National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Channel Islands National Park

Natural Resource Report NPS/CHIS/NRR—2019/1899

ON THE COVER

Santa Cruz Island. Photograph by Robert Schwemmer - NOAA.

Natural Resource Condition Assessment

Channel Islands National Park

Natural Resource Report NPS/CHIS/NRR—2019/1899

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Executive Summary

The Natural Resource Condition Assessment (NRCA) Program aims to provide documentation about the current conditions of important Park natural resources through a spatially explicit, multi-disciplinary synthesis of existing scientific data and knowledge. Findings from the NRCA will help Channel Islands National Park (CINP) managers to develop near-term management priorities. The central objectives of this assessment were to evaluate the current conditions and trends of key Park resources, identify important knowledge gaps, and determine key stressors and threats. Because a recent report provided an assessment of marine resources (Engle 2006), which constitute 50% of the park, this NRCA focused on terrestrial resources. For this NRCA, CINP resource managers identified that the greatest Park need was to know whether or not vegetation (primarily woody vegetation) is recovering on the Channel Islands and how this may be influencing recovery of the native terrestrial vertebrates. To address this, the CINP NRCA team evaluated the condition of island vegetation and vertebrate communities using both: 1) already available, summarized information from reports, theses, and journal articles and 2) new analyses of recently available, existing data collected on the islands. Descriptions of specific methods used to analyze available data by the NRCA team are provided within the assessment sections in Chapter 4 of this report.

The Team used the Vital Signs indicators as identified by Fancy et al. (2009) for monitoring the condition of Natural Resources in U.S. National Parks. Using this framework, the focal study resource components were the five CINP islands, because these are the bio-geophysical resources of greatest interest to the CINP. Each of the islands has its own unique history of human impacts, ecological conditions, restoration efforts, and natural resource monitoring. The Team evaluated island scrub recovery by assessing changes over time in two metrics: 1) vegetation community structure (species composition, cover, and spatial extent), and 2) vertebrate abundance, relative to the reference condition of each island. The reference conditions for this NRCA were the particular island's ecological state prior to European settlement or ranching, which represent the ecological state to which the NPS desires the park return. For each metric, the Team determined the Reference Conditions/Values, Current Condition, Trend, and Recovery Potential (based on a review of the literature and from the NRCA team's analysis of newly available data), Threats and Stressors, Data Gaps, Overall Condition. A qualitative statement of overall current condition was created for each metric, after all data and literature relevant to the measures (i.e., vegetation and vertebrates) of each resource component (i.e., island) were reviewed and evaluated. All information gathered for this NRCA is available and managed by CINP, so that the compilation of resources would be available not only for the assessment team, but will be provided for future Park reference.

Chapter 1 of this NRCA provides a descriptive background of NRCAs. Chapter 2 provides Park-wide natural resource background information, while Chapter 3 describes the overall methodological approach used in this assessment. Chapter 4 provides a detailed assessment of each island's condition, which is then summarized Park-wide and for each island in Chapter 5.

Based on both vegetation recovery and vertebrate population abundances, our assessment found Santa Cruz Island (SCI), Santa Rosa Island (SRI), San Miguel Island (SMI), and Anacapa Island (AI)

to be, overall, in moderate condition and slowly recovering following the removal of non-native herbivores. The condition of Santa Barbara Island (SBI) is poor and remains in a state that is not likely to improve without assisted recovery by the Park.

All islands have exhibited some level of native vegetation recovery, with most of the observed natural recovery occurring on SCI, SRI, SMI, and AI; very little recovery has occurred at present on SBI. Vegetation recovery is uneven across each island and largely limited to mesic areas, such as north-facing slopes. Areas that will likely require some assisted recovery efforts are those that are: at risk of erosion, isolated, lacking native seed banks, and plagued with high competition of non-native grasses and other invasives. Some plant communities, such as exposed upland vegetation on SRI, also have lower natural recovery potential and will likely require assisted recovery.

The overall condition of the Park's terrestrial island vertebrate species generally appears to be good and improving, with high potential for further recovery to reach pre-ranching era reference conditions. This is particularly true for vertebrates on SCI, SRI, and SMI. Although there are limited data for AI, the data that are available suggest that vertebrates on that island are in good condition and improving as well. However, the condition of SBI vertebrates is only moderate, with natural recovery potential being low, with many landbird species' populations currently declining, extinct, or not improving. An overarching theme across the Park's terrestrial island vertebrate populations is that many of them are in good condition because the particular animals are habitat generalists, so their population dynamics are not strongly tied to habitat conditions. However, those landbirds associated with riparian vegetation are not showing signs of recovery across the Park islands, and riparian areas appear to be one of the habitats with limited natural recovery potential on the islands.

Overwhelmingly, the most critical data gap that emerged from our analysis was the lack of current vegetation maps for most of the islands (AI, SCI, SRI, SMI). The lack of this information made it difficult to assess spatial changes in island vegetation over time, and to relate those changes to observed changes in vertebrate species abundances. Therefore, we were limited in our spatial assessment of vegetation recovery for AI, SCI, SRI, and SMI, and were only able to relate the current vegetation with island landbird analysis for SBI. Another common theme across islands was the lack of information on best techniques for shrub reintroduction and recovery, and the success of invasive species removal and re-vegetation efforts.

Abundance, distribution, and habitat affinities of reptiles and amphibians are poorly known for AI, SCI, SRI, and SMI, making it difficult to assess their population condition and trends, and their potential responses to shrub recovery. Mammal and landbird populations are reasonably well-sampled across most of the islands, but data are lacking for most vertebrates from AI, especially West and Middle AI where no vertebrate sampling occurs. The population status, cause of declines, and recovery needs are lacking for several landbird species across multiple islands, including loggerhead shrikes (*Lanius ludovicianus* ssp.) on SCI and SRI, and Santa Cruz Island rufous-crowned sparrows (*Aimophila ruficeps obscura*) on AI. Additionally, island song sparrows (*Melospiza melodia graminea*) remain extirpated on SBI and data are needed for assessing their recovery potential on the island.

The potentially major threats facing the islands' flora and fauna today are: areas of continued erosion, potential new non-native introductions, and climate change. The Park islands have already experienced warming over the last several decades due to human-induced climate change, and are projected to experience continued warming. These increasing stresses imposed by climate change may slow and inhibit natural recovery potentials for island fauna, and especially flora.

Acknowledgments

The work presented here represents the efforts of many people beyond the authors. We would like to thank Kate Faulkner and Paula Power for their invaluable insights and for coordinating the CINP efforts and input and Marsha Davis for managing the external peer review process and other assistance. The report greatly benefitted from insightful reviews by C. Schwemm, J. Orrock, C. Boser, Cause Hanna and Susan Harrison. R. Rudolph provided GIS assistance and contributed to several figures.

Chapter 1. NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter "parks." NRCAs also report on trends in resource condition (when possible), identify critical data gaps, and characterize a general level of confidence for study findings. The resources and indicators emphasized in a given project depend on the park's resource setting, status of resource stewardship planning and science in identifying high-priority indicators, and availability of data and expertise to assess current conditions for a variety of potential study resources and indicators.

> ***NRCAs Strive to Provide…***
>
> - *Credible condition reporting for a subset of important park natural resources and indicators*
> - *Useful condition summaries by broader resource categories or topics, and by park areas*

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement—not replace—traditional issue-and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- Are multi-disciplinary in scope;[1]
- Employ hierarchical indicator frameworks;[2]
- Identify or develop reference conditions/values for comparison against current conditions;[3]
- Emphasize spatial evaluation of conditions and GIS (map) products; [4]
- Summarize key findings by park areas; and [5]
- Follow national NRCA guidelines and standards for study design and reporting products.

Although the primary objective of NRCAs is to report on current conditions relative to logical forms of reference conditions and values, NRCAs also report on trends, when appropriate (i.e., when the underlying data and methods support such reporting), as well as influences on resource conditions. These influences may include past activities or conditions that provide a helpful context for

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[1] The breadth of natural resources and number/type of indicators evaluated will vary by park.

[2] Frameworks help guide a multi-disciplinary selection of indicators and subsequent "roll up" and reporting of data for measures ⇨ conditions for indicators ⇨ condition summaries by broader topics and park areas

[3] NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-up response (e.g., ecological thresholds or management "triggers").

[4] As possible and appropriate, NRCAs describe condition gradients or differences across a park for important natural resources and study indicators through a set of GIS coverages and map products.

[5] In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on an area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested.

understanding current conditions, and/or present-day threats and stressors that are best interpreted at park, watershed, or landscape scales (though NRCAs do not report on condition status for land areas and natural resources beyond park boundaries). Intensive cause-and-effect analyses of threats and stressors, and development of detailed treatment options, are outside the scope of NRCAs.
Due to their modest funding, relatively quick timeframe for completion, and reliance on existing data and information, NRCAs are not intended to be exhaustive. Their methodology typically involves an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in existing data and knowledge bases across the varied study components.

The credibility of NRCA results is derived from the data, methods, and reference values used in the project work, which are designed to be appropriate for the stated purpose of the project, as well as adequately documented. For each study indicator for which current condition or trend is reported, we will identify critical data gaps and describe the level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject-matter experts at critical points during the project timeline is also important. These staff will be asked to assist with the selection of study indicators; recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

NRCAs can yield new insights about current park resource conditions, but, in many cases, their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is both credible and has practical uses for a variety of park decision making, planning, and partnership activities.

Important NRCA Success Factors

- *Obtaining good input from park staff and other NPS subject-matter experts at critical points in the project timeline*
- *Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ⇨ indicators ⇨ broader resource topics and park areas)*
- *Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings*

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What an NRCA can do is deliver science-based information that will assist park managers in their ongoing, long-term efforts to describe and quantify a park's desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning[6] and help parks to report on government accountability measures.[7] In addition, although in-depth analysis of the effects of climate change on park natural resources is outside the scope of NRCAs, the condition analyses and data sets developed for NRCAs will be useful for park-level climate-change studies and planning efforts.

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) Program.[8] For example, NRCAs can provide current condition estimates and help establish reference conditions, or baseline values, for some of a park's vital signs monitoring indicators. They can also draw upon non-NPS data to help evaluate current conditions for those same vital signs. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

NRCA Reporting Products…

Provide a credible, snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:

- *Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations* ***(near-term operational planning and management)***
- *Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values* ***(longer-term strategic planning)***
- *Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public* ***("resource condition status" reporting)***

Over the next several years, the NPS plans to fund an NRCA project for each of the approximately 270 parks served by the NPS I&M Program. For more information visit the NRCA Program website.

[6]An NRCA can be useful during the development of a park's Resource Stewardship Strategy (RSS) and can also be tailored to act as a post-RSS project.

[7] While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

[8] The I&M program consists of 32 networks nationwide that are implementing "vital signs" monitoring in order to assess the condition of park ecosystems and develop a stronger scientific basis for stewardship and management of natural resources across the National Park System. "Vital signs" are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

Chapter 2. Introduction and Resource Setting

Brown pelican colony. NPS photo.

2.1. Introduction

2.1.1. Enabling Legislation

On April 26, 1938, President Franklin D. Roosevelt signed proclamation 2281 designating Anacapa and Santa Barbara islands as the Channel Islands National Monument. The proclamation noted that the islands warranted protection because they "contain fossils of Pleistocene elephants and ancient trees, and furnish noteworthy examples of volcanism, deposition, and active sea erosion, and have situated thereon various other objects of geological and scientific interest . . ." On February 9, 1949, President Harry S. Truman issued proclamation (2825) adding 17,635 ac to the monument. Specifically, the proclamation added the area within 1 nautical mile of the shoreline of Anacapa and Santa Barbara islands, which included several small islets and rocks and the offshore kelp beds around the islands. It was noted that these islets and rocks were "required for the proper care, management, and protection of the objects of geological and scientific interest located on lands within the said monument."

On March 5, 1980, President Jimmy Carter signed PL 96-199 (94 Stat 67), which established Channel Islands National Park. The park included the park Santa Barbara and Anacapa islands from the original monument, plus Santa Rosa, Santa Cruz, and San Miguel islands (the later to remain under the ownership of the U.S. Navy but managed by the Park Service). Prince Island was also included in the park, as well as the rocks, islets, and submerged lands and waters within 1 nautical mile of each island. The act stated that lands owned by The Nature Conservancy could be acquired only with their consent. Privately owned lands on Santa Rosa were to be acquired "as expeditiously as possible." The act specifically stated that nothing would affect the rights and jurisdiction of the state of California within the park, including its authority over submerged lands, waters, and marine resources within the park boundaries. Section 204(a) of the act declared that the park "shall be administered on a low-intensity, limited-entry basis." Section 204(b) further stated that "in recognition of the special fragility and sensitivity of the park's resources, it is the intent of Congress that the visitor use within the park be limited to assure negligible adverse impact on the park resources. The Secretary shall establish appropriate visitor carrying capacities within the park." Section 206 called for a review of the suitability or nonsuitability of the park for designation as wilderness within three fiscal years after the date of the enactment of the law. Section 207 stated that no fees shall be charged for entrance to the park. Section 208 provided for expenditure of federal funds for the cooperative management of The Nature Conservancy and other private property for research, resource management, and visitor protection and use.

In the park's enabling legislation (16 USC § 410ff) CINP was set aside to protect the nationally significant natural, scenic, wildlife, marine, ecological, historical, archeological, cultural, and scientific values of the Channel Islands in the state of California. These values include, but are not limited to, the following:

1. The brown pelican (Pelecanus occidentalis) nesting area
2. The undisturbed tide pools providing species diversity unique to the eastern Pacific coast
3. The pinnipeds (marine mammals such as seals and sea lions) that breed and pup almost exclusively on the channel islands, including the only breeding colony for northern fur seals (Callorhinus ursinus) south of Alaska
4. The eolian (wind-dominated) landforms and caliche
5. The archeological evidence of long-term use by many groups of Native Americans

Park purpose statements for all National Parks clarify the reasons the park was established as part of the national park system and provide the foundation for park management. They are based on the park's enabling legislation and legislative history (see Appendix).

2.1.2. Geographic Setting

Physical Environment and Processes

Channel Islands National Park comprises five islands (San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara) and surrounding waters located off the coast of southern California, in Santa Barbara and Ventura counties (Figure 2.1.1, Table 2.1.1). The area of the park is 100,994 ha (249,561 ac), of which 31,978 ha (79,019 ac) are owned by the federal government (NPS 2012). The Nature Conservancy (TNC) owns and manages 76% of SCI, the largest island in the park (Cohen et al. 2009).

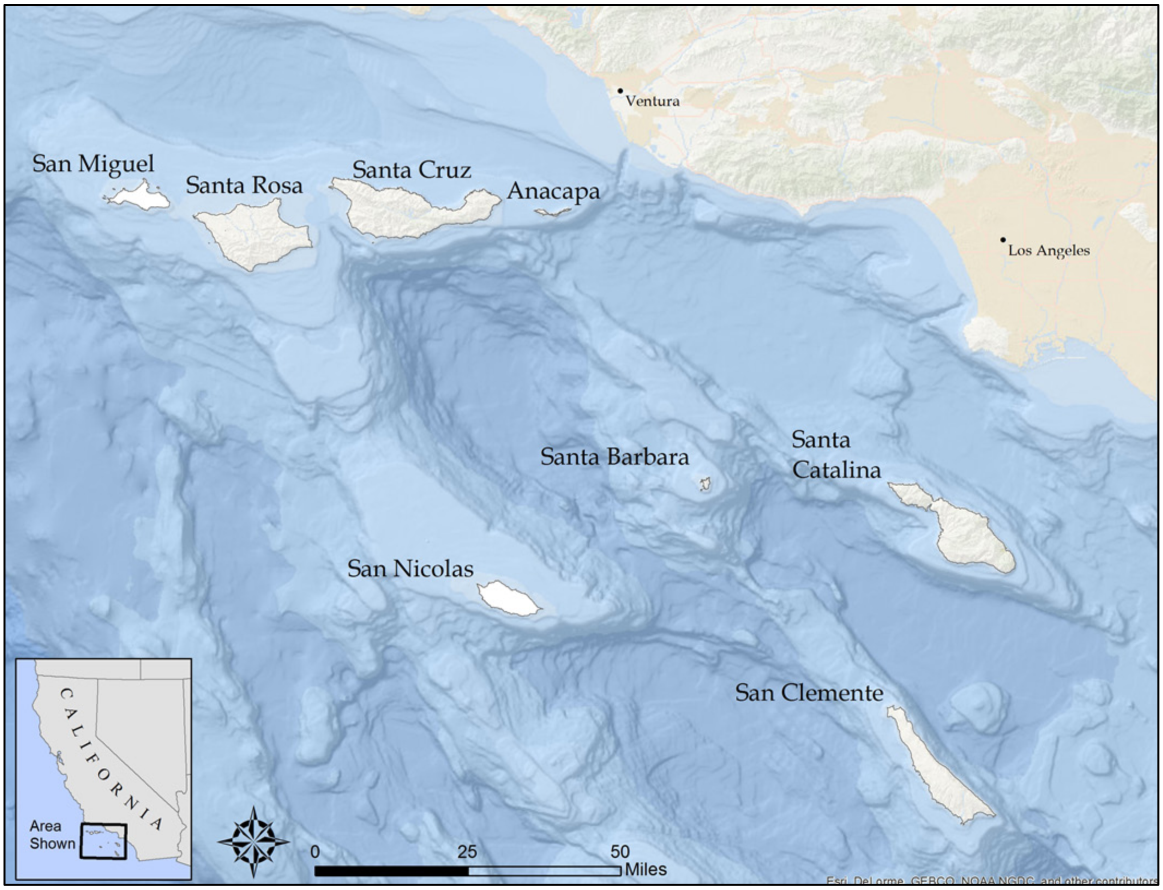


Figure 2.1.1. Overall map of Channel Islands in the Southern California bight, including 5 islands in the Park (NOAA).

Table 2.1.1. Physical characteristics of the five Channel Islands National Park islands. Data from Oberbauer 1999, Power 1980, Raven 1967, Channel Islands National Park Geographic Information Systems program 2014 (McEachern et al. 2016).

Island	Area km^2	Area mi^2	Highest elevation m (ft)	Distance to mainland km (mi)	Distance to nearest island km (mi)
San Miguel	37	14.5	253 (830)	42 (26)	5 (3)
Santa Rosa	217	83.1	475 (1560)	43 (27)	5 (3)
Santa Cruz	244	96.5	753 (2470)	30 (19)	8 (5)
Anacapa	2.9	1.1	283 (930)	19 (12)	8 (5)
Santa Barbara	2.6	1.0	194 (635)	61 (38)	39 (24)

About half of the park's total area is below the surface of the ocean. The park boundary extends 1 nautical mile (1.8 km) around each island and the Channel Islands National Marine Sanctuary extends 6 nautical miles (10.8 km) around each island (NPS 2014b). A diverse and productive marine ecosystem is formed by the confluence of cool water from the north (California Current) and warm water from the south (California Countercurrent). This strong regional temperature gradient represents a large portion of the California coast all within 100 km latitude (Richards 2009; Figure 2.1.2).

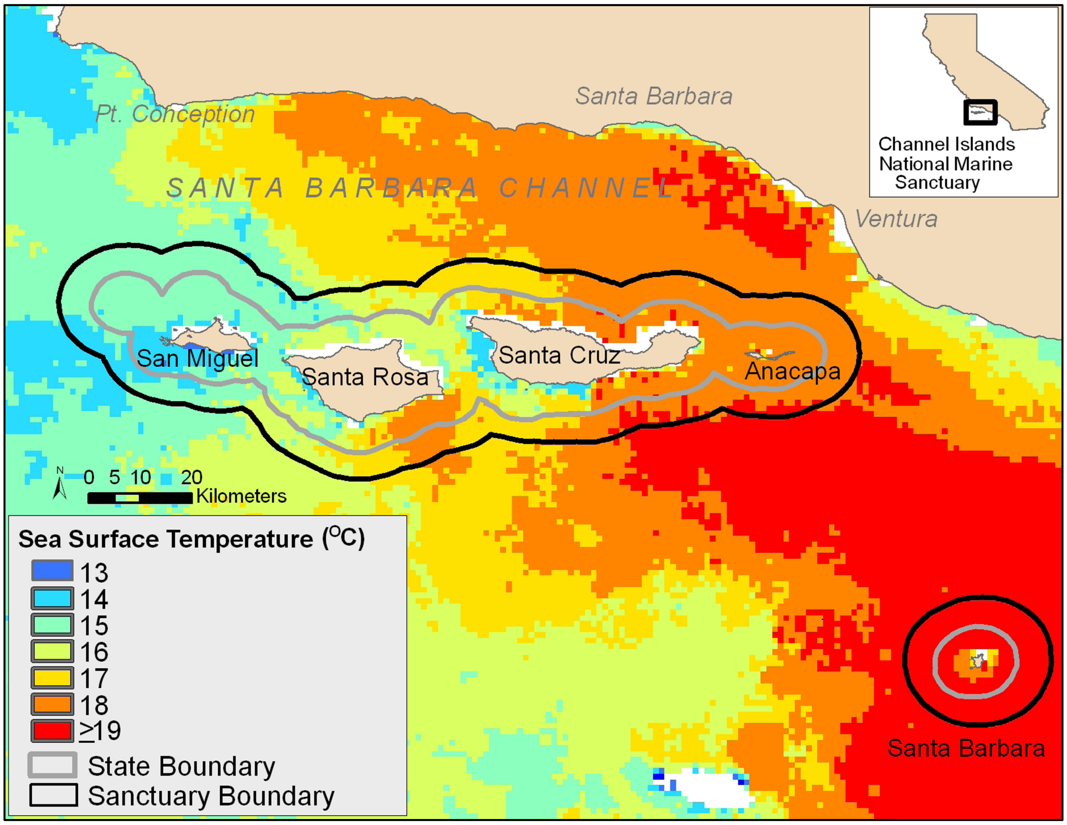


Figure 2.1.2. Thermal images of ocean currents and temperature around the northern Channel Islands. Cool water (shown in blue) sweeps southward from the north Pacific, mixing with warm water from the south (yellow) to create strong environmental gradients across the islands (NOAA 2009).

Weather and Climate

CINP has a Mediterranean-type climate. This climate type is characterized by cool, wet winters and hot, dry summers (NPS 2014c). On the Channel Islands the climate is moderated by the marine influence leading to milder summers, higher humidity and more frequent nocturnal fog compared to the mainland (NPS 2014c).

Temperature

December - March are the coolest months and July - October are the hottest months in the Channel Islands. The average mean temperature in January ranges from 11.7-15 degrees Celsius (C; 53-59 degrees Fahrenheit [F]); summers are a little warmer with an average mean temperature in July that ranges from 16.7-21.1 degrees C (62-70 degrees F) (NPS 2014c). Both winter and summer temperature extremes are moderated by the moist ocean air with generally high nighttime humidity and frequent fog.

Rainfall

Annual rainfall at CINP typically ranges from 20.3-101.6 cm (8-40 in). In most years, 95% of the rainfall in the Channel Islands occurs between November and April. January and February are the rainiest months (45% of average totals). Most rain comes from large storms that last for several days. The dry season generally extends from May-October. June, July and August are the driest months (1% of annual mean rainfall). Rainfall patterns vary geographically within the CINP.

Fog

Fog is a common weather feature, especially at SMI and SRI. Fog is most common in spring and summer, and west of the Santa Cruz Channel. The marine layer fog flows down the coast with the prevailing NW wind, and bends around Point Conception, usually blanketing SMI and SRI, and often the western portion of SCI. Fog frequently is thicker and lingers longer into the day offshore than along the mainland coast. Unlike much of coastal Southern California, fog has become more prevalent on the Channel Islands in the past 50 years (Williams et al. 2015).

Wind

Throughout the year, winds are primarily from the west-northwest, tending to increase throughout daylight hours and becoming east-northeasterly at night. Periodically, southern California experiences extreme foehn-type winds locally called Santa Ana winds. These high velocity winds are often associated with high temperatures and extremely low humidity. They have been identified as the primary driver of the wildfire regime in southern and central California shrublands. Santa Ana winds result from a regional, large scale weather pattern caused by the atmospheric pressure differential between a Great Basin high-pressure cell and a Pacific Coast trough of low pressure. On the mainland these winds average 20-25 mph and maximum gusts over 100 mph have been recorded (NPS 2014c). The Channel Islands experience Santa Ana winds, but in the northern Channel Islands the intensity becomes less severe as the winds move from east to west.

Gradients

There are strong climate gradients across the Channel Islands, from north to south and east to west, in response to gradients in ocean temperatures created by the mixing of currents around the islands. For xample, Figures 2.1.3 and 2.1.4 contrast long-term records of precipitation and air temperature on SRI in the northern island chain with SBI to the south in the warmer ocean. While patterns are similar in response to large-scale climate forcing, SBI is generally 2 to 4 degrees C (3.6-7.2 degrees F) warmer than SRI and it gets less rainfall. Average temperatures over the 1923 to 2011 period shown were 11.8 degrees C (53 degrees F) on SRI and 14.2 (57 degrees F) on SBI, and precipitation averaged 25.3 cm (10 in) and 20.1 cm (8 in) on the two islands respectively. This pattern of increased aridity in the southern islands exposed to the California Countercurrent is reflected in an east-west island gradient as well, as the warmer water near Anacapa mixes with the cooler water near San Miguel. Figure 2.1.5 shows how spatial patterns of morning fog across the northern Channel Islands change seasonally in response to water temperature: fog declines through the summer months as the eastern islands warm more than the western ones.

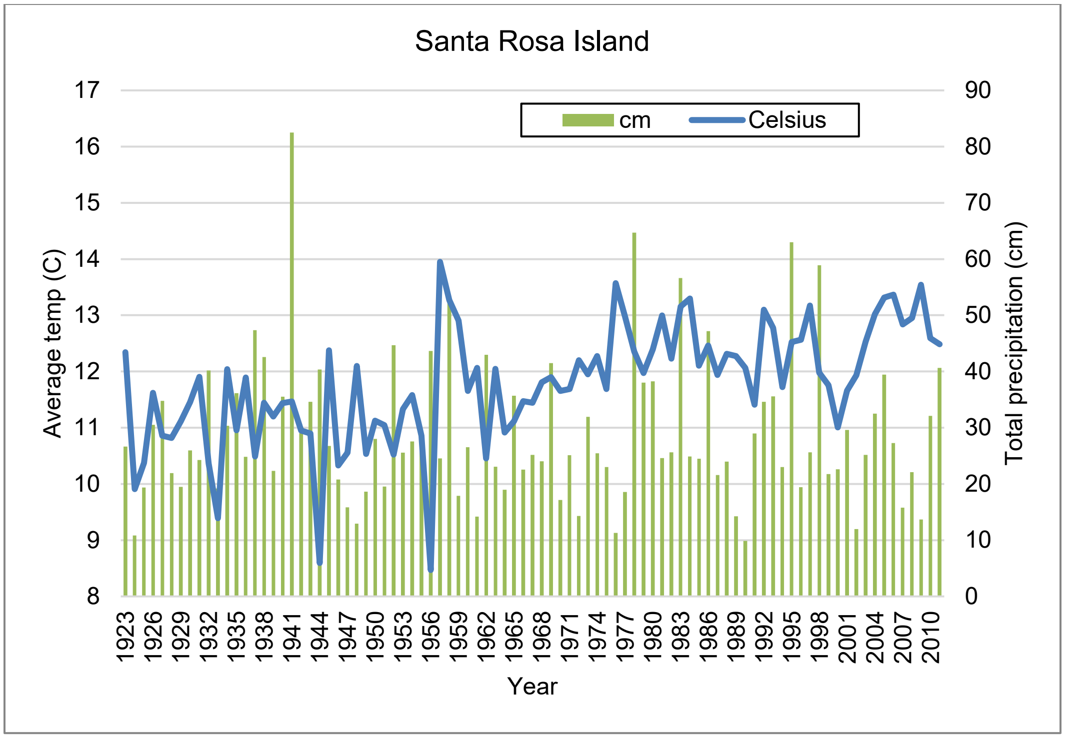


Figure 2.1.3. Average air temperature (C) and total water-year precipitation (cm) on Santa Rosa Island, 1923 - 2011. Annual total rainfall estimated by regression of measured Santa Rosa Island RAWS data 1990-2011 with Santa Cruz Island Main Ranch, temperature estimated by regression of data collected daily on the island by NPS staff and with NOAA stations 046569 and 046572 at Oxnard, California.

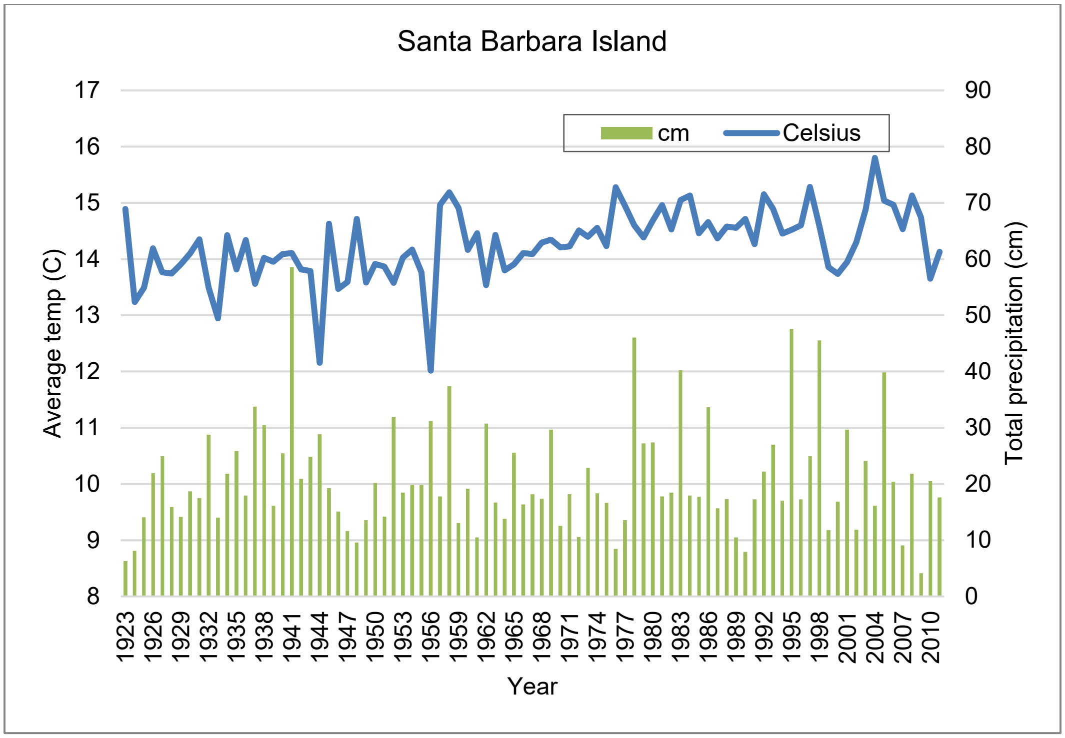


Figure 2.1.4. Average air temperature (C) and total water-year precipitation (cm) on Santa Barbara Island, 1923 - 2011. Annual total rainfall estimated by regression of measured Santa Barbara Island RAWS data 1992-2011 with Santa Cruz Island Main Ranch, temperature estimated by regression with NOAA stations 046569 and 046572 at Oxnard, California (modified from Handley et al. 2013).

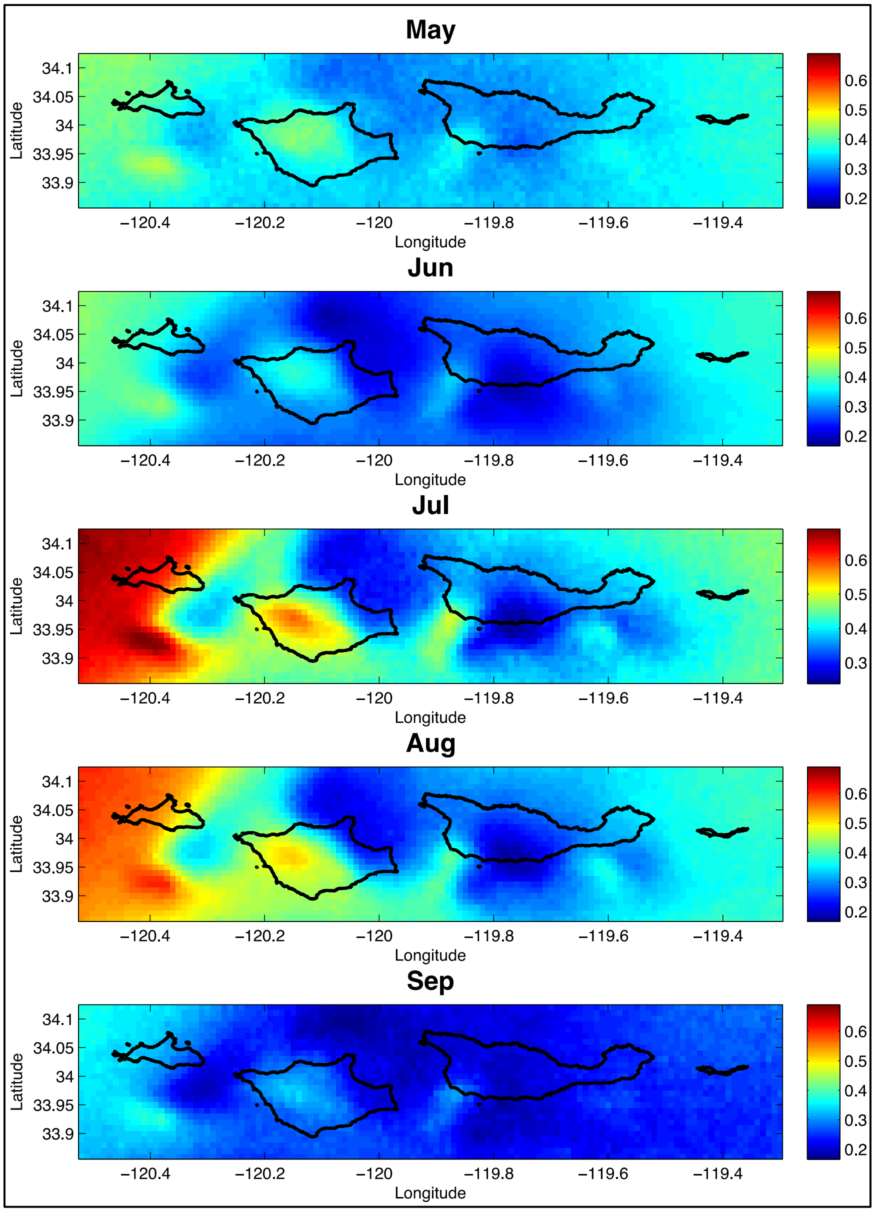


Figure 2.1.5. Cloud cover map for the northern Channel Islands calculated from GOES imagery, monthly means May- Sep 2004-2007. Higher values (warmer colors) indicate higher cloud cover (Rastogi et al. 2012).

2.1.3. Visitation Statistics

In 2014, CINP reported approximately 342,000 visitors. Of this number, about 105,000 people stopped at the visitor center in Ventura and about 14,000 visited the interagency contact station in Santa Barbara. Although visitation varies from year to year it has generally increased over time. Visitation is expected to continue to increase as the regional population and tourism increases. The five islands receive use year-round, although the greatest numbers of visitors come between March and October. In recent years winter use has been increasing on the islands.

Very little visitor profile information has been collected on the visitors who actually go out to the islands. Numbers of visitors on boats and ashore were recorded in 2008 and 2009 (Table 2.1.2). An August 1993 survey of visitors at the Ventura visitor center and of boats anchored offshore of the islands described some characteristics of visitors. It should be stressed however, that these data are more than 20 years old and represent a limited sample both in the visitors that were surveyed (e.g., no concessioner passengers were surveyed) and in the area and season of use. The 1993 survey revealed the following:

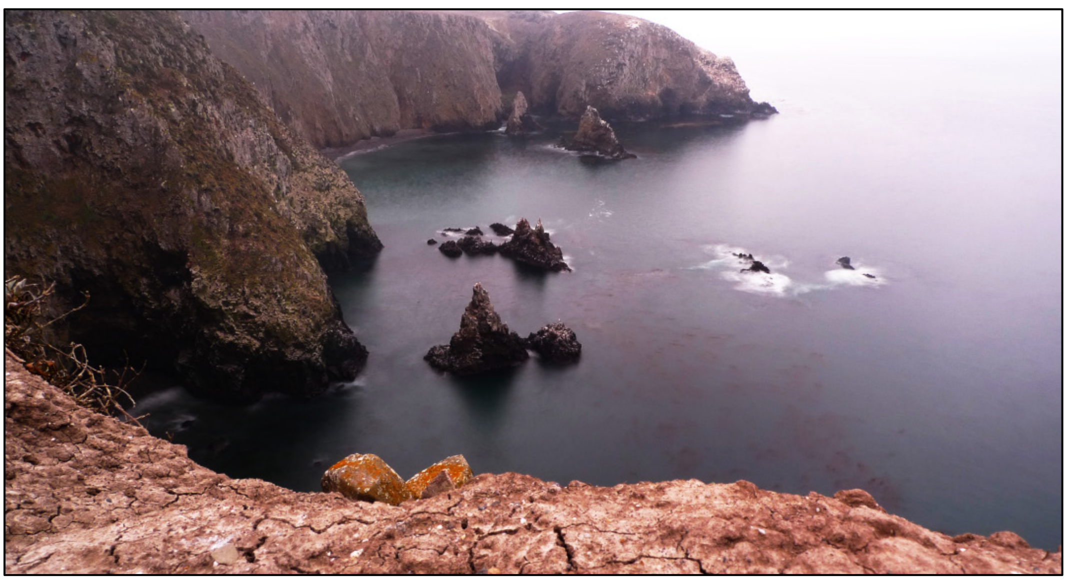
- Most visitors to the islands are residents of the three gateway counties—Santa Barbara, Ventura, and Los Angeles.
- Visitors were most often in family groups (56%).
- Forty-six percent of visitors were between the ages of 26 and 50; and 25% were 15 years old or younger.
- More than half (54%) had made previous visits to the park.
- Most U.S. visitors (75%) came from California.
- Visitors from foreign countries comprised 5% of the visitation.
- Fifty-two percent of visitors reported staying two hours or less at the Ventura visitor center.

Table 2.1.2. Visitor Data 2008–2009 (NPS Visitoruse statistics).

Island	2008 Visitors on boats	2008 Visitors ashore	2009 Visitors on boats	2009 Visitors ashore
Anacapa	8,165	12,998	27,415	10,385
Santa Cruz	53,389	50,055	27,762	51,064
Santa Rosa	9,766	4,306	9,108	3,580
San Miguel	2,662	1,053	3,646	1,409
Santa Barbara	1,118	561	1,140	543

Park visitors watching dolphins. NPS photo.

2.2. Natural Resources



Anacapa Island. NPS photo.

2.2.1. Introduction

Natural Environment and Processes

The Channel Islands unique island endemic species and assemblages include island chaparral, island oak (*Quercus tomentella*), island deer mouse (*Peromyscus maniculatus* ssp.), island night lizard (*Xantusia riversiana*), island fox (*Urocyon littoralis* ssp.), island scrub-jay (*Aphelocoma insularis*) and about 75 other plant taxa. The islands also provide critical habitat for seabird nesting, marine mammals, rare plant communities, and more federally listed species than any park in the contiguous

United States (NPS 2015). The islands are a refuge for species once more widespread during cooler moister climates of the past, like the Torrey pines (*Pinus torreyana*) and island ironwood (*Lyonothamnus floribundus*) that have largely vanished from the mainland. They also are used by migratory marine mammals and bird life that cover the extent of the Pacific, but rely on Channel Islands during critical times for mating and reproduction. Because of the islands' isolation, opportunities exist for potential, successful ecological recovery and removal of non-native species. Their isolation also allows for natural darkness on the islands, important for nocturnal seabirds and other animals, and a natural soundscape and clean air that contribute to wildlife habitat.

<u>Marine Environment</u>

The islands occur within a complex, protected marine ecosystem where the confluence of warm and cold currents provides a wide range environmental conditions in a relatively small area. The islands are surrounded by abundant tide pools and kelp forests supporting a rich diversity of species. The confluence of northern and southern currents makes the waters surrounding the islands a transitional zone, with species typical of warmer southern waters, such as garibaldi (*Hypsypops rubicunda*) common around Santa Barbara, and species typical of cooler northern waters, such as blue rockfish (*Sebastes mystinus*), common around San Miguel and Santa Rosa Islands (NOAA 2009).

2.2.2. Resource Descriptions

<u>Soils</u>

In general, the larger islands have more diverse soils. Soils range from fine sandy loams to clay, with larger islands having more diverse soils with distinct geographic units occurring with them (Butterworth et al. 1993). On Santa Cruz Island, uneroded soils are typically 30-90 cm thick (Butterworth et al. 1993) with some areas accumulating over a meter of soil (Tracy and King 2010). Soil types are clay-rich Vertisols or Alfisols and Mollisols with vertic properties, overlain by a silt-rich mantle (Muhs et al. 2008). The rich upper mantle is thought to be wind-born dust from mainland and Baja California deposited on the islands during Santa Ana conditions (Muhs et al. 2009). Cyanobacterial soil crusts are common on all of the islands. Surveys done by Belnap (1994) indicate that cyanobacterial crusts should cover the soil surfaces in most of the vegetation types found in the Channel Islands. These crusts are important for increased soil stability, water infiltration, and fertility of soils. They are also very susceptible to surface disturbance, such as through grazing, hooved animal and human foot traffic, and off-road vehicles. The absence of crusts can lead to increased erosion and disruptions of nutrient cycles. Recovery of the soil crusts is extremely slow, taking hundreds of years to fully recover (NPS 1999).

Soil Disturbance and Erosion

Many of the soils on the Channel Islands have been disturbed and altered. Soil erosion has occurred throughout all the islands due to a combination of factors including naturally erodible soils, erosion-prone sedimentary geologic formations, rugged topography with steep slopes, wave action, changes in vegetation, grazing by nonnative animals, road building, and cultivation practices. The impact of sheep grazing on soil erosion was demonstrated on Santa Cruz Island, where 80% of over 1900 slope failures across the island happened in the 10% of the island where sheep grazing occurred (Pinter and Vestel 2005). In a follow up survey after heavy storms in the winter of 2004-2005, 4 years after all sheep were removed from the island, soil slippage was virtually nonexistent in those same areas (Pinter and Vestel 2005).

Water Quality

Freshwater Quality

Only three of the islands have freshwater features: San Miguel, Santa Cruz and Santa Rosa. In general, the freshwater quality of CINP is relatively good, although water quality is not intensively monitored at most sites (Engle 2006). Streams on Santa Rosa Islands that once were severely impacted by cattle have recovered since their removal in 1998 (Wagner et al. 2004), although erosion remains a problem on all three islands (Engle 2006). Also, all of the islands tend to have a high mineral content, particularly calcium and sodium, due to the marine sediments found here.

Marine Water Quality

Generally, it is believed that water quality conditions are good, given the distance of the islands from the mainland, the volume of the ocean, and the shelves and basins near the mainland where many pollutants from the Los Angeles basin and other coastal regions settle (NPS 1980). However, there are many potential water pollution sources that likely have affected the park's water quality in the past and may affect conditions in the future. Elevated levels of fecal bacteria occur at anchorage sites, especially during periods of high use (Engle 2006). More than a billion gallons of urban waste is discharged daily into the southern California Bight (NPS 1999). Agricultural and urban runoff from the mainland, including debris, sediments, nutrients such as fertilizers, herbicides and insecticides, toxic chemicals, heavy metals, and other industrial effluents, and potentially harmful bacteria, can easily reach the islands during storms and there is evidence that heavy metals, trace elements, pesticides and other organics are present or elevated in the rocky intertidal zones (Engle 2006).

Petroleum pollution can occur due to natural oil seeps, boat groundings, oil and tar from nonpoint sources, and oil spills and leaks from the many oil production platforms in the area. The California Department of Fish and Wildlife (CDF&G Marine Resources Division 2002) noted there are a variety of pollutant discharges associated with oil and gas developments, including drill cuttings and mud, sewage, and trash; formation waters; and marine corrosion products. The discharge of polycyclic aromatic hydrocarbons (PAHs), which are persistent and can accumulate in the aquatic food chain, was of particular concern.

Past ocean dumping in the area may lead to transport of materials into park waters. Heavy metals and organochlorine pesticides due to dumping persist in ocean waters in the vicinity of the park. This resulted in reproductive failure of California brown pelicans (*P. o. californicus*), bald eagles (*Haliaeetus leucocephalus*), cormorants (*Phalacrocorax* spp.), and peregrine falcons (*Falco peregrinus*), and caused problems for marine mammals (NPS 1999).

Changes in marine water quality due to the above pollution sources can result in a variety of impacts on the park's marine ecosystem including lowered photosynthesis and oxygen levels; introduction of disease; disturbance of spawning and nursery areas; loss of food sources and habitats; chemical disturbances; interference with filter feeding and respiratory functions of marine organisms;

reproductive failures; other physiological and behavioral changes; injuries and deaths of benthic and other marine organisms; and changes in population levels and species distributions (CDF&G Marine Resources Division 2002).

Floodplains

Floodplains on Santa Cruz, Santa Rosa, and San Miguel islands exist where there are perennial and intermittent streams. Some of the floodplains are quite extensive, such as along Scorpion Creek or in the lower reaches of Cañada del Puerto on Santa Cruz. But in most cases, the floodplains are fairly confined and are in the lower reaches of the streams, in low gradient coastal areas. With the exception of Scorpion Valley and Prisoners Harbor area (mouth of Cañada del Puerto) on Santa Cruz, none of the Channel Islands floodplains have been mapped.

Wetlands

Although most of the wetlands of CINP have not been delineated, Santa Cruz, Santa Rosa, and San Miguel islands all have wetlands. Wetlands were delineated by NPS staff on Santa Cruz at the lower end of Scorpion Valley and at Prisoners Harbor in May 2003 (NPS 2003). They are considered to be jurisdictional wetlands by the Park Service and are under the Corps of Engineers' jurisdiction. In 2011, Channel Islands National Park and The Nature Conservancy restored 1.25 ha of coastal wetland at Prisoners Harbor to functional coastal wetland habitat (Power et al. 2014).

Terrestrial Flora and Plant Communities

CINP supports a diverse terrestrial flora that includes many rare and endemic species, as well as many nonnative species (Table 2.2.1). Because of their isolation, the islands support fewer plant species than grow in areas of similar size on the mainland. About 775 plant taxa, including species, subspecies, varieties, and forms, have been identified in the park, of which about 578 are native and 205 are nonnative (Junak et al. 1997).

Table 2.2.1. Numbers of taxa, percent natives, and total endemic species, subspecies and varieties of terrestrial plants found on the California Channel Islands. Data from Channel Islands National Park and U.S. Geological Survey, Channel Islands Field Station unpublished data, Santa Barbara Botanic Garden 2014, Center for Plant Conservation 2014 (McEachern et al. 2016).

Island	# Plant taxa	% Native plants	# Endemic taxa*
San Miguel Island	270	74	20
Santa Rosa Island	500	80	44
Santa Cruz Island	680	72	55
Anacapa Island	265	72	25
Santa Barbara Island	135	67	17

* Numbers of endemic species, subspecies and varieties, including taxa presumed extirpated from the island.

Each island supports a unique assemblage of plant communities, which differ in response to climate, microhabitats, topography, geology, soils, plant colonization history, isolation, and land use history. The species composition and distribution of the islands' native plant communities have been greatly altered by people and the introduction of nonnative species, and are in various stages of recovery.

Major plant communities include coastal dune, coastal bluff, coastal sage scrub, grasslands, chaparral, island oak woodlands, mixed hardwood woodlands, pine stands, and riparian areas. Currently, the most extensive vegetation communities on the islands are non-native grassland and coastal sage scrub with significant areas of chaparral on SCI, and to a lesser degree, on SRI. Various phases of coastal bluff scrub constitute the next largest category. Mixed broadleaf woodland stands, oak woodlands, and pine stands are scattered throughout the islands on sheltered slopes and canyons, or on ridges exposed to frequent moist fogs. Smaller but no less significant vegetation communities include coastal dune, *Baccharis* scrub, caliche scrub, and wetlands. In general, the understories of the native scrub communities are invaded by a variety of annual and perennial non-native grasses and herbs.

Endemic and Rare Plants

A relatively large number of the Channel Islands' plant species are endemic to the islands (Table 2.2.1 above). Some of these island endemics are relicts, representing species that occurred on the mainland when climates were cooler, resembling the current maritime island environment. Island oak (*Quercus tomentella*), Torrey pine (*Pinus torryeana* ssp. *insularis*) and island ironwood (*Lyonothamnus floribundus* ssp. *aspleniifolius*) are examples of this type of endemism. Evidence for these species having once grown on the mainland comes from an abundant fossil record. Other island endemics, however, evolved from a mainland ancestor that successfully established on the islands in the more recent past and rapidly adapted to island habitats. Of the approximately 775 plant taxa known to grow in the park, 64 species, subspecies, or varieties are endemic to the park; 23 of the 64 endemics are found on only one island; and 41 of the endemics are found on more than one island. Each of the islands has endemic species, ranging between 4% and 10% of the total taxa on each island (Table 2.2.2). Most of the islands' endemic species are considered rare and 15 are listed federally as threatened or endangered (USFWS 1976). The coastal bluff, chaparral, coastal sage scrub, and mixed woodland communities support the most rare plant taxa (NPS 1999). These communities are remnants of the native vegetation, recovering within a mosaic of non-native grassland and barren sites.

Table 2.2.2. Numbers of endemic species, subspecies and varieties of terrestrial plants found on the California Channel Islands. Data from Channel Islands National Park and U.S. Geological Survey, Channel Islands Field Station unpublished data, Catalina Island Conservancy 2014, Santa Barbara Botanic Garden 2014, Center for Plant Conservation 2014 (McEachern et al. 2016).

Island	Endemic to one island only	Endemic to more than one island	Endemic presumed extirpated	Island total
San Miguel Island	1	18	1	20
Santa Rosa Island	5	38	1	44
Santa Cruz Island	7	45	3	55
Anacapa Island	2	22	1	25
Santa Barbara Island	4	13	0	17
San Nicolas Island	2	15	1	18
Santa Catalina Island	8	26	1	35
San Clemente Island	15	47	1	63

Nonnative Plants

Islands generally are vulnerable to invasion of nonnative plants. In the case of CINP, many nonnative species have successfully established and spread rapidly on the islands during the past 150 years. The primary factors responsible for their spread were the introduction and proliferation of feral sheep and pigs, uncontrolled grazing, and browsing by cattle and nonnative deer and elk, and the resulting destruction of most of the native vegetation cover by these animals.

It is estimated that nonnative species compose about 25% of CINP's flora (Handley et al. 2016). About 197 taxa not known to be native to California have been introduced into the park since European contact. Thirteen species are native to the California mainland but have been accidentally or deliberately introduced to the islands. All of the islands have nonnative species, ranging from 38 species on Santa Barbara (33% of the total flora on the island) to about 170 species on Santa Cruz (about 28% of the total flora). Eleven of SCI's 88 plant families and 82 of its 348 plant genera are represented exclusively by nonnative taxa (NPS 2002a).

These nonnative species have changed the overall composition and ground cover of many of the park's vegetation communities; it is estimated that nonnative species cover two-thirds of the park's land surface (NPS 1999). Many of these species have become naturalized and persist tenaciously as part of the local flora. Annual grasses have spread over all of the islands and are probably the most widespread nonnatives. Between 35% and 75% of each island is covered by nonnative grasslands dominated by Mediterranean annual grasses, primarily brome (*Bromus*), barley (*Hordeum*), fescue (*Vulpia*), and oats (*Avena*) (McEachern 2004).

Five species of perennial iceplant (*Carpobrotus edulis*, *C. chilense*, *Malephora crocea*, *Mesembryanthemum crystallinum,* and *M. nodiflorum*) are common nonnative species. These species have occupied large areas of Santa Barbara, East Anacapa, and to a lesser degree San Miguel, in carpet-like mats. Two of the iceplant species are very successful weeds because they accumulate salts in their tissue. When they die, the salts are released into the soil, creating salt levels that exceed the tolerance of most plants, effectively eliminating them.

Several opportunistic species of concern grow on the islands that have the potential to rapidly colonize available habitat and dominate plant communities. These species include bull thistle (*Cirsium vulgare*), Russian thistle (*Salsola iberica*), and spiny cocklebur (*Xanthium spinosum*). Spread by the wind and animals, populations of these species are all increasing in size, number, and range. All of these species could form dense monotypic stands, completely excluding native island species.

Several slow-spreading weed species also grow on the islands, including lavatera (*Lavatera cretica*), black mustard (*Brassica nigra*), tamarisk (*Tamarix aphylla*), kikuyu grass (*Pennisetum clandestinum*), rice grass (*Piptatherum miliacea*), tall fescue (*Festuca arundinacea*), and Bermuda grass (*Cynodon dactylon*). These species are very persistent once they become established and can form dense populations. Their seeds are spread through animal feces, mud on vehicle tires, or animals' feet. Kikuyu grass is particularly aggressive and has taken over large areas of wetlands and riparian banks on Santa Cruz (NPS 2003).

The Park Service has taken several actions to control or limit the spread of nonnative plants in the park. There is a concentrated effort to remove perennial iceplant from East Anacapa. Occurrences of fennel and yellow star thistle were eliminated from Santa Rosa. Twelve acres of red gum eucalyptus in the Prisoners Harbor wetland were cut. Efforts have been made to eliminate fennel from the Scorpion anchorage area and thousands of olive saplings have been eliminated from the backcountry of SCI. Many young stone pines were eliminated from the Prisoners Harbor area. A program also is under development to educate visitors to the dangers of invasive nonnative plants.

Vegetation and People

Throughout their entire history of occupation on the Channel Islands, people have impacted the islands' vegetation (Rick et al. 2014). Possibly the first inhabitants affected vegetation through food-gathering activities. They also may have set fires to encourage certain plants or to enhance access; cut down trees or shrubs for shelter, fuel, or making baskets; and deliberately or inadvertently introduced new plants to the islands.

However, it was not until the arrival of Europeans and the establishment of ranching or farming that the islands' soils and vegetation were substantially altered (McEachern et al. 2016). Before the early 1800s, the islands were most likely covered by a mosaic of upland native scrub, riparian woodland, and coastal bluff and dune scrub interspersed with small native grass openings and grassland vegetation (NPS 1999; McEachern 2004). The uplands were largely shrublands. After Europeans settled on the islands, throughout the first half of the 19th century the vegetation of all of the islands changed due to clearing, burning, plowing, and the introduction of livestock, game animals, and nonnative plant species.

Ranching was the predominant land use of the islands beginning in the 1830s McEachern et al. (2016). There were two periods of sheep grazing on SBI, and rabbits grazed the island from 1941 to

1981 (Table 2.2.3). Middle and West Anacapa had sheep ranching. From the 1920s to the early 1980s Santa Cruz supported the largest single population of feral sheep in the world (Van Vuren and Coblentz 1989). On Santa Rosa ranching began during the 1840s. Sheep, feral pigs, cattle, horses, elk, and deer were introduced and grazed over much of the island. As many as 75,000 to 125,000 sheep once grazed the island in the 1800s and early 1900s. On San Miguel livestock ranching also occurred. The island was extensively overgrazed during the late 1800s and in the early part of the 20th century. The loss of vegetation due to sheep grazing was responsible for the development of major unstable dune systems that covered most of the island by the early 1900s (NPS 1984).

Table 2.2.3. Timeline of terrestrial mammal introductions and eradications in Channel Islands National Park that accompanied European settlement. Data from Von Bloeker 1967, Livingston 2006, P. Collins unpublished data, Channel Islands National Park unpublished data, U.S. Navy unpublished data, Santa Barbara Museum of Natural History Channel Islands unpublished archives, Santa Cruz Island Foundation unpublished archives (McEachern et al. 2016).

Species	San Miguel	Santa Rosa	Santa Cruz	Anacapa	Santa Barbara
European rabbit	–	–	–	–	1942-1981
European hare	–	–	–	1930s-Mid 1960s	1918-1930s
Black rat	Early 1900s-Present	–	–	1853 - 2002	–
Domestic dog	1884-1940s	1888-1993	1880s-1980, 2005-2007	–	–
Feral cat	1884-Early 1940s	Late 1930s, 2010-2011	Early 1920s - 1939	Late 1920s-Late 1940s	Pre 1863-1978
Horse	1851-1948	1844-2011	1830-2009	–	1915-1919
Mule/burro/donkey	Early 1950s-1976	1880s	–	–	1915-1922
Feral pig	1851-1897?	1853-1993	1852-2006	–	–
Fallow deer	–	1890-1949	–	–	–
Mule deer	–	1880-2013	–	–	–
Elk	–	1879-2011	–	–	–
Domestic cattle	1851-1917?	1844-1998	1830-1999	–	–
Goat	Late 1880s-1890?	1883-Early 1900s	Late 1880s, 1919-1920	–	–
European mouflon sheep	Pre 1850-Early 1970s	1844-Early 1960s	1853-2001	1869-1937	Pre 1863-1926, 1942-1946

Ranching caused rapid and pervasive vegetation changes on all of the park islands (McEachern et al. 2016). Land use practices during the ranching era resulted in the widespread conversion of native shrublands to grasslands, dominated by nonnative annual grasses, reduction in the extent of woody and succulent plant communities, loss of native plant understories in woodlands, weed invasion, increased rates of soil compaction and soil loss, and a decline or extirpation of populations of plant species due to the nonnative herbivores. Periodic drought exacerbated the effects of livestock on the island ecosystems (NPS 1999).

Several other human activities affected the islands' vegetation. Some cultivation of crops took place on SRI, SCI, SBI, and SMI. Vegetation on East Anacapa was altered by a Coast Guard station and the introduction of iceplant for erosion control. Extensive road systems were built on SRI, SMI, and SCI. In addition, the vegetation of parts of these three islands was affected by military activities, including the construction of facilities on the islands and bombing practice/military exercises on SMI.

Intensive grazing and ranching practices reduced the build-up of fuels for fires. However, the removal of grazing in the grass-dominated landscapes; increased human activities (including illegal campfires, smoking, and park maintenance activities); and changes in fuel conditions now pose fire hazard conditions that were never previously present on the islands.

Much woody vegetation has been lost from the islands during the last 100 years. There has been very little evidence of reproduction of native tree species due mostly to past livestock grazing and browsing, and to a lesser extent, rooting by feral pigs. The original distribution, size, and physical condition of coastal sage scrub, chaparral, riparian communities and island woodlands have been heavily affected by grazing, browsing, and rooting animals seeking shelter and food. Wetlands were altered by efforts to channel streams, create uplands for buildings, and control flooding in coastal areas.

Since the Park Service (and TNC on SCI) began managing the islands' resources by removing nonnative herbivores, rehabilitating eroded areas, planting native vegetation, and taking action to control nonnative species, several plant communities are recovering. In particular, with the removal of nonnative grazers on Anacapa and San Miguel islands, the coastal sage scrub habitat has increased in extent. On SMI, much of the native vegetation has recovered dramatically since all introduced herbivores were removed in 1977. On SCI, dramatic increases in both the variety and density of vegetation have occurred since sheep were removed (Pinter and Vestal 2005).

Climate Change and Terrestrial Vegetation

Global climate models indicate temperatures are going to increase and total annual precipitation is going to decrease in mainland coastal areas adjacent to the northern Channel Islands by the end of the century (TNC 2009). Although downscaled climate projections are not currently available for the Channel Islands, on the nearby mainland coast, future July maximum temperatures are projected to be greater than 99 of the 100 years in the 20th century, while future total annual precipitation is projected to be less than 54 out of the 100 years in the 20th century. These changes are likely to result in moderate drought stress and high heat stress, which in turn can directly and indirectly affect plant survival (e.g., increase some plants' vulnerability to pests). Increased temperatures can also result in the spread of more heat-tolerant nonnative species, such as grasses, which typically have a higher tolerance for a wide range of environmental conditions than native species (Largier et al. 2010).

Climate change is already affecting island vegetation. There has been a statistically significant increase in minimum nighttime temperature since the 1940s, measured at the National Weather Station in Oxnard, California (McEachern et al. 2009), and more recently 1989-2009 on SRI. This increase is correlated with increased mortality in small island paintbrush plants (*Castilleja mollis*), a single island endemic on Santa Rosa, listed as endangered by the Federal government (McEachern et al. 2009). Recent analyses of vegetation transect data collected by the CINP Inventory and Monitoring Program on SBI and SRI indicate that both the amount of precipitation and the date of sampling are two factors that correlate significantly with total species cover, as well as the abundance of certain community dominants and species guilds (Handley et al. 2013). Observations by park botanist Dirk Rodriguez (personal communication, 2013), indicate that flowering and onset of summer dormancy occurred earlier in the growing season in 2013 than when he began the vegetation monitoring in 1999.

Other changes associated with climate that could affect the islands' plants include:

- Potential for timing disruptions between pollinators and plants
- Increased potential for wildfires due to vegetation drying out and increased flammability
- Potential for changes in fog regimes, which in turn can affect plant growth and establishment
- Rise in sea levels, affecting vegetation on dunes, beaches, and rocky habitats
- Changes in precipitation and salt spray that may modify soil salinity and thus affect the composition of beach and dune plant communities
- Increased erosion of cliffs and hillsides due to larger waves from winter storms and higher water levels, affecting the physical habitat of plants (all of the Channel Islands have been classified as moderately vulnerable to shoreline erosion or accretion)
- Potential for floods due to more intensive storms (Wilkinson 2002, USGS 2005, California Natural Resources Agency 2009, McEachern et al. 2009, Largier et al. 2010).

Many Channel Islands species are at their northern or southern range limits, and any of the above changes may be enough to extirpate them on the islands. In addition, endemic species on the islands have limited distributions and have no place else to go in response to changes in climate. In other words, climate change could result in major changes to the park's flora due to the lack of connectivity and endemic nature of many of the park's plants.

Terrestrial Wildlife, Seabirds, and Pinnipeds

Native Terrestrial Animals

Because of their isolation and remote nature, the Channel Islands support fewer native animal species than similar habitats on the mainland. Species that reached the islands could fly, such as birds and bats, rafted across the water on debris and other material, or were perhaps introduced, intentionally or not, by aboriginal people. A total of 68 native terrestrial vertebrate species have been recorded in the park, including 3 amphibian, 6 reptile, 2 rodent, 2 carnivore, 11 bat, and 46 breeding landbird species

(see Tables 2.2.4 and 2.2.5 for a list of landbird and terrestrial vertebrate species; these numbers do not include nonnative species or migratory birds.)

Over time some vertebrate species evolved into distinct subspecies on the islands. For example, the deer mouse and island fox are recognized as distinct subspecies on their respective islands. A total of 23 endemic terrestrial animals have been identified in the park, including 11 landbirds, that are Channel Island subspecies or races (see tables 2.2.5 and 2.2.6).

Table 2.2.4. Island-specific breeding status of landbirds known to breed at Channel Islands National Park (Collins and Jones 2015). SMI = San Miguel Island; SRI = Santa Rosa Island; SCI = Santa Cruz Island; AI = Anacapa Island; SBI = Santa Barbara Island. B = regular breeder; O = occasional breeder.

Common name	Latin name	SMI	SRI	SCI	AI	SBI
Great blue heron	*Ardea herodias*	–	B	–	–	–
Golden eagle	*Aquila chrysaetos*	–	O	O	–	–
Red-tailed hawk	*Buteo jamaicensis*	B	B	B	B	–
Northern harrier	*Circus cyaneus*	O	O	–	–	–
Bald eagle	*Haliaeetus leucocephalus*	–	B	B	B	–
Peregrine falcon	*Falco peregrinus*	B	B	B	B	B
American kestrel	*Falco sparverius*	B	B	B	B	B
California quail	*Callipepla californica*	–	B	B	–	–
Rock pigeon	*Columba livia*	–	O	–	–	–
Mourning dove	*Zenaida macroura*	–	B	B	–	O
Barn owl	*Tyto alba*	B	B	B	B	B
Northern saw-whet owl	*Aegolius acadicus*	–	–	B	–	–
Short-eared owl	*Asio flammeus*	–	–	–	–	B
Burrowing owl	*Athene cunicularia*	–	–	–	–	B
White-throated swift	*Aeronautes saxatalis*	–	B	B	B	–
Anna's hummingbird	*Calypte anna*	O	O	B	–	–
Allen's hummingbird	*Selasphorus sasin*	B	B	B	B	–
Northern flicker	*Colaptes auratus*	–	–	B	–	–
Acorn woodpecker	*Melanerpes formicivorus*	–	B	B	–	–
Pacific-slope flycatcher	*Empidonax difficilis*	–	B	B	B	–
Black phoebe	*Sayornis nigricans*	O	B	B	O	–
Ash-throated flycatcher	*Myiarchus cinerascens*	–	–	B	–	–
Horned lark	*Eremophila alpestris*	B	B	B	–	B
Barn swallow	*Hirundo rustica*	B	B	B	B	B
Island scrub-jay	*Aphelocoma insularis*	–	–	B	–	–
Bushtit	*Psaltriparus minimus*	–	B	B	–	–
Common raven	*Corvus corax*	B	B	B	–	–
Red-breasted nuthatch	*Sitta canadensis*	–	–	B	–	–
Canyon wren	*Catherpes mexicanus*	–	–	O	–	–

Table 2.2.4 (continued). Island-specific breeding status of landbirds known to breed at Channel Islands National Park (Collins and Jones 2015). SMI = San Miguel Island; SRI = Santa Rosa Island; SCI = Santa Cruz Island; AI = Anacapa Island; SBI = Santa Barbara Island. B = regular breeder; O = occasional breeder.

Common name	Latin name	SMI	SRI	SCI	AI	SBI
Rock wren	*Salpinctes obsoletus*	B	B	B	B	B
Bewick's wren	*Thryomanes bewickii*	–	B	B	B	–
Blue-gray gnatcatcher	*Polioptila caerulea*	–	–	B	–	–
American robin	*Turdus migratorius*	–	–	O	–	–
Northern mockingbird	*Mimus polyglottos*	–	B	B	–	–
Loggerhead shrike	*Lanius ludovicianus*	–	B	B	–	–
European starling	*Sturnus vulgaris*	B	B	B	B	B
Hutton's vireo	*Vireo huttoni*	–	B	B	O	–
Orange-crowned warbler	*Vermivora celata*	B	B	B	B	B
Black-headed grosbeak	*Pheucticus melanocephalus*	–	–	B	–	–
Red-winged blackbird	*Agelaius phoeniceus*	–	–	O	–	–
Rufous-crowned sparrow	*Aimophila ruficeps*	–	–	B	B	–
Grasshopper sparrow	*Ammodramus savannarum*	–	–	B	–	–
Song sparrow	*Melospiza melodia*	B	B	B	–	–
Spotted towhee	*Pipilo maculatus*	–	B	B	–	–
Chipping sparrow	*Spizella passerina*	–	B	B	B	–
Western meadowlark	*Sturnella neglecta*	B	B	B	B	B
Lesser goldfinch	*Carduelis psaltria*	B	B	B	–	–
House finch	*Carpodacus mexicanus*	B	B	B	B	–
Total	**–**	**18**	**34**	**43**	**18**	**11**

Table 2.2.5. Nonavian native terrestrial vertebrates of Channel Islands National Park. SBI = Santa Barbara Island; AI = Anacapa Island; SCI = Santa Cruz Island; SRI = Santa Rosa Island; SMI = San Miguel Island.

Category	Common name	Latin name	SBI	AI	SCI	SRI	SMI
Amphibians	Black-bellied slender salamander	*Batrachoseps nigriventris*	–	–	X	–	–
	Channel Islands slender salamander	*B. pacificus pacificus*	–	X	X	X	X
	Baja California tree frog*	*Pseudacris hypochondriaca*	–	–	X	X	–
Reptiles	Island night lizard	*Xantusia riversiana*	X	–	–	–	–
	Southern alligator lizard	*Elgaria multicarinata*	–	X	X	X	X
	Island fence lizard	*Sceloporus occidentalis beckii*	–	–	X	X	X
	Side-blotched lizard	*Uta stansburiana*	–	X	X	–	–

*Formerly the Pacific tree frog (*Pseudacris regilla*).

Table 2.2.5 (continued). Nonavian native terrestrial vertebrates of Channel Islands National Park. SBI = Santa Barbara Island; AI = Anacapa Island; SCI = Santa Cruz Island; SRI = Santa Rosa Island; SMI = San Miguel Island.

Category	Common name	Latin name	SBI	AI	SCI	SRI	SMI
Reptiles (continued)	Santa Cruz Island gopher snake	*Pituophis catenifer pumilus*	–	–	X	X	–
	Western yellowbelly racer	*Coluber constrictor mormon*	–	–	X	–	–
	San Diego nightsnake	*Hypsiglena ochrorhyncha klauberi*	–	–	X	–	–
Mammals	California myotis	*Myotis californicus caurinus*	–	–	X	–	–
	Big-eared myotis	*M. evotis*	–	–	X	–	–
	Fringed myotis	*M. thysanodes*	–	–	X	–	–
	Townsend's western big-eared bat	*Corynorhinus townsendii townsendii*	–	–	X	–	–
	Big brown bat	*Eptesicus fuscus*	–	–	X	–	–
	Pallid bat	*Antrozous pallidus pacificus*	–	–	X	–	–
	Silver-haired bat	*Lasionycteris noctivagans*	–	–	X	–	–
	Hoary bat	*Lasiurus cinereus*	X	–	X	–	–
	Red bat	*L. borealis*	–	–	X	–	–
	Mexican free-tailed bat	*Tadarida brasiliensis*	–	–	X	–	–
	Western mastiff bat	*Eumops perotis californicus*	–	–	X	–	–
	Santa Barbara island deer mouse	*Peromyscus maniculatus (P. m.) elusus*	X	–	–	–	–
	Anacapa Island deer mouse	*P. m. anacapae*	–	X	–	–	–
	Santa Cruz Island deer mouse	*P. m. santacruzae*	–	–	X	–	–
	Santa Rosa Island deer mouse	*P. m. santarosae*	–	–	–	X	–
	San Miguel Island deer mouse	*P. m. streatori*	–	–	–	–	X
	Santa Cruz Island harvest mouse	*Reithrodontomys megalotis santacruzae*	–	–	X	–	–
	Santa Cruz island fox	*Urocyon littoralis (U.l.) santacruzae*	–	–	X	–	–
	Santa Rosa island fox	*U. l. santarosae*	–	–	–	X	–
	San Miguel island fox	*U. l. littoralis*	–	–	–	–	X
	Island spotted skunk	*Spilogale gracilis amphiala*	–	–	X	X	–

Table 2.2.6. Endemic landbird taxa at Channel Islands National Park.*

Species	Island form	Mainland form	Reference	Notes
Allen's hummingbird	*S. s. sedentarius*	*S. s. sasin*	Mitchell (2000)	*S. s. sedentarius* known also from Palos Verdes peninsula
Pacific-slope flycatcher	*E. d. insulicola*	*E. d. difficilis*	Lowther (2000)	–
Horned lark	*E. a. insularis*	*E. a. actia*	Beason (1995)	21 subspecies recognized
Island scrub-jay	*A. insularis*	*A. californica*	Delaney and Wayne (2005)	Only island endemic which is full species; mainland form is western scrub-jay
Bewick's wren	*T. b. nesophilus*	*T. b. charienturus*	Kennedy and White (1997)	*T. b. catalinae* occurs on Santa Catalina Island
Loggerhead shrike	*L. l. anthonyi*	*L. l. gambeli*	Eggert et al. (2004)	*L. l. mearnsi* occurs on San Clemente Island
Orange-crowned warbler	*V. c. sordida*	*V. c. lutescens*	Gilbert et al. (2010)	*V. c. sordida* also occurs on s. California coast
House finch	*C. m. clementis*	*C. m. frontalis*	Hill (1993)	*C. m. clementis* occurs on southern islands, including Santa Barbara; house finches on northern islands are the mainland subspecies, *C. m. frontalis*
Rufous-crowned sparrow	*A. r. obscura*	*A. r. ruficeps*	Collins (1999)	–
Song sparrow	*M. m. graminea*	*M. m. heermanni*	Arcese et al. (2002)	*Song sparrows on Santa Cruz are likely hybrids between M. m. graminea and M. m. heermanni*

* Spotted towhees on Santa Rosa were formerly thought to be the San Clemente spotted towhee (*P. m. clementae*), which occurs on San Clemente and Santa Catalina (Johnson 1972), but are now thought to be of the mainland subspecies, *P. m. megalonyx* (Greenlaw 1996). Spotted towhees were extirpated on San Clemente by 1976 (Greenlaw 1996).

A small amount of data exists on terrestrial invertebrate fauna populations on the islands. Miller (1979) reported the results of a preliminary survey of dominant insects on AI, SMI, and SBI. A total of 97 insect species and relatives were included on a provisional list for AI, 183 for SMI, and 123 for SBI. Hochberg (1979) reported that the three islands supported eight species of land snails. A 1989 survey reported 137 species of insects and other arthropods on AI (NPS 2000).

Although not listed in Table 2.2.4, many shorebirds use the park; 30 species have been recorded (NPS 2000). The park's islands, SRI in particular, are an important wintering area and stopover point. Common wintering shorebirds include willet (*Catoptrophorus semipalmatus*), wandering tattler (*Heteroscelus incanus*), whimbrel (*Numenius phaeopus*), black turnstone (*Arenaria melanocephala*), and sanderling (*Calidris alba*).

Nine raptor species live in the park and are primarily seen on Santa Cruz and SRIs. Hawks and owls also occur intermittently on Anacapa, San Miguel, and SBIs, which have limited habitat to support these birds.

Several bird species disappeared from the park during the 20th century. The Santa Barbara Island population of the Channel Island song sparrow (*Melospiza melodia graminea*) was driven to extinction due to habitat destruction by introduced rabbits, direct predation by feral cats, and a fire in 1959 that destroyed much of its habitat. Bald eagles and peregrine falcons also formerly bred on the islands, but disappeared due to harassment, shooting, egg stealing, and reproductive failure caused by organochlorine pesticides, such as DDT. However, both of these species are making a comeback due to reintroduction efforts. Peregrines were reintroduced on the islands in the 1980s, and currently over 40 active peregrine falcon nests are in the park (Sharpe 2014). Bald eagles were reintroduced on SCI beginning in 2002 and are now successfully nesting on SCI (six nests), SRI (two nests) and AI (one nest) (Sharpe 2017).

Golden eagles (*Aquila chrysaetos*) were live captured and removed from the park because golden eagle predation was responsible for the massive island fox decline from 1994 to 2000. Until recently, golden eagles had not been known to breed on the Channel Islands. The golden eagles were able to exist in the park because feral pigs provided abundant food on SCI, and because bald eagles were no longer present to exclude them (NPS 2002a, b).

Bats are the most diverse group of native mammals on the islands, with 11 species recorded just on SCI. Four bat species have been found on both SRI and SBI, and none on AI or SMI (Table 2.2.5). Of the 11 species recorded from park islands, three are breeding, year-round residents—Townsend's western big-eared bat (*Corynorhinus townsendii townsendii*), pallid bat (*Antrozous pallidus pacificus*), and California myotis (*Myotis californicus caurinus*).

Although they have not been well studied in the park, in part due to their reclusive nature, bats play important roles as insectivores. The Townsend's western big-eared bat colony on SCI is one of the few remaining breeding colonies of this species in southern California, where it has suffered serious declines (Charles Drost, USGS, personal communication, 2013).

Almost all of the native habitats on the islands have been altered to some degree by human land use practices, a situation that in turn affects native wildlife that evolved in the absence of these impacts. Areas that closely resemble native habitat are therefore especially important for terrestrial animals.

Seabirds

CINP is recognized as an important breeding and resting area for a variety of seabirds. The rich marine food sources and isolated islands support numerous colonies of seabirds. Although the mainland may provide roosting areas, in most cases, seabirds depend on the park islands for breeding and nesting. Collectively, the islands constitute a major seabird breeding area in the eastern north Pacific, the largest such area in the United States south of the Farallon Islands (NPS 1980). For example, 50% of the world's population of ashy storm-petrels (*Oceanodroma homochroa*) and western gulls (*Larus occidentalis*), 95% of the U.S. breeding population of Scripps's murrelets (*Synthliboramphus scrippsi*; 33.5% of the world's population and the only breeding ground north of Mexico), and the only major breeding population of California brown pelicans in the U.S. occur in the park (CDF&G Marine Resources Division 2005; NPS 1999). Hunt et al. (1980) called these islands the most important seabird colonies in southern California. Jones et al. (1989) noted that the particular association of northern and southern species found here is not duplicated anywhere else in the world.

Thirteen species are known to breed in CINP (Table 2.2.7), but many more species use the islands and/or park waters during migrations and in the winter. Western gulls are the most abundant breeding seabird in the park, with a population estimated at more than 15,000 pairs, followed by Cassin's auklet (*Ptychoramphus aleuticus*; approximately 12,600 pairs), brown pelican (more than 7,000 pairs), Brandt's cormorant (*Phalacrocrax penicillatus*; approximately 4,200 pairs), and Scripps's murrelet (850 to 2,450 pairs). About 3,100 pairs of ashy storm-petrels, 3,200 pairs of pigeon guillemots (*Cepphus columba*), 2,700 pairs of pelagic cormorants (*Phalacrocrax pelagicus*), and 640 pairs of double-crested cormorants (*Phalacrocrax auritus*) are estimated to breed on the islands. Five species have breeding populations of roughly 300 pairs or less—Leach's and black storm-petrels (*O. leucohoa and O. meliana*), double-crested cormorants, rhinoceros auklet (*Cerorhinca monocerata*), and tufted puffin (*Lundra cirrhata*; P. Martin, NPS, personal communication, M. Naughton, USFWS, personal communication, Carter et al. 1992, Burkett et al. 2003, Carter et al. 2004). Common murres (*Uria aalge*) bred on Prince Island in 2011.

Table 2.2.7. Seabird species nesting on the northern Channel Islands. Largest colony within the park is in Bold. Data from Baird 1993, L. Harvey, National Park Service, personal communication (2012), H. Carter, personal communication (2011), Carter et al. 1992, McChesney et al. 1995, and Carter et al. 2004.

Species Category	Species	Status[1]	Anacapa	Santa Cruz	Santa Rosa	San Miguel	Santa Barbara
Storm-petrels	*Ashy storm-petrel Oceanodroma homochroa*	CSC	B[2]	B	–	**B[5]**	B
	Black storm-petrel O. meliana	CSC	–	–	–	B?	**B[5]**
	Leach's storm-petrel O. leucorhoa	–	–	–	–	**B[5]**	B?
Cormorants	*Brandt's cormorants Phalacrocorax penicillatus*	–	B	B	B	**B[5]**	B
	Double-crested cormorant P. auritus	CSC	B	O	–	**B[5]**	B
	Pelagic cormorant P. pelagicus	–	B	B	B	**B[5]**	B
Pelicans	*California brown pelican Pelecanus occidentalis californicus*	–	**B[5]**	O	–	O	B

[1] F = Federal, S = State, E = Endangered, T = Threatened, FP = California Department of Fish and Wildlife – Fully Protected, CSC = California Species of Special Concern. B = Breedin, O = Occasional colony

[2] B = Breeding. O = Occasional colony

[3] The Scripps's murrelet was listed as a threatened species by the state of California on December 22, 2004.

[4] Previously bred, not currently attending.

[5] Largest colonies within the park (also in bold).

Table 2.2.7 (continued). Seabird species nesting on the northern Channel Islands. Largest colony within the park is in Bold. Data from Baird 1993, L. Harvey, National Park Service, personal communication (2012), H. Carter, personal communication (2011), Carter et al. 1992, McChesney et al. 1995, and Carter et al. 2004.

Species Category	Species	Status[1]	Anacapa	Santa Cruz	Santa Rosa	San Miguel	Santa Barbara
Gulls	*Western gull Larus occidentalis*	–	**B[5]**	B	B	B	B
Alcids	*Cassin's auklet Ptychoramphus aleuticus*	CSC	B	B	–	**B[5]**	B
	Pigeon guillemot Cepphus columba	–	B	B	B	**B[5]**	B
	Scripps's murrelet Synthliboramphus scrippsi	ST[3]	B	B	–	B	**B[5]**
	Rhinoceros auklet Cerorhinca monocerata	–	B?	–	–	**B?[5]**	–
	Tufted puffin Lundra cirrhata	CSC	–	–	–	**BP-NA[4,5]**	–
	Common murre Uria aalge	–	–	–	–	**B[5]**	–

[1] F = Federal, S = State, E = Endangered, T = Threatened, FP = California Department of Fish and Wildlife – Fully Protected, CSC = California Species of Special Concern. B = Breedin, O = Occasional colony

[2] B = Breeding. O = Occasional colony

[3] The Scripps's murrelet was listed as a threatened species by the state of California on December 22, 2004.

[4] Previously bred, not currently attending.

[5] Largest colonies within the park (also in bold).

Each of the Park's islands supports seabird colonies, with various species using different islands. However, the islands of Anacapa, Santa Barbara, and San Miguel, including its two small islets (Prince Island and Castle Rock), are especially important breeding areas for seabirds.

California Brown Pelican

Brown Pelicans on Santa Barbara Island. Photo by Tim Hauf.

As one of the species listed in the park's enabling legislation, the California subspecies of the brown pelican is of particular interest. This bird was classified as federally endangered in 1970 and as endangered by the state of California in 1971, but was delisted as a federally listed species in 2009. CINP provides essential habitat for this species. The only known breeding colonies of brown pelicans in the western United States are on West Anacapa and SBIs. The Channel Islands also provide roosting habitat for the birds, with major roosting areas occurring on Scorpion Rock off of SCI and near the lighthouse on East Anacapa (USFWS 1983).

On Anacapa and SBI pelicans generally nest on inaccessible slopes, canyons, and high bluff tops and edges. The peak of egg laying is usually March or April. Pelican breeding success is largely determined by the availability of their primary prey items, northern anchovies (*Engraulis mordax*) and Pacific sardines (*Sagax sarinops*), which during the breeding season compose nearly their whole diet.

In the 1970s, the park's colonies almost disappeared due to eggshell thinning and consequent reproductive failure (Gress 1995). Pelicans are extremely sensitive to bioaccumulation of the organochlorine contaminants in the marine environment, particularly DDT and its metabolites, and polychlorinated biphenyls (PCBs). DDT has been shown to alter the birds' calcium metabolism, resulting in egg-shell thinning.

The park's breeding populations have steadily increased since 1980, although they are now believed to be fairly stable. Between 1979 and 2001 the colony on West Anacapa produced a mean of about 3,600 nests per year. Pelicans were not known to nest on SBI in recent times until 1980; the first significant nesting occurred in 1985. From 1985 to 2001 the colony produced a mean of about 770 nests per year.

In order to protect breeding pelicans, park visitor access is restricted on West Anacapa. A no-entry closure from January 1 through October 31 also keeps boats well offshore to protect fledglings in the vicinity of the nesting colony and provides a buffer zone to nesting pelicans.

Pinnipeds (Seals and Sea Lions)

Channel Islands NP supports a larger and more varied population of seals and sea lions than any other area in the world that is close to a major human population center (NPS 1980). In southern California, sea lions breed and pup almost exclusively on the Channel Islands (NPS 1984). These marine mammals represent a major scientific resource and a significant wildlife watching opportunity. Four species of pinnipeds breed on the islands, while a fifth, the Guadalupe fur seal (*Arctostephalus townsendii*), hauls out but does not regularly breed in the Park (Table 2.2.8); however, a pup was born on SMI in 1997 (Melin and De Long 1999, CDF&G Marine Resources Division 2005). The California sea lion is the most common species and has established breeding colonies or haul-outs on all of the islands. Sea lion numbers have generally increased throughout the Channel Islands since the 1970s (Lowry et al. 2003, NMFS 2011), though the population experienced low reproductive success throughout the Channel Islands in 2013-2014 (Melin and Orr 2014, 2015). Northern elephant seals are the second most common species and breed or haul out on all of the islands. Elephant seal numbers in the park increased steadily from the 1960s through 2010. Numbers of elephant seals hauling out on SMI leveled off starting in the 1990s, when numbers began to increase rapidly on SRI (Lowry et al. 2014). Harbor seals (*Phoca vitulina*) are also common and breed on all of the islands. Harbor seal numbers on the Channel Islands have fluctuated between 2,000-4,000 over the past 25 years, about 70% of which use SCI, SRI and SMI (Lowry et al. 2008). Northern fur seals number around 400 on San Miguel Island (Melin and Orr 2014, 2015). The Guadalupe fur seal, a federal- and state-threatened species, occurs in very small numbers, usually from one to three individuals (CDF&G Marine Resources Division 2005), and occasionally breed on SMI (Melin and Orr 2014, 2015). The Steller sea lion (*Eumetopias jubatus*) formerly bred on SMI and SRI, and possibly SCI. Stellar sea lions appear to have largely abandoned these and other southern haul outs, perhaps due to warming ocean temperatures favoring California sea lions (NMFS 2008, Allen and Angliss 2012), although a few individuals have been recently spotted on SMI in three of the past five years (Melin and Orr 2014).

Table 2.2.8. Distribution and abundance of pinnipeds (seals and sea lions) on the Northern Channel Islands (Koski et al. 1998). FT = Federal Threatened; ST = State Threatened; B = Breeding; H = Haulout; FP = Formerly Present.

