

Galium buxifolium
(island bedstraw)

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



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Ventura Fish and Wildlife Office
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5-YEAR REVIEW

Galium buxifolium (island bedstraw)

I. GENERAL INFORMATION

Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

Species Overview:

As summarized from the recovery plan for this species (Service 2000), *Galium buxifolium* (island bedstraw) is a small, stout, woody subshrub in the madder family (Rubiaceae). It is restricted to Santa Cruz and San Miguel Islands off the coast of southern California, where it occurs on north-facing sea cliffs in coastal sage scrub and island pine forest. There are currently 21 known populations of *G. buxifolium* on Santa Cruz Island and 5 known populations on San Miguel Island (McEachern et al. 2008). Little is known about this species' biology; however, botanists have begun to study the unique floral biology of *G. buxifolium* at individual sites on Santa Cruz Island (McEachern 2008, Wilken pers. comm. 2009). The species is threatened by soil loss and erosion resulting from years of feral pig rooting and sheep grazing, and by loss of habitat to non-native, invasive plants. *Galium buxifolium* is also threatened by extinction from random naturally occurring events and those resulting from climate change due to its limited distribution and small population size. The species' unique floral biology (skewed sex ratios) could also lower fecundity in such a way as to be a limiting factor in the plant's probability for recovery (McEachern pers. comm. 2009, Wilken pers. comm. 2009).

Methodology Used to Complete This Review:

This review was prepared by the Ventura Fish and Wildlife Office following the Region 8 guidance issued in March 2008. We used information from the recovery plan, survey information from experts who have been monitoring various localities of this species, the Consortium of California Herbaria (CCH), and the California Natural Diversity Database (CNDDB) maintained by the California Department of Fish and Game (CDFG). The recovery

plan and personal communications with experts were our primary sources of information used to update the species' status and threats. We received no information from the public in response to our Federal Notice initiating this 5-year review. This 5-year review contains updated information on the species' biology and threats, and an assessment of that information compared to that known at the time of listing or since the last 5-year review. We focus on current threats to the species that are attributable to the Act's five listing factors. The review synthesizes all this information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, we recommend a prioritized list of conservation actions to be completed or initiated within the next 5 years.

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Federal Register Notice Citation Announcing Initiation of This Review: A notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public was published in the Federal Register (FR) on March 25, 2009 (74 FR 12878). No information was received in relation to this species.

Listing History:

Original Listing

FR Notice: 62 FR 40954

Date of Final Listing Rule: July 31, 1997

Entity Listed: *Galium buxifolium* (species)

Classification: Endangered

State Listing

Galium buxifolium was listed by the State of California as rare in November 1979.

Associated Rulemakings: N/A

Review History: Since the original listing in 1997, the recovery plan (Service 2000) has been the only written status review; however, the recovery plan did not re-evaluate the species' listing status.

Species' Recovery Priority Number at Start of 5-Year Review: The recovery priority number for *Galium buxifolium* is 2 according to the Service's 2009 Recovery Data Call for the Ventura

Fish and Wildlife Office, based on a 1-18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (Endangered and Threatened Species Listing and Recovery Priority Guidelines, 48 FR 43098, September 21, 1983). The recovery priority number of 2 indicates that the taxon is a species that faces a high degree of threat and has a high potential for recovery.

Recovery Plan

Name of Plan: Thirteen Plant Taxa from the Northern Channel Islands Recovery Plan

Date Issued: September 26, 2000

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) Policy

The Endangered Species Act defines “species” as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition of species under the Act limits listing as distinct population segments to species of vertebrate fish or wildlife. Because the species under review is a plant, the DPS policy is not applicable, and the application of the DPS policy to the species’ listing is not addressed further in this review.

Information on the Species and its Status

Description

Galium buxifolium is a small, stout, woody shrub in the madder (Rubiaceae) family. The plant grows to 1.2 meters (4 feet) in height, and has swollen nodes bearing numerous leafy branches. The leaves occur in whorls and are larger than those of most other *Galium* taxa, and have conspicuous lateral veins with stout hairs on the lower surface (Dempster 1973, 1993). The relatively broad leaves and the tiny upward-curved hairs that cover the fruits are unique characteristics that distinguish it from the six other species of *Galium* that occur on the islands (Hochberg et al. 1980).

