



Channel Islands National Park

Terrestrial Vegetation Monitoring Annual Report, 2023



Eschscholzia californica near Pocket Field on Santa Rosa Island.
NPS / REUVEN BANK

Channel Islands National Park: Terrestrial Vegetation Monitoring Annual Report, 2023

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Abstract

Long-term ecological research is critical for evaluating past resource management actions and guiding future decisions. This report presents the data collected at Channel Islands National Park (CHIS) in 2023 as part of its terrestrial vegetation monitoring program. The program's objective is to document long-term trends in the park's vegetation communities as part of the Mediterranean Coast Inventory and Monitoring Network, which also includes Santa Monica Mountains National Recreation Area and Cabrillo National Monument.

Monitoring at CHIS began in 1984 to observe vegetation recovery after the removal of nonnative ranched animals. In 2023, field data were collected from 143 transects. Analyzing all years of data together showed that annual rainfall correlated positively with percent cover of vegetation, and an apparent long-term decline in average percent cover of vegetation that started in the mid-1990s continued in the 2000s, with a slight increase in 2023. Analyzing the 2023 dataset by itself provided more nuanced results. Valley/foothill grassland had consistently low proportions of native species richness and relatively low overall richness. This community may have been more susceptible to grazing in the past and may currently be resistant to passive recovery. Vegetation was, on average, tallest on Santa Cruz and Santa Rosa islands due to the presence of tree-dominated communities. Perennial plant species and native plant species achieved significantly higher percent cover on Santa Cruz, Santa Rosa, and San Miguel islands compared to Santa Barbara or Anacapa islands. Shrubs at the seedling and juvenile developmental stages achieved more plants per square meter (i.e., density) on Santa Barbara, Santa Cruz, and San Miguel islands, while the highest adult shrub density occurred on San Miguel Island. Islands at more northwesterly positions generally supported higher biodiversity.

The tendency for vegetation height, cover of perennials and natives, shrub density, and biodiversity to each decline along a gradient from northwest to southeast indicates that moisture limitation is a strong driver of vegetation recovery after the removal of ranched animals. Moreover, moisture limitation at the park's most southeasterly islands may interact with poor soils and seabird abundance on Santa Barbara Island and seabird abundance on Anacapa Island to further inhibit recovery. Therefore, Santa Barbara and Anacapa islands may benefit greatly from targeted native plant restoration, especially given their low richness and Shannon diversity combined with a relatively large proportional contribution from nonnative species.

Executive Summary

This report presents the data collected in 2023 as part of the long-term terrestrial vegetation monitoring program at Channel Islands National Park, which consists of five islands off the coast of southern California.

The purpose of this monitoring program is to document long-term trends in the park's vegetation communities. Data are collected from 30 m transects using a line-point intercept method. In the past, each transect was sampled annually. However, beginning in 2012 the program began adding randomly located transects to improve the representativeness of the sampling and transitioned to a rotating panel design. Now only a core subset of the transects are surveyed annually, and non-core transects are assigned to one of four panels (A, B, C, or D), each of which is surveyed once every four years. In 2023, 73 core and 72 Panel B transects were scheduled for survey.

Field data were collected from 143 transects, distributed across the islands as follows: Santa Barbara Island ($n = 15$), Anacapa Island ($n = 13$), Santa Cruz Island ($n = 34$), Santa Rosa Island ($n = 68$), and San Miguel Island ($n = 13$). On Santa Barbara Island changes in Brown Pelican activity allowed one extra transect (Panel D) to be surveyed, whereas two Panel B transects were not surveyed. On Santa Rosa Island one transect was not surveyed due to Bald Eagle nesting activity.

