned conditions, the best information available indicates the species is not on the brink of extinction and therefore, does not meet the definition of an endangered Species.

B. New Recovery Priority Number: 14.

Based on the information gathered for this review, we believe that *C. bellonis* has a low degree of threat and high recovery potential. Despite its dioecious reproductive biology, it is feasible to propagate the species, and one of the outcomes of the ongoing fieldwork is the identification of reproductive female individuals. Thus, a propagation protocol and program considering the species population genetics may be developed in the near future.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- a. The PRDNER and the Service should develop a comprehensive survey program to inventory areas with potential habitat for *C. bellonis* in Río Abajo, Susúa and Maricao Commonwealth Forests.
- b. Studies should be conducted to determine the patterns of genetic variation within and among populations in order to develop a plan to preserve the species genetic variability.
- c. Development of a habitat suitability model for the species.
- d. Development of management plans or establishment of management practices in areas where the species occur to avoid and/or minimize impacts by road or trails maintenance activities.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Cordia alliodora* (no common name)

Current Classification Endangered

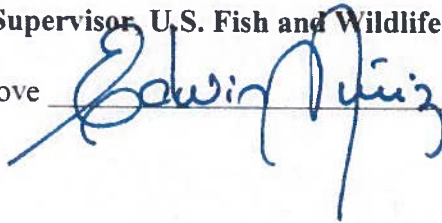
Recommendation resulting from the 5-Year Review

- ☒ **Downlist to Threatened**
☐ **Uplist to Endangered**
☐ **Delist**
☐ **No change is needed**

Review Conducted By Omar Monsegur, Caribbean Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve  Date April 3, 2017

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve  Date 6/13/12