Species Biology and Life History

Galium buxifolium has been described as “usually dioecious” (Junak et al. 1995), “imperfectly dioecious” or “variably polygamous,” producing both unisexual and bisexual flowers on the same plant (Dempster 1993), and “gynodioecious,” producing female and bisexual flowers on separate individual plants (Wilken pers. comm. 2009). The plant has been observed to be slow-growing (Wilken pers. comm. 2009), and plants reproduce mainly from seed although individuals have the ability to sprout numerous stems from a basal root crown when damaged. North-facing slopes near the sea (Junak pers. comm. 2009) and the intact canopy cover of native plant species on mesic sites (Service 2007, McEachern pers. comm. 2009) provide the moist and shaded conditions *G. buxifolium* requires for germination. Flowering occurs between March and July (Junak et al. 1995, Hochberg et al. 1980). At the time of listing, little was known about the life history of *G. buxifolium*; however, recent demographic studies suggest that the genus is still evolving—such that fruit and seed production patterns are highly variable, and these patterns are not consistent among populations (McEachern 2008, McEachern pers. comm. 2009).

Distribution

Galium buxifolium is known from Santa Cruz and San Miguel Islands. Approximately 24 percent of Santa Cruz Island is owned and managed by the National Park Service (NPS) and the remaining 76 percent of the island is owned by The Nature Conservancy (TNC). All 21 *G. buxifolium* localities on Santa Cruz Island are on lands owned by TNC, which has entered into a cooperative agreement with NPS to manage Santa Cruz Island as a single ecological unit. San Miguel Island is owned by the U.S. Navy, but NPS manages the island's natural resources and the island is designated as part of Channel Islands National Park.

Santa Cruz Island

E.L. Greene first described *Galium buxifolium* from specimens collected on Santa Cruz Island in 1886 (Ferris 1960). At the time of listing, populations were known to occur between Cueva Valdez and Eagle Canyon on the north shore of Santa Cruz Island near Buena Vista, in the western Central Valley, and near Rancho Nuevo on the south shore of the island (Junak et al. 1995). Since the time of listing, new sites (the terms site, population, and occurrence are used interchangeably throughout this review) have been discovered at Cañada del Agua, Marine Gardens, and Del Mar Cove. Surveys conducted from 2003 to 2006 searched for *G. buxifolium* at 10 of the 13 sites known from collection records and found plants still present at 7 of these sites. The same survey effort also resulted in the discovery of 14 new sites, bringing the total number of known occurrences on Santa Cruz Island to 21 (McEachern et al. 2008).

San Miguel Island

Less is known about the San Miguel Island populations of *Galium buxifolium* than those of Santa Cruz Island. Between 1961 and 1998, five sites were documented on the north shore of the island between Harris Point and Cardwell Point (McEachern et al. 2008). At the time of the 1997 listing, five historical collections that had been made from the island had not been visited in almost 30 years. Two sites were visited in 1993 and 1998 and one of the historic sites on the east end of the island was visited in July 2008 (McEachern 2008, Rodriguez pers. comm. 2009). As of October 2009, the remaining two historic sites identified at the time of listing have not been resurveyed. Because the steep bluffs and rocky slopes where the species grows are often unsafe or inaccessible, some biologists believe that there are likely more *G. buxifolium* populations on San Miguel Island than are currently known (McEachern pers. comm. 2009, Williams pers. comm. 2009).

Abundance

At the time of listing, 2 of the 8 populations of *Galium buxifolium* known to occur on Santa Cruz Island had fewer than 50 individuals each (Hochberg et al. 1980). Of the 24 populations surveyed between 2004 and 2006, 8 had fewer than 5 individuals, 6 had between 10 and 40 individuals, and 5 populations had an average of 150 individual plants (Table 1). During the same survey effort, three of the historic sites surveyed no longer harbored the species (McEachern et al. 2008). Since 2006, only four sites—Eagle Canyon, Tinker's Cove, Pelican Bay, and Cueva Valdez—have been revisited (McEachern 2008). Because the plant grows on often-inaccessible, steep sea cliffs, it is frequently very difficult to conduct comprehensive surveys and surveys are often conducted with binoculars; therefore, many abundance figures are based on best estimates by the surveyors. Demographic sampling studies on Santa Cruz Island have shown that recruitment of this species is occurring, although recruitment in individual

occurrences is difficult to observe because smaller plants are often hidden under larger ones and many surveys are conducted from a distance (McEachern pers. comm. 2009).