Name	Status	Anacapa	Santa Cruz	Santa Rosa	San Miguel	Santa Barbara
Northern fur seal *Callorhinus ursinus*	–	–	–	–	B	–
Northern elephant seal *Mirounga angustirostris*	–	H	H	B	B	B
California sea lion *Zalophus californianus*	–	H	H	H	B	B
Harbor seal *Phoca vitulina*	–	B	B	B	B	B
Steller sea lion *Eumetopias jubatus*	FT	–	–	–	FP	–
Guadalupe fur seal *Arctostephalus townsendii*	FT, ST	–	–	–	H	–

On land, all of the park's pinnipeds are sensitive to human disturbance. In particular, at the sight of a human or in response to auditory stimuli (e.g., sonic booms or overflights), California sea lions may panic and attempt to reach the water. Depending on the intensity of disturbance, they may startle to the point of a massive stampede, which can result in the crushing and/or abandonment of newborn pups as well as injuries to other animals. Frightened fur seals may suffer heat prostration, due to their dense fur, if immediate access to water is not available. Female harbor seals that are disturbed would often abandon their young, returning to their pups after the disturbance has ceased.

Non-native Animal Species

Beginning in the 19th century, humans purposefully introduced a variety of non-native species to the islands in the park including rabbits, cats, burros, horses, goats, pigs, sheep, and cattle (Table 2.2.2 and Table B-1 in Appendix B). Other species may have stowed away on ships and escaped onto the islands, such as black rats. These species dominated the islands' fauna and had a major impact on the natural vegetative communities and on soils (see "Vegetation and People"). They also caused the disappearance of several native species, as well as the reduction in numbers of other native animals. For instance, black rats are thought largely responsible for the long-term decline and lack of breeding success of Scripps's murrelets and ashy storm-petrel on AI (NPS 2001a). In the past 20 years most of the nonnative animals have been removed from the islands (Table 2.2.2). Four non-native bird species (European starlings [*Sturnus vulgaris*], rock pigeons [*Columba livia*], house sparrows [*Passer domesticus*], and brown-headed cowbirds [*Molothrus ater*]) are present on almost all of the islands (the house sparrow does not occur on AI). The effect of these birds on the islands' native birds is unknown.

Climate Change and Wildlife

Increased air temperatures, alteration of precipitation patterns, a rise in sea level, altered marine water temperatures, currents, and acidity, and alteration in recurrence and intensity of storms all can affect the park's plant and animal populations. In addition, changes in the composition and distribution of terrestrial vegetation due to climate change would indirectly affect wildlife populations.

Over the past century the sea level along California's coast has risen almost 8 in. Computer model projections indicate future sea level rise along the California coast could be 1.0 to 1.4 m (39 to 55 in) by the year 2100 (Cayan et al. 2009). The U.S. Geological Survey mapped the relative vulnerability of the coastline of CINP to future sea level rise (USGS 2005). The areas within the park that are likely to be most vulnerable to sea level rise are areas of unconsolidated sediment where regional coastal slope is low and wave energy is high. Of the 250 miles of coastline evaluated, 25% was determined to have a very high vulnerability, 28% had high vulnerability, 19% had moderate vulnerability, and 28% had low vulnerability. The largest stretches of very high vulnerability are on San Miguel and Santa Rosa islands. Sandy beaches and dunes may be subject to further loss from erosion due to flooding associated with more intensive storms (Largie et al. 2010) reducing the area available on the islands where seals and sea lions haul out, and areas where seabirds nest and breed. Increased sea levels and intensive storms can also flood island sea caves where some seabirds nest. For example, the sea caves that Ashy storm-petrels and murrelets use on the islands may no longer be usable with a rise in the sea level.

Another potential change regarding wildlife, particularly pinnipeds and seabirds, is an increase in air temperature. Increases in extreme temperatures or increases in average temperatures can stress wildlife species; affect food and water supplies; and affect interactions with competitors, predators, and invasive species (California Natural Resources Agency 2009). On the northern Channel Islands many of the wildlife species are adapted to cold and windy conditions, and can become stressed with high temperatures. During unusually warm conditions, seabirds may abandon their nests, neglect offspring, and die of heat stress (Warzybok and Bradley 2008 as cited in Largier et al. 2010). Likewise, seals and sea lions would likely spend less time hauled out and could abandon their young if conditions become too warm (Largier et al. 2010).

Increased temperatures can also increase the potential for the spread of insects such as mosquitoes and pest species that carry diseases, which in turn can affect the islands' native wildlife populations. For example, warmer conditions may favor the spread of West Nile virus, which could infect island bird populations. Other invasive species could affect the diversity or abundance of native island species through competition for resources, predation, parasitism, and interbreeding with native species, or by causing physical or chemical changes to the native species' habitats (California Natural Resources Agency 2009).

Phenological life cycle events, such as blooming, migration, insect emergence, fruit ripening, and breeding, also may be affected by climate change. As individual species react differently to warming, species interactions may change.

Several of the effects of climate change listed previously for plants could affect the islands' wildlife including:

- Increased erosion of cliffs and hillsides due to intensified winter precipitation, and larger waves from winter storms and higher water levels, affecting the frequency of rockslides and degrading nesting habitat, particularly for species that use rock crevices such as auklets and storm-petrels (Largier et al. 2010)
- Potential for floods due to more intensive storms
- Increased potential for wildfires.

Changes in the marine environment due to climate change also would likely affect wildlife populations on the islands. In particular, changes that affect fish and other marine populations would in turn affect island seabird and pinniped populations. For instance, if northern anchovy or Pacific sardine populations were to change due to an increase in water temperature or changes in upwellings, it would affect the brown pelicans that nest on the islands. Changes in ocean temperatures, currents, and upwellings can also affect the composition, distribution, and availability of phytoplankton and zooplankton, while ocean acidification can affect shell-building plankton, sea urchins, mussels, oysters, abalone, and crabs. This in turn can affect wildlife migration patterns (e.g., seabird and marine mammal migrations), abundance, timing of breeding, reproductive success, and behavior (Largier et al. 2010; Office of National Marine Sanctuaries 2009; Wilkinson 2002; California Natural Resources Agency 2009). If the frequency and intensity of the El Niño Southern Oscillation event were to change, it would impact Channel Islands wildlife populations.

Warming of ocean waters is expected to result in a range extension of warm water species and a contraction of cooler water species. Guadalupe fur seals are being seen more frequently in the park, perhaps due to the effects of climate change. On the other hand, the range for Steller sea lions has contracted and they no longer breed in the park, perhaps due to a reduction in their prey species (S. Allen, personal communication July 22, 2010).

All of the above effects associated with climate change would be expected to result in wildlife species adapting, changing their behavior (e.g., changing their breeding periods), persisting in suboptimal conditions with potentially major physiological costs, moving, or dying out. Wildlife populations that are unable to adapt or move may be extirpated or decline to extinction. And as noted previously for plants, many of the park's wildlife species are endemic to the islands, with limited distributions, and would have no place else to go in response to changes in climate.

Federally and State Listed Threatened and Endangered Species

CINP supports one federally threatened animals and fifteen listed plant species. (Many of these species are also listed as threatened or endangered by the state.) Formerly, the island night lizard and island fox were federally listed under the ESA, but were removed from the list in 2014 and 2016, respectively.

Island night lizard. Photo by Ryan P. O'Donnell.

Island night lizard (formerly listed, removed from list in 2014)

Island night lizards (*Xantusia riversiana*) are an endemic Channel Islands reptile, known only to occur on SBI in the park and on San Nicolas and San Clemente islands. They are the most morphologically distinct of the endemic vertebrates on the Channel Islands, indicating they have been isolated from the mainland for a long time (NPS n.d.). The best habitats for the lizards are boxthorn (*Lycium californicum*), prickly pear cactus (*Opuntia oricola* and *O. littoralis*), and cracks and crevices in and around rock outcrops and surface boulders. These areas provide protection from predators. They are also often found under rocks, driftwood, and fallen branches. Suitable habitat on SBI is in all of the canyons and on some of the sea cliffs, especially on the south side of Signal Peak. Island night lizards are very sedentary and have very small home ranges, averaging about 183 ft^2 (17 m^2). They are most active at midday. The lizards breed in April and young are born in September.

Fellers and Drost found densities of 1,300 lizards per acre in boxthorn and 1,000 lizards per acre in prickly pear (NPS n.d.). This high density is probably due to a combination of factors, including the lizard's low metabolism, diverse diet, sedentary nature, and small, overlapping home ranges.

Although abundant in their favored habitats, island night lizards are still sensitive to disturbance. Individual lizards can be trampled and habitat damaged by people walking off trail. On August 11, 1977, the Fish and Wildlife Service listed the island night lizard as a threatened species because of its restricted range and apparently low population levels on Santa Barbara and San Nicolas islands. Their populations were thought to have been reduced due to past farming and grazing, fire, and the introduction of nonnative animals and plants. However, Fellers and Drost (1991) estimated that the total population on SBI was at least 17,600, and concluded that the population was not threatened with extinction as previously thought (NatureServe Explorer 2005). On May 1st, 2014, the Fish and Wildlife Service removed the island night lizard from the Federal List of Endangered and Threatened Wildlife (USFWS 2014).

Island Fox

Island Fox. Photo by Tim Hauf.

The island fox (*Urocyon littoralis*), a relative of the mainland gray fox, is the largest native land mammal that lives in CINP. Three subspecies live in the park—the San Miguel Island fox (*U. l. littoralis*), Santa Rosa Island fox (*U. l. santarosae*), and Santa Cruz Island fox (*U. l. santacruzae*). On March 4, 2004, the three subspecies, along with the subspecies on Santa Catalina Island, were listed as endangered by the U.S. Fish and Wildlife Service. All three subspecies were declared recovered and removed from Federal List of Endangered and Threatened Wildlife in 2016 (USFWS 2016). The state of California lists the entire species as threatened.

Island foxes occur in virtually every habitat on the three islands. They eat a wide variety of plants and animals, including mice, ground-nesting birds, arthropods, and fruits. These foxes are territorial, generally monogamous, and breed once a year. Island foxes are relatively inquisitive and docile, and show little fear of humans. Beginning in 1994 the three island fox subspecies underwent major declines in numbers. On SMI, the island fox population fell from 450 in 1994 to 15 in 1999. On SRI the fox population fell from more than 1,500 to 14 animals in 2000. On SCI the population declined from about 2,000 animals in 1994 to an estimated 50 to 60 adults in 2001 (NPS 2001b, 2002a, 2002b; NOAA et al. 2002). Although the SCI population had increased by 2003, fewer than 100 foxes were estimated to be living in the wild.

The primary cause of these declines has been attributed to predation by golden eagles (NPS 2002a; see also the discussion above of golden eagles under *Native Terrestrial Animals*). The absence of bald eagles, whose presence may have kept golden eagles away, and the conversion of predominant vegetation from shrub to nonnative grasslands, which offer much less cover from aerial predators, were contributing factors to the increase in golden eagle predation.

In 1999, the Park Service established an island fox captive breeding program in the park to restore wild populations to viable levels. Breeding pens were built on SMI in 1999, and 14 of the 15 remaining wild island foxes were brought into captivity. In 2000, pens were built on SRI, and the 14 island foxes remaining on that island were captured. On SCI, where the fox population declined to 50 to 60 animals by 2001, captive breeding began in 2002 as a joint project between the Park Service and TNC.

Numbers of all three northern island fox subspecies increased in captivity and reached the target captive breeding population size that allowed for releases to the wild. Releases began in 2002, 2003, and 2004 on SCI, SRI, and SMI, respectively. Captive breeding was terminated on Santa Cruz and SMIs in 2007 and on SRI in 2008 due to the high survival and reproductive success in released foxes. Population estimates in 2015 were 2,100-200 adults on SCI, 350-400 adults on SMI, and 1200-1300 adults on SRI. Annual survival has been generally high (~90%) on the Park islands since 2010, although survival was lower on SRI through 2013 driven in part by golden eagle predation associated with the final removal of ungulates from the island, and on SMI in 2014 and 2015 possibly associated with drought (Friends of the Island Fox 2017, Coonan 2016).

Part of the consideration for removing the Park populations of island fox from the List of Endangered and Threatened Wildlife is that the Park has plans in place to address continuing risks of (breeding) golden eagle predation, disease, and fire. The Park developed a fire management plan in 2006 (NPS 2006). An epidemic response plan was developed for the park in 2013 (Hudgens et al. 2013) which included strategies for detecting diseases and management actions to prevent or minimize the effects of an epidemic should an infectious disease reach the islands. A golden eagle management strategy to detect potentially problematic golden eagle predation and prevent fox population declines due to eagles was developed in 2015 (Coonan 2016). The monitoring components of these plans have been implemented as part of post-delisting monitoring cooperative agreement between the NPS and USFWS.

Western Snowy Plover

Western snowy plovers. Photo by Dan Richards.

Western snowy plovers (*Charadrius alexandrinus nivosus*) breed from Washington State to Baja, California, and winter in coastal areas from southern Washington to Central America. Their nests typically are shallow scrapes or depressions on the ground on flat, open areas with sandy or saline substrates, where vegetation and driftwood is sparse or absent. On the Channel Islands they forage in the wet sand and amidst surf-cast kelp in the intertidal zone and in dry, sandy areas above the high tide. In winter, snowy plovers are found on many of the beaches used for nesting as well as on beaches where they do not nest, and on estuarine sand and mud flats.

The Pacific coast population of the western snowy plover was listed as threatened by the Fish and Wildlife Service on March 5, 1993. A decline in active nesting areas and in the size of the breeding and wintering populations is due to many factors: recreational and other human disturbance, loss of habitat to urban development, introduction of beachgrass (*Ammophila* spp.) and other nonnative species, and expanding predator populations. It is estimated that about 2,000 snowy plovers may breed along the U.S. Pacific Coast and that there are 157 current or historical snowy plover breeding or wintering locations along the U.S. Pacific Coast (USFWS 2001).

Channel Islands NP is one of the few locations in southern California that still supports breeding and wintering populations of western snowy plovers. In the 1990s Santa Rosa and San Miguel islands had both breeding and wintering populations, but numbers have declined precipitously. A few birds also lived on TNC property on SCI. On SRI the birds inhabited about 16 miles of coastline (less than 30 breeding pairs were on the island in 2002, down from 60 pairs in 1993), while on SMI they were present on about 10 miles of shoreline (USFWS 2001). The Skunk Point area on SRI is an important nesting area and foraging area for juvenile and migrating plovers. An estimated 200 birds still winter on the island's beaches. Forty to fifty percent of the nests in this area have been found on rocky outcrops in the back dunes, about 490 to 980 ft (150 to 300 m) from the shoreline (USFWS 1995).

To avoid disturbance of the birds, several of the beaches where snowy plovers currently nest are closed to recreational use. Specifically, all of the shoreline of SMI, primarily to protect pinnipeds, is closed to public landing or entry with the exception of Culyer Harbor. On SRI the coastline from and including Skunk Point to just north of East Point is closed to visitors, including landing or hiking, from March 1 to September 15.

Different factors may be responsible for these declines on the islands. On SMI human disturbance of plovers has not been documented, nor have data been collected on the impacts of people on the Cuyler Harbor beach — the only beach visitors are permitted to use and what was once an important nesting area (USFWS 1995). It is believed that the decline in the breeding population on SMI may be due to a large increase in the number of northern elephant seals and California sea lions that have occupied snowy plover nesting habitat. This increase occurred simultaneously with the western snowy plover decline. On SRI, past ranch activities affected the plovers, including cattle and horses trampling nests and flushing birds from nests. Ungulate carcasses may have attracted predators such as ravens. Raven numbers are thought to be unnaturally high on SRI, which may be resulting in an increase in predation by ravens on plover eggs. Accumulations of trash also may have attracted predators. In the past, visitors, including hikers, surfers, and kayakers, affected the plovers at Skunk Point (USFWS 1995). But with the beach closures these impacts are happening less frequently on the beaches. High winds and predators are still a frequent cause of nest loss. In the past winds accounted for 28% to 34% of all nest losses, while predators (e.g., ravens and Santa Rosa Island spotted skunks) accounted for another 26% to 44% of losses (USFWS 1995). Both SRI and SMI have 20- to 30-knot winds on a regular basis through the plover nesting season, which can cause eggs to be sandblasted or blown out of the nest when the adult steps off the nest. It is also possible that ravens, which eat plover eggs and chicks, live on the island and may be more numerous than once thought due to the presence of ungulate carcasses. In addition, increasing numbers of elephant seals hauling out on the south beaches of SRI could be reducing nesting habitat.

Terrestrial plants

Fifteen terrestrial plants are listed as threatened or endangered by the Federal government (USFWS 1976, 1997; Table 2.2.9). Most of them exist as small populations growing in places inaccessible to non-native ranch animals (McEachern et al. 1997, 2010a). Studies have shown that these plants are vulnerable to grazing and trampling (McEachern et al. 1997), increasing temperatures (McEachern et al. 2009), shifts in the timing and duration of rains (Levine et al. 2008, 2011), and competition from non-native annual grasses (Levine et al. 2010). Several listed taxa are presumed extirpated from one or more of the islands where they formerly occurred. Some have been re-discovered following feral animal eradication, providing hope that these plants may eventually recolonize sites where they persisted through ranching as seed banks in the soil. Federal Recovery Plans exist for the Channel Islands listed plants (USFWS 1985, 2000). Recovery actions have been identified and tested for many of the taxa, and recent funding is allowing NPS to pursue some of the recommended actions, such as out-planting new populations grown from island source populations (e.g., Wilken and McEachern 2011), or eradication of invasive competitors from rare plant populations (McEachern et al. 2010b).

Table 2.2.9. Federally listed plants of Channel Islands National Park.

Taxon	Life history	Status	# Pops	Islands[1]
Bochera (Arabis) hoffmannii	Perennial	E	5	SCI, SRI, AI[4]
Arctostaphylos confertiflora	Shrub	E	3	SRI
Berberis pinnata ssp. insularis	Shrub	E	5[2]	SCI, AI[4] , SRI[4]
Castilleja mollis	Perennial	E	2	SRI
Dudleya nesiotica	Perennial	T	1	SCI
Dudleya traskiae	Perennial	E	10	SBI
Galium buxifolium	Sub shrub	E	8	SCI, SMI, SRI[4]
Gilia tenuiflora ssp. hoffmannii	Annual	E	2	SRI
Crocanthemum (Helianthemum) greenei	Perennial	T	36	SCI, SRI, SCT
Malacothamnus fasciculatus var. nesioticus	Shrub	E	4[2]	SCI
Malacothrix indecora	Annual	E	6	SCI, SRI

[1] AI = Anacapa Island; SBI = Santa Barbara Island; SCI = Santa Cruz Island; SCT = Santa Catalina Island.

[2] Each population is represented by one clonal plant.

[3] (non-NPS), SMI = San Miguel Island; SRI = Santa Rosa Island.

[4] Presumed extirpated.

Table 2.2.9 (continued). Federally listed plants of Channel Islands National Park.

Taxon	Life history	Status	# Pops	Islands[1]
Malacothrix squalida	Annual	E	1	SCI
Phacelia insularis var. insularis	Annual	E	13	SRI, SMI
Sibara filifolia	Annual	E	0	SCI4, SCT
Thysanocarpus conchuliferus	Annual	E	8	SCI

[1] AI = Anacapa Island; SBI = Santa Barbara Island; SCI = Santa Cruz Island; SCT = Santa Catalina Island.

[2] Each population is represented by one clonal plant.

[3] (non-NPS), SMI = San Miguel Island; SRI = Santa Rosa Island.

[4] Presumed extirpated.

Climate Change and Threatened and Endangered Species

Island weather stations have documented warmer temperatures since the mid-1900s (McEachern et al. 2008), and climates are predicted to warm even faster in the future (Cayan et al. 2006). Plants restricted to islands may be particularly challenged by climate change, as options for long-distance dispersal to new areas are limited by island area. Rare plants are further challenged as they are often habitat specialists, rare because of restricted edaphic or micro-climate habitat requirements. The combination of small populations, altered habitats and climate change together could limit recovery options for the island plants.

Soundscape

No scientific studies have been conducted on the terrestrial soundscape, however, the park is generally considered a relatively quiet place that is rich in natural sounds. Very little noise is caused by people in most of the park. Sources of human-caused noise include boat traffic, machinery in developed areas, motor vehicles on Santa Cruz and Santa Rosa Islands, and plane and helicopter flights over the islands.

Santa Barbara Channel, well known for its high concentrations and diversity of marine mammals, is also one of the noisiest areas in the ocean with an average of one ship per hour passing through (McKenna et al. 2009). The combination of abundant marine life and high levels of shipping noise in this region has raised questions concerning the effect of sound on marine mammals (McDonald et al. 2006, McKenna et al. 2009, J. Hildebrand, Scripps Institute of Oceanography, personal communication).

2.3. Resource Stewardship

2.3.1. Management Directives and Planning Guidance

Stewardship of natural and cultural resources has been the overriding consideration in Park activities at CINP, with a focus on restoring species and ecosystems and protecting native species (NPS 1980, 2015). Management Park resources has been approached from an ecosystem perspective, recognizing the influence of larger regional and global processes have on species that use the park, especially sea birds and pinnipeds. Habitat restoration has, and continues to be, a management focus with a goal of restoring island vegetation to a "condition reminiscent of the period before Europeans began altering the islands," (NPS 2015).

At the time of this writing, park management is guided by the CINP Final General Management Plan/ Wilderness Study/ Environmental Impact Study, published in April 2015. The purpose of the plan is to clearly define a direction for resource preservation and visitor experience at CINP over the next 20 to 40 years. The Park Service has identified five goals that this planning effort would address. Specifically, the goals of this plan are to:

- Restore and maintain natural ecosystems and processes
- Preserve and protect cultural resources
- Provide opportunities and access for the public to experience and connect to the park
- Promote stewardship of park resources and
- Administer the park efficiently and effectively.

The preferred alternative management strategy maintains the previous focus on restoration and protection of native species and ecological interactions and ecosystem services while increasing visitor opportunities and designating approximately half of the land area of CINP as Wilderness.

2.3.2. Status of Supporting Science

Mediterranean Coast Network (MEDN) Inventory & Monitoring (I&M)

In an effort to improve overall park management through expanded use of scientific knowledge, the Inventory & Monitoring (I&M) Program was established to collect, organize, and provide natural resource data as well as information derived from data through analysis, synthesis, and modeling. The primary goals of the I&M Program are to:

- Inventory the natural resources under NPS stewardship to determine their nature and status
- Monitor park ecosystems to better understand their dynamic nature and condition and to provide reference points for comparisons with other altered environments
- Establish natural resource inventory and monitoring as a standard practice throughout the National Park System that transcends traditional program, activity, and funding boundaries
- Integrate natural resource inventory and monitoring information into NPS planning, management, and decision making and
- Share NPS accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives (NPS 2014a).

To complete these goals, 270 parks with significant natural resources were organized into 32 regional networks. Channel Islands Nation Park is part of the MEDN, which also includes Cabrillo National Monument and Santa Monica Mountains National Recreation Area. Through a rigorous multi-year, interdisciplinary scoping process, each network selected a number of important physical, chemical, and/or biological elements and processes for long-term monitoring. These ecosystem elements and processes are referred to as “vital signs”, and their respective monitoring programs are intended to provide high-quality, long-term information on the status and trends of those resources. The MEDN

Monitoring Plan (NPS 2005) provides detailed descriptions and strategy for monitoring vital signs (Table 2.2.10).

Table 2.2.10. Status of vital sign monitoring at CINP (NPS 2014d).

Vital sign category	Vital sign	Monitoring protocol status
Amphibians & reptiles	Aquatic herpetofauna	Complete
	Terrestrial herpetofauna	Complete
Birds	Land birds	Complete
	Sea birds	Complete
Climate & weather	Climate & Weather	Complete
Deer mouse	Deer mouse	Complete
Invasive plants	Invasive plants	Under development
Island fox	Island fox	Complete
Kelp forest communities	Kelp forest communities	Complete
Landscape dynamics	Landscape dynamics	Under development
Native plant communities	Native plant communities	Complete Under development
Pinnipeds	Pinnipeds	Under development
Rocky intertidal habitat	Rocky intertidal habitat	Complete
Sandy beaches & lagoons	Sandy beaches & Lagoons	Complete
Water quality	Fresh water quality	Under development

2.4. Literature Cited

Allen, B. M., and R. P. Angliss. 2012. Steller sea lion (*Eumetopias jubatus*): Eastern U. S. Stock.

Belnap, J. 1994. Cyanobacterial-lichen soil crusts of San Nicolas Island. *In* Abstracts, The Fourth California Islands Symposium: Update on the Status of Resources, March 23-24, 1994, edited by W. L. Halvorson and G. J. Maender. Santa Barbara Museum of Natural History. Santa Barbara, CA.

Burkett, E. E., N. A. Rojek, A. E. Henry, M. J. Fluharty, L. Comrack, P. R. Kelly, A. C. Mahaney, and K. M. Fien. 2003. Report to the California Fish and Game commission: Status review of Xantus's murrelet (*Synthliboramphus hypoleucus*) in California. Status Report 2003-01. California Department of Fish and Game, Habitat Conservation Planning Branch.

California Department of Fish and Game (CDF&G), Marine Resources Division. 2005. Final Market Squid Fishery Management Plan Environmental Document. Available at: www.dfg.ca.gov/mrd/msfmp (accessed 14 March 2005).

California Natural Resources Agency. 2009. Executive Summary. 2009 California Adaptation Strategy. A Report to the Governor of the State of California in Response to Executive Order S-13-2008. Available at: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF (accessed 1 March 2014).

Carter, H. R., G. J. McChesney, D. L. Jaques, C. S. Strong, M. W. Parker, J. E. Takekawa, D. L. Jory, and D. L. Whitworth. 1992. Breeding populations of seabirds in California 1989-1991. Draft report to Minerals Management Service.

Carter, H. R., R. J. Young, G. J. McChesney, W. R. McIver, R. T. Golightly, and F. Gress. 2004. Breeding colony surveys of Brandt's cormorants and other seabirds in California in 2003. Vol. 1. Draft report prepared for the U.S. Fish and Wildlife Service Unpublished Report. Dixon, CA.

Carter, H., D. Whitworth, P. Herbert, et al. 2008. Status of breeding seabirds in the San Miguel Island group, California. Victoria, BC: Carter Biological Consulting; and Davis, CA:M California Institute of Environmental Studies.

Cayan, D., E. Maurer, M. Dettinger, M. Tyree, K. Hayhoe, C. Bonfils, P. Duffy, and B. Santer. 2006. Climate scenarios for California. California Climate Change Center publication no. CEC-500-2005-203-SF. Accessible at: www.climatechange.ca.gov/ (accessed 16 April 2014).

Cayan, D., M. Tyree, M. Dettinger, H. Hidalgo, T. Das, E. Maurer, P. Bromirski, N. Graham, and R. Flick. 2009. Climate Change Scenarios and Sea Level Rise Estimates for California 2008 Climate Change Scenarios Assessment. California Climate Change Center. CEC–500–2009–014–F. Accessible at: www.climatechange.ca.gov/ (accessed 16 April 2014).

Center for Plant Conservation. 2014. Search CPC. Accessible at: http://www.centerforplantconservation.org/collection/NationalCollection.asp (accessed 16 January 2014).

Cohen, B., C. Cory, J. Menke, and A. Hepburn. 2009. A spatial database of Santa Cruz Island vegetation. Pages 229–244. *In* Proceedings of the Seventh California Islands Symposium. Institute for Wildlife Studies, edited by C. C. Damiani and D. K. Garcelon. Institute for Wildlife Studies, Arcata, CA.

Coonan, T. 2016. Seventeenth Annual Meeting Island Fox Working Group Summary Report. Ventura, CA.

Engle, D.L., 2006. Assessment of Coastal Water Resources and Watershed Conditions at Channel Islands National Park, California. National Park Service, US Department of the Interior. Water Resources Division, Denver, CO.

Fellers, G. M. and C. A. Drost. 1991. Terrestrial Invertebrate Monitoring Handbook. Channel Islands National Park. Ventura, CA. On file at Channel Islands National Park headquarters.

Friends of the Island Fox. 2017. Notes from the Island Fox Conservation Working Group Meeting June 14-15, 2016. Santa Barbara, CA.

Greenlaw, J. S. 1996. Spotted Towhee (*Pipilo maculatus*). *In* The Birds of North America, No. 263 (A. Poole, Ed.). The Birds of North America Online, Ithaca, New York.

Gress, F. 1995. Organochlorines, eggshell thinning, and productivity relationships in brown pelicans breeding in the southern California bight. Ph.D. dissertation. University of California, Davis.

Handley, T., D. Rodriguez, J. Yee, and A. K. McEachern. 2013. Draft: Exploring long-term trends in vegetation of Santa Barbara and Santa Rosa Islands, Channel Islands National Park. Unpublished technical report, U.S. Geological Survey, WERC, Channel Islands Field Station, Ventura, California. 275 pp.

Hochberg, F. G. Jr. 1979. Invertebrate Zoology: Land Mollusks. *In* Natural Resources Study of the Channel Islands National Monument, California, edited by D.M. Power. Prepared for the National Park Service by the Santa Barbara Museum of Natural History. Santa Barbara, CA.

Hudgens, B. R., T. W. Vickers, D. K. Garcelon and J. N. Sanchez. 2013. Epidemic Response Plan for Island Foxes of the Channel Islands National Park. Prepared for the National Park Service by Institute for Wildlife Studies. Arcata, CA.

Hunt, G. L., Jr., R. L. Ptiman, and H. L. Jones. 1980. Distribution and abundance of seabirds breeding on the California Channel Islands. *In* The California Islands: Proceedings of a Multidisciplinary Symposium, edited by D.M. Power. Pages 443-459. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Johnson, N.K. 1972. Origin and differentiation of the avifauna of the Channel Islands, California." Condor 74(3):295-315.

Jones, L., P. Collins, and R. Stefani. 1989. A checklist of the birds of Channel Islands National Park. Southwest Parks and Monuments Association, Tucson, AZ.

Junak, S., S. Chaney, R. Philbrick, and R. Clark. 1997. A checklist of vascular plants of Channel Islands National Park, 1997. Southwest Parks and Monuments Association, Tucson, AZ.

Koski, W. R., J. W. Lawson, D. H. Thomson, and W. J. Richardson. 1998. Point Mugu Sea range marine mammal technical report. Department of the Navy, Naval Air Warfare Center, Weapons Division, Point Mugu, CA.

Largier, J. L., B. S. Cheng, and K. D. Higgason, ed. 2010. Climate change impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils. Available at: http://sanctuaries.noaa.gov/science/conservation/pdfs/gf_cbnms_climate_report.pdf (accessed 22 February 2014).

Levine, J. M., A. K. McEachern, and C. Cowan. 2008. Effects of a fluctuating rainfall environment on rare island annual plants. Journal of Ecology 96:795-806.

Levine, J. M., A. K. McEachern and C. Cowan. 2010. Do competitors modulate rare plant response to precipitation change? Ecology 91(1):130–140.

Levine, J. M., A. K. McEachern, and C. Cowan. 2011. Seasonal timing of first rain storms affects rare plant population dynamics. Ecology 92(12):2236-2247.

Livingston, D. S. 2006. Historic resource study: A history of the islands within Channel Islands National Park. Technical Report to Channel Islands National Park, Ventura, California. 917 pp.

Lowry, M. S., J. V. Carretta, and K. A. Forney. 2008. Pacific harbor seal census in California during May-July 2002 and 2004. California Fish and Game, 94(4), 180-193.

Lowry, M. S., and O. Maravilla-Chavez. 2003. Recent abundance of California sea lions in western Baja California, Mexico and the United States. *In* Proceedings of the Sixth California Islands Symposium, Ventura, California pp. 485-497.

Lowry, M. S., R. Condit, B. Hatfield, S. G. Allen, R. Berger, P. A. Morris, and J. Reiter. 2014. Abundance, distribution, and population growth of the northern elephant seal (*Mirounga angustirostris*) in the United States from 1991 to 2010. Aquatic Mammals, 40(1), 20-31.

McDonald, M. A., J. A. Hildebrand, and S. M. Wiggins. 2006. Increases in deep ocean ambient noise west of San Nicolas Island, California. Journal of the Acoustical Society of America 120(2):711-717.

McEachern, A. K. 2004. Ecological effects of animal introduction at Channel Islands National Park. Park Science 22(2):46-52.

McEachern, A. K, T. Atwater, P. W. Collins, K. Faulkner and D. V. Richards. 2016. Managed Island Ecosystems. Pp 755-778 *in* Mooney, H. and Zavaleta, E. (eds.) Ecosystems of California. UC Press, University of California-Davis, Davis, CA.

McEachern, A. K., Chess, K. A., and Niessen, K. G. 2010a. Field surveys of rare plants on Santa Cruz Island, California, 2003–2006: Historical records and current distributions. U.S. Geological Survey Scientific Investigations Report 2009–5264, 34 pp. Available at: http://pubs.usgs.gov/sir/2009/5264/ (accessed 12 December 2013).

McEachern, A. K., K. Chess, K. Flag, K. Niessen, K. Owen and K. Thompson. 2010b. Herbicide treatment of invasive *Vinca major* growing with endangered *Galium buxifolium*, an island endemic. Proceedings of the California Invasive Plant Council Symposium. 14:63-66. Cal-IPC, Berkeley, CA.

McEachern, A. K., D. Thomson, and K. Chess. 2009. Climate alters response of an endemic island plant to removal of invasive herbivores. Ecological Adaptations 19(6):1574-1584.

McEachern, A. K., D. Wilken, and K. A. Chess. 1997. Inventory and monitoring of California Islands Candidate Plant Taxa. U. S. Geological Survey Open File Report 00-73. USGS-Western Ecological Research Center, Sacramento, CA. 46 pp.

McEachern, A. K., P. Power, L. Dye, and R. Rudolph. 2008. Weather and Climate Monitoring Protocol, Channel Islands National Park, California. U. S. Geological Survey Techniques and Methods 2–B1, 16 pp. Available at http://science.nature.nps.gov/im/units/medn/reports/index.cfm (accessed 10 June 2014).

McKenna, M. F., M. Soldevilla, E. Oleson, W. S. M. Wiggins, and J. A. Hildebrand. 2009. Increased underwater noise levels in the Santa Barbara Channel from commercial ship traffic and its potential impact on Blue Whales (*Balaenoptera musculus*). *In* Proceedings of the Seventh California Islands Symposium. Institute for Wildlife Studies, edited by C. C. Damiani and D. K. Garcelon. Institute for Wildlife Studies, Arcata, CA.

Melin, S. R. and R. L. DeLong. 1999. Observations of a Guadalupe fur seal (*Arctocephalus townsendi*) female and pup at San Miguel Island, California. Marine Mammal Science 15(3):885-888.

Melin, S. R. and T. Orr. 2014. Memorandum to the Director, National Marine Mammal Laboratory, March 2014. Subject: NMML 2013 Field Season at San Miguel and San Nicolas Islands. NOAA National Marine Mammal Laboratory, Seattle, WA.

Melin, S. R. and T. Orr. 2015. Memorandum to the Director, National Marine Mammal Laboratory and Program Leader, California Current Ecosystems Program, January 2015. Subject: Field report for assessment of health and condition of California sea lions at San Miguel Island 2014. NOAA National Marine Mammal Laboratory, Seattle, WA.

Miller, S. E. 1979. Invertebrate zoology: Insects and their relatives." *In* Natural Resources Study of the Channel Islands National Monument, California, edited by D.M. Power. Prepared for the National Park Service by the Santa Barbara Museum of Natural History, Santa Barbara, CA.

National Marine Fisheries Service (NMFS). 2008. Recovery plan for the Steller sea lion (*Eumetopias jubatus*). Revision. National Marine Fisheries Service, Silver Spring, MD. 325 pp.

National Marine Fisheries Service (NMFS). 2011. California sea lion (*Zalophus californianus*): U.S. Stock.

National Oceanic and Atmospheric Administration (NOAA). 2002. NOAA, U.S. Fish and Wildlife Service, National Park Service, California Dept. of Fish and Game, California State Lands Commission, California Department of Parks and Recreation Feasibility Study for Reestablishment of Bald Eagles on the Northern Channel Islands, California. Environmental Assessment. Montrose Settlements Restoration Program. Long Beach, CA.

National Oceanic and Atmospheric Administration (NOAA). 2009. National Marine Sanctuaries website. Channel Islands 2009 Condition Report. http://sanctuaries.noaa.gov/science/condition/cinms/pressures.html (accessed 5 December 2014).

National Park Service (NPS). 1980. General Management Plan. Anacapa-Santa Barbara-San Miguel Islands, Channel Islands National Park. Vol. 2. Natural / Cultural Resource Management. Denver Service Center, Denver CO.

National Park Service (NPS). 1984. Draft General Management Plan Supplement Environmental Assessment, Channel Islands National Park / California. Denver Service Center. Denver, CO.

National Park Service (NPS). 1999. Resource Management Plan Update. Available at: http://www.nps.gov/chis/rm/HTMLPages/RMP.htm (accessed 24 February 2014).

National Park Service (NPS). 2000. Anacapa Island Restoration Project. Final Environmental Impact Statement. Unpublished Report. Available at Park headquarters.

National Park Service (NPS). 2001a. Landbird Monitoring 1995-2000 Annual Report. Technical Report 2001-03. Channel Islands National Park. On file at park headquarters. Available at: http://www1.nature.nps.gov/im/units/chis/PDFReports/Terrestrial/9500LBAnnl.pdf (accessed 14 January 2014).

National Park Service (NPS). 2001b. Status and ecology of deer mice (*Peromyscus maniculatus* subsp.) on Anacapa, Santa Barbara, and San Miguel Islands, California. Summary of Monitoring 1992 – 2000, by C. A. Schwemm and T. J. Coonan. Technical Report 01-02. Available at Park headquarters.

National Park Service (NPS). 2002a. Santa Cruz Island Primary Restoration Plan. Final Environmental Impact Statement. Available at Park headquarters.

National Park Service (NPS). 2002b. Island Fox Captive Breeding Program. 2001 Annual Report. Technical Report 02-01. Prepared by T. Coonan and K. Rutz. Ventura, CA.

National Park Service (NPS). 2003. Report for Travel to Channel Islands National Park During May 11-16, 2003. Unpublished Report. Available at Park headquarters.

National Park Service (NPS). 2005. Mediterranean Coast Network - Vital Signs Monitoring Plan. Natural Resources Technical Report NPS/MEDN/NRTR—2007. National Park Service. Thousand Oaks, California.

National Park Service (NPS). 2006. Channel Islands National Park Wildlands Fire Management Plan. National Park Service. Thousand Oaks, California.

National Park Service (NPS). 2012. Listing of acreage as of December 31, 2012. Land Resource Division. http://irma.nps.gov/Stats/DownloadFile/1048 (accessed 23 April 2014).

National Park Service (NPS). 2014a. About the Inventory & Monitoring Program (I&M) website. Available at: https://science.nature.nps.gov/im/about.cfm (accessed 20 April 2014).

National Park Service (NPS). 2014b. Channel Islands National Park website. Nature & Science: Oceans. Available at: http://www.nps.gov/chis/naturescience/oceans.htm (accessed 20 April 2014).

National Park Service (NPS). 2014c. Channel Islands National Park website. "Nature & Science: Weather". Available at: http://www.nps.gov/chis/naturescience/weather.htm (accessed 20 April 2014).

National Park Service (NPS). 2014d. Inventory & Monitoring Program (I&M) website. Monitoring. Available at: https://science.nature.nps.gov/im/units/medn/monitor/index.cfm (accessed 21 April 2014).

National Park Service (NPS) 2015 Channel Islands National Park Final General Management Plan/Wilderness Study/Environmental Impact Statement. April 2015.

NatureServe Explorer. 2005. NatureServe Explorer, An Online Encyclopedia of Life (web application). Version 4.2 NatureServe, Arlington, VA. Available at: http://www.natureserve.org/explorer (accessed 24 January 2005).

Oberbauer, T. A. 1999. Analysis of vascular plant species diversity of the Pacific Coast Islands of Alta and Baja California. Pages 201-211 in D. K. Browne, K. L. Mitchell and H. W. Chaney, editors. Proceedings of the Fifth California Islands Symposium. U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region.

Office of National Marine Sanctuaries. Channel Islands National Marine Sanctuary Condition Report. 2009. U.S. Department of Commerce, National Oceanic & Atmospheric Administration. Office of National Marine Sanctuaries, Silver Spring, MD. Available at: http://sanctuaries.noaa.gov/science/condition/pdfs/cinms_conditionreport09.pdf (accessed 23 March 2014).

Pinter, N. and W.D. Vestal. 2005. El Nino-drive landsliding and postgrazing vegetative recovery, Santa Cruz Island, California." Journal of Geophysical Research Vol. 110, F02003.

Power, D. M. 1980. Introduction. Pages 1-4 in D.M. Power, editor. The California islands: Proceedings of a multidisciplinary symposium. Santa Barbara Museum of Natural History, Santa Barbara, California. 787 pp.

Power, P.J., Wagner, J., Martin, M. and Denn, M., 2014. Restoration of a coastal wetland at Prisoners Harbor, Santa Cruz Island, Channel Islands National Park, California. Monographs of the Western North American Naturalist, 7, pp.442-454.

Rastogi, B. D. T. Fischer, P. Williams, S. Iacobellis, K. McEachern, and C. J. Still. 2012. Characterizing spatial patterns of cloud cover and fog inundation in the northern Channel Islands using satellite datasets and comparison to ground measurements. Presented at 2012 Fall Meeting, AGU, 3-7 December, San Francisco, California.

Raven, P. H. 1967. The floristics of the California islands. Proceedings of the symposium on the biology of the California Islands, edited by R. N. Philbrick. Pp. 57–67. Santa Barbara Botanic Garden, Santa Barbara.

Richards, D. V. 2009. Foundations of marine reserves in the California Channel Islands. *In* Proceedings of the 2009 George Wright Society Conference: Rethinking Protected Areas in a Changing World. Portland, Oregon. Available at: http://www.georgewright.org/0955richards.pdf (accessed 23 April 2014).

Rick, T. C., T. C Sillett, C. K. Ghalambor, C. A. Hofman, R. Ralls, R. S. Anderson, C. L. Boser, T. J. Braje, D. R. Cayan, R. T. Chesser, P. W. Collins, J. M. Erlandson, K. R. Faulkner, R. Fleisher, W. C. Funk, R. Galipeau, A. Huston, J. King, L. Laughrin, J. Maldonado, K. McEachern, D. R. Muhs, S. D. Newsome, L. Reeder-Myers, C. Still, and S. A. Morrison. 2014. Ecological Change on California's Channel Islands from the Pleistocene to the Anthropocene. BioScience, 64(8), 680-692. Available at: https://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/53079/StillChristopherForestryEcologicalChangeCalifornia.pdf?sequence=1 (accessed 20 December 2014).

Santa Barbara Botanic Garden. 2013. Channel Islands. Available at: http://www.sbbg.org/conservation-research/channel-islands (accessed 16 January 2014).

Sharpe, P. B. 2014. Peregrine falcon monitoring on the California Channel Islands, California, 2013. Unpublished report prepared by the Institute for Wildlife Studies, Arcata, California for Montrose Settlements Restoration Program. 60 pp.

Sharpe, P. B. 2017. Bald Eagle Restoration on the California Channel Islands, January - December 2016, 15th Annual Report. Unpublished report prepared by the Institute for Wildlife Studies, Arcata, California for the National Park Service and Montrose Settlements Restoration Program. 23 pp.

The Nature Conservancy (TNC). 2009. ClimateWizard. http://www.climatewizard.org/ (accessed 20 November 2013).

U.S. Fish and Wildlife Service (USFWS). 1976. Proposed endangered status for some 1700 U. S. vascular plant taxa. FR. 41:1, June 16, 1976. U.S. Fish and Wildlife Service. Washington, D.C.

U.S. Fish and Wildlife Service (USFWS). 1983. The California Brown Pelican Recovery Plan. Prepared for the U.S. Fish and Wildlife Service by F. Gress and D.W. Anderson. Portland, OR.

U.S. Fish and Wildlife Service (USFWS). 1985. Santa Barbara Island live-forever (*Dudleya traskiae)* Recovery Plan. U.S. Fish and Wildlife Service. Portland, OR.

U.S. Fish and Wildlife Service (USFWS). 1995. Biological opinion for the effects of park activities on western snowy plovers and brown pelicans at Channel Islands National Park, California (1-8-94-F-32). Memorandum from the Acting Field Supervisor, Ventura Field Office. On file at park headquarters.

U.S. Fish and Wildlife Service (USFWS). 1997. Final rule for 13 plant taxa from the northern Channel Islands, California. Pages 40954-40974 *In*: Federal Register Vol. 62, No. 147, July 31, 1997. U.S. Department of the Interior, Washington, D.C.

U.S. Fish and Wildlife Service (USFWS). 2000. Thirteen plant taxa from the Northern Channel Islands Recovery Plan. Portland, Oregon. 94 pp.

U.S. Fish and Wildlife Service (USFWS). 2001. Western snowy plover (*Charadrius alexandrinus nivosus*) Pacific Coast Population Draft Recovery Plan. U.S. Fish and Wildlife Service, Region 1. Portland, OR.

U.S. Fish and Wildlife Service (USFWS). 2014. Final rule: Removing the island night lizard from the Federal list of endangered and threatened wildlife. Pages 18190-18210 *In*: Federal Register Vol. 79, No. 62, April 1, 2014. U.S. Department of the Interior, Washington, D.C.

U.S. Fish and Wildlife Service (USFWS). 2016. Final Rule: Removing the San Miguel Island Fox, Santa Rosa Island Fox, and Santa Cruz Island Fox From the Federal List of Endangered and Threatened Wildlife, and Reclassifying the Santa Catalina Island Fox From Endangered to Threatened. Pages 53315-53333 *In*: Federal Register Vol. 81, No. 156, August 12, 2016. U.S. Department of the Interior, Washington, D.C.

U.S. Geological Survey (USGS), U.S. Department of the Interior. 2005. Relative Coastal Vulnerability Assessment of Channel Islands National Park (CINP) to Sea-Level Rise. USGS Open File Report 2005-1057. Prepared by E. Pendleton, E. Thieler, and S. Williams. Available at: http://pubs.usgs.gov/of/2005/1057/images/pdf/chis.pdf (accessed 20 June 2013).

Van Vuren, D. and B. E. Coblentz. 1989. Population characteristics of feral sheep on Santa Cruz Island. Journal of Wildlife Management 53:306-313.

Von Bloeker, J. C. Jr. 1967. Land mammals of the Southern California Islands. Pages 245-263 in R. Philbrick, editor. Proceedings of the Symposium on the Biology of the California Islands, Santa Barbara Botanic Garden, Santa Barbara, California.

Wagner, J., Martin, M., Faulkner, K.R., Chaney, S., Noon, K., Denn, M. and Reiner, J., 2004. Riparian System Recovery after Removal of Livestock from Santa Rosa Island, Channel Islands National Park, California. United States Department of the Interior, National Park Service.

Warzybok, P., and R. W. Bradley 2008. Population size and reproductive performance of seabirds on Southeast Farallon Island, 2008. Unpublished report to U.S. Fish and Wildlife Service. PRBO Conservation Science, Petaluma, California.

Wilken, D. H., and A. K. McEachern. 2011. Experimental reintroduction of the federally threatened Santa Cruz Island bush mallow (*Malacothamnus fasciculatus* var. *nesioticus*). Pages 410–418 in Proceedings of the CNPS Conservation Conference, 17–19 January 2009, California Native Plant Society, Washington, D.C.

Wilkinson, R. 2002. Preparing for a changing climate: the potential consequences of climate variability and change for California. A Report of the California Regional Assessment Group for the U.S. Global Change Research Program. Available at: http://www.ncgia.ucsb.edu/pubs/CA_Report.pdf (accessed 21 May 2014).

Chapter 3. Study Scoping and Design

Santa Rosa Island dunes. Photo by Tim Hauf.

3.1. Preliminary Scoping

This Natural Resource Condition Assessment (NRCA) is a collaborative project among the National Park Service (NPS), U.S. Geological Survey (USGS), and the Institute for Wildlife Studies (IWS). A scoping meeting for the Channel Islands National Park (CINP) was held in Ventura, CA in December 2013. The meeting involved a visit to the CINP and a series of presentations by CINP and USGS biologists on the ecology of CINP. CINP managers identified the kind of information, datasets, and resources that would be available to the NRCA project and the primary needs and interests of Park resource managers. Meeting participants discussed the major goals of the NRCA project, identified the resource assessment priorities for CINP, and NRCA team members. The NRCA team consisted of CINP, USGS, Humboldt State University (HSU), and IWS biologists.

Because each of the islands has its own unique history of human impacts, ecological conditions, and restoration efforts, the NRCA team decided to address each of the five islands as a unique resource. This decision reflects the greater connections among different ecological communities within each island than exist among similar ecological communities on different islands. CINP resource managers indicated that the greatest need of the Park was to know if vegetation (primarily woody vegetation) is recovering on the islands and how that may be influencing recovery of the native terrestrial vertebrates. To help the NRCA team address this, CINP staff provided reports, theses, published papers, and summarized data to inform the NRCA following the initial scoping meeting in December. Once these information sources were provided by NPS staff, the NRCA team met again in February 2013 to outline the NRCA work plan and report and determine the approach and framework for assessing the islands' vegetation and terrestrial vertebrates. Based on the information and data sources available, the NRCA team decided to assess each of the island vegetation and vertebrate communities using both: 1) already available, summarized information from reports, theses, and journal articles and 2) new analyses of newly available data collected on the islands. This approach was then approved by NPS managers in March 2014 before the team moved forward with the NRCA. The Team also agreed during these discussions that all information gathered would be compiled into an online shared Dropbox folder managed by CINP, so that the compilation of resources would be available not only for the assessment team, but also for future Park reference, and that this compilation was a valued outcome of the NRCA for the Park.

3.2. Study Design

3.2.1. Indicator Framework, Focal Study Resources and Indicators

The CINP NRCA team used the Vital Signs indicators as identified by Fancy et al. (2009) for monitoring the condition of Natural Resources in U.S. National Parks. Using this framework, our focal study resource components were the five CINP islands, because these are the bio-geophysical resources of greatest interest to the CINP. The indicators assed for each island were metrics describing the state of vegetation and terrestrial vertebrate communities, in order to evaluate the recovery of scrub communities and associated vertebrates. The metrics used to assess the scrub recovery on each island were: 1) vegetation community structure, species composition and cover, and spatial extent; and 2) terrestrial vertebrate abundance. For each metric we identified the Reference Conditions/Values, Current Condition and Trend based on a review of the literature, Data and Methods the NRCA team used to evaluated new and unpublished data, Results from the NRCA team's analysis, Threats and Stressors, Data Gaps, Overall Condition, References, and Sources of Expertise.

3.2.2. Reporting Areas

Because each of the islands has its own unique history of human impacts, ecological conditions, restoration efforts, and natural resource monitoring the CINP NRCA centers on each of the five islands. So, the 'natural resource components' assessed for the CINP NRCA were the five islands, with a focus on determining the condition of each based on vegetation and terrestrial vertebrates.

3.2.3. General Approach and Methods

The general approach and methods used in this NRCA were designed to address the primary questions of interest to current CINP management:

1. Is native woody vegetation recovering on the islands?
2. If so, how are associated terrestrial vertebrate communities responding or recovering?

CINP has extensive monitoring data available on each of the islands, although the methods, data sets, and time periods, are not always consistent across the islands. Because such extensive data was available, our Team was able to address the Park's key questions by not only reviewing existing information, but also by conducting new summaries and analyses of datasets that have not yet been evaluated or reported on.

The NRCA team gathered and reviewed existing literature and data relevant to each of the resources included in the project framework. This effort began immediately following the initial scoping meeting, whereby the NRCA team compiled and provided data and literature in multiple forms, including: NPS reports and monitoring plans, reports from various state and federal agencies, published and unpublished research documents, databases, tabular data, spatial data, maps, charts, and solicited information from colleagues and local experts. The team created metadata for information obtained, indicating the sources and quality of the information, entered and error-checked raw data, compiled, reviewed, and summarized information into graphs, tables, and text. No new data were collected for this study; however, existing data were summarized and analyzed to provide insights into resource condition and to create new spatial representations. New analyses for this NRCA project included conducting population, spatial, and trend analyses and developing cross-walks among various vegetation types for each island, where data were available. A qualitative statement of overall current condition was created for each indicator, after all data and literature relevant to the measures of each resource component were reviewed and evaluated. Descriptions of specific methods used to analyze data by the NRCA team are provided within the assessment sections in Chapter 4 of this report.

Preparation and Review of Component Draft Assessments

The NRCA team worked closely together to develop draft assessments for each component. CINP and USGS Team members had 20-30 years of experience conducting research and management on the islands, and their expertise played a significant and invaluable role in providing insights into assessment of each component.

The process of developing draft documents for each component began with a detailed phone or e-mail conversation among the NRCA team members. During these conversations the Team determined the most relevant data that should be used and evaluated in order to inform the assessment of each resource component. Draft assessments were reviewed by experts, and feedback was addressed and incorporated into the final resource assessments. As a result of this process, and the insights from CINP resource staff, USGS biologists, and other experts, the final resource assessments represent the most relevant and current data available for each component and the opinions of park resource staff and outside experts.

3.3. Format of Component Assessments in Chapter 4

3.3.1. General Overview

This section provides the background of each resource component, which, for this project, are the five Park islands. Within this section, the Team described each island's: 1) physical setting, 2) a summary of the natural resources on each island, and 3) land use history. The natural resources discussed include terrestrial plant communities, native animals (herpetofauna, landbirds, seabirds, marine and terrestrial mammals) and non-native, introduced animals. General, Park-wide island descriptions are provided in Chapter 2.

3.3.2. Natural Resource Assessment

Measures

Resource component measures were identified in the scoping process and refined through discussions among NRCA team members. These measures were selected because they were most appropriate for assessing the current condition of each resource component and addressing the focal question this NRCA sought to address (i.e., island scrub recovery). The measures are listed as bulleted items. Specifically, the Team evaluated island scrub recovery by assessing changes over time in: 1) vegetation community structure, species composition and cover, and spatial extent and 2) vertebrate abundance, relative to the reference condition of each island.

Reference Conditions/Values

This section describes the reference condition determined for each measure (i.e., vegetation, vertebrates) of the resource component (i.e., island). The reference condition describes the island's ecological state prior to European settlement, and identifies the ecological state to which the NPS desires the park return.

Current Condition and Trend

This section provides an in-depth review of each resource component based on current literature and knowledge. The information is presented primarily with text and where information was available, maps, graphs, or tables summarize relevant data or show important relationships. All relevant data and information from the literature for a component is presented and interpreted in this section.

The Current Condition and Trend section for each resource component (i.e., island) is broken out according to the two key measures (i.e., vegetation, vertebrates). A summary of the current condition and trend for each resource and measure is given at the beginning of each section (Table 3.3.1). Under the *Vegetation community structure and spatial extent*, the Team provides a description of what the island vegetation condition was like pre-European settlement, followed by the historical vegetation that occurred on each island as a consequence of post-European human impacts, then a detailed review of the current vegetation condition and trends based on a literature review. Under *Vertebrate abundance* the Team describes the current condition and trend for vertebrate species relevant to assessing island scrub recovery. In most cases, this discussion includes all native island mammals and landbirds.

Table 3.3.1. Symbols used for overall and key measure condition and trend throughout CINP NRCA.

Condition Status		Trend in Condition		Confidence in Assessment	
Condition Icon	**Condition Icon Definition**	**Trend Icon**	**Trend Icon Definition**	**Confidence Icon**	**Confidence Icon Definition**
	Resource is in Good Condition		Condition is Improving		High
	Resource warrants Moderate Concern		Condition is Unchanging		Medium
	Resource warrants Significant Concern		Condition is Deteriorating		Low

NRCA team Data and Methods
This section describes the data sets and new analyses the Team used to evaluate the component and determine its current condition, and is organized under the subheadings of the key component measures (i.e., vegetation, vertebrates). These data are newly analyzed and not currently available in any unpublished or published literature.

NRCA team Results
This section describes results and conclusions from the new analyses the Team used to evaluate each component, and is organized under the subheadings of the key component measures (i.e., *Vegetation Community Structure and Spatial Extent*, *Vertebrate Abundance*). Figures and summary tables are provided to help summarize the findings accordingly.

Threats and Stressor Factors
This section provides a summary of the threats and stressors that may impact the resource and influence the current condition of a resource component in the future. The discussion of this section is organized by *Vegetation* and *Vertebrates*, under which the Team provides a summary of the key threats and stressors facing these measures.

Data Needs/Gaps
This section outlines critical data needs or gaps for the resource component, and the discussion is organized by *Vegetation* and *Vertebrates*. The Team describes how these data needs/gaps would provide improved insight into the current condition or trend of a given component in future assessments and help inform Park resource managers.

Overall Condition
This section summarizes the overall condition of the resource component, and highlights the key findings that generated these conclusions. The *Overall Condition* section first provides a qualitative summary statement of the current condition that was determined for the resource component (i.e., island). This statement is followed by a summary of the overall condition of each measure, under the subheadings *Vegetation Assessment* and *Vertebrate Assessment*. Condition was determined after thorough review of available literature, data, and insights from NPS staff and experts, which are presented under the Current Condition and Trend and NRCA team Results sections.

Sources of Expertise
This is a listing of the individuals (including their title and affiliation with offices or programs) who had a primary role in providing expertise to determine current condition of each resource component.

Literature Cited
This is a list of citations for literature used in the assessment of condition for the resource component. Digital copies of the literature were provided to CINP for archival.

3.4. Literature Cited

Fancy, S.G., J. E. Gross, S. L. Carter. 2009. Monitoring the condition of natural resources in U.S. National Parks. Environmental Monitoring and Assessment 151:161–174.

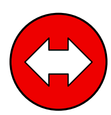
Chapter 4. Natural Resource Condition Assessments

Section 4.1. Santa Barbara Island

Blooming Coreopsis at Santa Barbara Island. NPS photo.

4.1.1. General Overview of Santa Barbara Island

Condition = Poor



Trend = Stable

Physical Setting

Santa Barbara Island (SBI) is about 2.6 km^2 (1 mi^2) in area, the southernmost island in the Channel Islands National Park. It is located approximately 61 km (38 mi) from the Palos Verde peninsula on the mainland coast and 39 km (24 mi) northeast of Santa Catalina, its nearest island neighbor (Figure 4.1.1). The island's climate is Mediterranean with warm dry summers and cool wet winters; the greatest amount of rain falls between December and March. Total annual rainfall at SBI from 1923 – 2011, averaged 21.0 cm per year (8. in), ranging from a high of 52.3 cm (21 in) in 1941 to a low of 4.2 cm (1.65 in) in 2009 (Handley et al. 2013). Mean annual temperature over that same period averaged 14.2 degrees Celsius (C; 58 degrees Fahrenheit [F]), ranging from a high of 15.8 C (60 F) in 2004 to 12.02 C (53.62 F) in 1956. Because of its location, SBI shares floristic elements with the southern islands of Santa Catalina, San Clemente and Baja California (Junak et al. 1993).

The island is the eroded top of a submerged seamount, probably inundated most recently in the late Pleistocene (Johnson 1979, in Power et al. 1980). The terrain is a northeast-southwest trending ridge, sloping to broad marine terraces to the east and west. The highest elevation is Signal Hill at 193 m (634 ft), at the southern end of the central ridge. Vertical ocean cliffs ranging from 60-180 m (200 to 590 ft) in height surround the island except on the extreme northwest tip where the terraces slope to near sea-level at Webster Point.

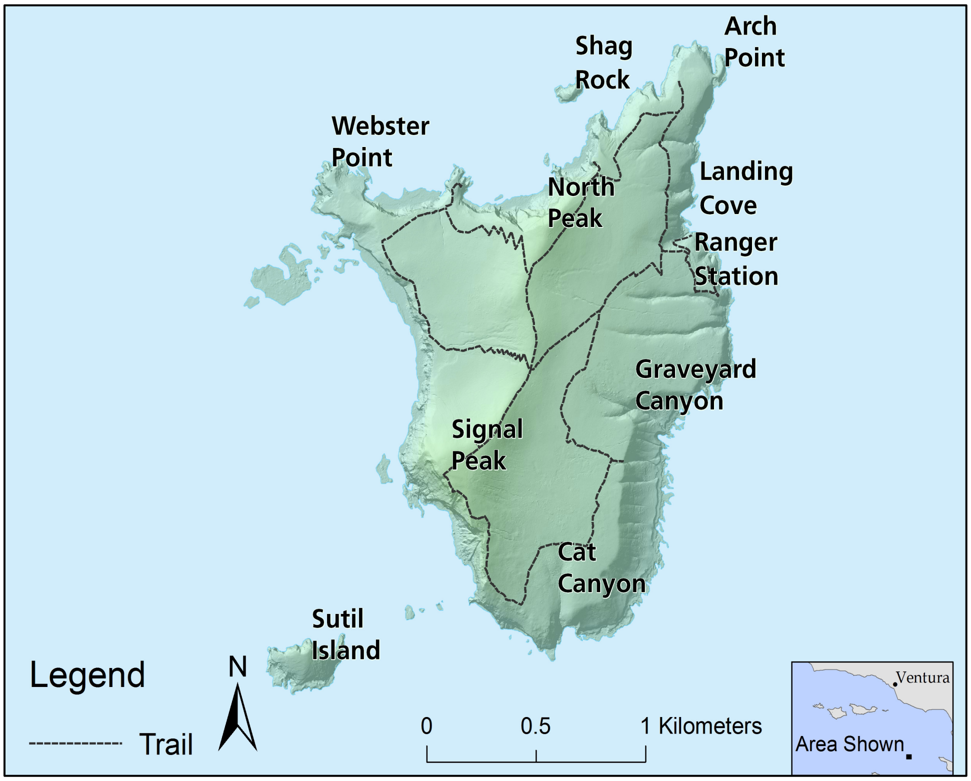


Figure 4.1.1. Santa Barbara Island locations, roads, and trails with hillshade (Map by R. Rudolph).

Five steep and narrow canyons bisect the eastern and southern terraces, but there are no sources of fresh water on the island. The upland ridge runs generally perpendicular to the prevailing west winds. Hourly wind speeds averaged 17.3 kph (10.2 mph) between 1995 and 2014 (Western Regional Climate Center). The island environment is strongly affected by the combination of wind exposure and terrain: western exposures are considerably drier than the eastern terraces and canyons. There are extensive kelp beds along the eastern and southern shores. Sutil Island lies immediately offshore to the south, a nearly inaccessible sea mount.

Natural Resources

Resource descriptions are discussed in detail in the Channel Islands National Park General Management Plan, and are briefly summarized here (NPS 2013).

Terrestrial Flora and Plant Communities

There are 135 plant taxa recorded from SBI, 67% of those are native including 4 taxa endemic to SBI alone and another 13 that occur on at least one other island but not on the mainland (McEachern et al. 2016; Tables 2.2.1, Table 2.2.2). Asteraceae and Poaceae, with 25 taxa each, are the most well-represented families among both native and exotic taxa, followed by Chenopodiaceae (8 taxa) and Fabaceae (7 taxa). Plant communities (Figure 4.1.2) include exotic annual grasslands and native scrub communities: Coreopsis (*Leptosyne*), boxthorn (*Lycium*) and cactus scrub, and a few small patches of other native shrub species (Rodriguez et al. 2012). About 42% of the island is covered by non-native grasses. Another 21% of the island is dominated by the non-native annual crystalline iceplant (*Mesembryanthemum crystallinum*) or the non-native cheeseweed (*Malva parviflora*). Several of these plant communities are shown in Figure 4.1.3. Santa Barbara's nearly vertical sea cliffs have provided a refuge for native plants that have been eliminated or reduced in more accessible areas. A multi-year restoration project was begun in 2007, to restore shrub habitat for nesting seabirds (Mazurkiewicz 2014).

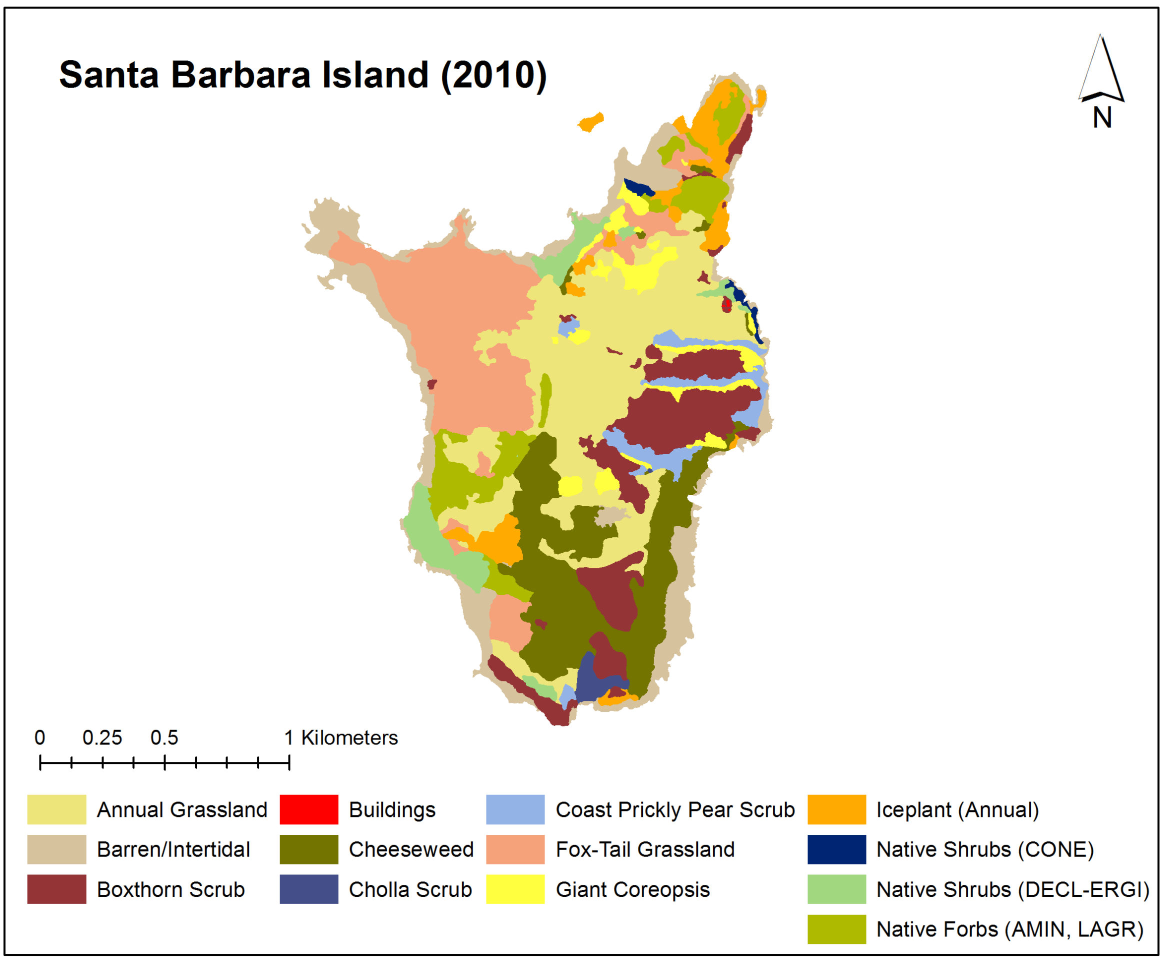


Figure 4.1.2. Vegetation of Santa Barbara Island, 2010 (Rodriguez et al. 2012).

Figure 4.1.3. Photos of annual grassland dominated by foxtail (*Hordeum murinum*) (top left), annual iceplant (*Mesembryanthemum crystallinum*) (top right), boxthorn scrub (*Lycium californicum*) (bottom left), and giant coreopsis (*Leptosyne gigantea*) on Santa Barbara Island in 2010 (bottom right).

Native Animal Species

Relatively few native terrestrial animal species occur on SBI. Endemic species that occur here include the island night lizard (*Xantusia riversiana*) and a subspecies of deer mouse (*Peromyscus maniculatus elusus*). The hoary bat (*Lasiurus cinereus*) is the only other native mammal known from the island. In addition, the island supports a high diversity of land mollusks, with six snail species. A total of 50 species of landbirds were recorded on SBI between 1993 and 2000, of which 11 species have been observed breeding on the island, including peregrine falcons (*Falco peregrinus*) and burrowing owls (*Athene cunicularia*). Common species include orange-crowned warblers (*Oreothlypis celata*; frequently found in coreopsis in the canyons), rock wrens (*Salpinctes obsoletus*; on cliffs), and western meadowlarks (*Sturnella neglecta*; in grasslands).

SBI with its offshore islets (Sutil Island and Shag Rock) is the second most important seabird nesting island in the park. The island supports 11 species of breeding seabirds, including the largest Scripps's murrelet (*Synthliboramphus scrippsi*) colony in the world, probably the only U.S. colony of black storm-petrels (*Oceanodroma melania*), brown pelicans (*Pelecanus occidentalis*), western gulls (*Larus occidentalis*), ashy storm-petrels (*Oceanodroma homochroa*), Brandt's, double-breasted, and pelagic cormorants (*Phalacrocorax penicillatus, P. auritus, P. pelagicus*), Cassin's auklet (*Ptychoramphus aleuticus*), and pigeon guillemot (*Cepphus columba*). SBI also is important for pinnipeds. California sea lions (*Zalophus californianus*), northern elephant seals (*Mirounga angustirostris*), and harbor seals (*Phoca vitulina*) all have breeding and pupping grounds and haul-outs on SBI.

Non-native Animal Species

SBI once had sheep (*Ovis aries*), goats (*Capra aegagrus hircus*), feral cats (*Felis catus*), and rabbits (*Oryctolagus cuniculus*), all of which were particularly devastating to the island's fauna prior to their removal from SBI. European starlings (*Sturnus vulgaris*) occurred on SBI until 1997, and house sparrows (*Passer domesticus*), and brown-headed cowbirds (*Molothrus ater*) continue to breed on the island.

Land Use History

The earliest uses of SBI were off-shore fishing and pinniped hunting by Native American, Russian, Asian and European entrepreneurs (e.g., Scammon 1874); there is no evidence of a continuous early Native American presence on the terrestrial part of the island. Botanical surveys began on SBI in the 1860s (Philbrick 1972, Junak et al. 1993), indicating that a mix of native and non-native species was already present. In 1896, Britton (1897) noted the skeletons of sheep or goats presumably introduced to the island several years earlier that were apparently unable to survive due to the lack of fresh water. The island was leased 1914 – 1922 by Alvin Hyder who transformed it to an agricultural operation by burning and clearing vegetation, plowing uplands and planting them with oats and potatoes, constructing cisterns, and stocking the island with horses (*Equus ferus caballus*), mules (*Equus africanus asinus*), rabbits, ducks (*Anas platyrhynchos domesticus*), geese (*Anser anser domesticus*), turkeys (*Meleagris gallopavo*), chickens (*Gallus gallus domesticus*), and sheep (Daily 1993). The island was largely unmanaged after the Hyder family departure, and a feral cat population grew to large numbers by predating the native island birds (Sumner and Bond 1939).

SBI became part of the Channel Islands National Monument in 1938, and was surveyed by federal biologists Lowell Sumner, R.M Bond and Myron Dunkle in 1939 and 1940. The Armed Forces staffed an aircraft early warning station on the island 1942 – 1946 (Philbrick 1972), and they released New Zealand red rabbits (*O. cuniculus*) in 1942, presumably as a potential emergency food source should staff become stranded there. Dunkle (1950) resumed his research in 1949, correlating detailed measurements of ecological factors such as exposure, soil type, and evaporation data with vegetation. Sumner revisited SBI in 1950 and 1953. These scientific expeditions found the SBI song sparrow populations greatly decimated by cat predation and the native vegetation decimated by rabbit herbivory (Sumner 1953). As a result, the National Park Service (NPS) removed the cats and conducted a rabbit control program 1954 – 1958, which greatly reduced, but did not completely eradicate, the rabbits (Sumner 1958). A fire ignited by vagrants burned the eastern half of the island in 1959, consuming most of what was left of the native vegetation and song sparrow habitat; song sparrows disappeared completely sometime after that, in the 1960s. Rabbit populations rebounded over the next decade, however, and they were not completely removed until a major hunting effort was conducted 1980-1981.

With development of the NPS Inventory and Monitoring Program in the late 1980s, funding was committed to long-term monitoring of vegetation, seabirds, weather, land birds, herpetofauna (mainly island night lizards), mice, rocky intertidal sites and kelp forests (NPS 2005). Additional shorter-term studies have been pursued to investigate individual species' autecology, genetics and evolution, environmental patterns, ecosystem functions and restoration strategies (e.g., Clark and Halvorson, 1987, 1988, 1990, Drost and Fellers 1991, Fellers and Drost 1991, D'Antonio et al. 1992, Danielsen 1989, Drost 1989, Halvorson et al. 1992, Halvorson et al. 1997, Salas 1990, Corry 2006, Schwemm 2008). Several targeted restoration projects have been carried out, including removal of debris left by the Armed Forces, badlands erosion control, crystalline iceplant and cheeseweed control, and native grass rehabilitation. After 1981, island-wide recovery was mainly passive, contributing to the de-listing of the island night lizard and the California brown pelican (*P. o. californicus*), and increasing numbers of Scripps's murrelets and the endangered succulent, Trask's live-forever (*Dudleya traskiae*). In 2007 a major seabird habitat restoration project was initiated with the objective of restoring at least 2 ha (5 ac) to upland scrub and establishing nesting populations of auklets, petrels and murrelets. The overarching management goal for SBI, according to the GMP, is the restoration of terrestrial ecosystems. Because of the legacy of detailed research started in the 1940s by federal scientists, SBI is arguably the best studied island ecosystem in the entire California Islands archipelago.

4.1.2. Natural Resource Assessment of Santa Barbara Island

Measures of Scrub Recovery

- Vegetation community composition, structure and spatial extent
- Vertebrate abundance

Reference Conditions/Values

The reference condition for SBI is pre-ranching and military use, characterized by native scrub that sustains nesting seabirds and endemic plants and animals.

By verbal accounts, before the 1890s, the island was covered with dense scrub vegetation. The land cover was rapidly converted to non-native annual vegetation and iceplant through farming, herbivory and fire, and it remains largely annual today. In addition to the introduction of non-native predators, these large-scale vegetation changes, resulted in dramatic changes in animal species composition, including the extinction of a songbird and loss of nesting seabirds. Indeed, early narratives (Howell 1917) and soil properties (USDA, NRCS 2007) indicate that Santa Barbara uplands were occupied almost exclusively by seabirds before European settlement. In the early 1990s there were still traces of seabird burrows in upland soils where Cassin's auklets and ashy storm petrels burrowed beneath low-growing shrubs to form nest cavities (H. Carter personal communication 1994), and the soils on the west slope of North Peak show acidification from long use by nesting gulls. These birds used the island seasonally, spending the majority of the year foraging at sea. Year-round, the island supported an endemic subspecies of deer mouse, the island night lizard, the California brown pelican, and the now extinct single-island endemic Santa Barbara Island song sparrow (*Melospiza melodia graminea*).

Vegetation

Perennial native scrub with an understory dominated by native herbaceous plants as the predominant land cover, resilient to decadal shifts in climate regimes and global change.

- Diverse community composition of shrubs and understory herbs and grasses
- Reduced erosion
- Deep, friable upland soils suitable for burrowing seabird habitat
- Stable populations of the endangered Trask's live-forever.

Vertebrates

Populations of native terrestrial vertebrates that are robust, persistent, and influenced only by native perennial ecosystem elements and processes, to the extent practicable. Specifically, populations should:

- Not be threatened by non-native species
- Not be at low numbers due to past influence of non-native grazers on island vegetation
- Have recovered from previous lows commensurate with vegetation recovery.

<u>Current Condition and Trend</u>

Vegetation Community Structure and Spatial Extent

<u>*Historical Vegetation Change*</u>

Federal scientists Richard Bond, Lowell Sumner and Myron Dunkle were fascinated with SBI ecology. Over several visits from 1939 to 1958, they provided a detailed understanding of plant species composition and distribution, and the devastating effects of predation, herbivory and invasion by exotic plants on the island ecosystem (Sumner and Bond 1939, Dunkle 1950, Sumner 1959). The story that emerges is that the pre-settlement vegetation was nearly impenetrable growth of giant coreopsis "forest" and native boxthorn thicket on the terraces and canyons, low evergreen and semi-deciduous shrubs on the uplands, succulents mixed with native grasses on the thinner soils and southern exposures of the island, and low scrub on the ocean bluffs. Dunkle (1950) hypothesized that prior to the introduction of goats in the 1890s, vegetation patterns were driven largely by the seasonality of the precipitation, soil type, slope aspect and wind exposure, moderated by seasonal disturbances created by seabirds and pinnipeds. Farming and the subsequent introduction of rabbits changed island vegetation from dominance by natives to widespread cover of non-natives, with cascading effects on island fauna (Sumner 1959). From the Hyder farming years until about 1980, vegetation composition and pattern was driven by disturbance and herbivory.

While the brief introduction of ungulates prior to 1896 resulted in visible disturbance to the native vegetation, it was nothing like the changes brought about by the agricultural practices of the Hyder years. Farming essentially changed the central ridge from perennial scrub to annual grassland and iceplant (*M. nodiflorum*) barrens; decades later the traces of plowing were still visible in soil profiles (Brooks 1980) and seed banks consisted overwhelmingly of iceplant (Halvorson et al. 1997). "Iceplant" was noted on the island as early as 1897 (Britton), and both *M. crystallinum* and *M. nodiflorum* were described as abundant by Howell in 1917. In trips made in 1939 and 1940, Sumner

(1939) and Bond (1940) observed that the island was dominated by other plants indicative of "abused land" as well, including the annual grasses foxtail (*Hordeum murinum glaucum*), wild oats (*Avena fatua*) and brome grasses (*Bromus sterilis, B. madritensis rubens*), prickly sow-thistle (*Sonchus asper*), cheeseweed, and bur clover (*Medicago polymorpha* var. *polymorpha*). Buster Hyder in an interview conducted in 1993, said, "I remember mostly iceplant on Santa Barbara Island" (Daily 1993:24). Vegetation maps made by Dunkle (1950), Philbrick (1972), Hochberg et al. (1979), D'Antonio (1992) and Rodriguez et al. (2012) show expansion and contraction of iceplant within predominately annual grassland over the central ridge and western terraces.

Vegetation on the mesic eastern leeward side of the island recovered more readily than on the rest of the island, after the Hyder departure in 1922. Dunkle (1950) and Sumner (1958) hypothesized several reasons for this: 1) these soils were not plowed and therefore native soil seed banks were still intact, 2) giant coreopsis and boxthorn persisted in the canyons and served as source populations for recovery, 3) the area is not subjected to the severe drying effects of the prevailing winds, 4) the deeper soils hold more water for seedling regeneration. Recovery of natives on the terraces was encouraging after 1922, particularly the development of fairly dense stands of coreopsis where it spread from the canyons back onto the intervening terraces. However, the introduction of rabbits in the 1940s reversed this recovery, as the rabbits ate the giant coreopsis and other native plants such as the endemic Trask's live-forever. Starting about 1952, and as long as rabbits persisted on the island, there was a waxing and waning of giant coreopsis and other organisms that depended on it, including the endemic southern island morning glory (*Calystegia macrostegia amplissima*) and narrow endemic Santa Barbara Island song sparrow. Sumner and Dunkle both noted how rabbit numbers were influenced by periodic drought that reduced native plant forage, increased iceplant and cactus cover, and resulted in rabbit die-offs. As native plants began to recover, so the rabbit population recovered, rabbit herbivory increased, and the cycle began again. Ralph Philbrick surveyed SBI in 1970, and noted a pronounced decline in coreopsis cover relative to Dunkle's 1950 map (Philbrick 1972). He summarized the trends noted by Sumner in a series of field visits 1952-1959 (Sumner 1959, Philbrick 1972; Figure 4.1.4). In 1956, rabbit numbers were estimated by Sumner at a high of 2,621, having rebounded after NPS hunting halted several years earlier. Sumner observed a brief increase in coreopsis in 1958, which he associated with resumed rabbit hunting and more rainfall. He made the last reported observation of the song sparrow that year, too; attributing its presence to the renewed vigor of the coreopsis. Later, however, he observed that nearly two-thirds of the island from the east coastline to the crest of the ridge was reduced to bare mineral soil in the 1959 fire (conversation reported in Philbrick (1972). Sumner's documentation of the devastating effects of rabbit population rebounds through the 1950s, and Philbrick's observations of only limited native plant recovery in 1970, formed the foundation for the NPS push to finally eradicate rabbits from the island in 1981.

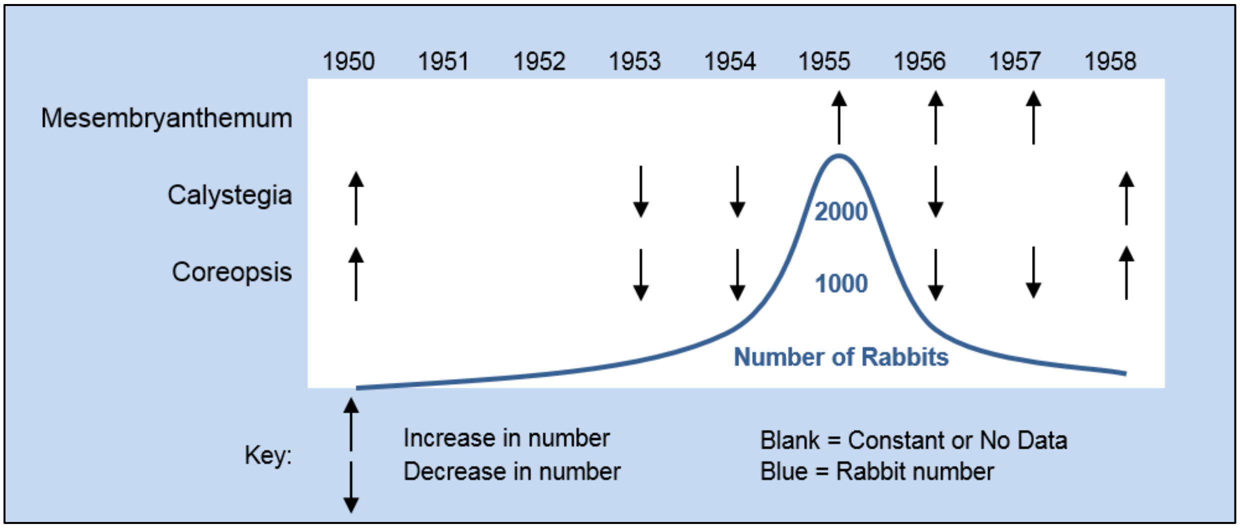
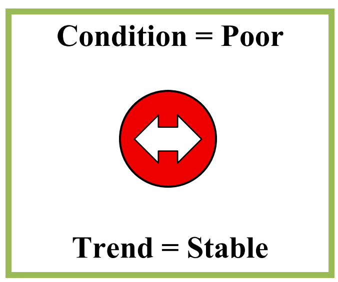


Figure 4.1.4. Increase and decrease in selected plants in relation to changes in the number of introduced rabbits on Santa Barbara Island (Redrawn from Philbrick 1972, p.351).

Current Vegetation Condition and Trends



The NPS vegetation monitoring program began in 1984, with the goal of documenting trends in species cover and community distribution over many years (Johnson and Rodriguez 2001). The study design employs nineteen transects located purposefully in representative stands of the major vegetation types identified in relevé surveys (Lenihan personal communication reported in McEachern 2001) to detect change within communities, complemented by periodic vegetation mapping to identify shifts in community dominance over the landscape. Transect monitoring has been done nearly annually since 1984, but the vegetation mapping part of the protocol was only done in 1979 (Hochberg et. al), and repeated again in 2010 (Rodriguez). Corry (2006) looked for trends in the data from 1984-2005, and more recent analyses of the transect data from 1984-2012. Handley et al. (2013) investigated change in cover of individual species, and in species groups consisting of exotics and natives, annuals and perennials. Results of both studies indicate little directional change at the sample sites. Corry found that vegetation patterns were closely related to nuanced differences in available moisture, related to landscape position and soil texture. Handley et al. (2013) found that cover of species and functional groups has not increased substantially along the transects (Table 4.1.1). Instead, cover and relative dominance of species and functional groups fluctuate with precipitation of the current year and total precipitation over the past two years. Cover also correlates strongly with the sample date. Otherwise, the analysis generally shows no significant correlation of cover with other parameters analyzed, including time since rabbit eradication, average air temperature, or variables related to the site. These results underscore the importance of moisture in the system seen and discussed by Dunkle (1950) and Sumner (1959), and more recently by Schwemm (2008): rainfall and drought drive vegetation abundance, soil moisture holding capacity affects vegetation pattern, and sites tend to stay the same across years whether they are on the mesic leeward side of the island, or the more xeric southerly and windward exposures. There is no evidence that shrubs are successfully invading grasslands at the transect locations, or that there is significant change in shrub stands that were already intact in 1984. Sites that were dominated by annual vegetation have tended to stay annual, and perennial sites have remained perennial. Observations in summer of 2015 indicate potential conversion of perennial coreopsis stands to annual (primarily iceplant) vegetation associated with trampling by large numbers of nesting gulls (C. Drost, personal communication, 2015).

Table 4.1.1. Trends in cover of species and species guilds 1984 – 2012 on SBI transects detected in models at two levels of statistical significance; ↓ indicates overall decline in total cover; ↑ indicates overall increase in total cover (Handley et al. 2013).