Key 2023 results and interpretation:

- A long-term decline in average percent cover of vegetation was apparent starting in the mid-1990s. Annual rainfall correlated positively with percent cover of vegetation.
- Valley/foothill grassland had consistently low overall richness and low proportions of native richness, suggesting that this habitat may have been more susceptible to browsing/grazing in the past and may currently be resistant to passive recovery.
- Vegetation was, on average, tallest on Santa Cruz and Santa Rosa islands due to the presence of tree-dominated communities.
- Perennial plant species and native plant species achieved significantly higher percent cover on Santa Cruz, Santa Rosa, and San Miguel islands compared to Santa Barbara and Anacapa islands.
- For shrubs, the density of seedlings was lowest on Anacapa Island compared to the other four islands, and the results were similar for juveniles. The density of adult shrubs was higher on San Miguel Island than the other four islands.
- Islands at more northwesterly positions generally supported higher biodiversity, as measured by species richness and Shannon diversity. Species evenness, a measure of relative dominance among species, did not differ among islands.
- The tendency for vegetation height, cover of perennials and natives, shrub density, and biodiversity to each decline along a gradient from northwest to southeast indicates that moisture limitation is a strong driver of vegetation recovery after the removal of ranched

animals. Moreover, moisture limitation at the park's most southeasterly islands may interact with seabird abundance at Santa Barbara and Anacapa islands and additionally with poor soils on Santa Barbara Island to further inhibit recovery. Therefore, Santa Barbara and Anacapa islands are the highest priorities for restoration, especially of shrub communities.



Bark of *Arctostaphylos confertiflora* on Santa Rosa Island.

NPS / MICHAEL READY

Acknowledgments

No one accomplishes their work without assistance from others. Field data were collected by Stacy Baker, Katie Debas, and Mark Mendelsohn from the National Park Service (NPS); Ian Sexton from the California Institute of Environmental Studies; and Annie Ayers, Neda Brehm, Kylie Etter, Caitlin Hazelquist, Zachary Phillips, and Rikke Reese Naesborg from the Santa Barbara Botanic Garden (SBBG). Denise Knapp from SBBG provided valuable administrative support. Kim Weisenborn from NPS assisted with data management. The data featured in this report were derived from surveys within Channel Islands National Park, which includes Chumash and Gabrieleño/Tongva homelands.



Vegetation monitoring on Santa Barbara Island.

SANTA BARBARA BOTANIC GARDEN / © RIKKE REESE NAESBORG.

Introduction

Channel Islands National Park (CHIS) hosts at least 800 species of vascular plants, including 70 endemics and 13 taxa protected under the Endangered Species Act. This oasis of biodiversity comprises five islands—Santa Barbara Island (SB), Anacapa Island (AN), Santa Cruz Island (SC), Santa Rosa Island (SR), and San Miguel Island (SM)—located off the coast of southern California (Figure 1). Although at least 13,000 years of Native American habitation influenced the ecology of these islands (Orr 1962; Johnson et al. 2002), the relatively brief tenure of browsing and grazing animals introduced through ranching activities from the mid-1800s through 2015 dramatically altered the trajectory of vegetation in the park today (Rick et al. 2014; McEachern et al. 2016).



Figure 1. Map of Channel Islands National Park.
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Long-term monitoring is a critical component of environmental science because it is inexpensive compared to the value of the resources it protects and management it guides, and the data can inform

interdisciplinary ecological inquiries (Lovett et al. 2007). A formal long-term terrestrial vegetation monitoring program was initiated at CHIS in 1984 when 54 transects were established across SB, AN, and SM. The goal was to monitor the dominant island vegetation communities, each defined as a stable state of vegetation in the absence of disturbance, using a line-point intercept method (Halvorson et al. 1988; McEachern 2001). Given the degraded state of vegetation on the islands at the time, these “legacy” transects were placed where native vegetation remained rather than randomly across the landscape. In subsequent years, shrub- and tree-based monitoring protocols were added (McEachern 2000). After the park acquired SR in 1990 and the eastern parts of SC in 1999 and 2001, an additional 86 and 43 transects were established, respectively. The remaining portion (western 76%) of SC is owned and managed by The Nature Conservancy (TNC) and is not included in the park’s long-term vegetation monitoring program.