Two populations of *Galium buxifolium* located on San Miguel Island in 1993, Devil's Knoll and Hare Rock, each consisted of approximately 200 individuals at that time. Another population located that year at Nidever Canyon was recorded to have 7 to 17 individuals. The Nidever Canyon and Devil's Knoll populations were revisited in 1998 and found to have approximately 121 and 300 individuals, respectively (Service 2000, CDFG 2005, Rodriguez pers. comm. 2009, USGS and NPS 2009). The increase in the number of individuals found at these sites is not interpreted as a strong indication of recruitment, but as the product of more thorough survey efforts on the part of the surveyors (McEachern pers. comm. 2009). The most recently visited population on San Miguel Island, Cardwell Point, was not comprehensively surveyed; however, at least 12 to 15 individuals in good health were observed in July 2008 (McEachern 2008, Rodriguez pers. comm. 2009, USGS and NPS 2009). See Table 1 in Appendix A for survey information from both Santa Cruz and San Miguel Islands.

Habitat or Ecosystem

Galium buxifolium occurs on "bluffs and rocky slopes" (Dempster 1973) in coastal sage scrub and island pine forest. Dominant plant species that are typically found with island bedstraw are *Artemisia californica* (California sagebrush), *Astragalus miguelensis* (San Miguel Island locoweed), *Dudleya greenei* (Greene's dudleya), *Erigeron glaucus* (seaside daisy), and *Eriogonum grande* ssp. *rubescens* (red buckwheat) (NPS 1998). Other associated species on rocky, exposed cliffs include *Achillea millefolium* (yarrow), *Lotus dendroideus* var. *veatchii* (San Miguel Island deerweed), *Malacothrix saxatilis* var. *implicata* (cliff aster), *Marah macrocarpa* (wild cucumber), and *Rhus integrifolia* (lemonade berry) (Halvorson et al. 1992).

Invasive species were identified in the listing rule as having a high probability of preventing recruitment and causing habitat displacement of *Galium buxifolium* (Service 1997). Field researchers have observed that *G. buxifolium* may be dependent on the microclimate provided by native plants such as *Coreopsis gigantea* (giant coreopsis) for survival (McEachern pers. comm. 2009). In particular, non-native plants that have the greatest ability to displace island bedstraw are those that are considered "ground covers" and form thick mats, such as *Carpobrotus chilensis* (sea fig) and *Vinca major* (greater periwinkle) (Junak pers. comm. 2009). In view of the fact that it has not dispersed more widely onto coastal bluffs and terraces since the removal of herbivores from the islands as various other plant species have, some researchers believe that its natural habitat is likely restricted to marine cliffs (Junak pers. comm. 2009). Other plant ecologists believe the plant was more widespread on coastal bluffs and terraces prior to the period of sheep grazing on the islands, and that habitat alteration from non-native plant species and grazing have prevented the plant from dispersing into its former range on coastal bluffs and terraces (McEachern pers. comm. 2009).

Changes in Taxonomic Classification or Nomenclature

No changes in taxonomy or nomenclature have been made since the time of listing.

Genetics

No new studies concerning the genetics of this taxon have been conducted since the time of listing.

Species-specific Research and/or Grant-supported Activities

The U.S. Geological Survey, Western Ecological Research Center, Channel Islands Field Station (USGS) conducted rare plant field surveys between 2003 and 2006 as part of a conservation and recovery research program for nine federally listed taxa of Santa Cruz Island. The objective of these surveys was to relocate historic occurrences and search for new locations of these species in suitable habitat. Plant voucher specimens and seeds were also collected to study floral biology and seed production potentials for individual *Galium buxifolium* sites for out-planting feasibility experiments. This demographic monitoring information will continue to contribute to the development of recovery prescriptions for the plants. As a part of this project, seeds collected from four sites on Santa Cruz Island were propagated in a greenhouse at the Santa Barbara Botanic Garden. The data collected from this propagation fit predictions for gynodioecy in *G. buxifolium*, where all of the plants produced either all unisexual (female) flowers or perfect (bisexual) flowers on separate individual plants (Wilken pers. comm. 2009).