Plant community	↑ Natives	↓ Natives	↑ Exotics	↓ Exotics
Boxthorn scrub ↓	–	Opuntia prolifera*	–	–
Boxthorn-coreopsis scrub ↓	–	–	Bromus hordeaceus	–
Cactus scrub ↓	–	Opuntia prolifera*	–	–
Coreopsis scrub ↓	Eriogonum giganteum* Opuntia littoralis/oricola Achillea millefolium* Native grass	Hemizonia clementina* Atriplex californica*	–	–
Grasslands ↓	–	All natives* All subshrubs* Hemizonia clementina*	–	–
Grassland-annual iceplant ↓	–	All natives All subshrubs* Suaeda taxifolia Ambylopappus pusillus	–	Mesembryanthemum nodiflorum
Sea cliff scrub ↓	Eriogonum giganteum*	All natives Hemizonia clementina* Atriplex californica*	–	–
Sea-blite scrub ↓	Native grass* Bromus arizonicus	All natives All subshrubs* Suaeda taxifolia*	Avena barbata/fatua*	Mesembryanthemum nodiflorum

* p<0.001 and p<0.01.

The lack of clear recovery trends in the transect data contrasts with management expectations of increasing native shrub cover following rabbit eradication. Botanists collecting on the island since 1980 have noted that native shrubs and some associated understory annuals were making incursions into uplands where they seemed to be establishing and spreading in small isolated patches (Drost 1983, Junak et al. 1993, Chaney personal communication 2011). It is possible that the monitoring study design employs too few transects to detect change at those locations, or that the point-line intercept methodology is too coarse to detect minor changes in species composition of small plants like annuals and shrub seedlings. NPS is adjusting the sample design to add more transects, and they are sampling belt transects for shrub density that might pick up fine-scaled differences in the future. However, strong directional patterns should have been detected through 25 years of sampling at the same site. Instead, transect sample results reflect and corroborate historical observations of fluctuations in cover and composition with precipitation with little overall trend.

The transect samples were designed to show localized change within stands, while vegetation mapping puts the transect samples in a broader context. Recent vegetation mapping and classification (Rodriguez et al. 2012) indicate that annual grasslands (*A. fatua*, *H. murinum*, *Bromus madritensis*, *Vulpia* spp.) occupy about 46% of the island, mainly on the central ridge and western terrace (Table 4.1.2, Figure 4.1.3 top left), while non-native annual iceplant and exotic cheeseweed cover another 21% (Figure 4.1.3 top right). Native-dominated communities occupy the remaining 33%, including boxthorn communities and giant coreopsis on the eastern terraces and canyons (Figure 4.1.3 left bottom & left right), cactus stands (*Cylindropuntia prolifera* and *Opuntia oricola*) on south-facing canyon slopes and at the southern tip of the island, tarplant (*Deinandra clementina*) and buckwheat (Eriogonum giganteum compactum) scrub on slopes and ocean bluffs, two stands of silver lace (*Constancea nevinii*), and native herb communities (*Amsinckia intermedia* and *Lasthenia gracilis*) on the thin soils of Arch Point. The island remains a largely annual-dominated ecosystem.

Table 4.1.2. Plant Alliances identified from vegetation relevé samples, 2010, Santa Barbara Island (Rodriguez et al. 2012).

Land Type	Alliance	# Of polygons (samples)	Acres
Shrublands	*Cylindropuntia prolifera*	2	11.7
	Deinandra clementina - Eriogonum giganteum compactum	11	23.6
	Constancea nevinii	2	2.6
	Leptosyne gigantea	17	21.7
	Lycium californicum	20	64.6
	Opuntia oricola	6	18.5
Herbaceous lands	*Avena fatua**	14	133.2
	Aminskia intermedia	9	24.6
	*Bromus madritensis**	2	6.8
	Lasthena gracilis	5	10.3
	*Hordreum murinum**	11	110.3

* Indicates an Alliance dominated by non-native plant cover.

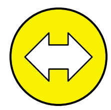
Table 4.1.2 (continued). Plant Alliances identified from vegetation relevé samples, 2010, Santa Barbara Island (Rodriguez et al. 2012).

Land Type	Alliance	# Of polygons (samples)	Acres
Herbaceous lands (continued)	*Malva parviflora**	14	89.1
	*Mesembryanthemum crystallinum**	22	28.2
	*Vulpia ssp.**	1	0.3
Total	**–**	**136**	**545.5**

* Indicates an Alliance dominated by non-native plant cover.

Current Condition and Trend: Vertebrate Abundance

Condition = Moderate



Trend = Stable

Herpetofauna

Island night lizards

On August 11, 1977, the United States Fish and Wildlife Service (USFWS) listed the island night lizard as a threatened species because of its restricted range and apparently low population levels on Santa Barbara and San Nicolas islands. Their populations were thought to have been reduced due to past farming and grazing, fire, and the introduction of non-native animals and plants. However, Fellers and Drost (1991) estimated that the total population on SBI was at least 17,599, and concluded that the population was not threatened with extinction as previously thought. The USFWS delisting in 2014 (USFWS 2014) determined that night lizards are “recovered” because all substantial threats to the lizard have been removed and remaining potential threats are being addressed through management, including removal of introduced herbivores and active restoration efforts to improve habitat conditions for the lizard.

The best habitats for the lizards are boxthorn, prickly pear cactus (*Opuntia oricola* and *O. littoralis*), and cracks and crevices in and around rock outcrops and surface boulders. These areas provide protection from predators. They are also often found under rocks, driftwood, and fallen branches. Suitable habitat on SBI is located in all of the canyons and on some of the sea cliffs, especially on the south side of Signal Peak (Figure 4.1.1). SBI contains very little of these habitat types, perhaps as much as 25.9 ac, because of the small size of the island and extensive habitat degradation when goats, sheep, and European rabbits inhabited the island (USFWS delisting report 2014). However, because island night lizards exist at densities as high as 1296 lizards per acre (Fellers and Drost 1991), a relatively large population may be supported on SBI.

Landbirds

Landbirds have been monitored on SBI since 1993, initially with line transects; point counts were added in 2002, and were established in association with key habitat types on SBI (see the Park's landbird trend report for methods details, Coonan et al. 2011a, b) The landbird trend report identified habitat associations of island landbirds, and evaluated population trends over time for 8 species which occur on the island (Coonan et al. 2011a, b).

The common species, horned larks (*Eremophila alpestris*), orange-crowned warblers and western meadowlarks (*Sturnella neglecta*) show clear habitat preferences on SBI (Coonan et al. 2011b). On SBI, horned larks and western meadowlarks occurred in grassland, whereas orange-crowned warblers occurred in grassland and scrub (Figure 4.1.5). The Landbird Trend report showed horned larks exhibiting high inter-annual variability and multi-year population cycles on SBI, while orange-crowned warblers increased in abundance from 1998-2001 and then declined from 2002-2009 and exhibited low-levels of inter-annual variation over these years. Rock wrens occurred at low densities overall and exhibited multi-year cycles, while western meadow lark densities declined from 2002-2009. Additionally, the endemic SBI Song sparrow disappeared in 1958 due to habitat loss and predation by feral cats, and merlins have not been detected on the island since 1998 (Figure 4.1.6; Coonan et al. 2011a). The introduced European starling was last detected on SBI in 1997.

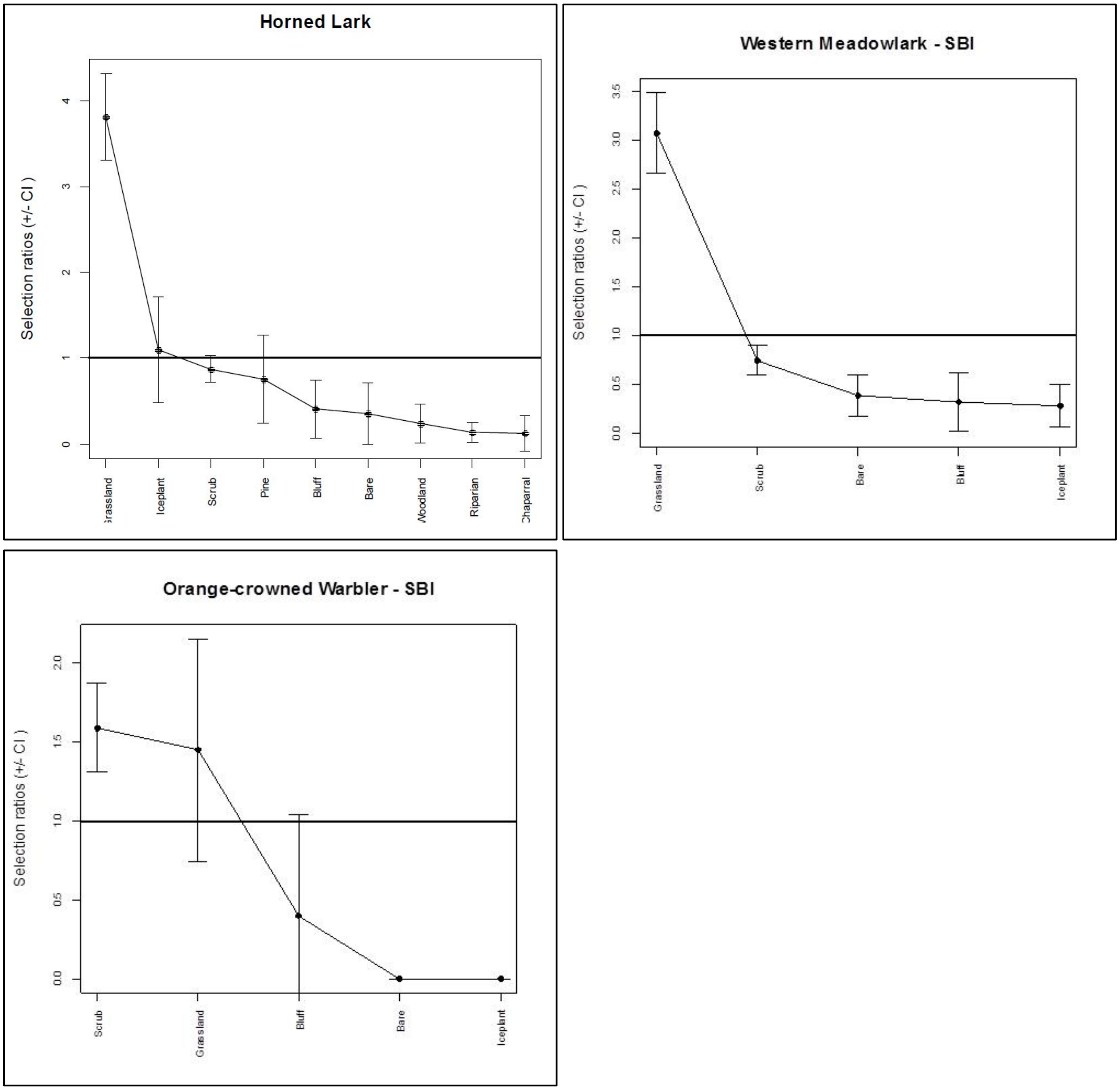


Figure 4.1.5. Habitat selection profiles for three landbird species on Santa Barbara Island (Coonan et al. 2011b). Positive selection ratios denote preferred habitats; negative selection ratios denote habitats that are avoided.

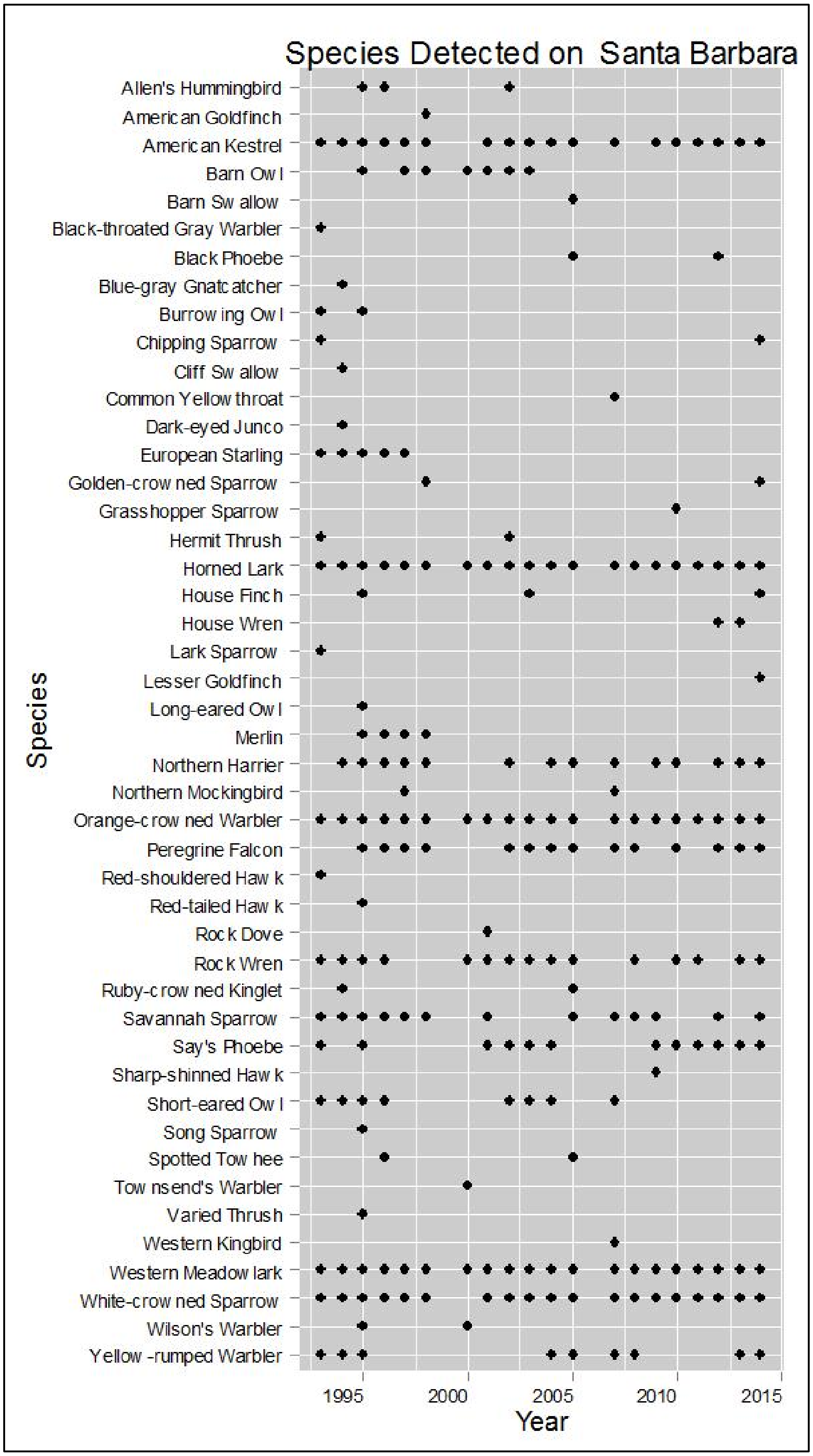


Figure 4.1.6. Species detected annually during landbird monitoring on Santa Barbara Island, 1993-2014 (Coonan et al. 2011a).

Mammals

Deer Mouse Abundance

The island's only terrestrial mammal is a subspecies of deer mouse (*P. m. elusus*). Mice play a major role in the SBI ecosystem, both as prey for resident birds of prey and as plant predators, and may be more dense here than anywhere else in the world (Drost and Fellers 1991, Schwemm and Coonan 2001). The SBI mouse population has been monitored for over 20 years, and the 2012 Deer Mouse Monitoring Report provides the most current information on the species and monitoring program across the islands (Fellers et al. 1988, Coonan 2012). Data from the early years of the program also has previously been reported in a series of annual reports (Schwemm 1995, Austin 1996, Schwemm 1996, Austin 1998) and a trend report (Schwemm and Coonan 2001).

Deer mice exhibit large fluctuations in population levels over a 3-4 year population cycle, driven by annual rainfall, predation pressure, and season (Figure 4.1.7; Drost and Fellers 1991, Schwemm and Coonan 2001, Coonan 2013). Their populations increase with increased precipitation and food resources, supporting an increase in a key predator on the island, the barn owl (Drost and Fellers 1991). Mice populations peak and then crash, driven further downward by the increased number of owls, which subsequently decline until precipitation promotes another population increase (Drost and Fellers 1991). On SBI the mice are only subject to predation from aerial predators; island foxes do not occur on SBI. Drost and Fellers (1991) suggest that increased densities of mice draw aerial predators to the island and when their populations are low, aerial predators return to forage on larger islands and the mainland.

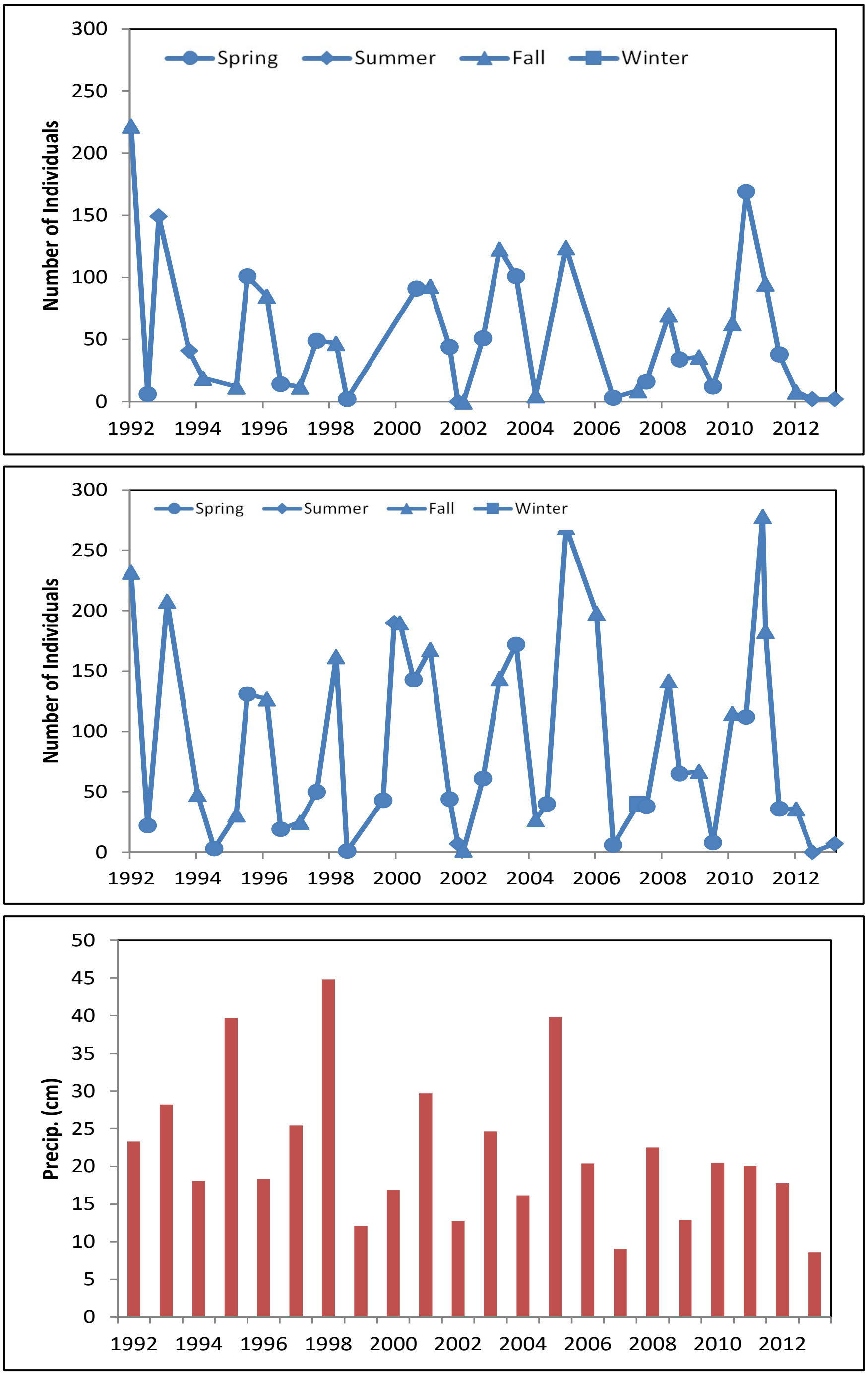


Figure 4.1.7. Deer mouse abundance (number of unique individuals) on the Terrace Coreopsis grid (top), and the Terrace Grassland grid (center), Santa Barbara Island, 1992-2012, along with annual precipitation on Santa Barbara Island for the water year (July 1 - June 30) (bottom).

Mouse populations can exceed 500 individuals/ha on the Channel Islands, far above mainland densities (Drost and Fellers 1991, Schwemm and Coonan 2001). Spring mouse densities were are most positively associated with winter rainfall during previous years and the previous year's spring plant growth (Schwemm and Coonan 2001). Evaluation of their population densities from 1992-2000 on SBI showed that their population densities ranged from < 10/ha to over 650/ha, with the lowest densities occurring during the spring and highest in the fall. Their populations have been shown to increase from the spring to the fall by as much as 1500% (Schwemm and Coonan 2001).

Monitoring of deer mice on SBI has been conducted on just two grids, one in coreopsis scrub and the other in grassland (Figure 4.1.7). Generally, mouse densities are higher in coreopsis habitat than in grassland (Schwemm and Coonan 2001). The coreopsis scrub provides generally better habitat than the non-native grassland, dominated by *Avena,* and their major predator, the barn owl, hunts mostly in grassland habitat (Drost and Fellers 1991). In some years, the densities of mice have been 6-fold greater in coreopsis, but their populations will increase in grassland habitat in years when their numbers are high and saturate coreopsis habitat (Schwemm and Coonan 2001). Analysis of mouse population abundance over time from 1992-2012 show mouse weights in the grassland habitat have increased since 2009, and Coonan (2012) suggest this may be an indicator of improved habitat quality, following the removal of non-native herbivores.

Because deer mice have high population densities, occur in all habitats, are the only native mammal on SBI, and are generalist foragers, they play important roles as consumers on SBI. The mice are important predators of seabird eggs, including Scripps's murrelets (*Synthliboramphus scrippsi*) eggs, and consequently have been considered one of the greatest threats to murrelet nest success (Millus et al. 2007, Schwemm and Martin 2005). But, work by Millus et al. (2007) found that large-scale removal of the mice for murrelet recovery is “not practical or desirable” because of the mouse’s endemic status and that recovery should, instead, address larger-scale impacts on land and at sea that are the primary causes for their decline. The mice also are also considered important seed predators, and their role in limiting coreopsis recovery has been of management concern (Schwemm 2014). Yet, Schwemm (2014) found that mice do not play a large role in affecting seedling recruitment of coreopsis (Schwemm 2014). Schwemm and Coonan (2001) also show the continued increase in coreopsis on SBI following the removal of non-native herbivores, and conclude that even under predation pressure from high mouse densities and, coreopsis was not regulated by mice.

<u>NRCA Team Data and Methods</u>

Vegetation Community Structure and Spatial Extent

Plant community distributions were mapped in 1941 (Dunkle 1941), 1979 (Hochberg et al. 1979), and 2010 (Rodriguez et al. 2012). We developed a cross-walk among the vegetation types identified in these maps and used GIS to identify changes over time. Others mapped the distributions of individual shrub species (Table 4.1.3) 1940 – 2013 (Dunkle 1940, 1942, 1950; Philbrick 1972, Hochberg et al 1979, Clark and Halvorson 1987, D’Antonio et al. 1992, Rodriguez et al. 2012, NPS unpublished data). We digitized and rectified these maps from reports and files, and layered them using GIS to identify changes in population extent through time.

Table 4.1.3. Species mapped on Santa Barbara Island, 1940-2013. Data from Dunkle 1940, 1942, 1950, Philbrick 1972, Hochberg et al. 1979, Clark and Halvorson 1987, D'Antonio et al. 1992, Rodriguez et al. 2012, NPS unpublished data. See text for details Vertebrate Abundance.

Common name	Latin name
Coastal sagebrush	*Artemisia californica*
Island sagebrush	*Artemisia nesiotica*
Trask's locoweed	*Astragalus traskiae*
Coyote brush	*Baccharis emoryi*
Giant coreopsis	*Leptosyne (Coreopsis) gigantea*
Buckwheat/St Catherine's lace	*Eriogonum giganteum compactum*
Boxthorn	*Lycium californicum*
Crystalline iceplant	*Mesembryanthemum crystallinum*
Coastal prickly pear	*Opuntia littoralis* (or *O. prolifera)*
Sea-blight	*Suaeda taxifolia*

The distributions of giant coreopsis and boxthorn individuals were mapped at a more fine scale several times in the past (see Figure 4.1.10 in the NRCA Team Results section below), in addition to the community-level surveys that generated the vegetation maps. The maps were made by researchers walking the island and mapping lone plants and groups of individuals on paper maps, or later, with high-resolution GPS units. Although the quality of mapping was uneven among researchers, they do show general patterns and trends over the past seven decades.

We entered and analyzed woody plant density data collected on SBI vegetation monitoring transects from 1998 to 2014, using stage-based counts of woody plants rooted in 30-by-1-meter transects placed alongside the point-line intercept monitoring transects. We collaborated with L. Starcevich and D. Esperanza of West-Inc on data analysis. Preliminary plots of adult and sapling stem counts by year and species indicated large proportions of zero counts. Trend analyses were conducted for the shrub species with adequate non-zero data for modeling. "Adequate" data is typically defined as exhibiting at least four years of non-zero observations and at least five sample locations on the island. Generalized linear models (GLM) were fit to the woody plant count data when sample size was sufficient. Since species tended to be represented differently between distinct plant communities, we fit separate models by plant community (e.g. herbaceous, scrub, riparian, woodland, etc.). Given the large proportion of zero observations for some species/community combinations, we examined zero-inflated models (Poisson, negative-binomial, and log-normal), followed by standard Poisson and negative-binomial models if the zero-inflated models did not provide a satisfactory fit. Model selection was accomplished by assessing standardized residuals, goodness-of-fit tests, and AIC. Data analysis was conducted in the R statistical software environment (R Core Team [2014], Zeileis et. al 2008). Significance was assessed at the 0.10 significance level given the low sample size for trend detection.

Vertebrate abundance

<u>Herpetofauna</u>

Island Night Lizards – Island night lizards have been sampled on SBI by tracking abundance on five cover board transects (Figure 4.1.8). Of those, Cave Canyon/Middle Canyon and Terrace Grassland transects have been sampled most consistently since 1994. To detect trend in island night lizards over time, we regressed night lizard abundance (number of night lizards detected on a transect) over time, after performing a square root transformation on the simple count data. We used SYSTAT 13.1 (Systat, IL, USA) for analysis.

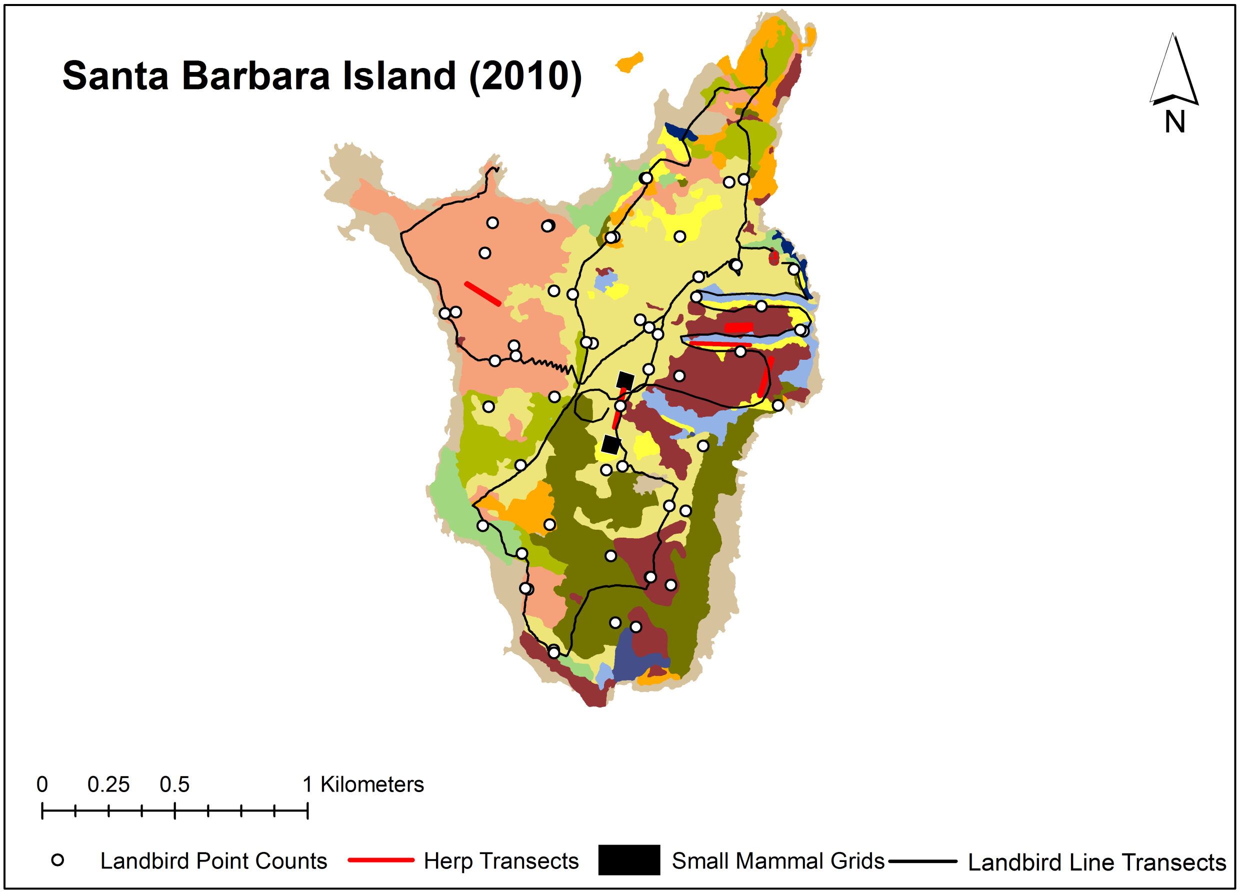


Figure 4.1.8. Location of vertebrate surveys conducted on Santa Barbara Island (2001-2013), including avian point counts (circles), herp surveys (red lines) and small mammal trapping grids (black squares). See Figure 4.1.2 legend for color scheme of vegetation types.

<u>Landbirds</u>

Three landbird species that inhabit SBI have generally different habitat preferences, making them ideal target species to investigate effects of vegetation change on landbirds. Horned larks generally prefer bare ground and very short grasses (Beason 1995), though recent studies show them to prefer grassland above all other habitats on the islands (Coonan et al. 2011b). Western meadowlarks inhabit many types of grassland (Davis and Lanyon 2008). On SBI, meadowlarks prefer grasslands exclusively (Coonan et al. 2011b). In contrast, orange-crowned warblers on the Channel Islands inhabit scrub and woodland communities such as coastal bluff and coastal sage scrub, island chaparral, pine and woodland on hill-slopes and bluffs, and in canyons and gullies (Gilbert et al. 2010). On SBI they prefer scrub communities, though there is some use of grasslands as well (Coonan et al. 2011b).

Given these habitat preferences, changes in landbird densities over time would be expected if native shrub communities were, in fact, recovering on SBI. If native shrubs such as coreopsis, California sagebrush (*Artemisia californica*), wooly sea-blite (*Sueda taxifolia*) and boxthorn were increasing in areal extent and in cover, and non-native grasses such as *Avena* spp. as well as bare ground were decreasing, one would expect an increase in orange-crowned warbler density over time, and decreases in horned larks and/or western meadowlarks. To evaluate this, trends in density are presented for each target species, for both line transect and point count data.

Landbirds were surveyed during spring on line transects and at point count stations using methods described in van Riper III et al. (1988) and Coonan et al. (2011a, 2011b, Figure 4.1.8). Line transect monitoring began in 1993, with several long (2.5 – 6.3 km) transects which traverse multiple habitat types. Monitoring at point counts was added in 2002, with a grid of 33 point count sites, each assigned to a habitat type. Avian point counts were conducted at 33 locations across SBI from 2001-2013 (Coonan et al. 2011a). At each point count location, we determined the vegetation type mapped in 1980 and in 2012. We then grouped point count locations by similar changes in vegetation type for further analysis (e.g., all point locations that were classified as Annual Grassland in 1980 and as Coastal Bluff, Coreopsis Phase in 2010 were grouped). We tabulated total number of individuals observed of each focal species at each group of point count locations.

Estimation of distance to birds observed allowed estimation of density via program Distance (version 6.0, release 2; Thomas et al. 2009). Models tested for each species included conventional distance sampling versus multiple covariate distance sampling with observer as covariate; three key-function adjustment term combinations (half-normal key with cosine adjustment, half-normal key with Hermite adjustment, and hazard-rate with simple polynomial adjustment), truncation, and grouping detection data by intervals to improve detectability curves. Models were chosen via Akaike's Information Criterion (AIC) and the ability of a model to return a probability of detection of 1.0 at a perpendicular distance of 0.

Trends over time for orange-crowned warbler (OCWA), horned lark (HOLA), and western meadowlark (WEME) were examined by regressing density on year, using SYSTAT 13.1, for both line transect and point count data. Orange-crowned warblers were expected to respond positively to shrubby habitats, while horned larks and western meadowlarks were expected to respond positively to grasslands. For comparative purposes, we also present line transect and point count densities from San Miguel and other islands for each species.

<u>NRCA Team Results</u>

Vegetation Community Structure and Spatial Extent

Vegetation maps made in 1941 (Dunkle 1950), 1979 (Hochberg et al. 1979) and 2010 (Rodriguez et al. 2012) show changes in plant community extent over many decades (Figure 4.1.9). The 1941 map was made on the basis of black-and-white aerial photo interpretation and ground surveys. In 1979, Hochberg et al. delineated vegetation polygons on a 1978 color infrared aerial photograph of the island, then conducted ground surveys to characterize the vegetation according to dominant species observed. They also sampled several point-intercept transects to better characterize species composition in the major communities. They described four variations of sea-cliff scrub (sea cliffs, coreopsis, sea-blight and iceplant), a single remnant stand of coastal sage scrub, patches of maritime cactus scrub and widespread annual grassland. In 2010, high-resolution color aerial photographs and LIDAR imagery were used to delineate vegetation polygons, and then each polygon was visited and species cover was sampled with a plotless relevé. The relevé data were classified using non-metric multidimensional scaling in PCOrd (McCune and Mefford 2011), generalized to the 14 plant alliances shown in Table 4.1.1.

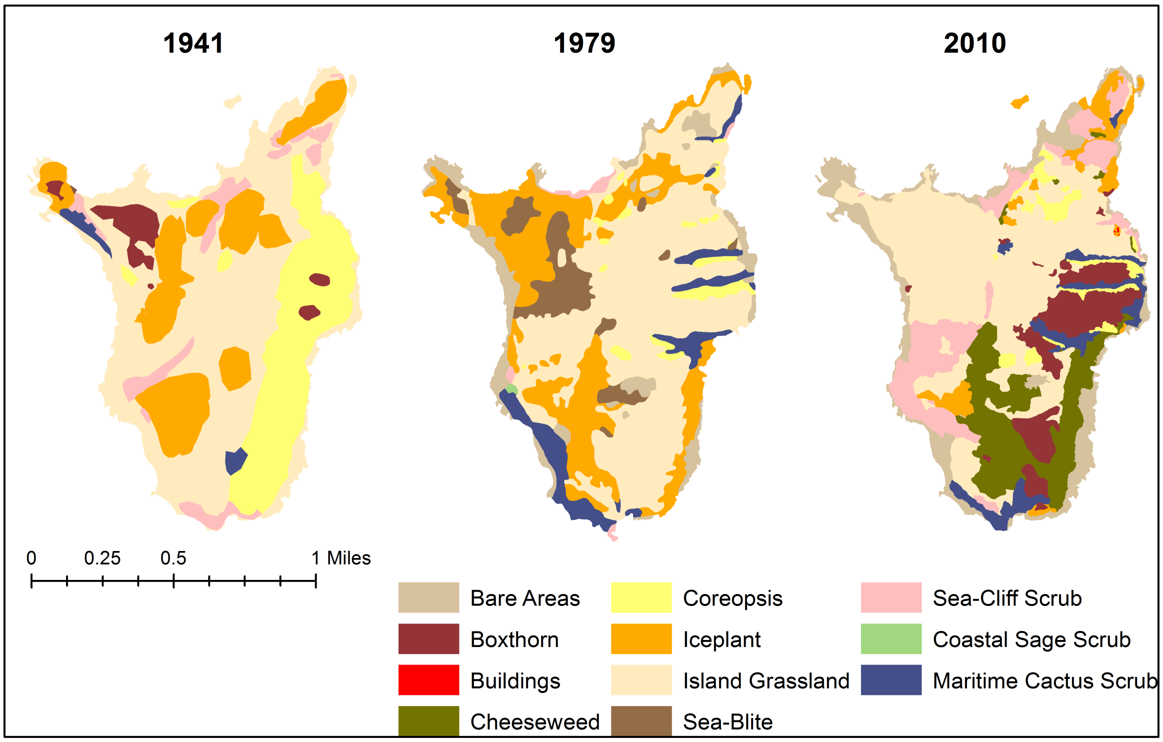


Figure 4.1.9. Estimated change in plant community extent on Santa Barbara Island, 1941, 1979, and 2010 (Dunkle 1950, Hochberg et al. 1979, Rodriguez et al. 2012).

Dunkle mapped five communities of particular interest to him, showing the general condition of the island about two decades after farming ended and immediately before rabbit introduction. By that time, annual grassland and crystalline iceplant were widespread, but giant coreopsis occupied nearly all of the eastern terrace. Boxthorn, sea-cliff scrub and cactus scrub were present in disjunct patches, occurring on slopes above Webster Point. Rabbits had been present on the island for 35 years by the time the 1979 map was produced. In addition to the communities recognized by Dunkle, the 1979 map shows sea-blight and coastal sage scrub, but no boxthorn. Hochberg et al. noted that boxthorn was "not particularly abundant", including it in maritime cactus scrub. They emphasized that all native scrub on SBI was depauperate and degraded, in need of protection from grazing and trampling. In 2010, annual grassland still occupied the greatest extent of any community on the island. The halophyte grass, foxtail, became the dominant cover on the western slopes above Webster Point where sea-blight and iceplant were mapped earlier. Transect data and personal observations (S Chaney, personal communication) indicate that foxtail, sea-blight and iceplant switch dominance in patterns that appear related to the weather, so this area of the island may be more dynamic over the short-term than appears from these static maps. Similarly, the expansion of iceplant into its 1941 footprint at Arch Point may reflect a weather-related dynamic equilibrium with grass. McEachern et al. (1997) found iceplant to be the most common seed in soil samples collected island-wide and grown in the greenhouse, as did Schwemm (2008) in her samples of soils under coreopsis stands. Crystalline iceplant seeds can persist for decades in the soil (Vivrette and Mueller 1977), germinating in response to a unique combination of disturbance and weather. It is likely that there is a substantial iceplant seedbank across much of the island, since it was described as covering nearly half of the island by Dunkle (1950) and Sumner (1953, 1959) at times in the past. Cheeseweed increased substantially by 2010. Clark and Halvorson (1988) observed cheeseweed in a few sites during vegetation surveys, and were concerned that it would increase and interfere with native plant recovery; they suggested that control of the early occurrences would be important to prevent spread. McEachern and Rugel hand-pulled cheeseweed in 1994-1995 (unpublished trip reports), but there was no further systematic effort at cheeseweed control, and cheeseweed seems to have invaded areas formerly occupied by iceplant, sea-blight and grassland. The declines in the giant coreopsis and boxthorn communities that lead to song sparrow extinction in the1950s and island night lizard endangerment in the 1970s can be seen in the vegetation community maps. Overall, SBI remains dominated by non-native vegetation, with annual grassland (*Hordeum, Avena* and *Bromus* spp.), annual iceplant, and cheeseweed making up a majority of the land cover.

It is clear that giant coreopsis has yet to recover its former extent on the eastern terraces of SBI, where Dunkle (1940) described it in nearly impenetrable thickets, although it has been spreading since 1979 (Figure 4.1.10). Boxthorn has disappeared from the western terraces and slopes near Webster Point where Dunkle mapped it in 1940, but it has been spreading on the eastern terraces and south part of the island. In the south it intermingles with cheeseweed (Figure 4.1.11).

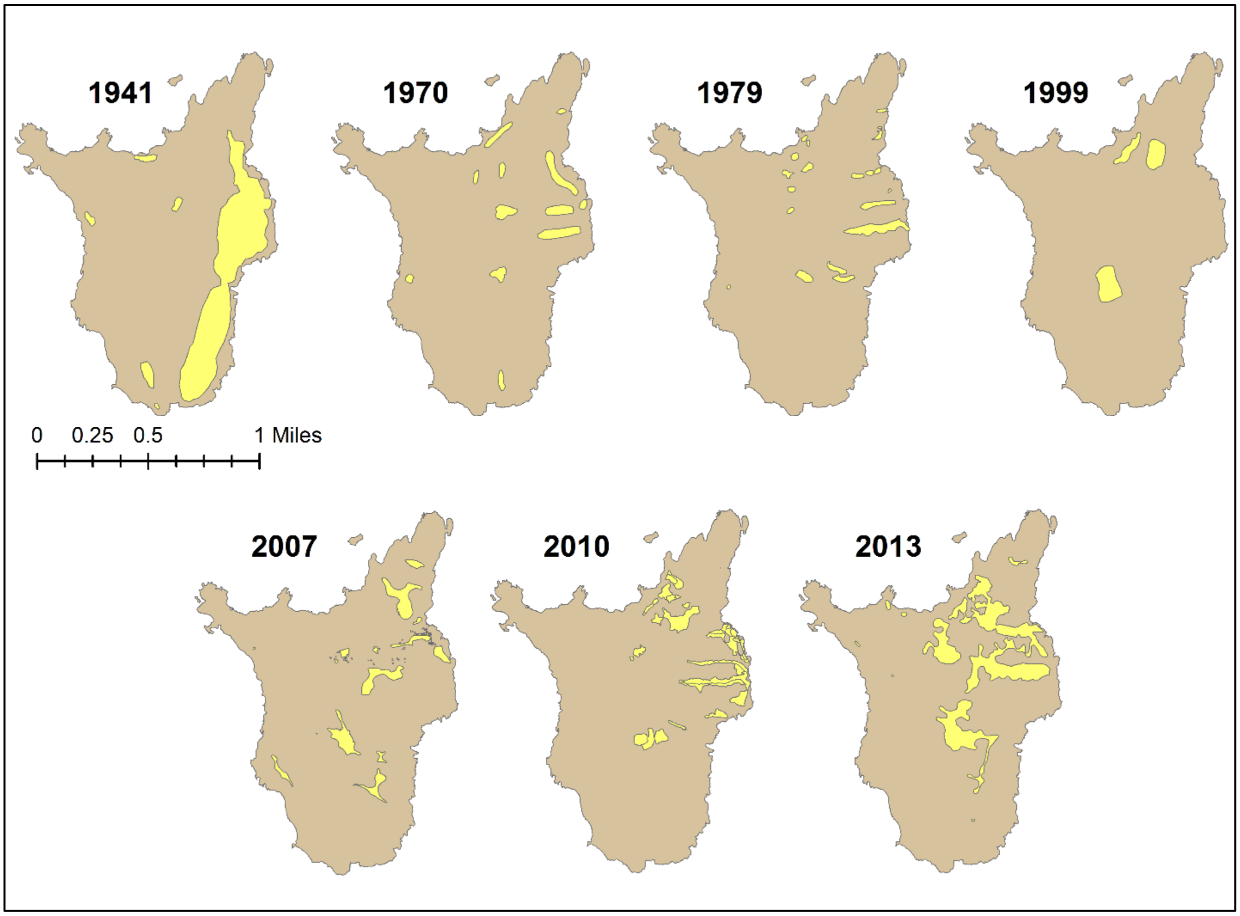


Figure 4.1.10. Distribution of giant coreopsis (*Leptosyne gigantea*) on Santa Barbara Island, 1941-2013 (Dunkle 1942, Philbrick 1972, Hochberg et al. 1979, Rodriguez et al. 2012, NPS unpublished data).

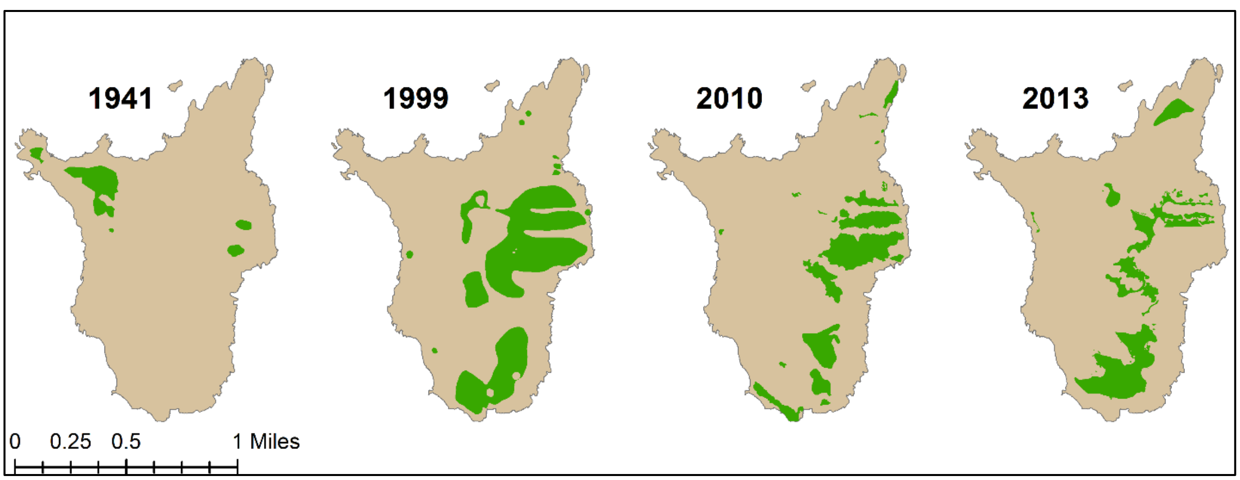


Figure 4.1.11. Distribution of boxthorn (*4.4.9*) on Santa Barbara Island, 1941-2013 (Dunkle 1942, Rodriguez et al. 2012, NPS unpublished data).

Table 4.1.4 shows changes in hectares occupied by several plants of interest over time. For example, giant coreopsis was widespread in the 1940s, occupying nearly 60 ha, declining to less than 10 ha by the 1970s. It occupied about 30 ha in 2013, but the distribution is highly fragmented in comparison to its former extent. Boxthorn has expanded and contracted with time, occupying about 9 ha in 1941 and 26 to 30 ha in recent years. Giant buckwheat appeared to have expanded in the 1990s, but more recently occupies a similar area as in 1941. This plant provides important cover and nesting habitat for seabirds, targeted for restoration plantings on the island recently and in the next few years (Mazurkiewcz unpublished data). Crystalline iceplant occupies nearly the same amount of area in 2013 as in 1941, although it had nearly doubled during the time rabbits were present on the island.

Table 4.1.4. Estimated area occupied by native shrubs of Santa Barbara Island, 1940 – 2013. Data from Dunkle 1940; Philbrick 1972; Hochberg et al. 1979; Clark et al. 1990; D'Antonio 1992; Rodriguez et al. 2012; NPS unpublished data.

Year	*Artemisia nesiotica*	*Leptosyne (Coreopsis) gigantea*	*Eriogonum giganteum*	*Lycium californicum*	*Mesembryanthemum crystallinum*	*Opuntia spp.*	*Suaeda tenuiflora*
1941	–	58	7	9	36	3	0
1970	–	10	–	–	–	–	–
1979	–	8	3	–	64	17	19
1990	–	–	26	–	–	–	–
1992	–	–	–	–	68	–	–
1999	0.5	7	12	56	–	0	46
2007	–	13	–	–	–	–	–
2012	0	14	8	26	32	12	34
2013	1	30	–	30	–	–	–

The endangered Trask's live-forever has been increasing in numbers since rabbit eradication (Clark 1989), however, the island's only ESA listed plant continues to be threatened by damage from nesting California brown pelicans (Chaney unpublished, USFWS 2012).

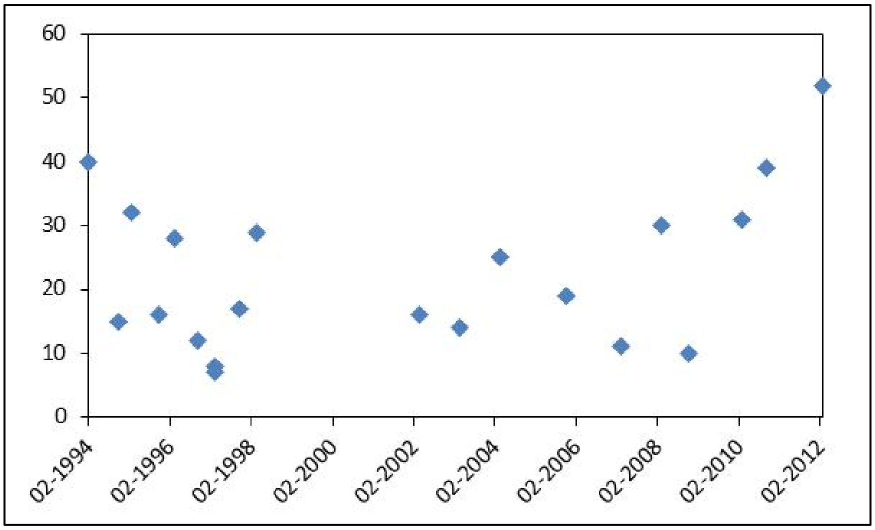
Recent shrub increase is patchy, generally confined to areas not plowed or not invaded by crystalline iceplant. A new project investigating ways to encourage native shrub spread into those areas will begin in 2015, as part of the seabird habitat restoration program (Mazurkiewicz et al. 2014). In general, the land cover of SBI is still predominantly non-native annual vegetation with fluctuations in species composition and cover driven largely by fluctuations in available moisture.

Four species sampled for woody plant density on Santa Barbara Island (SBI) were found in sufficient sample sizes to permit trend analysis, all in communities dominated by soft scrub vegetation. Both giant buckwheat and giant coreopsis decreased in abundance 1998 to 2014, but the decrease was not statistically significant. Both boxthorn and sea-blight decreased in abundance 1998 to 2014, and these trends were significant at the 0.10 significance level, the level of confidence chosen for this analysis given the low sample size for trend detection.

Vertebrate Abundance

Herpetofauna

Island Night Lizards **-** A graph of count data over time (Figure 4.1.12) suggests some recent (2010-2012) modest increase in the number of night lizards on both transects, though there is considerable seasonal and interannual variation. A regression of number on date, after a square-root transformation of lizard numbers, was non-significant for both transects. The regression for the Terrace Grassland transect was nearly significant, although still a very weak regression ($r^2 = 0.114$, $p = 0.063$).



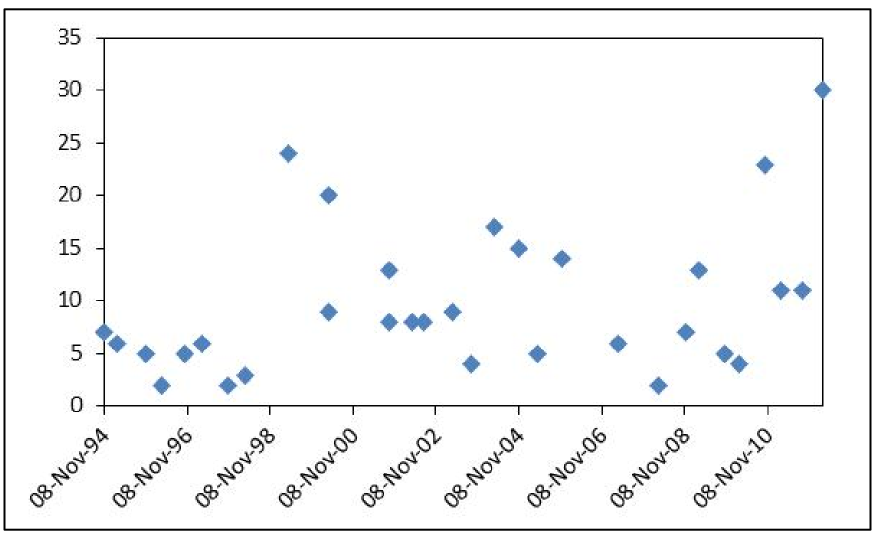


Figure 4.1.12. Number of island night lizards (*Xantusia riversiana*) counted on Cave-Middle (top) and Terrace Grassland cover board transects (bottom), Santa Barbara Island.

Landbirds

There were few discernible trends in target species on SBI, on line transects or at point count sites (Table 4.1.5, Figure 4.1.13). Orange-crowned warbler densities did not increase over time on either line transects or at point counts, consistent with other indications that significant shrub recovery has not occurred on the island in the past 21 years. Horned larks did not decrease, suggesting little appreciable change in the amount of bare ground and short-grass vegetation. In fact, point count data show an approximately 60% increase in horned larks since 2001, though the regression was not quite significant ($p = 0.082$), due to high interannual variability.

Table 4.1.5. Coefficient (slope), strength of regression (r^2) and p-value for regression of landbird target species density on year, for both line transect and point count data. SBI = Santa Barbara Island; SMI = San Miguel Island.

Data	Survey Method	SBI Slope	SBI r^2	SBI p	SMI Slope	SMI r^2	SMI p
Line Transect	Horned lark	0.002	0.00	0.958	-0.018	0.00	0.236
	Western meadowlark	-0.050	0.71	0.000*	-0.006	0.01	0.290
	Orange-crowned warbler	-0.001	0.00	0.926	0.055	0.26	0.190*
Point Counts	Horned lark	0.250	0.18	0.082	0.111	0.35	0.024*
	Western meadowlark	-0.038	0.00	0.420	0.080	0.38	0.019*
	Orange-crowned warbler	-0.039	0.00	0.629	0.180	0.00	0.423

* Significant regression.

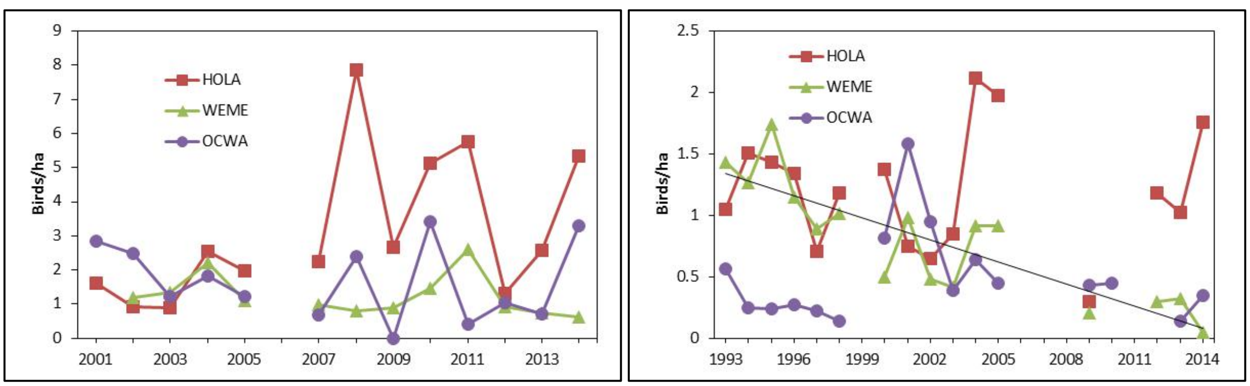


Figure 4.1.13. Annual densities for horned larks (HOLA), western meadowlarks (WEME) and orange-crowned warblers (OCWA) on Santa Barbara Island on line transects (left) and point counts (right). Trend line denotes a significant regression for western meadowlarks.

The most curious result was the steady, considerable decline in western meadowlarks on SBI line transects. Meadowlarks declined approximately 80% in 21 years, or almost 4% annually. Meadowlarks did not decline on other islands, and in fact, increased on San Miguel and on Santa Rosa Islands (coeff. = 0.076, $r^2 = 0.514$, $p = 0.018$), and there was no decline in meadowlark numbers observed in point count surveys on SBI from 2002-2014. Reasons for the decline on SBI transects are unclear, though it may be due to a decline in habitat quality if taller grasses declined due to conversion to shrubland or to bare ground/shorter grasses.

We did not discover any obvious trends in focal bird observations over the 12 years of data available (Figure 4.1.13). Potential impacts of vegetation changes on bird populations may not have been observed, however, if much of the observed transitions in vegetation between 1980 and 2010 had already occurred from 1980-2000, before the avian point counts commenced (Table 4.1.6).

Table 4.1.6. Focal bird species observations (N) at 33 point locations across Santa Barbara Island, 2001-2013. Locations were pooled based on vegetation community in 1980 and 2010. OCWA = orange-crowned warbler; HOLA = horned lark; WEME = western meadowlark.

Species	Vegetation (1980)	Vegetation (2010)	Max. annual count	Average annual count
OCWA	Coastal bluff, iceplant phase	Coastal bluff, sea-blite phase	2	0.3
OCWA	Coastal bluff, iceplant phase	Coastal bluff, iceplant phase	1	0.1
OCWA	Island grassland	Coastal bluff, coreopsis phase	2	0.3
OCWA	Island grassland	Island grassland	6	1.6
OCWA	Island grassland	Maritime cactus scrub	3	1.4
OCWA	Island grassland	Boxthorn scrub	14	4.2
OCWA	Island grassland	Coastal bluff, sea-blite phase	1	0.2
OCWA	Island grassland	Coastal bluff, iceplant phase	4	0.3
OCWA	Coastal bluff, coreopsis phase	Island grassland	1	0.1
OCWA	Coastal bluff, coreopsis phase	Boxthorn scrub	4	1.4
OCWA	Coastal bluff, coreopsis phase	Cheeseweed	3	0.4
OCWA	Coastal bluff, sea-blite phase	Cheeseweed	3	0.4
OCWA	Coastal bluff, sea-blite phase	Coastal bluff, sea-blite phase	1	0.1
OCWA	Bare areas	Maritime cactus scrub	7	1.1
HOLA	Coastal bluff, iceplant phase	Coastal bluff, sea-blite phase	15	4.7
HOLA	Coastal bluff, iceplant phase	Coastal bluff, iceplant phase	10	2.3
HOLA	Coastal bluff, iceplant phase	Island grassland	13	4.1
HOLA	Island grassland	Coastal bluff, coreopsis phase	6	2.1
HOLA	Island grassland	Island grassland	40	14.7
HOLA	Island grassland	Maritime cactus scrub	2	0.4
HOLA	Island grassland	Boxthorn scrub	29	11.8
HOLA	Island grassland	Coastal bluff, dea-cliff phase	30	13.5
HOLA	Island grassland	Coastal bluff, iceplant phase	4	0.9
HOLA	Island grassland	Cheeseweed	16	6.4
HOLA	Coastal bluff, coreopsis phase	Island grassland	10	2.1
HOLA	Coastal bluff, coreopsis phase	Boxthorn scrub	1	0.1
HOLA	Coastal bluff, coreopsis phase	Cheeseweed	5	0.4
HOLA	Coastal bluff, coreopsis phase	Cheeseweed	2	0.2
HOLA	Coastal bluff, sea-blite phase	Coastal bluff, sea-blite phase	1	0.1
HOLA	Bare areas	Maritime cactus scrub	3	0.6
HOLA	Maritime cactus scrub	Coastal bluff, sea-blite phase	15	6.1
WEME	Coastal bluff, iceplant phase	Coastal bluff, sea-blite phase	5	2.0
WEME	Coastal bluff, iceplant phase	Coastal bluff, iceplant phase	2	0.3
WEME	Coastal bluff, iceplant phase	Island grassland	2	0.4

Table 4.1.6 (continued). Focal bird species observations (N) at 33 point locations across Santa Barbara Island, 2001-2013. Locations were pooled based on vegetation community in 1980 and 2010. OCWA = orange-crowned warbler; HOLA = horned lark; WEME = western meadowlark.

Species	Vegetation (1980)	Vegetation (2010)	Max. annual count	Average annual count
WEME	Island grassland	Coastal bluff, coreopsis phase	6	2.7
WEME	Island grassland	Island grassland	94	19.3
WEME	Island grassland	Maritime cactus scrub	22	4.9
WEME	Island grassland	Boxthorn scrub	30	10.1
WEME	Island grassland	Coastal bluff, sea-cliff phase	7	1.8
WEME	Island grassland	Coastal bluff, iceplant phase	4	0.8
WEME	Island grassland	Cheeseweed	3	0.5
WEME	Coastal bluff, coreopsis phase	Island grassland	4	1.9
WEME	Coastal bluff, coreopsis phase	Boxthorn scrub	5	1.3
WEME	Coastal bluff, coreopsis phase	Cheeseweed	3	0.6
WEME	Coastal bluff, coreopsis phase	Cheeseweed	4	1.3
WEME	Coastal bluff, sea-blite phase	Coastal bluff, sea-blite phase	2	0.3
WEME	Bare areas	Maritime cactus scrub	2	0.4
WEME	Maritime cactus scrub	Coastal bluff, sea-blite phase	3	0.8

Threats and Stressor Factors

Vegetation

Shrub recovery is apparently limited by competition from annual grasses; shrubs are not establishing readily in places with dense grass and thatch. Aridity appears to be a factor also limiting shrub recruitment in more open areas – colonization is apparently most successful in low-lying terrain near canyons, and in localized depressions where soils collect and retain moisture longest (Corry 2006). There are only a few Emory's baccharis (*Baccharis emoryi*) individuals – propagule pressure therefore may limit its recruitment. Trask's live-forever recovery is hampered by nesting pelicans which destroy plants. Climate warming and increasing drought could pose a long-term threat to recovery, as increasing aridity could compound historical habitat impacts on the island and slow recovery of native scrub communities.

Vertebrates

Climate change is probably the primary threat today facing native terrestrial vertebrates on SBI, as many of the major threats that were facing island vertebrates have been removed (e.g., non-native predators and herbivores).

Data Gaps

Vegetation

Recent analyses of the Inventory and Monitoring Program vegetation transect data indicated that the sample size and design was insufficient to infer change island-wide. The park is transitioning to a more extensive transect monitoring program to fill this gap. Analyses of changes in plant community distributions 1979 to 2010, and individual species 1940 to 2013, presented here fill an additional gap in the long-term record of change in vegetation cover. This monitoring program should be continued as it shows changes in plant cover related to climate; it will become even more valuable with time. Climate change forms the context for continued recovery, both passive and through the ongoing active shrub planting effort on SBI. Particular information is still needed to help that recovery program:

- Seed set and germination rates of native shrubs for use in restoration plantings
- Effect of annual grass on recruitment in grasslands
- Methods for shrub establishment in upland grasslands on SBI
- Techniques for water harvest and minimizing water use in recovery operations
- Efficient monitoring for early detection of invasive plant occurrences
- Status monitoring of endangered Trask's live-forever, and development of methods for its protection from nesting pelicans.

Vertebrates

The park's long-term ecological monitoring program currently monitors all the island's terrestrial vertebrates annually, and thus will be able to track potential and responses in their populations due to climate change. There are no known existing gaps in knowledge pertaining to management of terrestrial vertebrates on SBI.

Overall Condition

Vegetation Assessment

SBI is still dominated by exotic annual vegetation more than 30 years after rabbits were removed, in what appears to be a new stable state for the island. Vegetation cover and composition fluctuate with the precipitation rather than trending toward a more native shrubby condition over most of the island. Upland native shrub recovery has not occurred naturally, and is insufficient to provide habitat for the nesting seabirds that used the island before ranching. However, one upland shrub with apparently good recovery potential is the St. Catherine's buckwheat/lace (*Eriogonum giganteum*), recruiting from seed and showing an upward trend where it occurs. Although it is colonizing in spots, giant coreopsis has not recovered the unfragmented stands that formerly blanketed the eastern terraces providing habitat for songbirds and native understory herbs. Boxthorn, habitat for the island night lizard, has spread since ranching, but has regained only a portion of its former extent. Plant species particularly at risk are the endangered Trask's live-forever, threatened by nesting California brown pelicans, the endemic island sagebrush (*Artemisia nesiotica*), and the rare *Baccharis emoryi*. Factors limiting recovery appear to be aridity, the lack of native soil seed banks, widespread crystalline iceplant seed bank, and plowing of the uplands that destroyed soil structure and native seed banks. The potential for natural recovery of SBI vegetation to a condition like pre-ranching is low. Island vegetation needs active recovery to move it out of its current annual-dominated state towards a landscape dominated by native scrub.

Vertebrate Assessment

Due to wide-spread overgrazing and introduction of non-native herbivores and predators, many island vertebrates on SBI are likely at lower population levels than might occur naturally, i.e., in the absence of human impacts. An extreme example of this is the endemic song sparrow that went extinct (last seen in 1958). Although these threats have been largely removed today, and vertebrate populations on the island are mostly stable, they may be impacted by climate change in the future. No doubt the lagging recovery of native scrub limits the availability of high quality habitat for some vertebrates on the island. Currently, island night lizards exist at high densities in suitable habitat. Deer mice numbers wax and wane in accordance with well-studied population cycles, and fare well in the several habitat types on the island, although they prefer native scrub habitat. Some landbird species, such as orange-crowned warblers, may not expand if native shrub recovery continues to lag. However, the island population is not threatened by lack of shrub recovery.

Sources of Expertise

Vegetation

- Kathryn McEachern
- U.S. Geological Survey, Western Ecological Research Center, Channel Islands Field Station

Vertebrates

- Tim Coonan
- National Park Service

4.1.3. Literature Cited

Austin, G. 1996. Terrestrial vertebrate monitoring, Channel Islands National Park, 1995 annual report. Technical Report 96-04. National Park Service, Channel Islands National Park, Ventura, California. 18 pp.

Austin, G. 1998. Terrestrial vertebrate monitoring, Channel Islands National Park, 1996 annual report. Unpublished report on file at park headquarters, Channel Islands National park. 22 pp.

Beason, R. C. 1995. Horned Lark (*Eremophila alpestris*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Available at the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/195 (accessed 3 March 2014).

Bond, R. M. 1940. Trip report on Channel Islands National Monument. Unpublished Report, Channel Islands National Park, Ventura, California. 7 pp.

Britton, J. R. 1897. Our Summer Isles. Land of Sunshine 7:192-197.

Brooks, W. H. 1980. Soil characteristics and associated vegetation types in the semiarid environment of Santa Barbara Island, California. Association for Arid Lands Studies. Albuquerque, New Mexico. 19 pp.

Clark, R. A. 1989. The ecological status and distribution of the endangered succulent, *Dudleya traskiae*, on Santa Barbara Island, California. Master's thesis. University of California, Santa Barbara, California.

Clark, R. A., W. L. Halvorson, A. Sado, and K. C. Danielson. 1990. Plant communities of Santa Rosa Island, Channel Islands National Park. Cooperative Park Studies Unit, Technical Report No. 42. University of California Davis, California. 88 pp.

Clark, R. A., W. L. Halvorson. 1987. The recovery of the Santa Barbara Island live-forever. Fremontia 14:3–6.

Clark, R. A., W. L. Halvorson. 1988. Alien vascular plant taxa on San Miguel and Santa Barbara Islands: A progress report. Unpublished Report, Channel Islands National Park, Ventura, California. 15 pp.

Clark, R. A., W. L. Halvorson. 1990. Endangered and rare plants of Santa Barbara Island, Channel Islands National Park. Technical Report No. 37, Cooperative National Park Resources Studies Unit, Davis, California. 69 pp.

Coonan, T. J. 2013. 2012 deer mouse monitoring annual report, Channel Islands National Park. Natural Resources Data Series NPS/MEDN/NRDS – 2013/571. National Park Service, Fort Collins, Colorado.

Coonan, T. J., L. C. Dye, and S. G. Fancy. 2011a. Landbird monitoring protocol for Channel Islands National Park – Version 2.0. Natural Resources Technical Report NPS/CINP/NRTR-2011/480. National Park Service, Fort Collins, Colorado. 42 pp.

Coonan, T. J., R. C. Klinger, and L. C. Dye. 2011b. Trends in landbird abundance at Channel Islands National Park, 1993-2009. Natural Resources Technical Report NPS/CINP/NRTR-2011/507. National Park Service, Fort Collins, Colorado. 86 pp.

Corry, P. M. 2006. Vegetation dynamics following grazing cessation on the Channel Islands, California. PhD Dissertation. University of North Carolina at Chapel Hill, Chapel Hill. North Carolina. 293 pp.

Daily, M. ed. 1993. Santa Barbara Island. Santa Cruz Island Foundation, Santa Barbara, California. 112 pp.

Danielsen, K., W. L. Halvorson. 1989. Monitoring Stipa pulchra on Santa Barbara Island. Unpublished Report, Channel Islands National Park, Ventura, California. 29 pp.

D'Antonio, C., W. L. Halvorson, and D. B. Fenn. 1992. Restoration of denuded areas and iceplant areas of Santa Barbara Island, Channel Islands National Park. Technical Report NPS/WRUC/NRTR-92/46. Cooperative National Park Resources Study Unit, Davis, California. 90 pp.

Davis, S. K., and W. E. Lanyon. 2008. Western Meadowlark (*Sturnella neglecta*), The Birds of North America Online (A. Poole, ed.). Ithaca: Cornell Lab of Ornithology; Available at the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/104 (accessed 7 March 2014).

Drost, C. A. 1983. Flora of Santa Barbara Island: Memorandum. Unpublished Report, Channel Islands National Park, Ventura, California. 3 pp.

Drost, C. A. 1989. Predation and population cycles on a southern California island. M.S. thesis, University of California, Davis. 109 pp.

Drost, C. A., and G. M. Fellers. 1991. Density cycles in an island population of deer mice, *Peromyscus maniculatus* (Wagner). Oikos 60: 351-364.

Dunkle, M. B. 1940. Los Angeles museum Channel Islands biological survey Santa Barbara Island report, Botany. Unpublished Report, Los Angeles Museum, Los Angeles, California. 13 pp.

Dunkle, M. B. 1942. Flora of the Channel Islands National Monument. Contributions from the Los Angeles museum Channel Islands biological survey No. 27 in Bulletin of the Southern California Academy of Sciences 41:125–137.

Dunkle, M. B. 1950. Plant ecology of the Channel Islands of California. Allan Hancock Pacific Expeditions 13:268–294.

Fellers, G. M. and C. A. Drost. 1991. Ecology of the island night lizard, *Xantusia riversiana*, on Santa Barbara Island, California. Herpetological Monographs 5: 28-78.

Gilbert, W. M., M. K. Sogge, and C. Van Riper III. 2010. Orange-crowned warbler (*Oreothlypis celata*), The Birds of North America Online (A. Poole, ed.). Ithaca: Cornell Lab of Ornithology; Available at the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/101

Halvorson, W. L., J. Belnap and A. K. McEachern. 1997. San Nicolas Island restoration and monitoring. Final Report to Pt. Mugu Naval Air Weapons Station. U.S. Geological Survey Cooperative National Park Resources Study Unit, Tucson, Arizona. 437 pp.

Halvorson, W. L., R. A. Clark, and C. R. Soiseth. 1992. Rare plants of Anacapa, Santa Barbara, and San Miguel in Channel Islands National Park. Technical Report NPS/WRUC/NRTR-92/47. Cooperative National Park Resources Study Unit, Davis, California. 134 pp.

Handley, T., D. Rodriguez, J. Yee, A. K. McEachern. 2013. Draft: Exploring long-term trends in vegetation of Santa Barbara and Santa Barbara Islands, Channel Islands National Park. Unpublished Technical Report, U.S. Geological Survey, WERC, Channel Islands Field Station, Ventura, California. 275 pp.

Hochberg, M. C., S. A. Junak, R. N. Philbrick, S. Timbrook. 1979. Chapter V, Botany. In D. M. Power ed. Natural Resources Study of the Channel Islands National Monument, California. Santa Barbara Museum of Natural History, Santa Barbara, California. 91 pp.

Howell, A. B. 1917. Birds of the islands off the coast of Southern California. Cooper Ornithological Club, Pacific Coast Avifauna 12:127.

Johnson, D. L. 1979. Geology, soils, and erosion. In Natural Resources Study of the Channel Islands National Monument, California, edited by D. M. Power. Prepared for the National Park Service by the Santa Barbara Museum of Natural History. Santa Barbara, CA.

Johnson, L., and D. Rodriguez. 2001. Terrestrial vegetation monitoring, Channel Islands National Park, 1996–2000, Technical Report 01-06. Report on file, Channel Islands National Park, Ventura, CA, 279 pp.

Junak, S., R. Philbrick, and C. Drost. 1993. A revised flora of Santa Barbara Island. Santa Barbara Botanic Garden, Santa Barbara, California.

Mazurkiewicz, D. 2014. Santa Barbara Islands restoration project improvement proposal to U.S. Fish and Wildlife Service, National Fish and Wildlife Foundation. Unpublished Proposal.

McCune, B. and M. J. Mefford. 2011. PC-ORD. Multivariate Analysis of Ecological Data. Version 6. MjM Software, Gleneden Beach, Oregon, U.S.A.

McEachern, A. K, T. Atwater, P. W. Collins, K. Faulkner and D. V. Richards. In press. Managed island ecosystems. Chapter 34 in Mooney, H. and Zavaleta, E., editors. Ecosystems of California. UC Press, University of California-Davis, Davis, CA.

McEachern, A. K. 2001. Vegetation monitoring program review for Channel Islands National Park. Unpublished Report, U.S. Geological Survey, Biological Resources Division, Western Ecological Research Station, Ventura, CA.

McEachern, A. K., D. Wilken, and K. A. Chess. 1997. Inventory and monitoring of California Islands Candidate Plant Taxa. U. S. Geological Survey Open File Report 00-73. USGS-Western Ecological Research Center, Sacramento, CA. 46 pp.

Millus, S. A., P. Stapp, and P. Martin. 2007. Experimental control of a native predator may improve breeding success of a threatened seabird in the California Channel Islands. Biological Conservation 138:484-492.

National Park Service (NPS). 2005. Mediterranean Coast Network - Vital Signs Monitoring Plan. Natural Resources Technical Report NPS/MEDN/NRTR, National Park Service, Thousand Oaks, California.

National Park Service (NPS). 2013. Channel Islands National Park Draft General Management Plan/Wilderness Study/Environmental Impact Statement. Ventura, California.

Philbrick, R. N. 1972. The plants of Santa Barbara Island, California. Madrono 21(2):329–393.

Power, D. M. 1980. ed. Natural resources study of the Channel Islands National Monument, California. Santa Barbara Museum of Natural History, Santa Barbara, California. 91 pp.

Rodriguez, D., T. Sajar, T. Handley and A. K. McEachern. 2012. Draft Santa Barbara Island vegetation mapping project. Technical Report to Channel Islands, National Park. 84 pp.

Salas, D. E. 1990. The population dynamics of *Coreopsis gigantea* on Santa Barbara Island, Channel Islands National Park. M.S. thesis, Northern Arizona University, Flagstaff. 112 pp.

Scammon, C. M. 1874. The marine mammals of the North-western Coast of North America: Together with an account of the American whale-fishery. Dover.

Schwemm, C. 1995. Terrestrial vertebrate monitoring, Channel Islands National park, 1993 annual report. Technical Report CINP 94-02. National Park Service, Channel Islands National Park, Ventura, California. 44 pp.

Schwemm, C. 1996. Terrestrial vertebrate monitoring, Channel Islands National park, 1994 annual report. Technical Report 96-03. National Park Service, Channel Islands National Park, Ventura, California. 44 pp.

Schwemm, C. A. 2008. Establishment limitations and population recovery of giant Coreopsis (*Coreopsis gigantea*) on the California Channel Islands. PhD Dissertation. University of California at Santa Barbara, Santa Barbara, California. 163 pp.

Schwemm, C.A., 2014. Importance of early life stage limitations on recovering populations of *Leptosyne gigantea*, San Miguel Island, California. Monographs of the Western North American Naturalist, 7, pp.489-499.

Schwemm, C. A. and T. J. Coonan. 2001. Status and ecology of deer mice (*Peromyscus maniculatus* subsp.) on Anacapa, Santa Barbara and San Miguel Islands, California; summery of monitoring, 1992-2000. Technical report 01-02. National Park Service, Channel Islands National Park.

Schwemm, C. A. and P. L. Martin. 2005. Response of nest success of Xantus's murrelets (*Synthliboramphus hypoleucus*) to native predator abundance, Santa Barbara Island, California. In Garcelon, D. K., Schwemm, C. A. (eds.) Proceedings of the Sixth California Island Symposium. Ventura, California, pp. 373–384.

Sumner, E. L. Jr. 1953. The 1953 Channel Islands National Monument inspection – Story in pictures, with summary and recommendations. Unpublished Report, Channel Islands National Park, Ventura, California. 10 pp.

Sumner, E. L. Jr. 1958. The rabbits of Santa Barbara Island – A progress report and summary. Unpublished Report, Channel Islands National Park, Ventura, California. 21 pp.

Sumner, E. L. Jr. 1959. The battle for Santa Barbara! Outdoor California. 20(2):1–7.

Sumner, E. L. Jr., R. M. Bond. 1939. An investigation of Santa Barbara, Anacapa, and San Miguel Islands, California. Unpublished Report, Channel Islands National Park, Ventura, California. 73 pp.

Thomas, L., S.T. Buckland, E.a. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J.R.B. Bishop, T.A. Marques, and K.P. Burnam. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47: 5-14. DOI: 10.1111/j.1365-2664.2009.01737.x.

United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS). 2007. Soil survey of Channel Islands national Park, California. Available at: http://soils.usda.gov/survey/printed_surveys/ (accessed 8 January 2014).

United States Fish and Wildlife Service (USFWS). 2012. Dudleya traskiae (Santa Barbara Island liveforever) 5 year review: Summary and evaluation. U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office Ventura, California. 25 pp.

Van Riper, C. III, M. K. Sogge, and C. Drost. 1988. Land bird monitoring handbook, Channel Islands National Park, California. National Park Service, Ventura, California.

Vivrette, N. J. and C. H. Muller. 1977. Mechanism of invasion and dominance of coastal grassland by *Mesembryanthemum crystallinum*. Ecological Monographs. 47:301-318.

Western Regional Climate Center, Reno, Nevada. Available at: http://www.wrcc.dri.edu/channel_isl/ (accessed 2 December 2014).

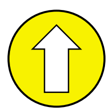
Zeileis, A., T. Hothorn, and K. Hornic. 2008. Model-Based Recursive Partitioning. Journal of Computational and Graphical Statistics, 17(2):492-514.

Section 4.2. Anacapa Island

Arch Rock and *The Californian*. NPS photo.

4.2.1. General overview of Anacapa Island

Condition = Moderate



Trend = Improving

Physical Setting

Anacapa Island (AI) is the easternmost of the northern islands, situated in warmer waters carried north by the California Counter-current. It consists of three islets (East, Middle, and West Anacapa Islands; Figure 4.2.1) of volcanic rocks overlain by sedimentary deposits, constituting a total area of 2.9 km^2 (1.1 mi^2). AI is 19 km (12 mi) from the mainland, and only 8 km (5 mi) from the east end of Santa Cruz Island (SCI); joined with the other northern islands during lowered sea levels of the Pleistocene. Vertical cliffs surround the island, except for a lowland at the eastern end of Middle Anacapa Island (MAI). The islet chain rises from nearly sea level there to 936 m (3070.9 ft) atop West Anacapa Island (WAI). Several canyons cut through the steep slopes of WAI, creating mesic conditions unusual on the other islets. AI has a Mediterranean climate characterized by wet winters and dry summer-fall periods that are ameliorated somewhat by the island's small size in a maritime setting. Rainfall averaged 20.77 cm (8.18 in) measured at the light station on the island 2004 to 2014.

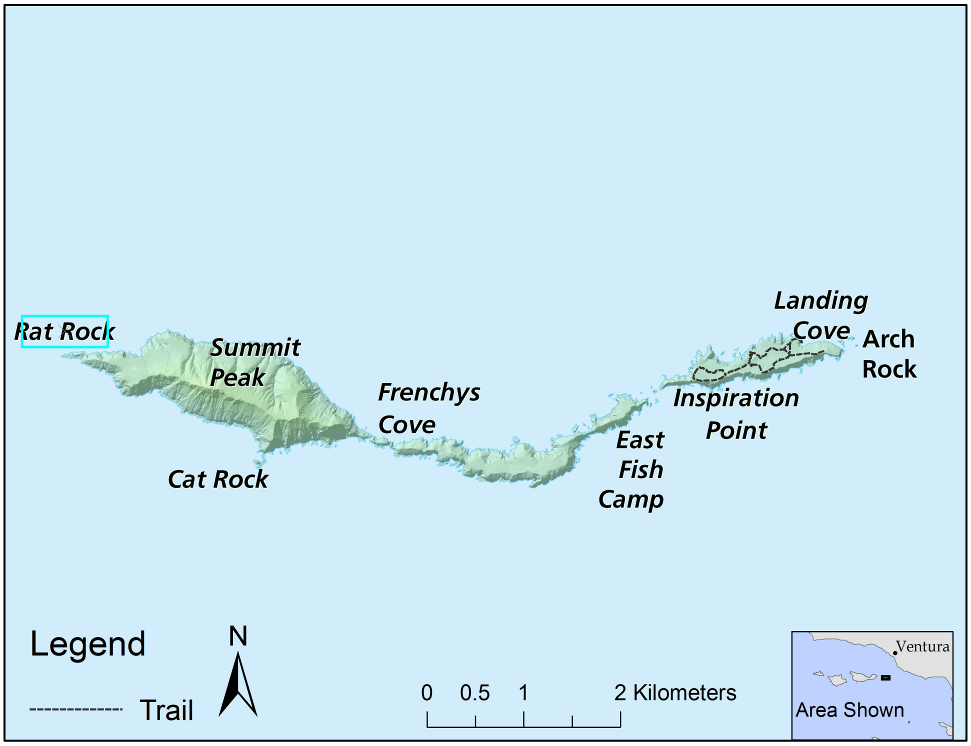


Figure 4.2.1. Anacapa Island locations, roads, and trails with hillshade (Map by R. Rudolph).

Natural Resources

Terrestrial Flora and Plant Communities

About 265 plant species have been documented on Anacapa, of which 72 percent are natives. Middle and WAI support more native species than East Anacapa Island (EAI) because they have greater topographic variation and were not as extensively developed. The two western islets are rich in native perennial bunchgrasses and have extensive stands of scrub dominated by giant coreopsis (*Leptosyne gigantea*) and island live forever (*Dudleya caespitosa*; Figure 4.2.2). A few deep, moist canyons on north-facing slopes of WAI contain small stands of oak and remnants of island chaparral. All three islets have sea cliff scrub on their northern slopes and coastal sage scrub or cactus scrub on their southern slopes. Mixed annual and perennial grasslands constitute slightly less than half of the land cover on EAI, but are less extensive on the other two islets. Large areas of EAI are also covered by non-native perennial iceplant, primarily red-flowered iceplant (*Malephora crocea*). Iceplant is currently very limited in extent on the other two islets. Several of the plant communities are shown in Figure 4.2.3.

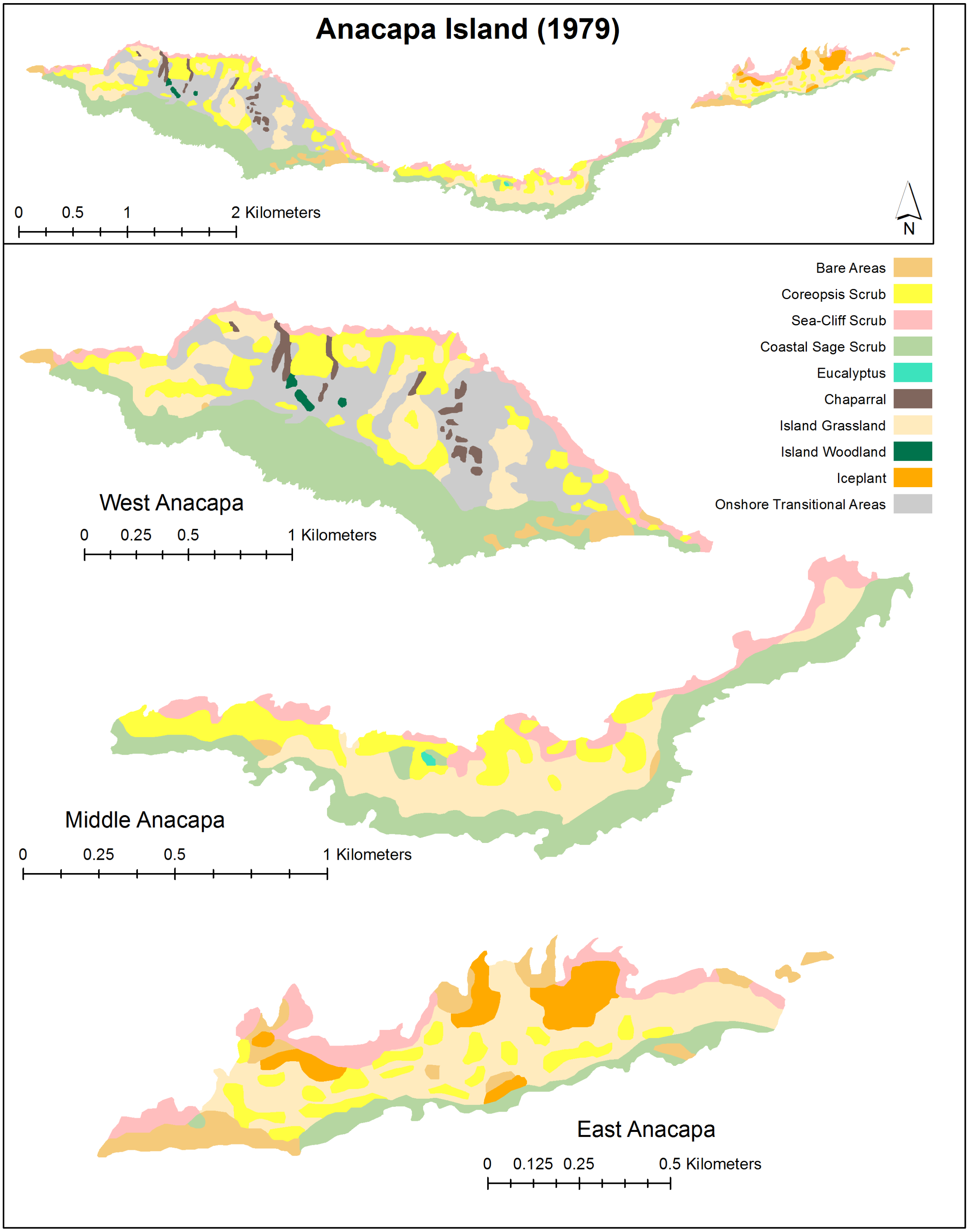


Figure 4.2.2. Plant associations of Anacapa Island (Hochberg et al. 1979).