The Mediterranean Coast Network (MEDN) of parks was defined by the Inventory and Monitoring (I&M) Division in 2000, when long-term terrestrial vegetation monitoring became one of the network’s 15 “Vital Signs” programs (Cameron et al. 2005). Beginning in 2012, changes to the original monitoring protocol corrected deficiencies to improve the underlying statistical framework. These changes included (1) adding probabilistically selected transects, and (2) transitioning from monitoring all original legacy transects annually to a rotating panel design. With this new design, a core set of transects is visited annually (hereafter, “core” transects), with each of the remaining transects assigned to one of four panels that are visited on a four-year rotating schedule (hereafter, “panel” transects). Both core and panel transects consist of a combination of legacy and probabilistically selected sites. These changes to the framework resulted in a loss of some statistical power to detect interannual variability at legacy transects, but they expanded spatial coverage and provided statistical inference to the islands as a whole. The modified program was then expanded to the other two parks within the MEDN—Santa Monica Mountains National Recreation Area and Cabrillo National Monument. See Tiszler et al. (2016a) for a detailed review of changes to the monitoring program.

This report summarizes the terrestrial vegetation monitoring data collected at CHIS in 2023. The cursory analyses and interpretation provided here are intended as a brief overview of the program’s activities in 2023 rather than a thorough analysis of long-term trends and covariates in the vegetation data. Interpretations are guided primarily by inter-island variation in climate and physiography as well as the history of browsing and grazing by introduced animals.

Methods

Monitoring Dates

The seasonality of monitoring can be an important variable that affects the data collected. California's Mediterranean-type climate is characterized by cool wet winters and warm dry summers, a pattern that drives much of the phenological variation in the state's vegetation, including at CHIS. The optimal period for terrestrial vegetation monitoring at CHIS is between February and June. The 2023 field schedule fit within this period, except for a handful of transects on AN that were surveyed in September and October to avoid disturbing nesting seabirds (Table 1), an approach that began in 2013.

Table 1. Field schedule for vegetation monitoring at Channel Islands National Park in 2023. Counts of transects surveyed by island and by core/panel are included, as are the number of transects for which the shrub and tree protocols were implemented.

Island	Dates Visited	Number of Transects					
		Total	Core	Panel B	Panel D	Shrub Protocol	Tree Protocol
Anacapa	• East: 3/31 • West: 9/22–9/23 • Middle: 10/25	13	8	5	0	10	0
Santa Barbara	2/15–2/19	15	7	7	1	13	0
Santa Cruz	3/2–4/10	34	17	17	0	26	11
San Miguel	5/30–6/3	13	6	7	0	13	0
Santa Rosa	• 4/19–5/25 • 6/14–6/17	68	34	34	0	56	9
Total (all islands)	N/A	143	72	70	1	118	20

Transect Locations

The sites monitored in 2023 consisted of a combination of legacy and probabilistically selected transects. Legacy transects were deliberately placed in areas with intact native vegetation, whereas probabilistic transects were placed using a generalized random tessellation stratified survey design (GRTS; Olsen et al. 2012) to achieve a spatially balanced probabilistic sample that allows inference to each entire island, and to the park portion of SC. A statistically appropriate analysis would need to account for this difference in placement of legacy versus probabilistic transects. However, for the purpose of summarizing the 2023 data for this annual report, the data are treated as a simple random sample. A total of 143 transects were surveyed (Figure 2), including 72 designated as core transects and 71 as panel transects (Table 1). All transects scheduled for 2023 were completed on AN, SC, and SM. On SB, changes in Brown Pelican nesting activity prevented two transects (Panel B #016, Core #301) from being surveyed but allowed one extra transect (Panel D #014) that was unavailable in previous years to be surveyed. On SR, one transect (Panel B #069) was not surveyed due to an active Bald Eagle nest located a few meters above the center of the transect.