In 2003, the Santa Barbara County Weed Management Area received funding through the Service's Private Stewardship Grant Program and Partners for Fish and Wildlife Program, along with the National Fish and Wildlife Foundation's Pulling Together Initiative to create the Santa Cruz Island Native Plant Restoration Project (Owen 2004). As a part of this project, *Vinca major*, an invasive weed that out-competes native vegetation and alters natural erosional processes, is being carefully removed from a population of *G. buxifolium* plants at Pelican Bay, on the north shore of Santa Cruz Island (Service 2006, Owen 2009). The Pelican Bay population is unique in that it is the only population documented to have significantly spread above the inaccessible sea bluffs, where most individuals can be safely accessed for research and recovery (McEachern and Chess 2007). This project is also part of USGS demography research investigating the effects of *Vinca* control on *Galium* population growth (McEachern 2008).

Five-Factor Analysis

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the Act.

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

At the time of listing, *Galium buxifolium* was threatened by soil loss and habitat alteration from feral pig rooting and sheep grazing. Historically, large-scale habitat alteration caused by large numbers of non-native mammals on the islands resulted in significant loss of soils, as well as changes in the structure, composition, and richness of plant communities (Service 1997). On Santa Cruz Island, *G. buxifolium* was threatened by trampling and pig rooting along the sea cliffs, increasing the likelihood of landslides (Hochberg et al. 1980).

By the time the recovery plan was published in 2000, sheep had been removed from all of the northern Channel Islands. In the recovery plan, we considered effective elimination of habitat damage from non-native animals, particularly pigs on Santa Cruz Island, to be one of the most important management tasks needed for recovery of this species and other listed plant taxa (Service 2000). TNC and NPS initiated an 18-month feral pig removal program that removed all pigs from the island by the end of 2006 (TNC 2009). The direct threat to the species from feral pigs is largely eliminated, although the residual effects of habitat alteration remain on Santa Cruz Island. On San Miguel Island, impacts from sheep and feral burros have resulted in soil loss and erosion of some areas down to the caliche layer and type-conversion of native shrublands to non-native annual grasslands (McEachern in litt. 2007; Faulkner in litt. 2007). Sheep were entirely removed from San Miguel Island in July 1966, and feral burros were eradicated in 1977 (Livingston 2006).

Although some plant species have increased in number following the removal of non-native herbivores and omnivores from the islands, other aspects of recovery of the native habitats can be slow (Hochberg et al. 1979, Lovich and Bainbridge 1999). In particular, community composition can be altered by the spread of non-native plants that were able to gain a foothold during the period of disturbance. For *Galium buxifolium*, a woody subshrub that relies on a microclimate provided by native vegetative cover, the presence of non-native plants in the landscape is a substantial barrier to dispersal and subsequent recovery.

Global climate change has the potential to diminish the habitat of *Galium buxifolium* because of the species' precarious occurrences on sea cliffs. As storm intensities are expected to increase with climate change, coastal bluffs and cliff faces where the species occurs are more susceptible to deleterious erosion. In 2004, researchers observed that a portion of the Cañada del Agua population had fallen into the sea as a result of bluff erosion (McEachern pers. comm. 2009). The impacts of climate change and sea level rise are further discussed in Factor E below.

FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization for commercial purposes was not known to be a factor in the 1997 final listing rule (Service 1997). Overutilization for any purpose does not appear to be a threat at this time.

FACTOR C: Disease or Predation

At the time of listing, predation resulting from sheep grazing was considered a major threat to *Galium buxifolium* on Santa Cruz and San Miguel Islands. Plants are very brittle and break easily when trampled or browsed; thus the species would have been easily eliminated from sites accessible to livestock. In the listing rule, we identified the effects of defoliation of plants, which include decreased above-ground biomass, fewer stems, lowered seed production, reduced height of leaves and stems, decreased root biomass, reduced root length, decreased carbohydrate reserves, and reduced vigor (Heady in Willoughby 1986). Manipulation of the vegetation by more than 150 years of intensive grazing and browsing had resulted in the widespread conversion of native shrublands and perennial grasslands to communities dominated by non-native annual grasses (Service 2000). Sheep and cattle were removed from the western (TNC-

owned) portion of Santa Cruz Island in 1986, and sheep were completely removed from the eastern (NPS-owned) portion in 1999 (McEachern et al. 2008). Domestic livestock grazing was eliminated from San Miguel Island when the last feral burros were removed in 1977 (Livingston 2006).