Figure 4.2.3. Photos of annual grassland on Middle Anacapa Island (top left), coastal sage scrub on West Anacapa Island (top right), dormant-season coreopsis (*Leptosyne gigantea*) scrub with red-flowered iceplant (*Malephora crocea*) in foreground on East Anacapa Island in 2009 (bottom left), and sea cliff scrub looking west from East Anacapa Island in 2013 (bottom right) (NPS unpublished data).

Native Animal Species

The island supports a number of endemics, including one snail species, 18 arthropod species, one salamander subspecies, and one deer mouse subspecies. Seven landbird taxa also are recognized as endemic subspecies, occurring only on Anacapa and one or more of the other Channel Islands (National Park Service [NPS] 2000). This includes the Santa Cruz rufous-crowned sparrow (*Aimophila ruficeps obscura*) which occurs on AI and SCI. One native amphibian, the Channel Islands (or Pacific) slender salamander (*Batrachoseps pacificus pacificus*), and two native lizards, the side-blotched lizard (*Uta stansburiana*) and the southern alligator lizard (*Elgaria multicarinatus*), live on AI. Seventeen landbird species are known to breed on Anacapa, including peregrine falcons (*Falco peregrinus*) on WAI. Common species found there include orange-crowned warbler (*Oreothlypis celata*) and rock wren (*Salpinctes obsoletus*). WAI provides the best landbird habitat of the three Anacapa islets due to its greater topography and more extensive stands of native shrub vegetation, including coastal sage scrub and coreopsis scrub. One native mammal species occurs on Anacapa, an endemic subspecies of deer mouse (*Peromyscus maniculatus anacapae*).

WAI supports the largest California brown pelican (*Pelicanus occidentalis californicus*) nesting colony in the western United States, and one of the largest western gull (*Larus occidentalis*) colonies in the Channel Islands is on MAI. Other seabirds that breed on Anacapa's three islets include Scripps's murrelet (*Synthliboramphus scrippsi*), Cassin's auklet (*Ptychoramphus aleuticus*), pigeon guillemot (*Cepphus columba*), and Brandt's, double-crested, and pelagic cormorants (*Phalacrocorax penicillatus, P. auritus, P. pelagicus*; Table 2.2.5). Harbor seals (*Phoca vitulina*) also breed on the island, predominately on inaccessible areas of the southern shores of the three islets, and California sea lions (*Zalophus californianus*) and northern elephant seals (*Mirounga angustirostris*) haul out on AI.

Non-native Animal Species

Non-native animals that lived on AI included cats (*Felis cattus*), black rats (*Rattus rattus*), sheep (*Ovis aries*) and rabbits (*Oryctolagus cuniculus*). Black rats are believed to have reached the island in the mid-1800s (Collins 1979). Sheep were raised on AI between 1869 and 1937. Cats and rabbits have been successfully eradicated from the island and the Park Service eradicated rats between 2000 and 2002 (see McEachern et al. 2016, Table 34.2).

Land Use History

Carbon dating of AI archaeological sites indicate that the island was occupied as early as 5,000 years ago, although there is no evidence of occupation during the Historic period (Rick 2006). Most Native American sites on Anacapa do not appear to be permanent settlements. Instead, they may have been used seasonally as people moved among the islands for fishing, hunting or shellfish collection (Perry 2005).

There were no Mexican land grants on Anacapa, and the island became the domain of the United States in 1848 (Livingston 2006). The entire island was reserved for a light station in 1854, limiting other uses of the land. Unlike the other northern islands, AI was used in the mid- to late-1800s mostly for fishing and hunting. In 1890 Chinese abalone hunters and fishermen were reported using the island, along with seal hunting from 1890-1895 by H.B. Webster, who also had a small sheep "camp" on MAI in 1885 to about 1902. The islet was formally leased by Webster for sheep ranching in 1907, and the herd was increased to about 600 sheep, decimating the native vegetation. There were several hundred sheep reported on WAI and MAI from 1917 to 1932, but EAI was reserved for lighthouse service with no sheep ranching during that time. Otherwise, the island supported unofficial fishing and egg gathering shacks and vacation cabins until the 1930s. The island was designated a National Monument in 1938, bringing an end to sheep ranching.

East Anacapa Island was opened to visitors beginning in 1959 for boating, fishing and camping; Island Packers began running regular ferry trips to the island in 1968 (Livingston 2006). R. "Frenchy" LeDreu established a lobster camp on MAI in 1928, and he stayed on as a caretaker under the National Monument until 1958. A light station was established on EAI in 1911, and by 1951 there was a housing complex for six men and their families. A photograph from 1963 (Figure 4.2.4) shows the settlement, with very little native scrub vegetation intact on the islet. AI was used as a Naval Air Missile Test Center observation post in the mid-1900s as well. Half of the buildings were removed in 1967, when the Coast Guard began to transition the light and fog signal to an automated system, and the last lighthouse keepers left in 1970. The remaining buildings are used by the NPS as staff housing, workshop, water storage and a Visitor Center. WAI and MAI are generally not visited because of their inaccessibility and the presence of protected California brown pelicans on WAI.

Figure 4.2.4. Aerial view of the Anacapa Light Station, December 6, 1963. Note the layout of the residences, upper left, and the rainshed, lower right. A radio tower is seen in the lower left. U. S. Navy photograph, Channel Islands National Park (Livingston 2006).

4.2.2. Natural Resource Assessment of Anacapa Island

Measures of Scrub Recovery

- Vegetation community structure, species composition and spatial extent
- Vertebrate abundance

Reference Conditions/Values

The reference condition for AI is pre-ranching era, characterized by low scrub with an understory of perennial bunchgrasses and live-forever, and native herbaceous plants on uplands and cliffs, with stands of island cherry, toyon and oak in the mesic canyons of Middle and WAI. The vertebrate reference conditions comprise robust populations of the three herptile species (slender salamander, southern alligator lizard and side-blotched lizard), one mammal (the endemic Anacapa island deer mouse [*Peromyscus maniculatus anacapae*]) and the 17 landbird species which breed on the island.

Vegetation

The reference conditions for AI is a land cover on the uplands and terraces of native coastal bluff scrub and perennial bunchgrass with an understory of herbaceous vegetation, including substantial amounts of island live forever; and coastal sage scrub, maritime cactus scrub and sea cliff scrub on the vertical cliff faces surrounding the islets. The vegetation community should also include:

- Landscape dominated by native scrub, with herbaceous understory that includes *Dudleya caespitosa*
- Woodland elements in the moist canyons, including island cherry (*Prunus ilicifolia lyonii*), toyon (*Heteromeles arbutifolia*), island oak (*Quercus tomentella*) and island scrub oak *Q. pacifica*
- Stands of dominant woody plants with stable populations and recruitment
- Replacement of the widespread, planted, exotic red-flowered iceplant on EAI with native cover
- Reduced cover (absence) of crystalline iceplant (M*esembryanthemum crystallinum* and *M. nodiflorum*).

Vertebrates

The reference conditions for AI vertebrates are populations of native terrestrial vertebrates that are robust, persistent, and influenced primarily by native perennial ecosystem elements and processes. Specifically, vertebrate populations should:

- Be free of threats from non-native species
- Be at their natural population densities and have recovered from lows due to past influence of non-native grazers on island vegetation.

Current Condition and Trend

Vegetation Community Structure and Spatial Extent

Historical Vegetation Change

Sheep ranching decimated the native vegetation of the island, especially WAI and MAI; the ranchers occasionally conducted matanzas (Spanish for “slaughter” or “killing”) to reduce herd size when sheep began to starve from overgrazing (Livingston 2006). Sheep ranching ended in 1938, earlier than on the other northern islands. M.B. Dunkle participated in Los Angeles County Museum surveys of the Channel Islands in 1939 (Dunkle 1950), observing that AI was overgrazed but was in better condition than the larger islands. Hochberg et al. (1979) surveyed AI vegetation in 1978. Like Dunkle, they found the island grassland on WAI and MAI richer in native perennial bunch grasses than on other Channel Islands, with a significant understory of native perennials, especially island live-forever and gumweed (*Grindelia latifolia*). However, EAI had mainly exotic annual grasses including wild oats (*Avena barbata*/*A. fatua*), brome grasses (*Bromus diandrus, B. mollis, B. madritensis* var. *rubens*), and foxtail (*Hordeum murinum*), along with substantial areas of red-flowered iceplant planted for erosion control by the U.S. Coast Guard. Other landscape plants on EAI included tamarisk (*Tamarix* spp.), blue gum (*Eucalyptus globulus*) and Monterey cypress (*Cupressus macrocarpa*).

Hochberg et al. (1979) mapped vegetation on the basis of field surveys and 1978 aerial infrared color photos (Figure 4.2.2), describing three phases of coastal bluff vegetation, coastal sage scrub, and island grassland on all three islets; plus small stands of island chaparral and island woodland on WAI. They noted the presence of "onshore transitional areas" on the northern bluffs with vegetation appearing transitional between coastal sage scrub, coastal bluff and grassland. Table 4.2.1 shows the approximate area occupied by each of these vegetation types in 1978.

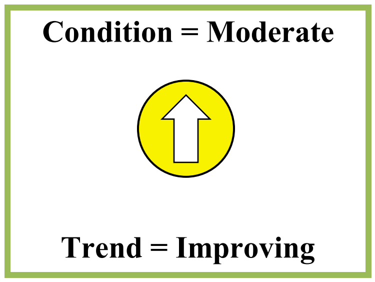
Table 4.2.1. Approximate area occupied by plant associations mapped on Anacapa Island in 1979 (Hochberg et al. 1979). EAI = East Anacapa Island, MAI = Middle Anacapa Island; WAI = West Anacapa Island.

Vegtype	EAI Acres	EAI Hectares	MAI Acres	MAI Hectares	WAI Acres	WAI Hectares
Bare areas	16.86	6.84	1.4	0.57	15.34	6.21
Coastal bluff, coreopsis phase	14.9	6.04	32.61	13.2	67.77	27.44
Coastal bluff, sea-cliff phase	16.41	6.64	21.56	8.72	34.74	14.05
Coastal sage scrub	11.71	4.75	60.55	24.51	136.94	55.42
Eucalyptus grove	–	–	0.36	0.15	–	–
Island chaparral	–	–	–	–	11.97	4.81
Island grassland	43.63	17.65	46.35	18.75	66.13	26.76
Island woodland	–	–	–	–	2.27	0.92
Malephora iceplant	14.35	5.8	–	–	–	–
Onshore transitional areas	–	–	–	–	122.5	49.57
Undefined	–	–	–	–	0.35	0.14
Total	**117.86**	**47.72**	**162.83**	**65.9**	**458.01**	**185.32**

Coastal bluff vegetation restricted to the north side of AI included two phases dominated by either native giant coreopsis or exotic crystalline iceplant, and a third sea cliff phase on the steep inaccessible bluffs, composed of mostly natives, but with inclusions of exotic grasses. Areas mapped as the coreopsis phase of sea cliff scrub had nearly continuous coreopsis cover, especially on WAI and MAI, but it was also present in grassland. In their opinion, these stands were the best examples of coreopsis scrub on any of the California islands. South side cliffs supported coastal sage scrub, sometimes including prickly pear cactus (*Opuntia prolifera*) in remnant maritime cactus scrub; coastal sage scrub was also seen occasionally on terraces of WAI and MAI. The island chaparral on WAI appeared relictual, occurring in four canyons. Island cherry (*Prunus ilicifolia lyonii*) was present in all of these stands, with big-pod ceanothus (*Ceanothus megacarpus insularis*) and toyon also present in Cherry Canyon. Island woodland was restricted to two small stands of island oak in Oak Canyon on WAI. The rare, and now Federally-listed, island barberry (*Berberis pinnata insularis*) was noted as probably extirpated from WAI as the result of long-term grazing.

Hochberg et al. (1979) sampled eleven 100-foot (30.5 m) transects with the point-line intercept method, placing two on EAI near the campground and nine on MAI in coreopsis stands, coastal sage scrub and island grassland. Generalized over all eleven transects, they documented 121 points with native cover versus 12 points with exotic cover, a similar ratio to SMI, but very different from SBI with 43 points native versus 91 points exotic plant cover. They observed that the island vegetation seemed to be recovering toward native dominance on WAI and MAI, and to some extent on EAI also. They recommended that the NPS work to reduce cover of red-flowered iceplant and crystalline iceplant on EAI, and allow recovery to occur naturally in other places.

Current Vegetation Condition and Trends



Vegetation Transect Samples - The NPS Inventory and Monitoring Program has sampled sixteen transects on the three islets since 1984. However, access is restricted during the pelican breeding season and sampling has not occurred annually, especially on WAI. Therefore, it is difficult to test for significant trends in plant cover or composition. The data do describe plant community composition and cover, however. Currently the AI plant communities sampled are coreopsis scrub, coastal sage scrub, grassland, and perennial iceplant. The NPS is in the process of making a new vegetation map and classification for AI; once completed it will be a useful tool for determining changes in spatial extent of the communities. Anecdotally, it appears to island botanists that grasslands on WAI and MAI are becoming more dominated by perennial bunchgrasses (*Stipa* spp.) and that cover of island live-forever, gumweed and giant coreopsis have been increasing. The remnant stands of island woodland appear much as they were described in 1979, and there has been little apparent change in the extent of island chaparral (D. Rodriguez 2014, S. Chaney 2013, personal communications).

Iceplant Eradication and Native Plant Restoration on EAI - In 2012, Channel Islands National Park began an aggressive three-year project to eradicate the invasive red-flowered iceplant from EAI and replace it with native shrubs, grasses and herbs. This plant was introduced for erosion control in areas around facilities in the 1950s by the U.S. Coast Guard. In 1979, it was present in large, but discrete, patches across the island from the landing cove to nearly Inspiration Point (Figure 4.2.2 above). By 1988, it had spread to cover a large portion of the northern half of the islet, eliminating native species as it spread (Halvorson et al. 1988). From 2012 through 2014, NPS has been killing the iceplant (Figure 4.2.5) with herbicide treatments or by hand pulling in more sensitive areas (S. Chaney, personal communication, 2014). Where possible the dead iceplant is left in place as an erosion control mulch, and natives grown on the island from island seed are planted into the mat and hand watered for several weeks until established (Figure 4.2.6). Survival of the planted stock has been good, despite drought, and the iceplant shows no signs of regrowth from roots or seed. The project is entering a maintenance phase now, organized to keep iceplant out of treated areas and encourage increasing cover of natives. In addition, several invasive plant species were documented on the islets, for example German ivy (*Senecio mikanoides*) in several canyons of MAI, and they are being treated with herbicide with the goal of complete eradication (S. Chaney, personal communication, 2014).

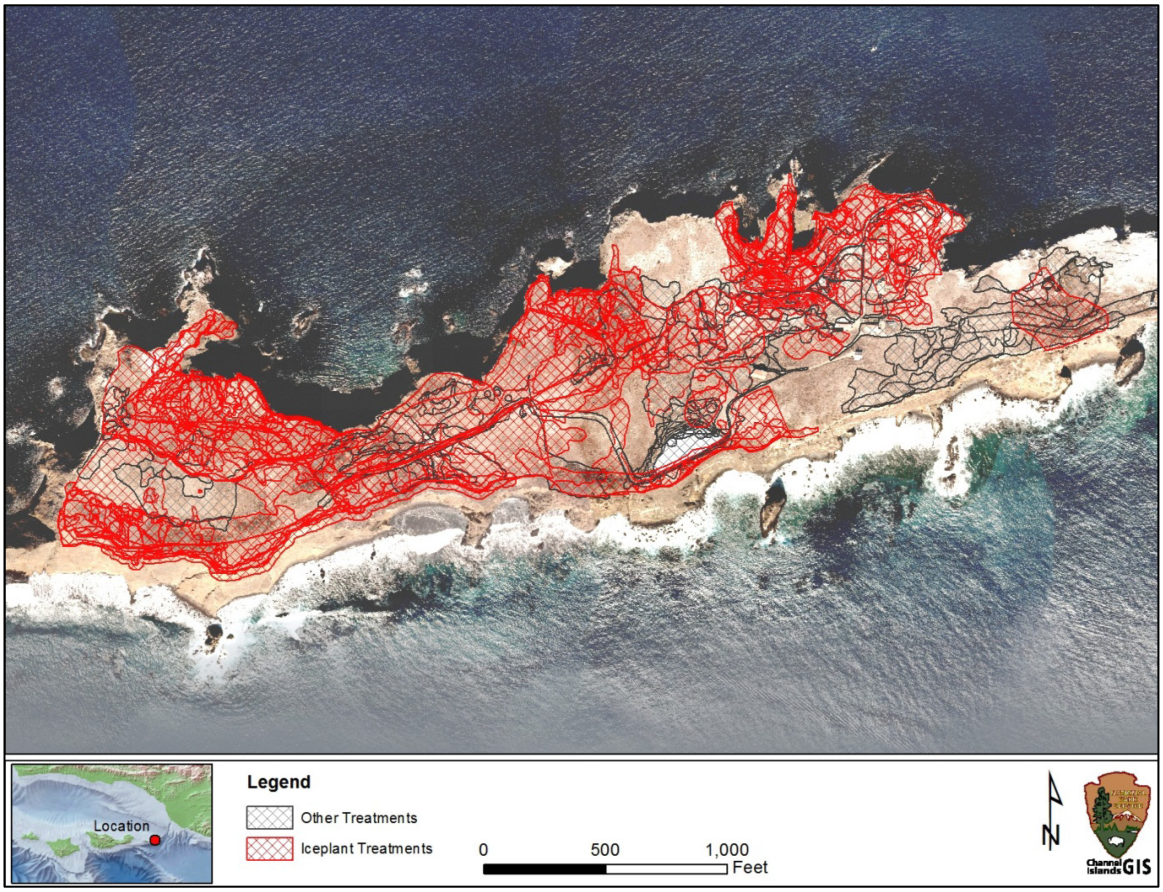


Figure 4.2.5. Areas where red-flowered iceplant was removed on East Anacapa Island, 2011-2014**.**

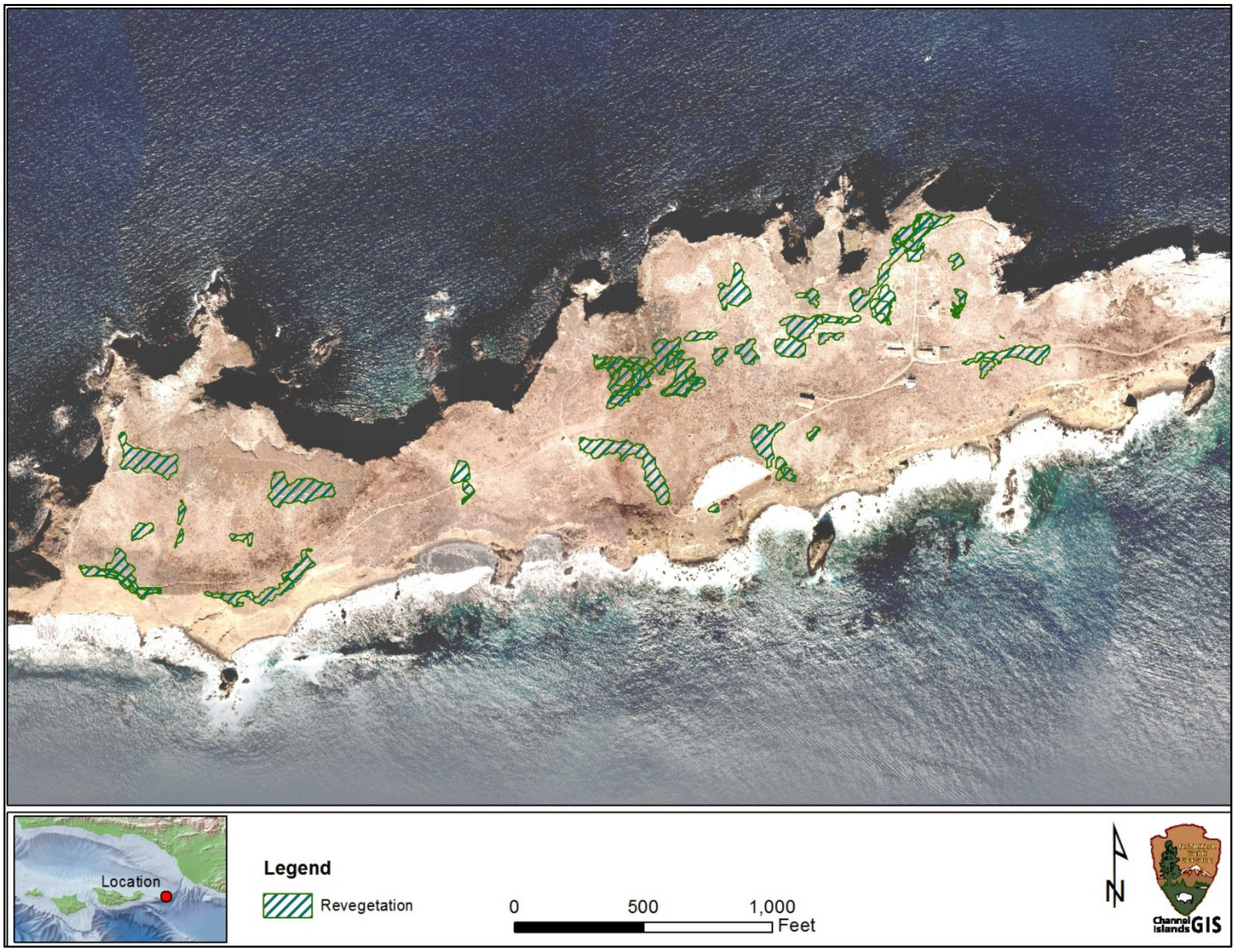


Figure 4.2.6. Revegetation sites on East Anacapa Island, 2011 – 2014 (Map by Tim Coonan).

Vertebrate Abundance

Condition = Insufficient Data

Trend = Improving

<u>*Herpetofauna*</u>

Reptiles and amphibians have been monitored on AI since 1993, but not consistently. Coverboard transects were established on all three islets (Figure 4.2.7), but those on Middle and WAI have not been monitored since the early 1990s, due to difficulty in gaining access to those islets, as well as lack of staffing.

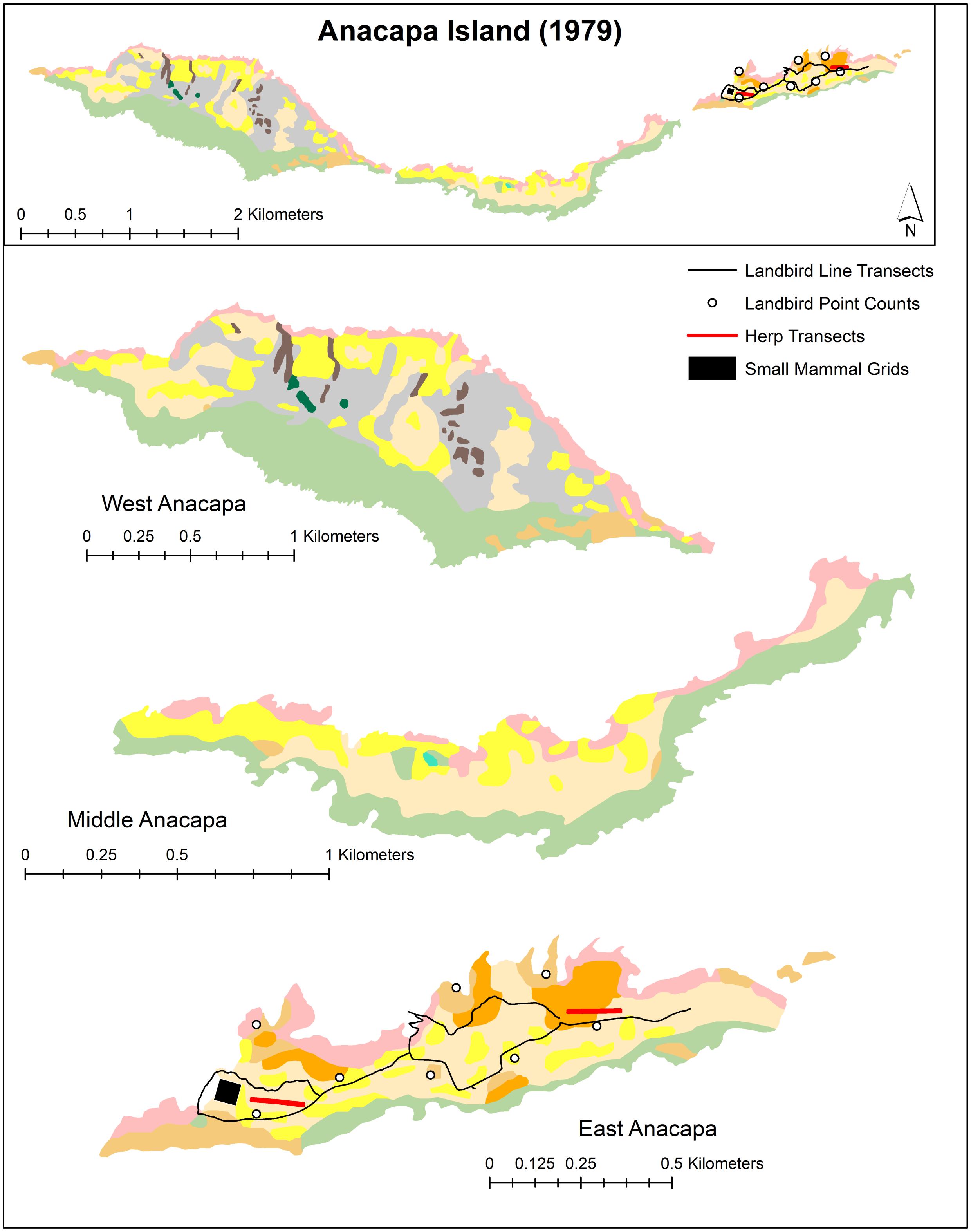


Figure 4.2.7. Small mammal (deer mouse [*Peromyscus maniculatus anacapae*]) and amphibian/reptile sampling grids, and landbird point count and transect locations on Anacapa Island, California (NPS, unpublished data).

Of the three reptile and amphibian species on Anacapa, only one, the southern alligator lizard, is adequately surveyed by the coverboard transects (Fellers et al. 1988). Side-blotched lizards are not caught in adequate numbers for population monitoring, due to their restricted distribution and low tendency to use coverboards. And although slender salamanders use coverboards, their presence aboveground is dependent on adequate soil moisture, which prevents raw abundance from being used as a population indicator.

A series of annual reports presented AI herp monitoring data from the 1990s (Schwemm 1995, 1996; Austin 1996, 1998). Although data have been collected irregularly since then, the data have not been reported, nor have they been analyzed beyond an examination of the effects of rat removal by Newton et al. (2016). They report no effect on alligator lizards, while abundance of slender salamanders is lower than pre-rat removal, but that rainfall, not rat removal, was driving observed variability in salamander abundance.

Landbirds

Landbirds have been monitored on Anacapa since 1993, initially with line transects; point counts were added in 2003, and were established in association with key habitat types on AI (see the Park's landbird trend report for method details, Coonan et al. 2011b). However, landbirds are monitored only on the small eastern islet of Anacapa (Figure 4.2.8) due to the difficulty of accessing the other two, larger islets. Sampling sites on EAI comprise one transect and 8 point count sites. Five point count sites are located in coreopsis scrub habitat, two in grassland, and one in iceplant. A total of 24 species have been observed on Anacapa during landbird monitoring (Figure 4.2.9). One recent addition of note is the song sparrow (*Melospiza melodia*), which was first observed in 2002 and may be breeding on EAI. Park biologist Helen Fitting recorded a song sparrow nest on EAI on April, 2012. Song sparrows are common on the other two Anacapa islets, where they are known to breed, but had not been recorded previously breeding on EAI. House finches (*Carpodacus mexicanus*) were observed from 1993-2006, but have not been recorded since then.

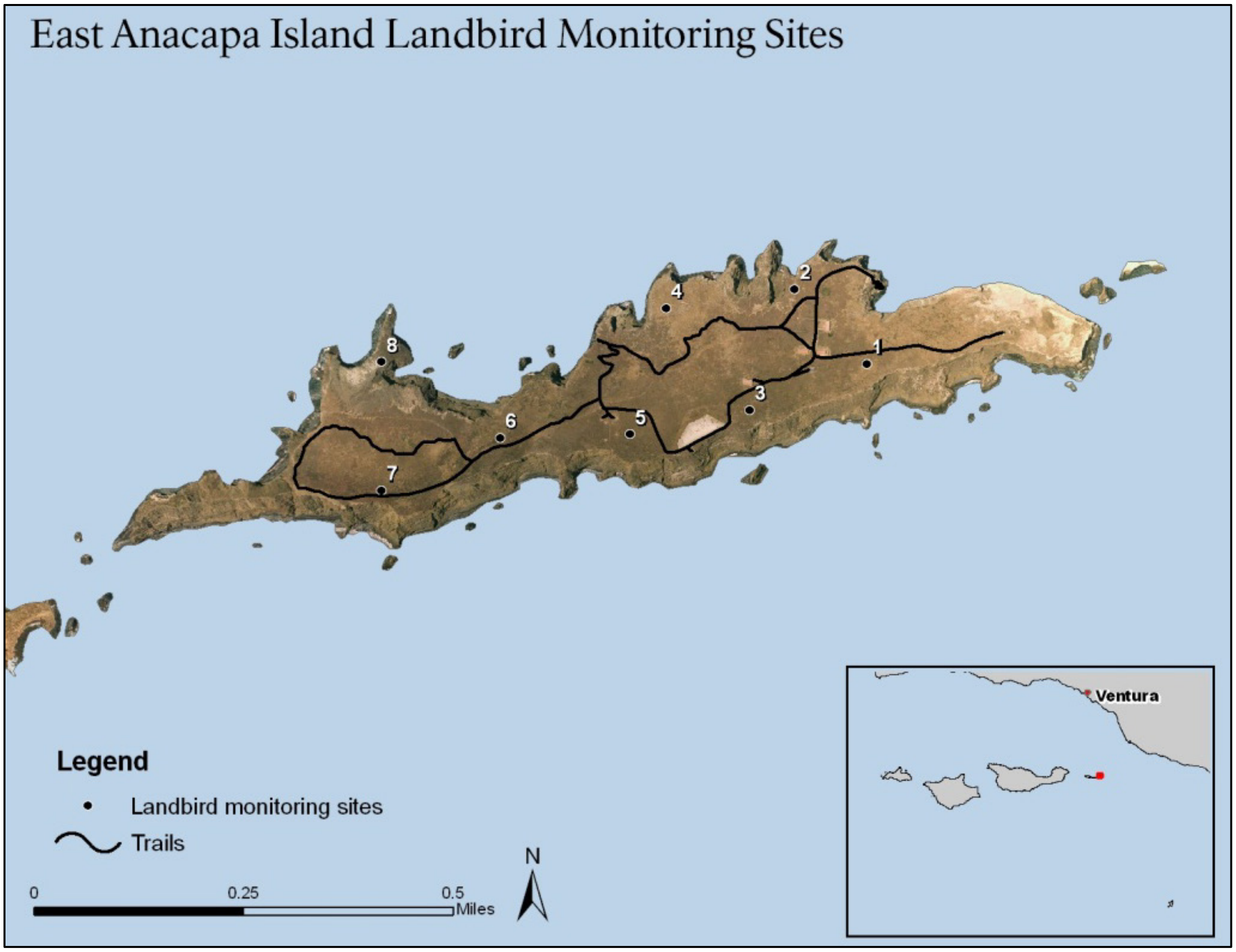


Figure 4.2.8. Landbird monitoring sites on Anacapa Island (Map by Tim Coonan).

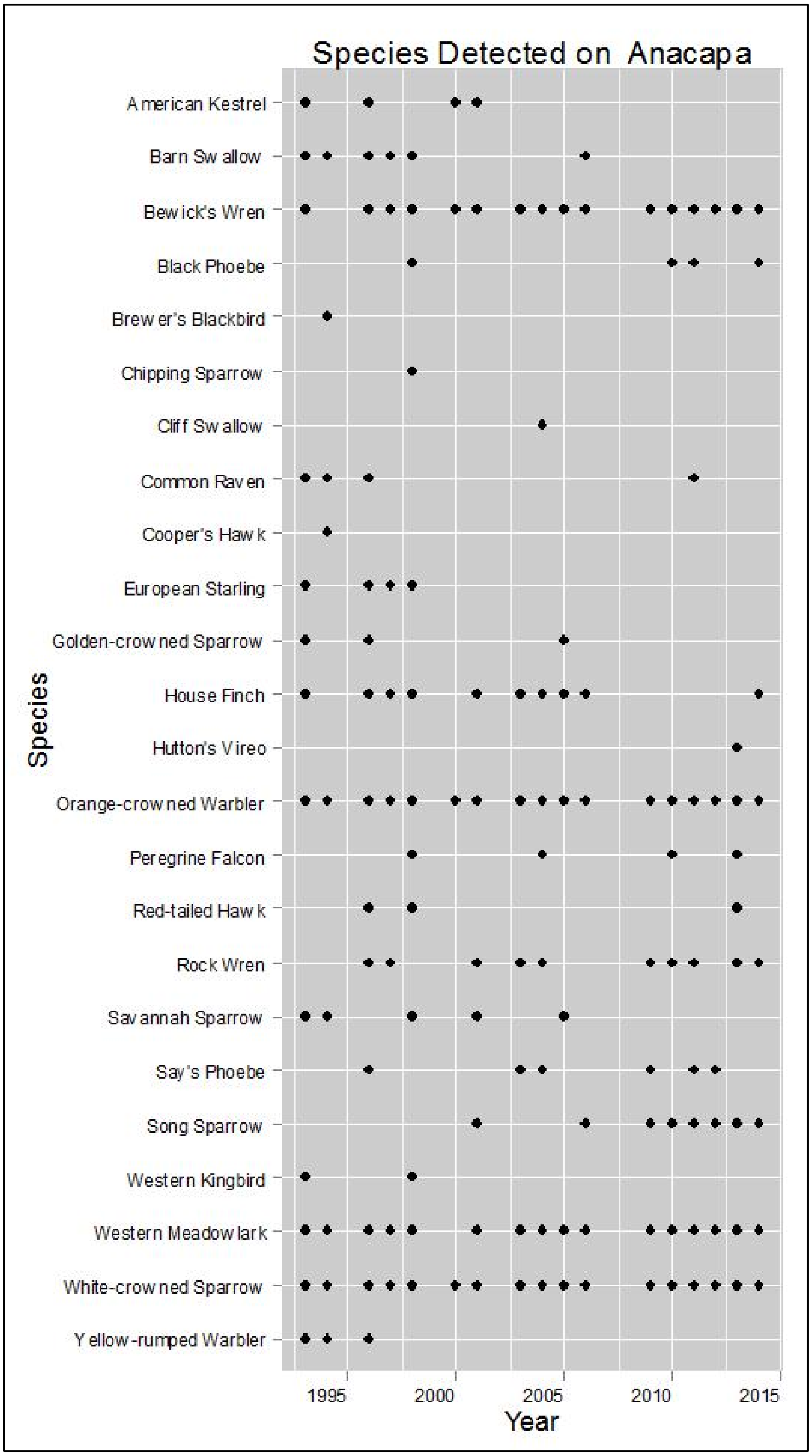


Figure 4.2.9. Species detected during annual landbird monitoring on Anacapa Island, 1993-2014 (Dye and Coonan 2015).

The monitoring on EAI captures only a fraction of the breeding birds on Anacapa. Besides song sparrows, other species that breed on West and MAI, but have not been recorded on EAI, include Allen's hummingbirds (*Selasphorus sasin*), Pacific-slope flycatchers (*Empidonax difficilis*), rufous-crowned sparrows (*A. r. obscura*) and chipping sparrows (*Spizella passerine*).

Habitat preference was investigated for only one landbird species on Anacapa Island as part of the park's trend report for its landbird monitoring program (Coonan et al. 2011b). Limited data and the low number of point count sites and habitat types prevented investigation of habitat preference for other species. Habitat selection for Bewick's wrens (*Thryomanes bewickii*) was evaluated by comparing proportional occurrence of wrens to proportional availability of habitats (Figure 4.2.10). Bewick's wrens preferred Coreopsis scrub habitat while avoiding iceplant and grassland.

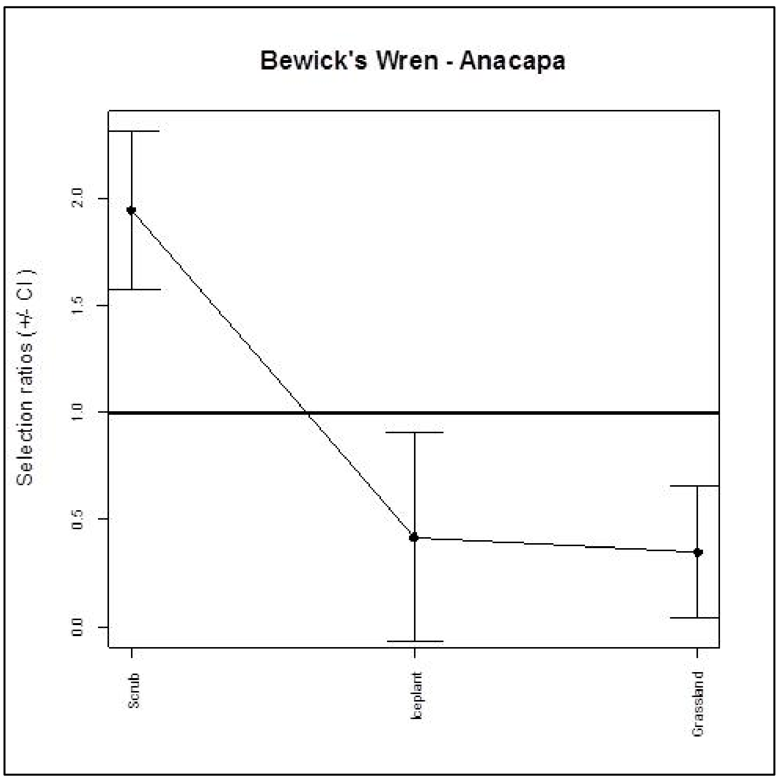


Figure 4.2.10. Habitat selection profile for Bewick's wrens (*Thryomanes bewickii*) on Anacapa Island (Coonan et al. 2011b).

One bird species, the Santa Cruz Island rufous-crowned sparrow (*Aimophila ruficeps obscura*), has been studied more in-depth on AI, mainly out of concern for impacts to the species from the 2001-2002 rat eradication project. This is an endemic subspecies restricted to SCI and AI (Collins 2008). The subspecies is known to prefer moderate to steep rocky slopes with grasses interspersed with clumps of low shrub vegetation. The species may have once been common on Middle and WAI Islands, where it presently occurs (Collins 2008), but has only been recorded once during NPS monitoring on EAI. The rufous-crowned sparrow is difficult to detect via traditional landbird monitoring, which typically does not occur on steep slopes or ravines, and via acoustic monitoring;

the species is shy and secretive and its song is easily overwhelmed by other more vocal species (McKown et al. 2011). The species may exist, undetected by current monitoring, in the steep-sloped canyons of EAI.

The rat eradication project (2001-2003) was expected to result in some incidental poisoning of granivorous birds and secondary poisoning of predatory birds, and a project summary (Howald et al. 2005) reported that 94 individuals of 16 species were found dead shortly after the treatments. Because the rufous-crowned sparrow is both granivorous and sedentary, it was thought to be particularly vulnerable to the rodenticide bait, and specific mitigation measures were implemented to minimize effects on the subspecies (Howald et al. 2009). On a 15-ha site on WAI, rodenticide bait was delivered via bait station rather than by aerial broadcast. Despite the mitigation measure, rufous-crowned sparrows experienced significant mortality from the rodenticide treatment, as determined by pre- and post-application monitoring (Howald et al. 2009). Transect surveys detected an immediate decline in abundance after treatment, and unlike other Anacapa bird species, rufous-crowned sparrows did not recover quickly, if at all, from the rodenticide. Monitoring trips to WAI in 2003, 2004 and 2005 detected no rufous-crowned sparrows (Howald et al. 2009). Because of the known difficulty in detecting the bird, more comprehensive surveys were conducted on WAI in 2007, 2008, and 2011 (Hamilton 2007, McKown et al. 2011). Walking surveys of WAI detected no rufous-crowned sparrows in 2007 and only 2 breeding pairs in 2008 (Hamilton 2007). In 2011, 12 acoustic sensors were deployed in rufous-crowned sparrow habitat on WAI; vocalizations were detected at 5 locations, and 2 rufous-crowned sparrows were visually observed at a separate location (McKown et al. 2011). The authors surmised that there were multiple pairs of rufous-crowned sparrows in multiple canyons on the island. Regardless, 9 years after rat eradication rufous-crowned sparrows exist at very low numbers, perhaps in the dozens, on AI. With little pre-eradication monitoring data for rufous-crowned sparrows on Anacapa Island, it is unclear whether the currently low numbers of rufous-crowned sparrows are the result of rat eradication or merely a reflection of the bird's rarity and secretiveness.

Mammals

Deer Mice - As on Santa Barbara and San Miguel islands, deer mice on Anacapa have been monitored since 1993 as part of the park's long-term ecological monitoring program. Mice are currently trapped semiannually on one 10 x 10-trap grid on EAI (Figure 4.2.11). Mice were previously monitored at sites on Middle and WAI Island, from 1993-1998 (Figure 4.2.12), until budget constraints prevented continued monitoring at those sites (Middle and WAI are accessible only by skiff). Results (Figure 4.2.13; Schwemm and Coonan 2001, Schwemm 2008, Coonan 2013) indicate that, as on other islands, mice on Anacapa have exhibited marked population fluctuation, both intra- and inter-annually. General annual cycles of spring population minima and fall maxima are overlain by multiyear cycles likely driven by precipitation. However, unlike mouse populations on Santa Barbara and San Miguel, which are currently at low numbers due to extended drought, Anacapa mice have increased in the past few years, and mouse weights on Anacapa in 2010 and 2011 were higher than on Santa Barbara and San Miguel (Coonan 2013). This may be due to the active restoration program on EAI (see Figure 4.2.11), in which native plants have been established and frequently watered, in the vicinity of the one deer mouse grid near Inspiration Point. Thus, mice at that site may be somewhat artificially at high numbers, and it is doubtful that mice elsewhere on the island are doing as well.

Figure 4.2.11. Location of deer mouse (*Peromyscus maniculatus anacapae*) monitoring grid on East Anacapa Island.

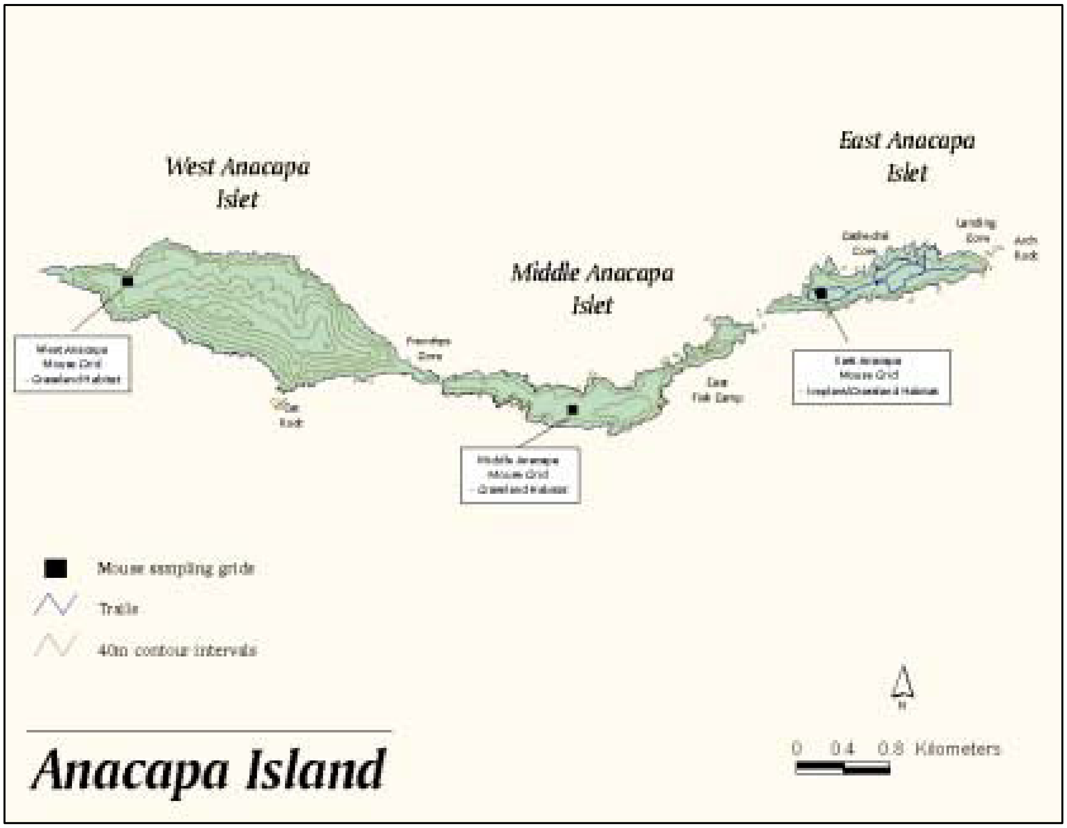


Figure 4.2.12. Location of previously monitored deer mouse (*Peromyscus maniculatus anacapae*) grids on Middle and West Anacapa Islands (Map by Tim Coonan).

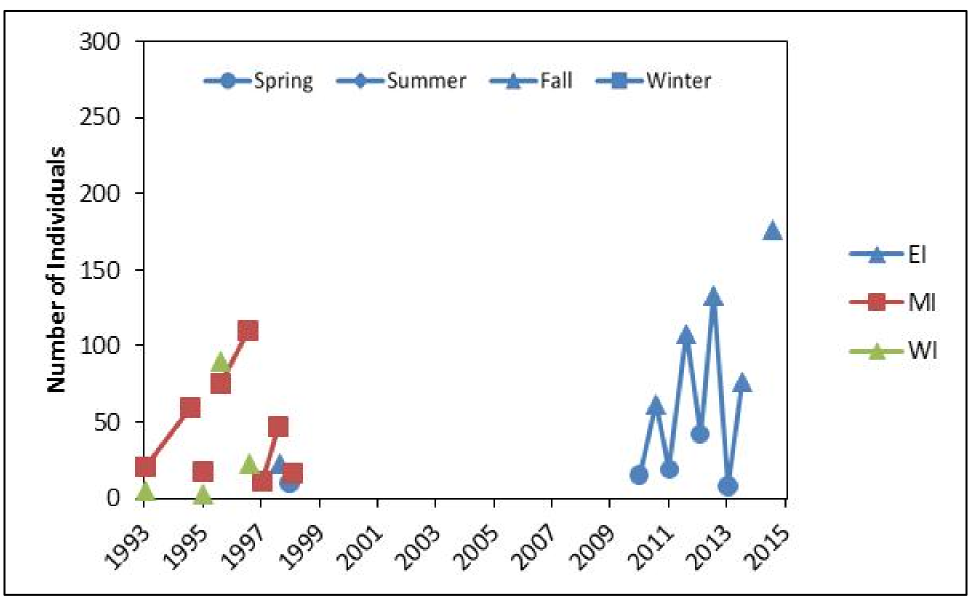


Figure 4.2.13. Deer mouse (*Peromyscus maniculatus anacapae*) abundance on Anacapa Island grids, 1993-2014.

Rat Eradication and Deer Mice - Non-native black rats were eradicated from Anacapa Island in 2001-2002 through aerial broadcast of a rodenticide, brodifacoum (Howald et al. 2005). Black rats likely impacted the island's deer mouse population, and their removal by rodenticide also affected mice, both positively and negatively. Rats likely competed with and preyed upon Anacapa Island deer mice. In fact, deer mice were apparently absent from EAI from 1973 or 1974 until sometime before 1997 (Collins 1979, Erickson and Halvorson 1990, Austin 1998, Schwemm and Coonan 2001), perhaps due to predation by and competition with black rats. Park staff began observing mouse sign in 1997 and subsequently established a mouse monitoring grid at Inspiration Point (Figure 4.2.11). Predation by rats may have prevented mice from occupying EAI during that time period (Collins 1979), though mouse re-colonization of EAI occurred prior to rat removal.

To prevent impacts to deer mice from the application of rodenticide to remove rats, deer mice were captured and placed in captivity during rodenticide application (Howald et al. 2005, Gellerman 2007). Genetic and population viability analysis determined that a population of 1,000 mice across all three islets would maintain sufficient genetic diversity and prevent extinction of Anacapa Island mice (Pergams et al. 2000). The rodenticide treatment was staggered over two years to insure that an extant mouse population existed in at least two areas of the island at all times. EAI mice were held in captivity while that islet was treated in 2001. Those mice were released back into the wild in 2002, when mice from West and MAI were held in captivity during eradication on those islets in 2002. Reintroduced mice fared well and re-established successfully on all three islets (Howald et al. 2005, Gellerman 2007), although there were genetic impacts to Anacapa mice from the translocation (Ozer et al. 2011). Prior to the rat removal project, mice from East, West and Middle were genetically differentiated from each other, but after the project EAI mice were less distinct. Ozer et al. (2011) concluded that the reintroduced populations experienced substantial drift, evident in shifts in allele frequencies and the disappearance of private alleles.

The removal of rats from the three Anacapa islets is likely to be beneficial to deer mice in the long run. However, there are few data which capture pre- and post-eradication mouse population dynamics. Population highs and lows (from different mouse grids and islets) appear to be similar for pre- and post-eradication monitoring (Figure 4.2.13).

Native Plant Restoration and Deer Mice - The U.S. Coast Guard introduced non-native red-flowered iceplant to EAI in the 1950s to stabilize soils, and by the late 1990s iceplant had spread to cover much of the top of that islet. Channel Islands National Park received funding in 2011 for a three-year effort to initiate the complete removal of iceplant from EAI. It is possible that the currently high mouse numbers on EAI – which stand in contrast to the drought-driven low mouse numbers on Santa Barbara and San Miguel Islands – are due to the removal of fennel and the active restoration of native plants to the island. With only one mouse monitoring grid on AI, is uncertain how widespread these effects may be.

NRCA Team Data and Methods

Vegetation Community Structure and Spatial Extent

We cannot yet quantify change in spatial extent of the AI plant communities. However that will be possible when the new vegetation maps are completed, filling a huge gap in quantitative knowledge of vegetation recovery on the islets.

Vertebrate Abundance

Landbirds

Landbirds have been surveyed on the 8 point count sites since 2002 (Coonan et al. 2011a, b). For species with an adequate number of detections (≥60) over time, density can be estimated with distance methods (Buckland et al. 2001). For this analysis we estimated annual island-wide density for selected species, utilizing program Distance and the distance-based observation data from the park's landbird monitoring program (Coonan et al. 2011b, Dye and Coonan 2014b). We estimated density for each species on line transects, which were surveyed from 1993 through 2014, and at point counts (2002-2014).

NRCA Team Results

Vertebrate Abundance

Landbirds

There were adequate numbers of detections to estimate density for four species: Bewick's wren, orange-crowned warbler, western meadowlark, and house finch. Landbird densities varied considerably over the period sampled with transects (1993-2014) and point counts (2002-2014) (Figures 4.2.14-4.2.17), but all four species appeared to decline over time. This included the virtual disappearance of house finches from EAI from 2007-2014. These trends are curious, because one would expect landbirds to have benefited directly from both rat removal and iceplant removal/revegetation. That they apparently did not, suggests a more complex interplay of ecological factors on the islet.

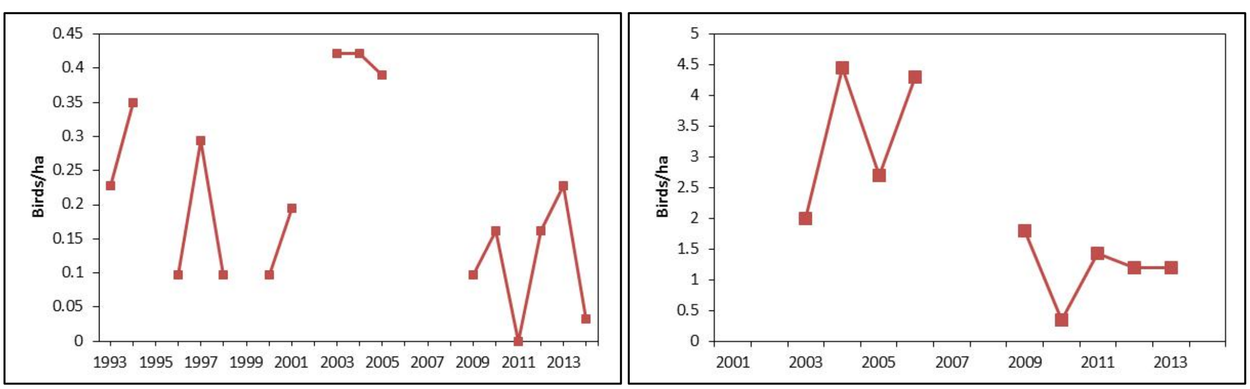


Figure 4.2.14. Density of Bewick's wrens (*Thryomanes bewickii*) on East Anacapa Island, from line transect (left) and point count data (right).

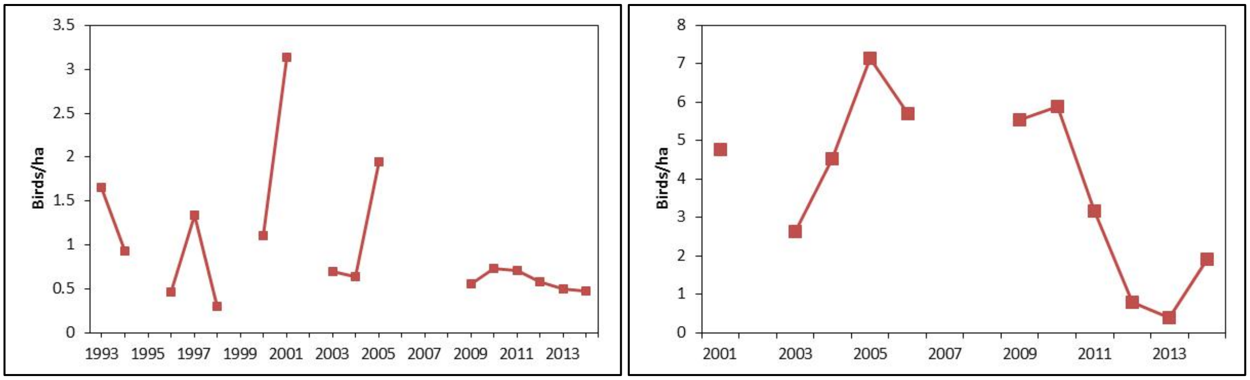


Figure 4.2.15. Density of orange-crowned warblers (*Oreoclypis celata*) on East Anacapa Island, from line transect (left) and point count data (right).

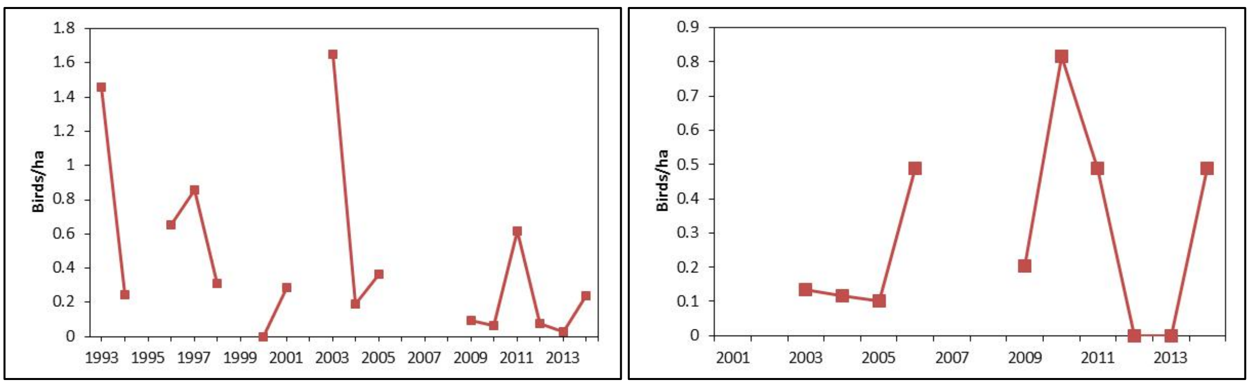


Figure 4.2.16. Density of western meadowlarks (*Sturnella neglecta*) on East Anacapa Island, from line transect (left) and point count data (right).

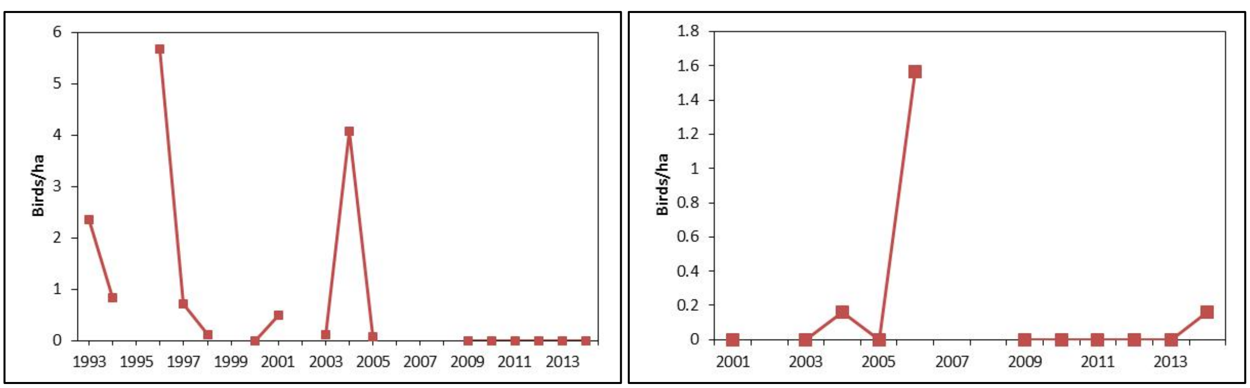


Figure 4.2.17. Density of house finches (*Carpodacus mexicanus*) on East Anacapa Island, from line transect (left) and point count data (right).

It is possible that the recent declines in EAI landbirds are due to drought conditions, which began in 2012 and continued through the end of 2014. However, the landbird declines began in 2009-2011, before drought conditions ensued in 2012. Moreover, landbird declines due to the recent drought are not apparent on the other park islands (see Sections 4.1-4.4). Alternatively, the landbird declines on

EAI may be due to predation by deer mice, which can be significant nest predators of birds (Blight et al. 1999, Schmidt et al. 2001, Bradley and Marzluff 2003). Several landbird species showed high numbers immediately following rat removal in 2001, suggesting a release from predation pressure, but declines later in the decade. Deer mice began increasing in 2009 and may have peaked in 2014.

Data Gaps

Vegetation

The new vegetation map and plant community classification expected in late 2015 or 2016, being prepared collaboratively with the California Department of Fish and Wildlife, will fill a large gap in evaluating change in the extent of native plant cover on AI. Additionally, the classification will allow a comparison of AI communities with those on other islands and the mainland. A vegetation monitoring program review conducted in 2000 (McEachern 2001) identified changes needed in the transect monitoring scheme, including the addition of samples to AI, and the establishment of transects located at random for greater statistical power of inference island wide. These changes have been designed and are being phased in; once implemented, they should improve detectability of trends in the data. In the meantime, the existing transect data (1984 – present) need to be fully analyzed for trends. Funding is not available presently for this analysis. A monitoring program tracking iceplant eradication and native community restoration success needs to be implemented to validate results and guide maintenance activities.

Vertebrates

Due to the difficulties of accessing Middle and WAI Islands, as well as the steep topographic slopes on all three islets, there are many gaps in knowledge concerning the island's vertebrates. In fact, the only vertebrates that are relatively well-known are landbirds on EAI. Even there, data is restricted to those species which inhabit the relatively flat top of the islet, and those data come from only 8 point count sites and one transect. Landbirds on Middle and WAI are not well-known; particularly the distribution and abundance of the rufous-crowned sparrow, an endemic species restricted to Anacapa and Santa Cruz Islands.

Deer mouse population dynamics are unknown except for at one monitoring site, at Inspiration Point on EAI. Deer mouse monitoring grids exist on Middle and WAI but have not been monitored since the 1990s. Several grids were established for the reintroduction of mice following rat eradication (Gellerman 2007), but those grids have not been monitored since, and their exact location is unknown.

Habitat relations of reptiles and amphibians are also not well known, although some detailed behavioral work has been conducted on side-blotched lizards as part of a larger study on their mating strategy evolution (Corl et al. 2009).

Overall Condition

Vegetation

West and MAI Islands have been recovering through mainly passive management since sheep ranching ended in 1938, and in the late 1990s support some of the best examples of native island perennial grassland and island live-forever communities in the entire California south coast area (R.

Philbrick, personal communication 1999). Additionally, neither WAI nor MAI are heavily visited under the current management plan, and consequently they are not threatened by visitor impacts such as trampling and the potential introduction of exotics to the extent of EAI. Targeted weed treatment has reduced threats from invasive plants on each islet, and these efforts need to be sustained. Consequently, WAI and MAI appear to be recovering native upland scrub vegetation on their own, although woodland and chaparral vegetation still appear in small, isolated and depauperate stands. EAI, on the other hand, was prevented from recovery by iceplant spread and heavy human use. Consequently active management is needed on EAI to continue the work begun with iceplant eradication, while passive management seems to be allowing native recovery on the other islets. However, proximity to the mainland and the constant seabird traffic means that the potential for introductions of invasive plants is high on all three islets, so that sustained monitoring for and eradication of new invasive plant introductions is needed as a regular management activity.

Vertebrates

Though sparse data exist regarding vertebrates across the three islets comprising Anacapa Island, terrestrial vertebrates are likely robust and plentiful, and habitat is not a limiting factor for any species. The island as a whole is recovering from historic grazing, and vertebrate populations have likely risen as a result. The recent eradication of black rats was largely beneficial for island vertebrates, with a few exceptions. The captive holding and reintroduction program to mitigate impacts to the endemic Anacapa deer mice succeeded in avoiding extinction of that subspecies, but resulted in reduced genetic variation in Anacapa mice. Density of mice on EAI, however, are substantially higher than prior to rat eradication there. Rufous-crowned sparrows may also have been impacted by rat eradication. Abundance declined after treatment with rodenticide, and in 2011, 8 years after treatment, surveys found very few rufous-crowned sparrows on WAI. However, densities of several other landbirds, such as Bewick's wrens, orange crowned warblers and meadowlarks on EAI, all increased from 2001-2005.

Mice on EAI are at population highs, unlike their counterparts on San Miguel and Santa Barbara Islands. While seasonal effects on mouse population fluctuations and other impacts on trapability complicate direct comparisons of mouse densities among islands, it is apparent that recent downward trends in mouse abundance seen on other islands do not match the trajectory of mice on EAI. The reasons for this are unknown. Anacapa mice may experience less predation pressure than do mice on San Miguel or Santa Barbara, where island foxes and barn owls, respectively, are important mouse predators. Alternatively, mice may be benefiting from the restoration program on EAI, where virtually all iceplant has been removed, and many areas revegetated with native plants. Interestingly, the high mouse population may be responsible for the recent declines in abundance of several landbird species on EAI. Such declines are not seen elsewhere, and may be due to mouse predation on landbird eggs.

Sources of Expertise

Vegetation

- Kathryn McEachern
- U.S. Geological Survey, Western Ecological Research Center, Channel Islands Field Station

Vertebrates

- Tim Coonan
- National Park Service

4.2.3. Literature Cited

Austin, G. S. 1996. Terrestrial vertebrate monitoring, Channel Islands National Park, 1995 annual report. Channel Islands National Park Technical Report # 96-04. National Park Service, Channel Islands National Park, Ventura, California.

Austin, G. S. 1998. Terrestrial vertebrate monitoring, Channel Islands National Park, 1996 annual report. Channel Islands National Park Technical Report # 98-03. National Park Service, Channel Islands National Park, Ventura, California.

Blight, L. K., Ryder, J. L., and Bertram, D. F. 1999. Predation by rhinoceros auklet eggs by a native population of *Peromyscus*. Condor, 101: 871–876.

Bradley, J. E., and J. M. Marzluff. 2003. Rodents as nest predators: influences on predatory behavior and consequences to nesting birds. The Auk 120(4):1180–1187.

Collins, P. W. 1979. Vertebrate zoology: the biology of introduced black rats on Anacapa and San Miguel Islands. Pages 14.11-14.56 *in* D. M. Power, editor. Natural resources study of the Channel Islands National Monument, California. Final technical report. U. S. National Park Service Washington, D. C.

Collins, P. W. 2008. Santa Cruz Island rufous-crowned sparrow (*Aimophila ruficeps obscura*). Pgs. 371-376 in Shuford, W. D. and T. Gardali, eds., California Bird Species of Special Concern: a ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento.

Coonan, T. J. 2013. 2012 deer mouse monitoring annual report, Channel Islands National Park. Natural Resources Data Series NPS. In press.

Coonan, T. J., L. C. Dye, and S. G. Fancy. 2011a. Landbird monitoring protocol for Channel Islands National Park – Version 2.0. Natural Resources Technical Report NPS/CINP/NRTR-2011/480. 42 pp. National Park Service, Fort Collins, Colorado.

Coonan, T. J., R. C. Klinger, and L. C. Dye. 2011b. Trends in landbird abundance at Channel Islands National Park, 1993-2009. Natural Resource Technical Report NPS/CINP/NRTR—2011/507. National Park Service, Fort Collins, Colorado.

Corl, A., A. R. Davis, S. R. Kuchta, T. Comendant, and B. Sinervo. 2009. Alternative mating strategies and the evolution of sexual size dimorphism in the Side-blotched Lizard, *Uta stansburiana*: a population-level comparative analysis. Evolution 64-1: 79–96.

Dunkle, M. B. 1950. Plant ecology of the Channel Islands of California. Allan Hancock Pacific Expeditions 13:268–294.

Dye, L. C., and T. J. Coonan. 2014a. Landbird monitoring 2013 annual report, Channel Islands Nation Park. In prep.

Dye, L. C., and T. J. Coonan. 2014b. Landbird monitoring 2014 annual report, Channel Islands Nation Park. In prep.

Erickson, W. A., and W. L. Halvorson. 1990. Ecology and control of the roof rat (*Rattus rattus*) in Channel Islands National Park. Cooperative National Park Resources Studies Unit. Technical Report No. 38, University of California, Davis.

Fellers, G. M., C. A. Drost, and B. A. Arnold. 1988. Terrestrial vertebrates monitoring handbook. National Park Service Unpublished Report, Channel Islands National Park, Ventura, California.

Gellerman, H. 2007. Conservation of the Anacapa deer mouse: impact and recovery from an eradication. Master's thesis. Faculty of the Biological Sciences Department California Polytechnic State University, San Luis Obispo, California.

Halvorson, W. L., S. D. Veirs, R. A. Clark, and D. D. Borgais. 1988. Terrestrial vegetation monitoring handbook. Channel Islands National Park.

Hamilton, R. A. 2007. Rufous-crowned sparrow survey on Anacapa and SCIs. Unpublished report on file at park headquarters, Channel Islands National Park.

Hochberg, M. C., S. A. Junak, R. N. Philbrick, and S. Timbrook. 1979. Chapter V, Botany. *In* D. M. Power ed. Natural Resources Study of the Channel Islands National Monument, California. Santa Barbara Museum of Natural History, Santa Barbara, California. 91 pp.

Howald, G. R., K. R. Faulkner, B. Tershy, B. Keitt, H. Gellerman, E. M. Creel, M. Grinnell, S. T. Ortega, and D. A. Croll. 2005. Eradication of black rats from Anacapa Island: biological and social considerations. Pages 299-312 in D. K. Garcelon, and C. A. Schwemm, editors. Proceedings of the Sixth California Islands Symposium. National Park Service Technical Publication CINP-05-01, Institute for Wildlife Studies, Arcata, California.

Howald, G. R., C. J. Donlan, K. R. Faulkner, S. Ortega, H. Gellerman, D. A. Croll, and B. R. Tershy. 2009. Eradication of black rats *Rattus rattus* from Anacapa Island. Fauna & Flora International, Oryx, 44(1):30–40.

Livingston, D. S. 2006. Historic resource study: A history of the islands within Channel Islands National Park. Technical Report to Channel Islands National Park, Ventura, California. 917 pp.

McEachern, A. K. 2001. Vegetation monitoring program review for Channel Islands National Park. Unpublished Report, U.S. Geological Survey, Biological Resources Division, Western Ecological Research Station, Ventura, CA.

McEachern, K., T. Atwater, P.W. Collins, K. Faulkner, and D.V. Richards. 2016. Chapter 34 Managed Island Ecosystems. Pages 755-778 in: H. Mooney and E. Zavaleta editors, Ecosystems of California. University of California Press, Oakland, CA. 984 pps.

McKown, M., D. Croll, and B. Tershy. 2011. Acoustic monitoring of Santa Cruz rufous-crowned sparrow (*Aimophila ruficeps obscura*) on West Anacapa Island – 2011. Unpublished report on file at park headquarters, Channel Islands National Park.

National Park Service (NPS). 2000. Anacapa Island Restoration Project. Final Environmental Impact Statement. Unpublished Report. Available at Park headquarters.

Newton, K.M., McKown, M., Wolf, C., Gellerman, H., Coonan, T., Richards, D., Harvey, A.L., Holmes, N., Howald, G., Faulkner, K. and Tershy, B.R., 2016. Response of Native Species 10 Years After Rat Eradication on Anacapa Island, California. Journal of Fish and Wildlife Management 7(1): 72-85.

Ozer, F., Gellerman, H., and M. V. Ashley. 2011. Genetic impacts of Anacapa deer mice reintroductions following rat eradication. Molecular Ecology 20(17): 3525-3529.

Perry, J. E. 2005. Early period resource use on eastern Santa Cruz Island. Pages 45-53 in Proceedings of the Sixth California Islands Symposium. Arcata, California: National Park Service Technical Publication CINP-05-01, Institute for Wildlife Studies, Arcata, California.

Rick, T. C. 2006. A 5,000-Year Record of Coastal Settlement on Anacapa Island, California. Journal of California and Great Basin Anthropology, 26(1):65-72.

Schmidt, K. A., J. R. Goheen, R. Naumann, R. S. Ostfeld, E. M. Schauber, and A. Berkowitz. 2001. Experimental removal of strong and weak predators: Mice and chipmunks preying on songbird nests. Ecology 82:2927–2936.

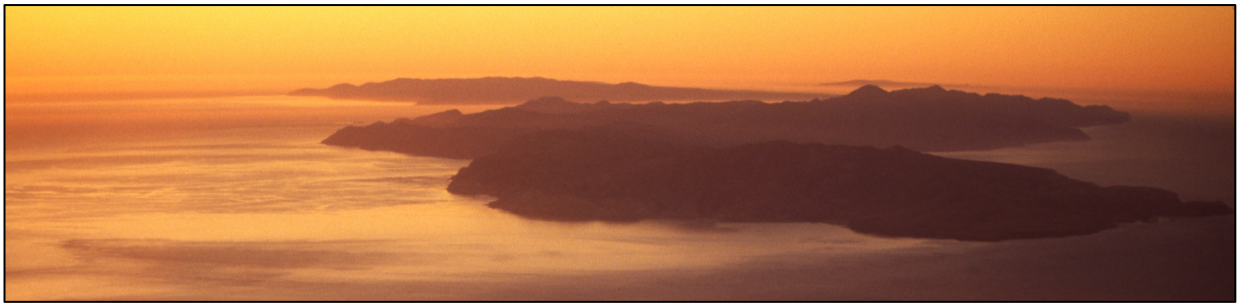
Schwemm, C. A. 1995. Terrestrial vertebrate monitoring, Channel Islands National Park, 1993 annual report. Channel Islands National Park Technical Report # 94-02. National Park Service, Channel Islands National Park, Ventura, California.

Schwemm, C. A. 1996. Terrestrial vertebrate monitoring, Channel Islands National Park, 1994 annual report. Channel Islands National Park Technical Report # 96-03. National Park Service, Channel Islands National Park, Ventura, California.

Schwemm, C. A. 2008. Establishment limitations and population recovery of giant coreopsis (*Coreopsis gigantea*) on the California Channel Islands. PhD dissertation. University of California at Santa Barbara, Santa Barbara, California. 163 pp.

Schwemm, C. A., and T. J. Coonan. 2001. Status and ecology of deer mice (*Peromyscus maniculatus* subsp.) on Anacapa, Santa Barbara and San Miguel Islands, California; summery of monitoring, 1992-2000. Technical report 01-02. National Park Service, Channel Islands National Park.

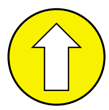
Section 4.3. Santa Cruz Island



Aerial view of Santa Cruz Island. NPS photo.

4.3.1. General overview of Santa Cruz Island

Condition = Moderate



Trend = Improving

<u>Physical setting</u>

Santa Cruz Island (SCI) is about 249 km^2 (96 mi^2) in area, located approximately 30 km (19 mi) from the mainland coast (Figure 4.3.1). It is roughly 38 km long (23.5 mi) and 12 km (7.5 mi) wide at its widest point, located in the northern island chain between Anacapa Island (AI) at 7 km (4.5 mi) to the west and Santa Rosa Island (SRI) 9 km (5.5 mi) to the east. The island trends east-west, with the western two-thirds bisected by a 20 km (12.5 mi) long central valley flanked by two mountain ranges with several peaks near 610 m (2000 ft). An isthmus and rugged northwest-southeast trending ridge segregate the eastern end, a factor influencing the cultural history of the island. The island has a shoreline of about 124 km (77 mi), bordered by rugged cliffs, sea caves and several anchorages popular with local boaters and fishermen. There are three main access points to the island, including Scorpion on the east end and Prisoners Harbor on the central north coast.

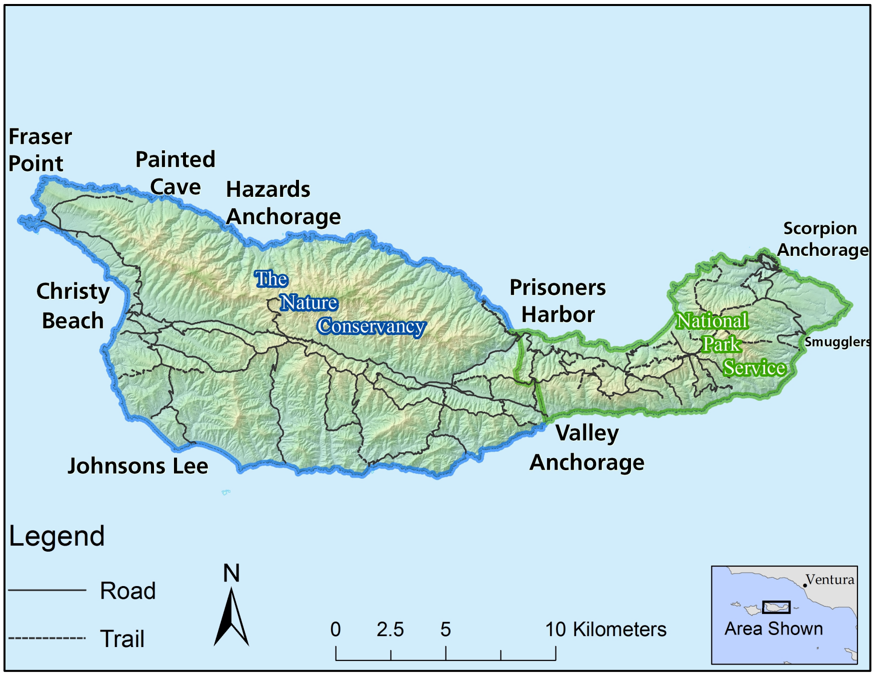


Figure 4.3.1. Santa Cruz Island locations, roads, and trails with hillshade (Map by R. Rudolph).

The island's climate is Mediterranean with warm dry summers and cool wet winters; the greatest amount of rain falls between December and March. Total annual rainfall measured at the Main Ranch in the Central Valley, 1904 – 2013, averaged 50 cm (20 in) per year (20 in; Laughrin, unpublished data). Mean annual temperature averages about 15.8 degrees Celsius (C; 60 degrees Fahrenheit [F]), ranging from a mean monthly high of 22 C (71 F) to a mean monthly low of 10 C (50 F). The Central Valley has a more continental climate regime (Junak et al. 1995), with greater temperature extremes and less fog than the rest of the island. Slightly less than half of SCI is composed of volcanic rocks (42%) which are exposed mainly on the north side and east end of the island, followed by sedimentary and metamorphic deposits (36%), with Quaternary sediments on alluvial slopes and marine terraces (Weaver and Meyer 1969). SCI is probably the most topographically and climatologically diverse of the northern islands, resulting in greater local variation in vegetation than on the other islands.

<u>Natural Resources</u>

Terrestrial Flora and Plant Communities

About 72 percent of the 680 plant taxa known from SCI are natives. There are 55 taxa endemic to SCI, including 7 that occur only on SCI, 45 found on SCI and at least one other island, and 3 presumed extirpated (CINP and USGS, Channel Islands Field Station unpublished data, Santa Barbara Botanic Garden, Center for Plant Conservation [2014], Table 2.2.2). Junak et al. (1995) provide detailed descriptions of SCI plant communities. Generally, the island's plant communities (Figure 4.3.2) are in various stages of recovery from overgrazing. On the NPS-owned eastern end of the island where sheep were removed as recently as 1999 and grasslands are dominated by exotic grasses including rip-gut brome (*Bromus diandrus*), soft-chess (*B. hordeacous*), red brome (*B.*

madritensis rubens), wild oats (*Avena fatua, A. barbata*), ryegrass (*Lolium multiflorum*), and foxtail barley (*Hordeum murinum*). Perennial native grasses such as purple needlegrass (*Nassella pulchra*) and California barley (*Hordeum brachyantherum californicum*) are becoming more extensive as natural recovery from sheep grazing. Native woody plant communities include coastal sage scrub, dominated by California sagebrush (*Artemisia californica*), and Santa Cruz Island buckwheat (*Eriogonum arborescens*), occupies the greatest acreage on the island, followed by island chaparral. Dominant chaparral species vary across the island in response to bedrock type (Junak et al. 1995), including island scrub oak (*Querus pacifica*) chamise (*Adenostoma fasciculatum* var. *prostratum*), manzanitas (*Arctostaphylos viridissima, A. insularis*), toyon (*Heteromeles arbutifolia*), island lilac (*Ceanothus arboreus*, *C. megacarpus*), and mountain mahogany (*Cercocarpus betuloides* var. *blancheae*). Woodlands include large stands of Bishop pine (*Pinus muricata*) on the slopes above Chinese and Prisoners Harbors and on the Christy Ranch end of the island. Smaller woodland stands emerge from the chaparral, ranging from ironwood (*Lyonothamnus floribundus* ssp. *aspleniifolius*) and island cherry (*Prunus ilicifolia lyonii*) to pure or mixed stands of oak (*Quercus* spp.). In addition to these native vegetation types, two widespread communities are dominated almost exclusively by invasive, non-native species. Fennel (*Foeniculum vulgare*) occupies areas formerly plowed and heavily grazed in the Central Valley and in areas of the Isthmus and Christy Ranch, and scattered stands of gum trees primarily (*Eucalyptus camaldulensis*, *E. globulus*) occur in the Prisoners drainage from the Prisoners pier to the Main Ranch in the Central Valley. Figure 4.3.3 shows several of these plant communities.

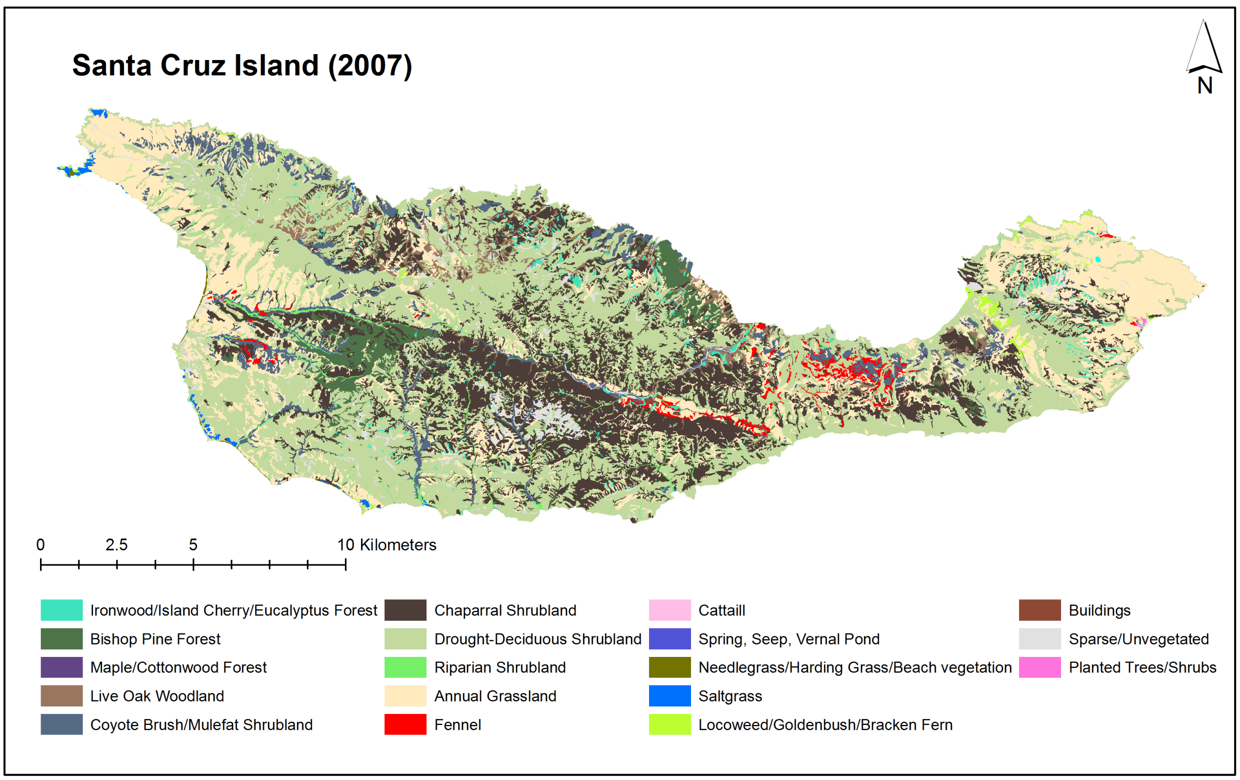


Figure 4.3.2. Vegetation of Santa Cruz Island (Junak et al. 1995).

Figure 4.3.3. Photos of annual island grassland being colonized by California sagebrush (*Artemisia californica*) and coyote brush (*Baccharis pilularis*) (top left), coastal sage scrub (top right), scrub oak (*Quercus pacifica*) and island manzanita (*Arctostaphylos insularis*) chaparral (bottom left), and open Bishop pine woodland (*Pinus muricata*) on Santa Cruz Island in 2003 (bottom right) (NPS files).

Native Animal Species

Santa Cruz is the largest island in the park, and supports more terrestrial wildlife species than the other islands. In addition to its area, SCI displays the greatest diversity of vegetation and topography of all of the park islands. The island harbors several species that are endemic to the island or the Channel Islands, including 1 amphibian, 2 reptile, 4 mammal, and 10 landbird species. Like all of the Channel Islands, the invertebrate fauna of SCI is not well studied, but about 600 species were reported on SCI and native bee diversity is higher on SCI than on other Channel Islands (Naughton et al. 2014, NPS 2002).

Six reptile and three amphibian species have been recorded on SCI. The Santa Cruz Island gopher snake (*Pituophis catenifer pumilus*) and Baja California tree frog (*Pseudacris hypochondriaca*) occur only on SCI and SRI. The yellow-bellied racer and the black-bellied slender salamander only occur on SCI.

Forty-four native landbird species are known to breed on SCI, and it has a greater diversity of breeding landbirds than the other islands. Extensive riparian areas, oak woodlands, chaparral, and pine forests provide habitat for acorn woodpeckers (*Melanerpes formicivorus*), red-breasted nuthatches (*Sitta canadensis*), northern flickers (*Colaptes auratus*), and the endemic island scrub-jay (*Aphelocoma insularis*), as well as Pacific-slope flycatchers (*Empidonax difficilis*), black phoebes (*Sayornis nigricans*), and spotted towhees (*Pipilo maculatus*). Eight subspecies are endemic to SCI and one or more of the other northern Channel Islands, while the island scrub-jay lives only on SCI.