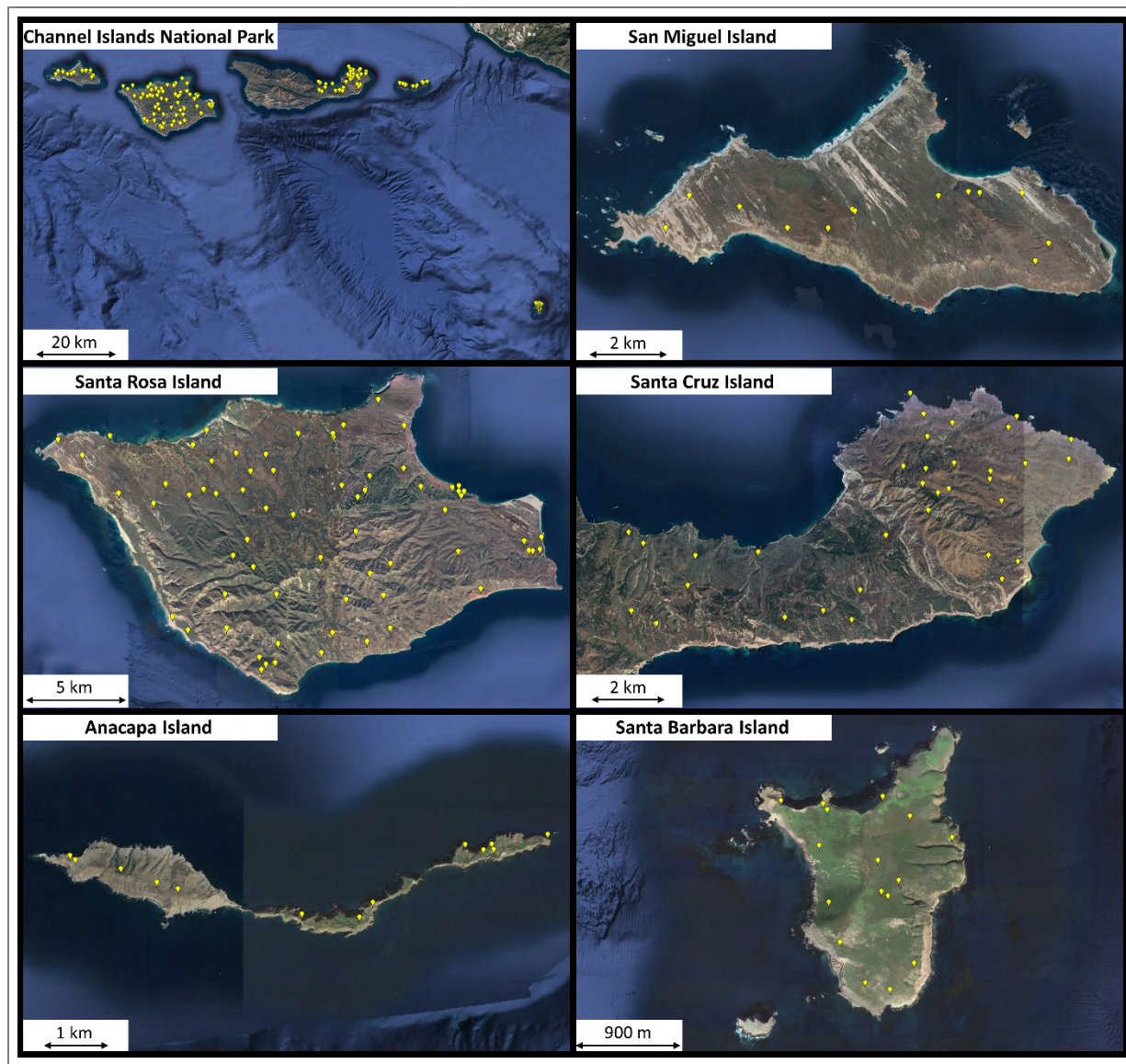


Figure 2. Locations of 143 vegetation monitoring transects surveyed in 2023 across five islands in Channel Islands National Park.