Years of grazing have restricted *Galium buxifolium* to small, fragmented habitat patches that were protected from the pressures of herbivory by their inaccessibility. Although these pressures have been relieved with the removal of feral livestock from the islands, undergrowth structure and species composition altered by years of grazing will be slow to recover. However, in some areas where the shrub canopy has begun to reestablish its connectivity, such as on north-facing slopes where there is deeper soil and more moisture, understory plants have a greater potential for recovery in these isolated patches (McEachern et al. 2008).

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

At the time of listing, regulatory mechanisms thought to have some potential to protect *Galium buxifolium* included: (1) listing as rare under the Native Plant Protection Act and the California Endangered Species Act; (2) the National Environmental Quality Act; (3) NPS Guidelines for Natural Resources Management (NPS 1991) and the NPS Statement for Management (NPS 1985); (4) a Memorandum of Agreement between the Department of the Navy and NPS; and (5) the Federal Endangered Species Act in those cases where *G. buxifolium* occurs and is incidentally protected in habitat occupied by a listed wildlife species. The listing rule (Service 1997) provides an analysis of the level of protection that was anticipated from those regulatory mechanisms. This analysis appears to remain currently valid.

Because NPS is involved with management of *Galium buxifolium* populations on San Miguel Island, all Federal laws and NPS policies and regulations apply to this species. The inadequacy of regulatory mechanisms was not considered a concern at the time of listing, and is not currently a concern. All island bedstraw localities are on lands owned by TNC, which has entered into a cooperative agreement with NPS to manage Santa Cruz Island as a single ecological unit (TNC 2003). USGS works cooperatively to share biological data and information with NPS and other Federal agencies (USGS 2009).

The species is also listed as rare by the State of California. However, because there have been few, if any, proposed projects that would potentially impact the species, the protections afforded to species with that status (Tibor 2001) have not been called into play.

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence

Competition with Non-native Species

Competition from non-native species currently threatens the existence of *Galium buxifolium* and its habitat. *Vinca major*, an aggressive ornamental groundcover known for its competitive displacement of natives at sites across North America (DiTomaso and Healy 2007), is growing in one of the largest populations of *G. buxifolium* at Pelican Bay on Santa Cruz Island. Removal treatments have begun to eradicate *Vinca major* from this population while minimizing adverse effects to the *G. buxifolium* plants that occur there. As noted previously, there are varying

opinions among plant ecologists as to whether non-native species are actually preventing *G. buxifolium* from dispersing more widely into its presumed former range on coastal bluffs and terraces (McEachern pers. comm. 2009, Junak pers. comm. 2009).

Small Population Size

As noted in the recovery plan, *Galium buxifolium* is threatened by the risk of stochastic extinction due to small population size and limited distribution (Service 2000). Only one individual plant was observed at each of three populations surveyed on Santa Cruz Island in 2005 and 2006 (McEachern et al. 2008). The conservation biology literature commonly notes the vulnerability of taxa known from one or very few locations and/or from small and highly variable populations (e.g., Shaffer 1981, 1987; Primack 1998; Groom et al. 2006). In particular, the small size of each population makes it difficult for this species to persist while sustaining the impacts of soil damage and habitat alteration from non-native species.

Small population size could also be a significant factor in terms of the species' unique floral biology. *Galium buxifolium* exhibits highly variable fruit and seed production across the populations on Santa Cruz Island. Demographic studies have suggested that the variable nature of the seed bearing pattern of *G. buxifolium* can lead to a loss of viability in isolated populations over time (McEachern pers. comm. 2009). Demographic monitoring studies at select sites on Santa Cruz Island have shown that in the field, the varying floral types include plants that are nearly unisexual, having either mostly male or mostly female reproductive structures. In the field, some researchers have observed unisexual flowers co-occurring on the same plant as perfect (bisexual) flowers, either alone or in combination with female flowers only (McEachern et al. 2008). Plants grown in a nursery from seeds collected from two sites on Santa Cruz Island, however, produced female and bisexual flowers in about a 50:50 ratio, indicating a consistent, predictable pattern of gynodioecy (Wilken pers. comm. 2009). Research has shown seed production to be lower in unisexual plants, and seed output could be a limiting factor for recovery at sites that are composed of mostly male or mostly female individuals (Service 2007, McEachern et al. 2008). For example, if a population consisting of seven individuals has six female plants and one bisexual plant, then the population will be limited by the pollen production of one individual plant, leading to reduced seed set (Wilken pers. comm. 2009).