Fifteen mammal species live on the island. Three mammal subspecies occur only on SCI—Santa Cruz Island deer mouse (*Peromyscus maniculatus santacruzae*), Santa Cruz Island harvest mouse (*Reithrodontomys megalotis santacruzae*), and Santa Cruz Island fox (*Urocyon littoralis santacruzae*). The island spotted skunk (*Spilogale gracilis amphiala*) is only present today on SCI and SRI. The historic masonry building at Scorpion Valley on SCI supports one of the few remaining known maternity colonies for Townsend's western big-eared bats (*Corynorhinus townsendii*) in California, and the only known colony on the islands. This island also supports large breeding populations of harbor seals (*Phoca vitulina*).

SCI supports seven nesting seabird species, including California brown pelican (*Pelicanus occidentalis californicus*) and Scripps's murrelet (*Synthliboramphus scrippsi*). Most of the seabird colonies either are on bluffs on the islands, in sea caves, or on rocks offshore of the island. Carter et al. (1992) reported there were 3,752 pairs of seabirds on SCI. The island sustains one of the most important breeding colonies of ashy storm-petrels (*Oceanodroma homochroa*) in southern California, has several small cormorant colonies, and a small gull colony on Gull Rock. In addition, there are auklets breeding on some of the rocks offshore of SCI, and murrelets are found in some dry sea caves.

Non-native Animal Species

A variety of non-native animals were introduced onto SCI including cattle (*Bos primigenius*), sheep (*Ovis aries*), wild turkey (*Meleagris gallopavo*), California quail (*Callipepla californica*), European honey bees (*Apis mellifera*), and Argentine ants (*Linepithema humile*). Cattle, sheep, turkeys, pigs (*Sus scrofa domesticus*), and honey bees have been removed, but five non-native bird species persist on the island. Pigs were present on SCI from the 1850s. They were found in all locations and habitat types on the island. Annual estimates of the island's pig population ranged from 500 to more than 4,000 (NPS 2002a). The pigs directly impacted the island's vegetation, including threatened and endangered plants, wildlife, and archeological resources, and indirectly affected island foxes (supporting golden eagles, which also fed on the foxes). The Park Service, in collaboration with The Nature Conservancy (TNC), successfully eradicated pigs from SCI by 2006.

<u>Land Use History</u>

Native Americans were present on SCI at least 7,000 to 10,000 years before present (Glassow 1980), and the oldest documented settlement dates from about 8,700 years ago (Glassow et al. 2009). At the time of European contact there were 11 settlements on the island. Braje et al. (2010) provide a detailed timeline of Chumash activities on the Park islands. SCI was converted to a ranch with the introduction of sheep, pigs, and horses (*Equus ferus caballus*) in the mid-1800s, under the management of several private ranch corporations (Junak et al. 1995, Livingston 2006). The island is currently owned by TNC and the National Park Service (NPS), who collaborate on management for conservation and recreation.

By 1875 there were about 60,000 sheep on the island, raised for their wool and managed from a network of a Main Ranch and five satellite locations dispersed across the island (Howarth and Laughrin 2009). In the early years the sheep were managed by rancheros on horseback, rounded up semi-annually for shearing (Van Vuren and Coblentz 1987). Attempts were made to reduce numbers of sheep in drought years, but by about 1920 the sheep had become feral, no longer managed in the most rugged areas of the island. Van Vuren and Coblentz (1987) studied the sheep population from 1979 to 1980, when the island supported about 21,240 sheep, at a stocking rate of an estimated 2.1 sheep per hectare. TNC began a sheep removal program in 1981 in their western two-thirds of the island, completely eradicating the sheep by 1987. Channel Islands National Park acquired the eastern end of the island in 1999, and removed sheep there by 2000 (Livingston 2006). Approximately 2,000 domestic cattle were removed by TNC in 1988-1989, and about 5,000 pigs were eradicated in 2005-2007 (Morrison 2007).

Several species of non-native trees were introduced for landscaping and agriculture (Livingston 2006), and many have spread from their original locations. A grove of olive trees (*Olea europaea*) and cypress trees (*Cupressus* sp.) are present in the Smugglers Cove area. In Cañada del Puerto, a significant percentage of the southern riparian woodland has been invaded by eucalyptus (*Eucalyptus globulus*). Several eucalyptus stands are established in the lower drainages of Smugglers Cove and Scorpion Canyon. Stone pine (*Pinus pinea*) also is present on SCI, particularly near Prisoners Harbor. Many of these have escaped cultivation, threatening to become widespread on the island. Management is now focused on maintaining some of these trees in closely managed areas for their historic value while eradicating others (Power et al. 2014a, McKnight et al. 2007). Fennel, a perennial culinary herb, increased in abundance in abandoned plowed fields and pastures after cattle removal in 1988, although the removal of cattle reduced spread among pastures (Howarth and Laughrin 2009). Fennel eradication has been the subject of much management research since then.

4.3.2. Natural Resource Assessment of Santa Cruz Island

<u>Measures of Scrub Recovery</u>

- Vegetation community structure, species composition and spatial extent
- Vertebrate abundance

<u>Reference Conditions/Values</u>

The reference condition for SCI is pre-ranching era, characterized by widespread cover of diverse native scrub and woodland with native understory that sustains endemic plants and animals.

SCI probably supported a mosaic of woody vegetation immediately before European settlement, in a less fragmented version of the remnant and recovering vegetation of today. Archaeological evidence indicates that human habitation dates back to at least 8700 years ago on the island (Glassow et al. 2009). There were 11 Chumash settlements on the island at the time of European settlement, in coastal areas on ridge tops and on marine terraces near water. While the Native Chumash relied heavily on the marine environment for food (Erlandson et al. 2011), they also used fire to manipulate the environment, and harvested bulbs and seeds (Timbrook et al. 1982). It is difficult to say exactly what the effects of the Chumash were on the vegetation, but certainly their harvesting, collecting, trampling and burning had an effect on the SCI ecosystem. Still, botanists infer that patterns of vegetation were much like they are now, with chaparral and drought deciduous scrub on steeper and more arid slopes with thin soils, woodlands in canyons and on mesic slopes exposed to fog, herb and grasslands on areas with deeper soils and marine terraces and sufrutescent scrub on ocean bluffs. Likely there was more marsh and riparian vegetation than today, especially in drainages that had perennial flow.

In the absence of impacts by non-native ungulates, and with more widespread chaparral and woodland, some vertebrate species were likely more abundant and more widespread in distribution than they are today. Island scrub-jays occupied much of the oak and other woodland, island shrikes (*Lanius ludovicianus anthonyi*) inhabited edges, and Santa Cruz Island rufous-crowned sparrows (*Aimophila ruficeps obscura*) occupied native grassland slopes and canyons. Harvest mice were more widespread because of the greater wetland and wet meadow habitat. With chaparral and woodland in better condition, those were preferred habitat for island foxes and for deer mice. Bald eagles (*Haliaeetus leucocephalus*), as well as osprey (*Pandion haliaetus carolinensis*), nested on the island, as did peregrine falcons (*Falco peregrinus*).

There are records of at least ten species of amphibians and reptiles historically inhabiting Santa Cruz Island (California Herps 2016). Amphibian species recorded from Santa Cruz are two species of slender salamander (*Batrachoseps pacificus and B. nigriventis*) and two frogs, the Baja California treefrog (*Pseudacris hypochondriaca hypochondriaca*) and the California red-legged frog (*Rana draytonii*). Three snakes, the Santa Cruz Island gopher snake (*Pituophis catenifer pumilis*), western yellow-bellied racer (*Coluber constrictor mormon*), and San Diego night snake (*Hypsiglena ochrorhyncha klauberi*), and three lizards, the California alligator lizard (*Elgaria multicarinata multicarinata*), island fence lizard (*Sceloporus occidentalis becki*) and western side-blotched lizard (*Uta stansburiana elegans*), are known from the island.

Vegetation

Perennial native scrub and woodland with an understory dominated by native herbaceous plants as the predominant land cover, resilient to decadal shifts in climate regimes and global change.

- Landscape dominated by native scrub, chaparral and woodland
- Re-establishment of marsh vegetation at the mouths of the larger watersheds
- Stands of dominant woody plants recruiting with stable populations
- Rates of sedimentation in canyons at or below pre-European levels
- Stream flash-flooding during large storms less frequent and severe than the ranching era

Vertebrates

Populations of native terrestrial vertebrates that are robust, persistent, and influenced only by native perennial ecosystem elements and processes, to the extent practicable. Specifically, populations should:

- Not be threatened by non-native species
- Not be at low numbers due to past influence of non-native grazers on island vegetation
- Have recovered from previous lows commensurate with vegetation recovery
- Include the full complement of species occurring on the island prior to the ranching era, at viable population levels (carnivores, rodents, reptiles and amphibians, landbirds)

Current Condition and Trend

Vegetation Community Structure and Spatial Extent

Historical Vegetation Change

Scientific studies over the years point to rapid loss of vegetation, widespread erosion and conversion of land cover to barrens and non-native annual grassland brought on by ranching but with effects lasting well beyond feral animal removal. Effects were pervasive, affecting all levels of ecological organization, including individual species, plant communities and habitats, substrates and ecological processes, and plant-animal interactions. For example, Bishop pine regeneration failed in areas that had been moderately to severely grazed (Hobbs 1986), and there was no recruitment of understory shrubs in coast live oak (*Quercus agrifolia*) stands (Peart et al. 1994). Populations of several rare endemic taxa were so reduced in size and number that they became endangered (McEachern and Wilken 1996). Both Hochberg et al. (1979) and Van Vuren and Bowen (2012) showed that several species of island endemic plants (island big-pod ceanothus [*Ceanothus meagacarpus insularis*], island cherry [*Prunus ilicifolia lyonii*], northern island bush-poppy [*Dendromecon rigida harfordii*], mountain mahogany [*Cercocarpus betuloides blancheae*]) lack leaf defenses against herbivory when compared to their mainland relatives and disappeared rapidly, resulting in pronounced changes to community composition and structure. Brumbaugh (1980) observed that chamise (*Adenostoma fasciculata*), several buckwheats (*E. arborescens*, *E. grande*), and California sagebrush, although not plants shown to lack particular defenses, were especially damaged by sheep, probably because of their low stature and accessibility. Many woody plants became "arborescent" as sheep browsed leaves and twigs within reach (Bjorndalen 1978, Brumbaugh and Leishman 1982, Philbrick and Haller 1990), reducing shading and making the understory more xeric (Moody 1991). Leishman (1981) documented numerous effects on woody plants, including decreased numbers of flowers, seeds and seedlings, reduced basal sprouting, arborescence, erosion and general decline in health of individuals.

In 1938, Stanton, owner of 90% of SCI, estimated that 40 percent of the rangeland was occupied by dense stands of coast prickly pear cactus (*Opuntia littoralis*, *O. oricola*) and their hybrids, Goeden et al. (1967). In 1981, Van Vuren documented that plant communities/habitats across about one-half of the island suffered moderate to severe impacts from sheep grazing. These impacts included shifts to annual grass dominance, open canopy structure, eroded and invaded understory, native plant community fragmentation, and barrenness. Several researchers observed that coast sage scrub, in particular, was more susceptible to damage and loss than other upland woody plant communities. Brumbaugh and Leishman (1982) presented a photographic chronosequence showing that coastal sage scrub stands on south-facing slopes in the Central Valley were greatly reduced in size between 1929 and 1969, and gone completely by 1980. Brumbaugh and other authors (e.g., Junak et al. 1995) noted the loss of entire forests that once blanketed the Montanon Ridge (mixed oak woodland) and Sierra Blanca Ridge (Bishop pine woodland). Loss of plant canopies and root structure resulted in severe erosion. Brumbaugh et al. (1982) analyzed landslide scars visible on aerial photography, and found that landslide rates were most frequent in annual grassland, followed by coastal sage scrub and then oak chaparral and pine woodland. Although slope failures were fewer in woodlands, these slides were much larger, taking the form of debris avalanches that denuded slopes, scoured canyon bottoms and filled the mouths of drainages with deep sediments. These results are corroborated by others (Hochberg et al. 1979, Mertes et al. 1999, Van Vuren et al. 2001, Pinter and Vestal 2005, Anderson et al. 2010). Glassow (2009) documented an archaeological settlement site at the mouth of Pozo Canyon buried by deep sediments deposited during ranching times. Pinter and Vestal (2005) observed that removal of sheep resulted in decreased slumping and the response was quick, occurring in years rather than decades. Van Vuren et al. (2001) observed that loss of root structure lead to reduced water infiltration into the soil and episodes of sudden scouring stream flow in the first storms of the year. Such erosion and deposition have greatly altered the hydrologic functions of the islands.

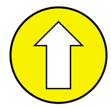
In addition to the grazing by livestock, the introduction of certain insects had cascading effects on island vegetation. For example, the introduction of European honeybees (*Apis mellifera*) to the island in the mid-1800s (Barthell et al. 1999, Thorp et al. 1994, Thorp et al. 2000) lead to displacement of native bees. Barthell et al. (1999) reported that honey bees were nearly the exclusive pollinators of the highly invasive yellow star thistle (*Centaurea solstitialis*), and that their exclusion dramatically reduced seed set. Thorp et al. (1994), and Barthell et al. (2001) suggest that honey bees and yellow star thistle became “invasive mutualists”, non-natives supporting each other in an altered ecosystem. From 1994 to 1997, honey bee colonies were located and destroyed and varroa mites (*Varroa destructor*), parasitic exclusively on honey bees, were introduced for biological control (Wenner et al. 2009). The last honey bees were detected in 2004, and the expectation is that star thistle has experienced lowered seed set and attrition of the seed bank. However, star thistle remains on the island and is a target of ongoing control efforts (C. Boser, TNC, personal communication 2014).

In a similar project, the leaf-mining cochineal insect, *Dactylopius opuntiae*, native to southern California, was introduced for cactus control in 1951 (Goeden et al. 1967). By the early 1970s, several predators of the cochineal insect, also native to California, reached SCI. In the decades prior to the advent of its natural predators the cochineal insect managed to greatly reduce cactus numbers. Since then, cactus decline has slowed, the cochineal insect and its predators are still present, presumably existing in a predator – prey network that may persist indefinitely (Goeden and Ricker 1980).

These studies depict an ecosystem that was changed abruptly across the entire island with the advent of ranching practices. In contrast to the activities of the Native Americans, ranching destabilized soils causing widespread erosion and alterations to hydrology (Glassow 1994). The result was a system vulnerable to invasions by non-native flora and fauna and highly sensitive to prolonged episodes of drought and flash flooding that accompany the periodic fluctuations in climate typical of the area.

Current Vegetation Condition and Trends

Condition = Moderate



Trend = Improving

There are several published maps showing the past distribution of island plant communities, including that by Minnich (1980) made on the basis of 1970 aerial photography, Jones et al. (1993) using 1984 color infrared and true-color aerial photographs, Cobb and Mertes (1999) coupling 1991 color infrared aerial photographs with 1993 Landsat thematic mapper imagery, and Cohen et al. (2009) with high-resolution natural color aerial photographs taken in 2005. These maps had varying degrees of quantitative sampling and ground checks to characterize and verify map accuracy, but they all reflect the general distribution of the vegetation just before and after final sheep and cattle removal. All of the maps show widespread grassland and barrens, with varying amounts of shrub and woodland cover. Table 4.3.1 shows the cover of generalized vegetation types from these maps. It is clear from these maps that vegetation cover has increased as annual grass has colonized barren areas, and that woody vegetation has begun to expand at stand boundaries to recolonize some areas of barrens and grassland.

Table 4.3.1. Percent land cover of major vegetation types on Santa Cruz Island for years of imagery, 1970, 1984, and 2005. Data from Minnich 1980, Jones et al. 1993, Cohen et al. 2009.

Vegetation Type	1970	1984	2005
Grassland	46.0	52.5	20.5
Coastal sage scrub	5.7	5.1	48.5
Chaparral	30.6	18.4	20.9
Woodlands	7.0	5.2	3.4
Pine	2.1	1.5	2.7
Riparian woodland	1.0	7.2	1.5
Woody exotic	0.2	0.3	0.1
Coastal bluff	NA	0.1	NA
Cactus	3.1	NA	NA
Barren	4.2	9.7	2.3

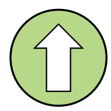
Considerable research has focused on describing patterns and mechanisms of vegetation recovery on SCI. Control-exclosure studies (e.g., Peart et al. 1994) were the first to indicate how fast woody plants could rebound from seeds and root sprouts in the absence of grazing. In 1986, Hobbs observed that sharp boundaries between coastal sage scrub and grassland were maintained by continuous feral animal activity, and that some native shrubs recolonized these ecotonal areas as soil compaction lessened and grazing became less intense. Yelenik and Levine (2009, 2010, 2011) found that seeds of two dominant coastal scrub plants, SCI buckwheat and California sagebrush, were abundant in such areas, yet recolonization differed between species and years in a complex interaction of soil nutrient availability, grass-shrub seedling competition and climate. They concluded that colonization rates were overwhelmingly correlated with rainfall compared to the other factors they studied. Repeat photography by L. Laughrin and P. Schulyer from the 1960s to the present (unpublished) shows exactly such episodic recruitment of woody plants into grasslands in years of above-normal rainfall. Van Vuren and Bowen (2012) showed, in contrast to Klinger et al. (2002), that exotic grasslands were invaded by native perennial grasses and shrubs at a single study site in Rams Canyon between 1980 and 1996. Similarly, Beltran et al. (2014) documented increased overstory shrub cover in Griffith Canyon between 1980 and 2012. Wehtje (1991) documented recovery of Bishop pines and understory woody perennials within four years of grazing cessation, and others have shown that the presence of maritime fog is key to that recovery (Fischer et al. 2009, Baguskas et al. 2014), and to carbon cycling in tree stands (Carbone et al. 2012). McEachern et al. (2009) recorded numerous new populations of the brittle, small-statured endangered island rush-rose (*Crocanthemum greenei*) in scattered open, but stabilizing, upland sites during 2006-2007 surveys. Beatty and Licari (1992) found that fennel failed to invade intact chaparral at the edges of dense fennel monocultures, whereas it did establish up to ten meters into adjacent open coastal sage scrub stands. After more than a decade of testing fennel control, Gliessman (Dash and Gliesman 1994) observed that most treatments opened fennel areas to further exotic grass and weed colonization, replacing one problem with another. He concluded that it may be best to allow the slow increase in native coastal sage scrub plants apparent after sheep removal from the Central Valley to continue in the fennel stands without further disturbance. Alternatively, if quick results are needed, Power et al. (2014b) found that hand-application of herbicide followed by native seedling plantings can accelerate native recovery within fennel stands.

The Nature Conservancy and CINP have used past research to guide restoration efforts. McKnight et al. (2007) conducted a comprehensive invasive weed survey, the basis for an ongoing weed control program run by the two agencies. In a holistic approach to watershed restoration (Power et al. 2015), sediment and construction fill was removed from the mouth of Cañada de la Puerta at Prisoners Harbor for wetland recovery. In 2013 nearly 14,000 exotic eucalyptus were removed from the lower one-third of the drainage to restore groundwater flow to the wetland; future plans call for eventual removal of the entire eucalyptus forest over its entire reach in the lower canyon. Native scrub habitat was restored to Scorpion Rock (Adams et al. 2014) for seabird conservation, a project now in the maintenance and monitoring phase. McEachern et al. maintain a rare plant monitoring and restoration program (McEachern and Wilken 2009) that includes the nine federally listed taxa of SCI. Surveys showed that nearly two-thirds of the populations of these plants known from historic collections still exist. However, they persist as isolated occurrences of 1 to 8 small native populations each.

Demographic and habitat monitoring has shown that taxa spanning a range of conditions from the highly endangered island barberry (*Berberis pinnata* var. *insularis*), to the island rush-rose appearing in greater numbers now that grazing and trampling animals are removed (McEachern and Wilken 2011). Further restoration includes outplantings of 10 new populations of the Santa Cruz Island bush-mallow (*Malacothamnus fasciculatus nesioticus*) and three new populations of Hoffmann's rock-cress (*Bochera hoffmannii;* McEachern et al. 2010). Ongoing research (McEachern unpublished, USFWS 2009a, b, c, 2010a, b, 2011, 2012) shows that major constraints on recovery include small population sizes and extreme isolation, competition from non-native plants, loss of native overstory structure, soil compaction and erosion, and altered climate regimes.

Vertebrate Abundance

Condition = Good



Trend = Improving

Herpetofauna

Overview – Little is known about any of the herpetofauna on Santa Cruz Island. Two of the species historically known from the island— the California red-legged frog and San Diego night snake—are known from specimens collected over 70 years ago, and probably no longer inhabit the island (California Herps 2016). The eight other native species recorded from Santa Cruz can still be found on the island, but their numbers and distributions are unknown, though some recent work has been done on the Santa Cruz Island gopher snake.

Santa Cruz Island Gopher Snake - Very little is known about use of habitat by SCI gopher snakes, which occur on both SCI and SRI. It is thought to be a habitat generalist, like its mainland relatives. According to Laughrin (1982, as cited in Jennings and Hayes [1994]), it is found in all vegetation types on the island, but is most common in open areas such as grasslands, dry streambeds and oak and chaparral woodlands.

Santa Cruz Island gopher snakes were prey for feral pigs, and so the recent removal of feral pigs from SCI likely had beneficial effects on gopher snakes, as did the earlier removal of feral pigs from SRI. Gopher snakes were also consumed by golden eagles (*Aquila chrysaetos*) when the eagles bred on the islands (in the mid-1990s to 2006; Collins and Latta 2009). The relocation of golden eagles for the benefit of island foxes (Coonan et al. 2010) likely also reduced predation pressure on gopher snakes.

Landbirds

Island Scrub-jay - Island scrub-jays primarily occupy oak habitat on SCI, though some occur in 3 distinct stands of Bishop pine. A recent effort to estimate habitat-specific abundance of island scrub-jays (Sillett et al. 2012) used distance-sampling data from 300 point count stations to elucidate habitat factors important to jays, and extrapolated density and population estimates island-wide via spatial analysis. The study found that jays were largely confined to chaparral and forest, in larger canyons and along hillsides. Jays were most abundant in continuous oak chaparral at upper and middle elevation areas; sparser chaparral and mixed chaparral-bishop pine woodlands had lower densities of jays. The environmental factor having the most influence on jay abundance was cover of chaparral or forest. The estimated island-wide population size was approximately 2300 jays based on fall 2009 sampling data.

To investigate likely changes in jay abundance over time, the authors applied habitat specific jay densities estimated from the 2009 sampling data to an island vegetation map from 1985. Jay abundance was estimated to have been 20-30% less in 1985, and the increase in jay abundance over time is likely due to vegetation recovery following removal of domestic sheep in the 1980s. The study also summarized seasonal differences in jay use of habitat. Jays hold and defend territories during the breeding season, with the highest-quality jay territories located on lower hill and canyon slopes with tall and continuous cover of oaks and other chaparral species. The high-quality habitat occurs primarily on north-facing slopes; south-facing slopes tend to have lower density of oaks and greater occurrence of grasses and *Artemisia* spp. In fall, jays shift to gathering and caching acorns in oak chaparral, and territory defense relaxes somewhat. Fall population estimates are higher than in spring, due to the presence of hatch-year birds in fall, and the increased frequency of vocalizations and interactions.

The authors point out that the high-quality oak chaparral habitat on the north-facing slopes of SCI's central valley essentially served as a refugium for jays during the ranching era. Dense cover seems to be essential for successful jay breeding. A study of island scrub-jay reproductive ecology (Caldwell et al. 2013) found nest predation to be the most important influence on jay reproductive success. Nest predation occurred at over 90% of jay nests, but was less likely at nests in denser vegetation. Species responsible for nest predation included the scrub-jay, island fox, Cooper's hawk (*Accipiter cooperii*), common raven (*Corvus corax*), and gopher snake. High occurrence of re-nesting allowed jays to achieve reproductive success, and the authors suggest that further recovery of chaparral habitat could improve and increase breeding habitat for the scrub-jay.

In general, scrub-jay abundance is closely linked to the abundance of mast crops, specifically oak acorns and pine nuts. Because of substantial interannual variation in mast production, particularly among oaks, jays in areas with asynchrony among mast production in different oak species may have more consistent access to food resources, and jay abundance has been associated with previous year's mast production (Koenig et al. 2009). This is currently being investigated on SCI, where preliminary studies show substantial interannual variation and asynchrony, including spatial asynchrony, in mast production between island scrub oaks (*Quercus pacifica*) and coast live oak (*Q. agrifolia*; Sillett et al. 2013). Island scrub-jays may depend more on island scrub oaks, because they are more reliable annual acorn producers than are coast live oaks, which have a 2-year mast cycle (S. Sillett, Smithsonian Institution, unpublished data).

Orange-crowned Warbler – The dusky orange-crowned warbler (*Oreothlypis celata sordida*) occurs on six of the Channel Islands (San Miguel, Santa Rosa, Santa Cruz, Anacapa, Santa Barbara and Santa Catalina Islands), as well as parts of the adjacent mainland. Habitat use by orange-crowned warblers on the islands differs somewhat from habitat use on the mainland (Gilbert et al. 2010). Mainland habitat comprises low hills with a mixture of broadleaf evergreen (oak) and brushy, open areas. On the islands, orange-crowned warblers are thought to inhabit humid and shady sites on hill-slopes, canyons, gullies and sea-cliffs, in a variety of vegetation types (chaparral, pine, mixed or oak woodland, coastal bluff and coastal sage scrub).

Because the islands on which orange-crowned warblers occur differ in vegetation composition, habitat preference by orange-crowned warblers may differ by island as well. Coonan et al. (2011) studied habitat use by 15 species using point-count data from San Miguel, Santa Rosa, Anacapa and Santa Barbara Islands. Tests of proportional occurrence versus proportional availability showed that orange-crowned warblers preferred scrub on all islands, while avoiding riparian, bluff, grassland, woodland, pine and iceplant habitats.

The threat of predation also affects habitat use by insular orange-crowned warblers, and this differs by islands, since the suite of predators varies (Table 4.3.2). Mainland orange-crowned warblers are ground-nesters, but insular orange-crowned warblers nest in shrubs and trees, as well as on the ground, with choice likely driven by perceived predation threat. Nest concealment is critical on SCI, where orange-crowned warblers co-occur with island scrub-jays, a visually-oriented nest predator. On that island, average nest height was lower (and presumably more concealed) and incubation visitation rate lower than on Santa Catalina Island, where the island scrub-jay does not occur (Peluc et al. 2008, Sofaer et al. 2013). Only 10% of SCI nests were in oaks, compared to 29% on Santa Catalina, and the vast majority of nests on both islands were in woody shrubs.

Table 4.3.2. Potential predators of insular orange-crowned warblers (*Oreothlypis celata sordida*) on the Channel Islands.

Predator	San Miguel	Santa Rosa	Santa Cruz	Anacapa	Santa Barbara	Santa Catalina
Santa Cruz Island gopher snake	–	X	X	–	–	X
Island scrub-jay	–	–	X	–	–	–
Deer mouse	X	X	X	X	X	X
Island fox	X	X	X	–	–	X
Island spotted skunk	–	X	X	–	–	–
Feral cat	–	–	–	–	–	X

Santa Cruz Island Rufous-crowned Sparrow - The SCI rufous-crowned sparrow is an endemic subspecies restricted to SCI and AI (Collins 2008a). The subspecies is known to prefer moderate to steep rocky slopes with grasses interspersed with clumps of low shrub vegetation. On SCI the bird inhabits coastal-bluff, coastal sage and open coyote-brush scrub, with prime habitat comprising grassy hill slopes and canyon walls with scattered bushes or clumps of cactus (Collins 2008a). Heavy grazing on SCI likely reduced the amount of grassland/coastal sage habitat for rufous-crowned sparrows (Van Vuren and Coblentz 1987), and recovery following sheep removal has likely increased breeding habitat for the sparrow (Collins 2008a). This sparrow may require disturbance, in the form of fire or even light grazing, to prevent habitat from becoming too dense (Shuford 1993, as cited in Collins 2008a).

The rufous-crowned sparrow is difficult to detect via traditional landbird monitoring, which typically does not occur on steep slopes or ravines, and via acoustic monitoring; the species is shy and secretive and its song is easily overwhelmed by other more vocal species (McKown et al. 2011). A walking survey of part of the Scorpion drainage on SCI in March 2007 recorded 6 pairs of rufous-crowned sparrows and two individuals, all in typical habitat for the species: rocky slopes vegetated with a mixture of grass and shrubs.

Song Sparrow - The insular subspecies of song sparrow (*Melospiza melodia graminea*) occurs on the Channel Islands and on Isla Los Coronados, Baja California, although song sparrows inhabiting SCI are thought to be hybrids of *graminea* and the adjacent mainland subspecies, *M. m. hermanii* (Arcese et al. 2002). Song sparrows are among the most widespread and diverse of North American birds, and inhabit a wide variety of habitat types. All of the many (20+) subspecies throughout North America occupy shrubs on moist ground along streams, sloughs, marshes, or coastlines. On San Miguel Island (SMI), for example, song sparrows are most abundant in areas with dense shrubs, not necessarily near water (unlike mainland birds), perhaps due to the availability of considerable fog-moisture on the islands (Sogge and van Riper 1988). A recent study of bird habitat use and preference on the islands showed that song sparrows preferred scrub and grassland on SMI and SRI (Coonan et al. 2011).

Island Loggerhead Shrike - Island loggerhead shrikes are an endemic subspecies of loggerhead shrike, and presently occur on Santa Catalina, SCI and SRI; they formerly occurred on SMI and AI, but disappeared from those islands by 1976 and 1978, respectively (Collins 2008b, Caballero and Ashley 2011). Santa Cruz is considered by some to have abundant, high quality shrike and coastal sage scrub in particular. The well-spaced shrubs interspersed with native bunchgrasses and low-lying forbs, should provide ideal habitat for shrikes on that island (P. Collins, Santa Barbara Museum of Natural History, personal communication to L. Dye of CINP). Hall and Kuehn (2012) investigated island shrike habitat use and selection using data from recent island shrike and landbird surveys on Santa Rosa and SCI. They found that shrikes used coastal sage scrub, grassland, *Baccharis* and toyon-dominated vegetation on both islands, as well as areas with less bare ground on SCI. Shrikes avoided xeric shrubland, ironwood, dunes and fennel on SCI. However, micro-habitat or fine-scale habitat may be relatively more important than simple habitat associations for shrikes; they are generally known to hunt from elevated perches, and are less successful hunting in thick vegetation, especially thick non-native grasses (Collins 2008b, Hall and Kuehn 2012). On the islands, shrikes typically inhabit grassland and open coastal sage scrub on terraces and in canyons (Collins 2008b).

Given these aspects of shrike habitat use, the possibility of habitat change following ungulate removal has been proposed by some as the reason for the currently low numbers of shrikes on the islands, particularly on SCI. Sheep were removed from the western 90% of SCI by 1988 and pigs by 2006. A petition to list the island shrike as endangered (Walter 2006) cited impacts to shrike habitat from growth of non-native grasses following removal of ungulates on the northern Channel Islands.

More recently, Stanley et al. (2012) suggested that vegetation recovery may not be beneficial for island shrikes, citing a suggestion by Lynn et al. (2006) to improve habitat for endangered San Clemente loggerhead shrikes by removing stands of tall, thick grass. However, vegetation recovery eventually results in additional shrike perches (trees and tall shrubs). Whether these ungulate removals have resulted in decline in suitable habitat for shrikes remains unknown.

It remains unclear as to whether habitat quality has decreased substantially following removal of grazers, and whether other factors, such as predation, may better explain low shrike numbers. The role of predation in limiting island shrike populations is currently unknown. The suite of potential shrike nest predators includes island foxes, island spotted skunks, common ravens and Santa Cruz Island gopher snakes.

Mammals

Deer Mice - Limited deer mouse monitoring or research has occurred on SCI (Schwemm 2009, Mayfield et al. 2000, Drost et al. 2009), compared to other Channel Islands. Mayfield et al. (2000) found mice to prefer habitats with woody vegetation (chaparral, oak woodland and coastal sage scrub) and to avoid habitats dominated by herbaceous vegetation (grassland and fennel-grassland). They suggested that removal of sheep from the island during the 1980s allowed native scrub cover to increase on SCI and this continued recovery would increase habitat quality for deer mice. However, they also cautioned that invasion of grasslands by fennel would not be beneficial for deer mice. Mayfield's study was restricted to one year, however, and island mice are notorious for interannual variation in population numbers (Drost and Fellers 1991, Coonan 2013). Longer-term mouse studies would likely shed more light on deer mouse habitat affinities on SCI. Drost et al. (2009) point out that deer mouse numbers on SCI are lower than on other islands in the archipelago, and that may be due to the lingering effects of sheep and pig presence on the island.

Harvest Mice - Harvest mice inhabit dense grass and herbaceous vegetation. Drost et al. (2009) conducted extensive surveys for harvest mice on SCI, and summarized habitat affinities for the species on the island. Although prior surveys found harvest mice at the Prisoner's Harbor marsh area, Drost et al. (2009) found increased numbers of harvest mice at many other locations, including other drainages and even upland areas, and attributed this to increase in habitat quality due to removal of feral sheep.

Drost et al. (2009) found harvest mice at 8 of 20 sampling locations, with the highest abundance at Prisoner's Harbor, in marsh, pasture and riparian habitat. At most sites the microhabitat consisted of dense herbaceous vegetation. Preferred habitat included back-beach/marsh edge habitat, wet grassland, and weedy edge habitats. Harvest mice generally avoided non-native pasture, dry grassland, coastal sage scrub, and any habitats with a closed tree overstory. The authors also found harvest mice in the tall, dense moist grasses in lower Scorpion Valley, and suggest that harvest mice might be found in similar areas in the mouths of other large drainages on the island. Harvest mice were found in some upland areas, in tall, thick grasslands or in coastal scrub with intermixed grass and herbaceous vegetation, often in gullies that were wetter and denser than surrounding shrubs. Moist microhabitats used by harvest mice included low boggy areas where ryegrass had replaced non-native wild oats and bromes.

Restoration of the marsh and wetland at Prisoner's Harbor is likely to increase habitat for harvest mice. Drost et al.'s survey work preceded the more recent removal of feral pigs from the island, and he anticipated further increase in harvest mouse numbers as native island vegetation recovered from the impact of feral pigs.

Island Fox - As generalist predators, island foxes show less habitat preference than other species and are found in every habitat type on SCI, SRI and SMI (Moore and Collins 1995, Coonan et al. 2010). Island foxes may show habitat preference under two conditions. First, island foxes may prefer certain habitats when populations are at low densities, when lack of competition allows it (Drake 2013). At high densities foxes may occupy all habitat types. Second, habitat preference may occur on larger islands, which are more topographically diverse, and have greater diversity in habitat types and thus habitat-specific differences in food availability (Laughrin 1977). Conversely, on smaller, low-lying islands, there are fewer habitat types and fewer differences in prey/food availability among them, and fox densities may be more equitable. However, this may not be true. Sanchez (2012) found wide differences in fox density among the few habitat types on relatively flat, less diverse San Clemente Island.

Few studies have addressed island fox habitat use and preference directly. Drake (2013) used GPS collars to study habitat use and preference of male island foxes on SRI, under low density conditions. She found island foxes had larger home ranges at low density (compared to the smaller home ranges found by Roemer (1999) under high density conditions on SCI) and there was very little habitat preference, even at low density. Foxes used most of the available habitat types, with no significant selection for any one type. However, there was selection according to topography. Overall, foxes avoided ridgetops and selected for valley bottom topography. At night they selected for bare areas and grassland, both of which are probably easier to travel through (foxes are often observed using roads at night, for their ease of travel).

Because Santa Cruz is a larger island with substantial topographic and habitat diversity, island foxes likely prefer some habitat types over others. In particular, island foxes may prefer woodland communities over grasslands on SCI. Laughrin (1971, 1977) found Santa Cruz Island fox densities highest in chaparral and woodland, which he attributed to higher food resources. Roemer (1999) also found foxes to be most abundant in SCI woodland and shrub communities.

Island fox diet studies underscore the importance of food resources in woodland habitat, especially on SCI. Island foxes have a generalist omnivore diet, with foxes selecting what is available seasonally and in the area (Moore and Collins 1995, Cypher et al. 2011). Thus, fox diet differs on the six islands, according to food availability, with larger islands having more diverse food resources. For example, in a yearlong study of fox diet on all six islands, few plant items were relatively important in the diet of the San Miguel island fox, except for non-native iceplant (*Carpobrotus* spp.) (Cypher et al. 2011). However, on Santa Cruz, manzanita (*Arctostaphylos* spp.) occurred in 48% of fox scats, while toyon (*Heteromeles arbutifolia*) occurred in 31% and summer holly (*Comarostaphylis diversifolia*) in 17%. Results from previous studies (Laughrin 1977, Crooks and Van Vuren 1995) underscore the importance of manzanita in summer and toyon in winter. Laughrin found that in summer and fall, manzanita comprised ¾ of the food eaten by Santa Cruz Island foxes, and that portion was replaced by toyon in the winter.

Ongoing research should clarify habitat preference for both foxes and skunks on SCI (Dillon 2013). Population monitoring for both foxes and skunks is accomplished through annual trapping on 18 small “ladder” grids on SCI (Figure 4.3.4). Because each trapping grid can be assigned to a habitat type or mix of types (The Nature Conservancy 2007), fox and skunk trapping data can be integrated with vegetation cover class data to investigate relative abundance of both species in different habitat types. This can also be done for SRI when current vegetation mapping is complete, because foxes on that island are also monitored on small trapping grids which can be assigned to habitat type.

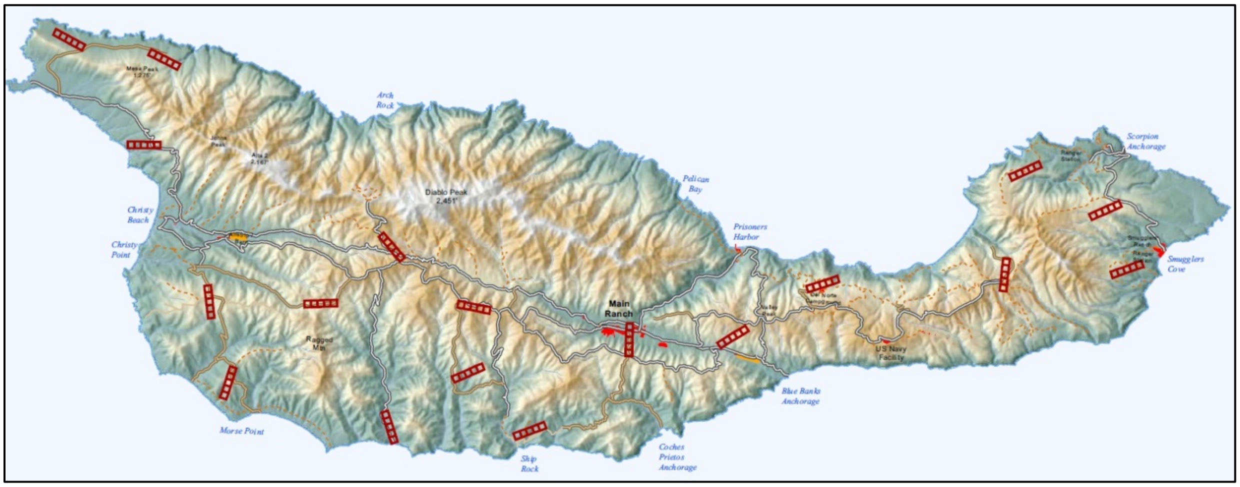


Figure 4.3.4. Location of 2 x 6 trap "ladder" grids used for island fox population monitoring on Santa Cruz Island (Rubin et al. 2005).

Island Spotted Skunk - Jones et al. (2008) compared island spotted skunk habitat use at both low and high densities. They compared skunk habitat use in 1992, before island fox decline caused competitive release of skunks, and in 2003-2004, when skunks were up to 30 times more abundant. The relationship between island foxes and island spotted skunks can be characterized as interference competition, in which one competitor (the fox) limits or prevents access of the other (the skunk) to shared resources. There is substantial niche overlap between the fox and the skunk, though the fox is thought to be the superior competitor (Crooks and Van Vuren 1995, Roemer et al. 2002). At low density, in 1992, skunks preferred ravines with coastal sage scrub (originally reported in Crooks and Van Vuren 1995). In 2003-2004 skunks used a wider variety of habitat types and were relatively generalized in their habitat use. If anything, they were more likely to avoid open habitat types such as open grassland. At higher density, skunks may have been forced into less-preferred habitat types.

Jones et al. (2008) sought to determine whether vegetation recovery following removal of sheep played a role in skunk population increases on SCI. They concluded that vegetative re-growth was a long-term process that could not adequately account for the irruption in skunk numbers, though there were modest shifts in habitat use and diet. Interestingly, at low island fox densities skunks used den sites in less-protected areas, compared to den site use in 1992 (reported in Crooks 1994), and female skunks were more diurnal during the dry season. Both of these findings imply skunks were released from interference competition by foxes, which are known to occasionally kill skunks (Coonan et al. 2010). This is further supported by the concurrent increase in island spotted skunks on neighboring SRI, when the island fox population declined by over 95% in the late 1990s (Coonan et al. 2010).

Compared to the generalist island fox, island spotted skunks were previously thought to be more specialized in their diet, having a carnivorous diet of mainly deer mice and insects (Crooks and Van Vuren 1994). Jones et al. (2008) found skunks to be more omnivorous, shifting from a mouse-centric diet in 1992 to one focused on invertebrates, other vertebrates, and even plant material in 2003-2004. The shift may be partly due to changes in mouse abundance, which was especially high in 1992. Skunk diet in 2003-2004 consisted primarily of invertebrates, particularly Jerusalem crickets (*Stenopalmatus*), vertebrates such as lizards, lizard and bird eggs, and some plant material (non-native cheeseweed, [*Malva parvivflora*], native Santa Cruz Island manzanita [*Arctostaphylos insularis*], and non-native bursage [*Medicago polymorpha*]).

NRCA Team Data and Methods

Vertebrate Abundance

Landbirds

In the early 1990s, 100 landbird point count monitoring sites were established on SCI by Robert C. Klinger, then of TNC. The points were established off of the island's unimproved road system (Figure 4.3.5), and were identified to habitat type (Table 4.3.3). The point count sites were surveyed from 1991-2003, and then by NPS in 2013-2014 (Dye and Coonan 2014a, b).

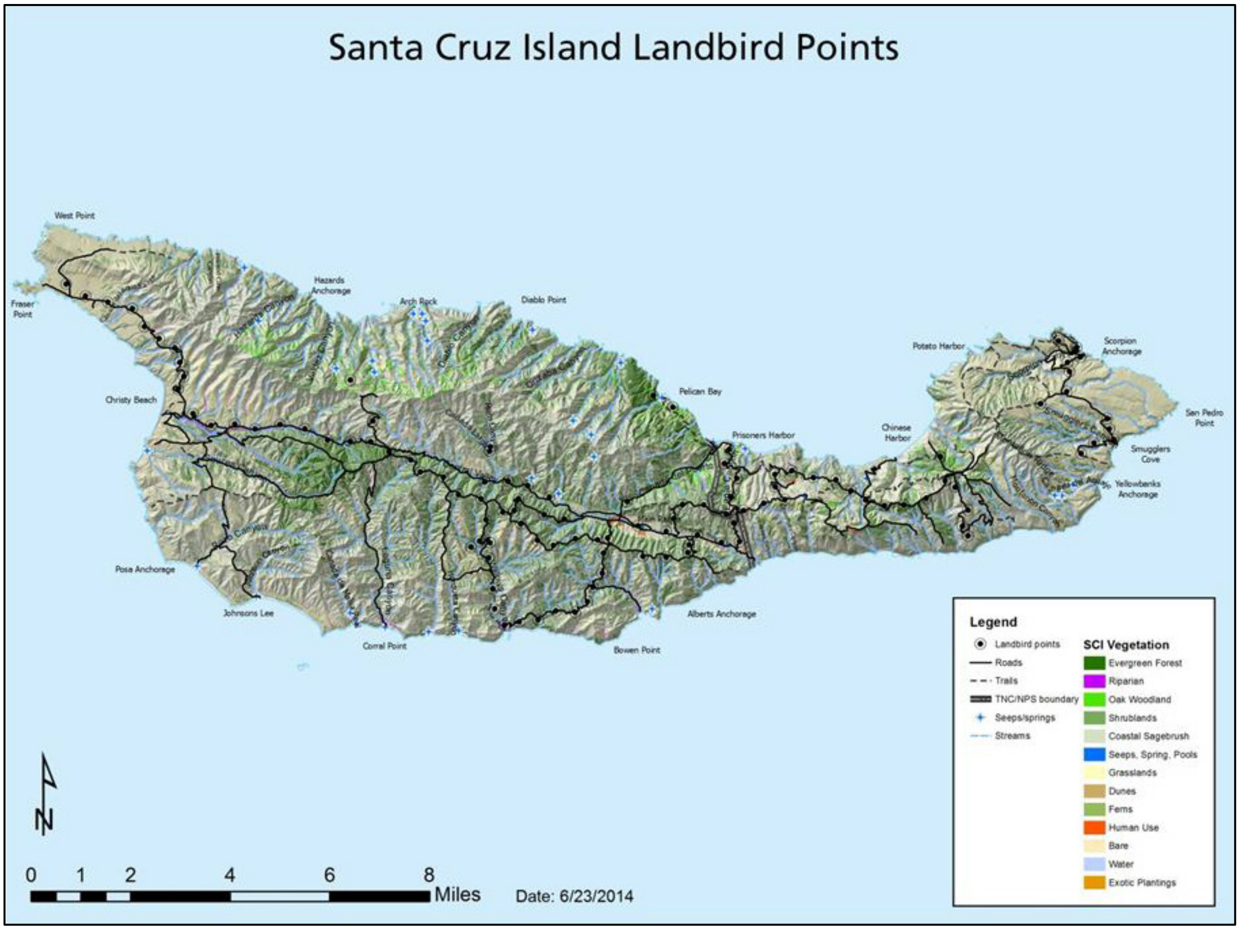


Figure 4.3.5. Location of 100 landbird point count monitoring sites on Santa Cruz Island.

Table 4.3.3. Number of point count sites on Santa Cruz Island, by habitat type.

Habitat type	Number of sites
Chaparral	29
Coastal sage	8
Fennel	12
Grassland	37
Oak woodland	11
Pine	3
Total	**100**

For some SCI landbird species, we were able to compare abundance data for this NRCA from the 100 points from the earlier time period (1991-1995) with data from those same 100 points in 2013-2014 (Dye and Coonan in press, T.J. Coonan, NPS, unpublished data). We tallied both annual numbers observed at the 100 points, and abundance (birds/station) in different habitat types.

NRCA Team Results

Vertebrate Abundance

Landbirds

Orange-crowned Warblers - Habitat utilization by orange-crowned warblers has not been specifically studied on SCI, but long-term monitoring data suggests that habitat quality has increased considerably on SCI. Analysis of data from the point count sites indicates that abundance of orange-crowned warblers has increased, and their distribution has changed since point count sampling began in the early 1990s. Warbler abundance increased overall from 1.6 to 6.5 birds/station between the two time periods (1991-1995 and 2013-2014), and their abundance increased in every habitat type, except pine (Figure 4.3.6). Sites identified as a certain habitat type when they were first established may have shifted some as there appears to be an overall increase in habitat quality (i.e., increasing native scrub recovery) island-wide, since the removal of sheep in the 1980s and feral pigs in the 2000s. The elimination of non-native gazers and consequent increase in shrub and herbaceous cover would provide greater protection from predation for breeding orange-crowned warblers.

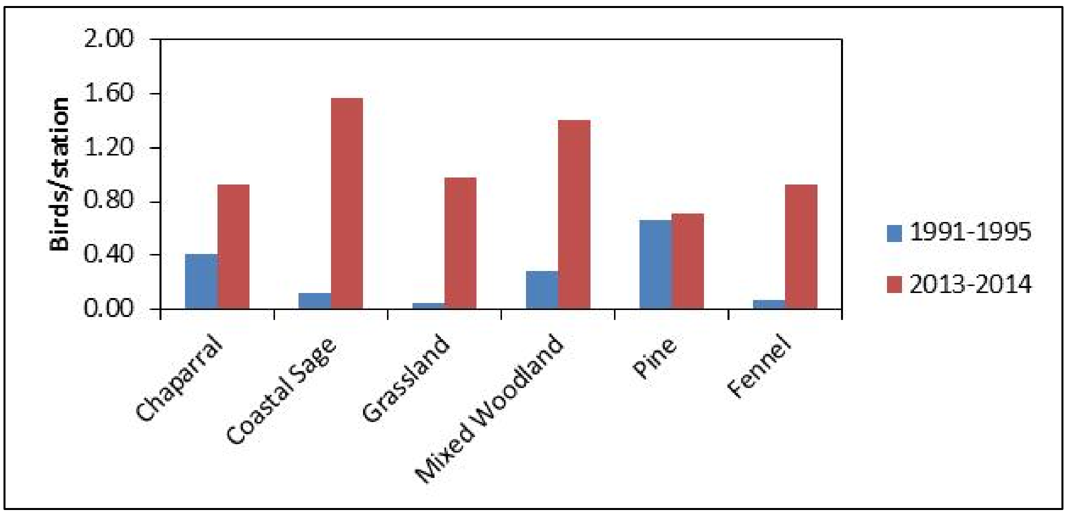


Figure 4.3.6. Average abundance of orange-crowned warblers (*Oreothlypis celata sordida*) in different habitat types on Santa Cruz Island (R. C. Klinger and T. J. Coonan, unpublished data).

Santa Cruz Rufous-crowned Sparrow - Rufous-crowned sparrows have been detected on point count surveys by R. Klinger, USGS, in 1991-1995, and by current NPS landbird monitoring in 2013-2014. However, their abundance did not increase over time (Figure 4.3.7). Their abundance was 0.58 birds/station in the early 1990s, and 0.44 birds/station in 2013-2014. Observations in the 1990s recorded an unusually high abundance of the sparrows in oak woodland, while recent observations recorded more of the sparrows in grassland, their preferred habitat type. One caveat is that none of the 100 point count sites were located on East SCI, which is known to harbor rufous-crowned sparrows (see above; rufous-crowned sparrows were found during surveys on East SCI in 2011 [McKown et al. 2011]). Thus, it is unclear whether rufous-crowned sparrows have increased or decreased following removal of grazers.

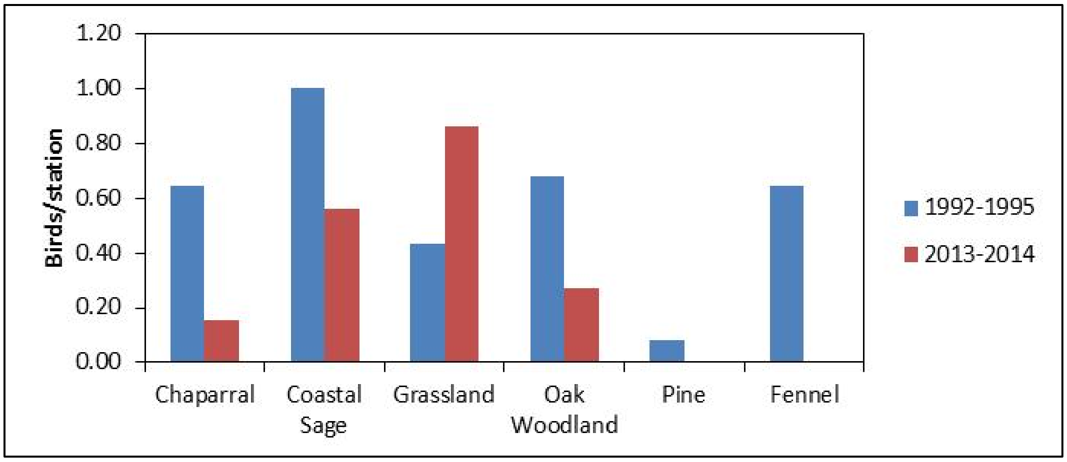


Figure 4.3.7. Abundance by habitat type of rufous-crowned sparrows (*Aimophila ruficeps obscura*) on 100 point counts sites on Santa Cruz Island, 1992-1995 and 2013-2014.

Song Sparrow - Data from point count surveys suggest that song sparrow numbers have increased markedly since the early 1990s (Figure 4.3.8), likely as a result of habitat improvement following removal of domestic sheep in the 1980s and feral pigs in 2006. Abundance by habitat type shows increases in all habitat types except chaparral and pine (Figure 4.3.9). However, the habitat-based differences should be interpreted cautiously, as the dominant vegetation at some sites may have changed over time.

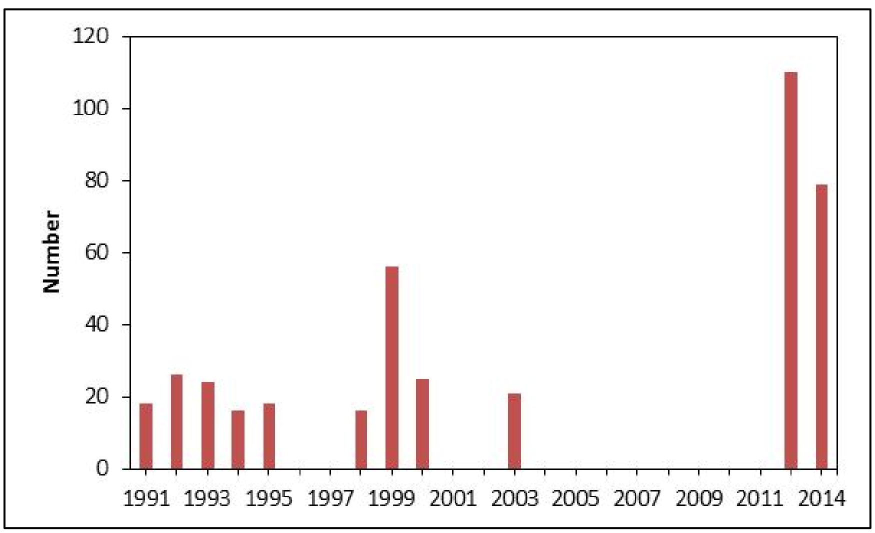


Figure 4.3.8. Number of song sparrows (*Melospiza melodia graminea*) recorded at 100 point count sites on Santa Cruz Island.

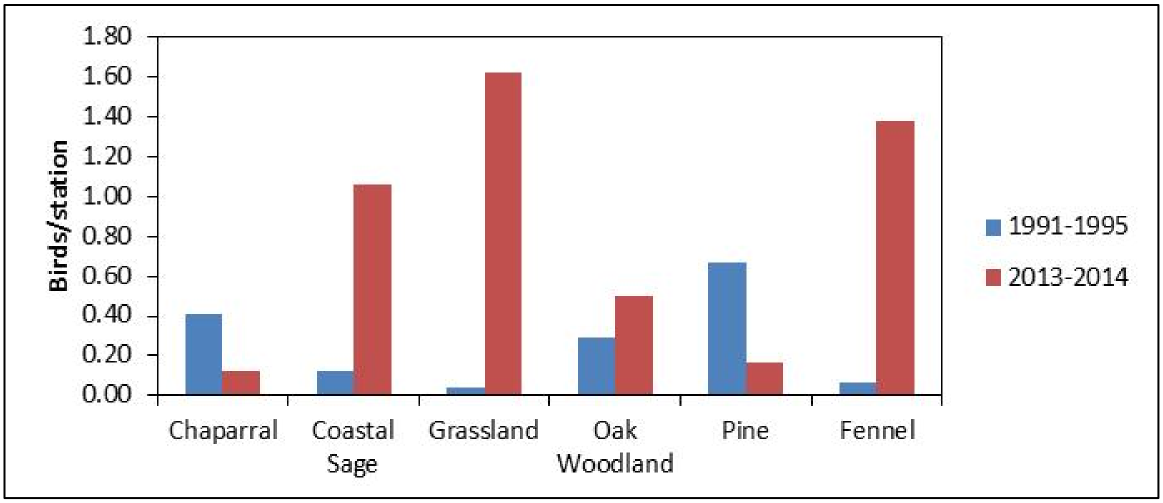


Figure 4.3.9. Abundance of song sparrows (*Melospiza melodia graminea*) in different habitat types on Santa Cruz Island, from the early 1990s and in 2013-2014.

Threats and Stressor Factors

Vegetation Community Structure and Spatial Extent

The vegetation of SCI is rebounding from past ranching, with lingering effects including altered species composition, non-native invasions and habitat fragmentation. Loss of vegetation cover has resulted in erosion and mass wasting (landslides or other movements of large amounts of rock and soil) that threatens to continue as infrequent large storms pass through the area in the future. Research has identified stressors that slow or prevent recovery including poor recruitment and continued loss of plants from populations, competition from invasive plants, mutualisms with exotic animals that foster dominance of exotic plants, and disruption of ecological networks. Many of these studies offer suggestions for recovery actions that could be taken, and still other studies demonstrate that island vegetation has an enormous innate capacity for passive recovery. Observations (K. McEachern personal observation, S. Junak personal communication, L. Laughrin personal communication) indicate that both active and passive recovery occur more rapidly during times of higher rainfall and in areas subjected to consistent summer fog.

Vertebrates

With non-native herbivores removed, and golden eagles no longer nesting, there are few existing threats to vertebrates on SCI. Of course, global climate change will have as-yet-undetermined effects on island species. Of particular concern is that increased temperatures (Li et al. 2014) could allow West Nile Virus (WNV) replication in mosquitoes on SCI. The establishment of WNV on Santa Cruz would threaten the endemic island scrub-jay (Morrison et al. 2011); corvids also are especially susceptible to WNV (Komar 2003).

Data Gaps

Vegetation

Numerous studies cited in this chapter show that vegetation recovery is uneven across the landscape, with slowest regrowth on steep and xeric slopes with thin to no soil. Information is needed to identify mechanisms for stabilization of such sites, particularly those that may be susceptible to continued mass wasting. The bishop pines are showing drought stress and populations are losing individuals; monitoring is needed to show the capacity of populations to recover unassisted as climate fluctuates. Plans are underway to sample and map vegetation in 2015, filling a gap to show vegetation condition post pig eradication. Continued monitoring is needed for early detection of new invasive plants, and to verify success of ongoing pest plant control efforts.

Vertebrates

The primary vertebrate data gap concerns the island loggerhead shrike, which exists at critically low population levels on the island (as few as 40 individuals; see Stanley et al. 2012). The reasons for these low numbers are entirely unclear. Island shrike numbers could be affected by habitat changes following grazing, or by predation. The park has thus far been unsuccessful in obtaining funding for a comprehensive study of shrike demographics that would investigate the cause of low reproductive success or survival.

There is also a noticeable data gap concerning the distribution and abundance of the herpetofauna on Santa Cruz Island. Although there are records of at least eight species of amphibians and reptiles on Santa Cruz, there were no reliable estimates available on the current population size or distribution of any of these. Likewise, there is little known about the population dynamics and distribution of the two native mice species on Santa Cruz.

Overall Condition

Vegetation

SCI is in a stage of rapid ecological change following sheep and cattle removal and native plant recovery is variable across the landscape in response to the interplay of terrain, maritime exposure and climate. The potential for recovery to a mosaic of diverse native woody vegetation with an understory of non-native and herbaceous vegetation seems high, with some areas recovering faster than others. Coastal sage scrub and riparian vegetation appear to be the native plant communities recovering most rapidly, along with pine and oak woodland in some places. However, woodland and scrub vegetation remain fragmented on much of the south side of the island. Mature oak woodlands have yet to return to the Montanon Ridge, and Bishop pine forests to the Sierra Blanca highlands where they were lost to grazing and erosion. Steep slopes with sparse vegetation remain at risk of mass failure with storm events well into the future. Dense fennel stands still occupy areas of the Central Valley and Christy Ranch area. Woodland understories are dominated by non-native herbaceous plants, mainly annual grasses. Some endemic species that suffered dramatic losses are rebounding while others are not. Thus, it appears that SCI is moving naturally toward a landscape dominated by native scrub, chaparral and woodland that retains annual grassland openings and non-native understory. Whether and how quickly ecosystem properties will come to mimic those operating before ranching is unknown, in part because we really have no good record of what those conditions were like. More likely, new ecological interactions already developed will influence further development toward an island ecosystem balancing non-native and native species into the distant future.

Vertebrates

Populations of terrestrial vertebrates on SCI are, for the most part, robust, as many species have benefited tremendously from the ecological changes wrought by removal of domestic sheep and feral pigs. These benefits are seen most directly in comparison of birds detected at a series of 100 point counts in the early 1990s and in 2013-2014. Both song sparrows and endemic orange-crowned warblers occur at higher numbers now, after removal of non-native ungulates. Harvest mice are also found at higher numbers now, and in more sites, than prior to removals. And although no direct evidence exists, deer mice and island scrub-jays likely benefited from ungulate removal and subsequent recovery of chaparral, forest and coastal sage scrub habitat.

Other vertebrates have likely benefited from ungulate removal (in terms of habitat quality) but were more influenced in the past several decades by other ecological processes, such as predation. Island foxes declined in the 1990s due to predation by golden eagles (facilitated by the availability of feral pigs) and have since recovered, due to captive breeding/reintroduction and the relocation of golden eagles. Island spotted skunks, a competitor of the fox, increased when foxes declined and have subsequently declined as foxes recovered.

The critically low population level of island loggerhead shrikes remains unexplained, and worthy of further study; possible causes include both habitat considerations and predation. Other species (such as Santa Cruz Island gopher snakes) have not been adequately surveyed or studied, and at least one other species (rufous-crowned sparrow) remains difficult to survey.

Sources of Expertise

Vegetation

- Kathryn McEachern
- U.S. Geological Survey, Western Ecological Research Center, Channel Islands Field Station

Vertebrates

- Tim Coonan
- National Park Service

4.3.3. Literature Cited

Adams, J., D. Mazurkiewicz, and A. L. Harvey. 2014. Population monitoring and habitat restoration for Cassin's Auklets at Scorpion Rock and Prince Island, Channel Islands National Park, California: 2009–2011. Interim Data Summary Report. U.S. Geological Survey, Western Ecological Research Center, Santa Cruz Field Station, Pacific Coastal Marine Science Center, Santa Cruz, California. 56 pp.

Anderson, R. S., S. Starratt, R. M. Brunner-Jass, and N. Pinter. 2010. Fire and vegetation history on Santa Rosa Island, Channel Islands, and long-term environmental change in southern California. Journal of Quaternary Science 25: 782–797.

Arcese, P., M. K. Sogge, A. B. Marr, and M. A. Patten. 2002. Song sparrow (*Melospiza melodia*), The Birds of North America Online (A. Poole, ed.). Ithaca: Cornell Lab of Ornithology;

Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/704 (accessed 14 March 2014).

Baguskas, S. A., Peterson, S. H., Bookhagen, G., Still, C., J. 2014. Evaluating spatial patterns of drought-induced tree mortality in a coastal California pine forest. Forest Ecology and Management. 315:43-53. Journal Article-2215088.

Barthell, J. F., J. M. Randall, R. W. Thorp, and A. M. Wenner. 2001. Promotion of seed set in yellow star-thistle by honey bees - evidence of an invasive mutualism. Ecological Applications 11(6):2001.

Barthell, J. F., R. W. Thorp, A. M. Wenner, and J. M. Randall. 1999. Yellow star-thistle, gumplant, and feral honey bees on Santa Cruz Island - a case of invaders assisting invaders. Unpublished report. Coastal Southern California Science and Learning website. Available at: http://www.mednscience.org/download_product/1679/0 (accessed 21 June 2014).

Beatty, S. W., and D. L. Licari. 1992. Invasion of fennel into shrub communities on Santa Cruz Island, California. Madrono 39:54–66.

Beltran, R. S., N. Kreidler, D. H. Van Vuren, S. A. Morrison, E. S. Zavaleta, K. Newton, B. R. Tershy, and D. A. Croll. 2014. Passive Recovery of Vegetation after Herbivore Eradication on Santa Cruz Island, California. Restoration Ecology 22:790–797. http://doi.wiley.com/10.1111/rec.12144 (accessed 2 Dec 2014).

Bjorndalen, J. E. 1978. The chaparral vegetation of Santa Cruz Island, California. Norwegian Journal of Botany 25: 255-269.

Braje, T. J., J. G. Costello, J. M. Erlandson, M. A. Glassow, J. R. Johnson, D. P. Morris, J. E. Perry, and T. C. Rick. 2010. Channel Islands National Park archeological overview and assessment. Edited by M.A. Glassow. Department of the Interior, National Park Service.

Brumbaugh, R. W. 1980. Recent geomorphic and vegetal dynamics on Santa Cruz Island, California. Pages 139–158 in The California Islands: proceedings of a multidisciplinary symposium (D. M. Power, Ed.). Santa Barbara Museum of Natural History, Santa Barbara, California.

Brumbaugh, R. W., and N. J. Leishman. 1982. Vegetation change on Santa Cruz Island, California: The effects of feral animals. Gen. Tech. Rep. PSW-58. Pacific Southwest Forest and Range Experiment Station, Forest Service, USDA. Berkeley, CA.

Brumbaugh, R. W., W. H. Renwick, and L. L. Loeher. 1982. Effects of vegetation change on shallow landsliding - Santa Cruz Island, California. Gen. Tech. Rep. PSW-58. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1982.

Caballero, I. C., and M. V. Ashley. 2011. Genetic analysis of the endemic island loggerhead shrike, *Lanius ludovicianus anthonyi*. Conservation Genetics 12:1485-1493.

Caldwell, L., V. J. Bakker, T. S. Sillett, M. A. Desrosiers, S. A. Morrison, and L. M. Angeloni. 2013. Reproductive ecology of the island scrub-jay. The Condor 115(3):603-613.

California Herps. 2016. Reptiles and Amphibians Found on California Islands. CaliforniaHerps.com/islands/caislandherps.html#3. Accessed January 4, 2017.

Carbone, M. S., A. P. Williams, A. R. Ambrose, C. M. Boot, E. S. Bradley, R. E. Dawson, S. M. Schaeffer. 2012. Cloud shading and fog drip influence the metabolism of a coastal pine ecosystem. Global Change Biology 19:484–497.

Carter, H. R., G. J. McChesney, D. L. Jaques, C. S. Strong, M. W. Parker, J. E. Takekawa, D. L. Jory, and D. L. Whitworth. 1992. Breeding populations of seabirds in California 1989-1991. Draft report to Minerals Management Service.

Center for Plant Conservation. 2014. Search CPC. Accessible at: http://www.centerforplantconservation.org/collection/NationalCollection.asp (accessed 16 January 2014).

Cobb, M., and L. A. K. Mertes. 1999. Mapping gradations among vegetation communities on Santa Cruz Island, California with field and remote sensing data. Pp 143-154 in D.R. Browne, ed. Proceedings of the 5th California Islands Symposium. USDI, Mineral Management Service, Pacific OCS Region, OCS Study MMS 99-0038.

Cohen, B., C. Cory, J. Menke, and A. Hepburn. 2009. A spatial database of Santa Cruz Island vegetation. Pages 229–244. In Proceedings of the Seventh California Islands Symposium. Institute for Wildlife Studies, edited by C. C. Damiani and D. K. Garcelon. Institute for Wildlife Studies, Arcata, CA.

Collins, P. W. 2008a. SCI rufous-crowned sparrow (*Aimophila ruficeps obscura*). Pages 371-376 in Shuford, W.D. and T. Gardali, eds., California Bird Species of Special Concern: a ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento.

Collins, P. W. 2008b. Island loggerhead shrike (*Lanius ludovicianus anthonyi*). Pgs. 278-283 in W. D. Shuford and T. Gardali, eds., California Bird Species of Special Concern, Studies of Western Birds No. 1.

Collins, P. W., and B. C. Latta. 2009. Food habits of nesting golden eagles (*Aquila chrysaetos*) on Santa Cruz and SRIs, California. Pages 255-268 in Damiani, C.C. and D.K. Garcelon (eds.). Proceedings of the 7th California Islands Symposium. Institute for Wildlife Studies, Arcata, CA.

Coonan, T. J. 2013. 2012 deer mouse monitoring annual report, Channel Islands National Park. Natural Resources Data Series NPS. In press.

Coonan, T. J., C. A. Schwemm, and D. K. Garcelon. 2010. Decline and recovery of the island fox: a case study for population recovery. Ecology, Biodiversity and Conservation Series. Cambridge University Press. 228 pp.

Coonan, T. J., R. C. Klinger, and L. C. Dye. 2011. Trends in landbird abundance at Channel Islands National Park, 1993-2009. Natural Resource Technical Report NPS/CINP/NRTR—2011/507. National Park Service, Fort Collins, Colorado.

Crooks, K. R. 1994. Den-site selection in the island spotted skunk of SCI, California. Southwestern Naturalist 39(4):354-357.

Crooks, K. R., and D. Van Vuren. 1994. Conservation of the island spotted skunk and island fox in a recovering island ecosystem. Pages 379-385 in Halvorson, W.L. and G.J. Maender, eds., The Fourth California Islands Symposium: Update on the Status of Resources. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Crooks, K. R., and D. Van Vuren. 1995. Resource utilization by two insular endemic mammalian carnivores, the island fox and island spotted skunk. Oecologia 104:301-307.

Cypher, B. L., E. Y. Madrid, C. L. Van Horn Job, E. Kelly, S.W.R. Harrison, and T. L. Westall. 2011. Resource exploitation by island foxes: implications for conservation. Contract Final Report (P085004) to California Department of Fish and Game. California State University – Stanislaus, Endangered Species Recovery Program, Turlock, California.

Dash, B. A., and S. R. Gliessman. 1994. Non-native species eradication and native species enhancement: fennel on Santa Cruz Island. In Halvorson, W. L., and G. J. Maender, editors. The Fourth California Islands Symposium: update on the status of resources. Santa Barbara Museum of Natural History, Santa Barbara, California. Pp. 505-512.

Dillon, A. 2013. Population ecology of endemic carnivores in a recovering island ecosystem. Ph.D. proposal, Colorado State University. Unpublished manuscript on file at park headquarters, Channel Islands National Park. 25 pp.

Drake, E. M. 2013. Home range and habitat use of Santa Rosa Island foxes (*Urocyon littoralis santarosae*). M.S. Thesis, California Polytechnic State University, San Luis Obispo, California. 100 pp.

Drost, C. A., and G. M. Fellers. 1991. Density cycles in an island population of deer mice, *Peromyscus maniculatus* (Wagner). Oikos 60:351-364.

Drost, C. A., L. Gelczis, and P. Power. 2009. Distribution and abundance of harvest mice and deer mice on Santa Cruz Island in relation to feral animal removal. Pages 349–361 in Damiani, C. C. and D. K. Garcelon, eds. 2009. Proceedings of the 7th California islands Symposium. Institute for Wildlife Studies, Arcata, CA.

Dye, L. C., and T. J. Coonan. 2014a. Landbird monitoring 2013 annual report, Channel Islands Nation Park. In prep.

Dye, L. C., and T. J. Coonan. 2014b. Landbird monitoring 2014 annual report, Channel Islands Nation Park. In prep.

Erlandson, J. M., T. C. Rick, T. J. Braje, M. Casperson, B. Culleton, B. Fulfrost, T. Garcia, D. Guthrie, N. Jew, D. J. Kennett, M. L. Moss, L. Reeder, C. Skinner, J. Watts, and L. Willis. 2011. Paleoindian seafaring, maritime technologies, and coastal foraging on California's Channel Islands. Science 331:1181–1185. Available at: http://www.ncbi.nlm.nih.gov/pubmed/21385713 (accessed 2 September 2014).

Fischer, D. T., C. J. Still, and A. P. Williams. 2009. Significance of summer fog and overcast for drought stress and ecological functioning of coastal California endemic plant species. Journal of Biogeography 36:783–799.

Gilbert, W. M., M. K. Sogge, and C. Van Riper III. 2010. Orange-crowned Warbler (*Oreothlypis celata*), The Birds of North America Online (A. Poole, ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/101 (accessed 12 July 2014).

Glassow, M. A. 1980. Recent developments in the archaeology of the Channel Islands. In The California Islands: Proceedings of a Multidisciplinary Symposium. (D. M. Power, ed), Santa Barbara Museum of Natural History, Santa Barbara, California, pp. 79-102.

Glassow, M. A. 1994. Prehistoric chronology and environmental change at the Punta Arena site, Santa Cruz Island, California. Pages 555-562 in Halvorson, W. L., and G. J. Maender, eds. The Fourth California Islands Symposium: Update on the Status of Resources. Santa Barbara Museum of Natural History, Santa Barbara.

Glassow, M. A., O. A. Chadwick, R. L. Perroy, and R. L. Jeff. 2009. Alluvial history and human prehistory in Pozo Canyon, Santa Cruz Island, California. Pages 53-65 in Damiani, C. C. and D. K. Garcelon, eds. Proceedings of the 7th California Islands Symposium. Institute for Wildlife Studies, Arcata, CA.

Goeden, R. D., and D. W. Ricker. 1980. Santa Cruz Island - revisited. Sequential photography records the causation, rates ... biological week control. In Proceedings of the Fifth International Symposium on Biological Control of Weeds, July 1980. E.S. Del Fosse, ed. Melbourne Australia: CSIRO, Australia, 1981.

Goeden, R. D., C. A. Fleschner, and D. W. Ricker. 1967. Biological control of prickly pear cacti on Santa Cruz Island, California. Hilgardia 38: 579-606.

Hall, L. S., and M. J. Kuehn. 2012. Habitat use and selection by loggerhead shrikes breeding on Santa Cruz and Santa Rosa Islands, California. Final report submitted to the National Park Service. Western Foundation of Vertebrate Zoology, Camarillo, California. 46 pp.

Hobbs, E. R. 1986. Characterizing the boundary between CA annual grassland and coastal sage scrub with differential profiles. Plant Ecology 65:115-126.

Hochberg, M. C., S. A. Junak, R. N. Philbrick, S. Timbrook. 1979. Chapter V, Botany. *In* D. M. Power, ed. Natural Resources Study of the Channel Islands National Monument, California. Santa Barbara Museum of Natural History, Santa Barbara, California. 91 pp.

Howarth, J. T., and L. L. Laughrin. 2009. Many small becoming many large: understanding changes in cultural landscapes. Pages 89-98 in Damiani, C.C. and D.K. Garcelon, eds. Proceedings of the 7th California Islands Symposium. Institute for Wildlife Studies, Arcata, CA.

Jennings, M. R., and M. P. Hayes. 1994. Amphibian and reptile species of special concern in California. Final report submitted to the California Department of Fish and Game under Contract Number 8023.

Jones, J. A., S. A. Junak, and R. J. Paul. 1993. Progress in mapping vegetation on Santa Cruz Island and a preliminary analysis of relationships with environmental factors. Pages 97–104. In Hochberg, F.G., ed. Third California Islands Symposium: Recent Advances in Research on the California Islands. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Jones, K. L., D. H. Van Vuren, and K. R. Crooks. 2008. Sudden increase in a rare endemic carnivore: ecology of the island spotted skunk. Journal of Mammalogy 89(1):75-86.

Junak, S., T. Ayers, R. Scott, D. Wilken, and D. Young. 1995. A flora of Santa Cruz Island. California Native Plant Society and the Santa Barbara Botanic Garden. 397 pp.

Koenig, W. D., A. H. Krakauer, W. B. Monahan, J. Haydock, J. M. H. Knops, and W. J. Carmen. 2009. Mast-producing trees and the geographical ecology of western scrub-jays. Ecography 32:56-570.

Komar, N. 2003. West Nile virus: epidemiology and ecology in North America. Advances in Virus Research. Vol. 61:1-234.

Laughrin, L. L. 1971. Preliminary account of the island fox. University of California, Santa Barbara. Unpublished report on file at park headquarters, Channel Islands National Park.

Laughrin, L. L. 1977. The island fox: a field study of its behavior and ecology. Ph.D. dissertation, University of California, Santa Barbara. 83 pp.

Leishman, N. J. 1981. Effects of feral animals on woody vegetation, Santa Cruz Island, California. MA Thesis, University of California, Los Angeles. 71 pp.

Li, H., Kanamitsu, M., Hong, S.Y., Yoshimura, K., Cayan, D.R., Misra, V. and Sun, L., 2014. Projected climate change scenario over California by a regional ocean–atmosphere coupled model system. Climatic change, 122(4), pp.609-619.

Livingston, D. S. 2006. Historic Resource Study: A History of the Islands within Channel Islands National Park. Technical Report to Channel Islands National Park, Ventura, California. 917 pp.

Lynn, S., C. M. Leumas, H. A. Carlisle, and N. Warnock. 2006. Final Report - 2005 Population Monitoring of the San Clemente Loggerhead Shrike on NALF, San Clemente Island, California, U.S. Navy, Environmental Department, Southwest Division, Naval Facilities Engineering Command, San Diego, California. 235 pp + electronic appendices.

Mayfield, R. L., D. Van Vuren, and M. J. Johnson. 2000. Demography of an insular endemic rodent, *Peromyscus maniculatus santacruzae*, on Santa Cruz Island. Southwestern Naturalist 45(4): 508-513.

McEachern, A. K., D. Thomson, and K. Chess. 2009. Climate alters response of an endemic island plant to removal of invasive herbivores. Ecological Adaptations 19(6):1574-1584.

McEachern, A. K., and D. Wilken. 1996. Inventory and Monitoring of California Islands Candidate Plant Taxa — Final National Biological Service Report. Channel Islands National Park, California." USGS-NBS, Channel Islands Research Station, Ventura, CA.

McEachern, A. K., and D. Wilken. 2009. Santa Cruz Island Rare Plant Recovery Proceedings of the CNPS Conservation Conference, 17–19 Jan 2009. pp. 162–167, California Native Plant Society.

McEachern, A. K., K. Flagg, and D. Hartley. 2010. Planting of SCI bush mallow (*Malacothamnus fasciculatus* var. *nesioticus*) from cuttings made in 2008. Data Report USGS-Channel Islands Field Station 2010-3, USGS Channel Islands Field Station, Ventura, CA.

McEachern, A. K. 2011. Summary of 2006 – 2010 Recovery research under Threatened and Endangered Species Recovery Research Permit TE044846-1. Unpublished report, dated March 9, 2011. USGS Channel Islands Field Station, Ventura, California.

McKnight, S., K. Walker, and N. Macdonald. 2007. Final weed mapping report for Santa Cruz Island. Technical report to The Nature Conservancy. Prohunt Incorporated. Ventura, CA. 22 pp.

McKown, M., D. Croll, and B. Tershy. 2011. Acoustic monitoring of Santa Cruz rufous-crowned sparrow (*Aimophila ruficeps obscura*) on West Anacapa Island – 2011. Unpublished report on file at park headquarters, Channel Islands National Park.

Mertes, L. A. K., K. D. Martella, M. Ruocco, and W. W. Bushing. 1999. Watershed analysis for runoff and erosion potential on Santa Catalina, Santa Cruz, and Santa Rosa Islands. Pages 461-468 in D.R. Browne, ed. Proceedings of the 5th California Islands Symposium. USDI, Mineral Management Service, Pacific OCS Region, OCS Study MMS 99-0038.

Moody, A. 1991. Spatial variability of soil properties under *Quercus agrifolia* on Santa Cruz Island, California. MS Thesis, University of California, Santa Barbara. 86 pp.

Moore, C. M, and P. W. Collins. 1995. *Urocyon littoralis*. Mammalian Species No. 489:1-7.

Morrison, S. A., T. S. Sillett, C. K. Ghalambor, J. W. Fitzpatrick, D. M. Graber, V. J. Bakker, R. Bowman, C. T. Collins, P. W. Collins, K. S. Delaney, D. F. Doak, W. D. Koenig, L. Laughrin, A. A. Lieberman, J. M. Marzluff, M. D. Reynolds, J. M. Scott, J. A. Stallcup, W. Vickers, and W. M. Boyce. 2011. Proactive conservation management of an island- endemic bird species in the face of global change. BioScience 61:1-13-1021.

Morrison. S. A. 2007. Reducing risk and enhancing efficiency in non-native vertebrate removal efforts on islands: A 25 year multi-taxa retrospective from Santa Cruz Island, California. Pages 398-409 in G.W. Witmer, W.C. Pitt and K.A. Fagerstone, eds. Managing Vertebrate Invasive Species: Proceedings of an International Symposium. USDA/APHIS/WS, National Wildlife Research Center, Fort Collins, CO.

National Park Service (NPS). 2002. Santa Cruz Island Primary Restoration Plan. Final Environmental Impact Statement. Available at Park headquarters.

Peart, D., D. T. Patten, and S. L. Lohr. 1994. Feral pig disturbance and woody species seedling regeneration and abundance beneath Coast Live Oaks (*Quercus agrifolia*) on Santa Cruz Island, California.

Peluc, S. I., T. S. Sillett, J. T. Rotenberry, and C. K. Gahalambor. 2008. Adaptive phenotypic plasticity in an island songbird exposed to a novel predation risk. Behavioral Ecology 19:830-835.

Philbrick, R. N., and J. R. Haller. 1990. The Southern California Islands. Pages 893-905 in M.G. Barbour and J. Major, eds. Terrestrial Vegetation of California. California Native Plant Society Special Publication Number 9, University of California, Davis.

Pinter, N., and W. D. Vestal. 2005. El Nino-drive landsliding and postgrazing vegetative recovery, Santa Cruz Island, California. Journal of Geophysical Research Vol. 110, F02003.

Power, P.J., J. Wagner, M. Martin, M. Denn. 2014a. Restoration of a coastal wetland at Prisoners Harbor, Santa Cruz Island, Channel Islands National Park, California. Monographs of the Western North American Naturalist, 7:442-454.

Power, P.J., T. Stanley, C. Cowan, and J.R. Roberts. 2014b. Native plant recovery in study plots after fennel (*Foeniculum vulgare*) control on Santa Cruz Island. Monographs of the Western North American Naturalist, 7:465-476.

Roemer, G. W. 1999. The ecology and conservation of the island fox (*Urocyon littoralis*). Ph.D. dissertation, University of California, Los Angeles, California. 229 pp.

Roemer, G. W., C. J. Donlan, and F. Courchamp. 2002. Golden eagles, feral pigs, and insular carnivores: how exotic species turn native predators into prey. Proceedings of the National Academy of Sciences 99:791-796.

Sanchez, J. N. 2012. Spatial ecology of disease spread in the island fox. M.S. thesis, Humboldt State University, Arcata, California. 110 pp.

Santa Barbara Botanic Garden. 2014. Santa Barbara Botanic Garden website. Santa Cruz Island. http://www.sbbg.org/conservation-research/channel-islands/santa-cruz-island (accessed 6 December 2014).

Schwemm, C. 2009. Population monitoring of deer mice (*Peromyscus maniculatus*) on the California Channel Islands. Unpublished report on file at park headquarters, Channel Islands National Park. 20 pp.

Shuford, W. D. 1993. The Marin County breeding bird atlas: A distributional and natural history of coastal California birds. California Avifauna Series 1. Bushtit Book, Bolinas, California.

Sillett, T. S., R. B. Chandler, J. A. Royle, M. Kery, and S. A. Morrison. 2012. Hierarchical distance-sampling models to estimate population size and habitat-specific abundance of an island endemic. Ecological Applications 22(7):1997-2006.

Sillett, T. S., M. B. Pesendorfer, M. C. Hague, and T.B. Ryder. 2013. Non-breeding ecology of the island scrub-jay (*Aphelocoma insularis*): report on the Fall 2013 field season. Unpublished report on file at park headquarters, Channel Islands National Park.

Sofaer, H. R., T. S. Sillett, S. I. Peluc, S. A. Morrison, and C. K. Ghalambor. 2013. Differential effects of food availability and nest predation risk on avian reproductive strategies. Behavioral Ecology 24 (3): 698-707.

Sogge, M. K. and C. van Riper III. 1988. Breeding biology and population dynamics of the San Miguel Island song sparrow (*Melospiza melodia micronyx*). Technical Report Number 26, Cooperative National Park Resources Studies Unit, University of California, Davis.

Stanley, T. R., S. Teel, L. S. Hall, L. C. Dye, and L. L. Laughrin. 2012. Population size of island loggerhead shrikes on Santa Rosa and Santa Cruz Island. Wildlife Society Bulletin 36(1):61-69.

The Nature Conservancy (TNC). 2007. Santa Cruz Island Vegetation, 2005. ARC/INFO Geodatabase. The Nature Conservancy, San Diego, California.

Thorp, R. W., A. M. Wenner, and J. F. Barthell. 1994. Flowers visited by honey bees and native bees on Santa Cruz Island. Pages 351–365. In Halverson, W. L., and G. J. Meander (eds.), Fourth California Islands Symposium: Update on the Status of Resources. Santa Barbara Museum of Natural History, Santa Barbara, California.

Thorp, R. W., A. M. Wenner, and J. F. Barthell. 2000. Pollen and nectar resource overlap among bees on Santa Cruz Island. Pages 261-268. In D. R. Browne, K. L. Mitchell and H. W. Chaney (eds.). Fifth California Islands Symposium. Santa Barbara Museum of Natural History, Santa Barbara, California. MBC Applied Environmental Sciences (under contract of the U.S. Dept. of the Interior).

Timbrook J., J. R. Johnson, and D. D. Earle. 1982. Vegetation burning by the Chumash. Journal of California and Great Basin Anthropology 4:163–186.

U.S. Fish and Wildlife Service (USFWS). 2009a. *Dudleya nesiotica* (Santa Cruz Island dudleya) 5-Year Review: Summary and Evaluation 5-Year Review: Summary and Evaluation. Ventura Fish and Wildlife Office, Ventura, California.