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Field Data Collection

Standard operating procedures (SOPs; Tiszler et al. 2016b) that describe the methodology used to conduct this vegetation monitoring include a foliar cover measurement, a species richness count, a shrub density measurement, and a tree density measurement. Each of these methods was referred to as a “protocol” in the CHIS legacy vegetation monitoring handbook (Halvorson et al. 1988) and in a USGS report on tree and shrub monitoring (McEachern 2000).

For the foliar cover measurement, a meter tape was stretched between two monument stakes that marked the ends of a transect (Figure 3), and data were recorded every 30 cm along the meter tape using a line-point intercept method. The data recorded at each point were the plant taxa present (both

live and, for perennial species, dead tissue) and the height of the tallest vegetation. Each transect was 30 m in length and provided 100 points of data, except for four legacy transects on SB, three of which were 132 m and one 55 m. Differences in transect length were reconciled during data analysis as described below.

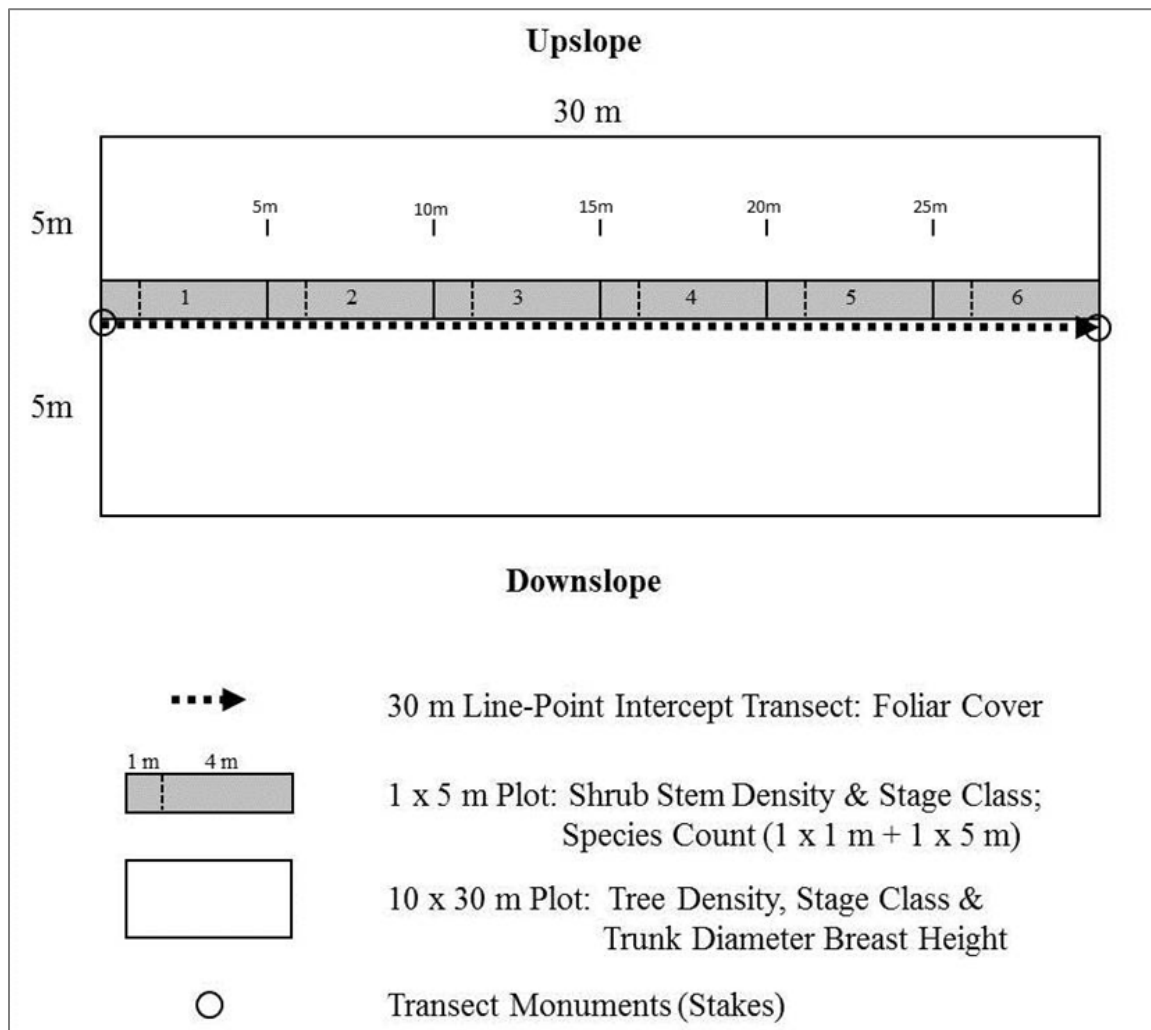


Figure 3. Schematic diagram of a 30 m vegetation monitoring transect with shrub and tree plots (Tiszler et al. 2016b) on Channel Islands National Park islands.

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The species richness count captured richness at three different spatial levels: (1) taxa encountered using the line-point intercept method, (2) taxa occurring within a 1 m plot adjacent to the transect line that were not already recorded by the line-point intercept method, and (3) taxa occurring within a 10 m wide plot centered on the 30 m transect line that were not already recorded by 1 or 2 above.

The density of shrubs, when present, was measured if not measured in the previous year. A 1×30 m plot was placed adjacent to the transect line, divided into six 1×5 m sub-plots, and the number of individuals present within each sub-plot was counted (Figure 3). Four developmental stages—

seedling, juvenile, live adult, and dead adult—were recorded. Importantly, two departures from the SOP occurred. First, the number of individuals, not the number of stems per shrub, was counted. Second, resprouts were not included as a developmental stage. These two departures from the shrub protocol were consistent with past surveys.