Climate Change

Current climate change predictions for terrestrial areas in the Northern Hemisphere indicate warmer air temperatures, more intense precipitation events, and increased summer continental drying (Field et al. 1999, Cayan et al. 2005, Intergovernmental Panel on Climate Change 2007). However, predictions of climatic conditions for smaller sub-regions such as California remain uncertain. It is unknown at this time if climate change in California will result in a warmer trend with localized drying, higher precipitation events, or other effects.

Galium buxifolium may be particularly threatened by climate change because its geographic distribution is so narrow and its current range is unlikely to overlap with regions that would be climatically suitable in the future (Levine et al. 2008). This potential threat is particularly acute for species on islands because they are unable to disperse to more favorable habitat as the environment changes. Because of this, Levine et al. (2008) suggest that the persistence of many rare species depends on how populations respond to climate change in their current locations.

Loarie et al. (2008) project that up to 66 percent of the flora of California will experience a greater than 88 percent reduction in range in the next century with conservative climate change predictions. This rate is exacerbated for species, such as *G. buxifolium*, that have limited or no ability to disperse from their current locations (Loarie et al. 2008).

Sea level rise as a result of climate change has the potential to adversely affect *Galium buxifolium* and its habitat. Mean sea level rise on the California coast is predicted to rise 3.3 to 4.6 feet (1.0 to 1.4 meters) by the year 2100 (California Climate Change Center (CCC) 2009). In particular, ocean bluffs along the coast will be subject to greater and more frequent wave attack, resulting in erosion and shoreline retreat (California Coastal Commission 2001). As a result of sea level rise, coastal cliffs in Santa Barbara County are predicted to erode an average distance of 177 feet (54 meters) by the year 2100 (CCC 2009). A portion of one *G. buxifolium* population on Santa Cruz Island has already been lost to cliff erosion (McEachern pers. comm. 2009). *Galium buxifolium* populations are found at 7 feet (2 meters) and 16 feet (5 meters) of elevation at Eagle Canyon and Cueva Valdez, 20 feet (6 meters) of elevation near Prisoners Harbor, and between 10 feet (3 meters) and 26 feet (8 meters) of elevation at Tinkers Cove on Santa Cruz Island (CCH 2009). The low elevation of these occurrences, combined with the fragile nature of the individual plants, make *G. buxifolium* particularly vulnerable to increased wave action and more intense storm events that are predicted with climate change. However, the extent to which such events are caused by climate change and the extent to which it could affect *Galium buxifolium* are unknown at this time.

III. RECOVERY CRITERIA

Recovery plans provide guidance to the Service, states, and other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. There are many paths to accomplishing the recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may determine that, over all, the threats have been minimized sufficiently, and the species is robust enough, to downlist or delist the species. In other cases, new recovery approaches and/or opportunities unknown at the time the recovery plan was finalized may be more appropriate ways to achieve recovery. Likewise, new information may change the extent that criteria need to be met for recognizing recovery of the species. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan. We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the species was listed by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

In the recovery plan, general delisting criteria for the suite of 13 covered plants involve increasing the number of known populations either through surveying historical sites and potential habitat within the historical range to locate currently unknown populations, or repatriating or introducing several additional populations of the species. The plan suggests that until research demonstrates otherwise, downlisting for subshrubs should target securing several

populations containing a minimum of 2,000 plants each (but preferably more). For long-lived species such as *Galium buxifolium*, recovery objectives should target a trend with increasing numbers of individuals and populations. Delisting and downlisting criteria specific to *G. buxifolium* are comprised of the following:

Downlisting Criteria

- 1) Stabilize or increase populations on Santa Cruz and San Miguel Islands with evidence of natural recruitment for a period of 20 years that includes the normal precipitation cycle. A precipitation cycle includes periods of drought and wet years, with annual rainfall starting at 100 to 135 percent of average, dropping below 65 percent of average, and returning to at least average (Service 2000). Although we believe the intent of this criterion is still appropriate in light of climate change, we may need to reassess how we evaluate species vigor against a changing climate. This criterion addresses Listing Factors A, C, and E. This criterion has not been met for several reasons, one of which is because the species was listed less than 20 years ago. With respect to natural recruitment, based on individual counts and population structure, it is apparent that some recruitment has been occurring over the last 20 years (McEachern pers. comm. 2009). We believe this criterion is adequate and appropriate for the recovery of the species.