U.S. Fish and Wildlife Service (USFWS). 2009b. *Galium buxifolium* (island bedstraw) 5-Year Review: Summary and Evaluation. Ventura Fish and Wildlife Office, Ventura, California.

U.S. Fish and Wildlife Service (USFWS). 2009c. *Thysanocarpus conchuliferus* (SCI Fringepod) 5-Year Review: Summary and Evaluation. Ventura Fish and Wildlife Office, Ventura, California.

U.S. Fish and Wildlife Service (USFWS). 2010a. *Helianthemum greenei* (island rush-rose) 5-Year Review: Summary and Evaluation. Ventura Fish and Wildlife Office, Ventura, California.

U.S. Fish and Wildlife Service (USFWS). 2010b. *Malacothrix indecora* (SCI malacothrix) and Malacothrix squalida (island malacothrix) 5-Year Review: Summary and Evaluation. Ventura Fish and Wildlife Office, Ventura, California.

U.S. Fish and Wildlife Service (USFWS). 2011. *Arabis [Boechera] hoffmannii* (Hoffmann's rock-cress) 5-Year Review: Summary and Evaluation. Ventura Fish and Wildlife Office, Ventura, California.

U.S. Fish and Wildlife Service (USFWS). 2012. SCI bushmallow *Malacothamnus fasciculatus* var. *nesioticus* 5-Year Review: Summary and Evaluation. Ventura Fish and Wildlife Office, Ventura, California.

Van Vuren, D. H., and B. E. Coblentz. 1987. Some ecological effects of feral sheep on Santa Cruz Island, California, USA. Biological Conservation 41:253-268.

Van Vuren, D. H., and L. Bowen. 2012. Response of grassland vegetation on Santa Cruz Island to removal of feral sheep. 59:190–195.

Van Vuren, D. H., M. L. Johnson, and L. Bowen. 2001. Impacts of feral livestock on island watersheds. Pacific Science 5(3): 285-289.

Walter, H. S. 2006. Petition to list the island loggerhead shrike (*Lanius ludovicianus anthonyi* Mearnsi 1898) as an endangered species. Petition sent to U.S. Fish and Wildlife Service October 12, 2006. On file at headquarters, Channel Islands National Park.

Weaver, D. W., and G. L. Meyer 1969, Stratigraphy of northeastern Santa Cruz Island. In Weaver, D. W., and others, eds., Geology of the northern Channel Islands (California): American Association of Petroleum Geologists and Social Economic Paleontologists and Mineralogists, Pacific Section, Special Publication, p. 95-104.

Wehtje, W. 1991. Response of bishop pine (*Pinus muricata*) to cessation of browsing by feral sheep on Santa Cruz Island, California. Master's Thesis, Department of Geography, University of California, Los Angeles.

Wenner, A. M., R. W. Thorp, and J. F. Barthell. 2009. Biological control and eradication of feral honey bee colonies on Santa Cruz Island, California: A summary. pp. 327–335.

Yelenik, S. G., and J. M. Levine. 2009. Processes limiting native shrub recovery in exotic grasslands after non-native herbivore removal. Restoration Ecology 18(2): 418-425.

Yelenik, S. G., and J. M. Levine. 2010. Native shrub reestablishment in exotic annual grasslands: Do ecosystem processes recover? Ecological Applications 20(3):716–727.

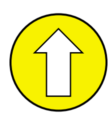
Yelenik, S. G., and J. M. Levine. 2011. The role of plant - soil feedbacks in driving native-species recovery. Ecology 92(1):66-74.

Section 4.4. Santa Rosa Island

Water Canyon Beach and Torrey Pines. NPS photo.

4.4.1. General Overview of Santa Rosa Island

Condition = Moderate



Trend = Improving

Physical Setting

Santa Rosa Island (SRI) is 217 km^2 (83.1 mi^2) in area, lying midway in the northern island chain between San Miguel (5 km [3.1 mi] to the west) and Santa Cruz Island (about 8 km [5 mi] to the east). The SRI fault runs east-west across the central part of the island, separating it into northern and southern geologic blocks (Dibblee and Ehrenspcek 1998). The terrain is dominated by a high ridge trending southwest across the center of the island south of the fault from Black Mountain at an elevation of 395.6 m (1298 ft) across Soledad Peak and Radar Mountain/Vail Peak reaching elevations of 479.8 m and 484.3 m (1574 ft and 1589 ft; Figure 4.4.1). Numerous canyons run north and south from this high ridge, cutting through thick-bedded sandstones, shales, colluvium and alluvium that overlay a core of sedimentary and metamorphic rocks. Gradients are steeper and shorter on the south side of the island, and the south side lacks the broad alluvial fans and marine terraces found on the north coast. Carrington Point and Skunk Point are prominent headlands on the north and east sides of the island capped with old sand dune deposits, while Sandy Point forms a low eroded caliche pan on the west side of the island.

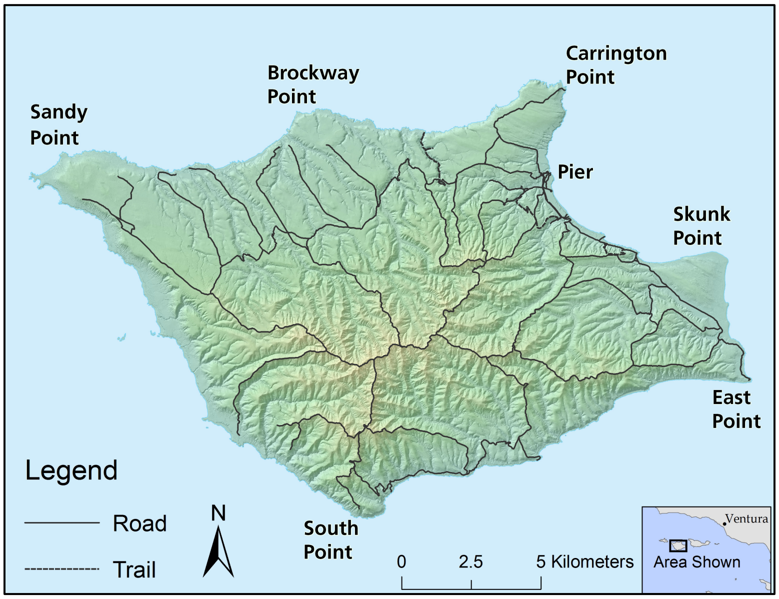


Figure 4.4.1. Santa Rosa Island with roads, trails and hillshade (Map by R. Rudolph).

SRI has a Mediterranean type climate with wet winters and dry summers. Average temperatures from 1923 to 2011 were 8.5 degrees Celsius (C) (47 Fahrenheit [F]) (see Chapter 2, *Weather and Climate*), and precipitation averaged 9.8 cm (4 in) over the same period. The high ridge runs roughly perpendicular to the prevailing northwest winds producing strong contrasts in temperature, wind and fog exposure north to south across the island. In general, the northern and western sides of the island tend to be more mesic, windy, and foggy. Winds measured at the weather station on SRI from 1990 through 2011 averaged 24.1 kph (15.0 mph) from 292°, but they can gust in excess of 80.5 kph (50 mph) as storm fronts move through the area. Bechers Bay, opening to the northeast, is the main point of island access. Much of SRI is bordered by marine terraces and low bluffs, but there are several sandy beaches providing access to kayakers and loafing areas for pinnipeds.

Natural Resources

Resource Descriptions are discussed in detail in the Channel Islands National Park General Management Plan, and are briefly summarized here (NPS 2013).

Terrestrial Flora and Plant Communities

The vegetation of Santa Rosa is diverse because of the island's relatively large size, elevation range and climatic variability. A total of 500 plant species have been recorded on the island, 80 percent of which are native. There are 44 plant taxa endemic to the island. Five occur only on SRI, and there is an additional one plant presumed extirpated (Table 2.2.2; island endemic plants). Seven taxa are listed as endangered or threatened by the U.S. Fish and Wildlife Service, as a result of ranching activities that altered habitats and harmed animal populations (USFWS 1997).

Approximately 75% of the land area is covered by non-native grassland, forming a matrix around fragmented remnants of what was formerly nearly continuous coastal sage and chaparral scrub (Figure 4.4.2, Clark et al. 1990). As with the other islands, many native species are now only found primarily in refuges on inaccessible steep sea bluffs and interior canyon walls. Grassland is dominated primarily by non-native annual species including rip-gut brome (*Bromus diandrus*), soft-chess (*B. hordeacous*), red brome (*B. madritensis rubens*), wild oats (*Avena fatua, A. barbata*), but native perennial grasses appear to be regaining cover, including four species of ryegrasses (*Leymus* spp., *Elymus* spp.), three species of needlegrass (*Stipa* spp.), and saltgrass (*Distichlis spicata*).

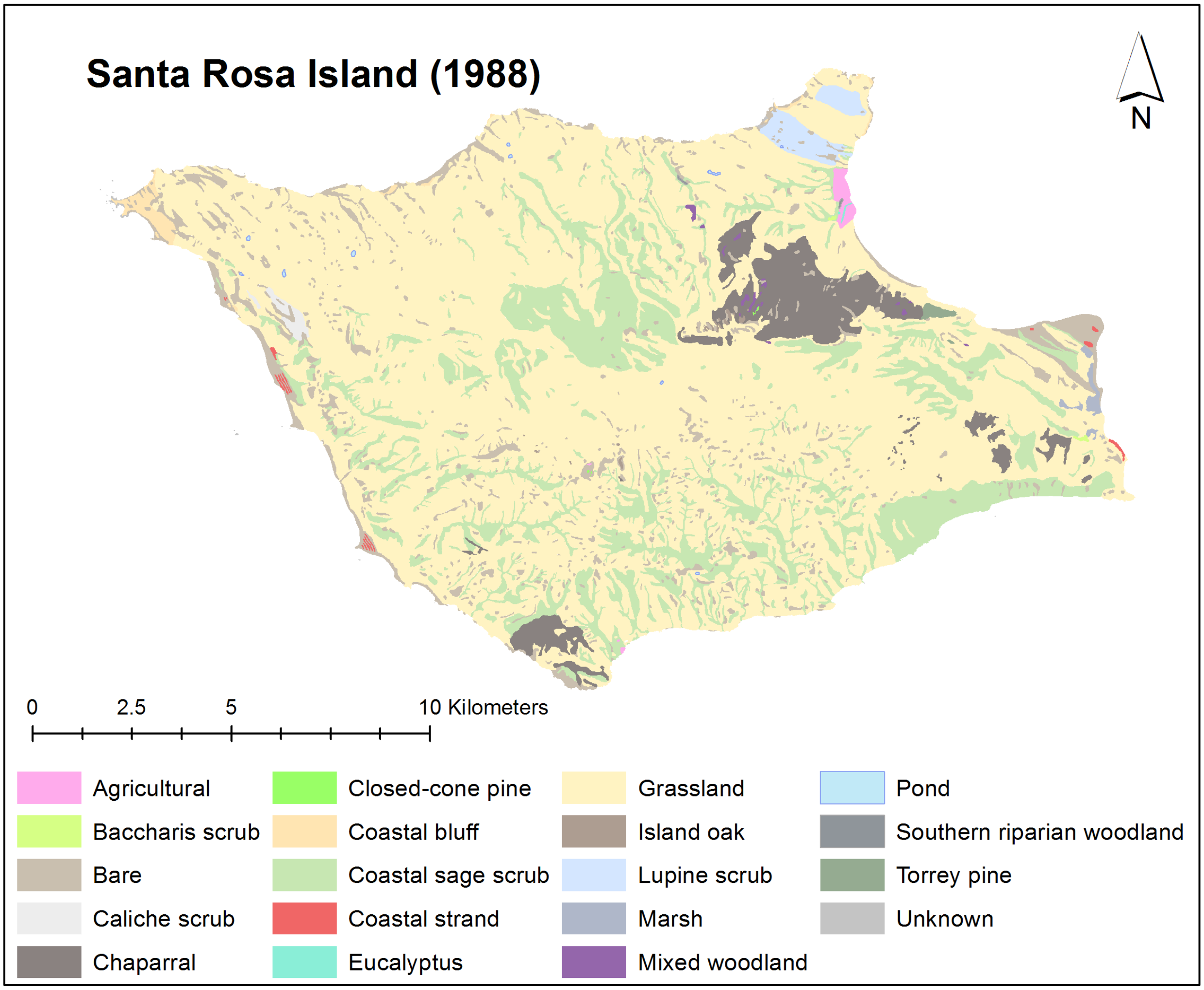


Figure 4.4.2. Vegetation of Santa Rosa Island (Clark et al. 1990).

Coastal sage scrub dominated by California sagebrush (*Artemisia californica*), and *Baccharis* scrub dominated by coyote brush (*Baccharis pilularis*) are two of the more common native woody plant communities (Figure 4.4.3 top right). Island chaparral is found in three distinct areas on the island: the largest extent is on the north- and east-facing slopes of Black Mountain; a smaller area is on northwest-facing slopes on South Point; the third area is on short, north-facing slopes on the eastern end of the island. Island scrub oak (*Quercus pacifica*), prostrate chamise (*Adenostoma fasciculata* var. *prostrata* and *A.f.* var. *fasciculata*), three endemic taxa of manzanita (including the endangered Santa Rosa Island manzanita [*Arctostaphylos confertiflora*]), summer-holly (*Comarostaphylos diversifolia planifolia*), and island monkey flower (*Mimulus flemingii*) characterize this community.

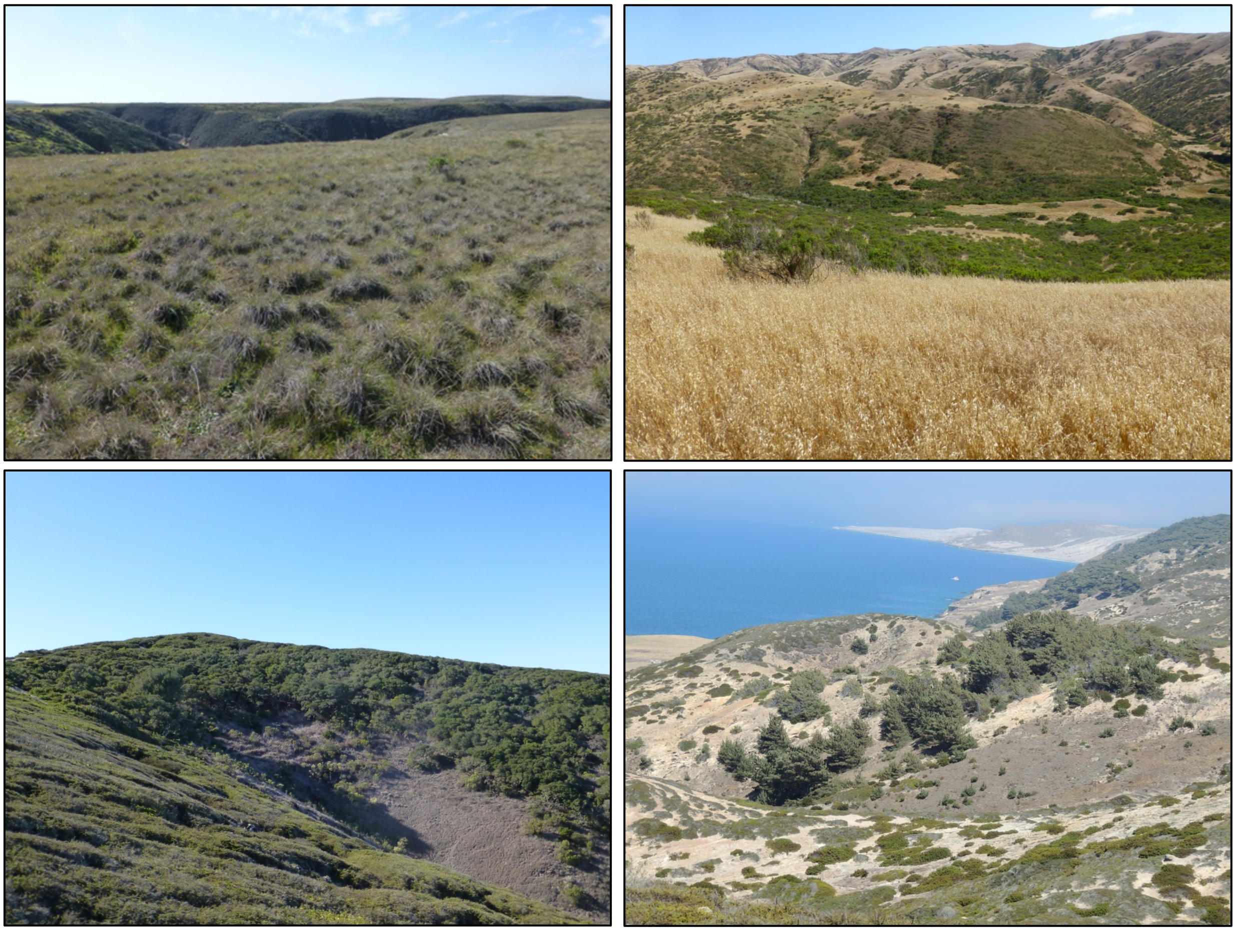


Figure 4.4.3. Photos of recovering island grassland with perennial native purple needlegrass (*Stipa pulchra*) in foreground and coastal sage scrub on the canyon slopes in the background (top left), coyote brush (*Baccharis pilularis*) scrub invading annual island grassland (top right), chaparral dominated by chamise (*Adenostoma fasciculata* var. *prostrata*) on the left and island scrub oak (*Quercus pacifica*) on the right (bottom left), and Torrey pine woodland (*Pinus torreyana*) on Santa Rosa Island in 2012-2013 (bottom right) (NPS files).

Less than 1% of SRI supports woodlands, which grow mostly in or intermixed with island chaparral. Upland woodlands include isolated stands of the multi-island endemics Santa Cruz Island pines (*Pinus muricata forma remorata*), island ironwood (*Lyonothamnus floribundus* a*spleniifolius*) and island oaks (*Quercus tomentella*). The island also supports the single-island endemic Santa Rosa Island Torrey pine (*Pinus torreyana insularis*). Mixed woodlands grow primarily in the larger canyons in the northeast portion of the island. Tree species in this area include coast live oak (*Quercus agrifolia*), island oak (*Q. tomentella*), and occasional island cherry (*Prunus ilicifolia lyonii*). Riparian woodland is restricted to isolated young stands of willow (*Salix exigua* and *S.*

latifolia) in some drainages. A number of other vegetative communities occur on Santa Rosa, usually in limited and discontinuous areas. These include Caliche scrub, Coastal bluff scrub, Lupine scrub, and Coastal strand, and several wetland communities.

Native Animal Species

SRI has a rich diversity of terrestrial wildlife due to its large size, topographic variety, and diversity of vegetative communities. However, the native animals of this island have been studied less than native animals most of the other islands. Two amphibian, three reptile, and four mammal species reside on SRI (Table 2.2.5). Like all of the islands, mice are the most common mammals found on SRI. Two subspecies, the Santa Rosa deer mouse (*Peromyscus maniculatus santarosae*) and Santa Rosa Island fox (*Urocyon littoralis santarosae*), are endemic to this island, while the Channel Islands slender salamander (*Batrachoseps pacificus pacificus*), island fence lizard (*Sceloporus occidentalis beckii*), Santa Cruz gopher snake (*Pituophis catenifer pumilus*), and island spotted skunk (*Spilogale gracilis amphiala*) are endemic to SRI and one or more other Channel Islands.

The spotted skunk inhabits brush and woodland areas on SRI and. Gopher snakes (*Pituophis catenifer*) and western fence lizards (*Sceloporus occidentalis*) are found in scattered areas throughout the island. Baja California tree frogs (*Pseudacris hypochondriaca*) are found in all canyons that have standing pools or slow-moving streams, and Pacific slender salamanders are most commonly found in moist canyon settings. Bat surveys conducted in fall 2003 on SRI recorded four species of bat (hoary [*Lasiurus cinereus*], Mexican free-tailed [*Tadarida brasiliensis*], Townsend's western big-eared [*Corynorhinus townsendii townsendii*], and California myotis [*Myotis californicus caurinus*]). The island is an important wintering ground and migration stopover for many birds. A total of 57 species were recorded from 1993 to 2000 on the island (NPS 2001a). Thirty bird species have been observed to breed on the island, including peregrine falcons (*Falco peregrinus*), bald eagles (*Haliaeetus leucocephalus*), and western snowy plovers (*Charadrius alexandrinus nivosus*). Eight subspecies occur only here and on one or more of the other Channel Islands (Table 2.2.6).

Most of the seabird colonies either are on bluffs on the islands, in sea caves, or on rocks offshore of the island. Carter et al. (1992) reported there were 3,149 pairs of seabirds on SRI in 1991. SRI has four nesting species. The island also supports large breeding populations of harbor seals (*Phoca vitulina*), and is becoming increasingly important for northern elephant seals (*Mirounga angustirostris*). California sea lions (*Zalophus californianus*) haul out on the island in a limited number of places.

Non-native Animal Species

Sheep (*Ovis aries*), cattle (*Bos primigenius*), pigs (*Sus scrofa domesticus*), horses (*Equus ferus caballus*), mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), chukar (*Alectoris chukar*), and California quail (*Callipepla californica*) are all non-native species that were introduced on SRI for ranching and hunting purposes. Pigs, sheep, cattle, elk and deer have all subsequently been removed, with pigs eliminated by 1993, sheep removed by 2001, cattle removed by 1998, elk removed by 2011, and deer removed by 2013. Chukar are also believed to have been extirpated from the island (Collins 2011).

Land Use History

Native American presence on SRI spans about the past 13,000 calendar years, dating from one of the earliest finds of human remains in North America near Arlington Canyon on SRI (Johnson et al. 2002). Archaeologists have documented nine villages on SRI (e.g., Erlandson et al. 2011). Their results indicate that the native Chumash used virtually all habitats on the island, including coastline, interior, canyon bottom, hilltops and ridgelines, caves and rockshelters. Settlements included seasonal or temporary camps and permanent settlements, shifting geographically with climate fluctuations, shoreline change and drought. After about 2500 years ago, people appear to have focused much of their settlement on the coast with the establishment of large villages during the late Holocene. Although the Chumash had a diet rich in seafood, there is evidence from tools like digging sticks and plant remains in charcoal pits that they also harvested seeds, corms and bulbs. When Juan Rodriguez Cabrillo claimed SRI for Spain, he recorded at least three native villages (Kelsey 1896), and by 1805 there were seven villages on the island (Woolley 1996).

It is apparent from early studies of island paleo cultures (Timbrook et al. 1982) and ecological evidence (Carroll et al. 1993) that the Native Americans used fire to manipulate the environment. Anderson et al. (2010) pieced together a Pleistocene to Recent fire history from sediment cores at two locations on the island. Their results show that fire has been present on the island for at least the last 12,000 years, with fire frequency fluctuating with climate-induced changes in plant biomass and Chumash population sizes. Keeley (2002, 2006) estimate that only about 2 to 5 percent of lightning strikes result in fire in coastal California, one of the lowest lightning-caused fire frequencies on the continent. Therefore, it is reasonable to expect that Chumash burning was sufficient to affect the patterns of vegetation seen on the pre-historic landscape.

Ranching began on SRI with the introduction of sheep and cattle in 1844, and feral pigs were introduced for recreational hunting in 1853. The island was sold to the Moore family in 1858, when an inventory reported 8,000 cattle, 6,000-7,000 wild sheep, and 250-300 horses, noting that the island was overstocked, there was little grass on the south side of the island and animals were in poor condition for lack of adequate feed. The sale was followed by a steep increase in the numbers of sheep on the island, ranging between 60,000 and 100,000 sheep on the island by the early 1860s (Livingston 2006). Several accounts indicate that by the 1860s the island had become largely dominated by grasses and other herbaceous plants indicative of overgrazing such as bur-clover (*Medicago polymorpha*) and alfileria (*Erodium* sp.). In 1876, drought lead to severe declines in range and animal conditions, and the ranch staged a matanza (Spanish for “slaughter” or “killing”) rendering about 25,000 sheep for tallow. The Santa Barbara Press (referenced in Thompson and West 1883) observed in June, 1876:

The island becomes at some times overstocked, and may be said to be in that condition much of the time. The result is, that the grasses, being cropped so close, die out, and allow the loosened soil to be removed by the wind and rain. Popular opinion is, that the amount of fertile land is thus being gradually lessened. In seasons of drought, or when the sheep become too numerous for profitable keeping, large numbers of them are slaughtered for their pelts and tallow.

When the Vail and Vickers Corp bought the island from the More family in 1901, they removed sheep and transitioned to a cattle operation (Livingston 2006). While most sheep were taken right away, it took until the early 1960s for ranch managers to completely eliminate them, as they were feral and difficult to round up. The Vail and Vickers ran a stocker cattle operation from about 1910 until 1998 (Livingston 2006). In this operation calves were brought to the island to feed on the winter and spring flush of growth, and then about half of them were shipped away with the onset of seasonal drought. The usual stocking rates were about 6,000 to 7,000 cattle at the spring peak, but this was adjusted somewhat according to range condition. Prior to WWII, cattle were finished on the island, for shipping directly to slaughter. In this operation, each steer spent about 18 months on the island, gaining an average of about 272.2 kg (600 lbs). In the mid-1940s market tastes for beef changed, and the ranch switched to shipping cattle to feedlots rather than directly to slaughterhouses. The ranchers did not use supplemental feed in this operation, as it was expensive and difficult to manage. They did develop several hayfields to feed horses, but otherwise did no plowing or crop seeding on the island. Landscape plants were planted near the ranch complex at Bechers Bay, including windbreaks of Monterey cypress (*Cupressus macrocarpa*) and blue gum (*Eucalyptus globulus*).

Elk and deer were introduced in 1879 and 1880, for recreational hunting (Appendix B). The Vails ran a profitable big game commercial hunting operation until 2011. Numbers of elk and deer ranged from 600-700 to more than a thousand over those years. The National Park Service bought SRI in 1987, transitioning land management from ranching to conservation and recreation. As a result, pigs were eliminated from the island in 1993, cattle were removed 1998. Big game numbers were reduced gradually starting in 1998, and the last elk and deer were taken in 2011 and 2013.

SRI was the site of other activities as well, in cooperation with the Vail and Vickers Corp. For example, oil exploration was conducted by seven different corporations between 1932 and 1975, involving improvement and building of roads and drilling pads, but ultimately no oil was found (Daily 1999). The U.S. Navy manned a radar post near Signal Peak from 1943 until 1946, and had a communications station on Navy Hill from 1952 to 1963. The U.S. Air Force ran an early warning radar base from the Johnson's Lee area from 1951 to 1963. These operations were accompanied by road building, scraping and leveling of some of the high peaks for radio and radar emplacements, and increased traffic from the mainland. Staff were generally confined to the barracks areas, reducing potential damage to ranching and hunting operations (Livingston 2006).

4.4.2. Natural Resource Assessment of Santa Rosa Island

<u>Measures of Scrub Recovery</u>

- Vegetation community structure, species composition and spatial extent
- Vertebrate abundance

<u>Reference Conditions/Values</u>

The reference condition for SRI is pre-European settlement, characterized by native scrub with native grassland openings, upland woodland and woody canyon and riparian forest with intact soils and native understory vegetation.

Pollen from cores taken on SRI (Cole and Liu 1994, Anderson et al. 2010) and archaeological evidence (e.g., Rick and Erlandson 2004) indicate that SRI supported coastal sage and coyote brush (*Baccharis* spp.) scrub, chaparral and open oak and pine woodland vegetation, with grassy openings in localized areas at the time of European contact. Traces of this vegetation can be seen in the distribution of remnant native plant communities today. Channel Island Botanist Sarah Chaney sketched the likely distributions of pre-ranching vegetation (unpublished; Figure 4.4.4), using the distributions of these remnant native stands along with occurrences of lone chaparral, woodland and coastal sage scrub plants seen in otherwise barren or annual grassland areas. These distributions indicate that there was a nearly continuous band of chaparral with emergent stands of oaks and pines blanketing the central ridge of the island, intergrading with coastal sage scrub along the lower elevation ridges and alluvial fans, lupine scrub on the dune soils, oak woodland in canyons and willow thickets fringing the riparian canyon bottoms. Archaeological evidence indicates that the Chumash likely burned the vegetation often enough to influence community structure (Timbrook et al. 1982, Carroll et al. 1993, Anderson et al. 2010). In the absence of grazing animals, this would have produced a dynamic mosaic of native woody vegetation with grassland openings, changing in relative extent with recurring burning.

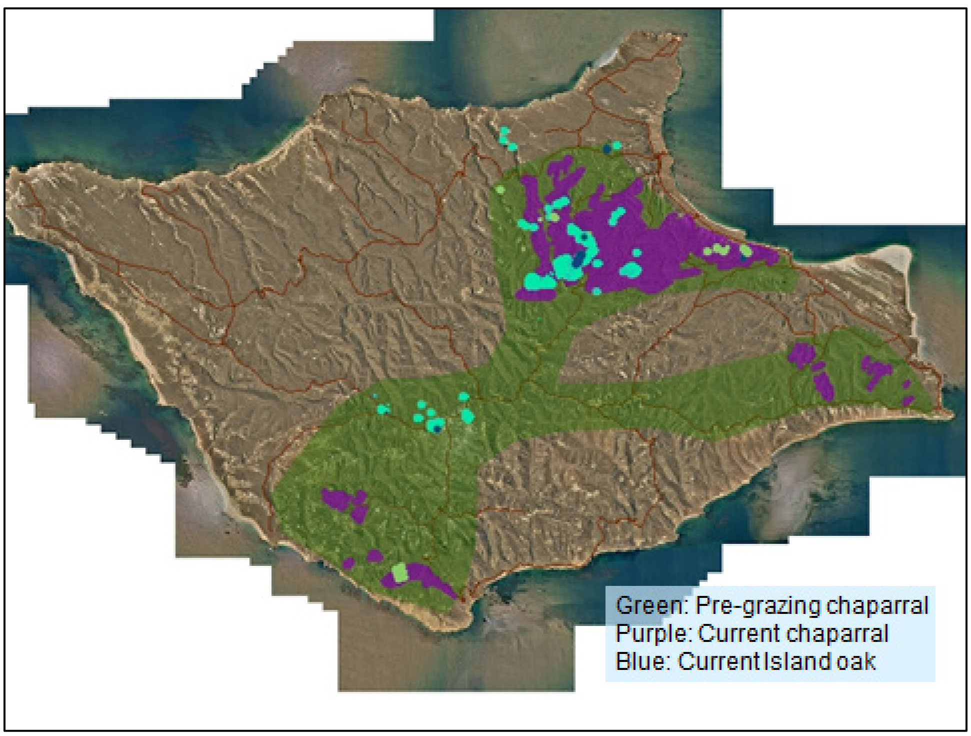


Figure 4.4.4. Current distribution and likely pre-ranching distribution of chaparral and island oak stands on Santa Rosa Island, based on remnant vegetation, soil type and solitary individual plant occurrences seen on the island 1993-2012. (S. Chaney 2012 unpublished).

As on Santa Cruz, in the absence of impacts by non-native ungulates, some vertebrate species were likely more abundant and more widespread in distribution than they are today. Island shrikes occupied edge habitat across the island, hunting from perches above grassland coastal sage scrub, and nesting in nearby woodland, although it is unclear what mix of grassland and shrubland on the island would lead to largest shrike populations. With chaparral and woodland in better condition, it was preferred habitat for island foxes and for deer mice (Mayfield et al. 2000, Drake 2013). Bald eagles and peregrine falcons nested on the island. Riparian corridors were thick with shrubs and trees, and supported a full complement of riparian birds, including Allen's hummingbirds (*Selasphorus sasin*), black phoebes (*Sayornis nigricans*) and Bewick's wrens (*Thryomanes bewickii*). The currently rare Hutton's vireo (*Vireo huttoni*) was likely more abundant, when pine and oak woodland was more extensive on the island.

Vegetation

Perennial native scrub and woodland with an understory dominated by native herbaceous plants as the predominant land cover, resilient to decadal shifts in climate regimes and global change.

- Landscape dominated by native scrub, chaparral and woodland
- Re-establishment of marsh vegetation at the mouths of the larger watersheds
- Stands of dominant woody plants recruiting with stable populations
- Rates of sedimentation in canyons at or below pre-European levels
- Decreased flash-flooding in streams in response to precipitation.

Vertebrates

Populations of native terrestrial vertebrates that are robust, persistent, and influenced only by native perennial ecosystem elements and processes, to the extent practicable. Specifically, populations should:

- Not be threatened by non-native species
- Not be at low numbers due to past influence of non-native grazers on island vegetation, and non-native attraction of predators (e.g., golden eagles, which also prey on foxes)
- Have recovered from previous lows commensurate with vegetation recovery
- Include the full complement of species occurring on the island prior to the ranching era, at viable population levels (carnivores, rodents, reptiles and amphibians, landbirds).

<u>Current Condition and Trend</u>

Vegetation Community Structure and Spatial Extent

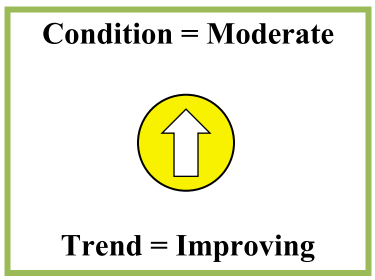
<u>*Historical Vegetation Change*</u>

Pollen cores indicate that with the onset of ranching, local erosion rates increased 12- to 36- fold, rates not seen at any other time during the Holocene (Cole and Liu 1994, Anderson et al. 2010). The U.S. Coast Survey made a topographic map of SRI in 1873, showing the land mostly covered in grass with thickets of dense prickly pear cactus (*Opuntia oricola, O. littoralis*) and isolated woodlands in much the same places as they are now (Livingston 2006). Although cochineal scale insects were not introduced, the cactus stands were greatly reduced by the 1960s, likely in response to the migration of the biological control insects from SCI. John Woolley, working in the 1990s (Woolley 1998), observed steep, vertical-sided stream channels cutting into the alluvial terraces.

These barrancas were visible on 1901 photographs, and Woolley inferred that they must have resulted from severe erosion during flooding in several wet winters in the late 1880s. A narrative account in Thompson and West (1883) observed that a “great storm” hit nearby SCI on February 19, 1878, raising creeks by as much as 3.05 m (10 ft), moving huge boulders and washing away all traces of a well-known Chumash burial ground. Although this storm missed the mainland coast, it could have affected SRI similarly.

It is apparent that SRI native vegetation structure was destroyed between 1844 and 1878, setting up conditions for continued wind and water erosion. From 1901 until 1998 the island was managed as grassland pasture with little change in woody vegetation, and the continued presence of cattle, elk and deer maintained that openness. With continued grazing pressure the island had little capacity to recover soil stability and native woody vegetation, and this pattern was exacerbated by periodic drought.

Current Vegetation Condition and Trends



In general, island botanists, archaeologists and the ranching community agree that native vegetation has begun to reappear on SRI since pig and cattle removal, particularly since reduction and ultimate removal of elk and deer (S. Chaney, D. Rodriguez, K. McEachern, K. Niessen, D. Morris, S. Junak, A. Vail, R. Vail, and T. Vail). Repeated photography along vegetation sampling transects and of island landscapes (McEachern and Demmond 2012) show variable rates of increase in native woody vegetation across much of the island. However, a 2012 photograph of an eroded upland island oak (*Quercus tomentella*) stand shows virtually no change since a 1901 photograph from the Peabody Museum collection (Figure 4.4.5). In addition to these observations, several studies initiated by NPS soon after acquisition of the island provide quantitative baselines for evaluating change since the early 1990s.

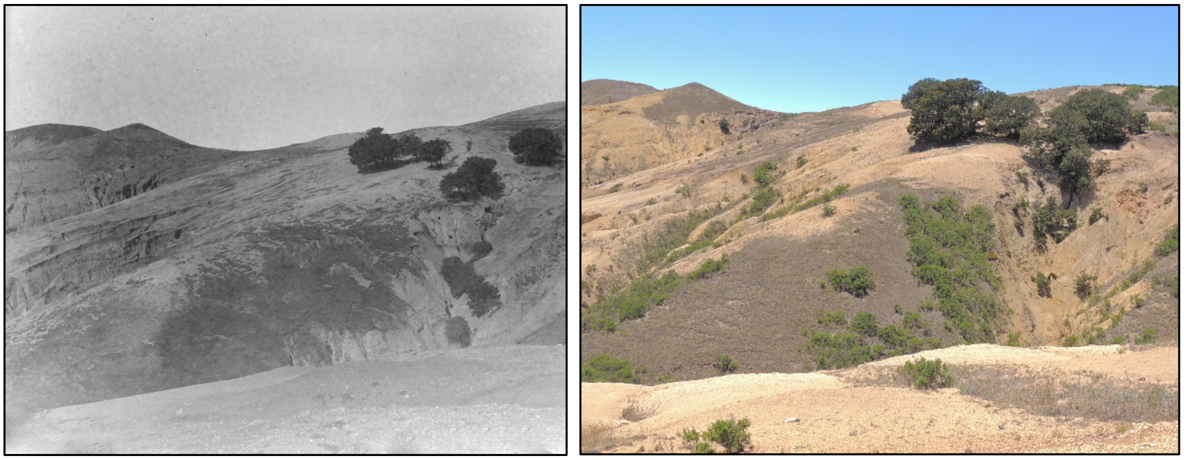


Figure 4.4.5. Island oak grove 1901 (left) and 2012 (right), Santa Rosa Island (McEachern and Demmond 2012).

Vegetation Mapping

A vegetation classification and map produced in 1988 using aerial photography and relevé samples (Clark et al 1990, Figure 4.4.2) showed about 70% of the island covered in grassland dominated by non-native bromes (*Bromus* spp.), oats (*Avena* spp.), foxtails (*Hordeum murinum leporinum*) and fescues (*Vulpia* spp.), with a variety of non-native herbs (Table 4.4.1). Coastal sage and coyote brush scrub were present as small isolated stands on steep slopes, small groves of woodland inhabited canyon bottoms, and there was virtually no riparian vegetation. Chaparral occurred in three stands on the island, characterized by open, heavily browsed canopy and sharp boundaries with grassland, no litter in the understory, and a dense reticulated network of game trails eroded into exposed bedrock. The relevé data indicate that understories in these stands were largely non-native grassland species; in 14 of the 15 plant communities exotic plants outnumbered natives, and 23% of the flora sampled was of exotic origin. However, relative importance values calculated from species cover, density and distribution measurements in plots (Table 4.4.2) showed that natives were still dominant in some stands, indicating potential for recovery with release from grazing pressure. Repeated vegetation mapping and sampling is currently underway (NPS unpublished).

Table 4.4.1. Extent of each plant community, and bare ground on Santa Rosa Island as a percentage of the total area. (Clark, et al. 1990, Table 7, p. 25).

Vegetation community	Area of Island (%)
Grassland	67.53
Coastal marsh	0.29
Caliche scrub	0.16
Coastal sage scrub	18.37
Baccharis scrub*	0.04
Lupine scrub	0.81
Coastal bluff scrub	0.43
Coastal dune scrub	0.16
Mixed chaparral	4.84
Mixed woodland	0.09
Torrey pine woodland	0.16
Closed-cone pine woodland	0.01
Island oak woodland	0.08
Riparian woodland	0.01
Riparian herbaceous vegetation	<0.01
Bare ground	6.90

* The Baccharis scrub plant community is under-represented by these data due to the inability to distinguish the baccharis scrub from coastal sage scrub community on aerial photographs.

Table 4.4.2. The total number of plant taxa observed in each plant community, and their origin (native vs. alien). The relative importance value (RIV) for the native and alien taxa are given in parentheses (Clark, et al. 1990, Table 8, p. 27).

Community	Total species	Native species (RIV)	Exotic species (RIV)
Grassland	94	63 (25.2)	31 (74.8)
Coastal marsh	15	6 (75.2)	9 (24.8)
Caliche scrub	44	25 (44.4)	19 (55.6)
Coastal sage scrub	103	77 (54.0)	26 (46.0)
Baccharis scrub	74	44 (37.2)	30 (62.8)
Lupine scrub	27	20 (74.4)	7 (25.6)
Coastal bluff scrub	24	17 (65.1)	7 (34.8)
Coastal dune scrub	15	9 (74.0)	6 (26.0)
Mixed chaparral	81	63 (72.9)	18 (27.3)
Mixed woodland	67	51 (71.5)	17 (27.2)
Torrey pine woodland	62	47 (72.5)	15 (27.5)
Closed-cone pine woodland	32	23 (71.0)	9 (29.0)

Table 4.4.2 (continued). The total number of plant taxa observed in each plant community, and their origin (native vs. alien). The relative importance value (RIV) for the native and alien taxa are given in parentheses (Clark, et al. 1990, Table 8, p. 27).

Community	Total species	Native species (RIV)	Exotic species (RIV)
Island oak woodland	17	11 (77.7)	6 (22.3)
Riparian woodland	44	26 (54.9)	18 (44.2)
Riparian herbaceous vegetation	19	11 (45.3)	8 (54.7)

Shrubland-grassland Boundaries

In 1997, just prior to cattle removal, Corry and McEachern (Section 5 in Halvorson et al. 1997) studied change across boundaries between grassland and coastal sage scrub, and between grassland and chaparral on SRI. Results indicated that there were sharp boundaries between the two communities, with few to no recruitment of shrubs in grassland at the stand edges. Hobbs (1986) had shown a similar pattern on SCI, attributing the lack of recruitment to maintenance of compacted soils and failed shrub seedling establishment in grass so long as grazing animals were present. In 2007, Christian (2007a) resampled the gradients, investigating what effects cattle removal had on species composition within each community type, shrub establishment in grassland, and soil compaction. There was little change in the sharpness of the shrub-grass ecotone and no recruitment of dominant shrubs into grassland, although soils were slightly less compacted overall. Ungulate (deer and elk) use was highest in chaparral and at the edges of coastal sage scrub stands, as indicated by fecal pellet counts. Where ungulate use was reduced, increased growth of individual shrubs led to less internal shrub stand fragmentation. In a separate study, Christian (2007b) showed that uncommon and endemic shrubs experienced higher browse rates than non-endemics, similar to rates shown by Bowen and Van Vuren (1997) on SCI when sheep were present. Thus, it appeared that elk and deer browsing continued to affect stand composition and prevent expansion on SRI, even after cattle removal.

Stream Surveys

A team of hydrologists and ecologists surveyed ten SRI streams in 1995 (Rosenlieb et al. 1995) using rapid survey techniques established by the Bureau of Land Management (1993). Only two of the ten were rated as having proper hydrologic function. Most streams were barren of vegetation, with beds of cobbles or exposed bedrock and channel reaches indicative of flash-flow, erosion and excessive downstream sedimentation as dominant processes. The alluvium that would have stored water for plant growth was either washed away or stranded several meters above the stream bed, resulting in barren conditions and a lost capacity to capture sediment and store water for riparian vegetation. NPS conducted a resurvey using the same methods in 2004 (Wagner et al. 2004), six years after cattle removal, finding the streams much improved. The growth of herbaceous vegetation in the absence of cattle trampling had begun to slow flow velocities, trapping sediment and creating meandering stream beds more resistant to severe erosion during heavy rainfall. These results highlighted a great potential for the riparian systems to recover function after ungulate removal. However, woody vegetation had not yet begun to establish because it was still heavily used by the remaining deer and elk, preventing full recovery of riparian habitats for native plants and animals. In 2014, another NPS team mapped standing water in all of the islands drainages, encountering thick cattails (*Typha domingensis*), coyote brush, and some young willow (*Salix lasiolepis, S. exigua*) thickets in many streams (Power et al. In prep.). While this was not a vegetation or stream condition survey, these observations point to very recent regrowth of woody riparian vegetation with the removal of elk and deer.

Riparian Area Weed Mapping and Prediction Matrix

In 2005, Dow (2008) resampled abundance and distribution of the 18 most common non-native species in ten SRI canyons sampled in 1998 by Chaney and McEachern (2000), all of which were herbaceous species. Objectives were to document whether changes seven years after cattle removal could be predicted by life-history characteristics including seed viability in the soil, seed production, life history, and dispersal ability. Species were classified as decreasers, persisters or invaders following cattle removal based on their predicted ability to thrive in the absence of continued disturbance (Table 4.4.3). Results showed that changes were not always consistent with life-history model predictions. Overall, herbaceous exotic species were increasing and spreading in the canyon streambeds. Change was variable in several weedy species that were dense in cattle loafing areas on terraces stranded above the streambed in 1998, including decreases in spiny cocklebur (*Xanthium spinosum*) and horseweed (*Conyza canadadensis*), persistence of milk thistle (*Silybum marianum*), and increases in cheeseweed (*Malva parviflora*) and horehound (*Marrubium vulgare*). These results were consistent with the Wagner et al. stream survey observations of greater herbaceous vegetation cover. However, it was apparent that recovery was uneven and continued disturbance by elk and deer complicated recovery of native species dominance, and in particular of woody plants.

Table 4.4.3. Exotic herb species change 1998-2005 in plotless relevés located in ten Santa Rosa Island canyons (Dow 2008).

Life form	# Spp. increased	# Spp. decreased	# Spp. persisted (no change)
Perennial	2	1	0
Annual	8	2	5

Vegetation Transect Analysis

It is clear that the SRI ecosystem was pushed into an altered state by the dramatic changes that accompanied ranching. Several authors have suggested that ecosystem change following grazing removal would follow unpredictable trajectories affected by a multitude of interacting physical and biological factors, and that conditions might be unstable initially as species dominance sifted and ecological networks changed (e.g., summarized in Zavaleta et al. 2001). Plant community monitoring began on SRI in 1990, to anticipate problems and document changes through time as grazers were removed from the island. The sample protocol tracks species frequency on 89 permanent point-intercept transects established in the 15 major plant communities defined by Clark et al. for the island. Transect data analyses 1990 – 2007 (Dow 2008) and 1990 – 2012 (Handley et al. 2013) provide an opportunity to investigate rates and directions of change with removal of pigs (1993), cattle (1998), and reduction of elk and deer to near zero (from 1998 to 2011). Both studies used general linear mixed effects (GLMM) modeling approaches to detect trends in species and species guilds related to time and other environmental variables (Table 4.4.4 model variables). In the more general analysis of the two, Dow modeled change in species and guilds, island-wide, with a repeated measures model (Littell et al. 1996), while Handley et al. used a Bayesian Markov Chain Monte Carlo (MCMC) approach for model fitting (Zuur et al. 2009, Crawley 2007) to model change individually within each of the sampled plant communities.

Table 4.4.4. Environmental effect variables.

Analysis	Variables
Bayesian MCMC analysis of Santa Rosa Island transect data by community, 1990-2012 Handley et al. 1990 – 2012[1]	Fixed effects
	Year
	Total precipitation in current water year
	Average growing season temperature
	Solar radiation
	Wind speed
	Monitoring date
	Random effects
	Site on intercept
	Community on intercept
	Year on intercept
	Visit on intercept
	Community on annual trend
PROC MIXED Model Analyses of Santa Rosa Island transect data island wide Dow 1990 – 2007[2]	Cattle present/absent
	Year
	Precipitation
	Elevation
	Slope steepness
	Northness (# degrees from north)
	Island side (north vs. south)
	Soil texture
	Plant community

[1] (n= x transects within 15 communities each × 21 years; Handley et al. 2013).

[2] (n = 86 transects × 16 years = 1376 sample units), 1990-2007 (Dow 2008).

Although model approaches and parameters differed between the two studies, there is agreement that certain of the communities are recovering native dominance faster than others, and that species and guilds do respond variously in response to complex interactions of environment and community. Dow was particularly interested in the roles of exotic plants in recovery after grazing. In general, she found several communities with increased relative cover of natives over exotics, including *Baccharis*- scrub, lupine scrub and caliche scrub, and to a lesser extent, coastal strand and mixed oak woodland. Reasons for increased nativity were varied, ranging from increases in natives over exotics to decline in exotics without change in the natives. In general, the strongest trends associated with cattle removal in her model included an overall increase in native perennial grasses, a decrease in exotic annual grasses, a decrease in exotic annual herbs and a decrease in California sagebrush (*A. californica*). In general, the strongest species and species guild associations with environmental variables included exotic species association with northness and the north side of the island. Overall, native species were more variable, but demonstrated significant negative associations with northness and the north side of the island. In these more northerly, mesic sites, exotic grasses were denser, apparently outcompeting native seedlings, a mechanism observed by Corry (2006) and Yelenik and Levine (2011) on other islands. Interestingly, the native shrub guild was also associated with the north side of SRI (t-test average cover before vs after cattle removal, $p<0.001$), largely driven by the higher presence of California sagebrush, toyon (*Heteromeles arbutifolia*), island scrub oak (*Quercus pacifica*), and to a lesser extent, coyote brush north of the island's central ridge. The model variables "northness" and "north" are both indices of moisture on SRI, combining the effects of northerly slope and aspect with those of summertime fog and overcast clouds. Paradoxically, west-facing slopes on the north side of SRI capture moist onshore winds, resulting in more mesic conditions than normally associated with west slopes. These winds bring fog to SRI nearly every night during the summer drought (Rastogi et al. 2013; Figure 2.1.4), substantially increasing moisture availability on the north side of the island.

Interestingly, the Handley et al. analysis showed an overall decrease in total vegetation cover for nine of the 15 plant communities from 1990 to 2012, with no statistically significant change in the remaining six (Table 4.4.5). Exotics did not increase significantly in any communities except grassland and marsh, where ripgut brome (*Bromus diandrus*) may be replacing saltgrass (*Distichilis spicata*). Declines were most consistent among exotic annual grasses and herbs that form the matrix of the grassland community and understories in the island's shrub and woodlands (Clark et al. 1990). Declines were observed in some native species as well, most notably saltgrass (in 8 of 15 communities) and coyote brush (*Baccharis pilularis*, in 3 of 15 communities). California sagebrush, a species thought to be widespread on the island before ranching, decreased significantly in coastal sage scrub and grassland, but increased in *Baccharis* and caliche scrub. Christian (2007a) showed that ungulate use was still high in shrub stands, leading to lack of native recovery in the chaparral, coastal sage scrub and grassland stands that she sampled. Why sagebrush increased in *Baccharis* and caliche scrub at the same time is unknown, but probably relates to a complex interaction of variable deer pressure with both facilitation and competition from other plants across the transects. The federally listed (endangered) SRI manzanita (*Arctostaphylos confertiflora*), shown to be heavily browsed by deer in a separate exclosure-control study (NPS unpublished data) and in Christian's (2007b) browse measurements, increased significantly in chaparral and SCI pine (*Pinus muricata*) and Torrey pine (*P. torreyana*) woodlands. Woody plants that dominate or co-dominate SRI shrub and woodland stands increased significantly in cover in 8 of the 15 communities sampled, while they declined in another 6 stands (Table 4.4.5).

Table 4.4.5. Trends in cover of species and species guilds 1990 – 2012 on Santa Rosa Island transects detected in models at two levels of statistical significance (p<0.001 and p<0.01). ↓ indicates overall decline in total cover at p <0.01, except Caliche Scrub with p<0.05 (Handley et al. 2013).

Plant community	↑ Natives	↓ Natives	↑ Exotics	↓ Exotics
Baccharis scrub ↓	*Artemisia californica** Native grasses *Bromus carinatus** *Leymus triticoides/pacificus*	Native shrubs* *Baccharis pilularis** *Amsinckia iintermedia** *Distichilis spicata**	–	All exotics* Exotic shrubs* *Atriplex semibaccata** Exotic herbs *Erodium spp.** *Hypochaeris glabra* *Medicago polymorpha* Exotic grasses
Lupine scrub ↓	–	Native grasses *Distichilis spicata** *Juncus meaxicanus*	–	Exotic herbs *Erodium spp.* *Hordeum murinum*
Caliche scrub ↓	*Artemisia californica** *Nassella pulchra*	*Distichilis spicata**	–	All exotics Exotic herbs* *Erodium spp.* *Medicago polymorpha** *Hordeum murinum*
Coastal strand	*Lupinus albifrons* Native grasses	–	–	–
Coastal bluff scrub	–	All natives Native shrubs* *Isocoma menziesii**	–	*Erodium spp.*
Riparian ↓	Native trees* *Salix lasiolepus** Native shrubs* Native herbs* *Typha domingensis**	Native herbs* Native grasses* *Distichilis spicata* *Juncus meaxicanus*	–	All exotics* Exotic herbs* *Erodium spp.* *Medicago polymorpha* Exotic grasses* *Bromus diandrus**
Coastal sage scrub ↓	–	Native shrubs* *Artemisia californica* *Baccharis pilularis** *Isocoma menziesii** *Distichilis spicata*	–	All exotics Exotic shrubs *Atriplex semibaccata* *Erodium spp.* *Hypochaeris garb** *Hordeum murinum**

* p<0.001

Table 4.4.5 (continued). Trends in cover of species and species guilds 1990 – 2012 on Santa Rosa Island transects detected in models at two levels of statistical significance ($p<0.001$ and $p<0.01$). ↓ indicates overall decline in total cover at $p<0.01$, except Caliche Scrub with $p<0.05$ (Handley et al. 2013).

Plant community	↑ Natives	↓ Natives	↑ Exotics	↓ Exotics
Island chaparral	Native trees *Pinus muricata** *Quercus agrifolia** *Arctostaphylos confertiflora**	*Adenostoma fasciculatum** *Baccharis pilularis** Native herbs Native grasses*	–	All exotics* Exotic herbs *Erodium spp.* *Hypochaeris glabra* Exotic grasses* *Avena barbata/fatua** *Bromus diandrus** *Bromus hordeaceus* *Bromus madritensis** *Vulpia bromoides/myuros*
Island oak (Quercus tomentella)	–	–	–	Exotic herbs
Mixed woodland (Lyonothamnus floribundus, Q. tomentella, Q. agrifolia) ↓	Native grasses	–	–	All exotics *Silene gallica* *Avena barbata/fatua** *Hordeum murinum**
SCI pine ↓	Native shrubs* *Arctostaphylos confertiflora**	All natives* Native trees* *Pinus muricata** Native herbs	–	*Avena barbata/fatua**
Torrey pine	Native trees* *Pinus torreyana* *Quercus pacifica** *Arctostaphylos confertiflora**	*Heteromeles arbutifolia** Native herbs Native grasses *Distichilis spicata**	–	All exotics* Exotic herbs *Erodium spp.** *Hypochaeris glabra* *Silene gallica* Exotic grasses* *Avena barbata/fatua** *Bromus diandrus** *Vulpia bromoides/myuros*
Grassland ↓	Native shrubs* *Artemisia californica** *Baccharis pilularis** *Bromus carinatus** *Nassella pulchra**	Native herbs *Distichilis spicata**	*Bromus diandrus**	All exotics Native shrubs *Atriplex semibaccata* Exotic herbs* *Erodium spp.** *Hypochaeris glabra** *Bromus hordeaceus* *Bromus madritensis* *Vulpia bromoides/myuros*

* $p<0.001$

Table 4.4.5 (continued). Trends in cover of species and species guilds 1990 – 2012 on Santa Rosa Island transects detected in models at two levels of statistical significance ($p<0.001$ and $p<0.01$). ↓ indicates overall decline in total cover at $p<0.01$, except Caliche Scrub with $p<0.05$ (Handley et al. 2013).

Plant community	↑ Natives	↓ Natives	↑ Exotics	↓ Exotics
Coastal marsh ↓	*Leymus triticoides/pacificus**	All natives* Native herbs* Native grasses* *Distichilis spicata**	All exotics* Exotic grasses* *Avena barbata/fatua** *Bromus diandrus**	*Bromus hordeaceus*

* p<0.001

Santa Rosa Island Torrey pine. Photo by Geographer; license CC 2.5.

There was a variety of statistically significant effects among the covariates on trends 1990 – 2012. Total rainfall in the current water year had statistically significant positive effects on the cover and diversity of most annual plant species and guilds. This could be one factor related to declining overall cover, as drought stress has increased over the past several decades with increasing temperatures (Figure 2.1.3). The average growing season temperature was not a good predictor of cover for any of the groups and species. Wind speed was rarely statistically significant, although higher wind speeds appear to promote diversity of both native (p=0.005) and non-native herbs (p=0.01) on SRI. Solar radiation was a useful predictor for a variety of species and groups; overall, native cover and richness were higher on shadier locations (p=0.006, p=0.001), while cover and richness of non-natives was higher in more sunny locations (p=0.05, p=0.42). Of the all the covariates tested, however, the two effects related to seasonal timing of monitoring visits (monitoring date and monitoring date^2) were the ones with the greatest frequency of statistically significant p-values. Sampling generally occurs on SRI in June and July, when the onset of summer drought brings on the transition to warmer and drier conditions, smaller canopy area and decadence of annual plant tissues. If, as suggested by climate models (e.g., IPCC 2013), this transition is occurring earlier each year, it could have an effect on the measurement of plant cover, for a net effect of declining vegetation cover earlier in the year. This phenomenon may indicate a temporal shift important to island wildlife.

Species Distributions and Trends

Danielson (1987) mapped and sampled vegetation composition in the 17 upland island oak groves of SRI. Kindsvater (2006) found these groves relatively unchanged nearly 15 years later. In a Restoration Rapid Assessment Project evaluating sites for recovery potential Hiebert et al. (2012) found these and other upland sites to be heavily eroded into bedrock with gullying and sheetwash, concluding that they were in need of work to stop the erosion before recovery was possible. In contrast, studies of several other iconic SRI woody plants showed recovery related to ungulate reduction and removal. In 1888 the Torrey pine grove at Bechers Bay was noted to have about 100 trees (Brandegee 1888 field notes in the Consortium of California Herbaria); in a 2014 count there were about 3,062 reproductive trees in the stand, for a total of more than 24,000 individuals if seedlings and sapling are included in the count. A control-exclosure study of the endangered SRI manzanita (*Arctostaphylos confertiflora*) showed that deer browsing significantly reduced numbers of inflorescences at three sites in most years between 1998 and 2013 (Rodriguez unpublished, NPS files), effectively eliminating the possibility of reproduction. Continued data collection post-deer removal indicates that manzanita canopies are expanding, seeds are being produced, litter is accumulating and seedlings are present. McEachern et al. (1997) mapped a suite of about 60 rare plants in SRI canyons, in 1994 through 1996, finding them occurring at very low numbers in isolated locations out of reach of the feral animals. A resurvey in 2012-2013, showed remarkable recovery in many of the taxa, as expansion at existing stand boundaries and as new occurrences within the canyons (McEachern et al. 2011). Long-term demographic studies of the endangered soft-leaved island paintbrush (*Castilleja mollis*) showed nearly exponential increase in numbers immediately after 1998, followed by population decline related to small plant mortality as average temperatures increased on the island after about 2002 (McEachern et al. 2009). Demographic monitoring and field experiments of another suite of federally endangered annual plants of SRI, Hoffmann's slender-flowered gilia (*Gilia tenuiflora hoffmannii*), island phacelia (*Phacelia insularis* var. *insularis*), and dune dandelion (*Malacothrix indecora*), showed that population growth was closely tied to the timing and duration of annual precipitation, often complicated by competition from other annual exotic and native plants (Levine et al. 2008, 2010, 2011). The phacelia, in particular, cannot compete with the dense ripgut brome thatch and dense growth and appears in decline. Still two other listed taxa, island rock cress (*Boechera hoffmannii*) and island rush-rose (*Crocanthemum greenei*) appeared in deer and elk exclosures soon after they were erected, and recent surveys have found several more individuals of both species since deer and elk removal (McEachern et al. 2016). These results show that recovery is mixed, varying across species, island locations and biological contexts.

Vertebrate Abundance

Condition = Good

Trend = Improving

<u>*Herpetofauna*</u>

Santa Cruz Island Gopher Snake - Very little is known about use of habitat on SRI by Santa Cruz Island gopher snakes, which occur on both SCI and SRI. The subspecies is thought to be a habitat generalist, like its mainland relatives. According to Laughrin (1982, as cited in Jennings and Hayes [1994]), it is found in all vegetation types on the island, but is most common in open areas such as grasslands, dry streambeds and oak and chaparral woodlands.

Charles Drost (USGS, Southwest Biological Science Center) conducted surveys for Santa Cruz Island gopher snakes on both islands in the mid-1990s. Most of the specimens he found were from rocky canyons or outcrops, with a few records from mixed coastal shrub/grass and oak/pine woodland. Rocks, downed wood and other surface cover are important, and he doubts grassland itself is very important habitat for the species (C. A. Drost, personal communication).

SCI gopher snakes were prey for feral pigs, so the removal of feral pigs from Santa Rosa in 1992-1993 likely had beneficial effects on gopher snakes. Gopher snakes were also consumed by golden eagles (*Aquila chrysaetos*) when the eagles bred on the islands (mid-1990s to 2006; Collins and Latta 2009). The relocation of golden eagles for the benefit of island foxes (Coonan et al. 2010), probably also reduced predation pressure on gopher snakes.

<u>*Landbirds*</u>

Habitat preferences were investigated for 15 landbird species on SRI as part of the park's trend report for its landbird monitoring program (Coonan et al. 2011b). Coonan et al. (2011b) evaluated habitat selection for each species by comparing proportional occurrence of each species to proportional availability of habitats (Table 4.4.6). Five species showed preference for grassland, five for coastal sage scrub, one for chaparral, one for pine woodland, none for mixed woodland, and four for riparian.

Table 4.4.6. Habitat preference (P) and avoidance (A) for 15 landbird species on Santa Rose Island (Coonan et al. 2011b). Blanks (–) indicate no statistically significant preference or avoidance for that habitat type.

Common name	Latin name[1]	GRS[2]	SCRB	CHP	PINE	WOOD	RIP
California quail	*Callipepla californica*	–	–	–	–	–	–
Anna's hummingbird	*Calypte anna*	–	–	–	–	–	–
Allen's hummingbird	*Selasphorus sasin sedentarius*	–	A	–	–	–	P
Pacific-slope flycatcher	*Empidonax difficilis insulicola*	–	A	–	P	–	–
Black phoebe	*Sayornis nigricans*	–	–	A	A	A	P
Horned lark	*Eremophila alpestris insularis*	P	–	A	–	A	A
Rock wren	*Salpinctes obsoletus*	–	–	–	A	A	P
Bewick's wren	*Thryomanes bewickii nesophilus*	–	A	–	A	–	P
Orange-crowned warbler	*Vermivora celata sordida*	–	P	–	A	A	–
Song sparrow	*Melospiza melodia graminea*	P	P	A	A	A	–
Spotted towhee	*Pipilo maculatus*	P	P	P	A	A	A
Chipping sparrow	*Spizella passerina*	P	P	–	–	A	A
Western meadowlark	*Sturnella neglecta*	P	P	–	A	A	A
Lesser goldfinch	*Carduelis psaltria*	–	–	–	–	–	A
House finch	*Carpdacus mexicanus clementis*	P	–	–	–	A	–

[1] Addition of subspecific name indicates endemic subspecies.

[2] GRS = grassland; SCRB = coastal sage scrub; CHAP = chaparral, PINE = closed-cone pine, WOOD = mixed woodland; RIP = riparian.

Island Shrike - Island shrikes (*Lanius ludovicianus anthonyi*) are an endemic subspecies of loggerhead shrike, and presently occur on Santa Catalina, Santa Cruz and SRI; they formerly occurred on San Miguel and Anacapa Islands, but disappeared from those islands by 1976 and 1978, respectively (Collins 2008, Caballero and Ashley 2011). Island shrikes are not detected in adequate numbers during annual landbird monitoring to detect trends. However, a rigorous survey conducted in 2009-2010 resulted in population estimates of <250 on Santa Rosa and <50 on Santa Cruz (Stanley et al. 2012).

Hall and Kuehn (2012) investigated island shrike habitat use and selection using data from recent island shrike and landbird surveys on Santa Rosa and Santa Cruz. They found that shrikes used coastal sage scrub, grassland, *Baccharis*- and toyon-dominated vegetation on both islands. Shrikes avoided Torrey pine and manzanita on Santa Rosa. However, micro-habitat or fine-scale habitat may be relatively more important than simple habitat associations for shrikes; they are generally known to hunt from elevated perches, and are less successful hunting in thick vegetation, especially thick non-native grasses (Collins 2008, Hall and Kuehn 2012). On the islands, shrikes typically inhabit grassland and open coastal sage scrub on terraces and in canyons (Collins 2008).

Given these aspects of shrike habitat use, the possibility of habitat change following ungulate removal has been proposed by some as the reason for the currently low numbers of shrikes on the islands. There has likely been considerable vegetation change on SRI following removal of sheep (1930s), feral pigs (1993), cattle (1998) and elk (2011) and deer (2013). A petition to list the island shrike as endangered (Walter 2006) cited impacts to shrike habitat from growth of non-native grasses following removal of ungulates on the northern Channel Islands, and suggested this was the cause of shrike decline from historically higher numbers. Thick non-native grasses are difficult for shrikes to forage in, and may also have lower abundance of native arthropods. More recently, Stanley et al. (2012) suggested that vegetation recovery may not be beneficial for island shrikes, citing a suggestion (Lynn et al. 2006) to improve habitat for endangered San Clemente loggerhead shrikes by removing stands of tall, thick grass. However, vegetation recovery eventually results in additional shrike perches (trees and tall shrubs). Whether these ungulate removals have resulted in decline in suitable habitat for shrikes is unknown.

It remains unclear as to whether habitat quality has decreased substantially following removal of grazers, and other factors, such as predation, may better explain low shrike numbers. The role of predation in limiting island shrike populations is currently unknown. The suite of potential shrike nest predators includes island foxes, island spotted skunks, common ravens and Santa Cruz Island gopher snakes.

Mammals

Island Fox - As generalist predators, island foxes are found in every habitat type on the Channel Islands, and so show less habitat preference than other species (Moore and Collins 1995, Coonan et al. 2010). Drake (2013) used GPS collars to study habitat use and preference of male island foxes on SRI, under low density conditions. She found island foxes had larger home ranges at low density (compared to the smaller home ranges found by Roemer [1999] under high density conditions on SCI), and there was very little habitat preference, even at low density. Foxes used most of the available habitat types, with no significant selection for any one type. However, there was selection according to topography. Overall, foxes avoided ridgetops and selected for valley bottom topography. At night they selected for bare areas and grassland, both of which are probably easier to travel through (foxes are often observed using roads at night, for their ease of travel).

One reason that Santa Rosa Island foxes may not display much habitat preference, even at low densities, is the fact that there is less topographic and habitat diversity on SRI than on the other two large islands, Santa Cruz and Santa Catalina. Both of the latter have relatively more chaparral and woodland than does SRI, for which non-native grasslands have formed up to 2/3 of the island's cover until very recently. On Santa Cruz, Laughrin (1971, 1977) found fox densities highest in chaparral and woodland, which he attributed to higher food resources. Roemer (1999) also found foxes to be most abundant in SCI woodland and shrub communities. Such effects are apparently not seen on Santa Rosa, though in the near future the park will be able to investigate fox densities in different habitat types. Fox density is currently monitored at 18 small grids (Figure 4.4.6), each of which can be assigned to vegetation type when the park's current vegetation mapping is completed. In 2013, at low to moderate density (4 foxes/km^2), the number of foxes caught on each grid varied from 0 to 23, implying some habitat selection.

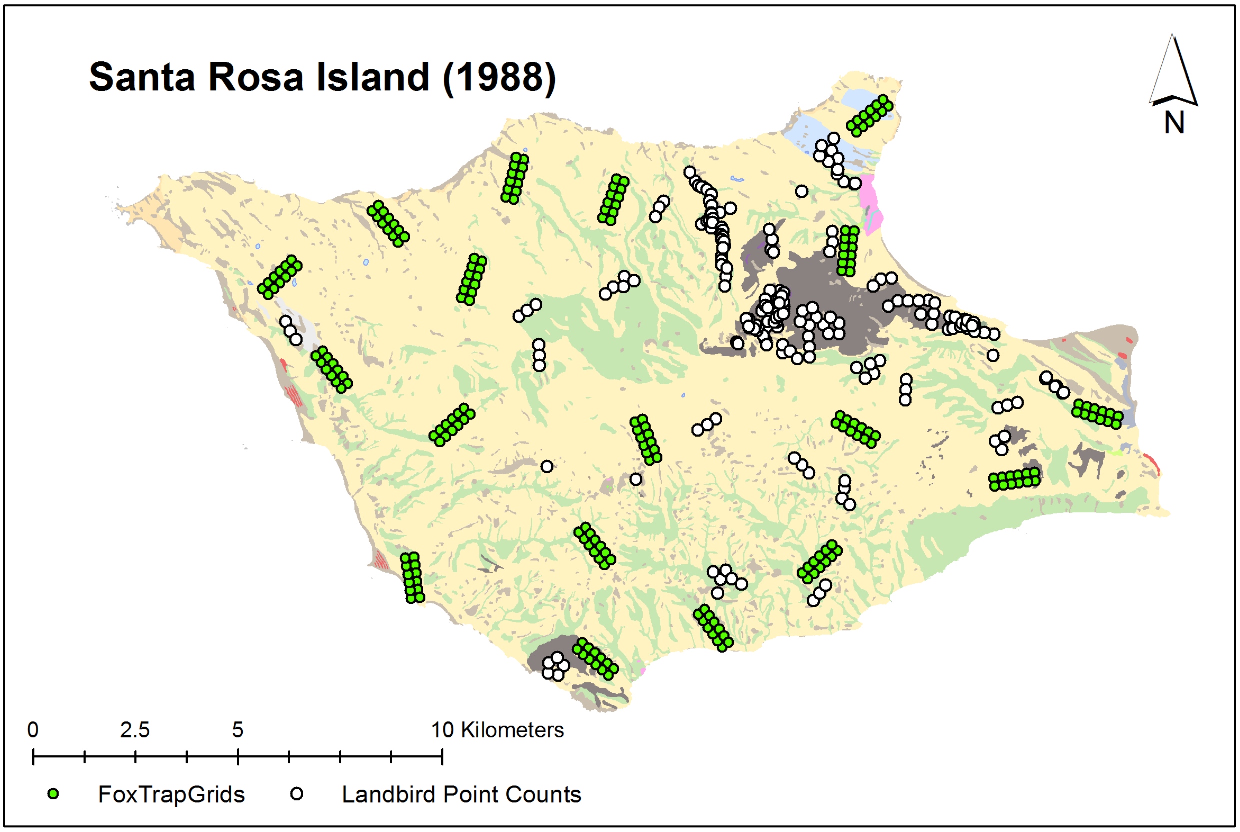


Figure 4.4.6. Locations of grids used to annually monitor island foxes and island spotted skunks, and locations of 145 landbird point count sites on Santa Rosa Island. See Figure 4.4.2 legend for color scheme of vegetation types.

The removal of ungulates from SRI should result, over time, in decreased importance of non-native grasses, and establishment and recovery of woody plant communities. This should benefit island foxes, which, at least at lower densities, favor woodland and chaparral habitats.

Island Spotted Skunk - Island spotted skunks have not been studied specifically on SRI, but their general ecology, habitat relations and population trend on Santa Rosa is probably similar to that observed on SCI. There is substantial niche overlap between the fox and the skunk, though the fox is thought to be the superior competitor (Crooks and Van Vuren 1995, Roemer et al. 2002). On both Santa Rosa and Santa Cruz, skunks increased in number when foxes declined. Skunk population dynamics on Santa Cruz are echoed by the concurrent increase in island spotted skunks on SRI, when the island fox population declined by over 95% in the late 1990s (Coonan et al. 2010). The island fox population has increased steadily since 2003, due to reintroduction success and good survival and reproductive success of wild foxes (Coonan et al. 2014). As foxes have increased, skunks have gradually decreased, although they still exist at relatively high numbers. In 2013 number of foxes caught on the grids exceeded the number of skunks for the first time since their reintroduction, and skunks declined further in 2014 (Figure 4.4.7).

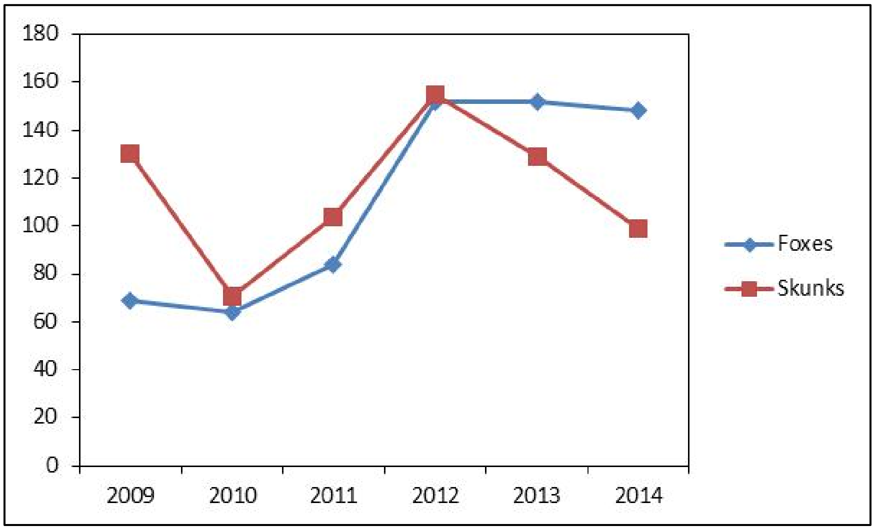


Figure 4.4.7. Number of island foxes (*Urocyon littoralis*) and island spotted skunks (*Spilogale gracilis amphiala*) captured on Santa Rosa Island monitoring grids, 2009-2014.

NRCA Team Data and Methods

Vegetation Community Structure and Spatial Extent

We entered and analyzed woody plant density data collected on transects from 1998 to 2013, using stage-based counts of woody plants rooted in 30-by-1-meter transects placed alongside the point-line intercept monitoring transects. We collaborated with L. Starcevich and D. Esperanza of West-Inc on data analysis. Preliminary plots of adult and sapling stem counts by year and species indicated large proportions of zero counts. Trend analyses were conducted for the shrub species with adequate non-zero data for modeling. "Adequate" data is typically defined as exhibiting at least four years of non-zero observations and at least five sample locations on the island. Generalized linear models (GLM) were fit to the woody plant count data when sample size was sufficient. Since species tended to be represented differently between distinct plant communities, we fit separate models by plant community (e.g. herbaceous, soft scrub, riparian, woodland, etc.). Given the large proportion of zero observations for some species/community combinations, we examined zero-inflated models (Poisson, negative-binomial, and log-normal), followed by standard Poisson and negative-binomial models if the zero-inflated models did not provide a satisfactory fit. Model selection was accomplished by assessing standardized residuals, goodness-of-fit tests, and AIC. Data analysis was conducted in the R statistical software environment (R Core Team [2014], Zeileis et. al 2008). Significance was assessed at the 0.10 significance level given the low sample size for trend detection.

When NPS completes the draft map of SRI, the Park will have the opportunity to crosswalk vegetation and make a spatial analysis of change in community extent as we did for Santa Barbara Island.

Vertebrate Abundance

Landbirds

Landbirds on SRI have been surveyed on the full suite of point counts (145) since 2002 (Coonan et al. 2011a, b; Figure 4.4.6). The point count sites are clustered in groups of 3 to 5, with starting points randomly located within 100 m of the island's unimproved road system for "near-road" sites, and randomly located for "off-road" sites. Point count site locations were adjusted to ensure representation of all the major habitat types, based on an older (1985) vegetation map and ocular estimation of dominant cover at each site. The distribution of points by habitat type is given in Table 4.4.7. For this NRCA project, we estimated annual, island-wide density over time for selected species (species with adequate number of detections, 60), utilizing program Distance and the distance-based observation data from the Park's landbird monitoring program (Buckland et al. 2001, Coonan et al. 2011b, Dye and Coonan 2014).

Table 4.4.7. Distribution of landbird point count sites by habitat type.

Habitat type	Point count sites
Coastal sage scrub	37
Grassland	30
Chaparral	30
Riparian	16
Mixed woodland	9
Closed-cone pine	6
Torrey pine	6
Oak woodland	6
Lupine	5

NRCA Team Results

Vegetation Community Structure and Spatial Extent

Woody plant density results are shown in Table 4.4.8. Twelve species had sufficient numbers within plots on SRI to permit analysis in the chaparral, grassland, riparian, and coastal sage soft scrub plant communities. Overall, 7 of 20 (35%) species/community combinations analyzed showed a directional trend in abundance from 1996 to 2013 that was significant at the 0.10 significance level. For most of the species X community combinations analyzed (13/20, 65%) there was no trend in abundance of the focal species within the community where it occurred. Four species (25%) decreased and 3 species (15%) increased in abundance in one of the communities in which they occurred. In chaparral, chamise had a positive trend, while coyote brush showed a declining trend. Among the 8 species evaluated in coastal sage scrub communities, 4 demonstrated no statistically significant trend, 3 (saw-toothed goldenbush [*Haplopappus squarrosa*], toyon [*H. arbutifolia*], and bush lupine [*Lupinus arboreus*]) showed declining trends, and 1, coastal goldenbush (*Isocoma menziesii*), increased in abundance over the 17-year period. In riparian habitats, only California sagebrush and coyote brush were found in sufficient abundance to evaluate; neither species exhibited a statistically significant trend in time. Of the 3 species evaluated in grasslands, bush lupine was the only species to exhibit a statistically significant trend in time; the trend was positive.

Table 4.4.8. Summary of model trend results for woody plant species found on Santa Rosa Island, 1996 - 2013. Trends were assessed within plant communities that were sampled with at least five plots (0 = no significant trend, + = positive significant trend, - = negative significant trend, NA = not able to fit model).

Species	Chaparral	Grassland	Riparian	Coastal sage scrub
Adenostoma fasciculate var. prostratum	+	NA	NA	NA
Artemisia californica	0	0	0	0
Arctostaphylos confertiflora	0	NA	NA	NA
Baccharis pilularis	–	0	0	0
Eriogonum giganteum	NA	NA	NA	NA
Haplopappus squarrosa	NA	NA	NA	–
Heteromeles arbutifolia	NA	NA	NA	–
Isocoma menziesii	NA	NA	NA	+
Leptosyne gigantea	NA	NA	NA	NA
Lupinus albifrons	NA	+	NA	0
Lupinus arboreus	NA	NA	NA	–
Lycium californicum	NA	NA	NA	NA
Quercus pacifica	0	NA	NA	NA
Rhus integrifolia	NA	NA	NA	0
Salvia brandegei	0	NA	NA	NA
Suaeda californica var. taxifolia	NA	NA	NA	NA
Vaccinium ovatum	0	NA	NA	NA

Vertebrate Abundance

Landbirds

We assessed abundance over time for the 10 SRI species that had an adequate number of detections for estimating density (Figures 4.4.8 – 4.4.17). Three species, (song sparrows [*Melospiza melodia*], spotted towhees [*Pipilo maculatus*] and western meadowlarks [*Sturnella neglecta*]) increased over the time period (2002 – 2014) while the other seven species exhibit no temporal trend. Habitat preferences for the 10 species were previously determined (Coonan et al. 2011b), and the species which increased preferred multiple habitat types (song sparrows: grassland and scrub; spotted towhees: grassland, scrub and chaparral; western meadowlark: grassland and scrub). The apparent increases are consistent with improvements in these habitats. On the other hand, increases were not observed in species which prefer riparian habitat (black phoebes and Bewick's wrens) or pine habitat (Pacific-slope flycatcher [*Empidonax difficilis*]). This may be because riparian woody vegetation was still impacted by browsing by mule deer until this non-native ungulate was removed in 2011 (cattle had been removed in 1998). Two other grassland species, the chipping sparrow (*Spizella passerine*) and horned lark (*Eremophila alpestris*), showed no increase. Orange-crowned warblers (*Oreothlypis celata*), which prefer scrub on SRI, did not increase, nor did lesser goldfinches (*Carduelis psaltria*); the latter had no statistically significant habitat preference.

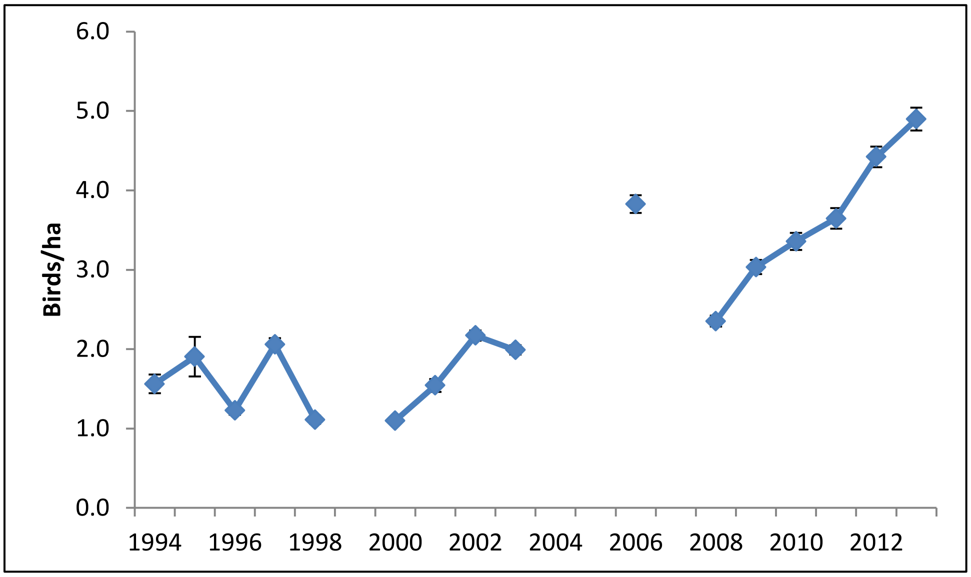


Figure 4.4.8. Spotted towhee densities on Santa Rosa Island, 2002-2013.

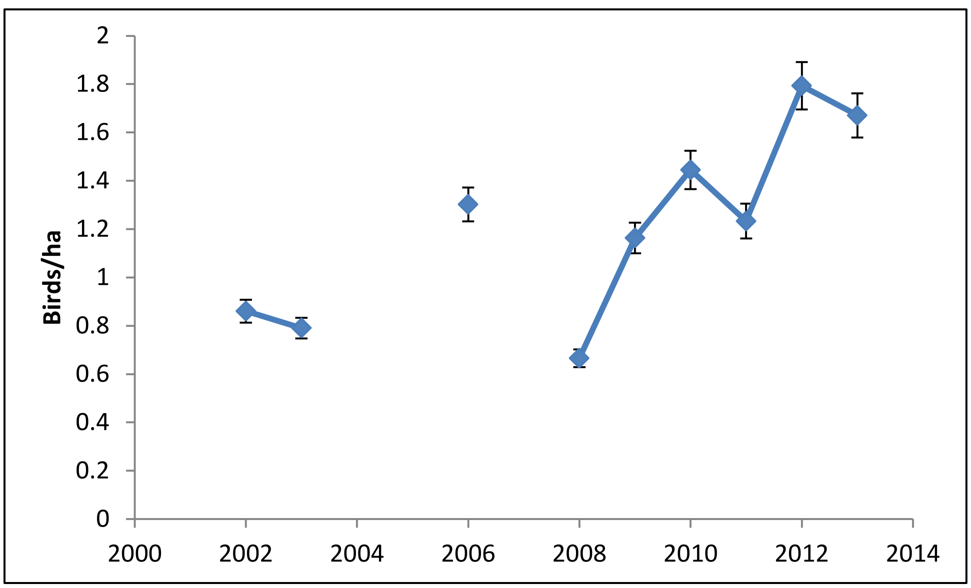


Figure 4.4.9. Western meadowlark densities on Santa Rosa Island, 2002-2013.

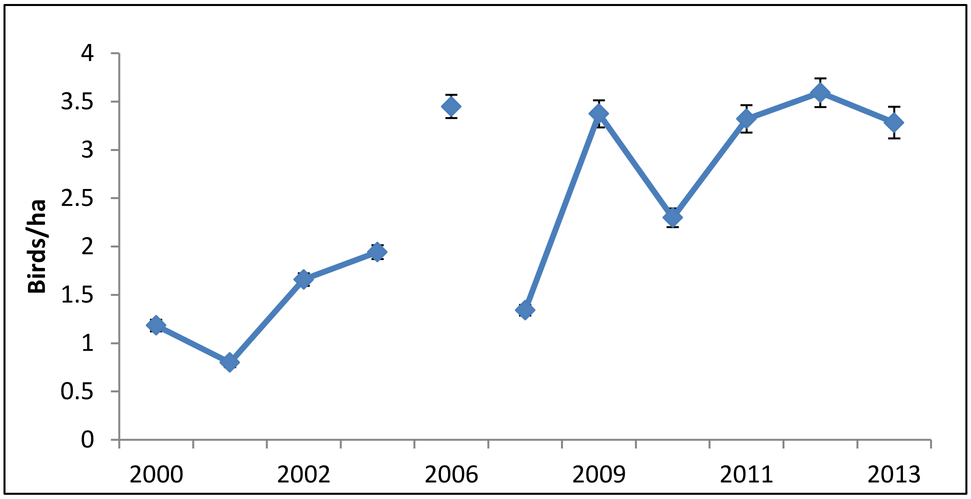


Figure 4.4.10. Song sparrow densities on Santa Rosa Island, 2002-2013.