In tree-dominated communities, tree density was measured within a 10×30 m plot centered on the 30 m line-point intercept transect with half of the plot on the uphill side of the transect line and the other half on the downhill side (Figure 3). Within the plot, tree species were recorded in five categories: seedlings, juveniles, live adults, dead adults, and basal resprouts. For the live adult stage, diameter at breast height was also measured if greater than 12.5 cm.

Precipitation Records

Long-term precipitation records from the park islands are incomplete, so a complete rainfall dataset (1957–present) was retrieved from Station 168 (Ventura County Public Works Agency 2023) located near Oxnard, California, to represent the timing and relative quantity of rainfall received by the park as a whole. Annual precipitation from Station 168 was based on water years extending from October to September.

Data Management and Analysis

All monitoring data were recorded directly into iPads via a FileMaker (version Pro; Claris International 2019) graphical user interface customized for the MEDN long-term vegetation monitoring program. After each field day, the park botanist conducted an initial quality assurance (QA) and quality control (QC) check on the iPads before backing up the data files by email. At the end of the field season, data files were shuttled into a Microsoft Access (version 365; Microsoft Corporation 2021a) database maintained by the MEDN I&M data manager. The database was then queried to export data summaries to Microsoft Excel (version 365; Microsoft Corporation 2021b). Finally, each of the data summaries underwent a second QA and QC check using the sort function in Excel to systematically identify additional errors. Quantitative analyses were subsequently performed in R (R Core Team 2024) to calculate community indicators such as vegetation height, cover, and density, along with species richness, evenness, and diversity.

To allow frequency data for the foliar cover measurement to be comparable across transects of different length, they were converted to absolute cover by summing across each transect the number of taxa recorded at each point and then dividing that sum by the total number of points. A logarithmic regression model was then used to explore the relationship between precipitation and absolute cover.