- 2) Reintroduce plants to historic locations.
This criterion addresses Listing Factors A, C, and E. This criterion has not been met.

As discussed previously in this 5-year review, USGS has begun seed viability experiments to study the feasibility of outplanting populations of *Galium buxifolium*. As of this writing, no reintroductions of *G. buxifolium* have yet begun. The feasibility of reintroduction efforts is dependent on the success of attempts to better understand the floral biology of this species. Recent research into the floral biology of the species from one population on Santa Cruz Island suggests that because of the unique floral biology of the species, it is important that outplantings are conducted with plants in a 50:50 ratio of unisexual and bisexual plants (Wilken pers. comm. 2009). We believe this criterion is adequate and appropriate for the recovery of the species.

Delisting Criteria

- 1) Discover or establish five additional populations per island (San Miguel and Santa Cruz). This criterion addresses Listing Factors A, C, and E. This criterion has not been fully met, although 14 new *Galium buxifolium* sites were discovered on Santa Cruz Island during the 2003-2006 surveys conducted by USGS. Similarly comprehensive surveys searching for additional populations of *G. buxifolium* in suitable habitat have not been conducted on San Miguel Island. We believe this criterion is adequate and appropriate for the recovery of the species.
- 2) No decline after downlisting for 10 years. This criterion addresses Listing Factors A, C, and E. This criterion has not been met.

Although we believe the intent of this criterion is appropriate, we think it should be refined to focus on long-term trends, rather than a short-term, absolute decline. This criterion should be revised once additional information about the life history of the species and the species' response to recovery actions are better understood.

Listing Factors B and D are not relevant to *Galium buxifolium* at this time.

IV. SYNTHESIS

At the time of listing, eight populations of *Galium buxifolium* were known on Santa Cruz Island and seven historic populations were known from San Miguel Island; currently there are 21 known populations on Santa Cruz Island and six San Miguel Island populations are presumed extant. Some of the San Miguel Island populations have been observed but not comprehensively surveyed in recent years. The primary threats to *G. buxifolium* at the time of listing included the ongoing damage to soils and habitat alteration from livestock grazing and herbivory resulting from sheep and feral burro browsing as well as pig rooting. Since that time, sheep and pigs have been removed and plant communities have begun to recover; however, the adverse effects on *G. buxifolium* habitat due to the long history of grazing on the islands remains.

Recent surveys suggest that *Galium buxifolium* populations appear to be relatively stable since the time of listing. While three historic populations were no longer present on Santa Cruz Island, several new populations were discovered. There is a paucity of information about the status of the San Miguel Island populations, but those that were visited in recent years appeared to have been healthy, although with small individual numbers of plants (McEachern 2008, Rodriguez pers. comm. 2009).

We believe that *Galium buxifolium* still meets the definition of an endangered species (a species that is threatened with extinction throughout all or a significant portion of its range). This is an appropriate designation for several reasons. First, although non-native animals have been removed from Santa Cruz and San Miguel Islands, the effects of habitat alteration still remain, particularly in the form of damage to soils and hydrologic regimes. In addition, the widespread occurrence of non-native plants on the islands may preclude *Galium buxifolium*'s ability to disperse into quality native habitat in its assumed former range on marine slopes and terraces. It may take several decades of natural and assisted restoration to provide the microhabitat conditions that will once again support populations of *Galium buxifolium*. Secondly, recovery potential for the species may be limited at certain sites on Santa Cruz Island because of the species' unique floral biology—if seed production is lower in unisexual plants, then its ability to reproduce will be limited at those sites. Lastly, climate change has significant potential to cause bluff erosion in the small habitat patches that now comprise the limited remaining habitat for the species. Therefore, the species continues to be endangered and no change in status is recommended.