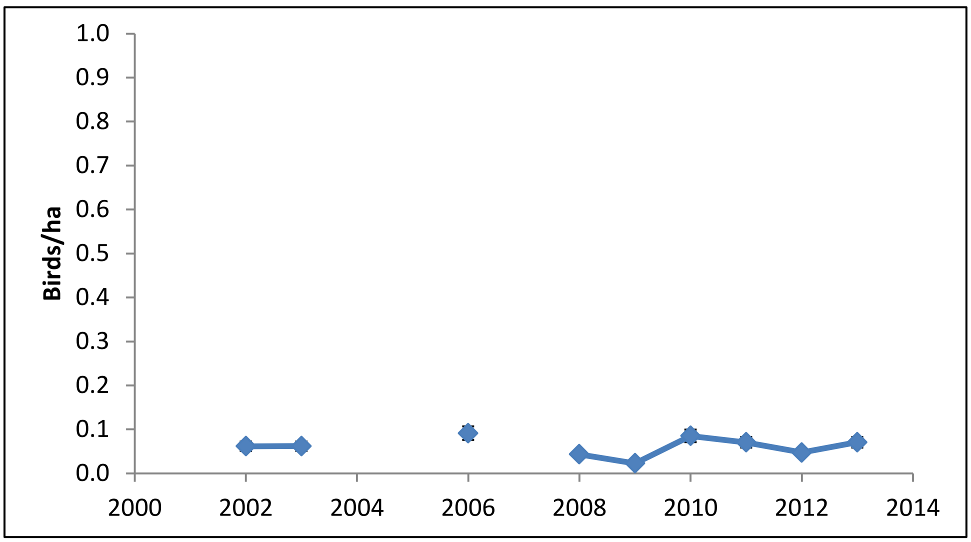


Figure 4.4.11. Black phoebe densities on Santa Rosa Island, 2002-2013.

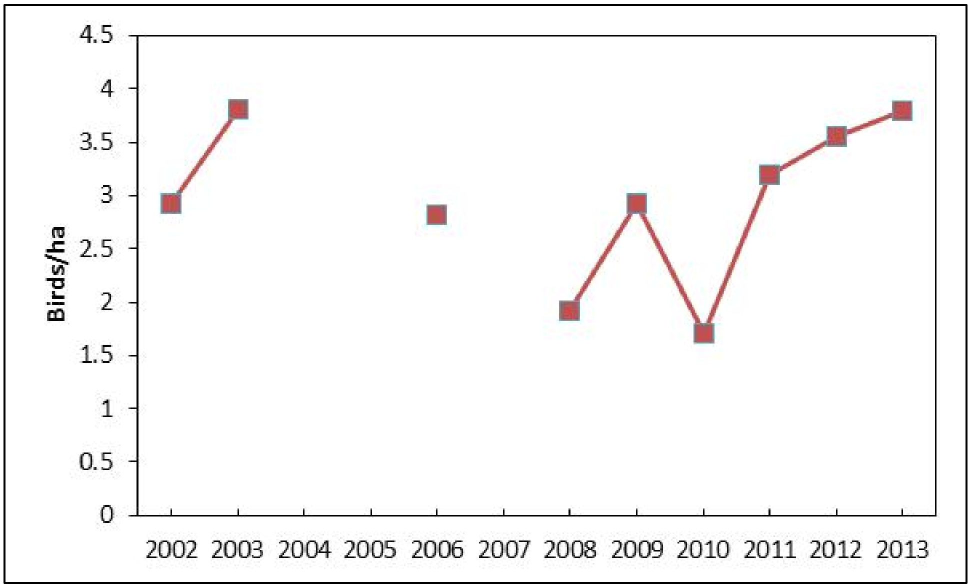


Figure 4.4.12. Bewick's wren densities on Santa Rosa Island, 2002-2013.

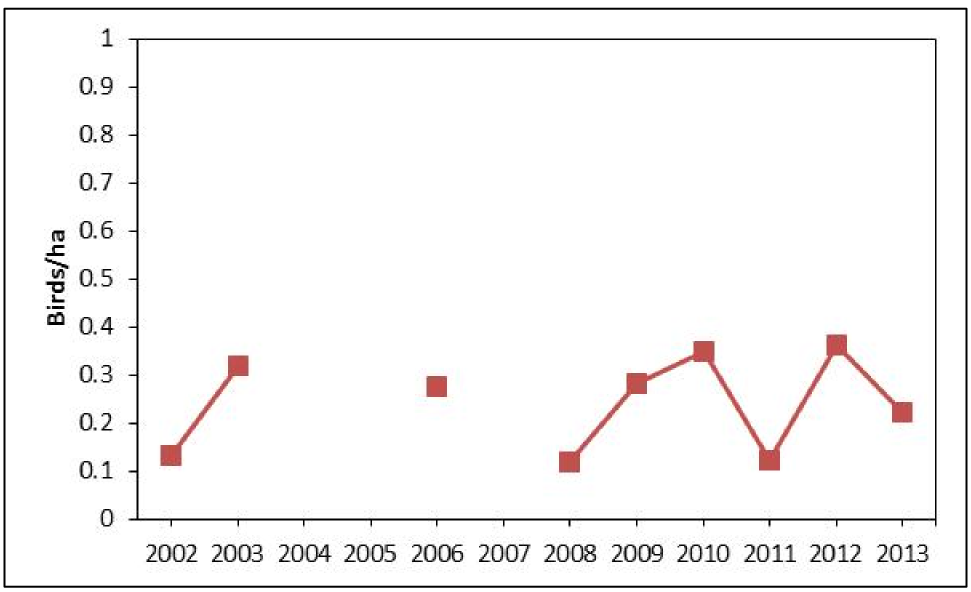


Figure 4.4.13. Horned lark densities on Santa Rosa Island, 2002-2013.

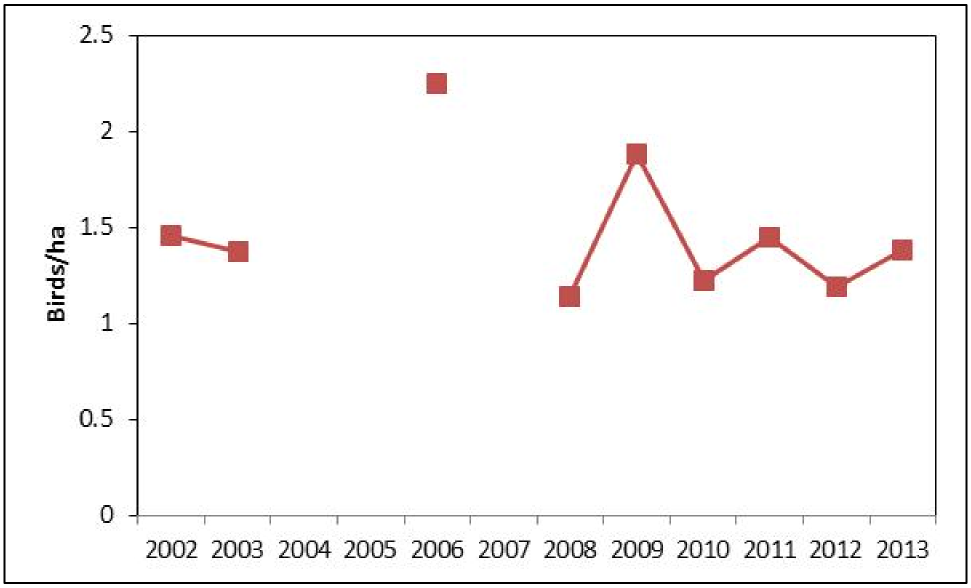


Figure 4.4.14. Chipping sparrow densities on Santa Rosa Island, 2002-2013.

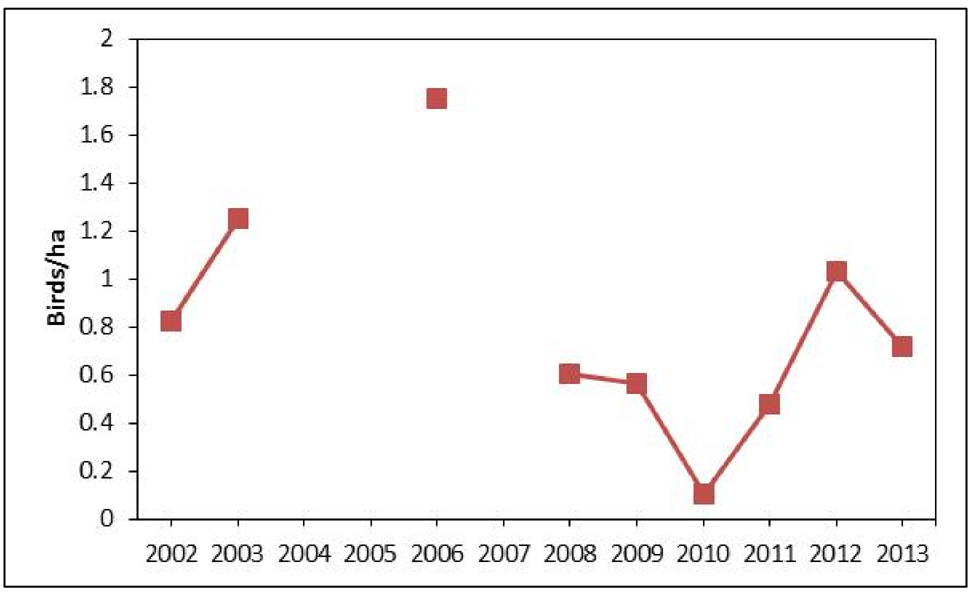


Figure 4.4.15. Lesser goldfinch densities on Santa Rosa Island, 2002-2013.

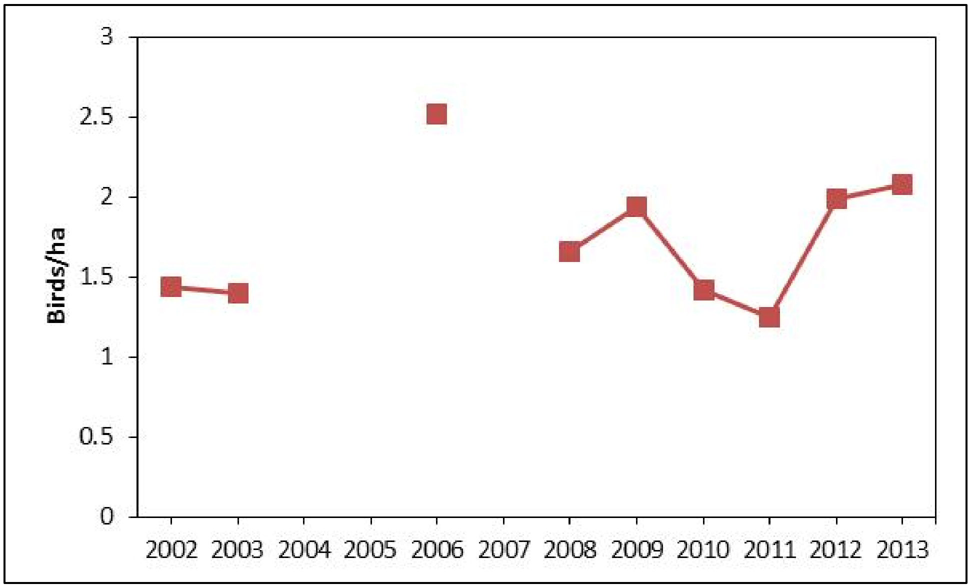


Figure 4.4.16. Pacific-slope flycatcher densities on Santa Rosa Island, 2002-2013.

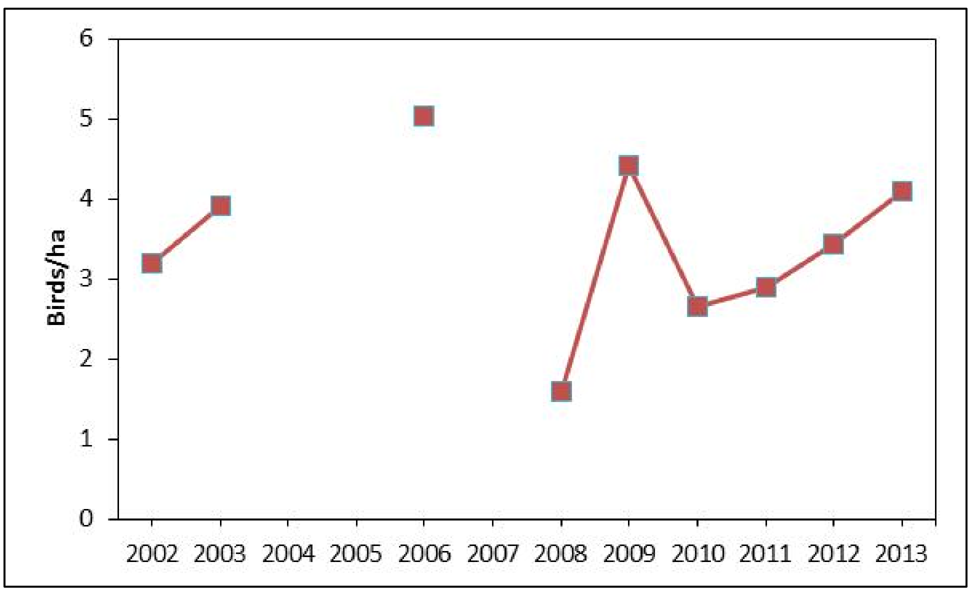


Figure 4.4.17. Orange-crowned warbler densities on Santa Rosa Island, 2002-2013.

Although other species were too rarely observed during monitoring to detect trends, presence/absence and general abundance data speak to trends in two species, bushtits (*Psaltriparis minimus*) and acorn woodpeckers (*Melanerpes formicivorus*). Bushtits appeared on SRI in the latter part of the study period, and may be breeding there now. Bushtits were first recorded during monitoring in 2010, and 25 of them were observed during 2013 monitoring (Figure 4.4.18). The majority of those were observed in chaparral in 2013, with others observed in riparian, mixed woodland and closed-cone pine habitats. On the mainland, bushtits prefer open mixed woodland with some evergreen foliage (juniper, pine oak and evergreen chaparral; Sloane 2001). Bushtits breed on neighboring SCI, and their recent establishment on SRI suggests improved habitat quality in woody plant communities on that island. Likewise, acorn woodpeckers, uncommon breeders on Santa Rosa, were observed more in the latter part of the study period, perhaps signaling improvement in woodland/oak habitat.

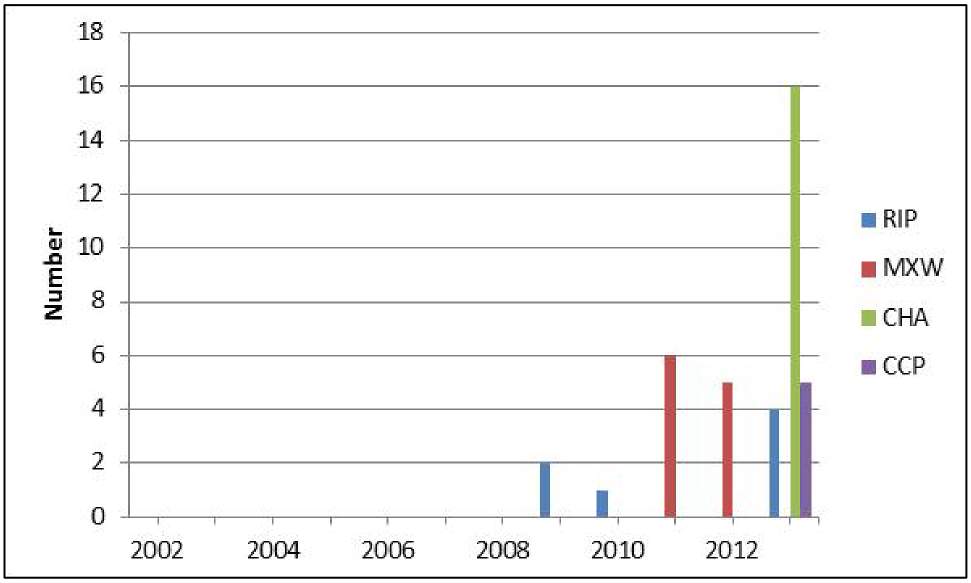


Figure 4.4.18. Number of bushtits (*Psaltriparis minimus*) recorded, by habitat type, during landbird monitoring on Santa Rosa Island, 2002-2013. RIP=Riparian; MXW=Mixed woodland; CHA=Chaparral; CCP=Closed-cone pine.

<u>Threats and Stressor Factors</u>

Vegetation

Threats to vegetation recovery include continued erosion, especially in upland areas, competition from exotic herbaceous species, and lost ability to harvest fog and retain water in soils and groundwater. There are signs of an incredible capacity for recovery in some species and areas, while others clearly need active restoration. Recovery trajectories appear uneven across species and environments, with some areas needing active restoration more than others. Recovery appears to occur more rapidly during times of higher rainfall and in areas subjected to consistent summer fog.

Vertebrates

There are few threats to vertebrates on SRI. The one vertebrate species that is at most risk due to currently low population levels is the island shrike, which numbers less than 250 individuals on SRI (and less than 50 on SCI). Thus, stochastic extinction processes threaten the shrike, more than any other species (extinction probability is less than 5% for SRI foxes (Coonan et al. 2014). The reasons for the shrike's currently low numbers are unknown (see *Data Gaps*, below), but may be due to habitat changes, or to predation. Another concern is that increased temperatures could allow West Nile Virus replication in mosquitoes on SRI. Shrikes are susceptible to WNV (Bertelsen et al. 2004).

Non-native vertebrate species no longer threaten native vertebrates on SRI. Feral pigs and mule deer no longer provide food resources for golden eagles, which have been removed; habitat impacts from non-native ungulates have ceased, and recovery of island vegetation is occurring.

Data Gaps

Vegetation

The lack of current vegetation and bedrock maps limit habitat-level analyses that can be made. In particular, we need to overlay 1989 and 2015 vegetation maps (in draft) for an analysis of factors related to rates of change across the landscape to identify places most at-risk. Additionally, while it is clear that fog plays a large role in the water cycle of the island, we know little about how fog contributes to groundwater recharge.

Vertebrates

Some vertebrates on Santa Rosa, such as the island fox, island spotted skunk, and many landbird species, are fairly well-studied, and/or their populations will be monitored annually, as part of the park's long-term ecological monitoring program (Coonan et al. 2011a, 2014). There are significant gaps for some individual species, however. The currently low number of island shrikes is unexplained, and warrants study. Santa Cruz Island gopher snakes have not been adequately surveyed on either Santa Cruz or Santa Rosa, and so their range, abundance and habitat relations are relatively unknown.

Several garter snakes (*Thamnophis elegans*) have been found in Water Canyon, some during surveys several years ago, and two during stream surveys in 2014 (Paula Power, NPS, unpublished data). The species may occur in other Santa Rosa streams, such as Lobo Canyon. A thorough survey along likely stream reaches would establish distribution of this species (which may or may not have been introduced).

The current NPS vegetation mapping project for the park should allow some further investigation of the relationship between vertebrates and habitat on SRI. The park currently monitors foxes, skunks and landbirds at fixed sites, which can be assigned to habitat types or mixes of habitat types, for relation to relative density/abundance of species.

Overall Condition

Vegetation

Santa Rosa Island is in the early stages of native vegetation recovery, with recovery accelerating since removal of the last ungulates. The potential for natural recovery is high over most of the island, but some areas are recovering faster than others. Riparian areas have regained herbaceous vegetation but still lack riparian trees because deer browsed the woody plants up until their removal. Woody plants have just begun to recruit in woodland, chaparral and coastal sage scrub since release from deer browsing. At this point the major limiting factors include competition from dense brome grasses in some areas, lack of soil and litter to form seedbeds in upland areas, inability to capture and retain water from fog, continued erosion and sedimentation, and drought. There are no weed explosions apparent at present, likely related to consistent weed-control work by NPS (e.g., fennel [*Foeniculum vulgare*], mustards [*Brassica nigra* and *Hirshfeldia incana*]; Chaney, personal communication and to the drought conditions experienced in the last 3-5 years. Monitoring shows that the pace of vegetation change oscillates with precipitation, so it is reasonable to expect that conditions will be different in a series of relatively high rainfall years. Significant erosion in upland areas prevents recovery there; active restoration is needed to stop soil and bedrock loss to wind and water. As a result, SRI is on a trajectory to recover in many sites, but progress is uneven and the island has many years to go before recovery to the pre-ranching condition of diverse native scrub and woodland over most of the island.

Vertebrates

The removal of non-native ungulates from SRI began in 1990 with the removal of feral pigs, continued in 1998 with the removal of cattle, and concluded in 2011 with the virtual elimination of elk and deer. In the 1980s about 2/3 of the island was considered to be dominated by non-native grasses, riparian areas were in poor shape, and chaparral and woodland were impacted by browsing. The removal of ungulates over a 20-year period has likely allowed incipient recovery of native communities, and one would expect vertebrate species to generally benefit from such habitat recovery.

There has likely been little change in habitat quality for Santa Cruz gopher snakes, which primarily inhabit rocky canyons. If there has been an increase in downed wood and other surface debris as a result of ungulate removal, this would create more cover for gopher snakes.

Habitat is likely better for landbirds, with perhaps the exception of horned larks, which prefer short grassland and barren habitat types. Increases were observed in 3 of 10 landbird species, and those preferred grassland, scrub and chaparral habitat. However, riparian species did not increase, nor did the one species which preferred pine habitat (Pacific-slope flycatcher). Some other species which prefer grassland (chipping sparrow) and scrub (orange-crowned warbler) did not increase, but the appearance of new species which are now possibly breeding (bushtits and acorn woodpeckers) suggests improvement in woody plant communities.

Habitat for the three mammal species on Santa Rosa has likely improved, though there is no data to support this. Endemic deer mice have not been studied on Santa Rosa, but the eventual conversion of heavily grazed, non-native grasslands to ungrazed grasslands dominated by native bunchgrasses and to shrub and woodland communities would increase habitat quality for mice. Population dynamics of the island's two carnivores, the island fox and island spotted skunk, have been dominated by predation in the past two decades, and not as much by habitat quality. Island foxes declined nearly to extinction in the mid to late 1990s due to golden eagle predation, and have since recovered to perhaps 75% of their pre-decline levels thanks to captive breeding/reintroduction, and the capture and relocation of golden eagles (Coonan et al. 2010, Coonan et al. 2014). Island spotted skunks increased when foxes decreased, and began decreasing in 2013, concomitant with fox recovery. It is reasonable to postulate that conversion of heavily grazed non-native grasslands to native grasslands and eventually to woodland habitat will benefit both carnivores, due to increases in cover and food resources. There is some evidence that island foxes, on larger islands, prefer woodland habitat (at least at low fox densities), and densities in woodland habitat are higher than in other habitats. However, Drake (2013) found little habitat selection in male SRI foxes, at low density. This suggests that SRI, though large in size, acts more like a small island fox island (such as San Miguel), where less diverse habitat and topography results in less habitat selection and more equitable fox densities across the island.

Sources of Expertise

Vegetation

- Kathryn McEachern
- U.S. Geological Survey, Western Ecological Research Center, Channel Islands Field Station

Vertebrates

- Tim Coonan
- National Park Service

4.4.3. Literature Cited

Anderson, R. S., S. Stewart, R. M. Brunner, and N. Pinter. 2010. Fire and vegetation history on Santa Rosa Island, Channel Islands, and long-term environmental change in southern California. Journal of Quaternary Science 25:782-797.

Bertelsen, M.F., Ølberg, R.A., Crawshaw, G.J., Dibernardo, A., Lindsay, L.R., Drebot, M. and Barker, I.K., 2004. West Nile virus infection in the eastern loggerhead shrike (*Lanius ludovicianus migrans*): pathology, epidemiology, and immunization. Journal of Wildlife Diseases, 40(3), pp.538-542.

Bowen, L., and D. van Vuren. 1997. Insular endemic plants lack defenses against herbivores. Conservation Biology 11(5):1249-1254.

Brandegee, T. S. 1888. Field notes in the Consortium of California Herbaria. Available at: ucjeps.berkeley.edu/consortium/ (accessed 26 November 2014).

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, Oxford, United Kingdom.

Caballero, I. C., and M. V. Ashley. 2011. Genetic analysis of the endemic island loggerhead shrike, *Lanius ludovicianus anthonyi*. Conservation Genetics 12:1485-1493.

Carroll M., L. Laughrin, A. Bromfield. 1993. Fire on the California Islands: does it play a role in chaparral and closed-cone pine forest habitats? *In* Third California Islands Symposium: Recent Advances in Research on the California Islands, Hochberg, F. (ed.) Santa Barbara Museum of Natural History. Santa Barbara CA; 73–88.

Carter, H. R., G. J. McChesney, D. L. Jaques, C. S. Strong, M. W. Parker, J. E. Takekawa, D. L. Jory, and D. L. Whitworth. 1992. Breeding populations of seabirds in California 1989-1991. Draft report to Minerals Management Service.

Chaney, S., and A. K. McEachern. 2000. Development and implementation of an alien plant control strategy for Channel Islands National Park. Technical Report, Channel Islands National Park, Ventura, CA. 37pp.

Chaney, S. 2012. Current distribution and likely pre-ranching distribution of chaparral and island oak stands on Santa Rosa Island. Unpublished map. Channel Islands National Park, Ventura, CA.

Christian, J. A. 2007a. Native shrub response after reduction of browse by introduced ungulates on Santa Rosa Island, California. MS Thesis, University of Wisconsin-Madison, Madison, WI. 44 pp.

Christian, J. A. 2007b. Browse use of native shrubs by introduced ungulates on Santa Rosa Island, California. MS Thesis, University of Wisconsin-Madison, Madison, WI. 29 pp.

Clark, R. A., W. L. Halvorson, A. Sado, and K. C. Danielson. 1990. Plant communities of Santa Rosa Island, Channel Islands National Park. Cooperative Park Studies Unit, Technical Report No. 42. University of California Davis, California. 88 pp.

Cole, K. L., and G. Liu. 1994. Holocene paleoecology of an estuary on Santa Rosa Island, California. Quaternary Research. 41:326-335. Journal Article-2216508.

Collins, P. W. 2008. Island loggerhead shrike (*Lanius ludovicianus anthonyi*). Pgs. 278-283 in W. D. Shuford and T. Gardali, eds., California Bird Species of Special Concern, Studies of Western Birds No. 1.

Collins, P. W. 2011. Bird Checklist Channel Islands National Park. National Park Service.

Collins, P. W., and B. C. Latta. 2009. Food habits of nesting golden eagles (*Aquila chrysaetos*) on Santa Cruz and Santa Rosa Islands, California. Pages 255-268 in Damiani, C. C. and D. K. Garcelon (eds.). Proceedings of the 7th California Islands Symposium. Institute for Wildlife Studies, Arcata, CA.

Coonan, T. J., A. Guglielmino, and R. Shea. 2014. Island fox recovery program, Channel Islands National Park, 2013 annual report. Natural Resource Report NPS/MEDN/NRR-2014/845. National Park Service, Fort Collins, Colorado. 31 pp.

Coonan, T. J., C. A. Schwemm, and D. K. Garcelon. 2010. Decline and recovery of the island fox: a case study for population recovery. Cambridge University Press, Cambridge, U.K.

Coonan, T. J., L. C. Dye, and S. G. Fancy. 2011a. Landbird monitoring protocol for Channel Islands National Park – Version 2.0. Natural Resources Technical Report NPS/CINP/NRTR-2011/480. 42 pp. National Park Service, Fort Collins, Colorado.

Coonan, T. J., R. C. Klinger, and L. C. Dye. 2011b. Trends in landbird abundance at Channel Islands National Park, 1993-2009. Natural Resources Technical Report NPS/CINP/NRTR-2011/507. 86 pp. National Park Service, Fort Collins, Colorado.

Corry, P. M. 2006. Vegetation dynamics following grazing cessation on the Channel Islands, California. PhD. Dissertation. University of North Carolina at Chapel Hill, Chapel Hill. North Carolina. 293 pp.

Crawley, M. J. 2007. The R book. John Wiley & Sons, Ltd. West Sussex, England.

Crooks, K. R., and D. Van Vuren. 1995. Resource utilization by two insular endemic mammalian carnivores, the island fox and island spotted skunk. Oecologia 104:301-307.

Cypher, B. L., E. Y. Madrid, C.L. Van Horn Job, E. Kelly, S. W. R. Harrison, and T. L. Westall. 2011. Resource exploitation by island foxes: implications for conservation. Contract Final Report (P085004) to California Department of Fish and Game. California State University – Stanislaus, Endangered Species Recovery Program, Turlock, California.

Daily, M. 1999. Santa Rosa Island geologic mapping and oil exploration. Santa Cruz Island Foundation, Santa Barbara, California. Available at: http://www.mednscience.org/download_product/1600/0 (accessed 13 May 2014).

Dibblee, T. W., Jr., and H. E. Ehrenspeck. 1998. General geology of Santa Rosa Island, California, Pages 45-75. *In* Weigand, P. W., ed., Contributions to the geology of the northern Channel Islands, Southern California: Pacific Section American Association of Petroleum Geologists, 1998 Annual Meeting, Ventura, California.

Dow, T. 2008. Predicting invasive plant persistence and tracking trends following removal of livestock disturbance from Santa Rosa Island, Channel Islands National Park. MS Thesis, Northern Arizona University, Flagstaff, AZ. 123 pp.

Drake, E. M. 2013. Home range and habitat use of Santa Rosa Island foxes (*Urocyon littoralis santarosae*). M.S. Thesis, California Polytechnic State University, San Luis Obispo, California. 100 pp.

Erlandson, J. M., T. C. Rick, T. J. Braje, M. Casperson, B. Culleton, B. Fulfrost, T. Garcia, D. Guthrie, N. Jew, D. J. Kennett, M. L. Moss, L. Reeder, C. Skinner, J. Watts, and L. Willis. 2011. Paleoindian seafaring, maritime technologies, and coastal foraging on California's Channel Islands. Science 331:1181–1185. Available at: http://www.ncbi.nlm.nih.gov/pubmed/21385713 (accessed 2 September 2014).

Halvorson, W. L., J. Belnap, and A. K. McEachern. 1997. San Nicolas Island restoration and monitoring. Final Report to Pt. Mugu Naval Air Weapons Station. U.S. Geological Survey Cooperative National Park Resources Study Unit, Tucson, Arizona. 437 pp.

Hall, L. S., and M. J. Kuehn. 2012. Habitat use and selection by loggerhead shrikes breeding on Santa Cruz and Santa Rosa Islands, California. Final report submitted to the National Park Service. Western Foundation of Vertebrate Zoology, Camarillo, California. 46 pp.

Handley, T., D. Rodriguez, J. Yee, and A. K. McEachern. 2013. Exploring long-term trends in vegetation of Santa Barbara and Santa Rosa Islands, Channel Islands National Park. Draft technical report, USGS, Channel Islands Field Station, Ventura, CA. 276 pp.

Hiebert, R., S. Chaney, K. Niessen, and A. K. McEachern. 2012. Application of the Restoration Rapid Assessment Tool to Selected Disturbed Sites on Santa Rosa Island, Channel Islands National Park, California. National Park Service Natural Resource Technical Report NPS/CINP/NRTR—2012/583. 174 pp.

Hobbs, E. R. 1986. Characterizing the boundary between CA annual grassland and coastal sage scrub with differential profiles. Plant Ecology 65:115-126.

IPCC. 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T. F., D. Qin, G. K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P. M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, New York, USA, 1535 pp.

Jennings, M. R., and M. P. Hayes. 1994. Amphibian and reptile species of special concern in California. Final report submitted to the California Department of Fish and Game under Contract Number 8023.

Johnson, J. R., T. W. Stafford Jr., H. O. Ajis, and D. P. Morris. 2002. Arlington Springs revisited. *In* Proceedings of the 5th California Channel Islands Symposium. Pages 541-545. D. R. Browne, K. L. Mitchell, and H. W. Chaney (eds.). Santa Barbara Museum of Natural History, California.

Keeley, J. F. 2002. Native American impacts on fire regimes of the California coastal ranges. Journal of Biogeography 29: 303–320.

Keeley, J. F. 2006. South Coast Bioregion. Pages 350-390. *In* Fire in California's Ecosystems, N. G. Sugihara et al. (eds.). University of California Press, Berkeley, California. 612 pp.

Kelsey, H. 1896. Juan Rodriguez Cabrillo. Huntington Library. San Marino, California.

Kindsvater, L. C. 2006. Conservation and restoration of the endemic island oak, *Quercus tomentella*, in Channel Islands National Park using a habitat approach. PhD. dissertation, University of California–Davis.

Laughrin, L. L. 1971. Preliminary account of the island fox. University of California, Santa Barbara. Unpublished report on file at park headquarters, Channel Islands National Park.

Laughrin, L. L. 1977. The island fox: a field study of its behavior and ecology. PhD. dissertation, University of California, Santa Barbara. 83 pp.

Levine, J. M., A. K. McEachern, and C. Cowan. 2008. Effects of a fluctuating rainfall environment on rare island annual plants. Journal of Ecology 96:795-806.

Levine, J. M., A. K. McEachern, and C. Cowan. 2010. Do competitors modulate rare plant response to precipitation change? Ecology 91(1):130–140.

Levine, J. M., A. K. McEachern, and C. Cowan. 2011. Seasonal timing of first rain storms affects rare plant population dynamics. Ecology 92(12):2236-2247.

Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. Wolfinger. 1996. SAS System for Mixed Models. SAS Institute Inc. Cary, NC.

Livingston, D. S. 2006. Historic resource study: A history of the islands within Channel Islands National Park. Technical Report to Channel Islands National Park, Ventura, California. 917 pp.

Lynn, S., C. M. Leumas, H. A. Carlisle, and N. Warnock. 2006. Final Report - 2005 Population Monitoring of the San Clemente Loggerhead Shrike on NALF, San Clemente Island, California, U.S. Navy, Environmental Department, Southwest Division, Naval Facilities Engineering Command, San Diego, California. 235 pp.

Mayfield, R. L., D. Van Vuren, and M. J. Johnson. 2000. Demography of an insular endemic rodent, *Peromyscus maniculatus santacruzae*, on Santa Cruz Island. Southwestern Naturalist 45(4): 508-513.

McEachern, A. K., D. Thomson, and K. Chess. 2009. Climate alters response of an endemic island plant to removal of invasive herbivores. Ecological Adaptations 19(6):1574-1584.

McEachern, A. K., D. Wilken, and K. Chess. 1997. Inventory and monitoring of California Islands rare plant taxa. Technical Report to the Species at Risk Program, USGS-BRD, Channel Islands Field Station, 46 pp.

McEachern, A. K., and E. C. Demmond. 2012. Changing landscapes of Santa Rosa Island photo point database and internet video project. U.S. Geological Survey, WERC, Channel Islands Field Station. Ventura, CA. Accessible at: http://gallery.usgs.gov/video_sets/Ecosystems (accessed 30 March 2014).

McEachern, A. K., L. Z. Almeida, E. L. Schultz, and D. M. Thomson. 2011. Quantifying effects of invasive pigs and climate variation on survivorship of an island endemic plant. MEDECOS XII Conference Abstracts, Los Angeles, CA.

Moore, C. M., and P. W. Collins. 1995. *Urocyon littoralis*. Mammalian Species 489:1-7.

National Park Service (NPS). 200. Landbird Monitoring 1995-2000 Annual Report. Technical Report 2001-03. Channel Islands National Park. On file at park headquarters. Available at: http://www1.nature.nps.gov/im/units/chis/PDFReports/Terrestrial/9500LBAnnl.pdf (accessed 14 January 2014).

National Park Service (NPS). 2013. Channel Islands National Park Draft General Management Plan/Wilderness Study/Environmental Impact Statement. Ventura, California.

Power, P. J., T. Stanley, C. Cowan, and J. R. Roberts. 2014. Native plant recovery in seeded and non-seeded plots following exotic fennel (*Foeniculum vulgare*) control on east Santa Cruz Island. *In* A. Little et al. eds. Proceedings of the 8th California Islands Symposium, Ventura, California.

Rastogi, B., Fischer, D. T. Williams, P. Iacobellis, S. McEachern, K. and Still, C. J. 2013. Characterizing spatial patterns of cloud cover and fog inundation in the California Channel Islands American Geophysical Union, Fall Meeting 2013, abstract #A41E-0105.

Rick, T. C., and J. M. Erlandson. 2004. Archaeological site assessments on San Miguel and Santa Rosa Islands, Channel Islands National Park, California. Report on file: Channel Islands National Park, Ventura, California.

Roemer, G. W. 1999. The ecology and conservation of the island fox (*Urocyon littoralis*). PhD. dissertation, University of California, Los Angeles, California. 229 pp.

Roemer, G. W., C. J. Donlan, and F. Courchamp. 2002. Golden eagles, feral pigs, and insular carnivores: how exotic species turn native predators into prey. Proceedings of the National Academy of Sciences 99:791-796.

Rosenlieb, G., B. Jackson, C. Sellgren, J. Wolf, J. Wagner, J. Reiner, K. McEachern, and D. Pritchard. 1995. Federal interagency riparian assessment and recommendations for achieving water quality management goals – Santa Rosa Island, Channel Islands National Park. Technical Report NPS/NRWRD/NRTR-98/202. National Park Service – Water Resources Division, Fort Collins, CO.

Sloane, S. A. 2001. Bushtit (*Psaltriparus minimus*), The Birds of North America Online (A. Poole, ed.). Ithaca: Cornell Lab of Ornithology; retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/598 (accessed 9 June 2014).

Stanley, T. R., S. Teel, L. S. Hall, L. C. Dye, and L. L. Laughrin. 2012. Population size of island loggerhead shrikes on Santa Rosa and Santa Cruz Islands. Wildlife Society Bulletin 36(1):61-69.

Thompson, T. H., and A. A. West. 1883. History of Santa Barbara and Ventura Counties, California, with illustrations and biographical sketches of its prominent men and pioneers. Reprinted, 1961, Howell-North Berkeley, California.

Timbrook, J., J. R. Johnson, and D. D. Earle. 1982. Vegetation burning by the Chumash. Journal of California and Great Basin Anthropology 4:163–186.

U.S. Department of the Interior, Bureau of Land Management. 1993. Riparian Area Management: Process for Assessing Proper Functioning Condition. TR 1737-9. Bureau of Land Management Service Center. Denver, CO. 51 pp.

U.S. Fish and Wildlife Service (USFWS). 1997. Final rule for 13 plant taxa from the northern Channel Islands, California. Pages 40954-40974 *in*: Federal Register Vol. 62, No. 147, July 31, 1997. U.S. Department of the Interior, Washington, D.C.

Wagner, J., M. Martin, K. R. Faulkner, S. Chaney, K. Noon, M. Denn, and J. Reiner. 2004. Riparian System Recovery after Removal of Livestock from Santa Rosa Island, Channel Islands National Park, California. Technical Report NPS/NRWRD/NRTR-2004-324. Fort Collins, Colo.: National Park Service, Water Resources Division. Available at: www.nature.nps.gov/water/technicalReports/CINP_RiparianReport-2004.pdf (accessed 24 May 2014).

Walter, H. S. 2006. Petition to list the island loggerhead shrike (*Lanius ludovicianus anthonyi* Mearnsi 1898) as an endangered species. Petition sent to U.S. Fish and Wildlife Service October 12, 2006. On file at park headquarters, Channel Islands National Park.

Woolley, J. J. 1998. Sedimentology of the Oligocene Sespe and Miocene Vaqueros formations, Santa Rosa Island, California. In Contributions to the Geology of the Northern Channel Islands, Southern California, edited by Peter W. Weigand. Pages 77-89. American Association of Petroleum Geologists, Tulsa, Oklahoma.

Woolley W. 1996. Santa Rosa Island: an introduction. *In* Island of the Cowboys, Allen K. B. (ed.) Pages 5–7. Santa Rosa Island Chapter Occasional Paper 7. Santa Cruz Island Foundation: Santa Barbara/Kimberly Press: Goleta, California.

Yelenik, S. G., and J. M. Levine. 2011. The role of plant - soil feedbacks in driving native-species recovery. Ecology 92(1):66-74.

Zavaleta, E. S., R. J. Hobbs, and H. A. Mooney. 2001. Viewing invasive species removal in a whole-ecosystem context. Trends in Ecology and Evolution 16:454–459.

Zeileis, A., T. Hothorn, and K. Hornik. 2008. Model-Based Recursive Partitioning. Journal of Computational and Graphical Statistics, 17(2), 492–514.

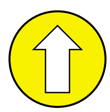
Zuur, A. F., E. N. Ieno, N. J. Walker, A. A. Saveliev, and G. M. Smith. 2009. Mixed effects models and extensions in ecology with R. Springer, New York, New York, USA.

Section 4.5. San Miguel Island

Caliche “Forest.” NPS photo.

4.5.1. General Overview of San Miguel Island

Condition = Moderate



Trend = Improving

<u>Physical Setting</u>

San Miguel Island (SMI) is a low profile island 44 km (27.3 mi) off the Santa Barbara coast, exposed to the full brunt of cool, moist winds sweeping southward around Point Conception. The island is about 15 km (9.3 mi) long and 8 km (5.0 mi) wide with a total land area of about 37 km^2 (23.0 mi^2). San Miguel is a tilted tableland underlain by Cretaceous, Tertiary, and Quaternary marine sediments, volcanics, and eolianite deposits (Johnson 1980, Muhs et al. 2009). San Miguel Hill and Green Mountain, at 253.3 m and 249.0 m (831 ft and 817 ft) respectively, are the highest points, located in the south-central part of the island (Figure 4.5.1). Several short canyons cut through the uplifted terraces running to the ocean north and south of these highlands. There are few sources of fresh water as these canyons support mainly ephemeral flow. During sheep grazing in the mid-1800s the natural vegetation was destabilized and replaced by extensive dune fields and barren erosion pavement. Rocky shorelines were likely more extensive around the island before that time (Johnson 1980); now much of the island has shorelines of sand blown from the island surface. The climate is Mediterranean with most of the rainfall occurring in winter; on nearby Santa Rosa Island (SRI), mean precipitation is 25.3 cm (10 in; 1923 – 2011). However, the summer dry period on San Miguel Island is ameliorated a bit relative to the other Park islands by the nearly constant summer fog. Winds are predominantly from the northwest, historically forming the dunes into narrow ridges and swales oriented northwest-southeast paralleling each other across the width of the island. Point Bennett, at the western tip of the island, supports one of the largest pinniped rookeries in the world (DeLong and Melin 2000).

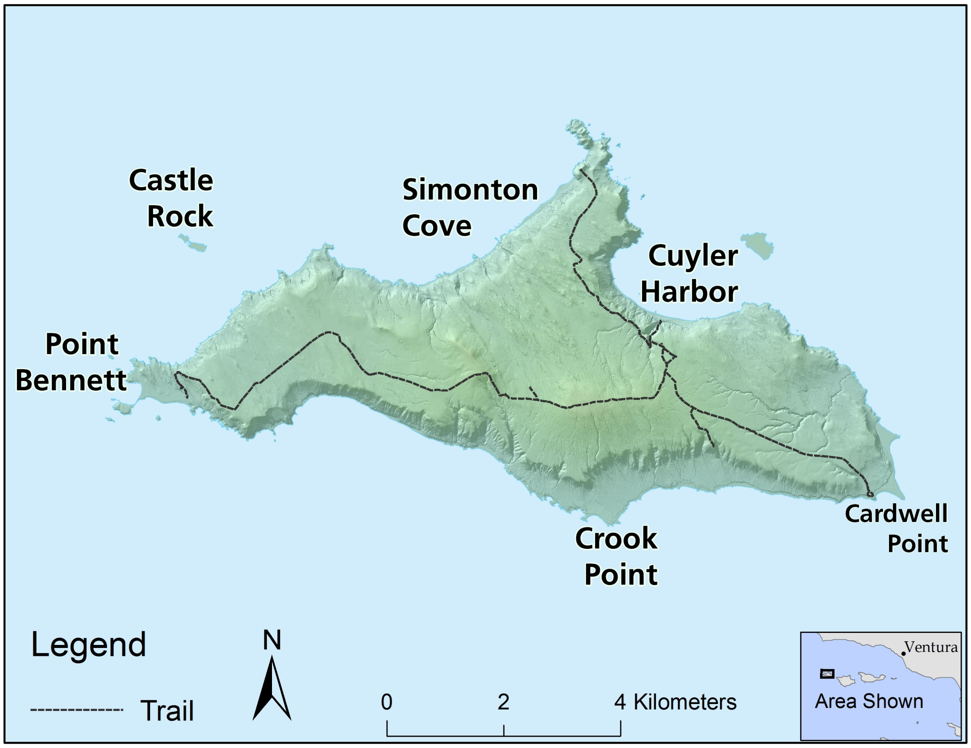


Figure 4.5.1. San Miguel Island locations, roads, trails and hillshade (Map by R. Rudolph).

Natural Resources

Terrestrial Flora and Plant Communities

About 270 plant species are known to occur on SMI, and about 74% of them are natives (Table 2.2.2). SMI is home to 20 endemic taxa, with one endemic to SMI exclusively, 18 occurring on other islands also, and 1 presumed extirpated. Grassland dominated by rip-gut brome (*Bromus diandrus*), soft-chess (*B. hordeacous*), red brome (*B. madritensis rubens*), and wild oats (*Avena fatua, A. barbata*) is the most widespread vegetation type on the island (Figure 4.5.2, Hochberg et al. 1979). Perennial native bunchgrasses, such as purple needlegrass, grow in small areas toward the eastern end of the island. *Isocoma/Happlopappus* scrub, the second most abundant plant community, also grows throughout the island on poorly developed thin, rocky, or sandy soils. Coastal goldenbush *(Isocoma menziesii*) dominates this community. Coastal sage scrub dominated by California sagebrush (*Artemisia californica)* and caliche scrub, with sparse cover of coastal goldenbush and San Miguel Island locoweed (*Astragalus miguelensis*) is less frequent on the island. San Miguel also has extensive coastal dunes, in various stages of stabilization by sea rocket (*Cakile maritime*) and sand verbena (*Abronia maritima*) in the most open locations and by beach bur (*Ambrosia chamissonis*) and beach primrose (*Camissonia cheiranthifolia*) farther from the beach. Figure 4.5.3 shows examples of some of the SMI vegetation types.

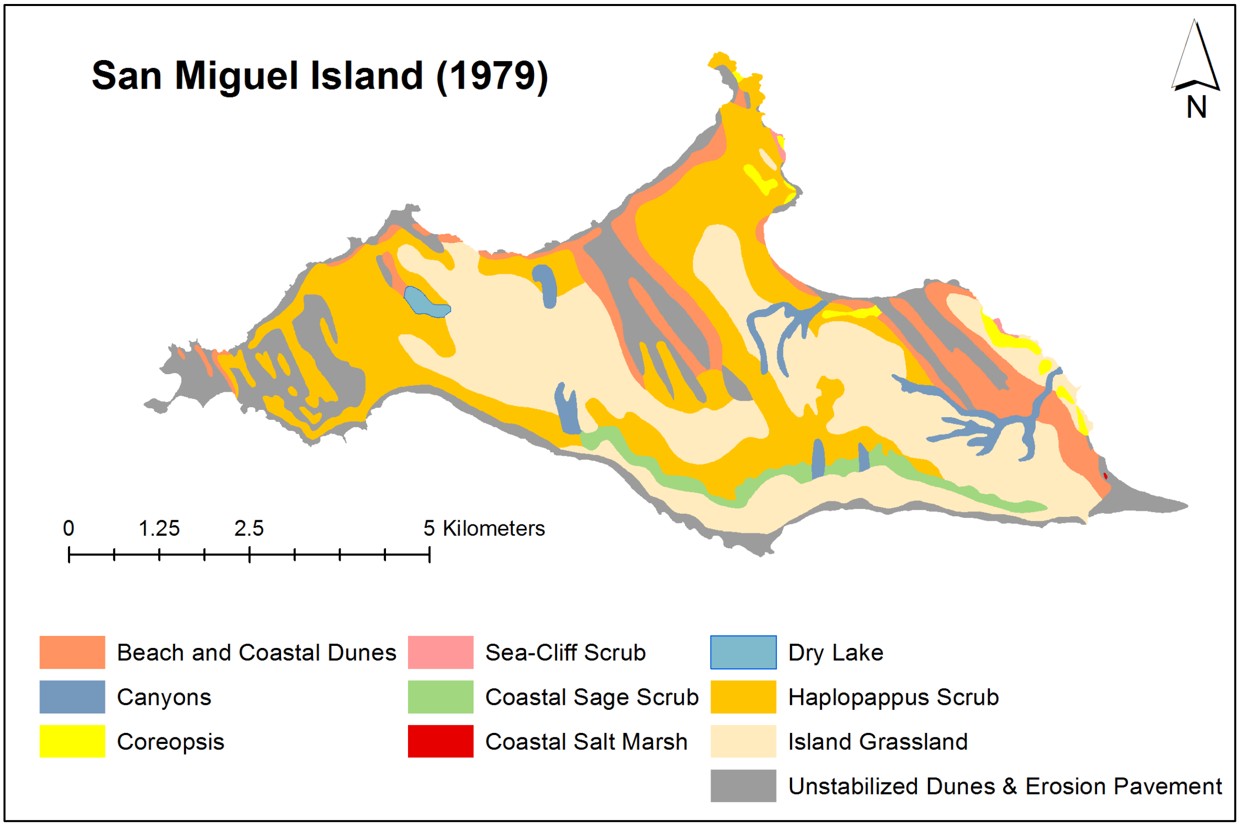


Figure 4.5.2. Vegetation types of San Miguel Island in 1979 (Hochberg et al.).

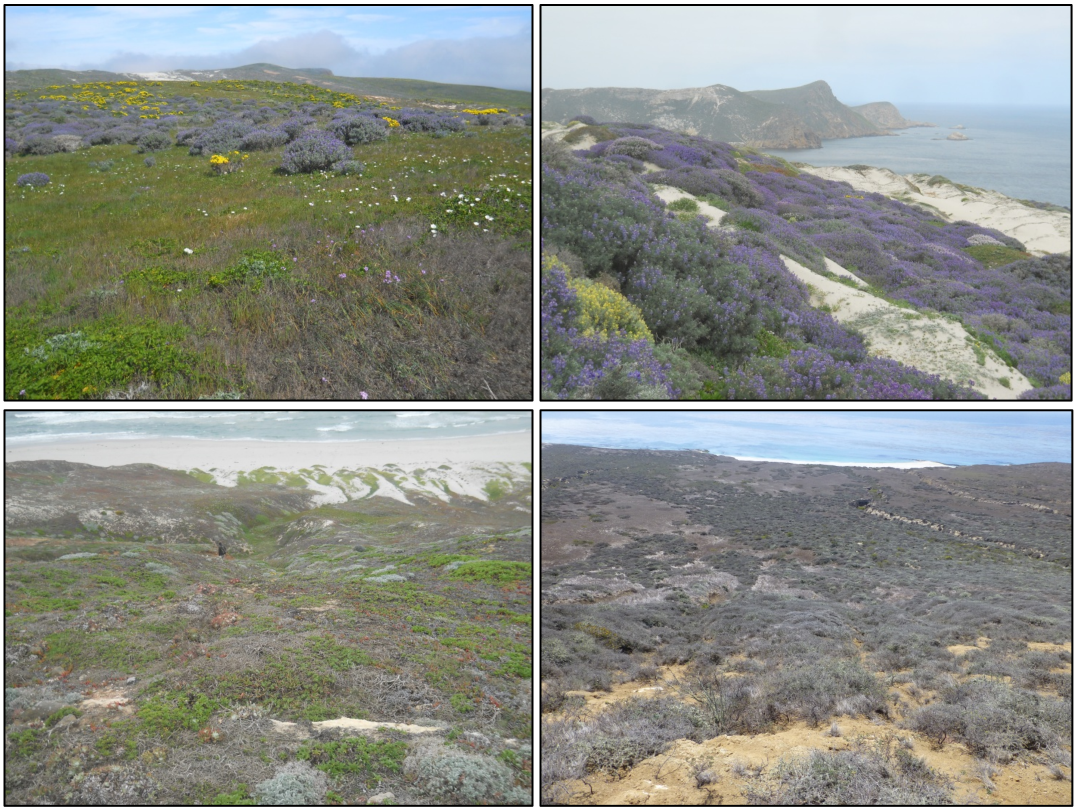


Figure 4.5.3. Photos of annual island grassland with stands of giant coreopsis (Leptosyne gigantea) and silver lupine (Lupinus albifrons) (top left), coastal dunes (top right), coastal goldenbush (Isocoma menziesii) scrub (bottom left), and dormant-season patchy coastal sage scrub and grassland on San Miguel Island in 2014 (bottom right) (NPS files).

Native Terrestrial Animals

One native amphibian, two reptile, and two mammal species occur on SMI. There are probably also some bat populations, although they are undocumented (I. Williams, personal communication). With the exception of the southern alligator lizard (*Elgaria multicarinata*), all of these animals are endemic to the Channel Islands. The Channel Islands slender salamander (*Batrachoseps pacificus*) and Island fence lizard (*Sceloporus occidentalis becki*) occur on multiple islands, while the San Miguel deer mouse (*Peromyscus maniculatus streatoi*) and San Miguel island fox (*Urocyon littoralis littoralis*) only occur on this island. A total of 48 species of landbirds were recorded from 1993 to 2000 on SMI (National Park Service [NPS] 2001a). Thirteen species of native landbirds are known to be breeding on SMI (Table 2.2.4). Common breeding species include Allen's hummingbird (*Selasphorus sasin*), San Miguel song sparrow (*Melospiza melodia micronу*), house finch (*Carpodacus mexicanus*), horned lark (*Eremophila alpestris*), orange-crowned warbler (*Oreothlypis celata*), western meadowlark (*Sturnella neglecta*), and lesser goldfinch (*Carduelis psaltria*). Less common breeders include red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), peregrine falcon (*Falco perigrinus*), barn swallow (*Hirundo rustica*), black phoebe (*Sayornis nigricans*), rock wren (*Salpinctes obsoletus*), and barn owl (*Tyto alba*). The San Miguel song sparrow only occurs on this island, while four other subspecies are endemic to SMI and one or more other

Channel Islands. The rocky cliffs along the shoreline provide habitat for peregrine falcon nests and roosts, and certain beaches are also important for wildlife.

Pinnipeds at Point Bennett. NPS photo.

San Miguel Island, and more importantly its two small offshore islets (Prince Island and Castle Rock), support the largest and most diverse seabird colonies in the Channel Islands. Sixty percent of the seabirds nesting in the Channel Islands and 11 of the 13 species that breed in the park occur on SMI and its islets (Table 2.2.7). Hunt et al. (1980) observed that SMI and its islets (particularly Prince Island and Castle Rock) support by far the largest and one of the most diverse seabird colonies in southern California. They further noted that 7 of the 11 species that breed in the Southern California Bight have their most important colonies here (Leach's and ashy storm-petrel [*Oceanodroma leucorhoa, O. homochroa*]; Brandt's, double-crested and pelagic cormorant [*Phalacrocorax penicillatus, P. auritus, P. pelagicus*]; pigeon guillemot [*Cepphus columba*]; and Cassin's auklet [*Ptychoramphus aleuticus*]). Five species that breed on the island are listed as species of special concern by the California Department of Fish and Wildlife—ashy storm-petrel, double-crested cormorant, Scripps's murrelet (*Synthliboramphus scrippsi*), rhinoceros auklet (*Cerorhinca monocerata*), and tufted puffin (*Fratercula cirrhata*). The Scripps's murrelet is listed as a threatened species by the California Department of Fish and Wildlife.

San Miguel Island is the most important island in the park for pinnipeds. Northern fur seals (*Callorhinus ursinus*), northern elephant seals (*Mirounga angustirostris*), California sea lions (*Zalophus californianus*), and harbor seals (*Phoca vitulina*) all breed there. This is also the only island where Guadalupe fur seals (*Arctocephalus townsendi*) and northern fur seals haul out. When Steller sea lions (*Eumetopias jubatus*) used the island in the past, SMI was the only island where six pinniped species were found together - more species than were found in any other single location in the world. The island is estimated to support about 60,000 northern elephant seals, about 80,000 California sea lions, more than 12,000 northern fur seals, and about 1,000 harbor seals (D. Richards, NPS marine biologist, personal communication 2013; S. Melin, NMFS marine biologist, personal communication 2013).

Non-native Animal Species

Sheep (*Ovis aries*), cattle (*Bos primigenius*), pigs (*Sus scrofa domesticus*), horses (*Equus ferus caballus*), burros (*Equus asinus*), and black rats (*Rattus rattus*) were among the non-native animals that were introduced on SMI at differing times in the 19th and 20th centuries. With the exception of black rats, all of these animals were subsequently removed from the island. While generally confined to a few beaches, black rats have the potential to expand when island fox populations are low. In addition to preying on seabird adults, eggs, and chicks, black rats consume land mollusks and intertidal invertebrates, may compete with the native deer mice (*Peromyscus maniculatus*), and are carriers of diseases harmful to animals such as the island fox (NPS 1980, U.S. Navy 2002). Burrowing by black rats has negatively impacted the integrity of archeological resources.

<u>Land Use History</u>

Archaeological studies indicate that SMI was occupied on at least several occasions starting around 12,000 years ago, with continuous settlement in the last 8,000 years (Erlandson et al. 2009). Evidence suggests that the SMI Chumash subsisted mainly on marine resources, as the terrestrial sources of food and water were scarcer than on other islands (Rick et al. 2001). Island people apparently hunted sea mammals at Pt. Bennett and sea otters along the coast in sufficient numbers to change pinniped population structure (Walker et al. 1999) and the composition of kelp forest shellfish (Erlandson et al. 2009). Reconstruction of Native American diets 4,500 and 2,500 radiocarbon years before present do not show use of island plants as a major source of food (Vellanoweth et al. 1999). The first contact between Chumash and Europeans was probably in 1542, when Juan Rodriguez Cabrillo may have overwintered on SMI. There are two Chumash villages known from the island, with about 50 people in 1796 (Erlandson et al. 2003).

Most travelers passing by or landing on the island in the early 1800s described it as low, windy and either barren or colonized by low shrubs. Members of the U.S. Coast Survey reported it covered in grasses and low bushes and entirely destitute of wood (Alden 1852, Davidson 1858). Sheep ranching started on the island shortly before it was bought by George Nidever in 1850. By 1862 there were 6,000 sheep, 200 head of cattle, 100 hogs and 32 horses. About 80% of these animals starved during the drought of 1863-1864, and by the mid-1870s the island was reported covered with drifting sand. Through the 1870s Livingston reports observations of barrens, starving sheep, and drifting sand, but also fields of pasture grasses in certain areas. Ranchers plowed and cultivated about 47 ac in the late

1800s to support ranching operations. Numbers of sheep reported in shearing operations and sales documents 1888 through 1921 ranged from about 2,000 to 4,000. In 1934, the U.S. Navy gained jurisdiction of the island, and the number of sheep was capped at 1,000. Repeated attempts were made to remove the sheep from the island, but they were difficult to round up and persisted at low numbers (up to several hundreds) until the last of them were finally removed in 1967.

The U.S. Navy and Air Force used SMI from the 1930s through 1976 as a communications and lookout post, bombing range and target practice range. The NPS began management of the island by agreement between the Department of the Interior and Department of Defense in 1976. The island was visited infrequently before the transition to NPS management, and it remains the least visited island in the Park today.

4.5.2. Natural Resource Assessment of San Miguel Island

<u>Measures of Scrub Recovery</u>

- Vegetation: community structure, composition and spatial extent
- Vertebrate: abundance of representative taxa- island fox, deer mice and landbirds

<u>Reference Conditions/Values</u>

The reference condition for SMI is pre-European settlement, characterized by widespread cover of diverse native scrub.

It is likely that the pre-settlement vegetation of SMI was largely perennial scrub. E.L. Greene collected the hard chaparral shrubs island big-pod ceanothus (*Ceanothus megacarpus*), island redberry (*Rhamnus pirifolia*) and toyon (*Heteromeles arbutifolia*) from the island in 1886; he also noted that he believed that lemonade berry (*Rhus integrifolia*) was a widespread and dominant plant on SMI mountains and coastal bluffs before grazing. Recent paleontological work on San Miguel Island (P. Collins, unpublished) indicates that the island scrub-jay and spotted towhee, species using chaparral habitat, occupied the island about 1000 years ago. Hochberg et al. (1979) surveyed SMI in 1978-1979, mapping vegetation and locating populations of rare and endemic plants. Based on herbarium records and historic field notes, remnant stands of native vegetation and dead wood, they surmised that the prehistoric vegetation of the island consisted of terraces of giant coreopsis inter-fingering with perennial grasslands, bluff scrub vegetation on cliff faces, scattered shrublands, riparian vegetation in moist canyon spots, and scattered pioneering dune vegetation near the few sandy beaches then extant on the island. They hypothesized that there were three types of scrub, characterized by different dominant species: 1) soft scrub of lemonade berry, coyote brush (*Baccharis pilularis*), California sagebrush (*Artemisia californica*) and coastal goldenbush (*Isocoma menziesii*); 2) chaparral with island big-pod ceanothus (*Ceanothus meagacarpus insularis*), island redberry, and toyon; and 3) dense monotypic stands of Lavaterra (*Lavatera assurgentiflora*).

Reference conditions for vertebrates comprise the same species as presently occur on the island, except black rats. The pre-ranching vegetation, dominated by scrub and chaparral, likely did not harbor species different than those currently seen. It is possible, that chaparral landbird species such as spotted towhees could have existed on SMI in such chaparral habitat, but there is no evidence that they ever did so. The land mammal community would have comprised island foxes and deer mice.

Vegetation

Perennial native scrub with an understory dominated by native herbaceous plants as the predominant land cover, resilient to decadal shifts in climate regimes.

- Landscape dominated by native scrub and chaparral
- Stands of dominant plants recruiting with stable populations
- Decreased erosion - No new mobilization of sand.

Vertebrates

Populations of native species historically present on the island before modification by Europeans. Populations of native terrestrial vertebrates that are robust, persistent, and influenced only by native perennial ecosystem elements and processes, to the extent practicable. Specifically, populations should:

- Not be currently threatened by non-native species
- Not be at currently low numbers due to past influence of non-native grazers on island vegetation, and non-native attraction of predators (e.g., golden eagles, which also prey on foxes)
- Have recovered from previous lows commensurate with vegetation recovery.

Current Condition and Trend

Vegetation Community Structure and Spatial Extent

Historical Vegetation Change

The surficial geology of SMI is composed of highly erosive sedimentary and eolian deposits, easily destabilized by disturbance (Johnson 1972). Johnson et al. (1980) provide evidence that fires occurred on the northern islands from about 40,000 to 10,000 years ago, periodically stripping vegetation from the least stable surfaces. However, vegetation was able to recolonize SMI after these episodes (Johnson 1980), unlike during sheep ranching that accompanied European settlement. Johnson recounted recurring episodes of vegetation stripping and stabilization on SMI corresponding to drought and fluctuations in sheep numbers. Much like the cycles of rabbits and vegetation observed on Santa Barbara Island by Dunkle (1950) and Sumner (1958), reduced vegetative biomass during drought stimulated die-off in the sheep population, and drought relief resulted in grass growth and increases in sheep numbers. Johnson (1980) provides evidence that the devastating stripping of SMI began with the drought of 1863, when there were 6,000 sheep on the island. Soil cores and aerial photographs showed that drying trends and renewed stripping occurred in 1870-72, 1877, 1893-1904, 1917-35, 1944-64. The greatest volume of sand loss was between 1863 and 1876, when much of the island's veneer of sand was blown across the island from the northwest, covering the rocky shorelines with sand and depositing large volumes of sediment in Cuyler Harbor. Johnson analyzed aerial photos 1929 through 1972, showing that vegetation expanded in climate-driven pulses after sheep reduction in the 1950s. The expansion was mainly through the growth of exotic annual grasses, with notable areas of stability east of San Miguel Hill to the playa lake bed of Jackass Flats, and in the east-central "gangplank" area of the island. He noted that the caliche flats on the west end of the island contain root casts of trees or large shrubs that must have formed thickets or forests in the past, likely in more mesic Pleistocene, or earlier, times.

Current Vegetation Condition and Trends

Condition = Moderate

Trend = Improving

Vegetation Survey and Mapping - Hochberg et al. (1979) developed a vegetation map for SMI (Figure 4.5.2) using May 1978 color infrared 1:6,000 scale aerial photos, field surveys and limited transect sampling. They followed the classification scheme of Philbrick and Haller (1977), assigning SMI vegetation to seven different plant associations, based on dominant vegetation or the existence of diagnostic, but not dominant, species (e.g., *Ceanothus* wood indicating chaparral). They observed that the plant cover was largely successional vegetation highly fragmented by blowing sand and erosion. Much of the island was barren, characterized as either unstabilized dunes of blown sand, or erosion pavement, where the soil was eroded down to hardpan. It appeared that coastal bluff vegetation was developing on recovering erosion pavement, and coastal dune vegetation on unstabilized dunes. They hypothesized that coastal dune vegetation would eventually develop into perennial coastal goldenbush scrub. Alien annual grassland of wild oats (*Avena barbata/fatua*), ripgut brome (*Bromus diandrus*) and soft chess (*B. hordeaceus*), with occasional native bunchgrass (*Stipa* spp.) was the most widespread plant association. Goldenbush scrub was the second-most widespread association, colonizing stabilized dunes on the interior of the island; they observed that this association was unique to SMI. Small stands of willows (*Salix lasiolepis*) were observed in three canyons of the island, along with a few other plants indicative of mesic conditions in localized areas. Halvorson et al. (1992) surveyed SMI for a suite of rare plants, observing that wood gathering lead to the depletion of the willows and extirpation of at least two chaparral species, island big-pod ceanothus and island redberry. NPS is currently making a new vegetation classification and map for SMI, using 2013 aerial photographs, relevé samples and plotless rapid assessments. Preliminary results suggest more widespread perennial vegetation than in 1979.

The Santa Barbara Natural History Museum had sampled vegetation on several 100-foot (30.5 m) long point-line intercept transects in 1968 and 1972; Hochberg et al. (1979) resampled these in 1978. They reported that in 1968, the airstrip near the ranch was covered in filaree (*Erodium* spp.), yellow sweet clover (*Melilotus indicus*), and ripgut brome. By 1978, the erodium had disappeared, yellow sweet clover was on only half of the sites and brome cover had decreased. They reported increases in the non-native grasses wild oats, soft chess, sickle grass (*Parapholis incurva*); the exotic herb sow thistle (*Sonchus oleraceus*; SOOL) and the native shrub coastal goldenbush.

Inventory & Management Program Vegetation Transect Analysis - Corry (2006) analyzed change in cover of individual species and species guilds island-wide on the SMI Inventory and Monitoring Program transects sampled 1984 through 2002 (n=19 transects), and by comparing cover in 28 relevé plots sampled in 1983 and again 2002. She correlated precipitation-adjusted change on transects with several environmental characteristics, including elevation, heat load, slope shape, topographic position, soil drainage class, percent bare ground, percent cover cryptobiotic crust, and vegetation history. Soil texture and related parameters such as soil drainage and bulk density were the strongest and most consistent correlates with vegetation composition. In both transect and relevé samples exotic species richness and abundance consistently correlated with fine-grained substrates, and more generally with higher site heat load, suggesting that competition for soil moisture is an important factor in native vegetation recolonization. Native communities tended to associate with cooler, more mesic sites and exotic grass cover with warmer, drier sites. Additionally, total vegetative cover and precipitation were shown to be significantly correlated on all SMI transects, in two ways. Species with percent cover significantly affected by total precipitation received in the current water-year (June to July) were primarily exotic annual grasses, herbs (mostly exotic but some native) associated with exotic grasslands, and native herbs from a variety of communities. However, cover in native woody communities correlated best with precipitation averaged over the previous three years, even in some sites with a large annual grass components.

Species tended to respond individualistically to grazing release. Although post-grazing cover trends were significantly different among species, a given species' trend was generally consistent across all plots and plant community types in which it occurred (Corry and McEachern 2009). Most species that increased significantly were native, particularly native shrubs. Native perennial colonizers appeared to be at greatest advantage on sites where well-drained soils or rocky, fractured substrates such as erosion pavements allowed more percolation to deeper rooting zones. Table 4.5.1 shows directional trends for species with significant change on transects and relevés. Overall, Corry's results indicate that moisture is key to recovery on SMI, affected by properties ranging from local soil texture to broad inter-annual rainfall patterns. Thus, rates of recovery appear driven by precipitation, but with spatial patterns related to local variations in soil moisture availability throughout the growing season.

Table 4.5.1. Directional trends for species with significant change over time (1984 – 2002) on transects and relevés, ordered by direction and magnitude of trend, San Miguel Island (Corry 2006, Tables 1.5 and 1.8).

Sample area and time frame	Species	Time trend*	*p, Time trend*	Mean change in cover	*p-value*
Transects 1984-2002	*Eriophyllum confertiflorum*	1.392	0.001	–	–
	Leptosyne gigantea	1.244	<0.001	–	–
	Sisyrinchium bellum	0.901	<0.001	–	–
	Bromus hordeaceous	0.896	0.001	–	–
	Carpobrotus chilensis	0.807	<0.001	–	–
	Eriogonum grande v. rubescens	0.539	<0.001	–	–
	Acmispon dendroideus v. dendroideus	0.482	0.004	–	–
	Dudleya greenei	0.436	<0.001	–	–
	Pterostegia drymarioides	0.182	0.004	–	–
	Sonchus oleraceus	0.176	0.007	–	–
	Atriplex californica	-0.260	<0.001	–	–
	Erodium cicutarium	-0.428	0.001	–	–
	Medicago polymorpha	-0.462	0.003	–	–
	Marah macrocarpus	-0.55	0.013	–	–
	Atriplex semibaccata	-0.602	0.01	–	–
	Calystegia macrostegia	-0.631	<0.001	–	–
	Lupinus succulentus	-0.862	0.005	–	–
	Malacothrix incana	-0.987	<0.001	–	–
	Bromus diandrus	-1.035	<0.001	–	–
	Ambrosia chamissonis	-1.174	0.007	–	–
	Hordeum murinum	-1.424	<0.001	–	–
	Artemisia californica	-1.684	0.008	–	–
	Opuntia littoralis	-1.93	<0.001	–	–
Relevés 1983 vs. 2002	*Bromus hordeaceus*	–	–	1.500	0.001
	Lupinus albifrons	–	–	1.000	0.002
	Distichlis spicata	–	–	0.778	0.015
	Leptosyne gigantea	–	–	0.615	0.005
	Baccharis pilularis	–	–	0.478	0.008
	Cirsium occidentale	–	–	0.292	0.016
	Sonchus oleraceus	–	–	-0.417	0.009
	Malacothrix incana	–	–	-0.632	0.001
	Atriplex semibaccata	–	–	-0.769	0.002
	Melilotus indicus	–	–	-0.778	0.001
	Hordeum murinum	–	–	-1.375	<0.001

* Change in species cover over time from 1984 to 2002.

Vegetation and Biological Soil Crust – Research by Belnap (2002) indicated that colonization by biological soil crust might be a crucial first step in stabilization of SMI dunes. Zellman (2015) investigated the roles of biological soil crust and colonizing vegetation in SMI dune stabilization. She mapped vegetation visible on aerial photographs of the central dunes of the island from 1929, 1954, 1977, and 2009 (Figure 4.5.4); and then sampled vegetation, soil texture and soil crust on transects stratified by vegetation stand age and type. Results revealed a continuing increase in vegetative cover, and corroborated the hypothesis of Hochberg et al. (1979) that pioneering dune vegetation is replaced by a form of Isocoma scrub over time, along with lupine scrub, coyote-brush scrub, and coreopsis scrub. Soil crusts were found only on dunes with vascular vegetation already present, but not in closed-canopy situations, indicating facilitation of crust by vegetation and a transitory role of soil crust in dune stabilization. Paradoxically, transect analyses indicated that grasslands were present mostly on dunes that appeared stabilized in the 1929 photographs. These dunes were colonized while sheep were still present; the exotic grasses may have gained a competitive advantage under continued grazing that allows them to persist. Otherwise, open dunes colonized between 1929 and 2009 supported native woody shrub communities, while dunes colonized between 2009 and 2011 had pioneering plants typical of nearshore dunes such as sea rocket (*Cakile maritima*), dune dandelion (*Malacothrix incana*), beach-bur and others. Thus, while vegetation cover developed across much of SMI within the nine decades studied, it did not follow the classic pattern of colonization by pioneering soil crust that facilitated vegetation colonization. Instead recovery took a variety of trajectories, with some areas reaching a stable state characterized by persistent exotic grassland while other areas tended toward the predicted woody plant community. This means that these grasslands may require some intervention to change toward the native shrublands characteristic of the pre-ranching cover.

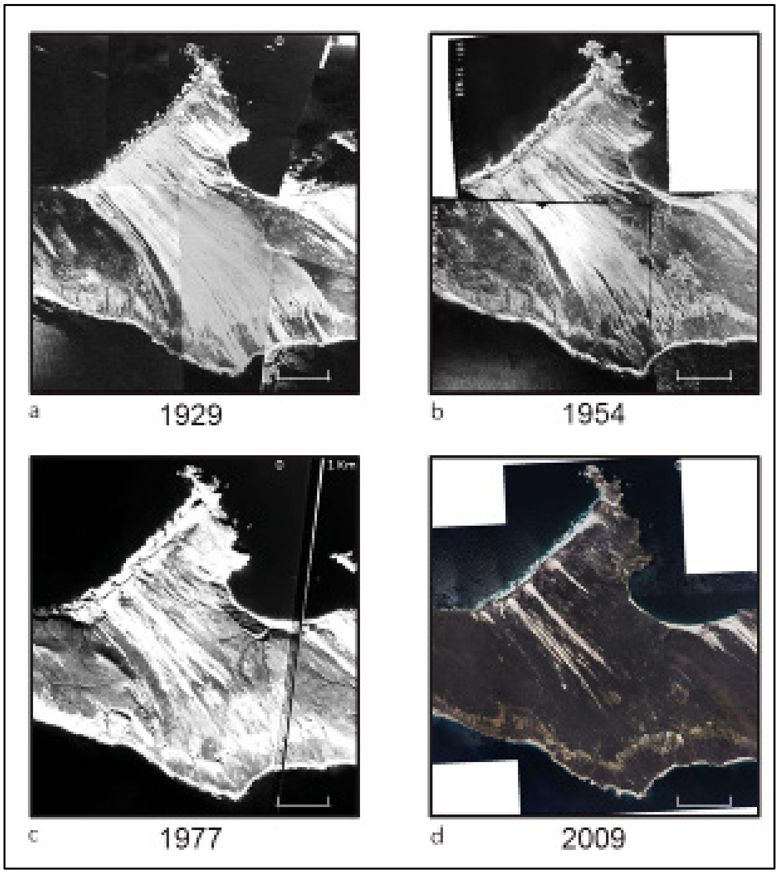
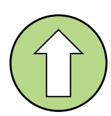


Figure 4.5.4. Aerial photographs of the Central Dune Field (a) 1929, (b) 1954, (c) 1977, and (d) 2009 (Zellman 2015).

Vertebrate Abundance

Condition = Good



Trend = Improving

<u>*Landbirds*</u>

Landbirds have been monitored on SMI since 1993, initially with line transects; point counts were added in 2002, and were established in association with key habitat types on SMI (see the Park's landbird trend report for methods details, Coonan et al. 2011b). A total of 67 species have been observed on San Miguel during landbird monitoring (Figure 4.5.5).

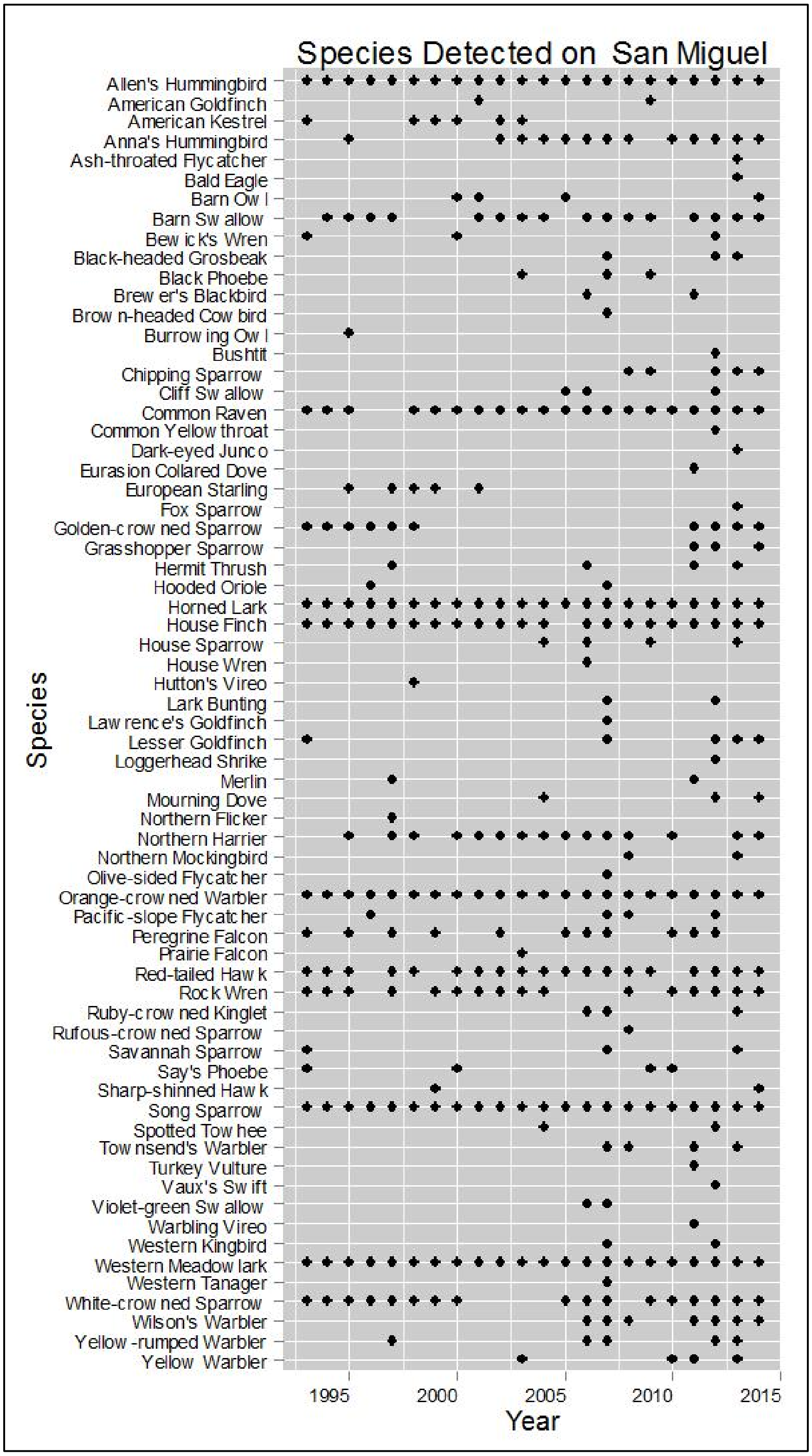


Figure 4.5.5. Species detected during annual landbird monitoring on San Miguel Island, 1993-2014.

Habitat preferences were investigated for 6 landbird species on SMI as part of the park's trend report for its landbird monitoring program (Coonan et al. 2011b). Coonan et al. (2011b) evaluated habitat selection for each species by comparing proportional occurrence of each species to proportional availability of habitats (Table 4.5.2). Three species showed preference for grassland, two for coastal sage scrub, and none for riparian. Preference for riparian habitat by Allen's hummingbird was nearly significant at the P=0.05 level (P = 0.0722).

Table 4.5.2. Habitat preference (P) and avoidance (A) for 6 landbird species on San Miguel Island (data from Coonan et al. 2011b). Blank cells (–) indicate no statistically significant preference or avoidance for that habitat type.

Common name	Latin name	RIP[1]	GRS[2]	SCRB[3]
Allen's hummingbird	*Selasphorus sasin sedentarius*	–	–	–
Orange-crowned warbler	*Oreothlypus celata sordida*	A	–	P
Song sparrow	*Melospiza melodia graminea*	A	P	P
Western meadowlark	*Sturnella neglecta*	A	P	–
Horned lark	*Eremophila alpestris insularis*	A	P	–
House finch	*Carpdacus mexicanus clementis*	–	–	–

[1] RIP = riparian.

[2] GRS = grassland.

[3] SCRB = all scrub, combined.

Mammals

Island Fox - Foxes have fully recovered from the predation-driven decline of the late 1990s, and have appeared to have reached carrying capacity. For the past several years the estimated total number of foxes has hovered 550 foxes (Figure 4.5.6; Coonan et al. 2014), but has subsequently declined to 350-400 adults (Coonan 2016). Thus, they are unlikely to exhibit habitat preference at high density, with foxes being pushed into all areas and habitats. A deep drought has impacted San Miguel Island foxes for the past several years (Coonan et al. 2013, 2014). Island fox reproduction effectively shut down in 2013 and 2014. Also, San Miguel island foxes weighed significantly less in 2013 and 2014 than in other years. The drought may have effectively lowered carrying capacity on the island. This may have actually encouraged foxes to occupy habitats and areas where prey and other food resources are still available (see below).

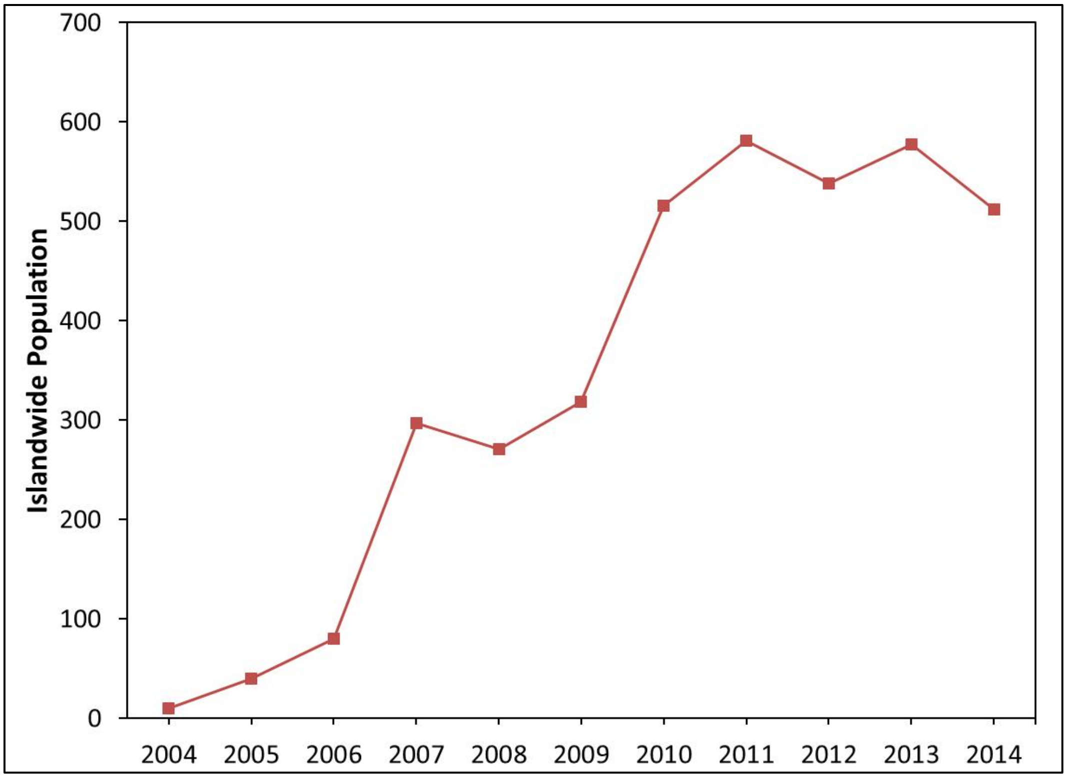


Figure 4.5.6. Estimated total number of island foxes on San Miguel Island, 2004-2014 (Coonan et al. 2014, T.J. Coonan, unpublished data).

Data from the park's island fox monitoring program show little difference in density among grids until recently. San Miguel island foxes have been monitored since 2006 on 4 medium-sized trapping grids (Figure 4.5.7), and although densities have increased over time as foxes have recovered, there is little difference in density among the grids (Figure 4.5.8), until 2013, when drought conditions deepened. Prey availability and food resources may be greater on the Cardwell Point and Sandblast Pass Grids and may be poorer on the Jackass Flats and Charcoal Canyon (Harris Point) grids. The latter grid has had generally lower island fox densities in some other years. Analysis of differences in habitat composition and quality among fox grids on SMI will not be possible until the current vegetation mapping project is completed.