Species richness is defined as the number of species in a given area. Included in species richness were taxa encountered during the foliar cover measurement plus any additional species registered within the 10×30 m plot to improve representation of infrequent taxa, since data from line-point intercept transects typically underestimate infrequent species (Dethier et al. 1993). Species evenness, a measure of relative dominance among species (Smith and Wilson 1996), was represented by Pielou's J (Pielou 1966) for each transect, using Equation 1:

$$J = H' / H'_{max}$$

in which H'_{max} is the maximum possible value of H' , the Shannon index, calculated as follows in Equation 2:

$$H' = - \sum_{i=1}^s P_i \ln P_i$$

(McCune and Grace 2002), where s is the number of species and P_i is the proportion of the entire population or sample made up of species i ; in other words, the number of individuals of species i divided by the total number of individuals across all species within the population or sample. Pielou's J ranges from 0 to 1 and is highest when all species have equal abundance.

Statistical distributions of vegetation height and cover, shrub density, and each of the three diversity indices were checked for normality via Shapiro-Wilk tests. Normally distributed data were compared among islands using ANOVA and then between pairs of islands using Tukey's honestly significant difference (HSD) test. Non-normally distributed data were compared using Kruskal-Wallis tests (Kruskal and Wallis 1952), followed by Conover-Iman tests of multiple comparisons (Conover and Iman 1979). Although all pairwise comparisons between islands were tested for differences, only those that were significant are reported below.

Results and Interpretation

Data from all 143 transects visited in 2023 were included in the analyses. The results and interpretations that follow emphasize among-year relationships between vegetation cover and annual precipitation, as well as among-island comparisons of vegetation height and cover, woody plant density, and diversity indices. It is possible the late (September–October) survey timing at Middle and West AN yielded underestimates of abundance and diversity at these islets. Overall, the data suggest that moisture availability is a strong driver of the rate of vegetation recovery.

Vegetation Height and Cover

The long-term vegetation monitoring data from CHIS have historically portrayed a positive relationship between precipitation and the mean number of “hits” per transect (e.g., Rodriguez 2021), which for a given transect is the sum of the species richness recorded at each point along that transect (Tiszler et al. 2016a). For example, the 2012–2016 California drought, which may have been the driest four years of the previous 1,200 (Dong et al. 2019), manifested as a dip in the mean number of hits per transect during those years (Rodriguez and Williams 2022). A similar pattern emerged when analyzing the data through 2023—absolute cover was positively correlated with annual rainfall (Figure 4). This analysis also revealed an apparent long-term decline in absolute cover since the early to mid-1990s, but caution is urged in this interpretation because legacy versus probabilistic transect data would be more appropriate to analyze separately.

Transects that captured the tallest vegetation were on SC and SR, which harbored several tree-dominated communities. These tree-dominated communities were statistical outliers responsible for the non-normality of vegetation height data for these two islands (Figure 5). Vegetation was taller on SC and SR than SB or AN, and also taller on SM than SB (Conover-Iman test, $p < 0.006$ for each of the five pairwise comparisons). The high density of trees in the oak woodland and *Lyonothamnus* grove communities supported the tallest canopies, whereas the shortest communities were seablite scrub and boxthorn scrub at 1.5 cm tall and 1.0 cm tall, respectively (Table 2). These short communities are on SB in areas with abundant seabirds that appear to be harvesting plants for nest material.

Total plant cover and the cover of perennial and native taxa can help evaluate the condition of the park’s vegetation after years of ranching, as the removal of nonnative herbivores has resulted in substantial natural recovery on the islands (Beltran et al. 2014; Willis et al. 2018; Thomson et al. 2022; Honzák et al. 2024). Important environmental variables influential to vegetation recovery at the park include land-use history, hydrology, geology, and soil types (McEachern et al. 2016; Schoenherr et al. 2003).