V. RESULTS

Recommended Listing Action:

- Downlist to Threatened
 Uplist to Endangered
 Delist (indicate reason for delisting according to 50 CFR 424.11):
 Extinction
 Recovery
 Original data for classification in error
 No Change

New Recovery Priority Number and Brief Rationale: 5. This recovery priority number reflects a species facing a high degree of threat and low recovery potential. We believe this recovery priority number is appropriate for *Galium buxifolium* due to its lack of suitable habitat, irregular seed production regimes, limited distribution, and vulnerability to detrimental effects of climate change. We believe this is more accurate than the former recovery priority number of 2, which reflected a species facing a high degree of threat but with high recovery potential. We believe the recovery potential of the species is lower than was thought at the time the recovery plan was published (2000) because of the threats posed by non-native plant species, altered soil composition, high variability in recruitment potential, historically limited distribution, and the possible threats of climate change.

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

1. The USGS and NPS should seek additional funding to continue field surveys and monitoring, demographic monitoring, population viability analyses, and further investigations into recovery projects. Specifically, studies that track germination and individual growth rates to determine variability in fruit and seed set and differential germination success across floral types should be expanded to include more plants from more populations.
2. Establish an ex situ seed bank for research and outplanting experiments.
3. Comprehensive field surveys of *Galium buxifolium* populations on San Miguel Island are needed to fully assess the species' status in its known range.
4. The Service should work cooperatively with NPS and USGS to refine downlisting and delisting criteria to emphasize long-term population growth trends rather than short-term gains or declines in the species.
5. The USGS and NPS should investigate the community-level factors that influence population abundance, distribution, and demographic trends of the species.

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Table 1. Known occurrences of *Galium buxifolium*, prepared for the 5-year review, 2009.

Location	Island	Historic/ New (since 2004) Occurrence	Last observed	Number of Individuals
Hazard's	Santa Cruz	H	1930	-
Lady's/Baby's Canyon	SCI	H	2005	1
Platt's Cove/Dix Harbor	SCI	H	2006	50-150
Pelican Bay	SCI	H	2009	140
East of Prisoner's Harbor	SCI	H	2004	~200
Tinker's Cove	SCI	H	2008	35+
Cueva Valdez	SCI	H	2008	91
Buena Vista	SCI	H	2004	0
Eagle Canyon	SCI	H	2008	175
Fry's Harbor	SCI	H	-	-
West of Prisoner's Harbor	SCI	H	2005	0
West of Cueva Valdez	SCI	H	2006	0
East of Forney's Cove	SCI	H	-	-
Cañada del Agua	SCI	N	2004	147
E of Cañada del Agua	SCI	N	2004	25
Marine Gardens	SCI	N	2005	1
West End Flats	SCI	N	2005	4+
1.15 km East of Del Mar Cove	SCI	N	2005	1+
1.55 km East of Del Mar Cove	SCI	N	2005	12+
Cove East of Hazard's	SCI	N	2006	1
NW side 1.7 km east	SCI	N	2006	28+
NW side 1.2 km east	SCI	N	2006	58+
NW side 680 m east	SCI	N	2006	2+
NW side 45 m east	SCI	N	2006	2+
West End, north of ridge	SCI	N	2006	3
West End, south of ridge	SCI	N	2006	15+
Marine Gardens West	SCI	N	2006	20+
Bat Rock Point	San Miguel	H	1998	>200
Nidever Canyon Mouth	SMI	H	1998	121
Hoffman Point	SMI	H	1978	15-18
Hare Rock	SMI	H	1993	~200
Unknown	SMI	H	1930	-
Devil's Knoll	SMI	H	1998	~300
Cardwell Point Area	SMI	H	2008	12-15

Sources: Service 2000; McEachern et al. 2008; CCH 2009; CNDDDB 2009; Rodriguez, pers. comm. 2009; USGS and NPS 2009.

**U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW**

Galium buxifolium (island bedstraw)

Current Classification: Endangered

Recommendation Resulting from the 5-Year Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Appropriate Listing/Reclassification Priority Number: 5

Review Conducted By: Andrea Adams

FIELD OFFICE APPROVAL:

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

Approve

Daniel K. Ude

Date

10/20/09