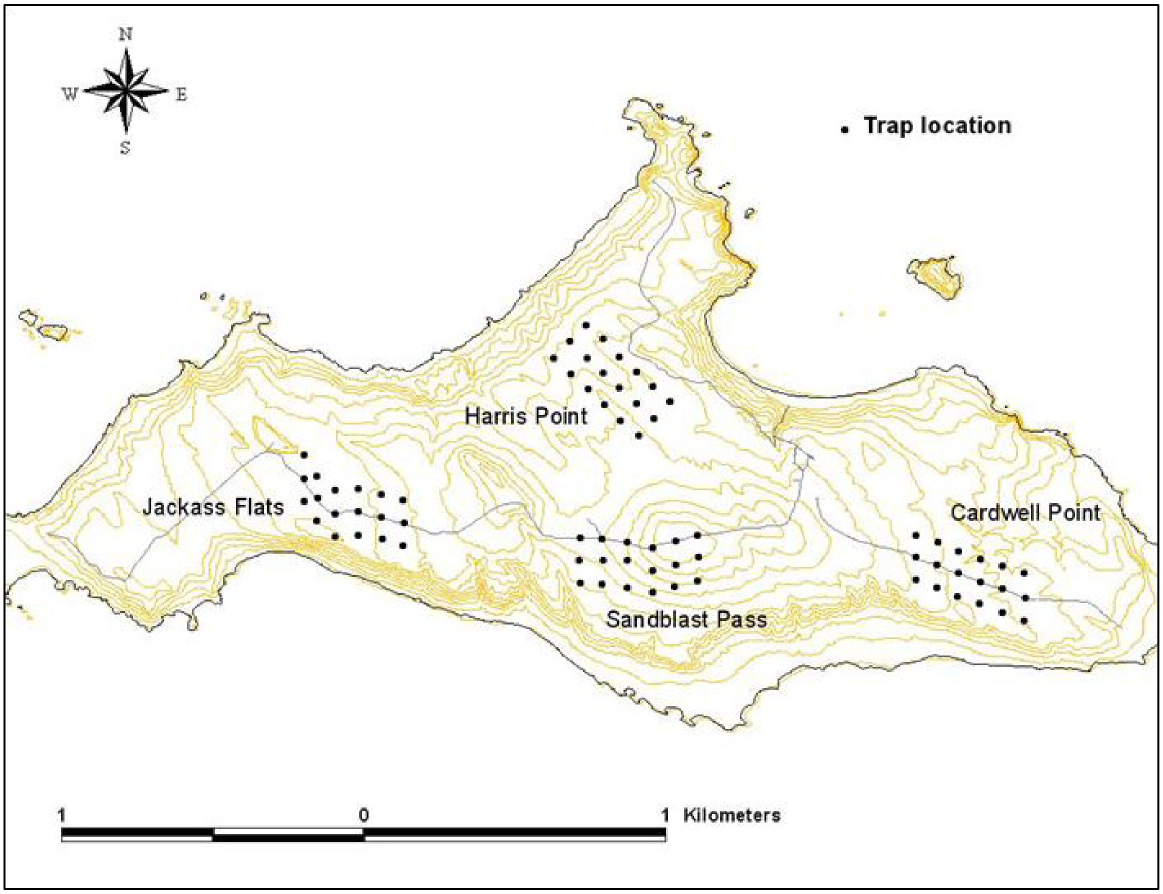


Figure 4.5.7. Location of grids used to annually monitor island foxes on San Miguel Island (Map by Tim Coonan).

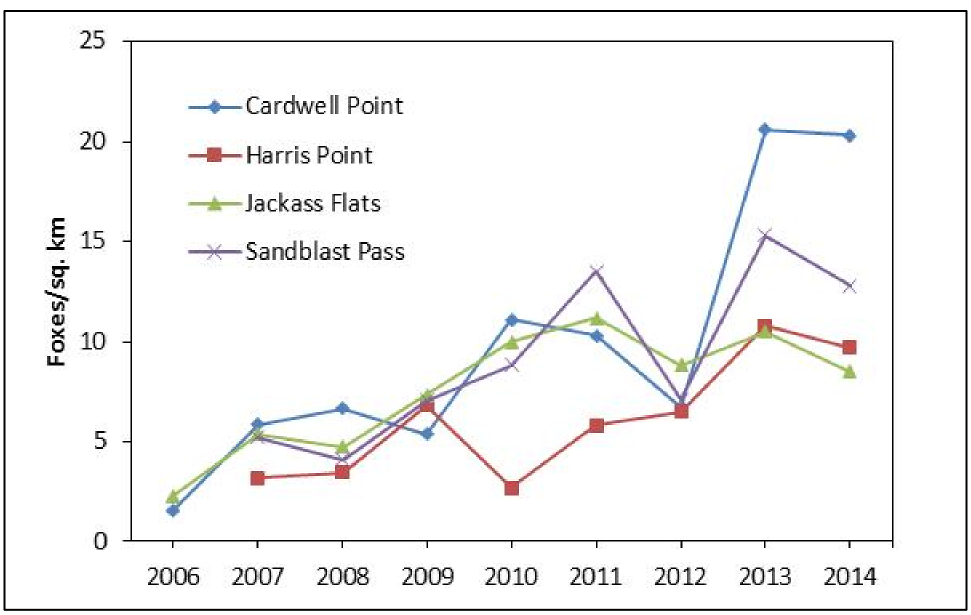


Figure 4.5.8. Adult island fox densities on four San Miguel Island grids, 2006-2014 (Coonan et al. 2014, T. J. Coonan, NPS, unpublished data).

With home ranges of 0.5-1.0 km^2 (Roemer et al. 2004, Drake 2013) island foxes on SMI likely encounter multiple habitat types in their home ranges, ensuring them access to food resources, which may be somewhat patchy. Island foxes are generalist predators which switch to alternate food resources when they become available (Figure 4.5.9). San Miguel foxes exhibit high use of beetles and non-native ice plant fruits in spring and summer (Cypher et al. 2011), taking advantage of those seasonal food resources. However, even the generalist island fox is affected by long periods of drought, as the virtual shutdown of reproduction in 2013-2014 indicates. Some radio collared island foxes have been observed far from their typical use areas in that time period, suggesting they were searching for food.

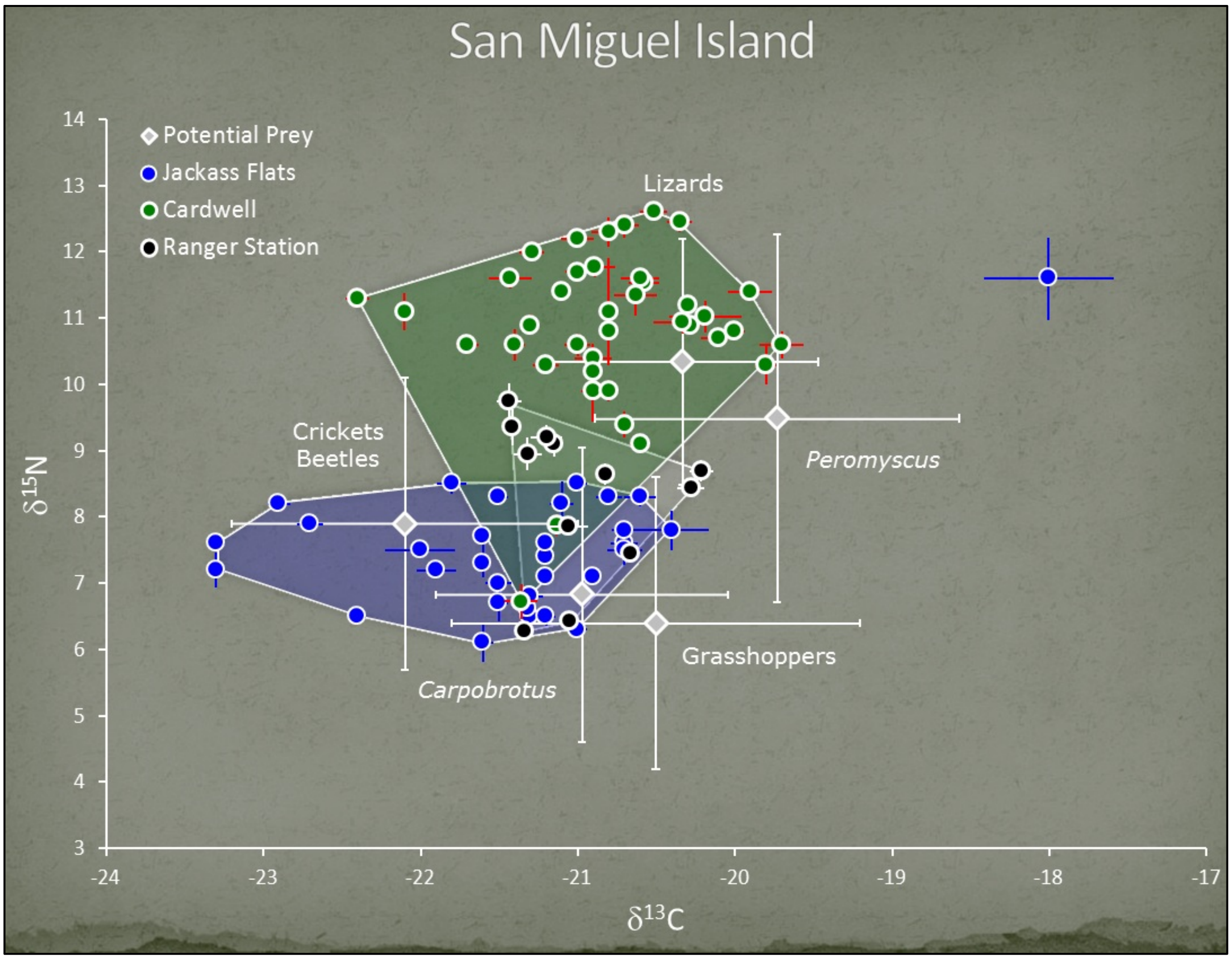


Figure 4.5.9. Carbon and nitrogen isotope ratios for island foxes at three sites, San Miguel Island (S. Newsome, University of New Mexico, unpublished data).

Deer mice - As on Santa Barbara Island (SBI) and Anacapa Island (AI), deer mice on San Miguel have been monitored since 1993 as part of the park's long-term ecological monitoring program. Mice are trapped semiannually on three 10 x 10-trap grids located in somewhat different habitat types (Figure 4.5.10). As on SBI, mice on San Miguel have exhibited marked population fluctuation, both intra and interannually (Figures 4.5.11a and 4.5.11b; Schwemm and Coonan 2001, Schwemm 2008, Coonan 2013). Apparent annual cycles of spring population minima and fall maxima appeared to change to more multi-year cycles (as on Santa Barbara) when island foxes were at low levels or in captivity (1998-2005). High precipitation and low fox density in 1998 resulted in record-high mouse numbers. Island foxes appear to dampen or depress population swings. Mice exhibited their some of their highest peaks and greatest variability when foxes were absent from the system (Coonan et al. 2010). San Miguel mice are currently at very low numbers, due to extended drought, and perhaps very high fox densities, the highest yet recorded on San Miguel (Coonan et al. 2014). On Santa Barbara, multi-year cycles are driven by specialist predators (barn owls [*Tyto alba*]), while on San Miguel the typical annual cycle driven by resource limitations is modified by the presence of a generalist predator (the island fox).

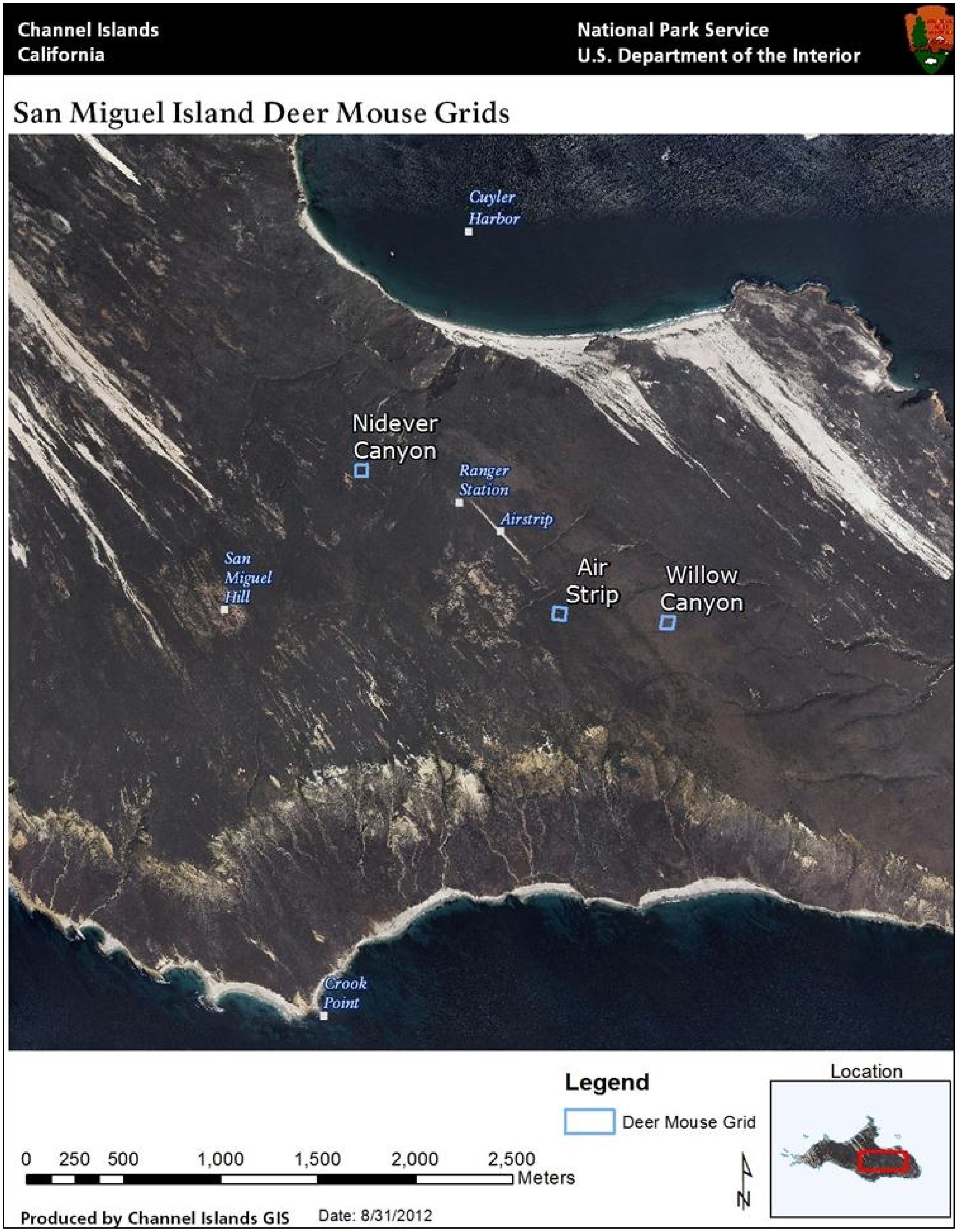


Figure 4.5.10. Location of deer mouse monitoring grids on San Miguel Island (Coonan 2013).

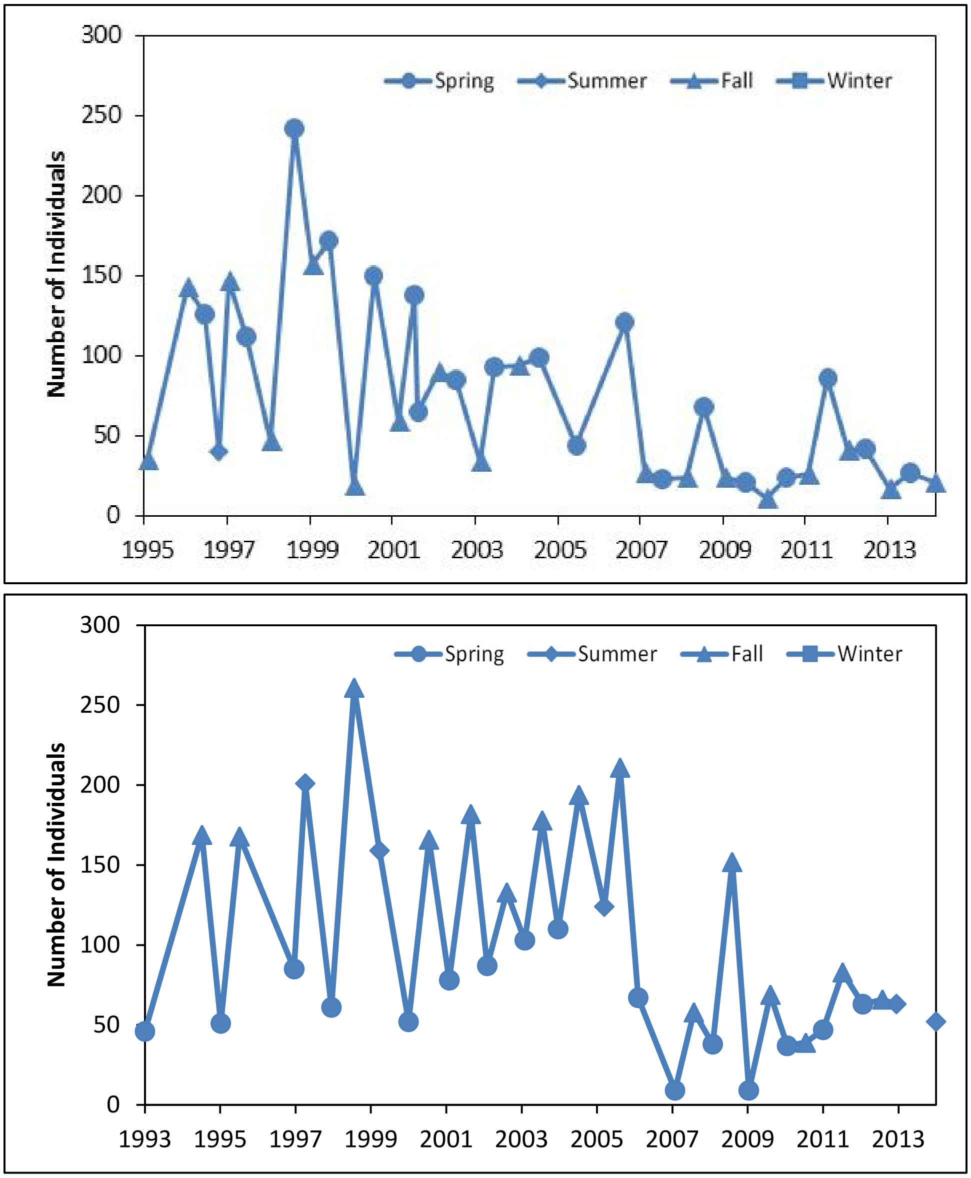


Figure 4.5.11a. Number of deer mice caught on the Airstrip Grid (top), and the Nidever Canyon Grid (bottom), San Miguel Island, during different seasons.

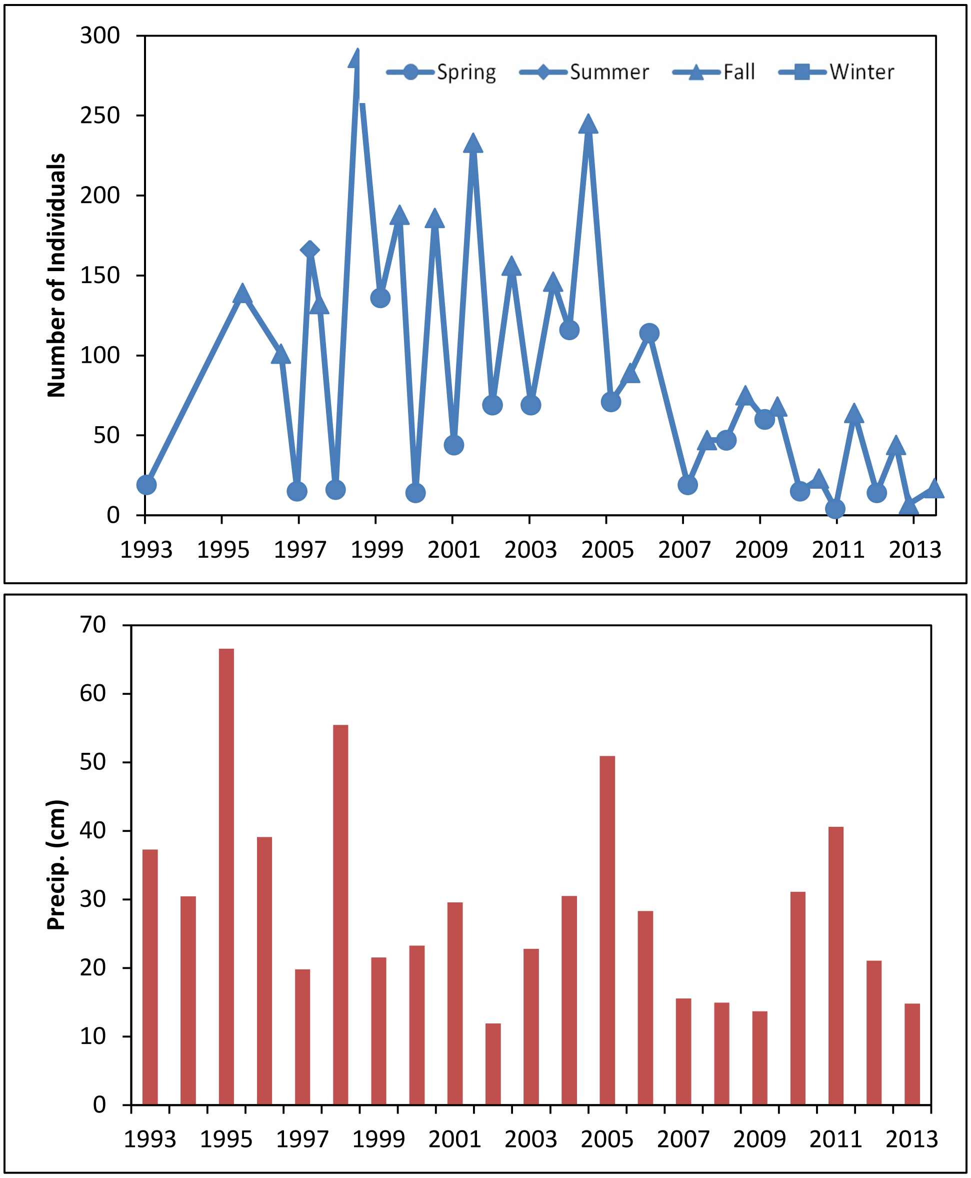


Figure 4.5.11b. Number of deer mice caught on the Willow Canyon Grid (top), San Miguel Island, during different seasons' precipitation levels (bottom) (Coonan 2013).

In terms of habitat, there appears to be very little difference in mouse densities among the different grids. According to the monitoring protocol (Fellers et al. 1988), the Airstrip Grid is in *Isocoma/Haplopappus* scrub, Nidever Canyon Grid is in lupine scrub, and Willow Canyon Grid is grassland, primarily non-native *Avena*. Grassland is generally thought to be lower quality habitat for deer mice (Schwemm and Coonan 2001). Mouse weights, which may be a good indicator of individual condition, and hence resource abundance, suggest that grassland habitat on San Miguel may be improving as deer mouse habitat (Coonan 2013). Prior to 2010, weights were higher on the Nidever Canyon Grid and lower on the Willow Canyon Grid, but after 2010 there was no difference in weights, suggesting somewhat equivalent habitat quality.

It is possible that, as in other species, mice prefer certain habitats and show habitat selection when at low densities, but at high densities are pushed into lower-quality habitats (Schwemm and Coonan 2001). Although there seems to be some evidence for this on SCI, there is less evidence for this on San Miguel, where there are fewer differences in habitat (e.g., no woodland or chaparral). Under current low density conditions, grassland and other habitats have equivalent mouse abundances (Figure 4.5.11a, b), though Schwemm (2008) found lower mouse abundances in grassland on San Miguel, at high mouse densities.

At present it is unclear whether non-native grasslands are being successfully invaded by native shrubs, and, if this is occurring, whether this represents improvement in habitat quality. Schwemm (2008) studied the effect of deer mice on reestablishment of giant coreopsis, and concluded that although mice had little impact on coreopsis recruitment, non-native grasslands were unlikely to be successfully invaded by native shrubs such as coreopsis due to the thick thatch present in non-native grasslands. Deer mouse seed predation is greater on the larger seeds of non-native annual grasses than the smaller seeds of native plant species.

Deer mice are an important prey item for San Miguel island foxes (Cypher et al. 2011) and thus habitats which harbor more deer mice may represent better habitat for island foxes. In a one-year study of island fox diet, deer mice occurred in about 50% of fox scats in all four seasons, and Santa Rosa was the only island to show more use of deer mice by island foxes (Cypher et al. 2011). Other studies have found high use of deer mice by San Miguel foxes (Collins 1980, Crowell 2001). Shrub habitat may provide deer mice with more cover from predators such as island foxes, red-tailed hawks and barn owls, than grassland habitat. In a study of deer mouse predator behavior, Orrock and Fletcher (2014) documented higher deer mouse foraging in sheltered microhabitats than in exposed habitats on San Miguel. In fact, deer mice effectively tracked the risk of predation risk and fox population size, showing less foraging in both types of microhabitats at high fox densities.

NRCA Team Data and Methods

Vegetation Community Structure and Spatial Extent

Two original vegetation maps were made for SMI: in 1979 by Hochberg et al. (1979) on the basis of field reconnaissance and 1978 aerial photointerpretation, and in 1984 by Veirs, Lennox and Lenihan (Veirs and Lenihan 1984 unpublished manuscript, Lenihan 1984 unpublished manuscript) on the basis of relevé sample classification and 1983 aerial photointerpretation. Two additional vegetation maps exist on the Chanel Islands GIS server labelled 1991 and 1994. The 1991 is a digitized version of the 1979 map, done by D'Antonio and Halvorson with minimal editing to fit the polygons to the topographic base. The 1994 map is an edited version of the 1991 version, reinterpreted for fox habitat by Schwemm. We attempted to develop a crosswalk between the 1979 and 1984 maps based on community descriptions provided in accompanying reports (Hochberg et al. 1979, Lenihan et al. 1983) with no success – there is much overlap among the vegetation types. We did summarize the area occupied as a percentage of the island for each type using GIS. Longer-term change in vegetation 1979 to 2013 can be evaluated once the draft vegetation map being made by NPS is completed.

Vertebrate Abundance

<u>*Landbirds*</u>

Landbirds have been surveyed on the full suite of point counts (40; Figure 4.5.12) since 2002 (Coonan et al. 2011a, b). For species with adequate number of detections (60), density can be estimated with distance methods (Buckland et al. 2001). The distribution of points by habitat type is given in Table 4.5.3.

Table 4.5.3. Number of landbird point count sites in different habitat types on San Miguel Island.

Habitat type	Point count sites
Baccharis scrub	1
Caliche scrub	2
Coastal bluff scrub	1
Coastal sage scrub	2
Other scrub	5
Coreopsis scrub	8
Grassland	11
Lupine scrub	8
Riparian	2

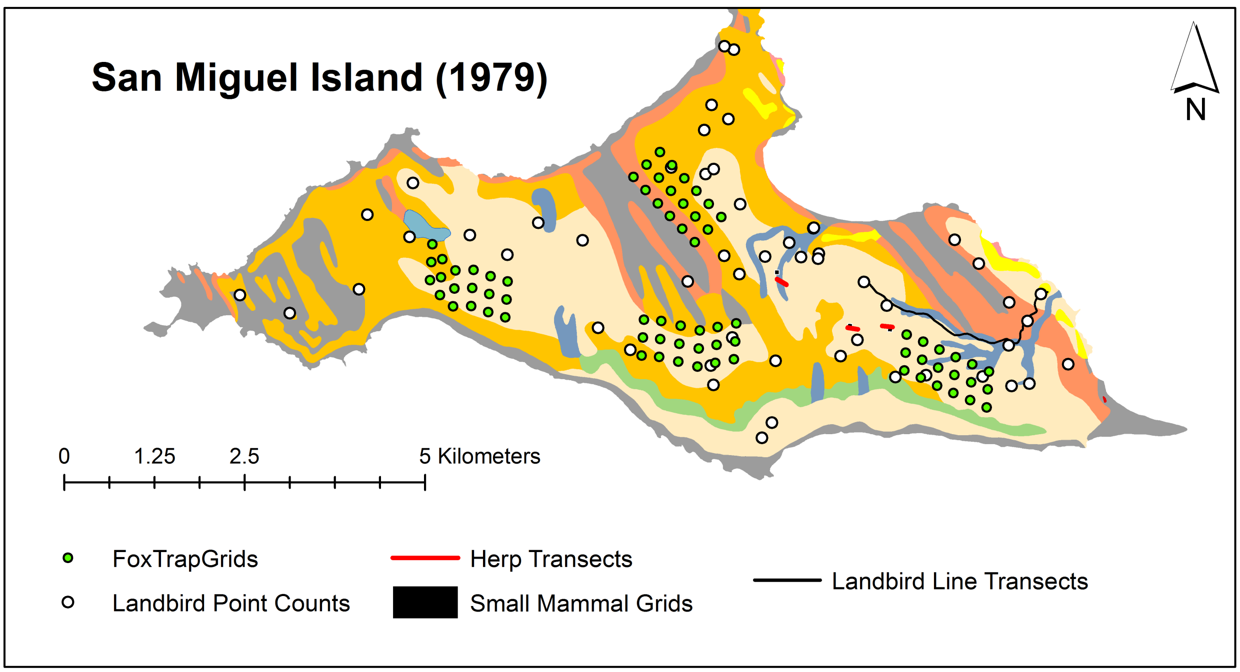


Figure 4.5.12. Location of vertebrate sampling sites on Santa Miguel Island. See Figure 4.3.2 legend for color scheme of vegetation types (Coonan et al. 2011a, Coonan et al. 2013, Fellers et al. 1988).

For this analysis we estimated annual island-wide density for selected species, utilizing program. Distance and the distance-based observation data from the park's landbird monitoring program

(Coonan et al. 2011b, Dye and Coonan 2014). We estimated density for each species on line transects, which were surveyed from 1993 through 2014, and at point counts (2002-2013).

NRCA Team Results

Vegetation

SMI vegetation patterns in 1984 were very similar to 1979 (Figure 4.5.13). Table 4.5.4 shows the percent of the island area occupied by the plant communities identified in each mapping project. Both maps indicate that between 10 and 11 percent of the island was occupied by coastal dune vegetation, 35 to 39 percent in grassland, and 29 to 25 percent shrubs. Rather than showing much change over the intervening 6 years, the two maps tended to corroborate one another, indicating strong correlations of vegetation and soils, similar successional pathways and consistent dominant species between the two studies. Together, the two maps provide a firm baseline for judging change when the current vegetation mapping effort is complete. The 1983 map was used to stratify transect locations for the long-term vegetation transect monitoring program carried out by NPS 1984-present. Based on the literature reviewed here and personal observations (D. Rodriguez, S. Chaney. I. Williams), it is apparent that vegetation cover has increased on SMI in the decades since sheep removal, and that there is substantially more shrub cover than when the island was still grazed.

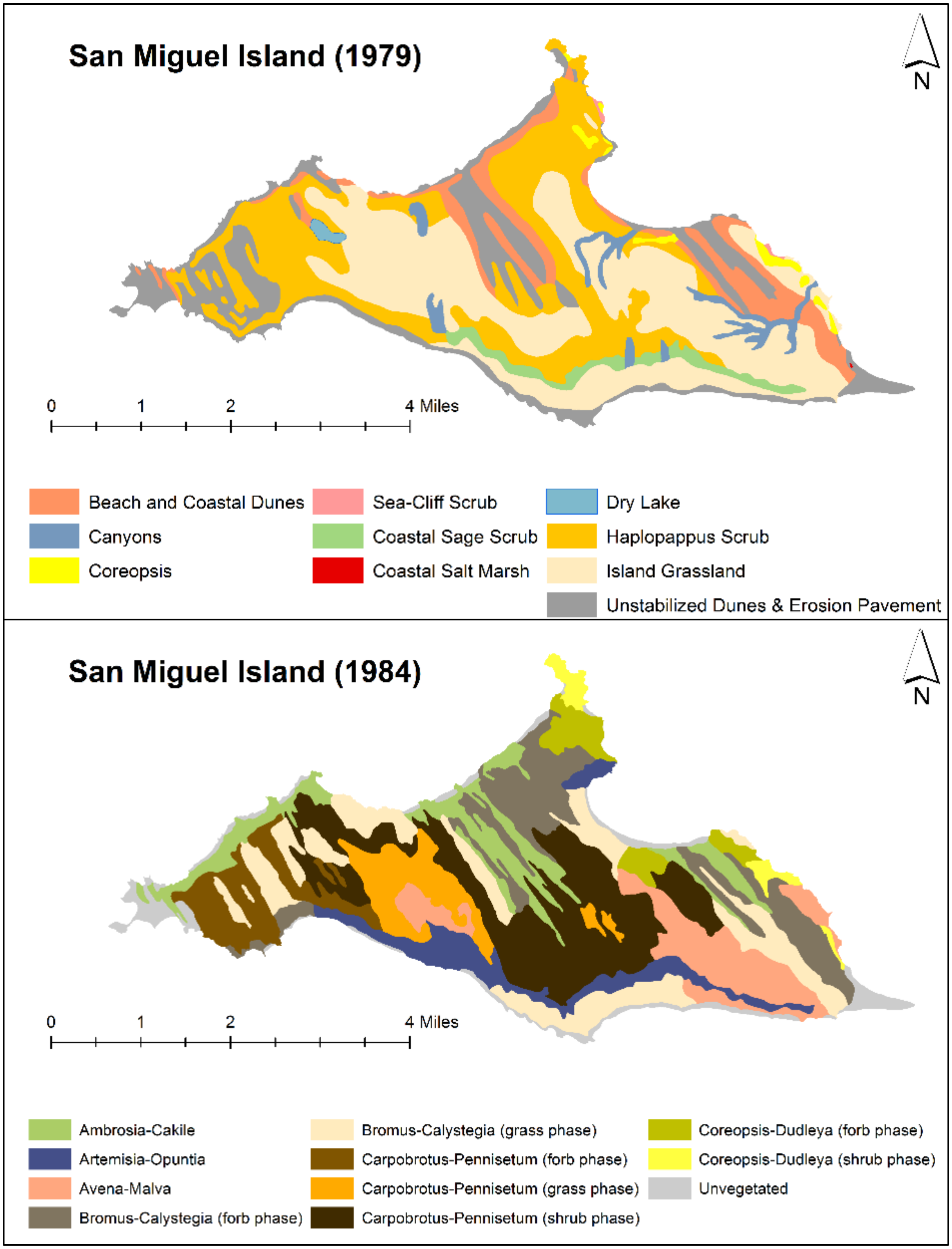


Figure 4.5.13. San Miguel Island vegetation mapped using aerial photo interpretation and field work in 1979 (top; Hochberg et al.) and 1984 (bottom; Veirs, Lenihan and Lennox, unpublished).

Table 4.5.4. San Miguel Island plant communities mapped in two separate studies, 1979 (Hochberg et al.) and 1984 (Veirs, Lenihan and Lennox, unpublished).

Year	1979 vegetation map	Percent of total map area
1979	Beach and coastal dunes	10
	Canyons	3
	Coastal bluff, coreopsis phase	1
	Coastal bluff, sea-cliff phase	0
	Coastal sage scrub	3
	Coastal salt marsh	0
	Dry lake	0
	Haplopappus scrub	29
	Island grassland	35
	Unstabilized dunes and erosion pavement	18
1984	*Ambrosia-Cakile*	11
	Artemisia-Opuntia	8
	Avena-Malva	11
	Bromus-Calystegia (forb phase)	4
	Bromus-Calystegia (grass phase)	16
	Carpobrotus-Pennisetum (forb phase)	7
	Carpobrotus-Pennisetum (grass phase)	7
	Carpobrotus-Pennisetum (shrub phase)	23
	Coreopsis-Dudleya (forb phase)	4
	Coreopsis-Dudleya (shrub phase)	2
	Unvegetated	6

Vertebrate Abundance

Landbirds

We assessed abundance over time for the 6 San Miguel species which had an adequate number of detections for estimating density (Figs. 4.5.14 – 4.5.19). The line transect dataset (1993-2013) spans the period of island fox decline (1995-1999), removal from the wild for captive breeding (1999-2004) , and reintroduction and recovery (2004-2013). The decline and subsequent absence of this important predator from the system appears to have affected landbirds (Coonan et al. 2010, Coonan et al. 2011b). Two species, orange-crowned warblers (*Oreoclypis celata*) and Allen's hummingbirds (*Selasphorus sasin*), appeared to increase in the decline and absence of foxes. As open-cup nesters, orange-crowned warblers are known to be vulnerable to nest predators on the Channel Islands, and even adjust their nest height and placement according to predation risk (Peluc et al. 2008, Sofaer et al. 2012). Orange-crowned warblers, as well as Allen's hummingbirds, may have been released from predation pressure in the absence of foxes. Allen's hummingbirds, song sparrows (*Melospiza melodia*), and western meadowlarks (*Sturnella neglecta*) appeared to shift from 2-year cycles to cycles of 3-4 years in the absence of foxes, as mice did. This may represent, as in mice, the effect of losing a generalist predator. And since mice reached record highs and lows during that period, some variability in landbirds may be due to increased predation by mice.

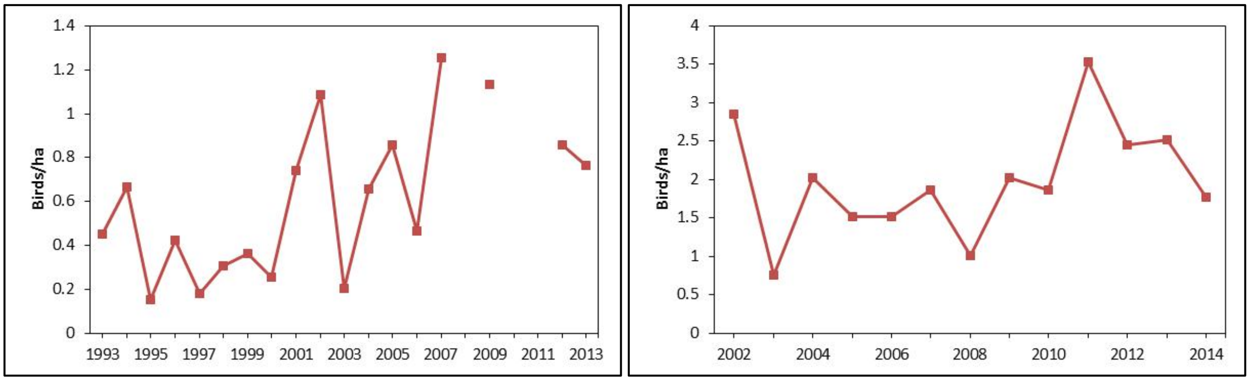


Figure 4.5.14. Annual densities of Allen's hummingbirds (*Selasphorus sasin*), San Miguel Island, on line transects (left) and point counts (right).

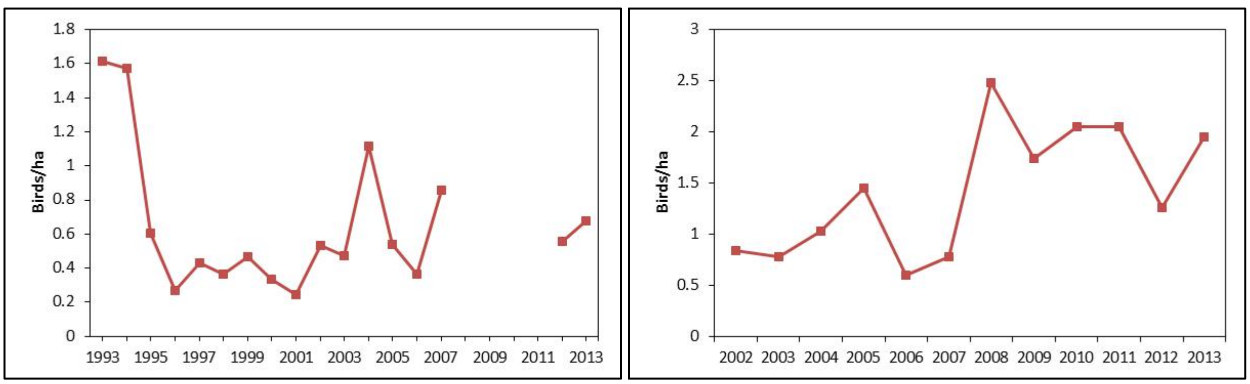


Figure 4.5.15. Annual densities of horned larks (*Eremophila alpestris*), San Miguel Island, on line transects (left) and point counts (right).

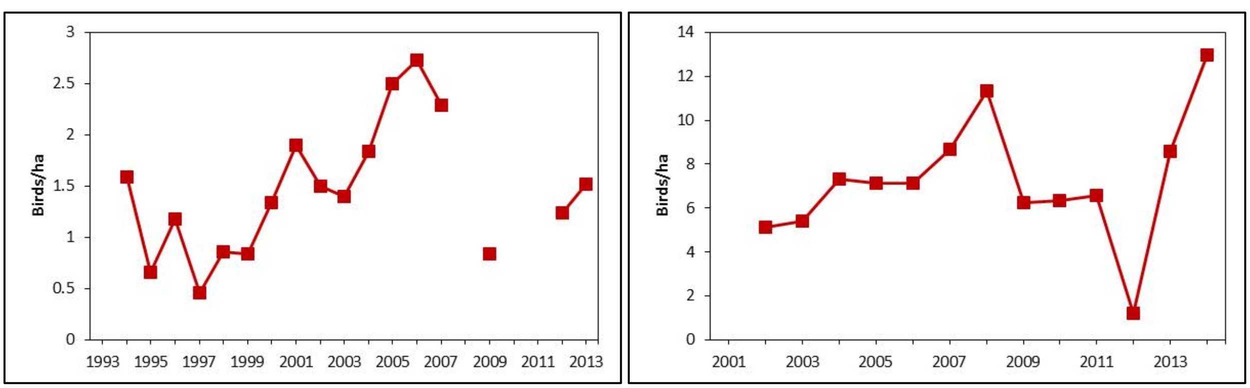


Figure 4.5.16. Annual densities of orange-crowned warblers (*Oreoclypis celata*), San Miguel Island, on line transects (left) and point counts (right).

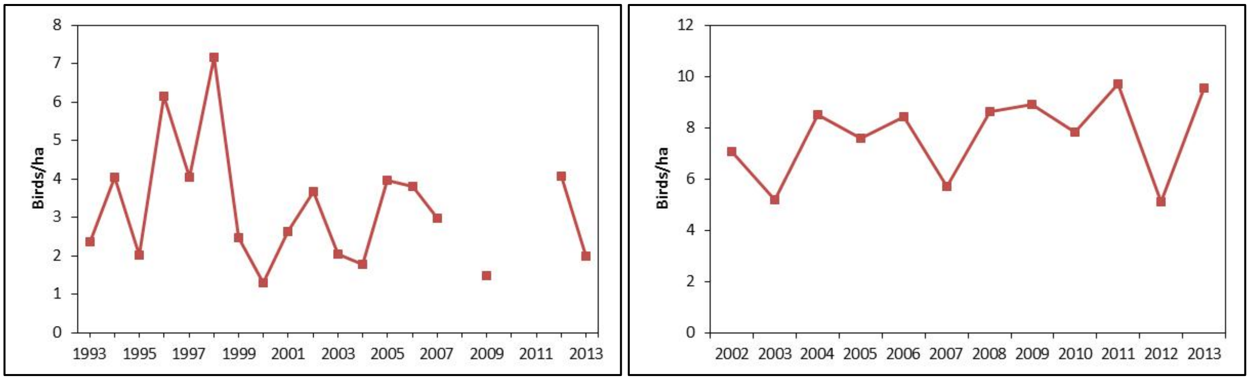


Figure 4.5.17. Annual densities of song sparrows (*Melospiza melodia*), San Miguel Island, on line transects (left) and point counts (right).

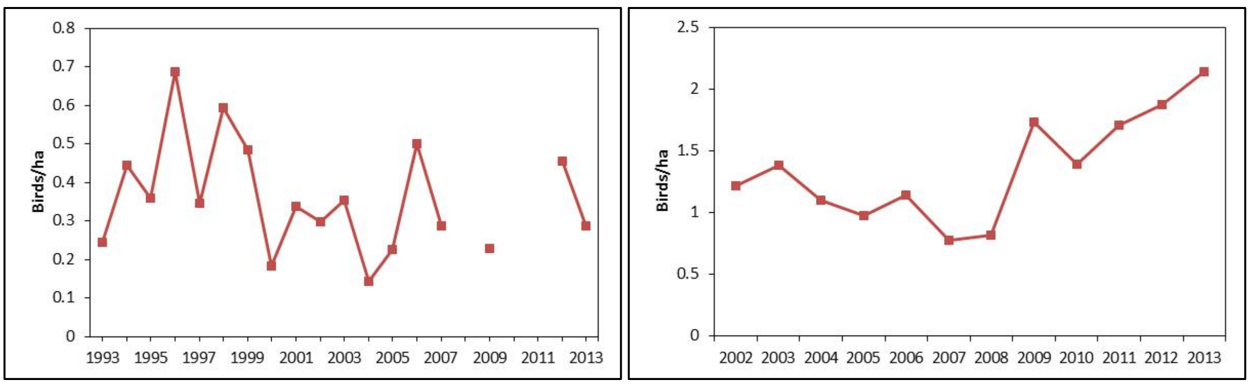


Figure 4.5.18. Annual densities of western meadowlarks (*Sturnella neglecta*), San Miguel Island, on (left) line transects and (right) point counts.

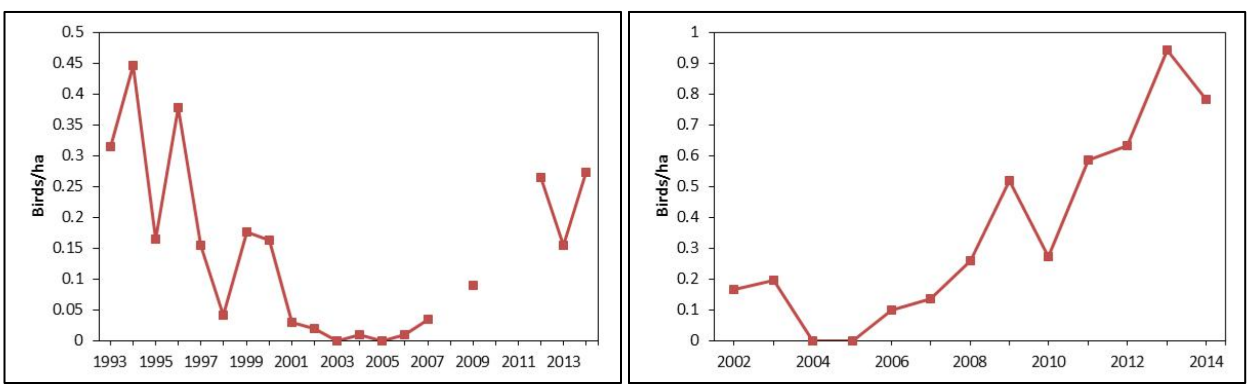


Figure 4.5.19. Annual densities of house finches (*Carpodacus mexicanus*), San Miguel Island, on (left) line transects and (right) point counts.

The virtual disappearance of house finches (*Carpodacus mexicanus*) from San Miguel in the mid-2000s remains unexplained, as does their subsequent increase from 2005-2014.

Landbird populations display notoriously high interannual variation (Taylor et al. 1994), and this may explain some of the considerable variation seen in San Miguel landbird populations. One would think that a long-term dataset such as that for line transects (1993-2013) would capture some changes due to habitat recovery, but this is not immediately apparent. Recovery of San Miguel may be occurring so slowly that such changes are not apparent, or there may not be substantial differences in landbird habitat use among many of the shrub communities on the island. If grasslands were being colonized by shrub species, one would expect a decline over time in grassland species such as horned larks and western meadowlarks, but this is not the case. Nor was there an increase in species more associated with shrubs, such as song sparrows and orange-crowned warblers that could not be explained by island fox population dynamics.

Threats and Stressor Factors

Vegetation

Johnson's work (1972, 1980) showed that surface disturbance combined with SMI's strong winds stripped the island of vegetation, first in the Holocene and later during sheep ranching. As long as disturbance is minimal, ground cover should continue to recover. However, aridity, influenced by both local soil characteristics and drought, slows recovery rates and influences whether annual or perennial vegetation is able to establish. Thus, the greatest threat to the integrity of the island's soils and vegetation is land management that increases the threat of fire and allows or renews ground disturbance such as might come with renewed military uses. The risk of renewed erosion was exacerbated during drought, especially in annual grass-dominated areas of the island. If climate change affects fog and precipitation patterns in ways that exaggerating drought conditions, SMI will experience increasing risk of erosion should a disturbance occur.

Vertebrates

There are few known threats to vertebrates on SMI, beyond the general and uncertain future effects of global climate change. Island foxes are highly unlikely to undergo further population declines due the stochastic effects of low population size; the current risk of extinction for San Miguel Island foxes is less than 5% (Coonan et al. 2014). The threat of disease is probably of highest concern for San Miguel island foxes, as for other island fox subspecies. For this reason foxes on San Miguel and other islands are vaccinated yearly against canine distemper virus and rabies, and an epidemic response plan has been developed to address the threat of future pathogen introduction (Coonan et al. 2014).

Although recovery of native shrub communities has not proceeded very quickly, and non-native grasses still occur over much of San Miguel, no vertebrate species are likely threatened by these conditions. There is no that any vertebrates are currently at greatly reduced numbers.

Data Gaps

Vegetation

The forthcoming vegetation classification and map will fill a huge gap in our knowledge of the composition and extent of SMI plant communities, allowing comparison with the past, with other islands and forecasting potential future habitat scenarios. The U.S. Geological Survey (USGS; McEachern, Yee and Halstead, In prep.) is in the process of updating analyses of the Inventory & Monitoring vegetation transect data for trends in correlation with environmental factors likely to influence vegetation patterns on the island. A major gap in assessing factors related to trends in plant and animal communities is the lack of weather data from the island. We know that weather varies across the islands, and currently we use data from SRI as a proxy for SMI. However, our ability to predict effects of climate change on SMI apart from other islands would be much better with local data from a weather station on the island. Finally, chaparral does not appear to be recovering on the island, so we need to identify seed sources and methods for assisting recovery.

Vertebrates

As on Santa Rosa, the island fox and many landbird species are fairly well-studied, and/or their populations will be monitored annually, as part of the park's long-term ecological monitoring program. There are significant gaps for some individual species, however. The distribution and abundance of amphibians and reptiles is not well known on the island. Herpetofauna are monitored as part of the park's long-term ecological monitoring program (Fellers et al. 1988), with herptile presence at three coverboard transects, but resulting data are limited, and in the case of amphibians, may not represent population dynamics, since salamander presence above ground may depend on soil moisture and recent precipitation.

Overall Condition

Vegetation

SMI is slowly stabilizing through colonization of blowing sand dunes and erosion pavement by a mix of native and non-native plants. The successional trajectory suggested in the 1979 Hochberg et al. study from open sand to pioneering coastal dune cover to low scrub is corroborated generally by NPS Inventory and Monitoring Program transect analysis, and Zellman's independent study of aerial photographs. However, areas of exotic grassland persist in an alternative stable state that may need active restoration to facilitate native shrub invasion. Hard chaparral characterized by the presence of *Ceanothus*, *Rhamnus*, and *Rhus*, apparently present before settlement, is not reappearing on the island. Active restoration may be needed to find native seed sources, grow plants for seed increase, and develop chaparral habitat on the island.

Vertebrates

Vertebrate populations appear to be robust and at relatively high densities. Island foxes have recovered from the precipitous decline of the mid-1990s, and in 2014 numbered above 500 individuals, a population level greater than that recorded before the decline (Coonan et al. 2014, T.J. Coonan, NPS, unpublished data). This said, there may be differences among habitat types regarding vertebrate prey availability, and this may account for some differences in fox density among grids (see Figures 4.5.8 and 4.5.9).

Landbirds also exist at fairly high densities likely due to the fact that there are fewer species on small islands such as SMI; with fewer competitors, niches are expanded, and island species can expand into more habitat types (Blondel et al. 1988). Habitat selection data show island species preferring multiple habitat types, with few being true habitat specialists (Coonan et al. 2011b). Consequently, SMI landbird species currently exist at high population numbers, with conservative island wide estimates for each of the six focal species numbering between 1,000 and 8,000 (T. J. Coonan, NPS, unpublished data). Indeed, songs sparrows on SMI might be considered hyper-abundant, occurring at higher densities than any other species on any other island, and having been observed at all 40 point count sites (T.J. Coonan, NPS, unpublished data).

While there are not data on herpetofauna population size included in this assessment, both Channel Island slender salamander and Island fence lizard are known to be present on the island.

With island species existing at high densities and in multiple habitat types, and with many similarities among habitat types, habitat is likely not a limiting factor for SMI vertebrates. Island vegetation has certainly recovered, somewhat, from the ungulate-driven impacts of the 20th century. By 1929 acute multi-year droughts combined with overgrazing by sheep had resulted in an island landscape dominated by sand dunes (Johnson 1979, 1980). Vegetation has slowly recovered since the removal of sheep in the 1930s and burros in the 1970s. While there may not be the same composition of native vegetation communities that existed prior to the introduction of non-native grazing animals, existing data does not suggest that this is important. This is likely due to similarities among scrub (and even grassland) habitats on San Miguel, the relaxed niches exhibited by island species, and the generalist nature of island foxes.

<u>Sources of Expertise</u>

Vegetation

- Kathryn McEachern
- U.S. Geological Survey, Western Ecological Research Center, Channel Islands Field Station

Vertebrates

- Tim Coonan
- National Park Service

4.5.3. Literature Cited

Alden, J. 1852. Pages 105-106 *in* U.S. Coast Survey Report of the Superintendent. 1852. Appendix 18.

Belnap, J. 2002. Biological soil crusts: Webs of life in the desert. US Geological Survey Fact Sheet No. FS-065-01.: Moab, Utah, US Geological Survey. Available at: http://fresc.usgs.gov/products/fs/fs-065-01.pdf (accessed 10 July 2014).

Blondel, J., D. Chessel, and B. Frochot. 1988. Bird species impoverishment, niche expansion, and density inflation in Mediterranean island habitats. Ecology 69(6):1899-1917.

Collins, P. W. 1980. Food habits of the island fox (*Urocyon littoralis littoralis*) on San Miguel Island, California. Pages 152-164 in Proceedings of the second conference on scientific research in the national parks. Vol. 12: Terrestrial Biology and Zoology. NTIS PB81-100133.

Coonan, T. J. 2013. 2012 deer mouse monitoring annual report, Channel Islands National Park. Natural Resources Data Series NPS/MEDN/NRDS – 2013/571. National Park Service, fort Collins, Colorado.

Coonan, T. 2016. Seventeenth Annual Meeting Island Fox Working Group Summary Report. Ventura, CA.

Coonan, T. J., A. Guglielmino, and R. Shea. 2013. Island fox recovery program: Channel Islands National Park 2013 annual report. Natural Resource Report NPS/MEDN/NRR—2013/703. National Park Service, Fort Collins, Colorado.

Coonan, T. J., A. Guglielmino, and R. Shea. 2014. Island fox recovery program: Channel Islands National Park 2013 annual report. Natural Resource Report NPS/MEDN/NRR—2014/845. National Park Service, Fort Collins, Colorado.

Coonan, T. J., C. A. Schwemm, and D. K. Garcelon. 2010. Decline and recovery of the island fox: a case study for population recovery. Cambridge University Press, Cambridge, U.K.

Coonan, T. J., L. C. Dye, and S. G. Fancy. 2011a. Landbird monitoring protocol for Channel Islands National Park – Version 2.0. Natural Resources Technical Report NPS/CINP/NRTR-2011/480. 42 pp. National Park Service, Fort Collins, Colorado.

Coonan, T. J., R. C. Klinger, and L. C. Dye. 2011b. Trends in landbird abundance at Channel Islands National Park, 1993-2009. Natural Resources Technical Report NPS/CINP/NRTR-2011/507. 86 pp. National Park Service, Fort Collins, Colorado.

Corry, P. M. 2006. Vegetation dynamics following grazing cessation on the Channel Islands, California. PhD Dissertation. University of North Carolina at Chapel Hill, Chapel Hill. North Carolina. 293 pp.

Corry, P. M., and A. K. McEachern. 2009. Patterns in post-grazing vegetation changes among species and environments, San Miguel and Santa Barbara Islands. Pages 201–214. *In* Damiani, C. C., and D. K. Garcelon (eds.), Proceedings of the 7th California Islands Symposium. Institute for Wildlife Studies, Arcata, CA.

Crowell, H. E. D. 2001. Food habits and prey availability of the threatened San Miguel Island fox, *Urocyon littoralis littoralis*, during a decline in population, 1993-1995. Unpublished master's thesis. California Polytechnic State University, San Luis Obispo.

Cypher, B. L., E. Y. Madrid, C. L. Van Horn Job, E. Kelly, S. W. R. Harrison, and T. L. Westall. 2011. Resource exploitation by island foxes: implications for conservation. Contract Final Report (P085004) to California Department of Fish and Game. California State University – Stanislaus, Endangered Species Recovery Program, Turlock, California.

Davidson. G. 1858. San Miguel Island. Pages 23-24 i*n* Directory for the Pacific Coast. Washington, D.C.

DeLong, R. L., and S. R. Melin. 2000. Thirty years of pinniped research at San Miguel Island. In: The Fifth California Islands Symposium (CD Publication). Pages 401–406. In: Brown, D., K.

Mitchell, and H. Chaney, eds. U.S. Department of the Interior Minerals Management Service, Pacific OCS Region.

Drake, E. M. 2013. Home range and habitat use of Santa Rosa island foxes (*Urocyon littoralis santarosae*). M.S. Thesis, California Polytechnic State University, San Luis Obispo, California. 100 pp.

Dunkle, M. B. 1950. Plant ecology of the Channel Islands of California. Allan Hancock Pacific Expeditions 13:268–294.

Dye, L. C., and T. J. Coonan. 2014. Landbird monitoring 2013 annual report, Channel Islands national Park. Natural Resource Data Series NPS/MEDN/NRDS – 2014/713. National Park Service, fort Collins, Colorado.

Erlandson, J. M., T. C. Rick, and R. L. Vellanoweth. 2003. Human impacts on ancient environments: a case study from California's northern Channel Islands. *In* Voyages of Discovery: The Archaeology of Islands. S. Fitzpatrick, ed. Praeger Publishers/Greenwood Press, Westport, Connecticut.

Erlandson, J. M., T. C. Rick, and T. J. Braje. 2009. Fishing up the food web? 12,000 years of maritime subsistence and adaptive adjustments on California's Channel Islands. Pacific Science 63(4):771-724.

Fellers, G. M., C. A. Drost, and B. A. Arnold. 1988. Terrestrial vertebrates monitoring handbook. National Park Service Unpublished Report, Channel Islands National Park, Ventura, California.

Halvorson, W. L., R. A. Clark, and C. R. Soiseth. 1992. Rare plants of Anacapa, Santa Barbara, and San Miguel in Channel Islands National Park. Technical Report NPS/WRUC/NRTR-92/47. Cooperative National Park Resources Study Unit, Davis, California. 134 pp.

Hochberg, M. C., S. A. Junak, R. N. Philbrick, and S. Timbrook. 1979. Chapter V, Botany. *In* D. M. Power ed. Natural Resources Study of the Channel Islands National Monument, California. Santa Barbara Museum of Natural History, Santa Barbara, California. 91 pp.

Hunt, G. L., Jr., R. L. Ptiman, and H. L. Jones. 1980. Distribution and abundance of seabirds breeding on the California Channel Islands. *In* The California Islands: Proceedings of a Multidisciplinary Symposium, edited by D.M. Power. Pages 443-459. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Johnson, D. L. 1972. Landscape evolution on San Miguel Island, California. Ph.D. dissertation, University of Kansas.

Johnson, D. L. 1979. Hydrology and water resources. Pages 4.1-4.21 in Power, D.M. (ed.), Natural resources study of the Channel Islands National Monument, California. Report submitted to the National Park Service. Santa Barbara Museum of Natural History, Santa Barbara, California.

Johnson, D. L. 1980. Episodic landscape stripping, soil erosion, and landscape modification in prehistoric and recent historic time, San Miguel Island, California. Pages 103-121 in D. M. Power, ed., The California islands: proceedings of a multidisciplinary symposium. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Lenihan, J., J. Lennox, and S. Veirs. 1983. Classification and ordination of plant communities of San Miguel Island. Unpublished report. Cooperative Park Studies Unit, UC Davis, Davis, CA.

Muhs, D. R., S. G. Skipp, R. R. Schumann, D. L. Johnson, J. P. McGeehin, J. Beann, J., Freeman, T. A. Pearce, and , Z. M. Rowland. 2009. The origin and paleoclimatic significance of carbonate sand dunes deposited on the California Channel Islands during the last glacial period. *In* C. C. Damiani, D. K. Garcelon (Eds.), Proceedings from the Seventh California Islands Symposium. Institute for Wildlife Studies, Oxnard, California, pp. 3-14.

National Park Service (NPS). 1980. General Management Plan. Anacapa-Santa Barbara-San Miguel Islands, Channel Islands National Park. Vol. 2. Natural / Cultural Resource Management. Denver Service Center, Denver CO.

National Park Service (NPS). 2001a. Landbird Monitoring 1995-2000 Annual Report. Technical Report 2001-03. Channel Islands National Park. On file at park headquarters. Available at: http://www1.nature.nps.gov/im/units/chis/PDFReports/Terrestrial/9500LBAnnl.pdf (accessed 14 January 2014).

Orrock, J. L., and R. J. Fletcher. 2014. An island-wide predator manipulation reveals immediate and long-lasting matching of risk by prey. Proceedings of the Royal Society B 281: 20140391.

Peluc, S. I., T. S. Sillett, J. T. Rotenberry, and C. K. Ghalambor. 2008. Adaptive phenotypic plasticity in an island songbird exposed to a novel predation risk. Behavioral Ecology 19:830-835.

Philbrick, R., and J. Haller. 1977. The Southern California Islands. Pages 893-906 *in* M. Barbour and J. Major, editors. Terrestrial Vegetation of California. John Wiley and Sons.

Rick, T. C., J. M. Erlandson, and R. L. Vellanoweth. 2001. Paleocoastal marine fishing on the Pacific Coast of the Americas: perspectives from Daisy Cave, California. American Antiquity 66(4):595-613.

Roemer, G. W. 2004. Island foxes. Pages 173-183 in David W. Macdonald, Claudio Sillero-Zubiri, (eds). The Biology and Conservation of Wild Canids. Oxford University Press.

Schwemm, C. 2008. Establishment limitations and population recovery of giant coreopsis (*Coreopsis gigantea*) on the California Channel Islands. PhD dissertation. University of California at Santa Barbara, Santa Barbara, California. 163 pp.

Schwemm, C. A., and T. J. Coonan. 2001. Status and ecology of deer mice (*Peromyscus maniculatus* subsp.) on Anacapa, Santa Barbara and San Miguel Islands, California; summery of monitoring, 1992-2000. Technical report 01-02. National Park Service, Channel Islands National Park.

Sofaer, H. R., T. S. Sillett, S. I. Peluc, S. A. Morrison, and C. K. Ghalambor. 2012. Differential effects of food availability and nest predation risk on avian reproductive strategies. Behavioral Ecology 24:698-707.

Sumner, E. L. Jr. 1958. The rabbits of Santa Barbara Island – A progress report and summary. Unpublished Report, Channel Islands National Park, Ventura, California. 21 pp.

Taylor, D. M., D. F. DeSante, G. R. Geupel, and K. Houghton. 1994. Autumn populations of landbirds along central coastal California 1976-1986. Journal of Field Ornithology 65(2):169-185.

U.S. Department of the Navy (U.S. Navy). 2002. Final Natural Resources Summary Report. San Miguel Island. Naval Air Warfare Center Weapons Division, Point Mugu, CA.

Zellman, K. L. 2015. Changes in vegetation and biological soil crust communities on sand dunes stabilizing after a century of grazing on San Miguel Island. In press. Proceedings of the 8th California Islands Symposium, Ventura, CA. WNAN.

Chapter 5. Summary

Giant Coreopsis on Anacapa Island. NPS photo.

In this chapter we summarize our assessment findings and discuss the overarching themes that have emerged across the five islands, and on each of the islands. We highlight the key information that has informed our condition assessment, and also summarize major data gaps and needs in order to better inform island conditions and future management objectives.

5.1. Component Data Gaps and Needs

Identifying key data gaps is an important component of NRCAs. Data gaps and needs are information that is currently unavailable, but needed in order to better inform Park resource condition, recovery potential, and management needs. Data gaps and needs are summarized in Table 5.2.2, and further details on each are provided in the individual island sections of Chapter 4.

5.1.1. Vegetation

Vegetation data that informed this NRCA largely came from vegetation transects, historic and current vegetation mapping, reports and theses, and published literature. Overwhelmingly, the most critical data gap that emerged from our analysis was the lack of current vegetation maps for most of the islands (SCI, SRI, SMI, AI); the lack of this information made it difficult to assess spatial changes in island vegetation over time, and to relate those changes to observed changes in vertebrate species abundances. Therefore, we were limited in our spatial assessment of vegetation recovery for SCI, SRI, SMI, AI, and only were able to spatially relate the current vegetation with island landbirds for SBI. Another common theme across islands was the lack of information on best techniques for shrub reintroduction and recovery, and the success of invasive species removal and re-vegetation efforts. Additionally, we found that natural (unassisted) recovery potential of native shrubs varied across the islands, with particular island areas (e.g., steep and south-facing slopes) and certain islands (SBI, AI) needing assisted recovery (see Table 5.2.2 in section 5.2). Information on the role of fog and current and future and climate (for all islands), mass wasting (SCI), and ground water recharge (SRI) would also be useful to understanding vegetation community dynamics and recovery potential. While not a focal point of this assessment, there are transect data for herbs and some population data for herbs of conservation concern.

5.1.2. Vertebrates

Data that informed this NRCA largely came from cover-board surveys used to sample lizards (only on SBI), point counts used to sample landbirds (across all islands) as well as landbird transects (SBI, AI and SMI), and mark-recapture live trapping to sample mammals [deer mice (SBI, SMI, AI), foxes (SMI and SRI), and skunks (SRI)]. Across the islands, herpetofauna are consistently the least known of the terrestrial vertebrates, and consistent monitoring across islands would be useful. Abundance, distribution, and habitat affinities of reptiles and amphibians are poorly known for SCI, SRI, SMI and AI, making it difficult to assess their population condition and trends, and their potential responses to shrub recovery. Mammal and landbird populations are reasonably well-sampled across most of the islands, but data are lacking for most vertebrates from AI, especially West and Middle AI where no vertebrate sampling occurs. The population status, cause of declines, and recovery needs are lacking for several landbird species across multiple islands, including loggerhead shrikes on SCI and SRI, and SCI rufous-crowned sparrows on AI. Additionally, island song sparrows remain extirpated on SBI and data are needed for assessing their recovery potential on the island.

5.2. Component Condition, Trend, Recovery Potential, and Threats

Here, we summarize the condition, trend, recovery potential, and threats across the Park islands and provide condition, trend, and recovery summaries in Table 5.2.2 for each island. Definitions of condition graphics are located in Table 5.2.1; the graphical condition designations in Table 5.2.2 are highly simplified symbols, informed by a variety of factors. The details and condition justification and summaries of each resource are provided in the individual sections of Chapter 4. Condition designations for some components are supported by existing datasets and monitoring information and/or the expertise of NPS staff, while others lack complete information. *Note that the reference condition for all islands is the pre-ranching era, which was characterized by native vegetation that sustained native and endemic animal communities.*

Table 5.2.1. Symbols used for conditions and trends presented in Table 5.2.2.

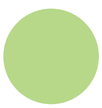
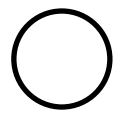
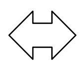
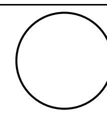
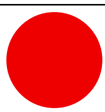
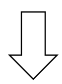
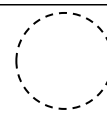
Condition Status		Trend in Condition		Confidence in Assessment	
Condition Icon	**Condition Icon Definition**	**Trend Icon**	**Trend Icon Definition**	**Confidence Icon**	**Confidence Icon Definition**
	Resource is in Good Condition		Condition is Improving		High
	Resource warrants Moderate Concern		Condition is Unchanging		Medium
	Resource warrants Significant Concern		Condition is Deteriorating		Low

Table 5.2.2. Summary of island condition and data needs and gaps for the 5 islands in Channel Islands National Park.

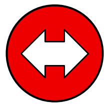
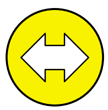
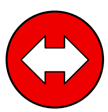
Island	Key Measure	Condition/trend	Key Points	Needs & data gaps
Santa Barbara Island	Vegetation	Condition = poor; Trend = stable; Natural recover potential = low 	• Large areas of exotic annual vegetation • Patchy native shrub cover • Minimal expansion of Coreopsis, important to song birds and native understory plants • Lacks upland shrub vegetation structure for seabirds • SBI stuck in an annual state not regaining native perennial shrubs overall	• Assisted recovery of native shrubs • Best strategies for shrub reintroduction & recovery
	Vertebrates	Condition = moderate; Trend = stable; Natural recovery potential = low 	• No increase in shrub occupying bird species (orange-crowned warbler) • No decline in bird species that associate with bare ground cover (horned lark) • Unexplained decline in grassland species (western meadowlark) • Extirpation of island song sparrows due to non-native herbivores/predators and loss of suitable habitat • No change in deer mice (their population dynamics are largely driven by precipitation and predation) • Night lizard population is dense and stable; boxthorn habitat is good	• Song sparrow population re-establishment potential
	Overall	Condition = poor; Trend = stable 	–	–

Table 5.2.2 (continued). Summary of island condition and data needs and gaps for the 5 islands in Channel Islands National Park.

Island	Key Measure	Condition/trend	Key Points	Needs & data gaps
Anacapa Island	Vegetation West and Middle Anacapa (WAI & MAI)	Condition = moderate; Trend = improving; Natural recovery potential = high. East Anacapa: Condition = low; Trend = improving (through active restoration); Natural recovery potential = low	• West and Middle Anacapa are recovering native coastal scrub and perennial grasses on bluffs and uplands • Woodland and chaparral are still very limited in canyons of WAI and MAI • East Anacapa supports remnant native vegetation, with best native scrub or bluffs	• Current vegetation map • Status and condition of trees on WAI and MAI • Success of iceplant removal and re-vegetation
	Vertebrates	Condition = insufficient data; Trend = improving; Natural recovery potential = high	• Status and trends of vertebrate populations on AI are complex and sparse data exist • Sparse data, but terrestrial vertebrate populations likely robust and plentiful because habitat conditions are not limiting for AI vertebrates • However, following black rat removal, SCI rufous-crowned sparrows remain in low numbers & deer mice have reduced genetic variation • Landbird abundance on EAI has declined despite iceplant removal, and cause is unknown • Herpetofauna have been monitored, but the data have not been evaluated	• Distribution and abundance and habitat affinities of vertebrates on WAI and MAI
	Overall	Condition = moderate; Trend = improving	–	–

Table 5.2.2 (continued). Summary of island condition and data needs and gaps for the 5 islands in Channel Islands National Park.

Island	Key Measure	Condition/trend	Key Points	Needs & data gaps
Santa Cruz Island	Vegetation	Condition = moderate; Trend = improving Natural recovery potential = high, but uneven	• Areas formerly exotic grassland, cactus and barren are being colonized by native scrub in mesic areas of the island • Riparian woody vegetation cover is increasing • South-side slopes and ridges still barren with fragmented vegetation • Erosion is still a risk in steep drainages • Fennel is being slowly invaded by natives in areas not plowed, but remains dense in old grape fields • Recovery of native vegetation is uneven across the landscape • Introduced trees such as eucalyptus and olives will continue to spread if there is no control program	• Recovery techniques for ridges, south-facing and steep slopes • Potential for mass wasting in response to big storms • Causes for decline in Bishop pines • Current vegetation map • Surficial bedrock map
	Vertebrates	Condition = good; Trend = improving; Natural recovery potential = high	• Robust vertebrate populations following ungulate removal, including abundance of some landbirds, including increased abundance and more widespread distribution of harvest mice • Other vertebrates benefited from golden eagle removal • Unknown reasons for decline/low abundance of shrikes • Rufous-crowned sparrow population status unknown—hard to survey • Other species inadequately studied/surveyed, e.g., gopher snake	• Cause of low loggerhead shrikes population • Gopher snake abundance, distribution, and habitat affinities • Distribution and abundance of rufous-crowned sparrows
	Overall	Condition = moderate; Trend = improving	–	–

Table 5.2.2 (continued). Summary of island condition and data needs and gaps for the 5 islands in Channel Islands National Park.

Island	Key Measure	Condition/trend	Key Points	Needs & data gaps
Santa Rosa Island	Vegetation	Condition = moderate; Trend = improving; Natural recovery potential = high, but uneven	• SRI is in a very early stage of release from grazing and browsing • Overall decrease in total plant cover, related to decrease in annual understory plants with little change in native woody plant cover • Rapid in-filling of riparian areas with cattails and other early successional species, riparian trees still not common • Uplands remain barren, erosion still predominates • Native scrub beginning to increase in cover on north slopes, alluvial fans and marine terraces, especially in fog zone • Increases in coyote brush and perennial grasses in grassland, endemic shrubs and herbs in canyons, expansion of Torrey and Bishop pine populations	• Current vegetation map • Role of fog in groundwater recharge • Vegetation recovery in springs and seeps • Surficial bedrock map
	Vertebrates	Condition = good; Trend = improving; Natural recovery potential = high	• Likely habitat improvement for all vertebrates due to removal of pigs, deer, and elk, including some landbird species • Appearance and apparent breeding by new landbird species (bushtits and acorn woodpeckers) • Likely increase in prey and cover for native carnivores (fox/skunk) • But, riparian bird species did not increase as expected. Relatively unknown status of island shrikes and gopher snakes	• Causes of low shrike population • Gopher snake abundance, distribution, and habitat affinities\ • Distribution and abundance of garter snakes • Habitat affinities for spotted skunks and island foxes
	Overall	Condition = moderate; Trend = improving	–	–

Table 5.2.2 (continued). Summary of island condition and data needs and gaps for the 5 islands in Channel Islands National Park.

Island	Key Measure	Condition/trend	Key Points	Needs & data gaps
San Miguel Island	Vegetation	Condition = moderate; Trend = improving; Natural recovery potential = high—except native chaparral, which is low	• Formally barren areas are stabilizing with a mix of native and non-native species • Vegetation is now a mix of grassland and low coastal scrub. • Chaparral is no longer present on the island • Stands of trees are small and infrequent, occurring as remnants in canyons	• Current vegetation map. • Analyze trends in vegetation transect monitoring data • Weather data • Techniques for chaparral establishment • Causes of stability in exotic annual grassland
	Vertebrates	Condition = good; Trend = improving; Natural recovery potential = high	• Vertebrate populations robust and at high densities • Island foxes are recovered • Landbirds exist at high densities • Although native vegetation cover has declined on SMI since pre-ranching era, this does not appear to be greatly impacting the native vertebrate community	• Distribution and abundance of reptiles and amphibians
	Overall	Condition = moderate; Trend = improving	–	–

5.2.1. Overall Park Condition Summary

The Park islands have been inhabited by humans for hundreds of years, influenced by the Chumash and Gabrieleño starting in the early Holocene. Europeans settled the islands in the 1850's, which began the island's ranching era, during which large numbers of non-native herbivores were introduced to the islands. This devastated much of the island's native flora and fauna and caused widespread soil erosion. Efforts have been made over the last 30-35 years to remove these non-native herbivores across all the of the Park islands, with removal time periods differing for each island. In this NRCA, we evaluated the condition and recovery of the islands' terrestrial flora following removal of these non-native herbivores and the end of the ranching era on each of the islands. We assessed these resource conditions relative to the pre-ranching era. All of the ranching era herbivores have been removed, and the island system overall is rebounding. Based on both vegetation recovery and vertebrate population abundances, we find that SCI, SRI, SMI, and ANI are, overall, in moderate condition and are slowly recovering. But, the condition of SBI is poor and remains in a state that is not likely to improve without assisted recovery by the Park. The only potentially major threats facing the islands' flora and fauna today are areas of continued erosion, potential new non-native introductions and climate change. The Park islands have already experienced warming over the last several decades due to human-induced climate change, and are projected to experience continued warming, increasing drought stress. These increasing stresses imposed by climate change may slow and inhibit natural recovery potentials for island fauna, and especially flora.

<u>Vegetation</u>

All islands have exhibited some level of native vegetation recovery following removal of non-native herbivores, with substantial natural recovery occurring on SCI, SRI, SMI, and ANI, but very little occurring yet on SBI. Our assessment of the natural resource condition of SCI, SRI, SMI, and ANI, based on shrub recovery, is moderate, and unassisted recovery potential is high for all of these islands. However, the condition of SBI remains poor, and our findings indicate that assisted recovery of shrubs is required to return SBI to its reference condition (i.e., pre-ranching era). Additionally, vegetation recovery is uneven across each island and largely limited to mesic areas, such as north-facing slopes. A consistent theme across all islands is that natural recovery is much lower in drier locations more prone to drought conditions and where soil water absorption is limited, such as along south-facing and steep slopes. Climate change may make natural recovery of these locations even more challenging, as the climate continues to become warmer and drier. Additionally, some areas remain at risk of erosion in large storms that may increase in intensity with climate change. Other key factors limiting natural recovery potential across the islands included locations that are isolated, lacking native seed banks, and where competition with non-native grasses and other invasives is high. Some plant communities, such as exposed upland vegetation on SRI, exhibited less recovery potential than others. These locations and plant communities will likely require some assisted recovery efforts in order for them return to their reference condition states.

<u>Vertebrates</u>

The overall condition of the Park's terrestrial island vertebrate species appears to be mostly good and improving, with high potential for further recovery to reach pre-ranching era reference conditions. This is particularly true for vertebrates on SCI, SRI, SMI, and also for AI, despite limited vertebrate data for AI. However, we find the condition of SBI vertebrates is only moderate, with natural recovery potential being low due to a number of landbird species' populations currently declining, extinct, or not improving.

An overarching theme across the Park's terrestrial island vertebrates is that many of them are in good condition because they are habitat generalists, so their population dynamics are not strongly tied to habitat conditions. This is the case especially for island foxes and skunks, and many landbird species. Further, some species have shown positive responses to habitat recovery, including orange crowned warblers and island song sparrows on SCI, chaparral landbirds on SRI, and harvest and deer mice. Additionally, landbirds associated with riparian vegetation are not showing signs of recovery across the Park islands, and riparian areas appear to be one of the habitats with limited natural recovery potential on the islands.

Condition Summary of Each Island

Santa Barbara Island

The overall condition of SBI is poor, trend is stable, and natural recovery potential of vegetation and vertebrates is low. SBI is still dominated by exotic annual vegetation more than 30 years after non-native herbivores have been removed, in what appears to be a new stable state for the island. Many species of birds on SBI are likely at lower population levels than prior to the island's ranching era. No doubt the lagging recovery of native scrub limits the availability of high quality habitat for vertebrates on the island. Large-scale, active restoration appears to be needed to push the SBI ecosystem back toward its native perennial state in order to sustain populations of nesting seabirds and other plants and animals. In order to promote the recovery of SBI, information is needed to determine best strategies for shrub reintroduction and recovery.

Anacapa Island

The overall condition of AI, considering both vegetation and vertebrates, is moderate and trend is improving. However, while West and Middle AI vegetation condition is moderate, trend is improving, and recovery potential high, East AI vegetation condition and natural recovery potential is low, though improving due to active restoration efforts (i.e., invasive red-flowered ice plant removal). WAI and MAI have been recovering through mainly passive management since sheep ranching ended in 1938, and now support some of the best examples of native island perennial grassland and island live-forever communities along the entire south coast of California area. WAI and MAI appear to be recovering native upland scrub vegetation on their own, although woodland and chaparral vegetation still appear in small, isolated and depauperate stands. EAI, on the other hand, has been prevented from recovery by iceplant spread and heavy human use and has required active management to remove invasive iceplant. Potential for introductions of invasive plants is high on all three islets, so monitoring for and eradication of new invasive plant introductions is needed as a regular management activity. Though sparse data exist regarding vertebrates across the three islets making up AI, habitat is probably not a significant limiting factor for any species and natural recovery potential appears high. Efforts to remove black rats from AI reduced the genetic variation of the island's endemic Anacapa deer mice, although the removal effort succeeded in avoiding extinction of deer mice from the island and mouse populations appear to be larger now than prior to rat removal. Rufous-crowned sparrows may also have been impacted by rat eradication. Abundance declined after treatment with rodenticide, and in 2011, 8 years after treatment, surveys found very few rufous-crowned sparrows on WAI. Additionally, landbird abundance on EAI has declined and the causes for this remain unknown.

Santa Cruz Island

The overall condition of SCI is moderate, trend is improving, and natural recovery potential of vegetation and vertebrates appears high. SCI is currently in a stage of rapid ecological change following sheep and cattle removal. Native plant recovery is variable across the landscape in response to the interplay of terrain, maritime exposure and climate, with some areas recovering faster than others. Coastal sage scrub and riparian vegetation appear to be the native plant communities recovering most rapidly, along with pine and oak woodland in some places. However, woodland and scrub vegetation remain fragmented on much of the south side of the island. At present there are no known threats to terrestrial vertebrates on SCI as many species have benefited tremendously from the ecological changes wrought by removal of domestic sheep and feral pigs. However, the critically low population level of island loggerhead shrikes remains unexplained, and warrants further study. Other species (such as SCI gopher snakes) have not been adequately surveyed or studied, and at least one other species (rufous-crowned sparrow) remains notoriously difficult to survey.

Santa Rosa Island

The overall condition of SRI is moderate, trend is improving, and natural recovery potential of vegetation is high, but uneven, and appears high for vertebrates. The removal of non-native ungulates from SRI has been recent, beginning in 1993 and concluding in 2013, so SRI is only in the initial stages of native vegetation recovery. SRI is on a trajectory to recover in many sites, but the island has many years to go before recovery to the pre-ranching condition of diverse native scrub and woodland over most of the island. Riparian areas have regained herbaceous vegetation but still lack riparian trees because deer heavily browsed the woody plants up until their removal. Woody plants have just begun to recruit in woodland, chaparral, and coastal sage scrub, since release from deer browsing in 2013. The major limiting factors to vegetation recovery currently include competition from dense brome grasses in some areas, lack of soil and litter to form seedbeds in upland areas, inability to capture and retain water from fog, continued erosion and sedimentation, and drought. The island's vertebrates have likely benefited from exotic ungulate removal and ensuing habitat recovery. This has included increases in 3 of 10 monitored landbird species and the recent appearance and apparent breeding by two species of landbirds, bushtits and woodpeckers, which associate with woody plant cover. But, populations of riparian birds and shrikes remain low, and information is needed to better understand the status and distributions of the island's herpetofauna and deer mice.

San Miguel Island

The overall condition of SMI is moderate, trend is improving, and natural recovery potential of vegetation is high, except for native chaparral which is low, and appears high for vertebrates. By 1929, acute multi-year droughts combined with overgrazing by sheep resulted in an island landscape dominated by sand dunes. Vegetation has recovered slowly since the removal of sheep in the 1930s and burros in the 1970s, stabilizing through colonization of blowing sand dunes and erosion pavement by a mix of native and non-native plants. However, hard chaparral characterized by the presence of *Ceanothus*, *Rhamnus*, and *Rhus*, apparently present before settlement, is not reappearing on the island. Active restoration may be needed to find native seed sources, grow plants for seed increase, and develop chaparral habitat on the island. The island's vertebrate populations appear to be robust and at relatively high densities, despite the current conditions of vegetation. Island foxes have recovered from the precipitous decline of the mid-1990s, and landbirds exist at fairly high densities. With island species existing at high densities and in multiple habitat types, and with many similarities among habitat types, suitable habitat does appear to be a limiting factor for SMI vertebrates. Nevertheless, little remains known on the abundance and distribution of the island's herpetofauna.

Below, we summarize the overall conditions, trends, and recovery potential for each of the islands, and for the vegetation and vertebrate communities on each island.

Appendix. Summary of Legislative History for Channel Islands National Park

On April 26, 1938, President Franklin D. Roosevelt signed proclamation 2281 designating Anacapa and Santa Barbara islands as the Channel Islands National Monument. The proclamation noted that the islands warranted protection because they “contain fossils of Pleistocene elephants and ancient trees, and furnish noteworthy examples of volcanism, deposition, and active sea erosion, and have situated thereon various other objects of geological and scientific interest . . . Several parts of the islands were reserved for lighthouse purposes.”

On February 9, 1949, President Harry S. Truman issued another proclamation (2825) that added 17,635 ac to the monument. Specifically, the proclamation added the area within 1 nautical mile of the shoreline of Anacapa and Santa Barbara islands, which included several small islets and rocks and the offshore kelp beds around the islands. It was noted that these islets and rocks were “required for the proper care, management, and protection of the objects of geological and scientific interest located on lands within the said monument.”

PL 93-477 (88 Stat 1445), enacted on October 26, 1974, authorized funds for the development of an administrative (headquarters) site and visitor facilities for the monument. Section 401 of the act authorized the secretary of the interior to accept the donation of the fee simple title of up to 5 ac of land and submerged land within the Ventura Marina in Ventura for these facilities.

On March 5, 1980, President Jimmy Carter signed PL 96-199 (94 Stat 67), which established Channel Islands National Park. The act included in the park Santa Barbara and Anacapa islands from the original monument, plus Santa Rosa, Santa Cruz, and San Miguel islands (the later to remain under the ownership of the U.S. Navy but managed by the Park Service). Prince Island was also included in the park, as well as the rocks, islets, and submerged lands and waters within 1 nautical mile of each island. The act stated that lands owned by The Nature Conservancy could be acquired only with their consent. Privately owned lands on Santa Rosa were to be acquired “as expeditiously as possible.” The act specifically stated that nothing would affect the rights and jurisdiction of the state of California within the park, including its authority over submerged lands, waters, and marine resources within the park boundaries. Section 204(a) of the act declared that the park “shall be administered on a low-intensity, limited-entry basis.” Section 204(b) further stated that “in recognition of the special fragility and sensitivity of the park’s resources, it is the intent of Congress that the visitor use within the park be limited to assure negligible adverse impact on the park resources. The Secretary shall establish appropriate visitor carrying capacities within the park.” Section 206 called for a review of the suitability or nonsuitability of the park for designation as wilderness within three fiscal years after the date of the enactment of the law. Section 207 stated that no fees shall be charged for entrance to the park. Section 208 provided for expenditure of federal funds for the cooperative management of The Nature Conservancy and other private property for research, resource management, and visitor protection and use.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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