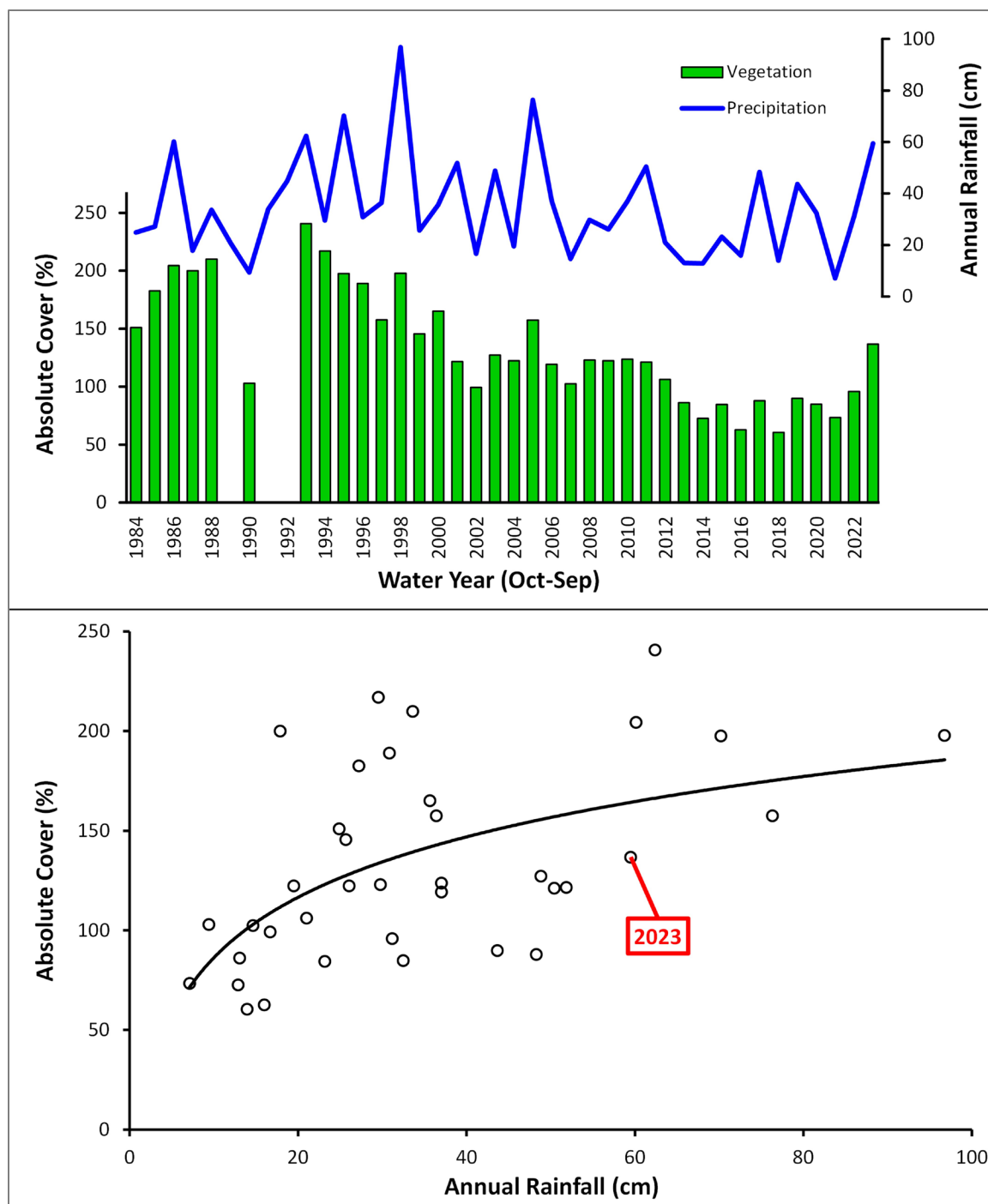


Figure 4. Relationships between annual rainfall and absolute vegetation cover, 1984 to 2023, at long-term vegetation monitoring sites in Channel Islands National Park. Upper panel: Percent vegetation cover since 1984, compared to annual rainfall retrieved from Station 168 (Ventura County Public Works Agency 2023) near Oxnard, California. Vegetation data were not collected in 1989, 1991, or 1992. Lower panel: Positive correlation between annual rainfall and absolute cover of vegetation. Data were fitted to a logarithmic regression model: $y = 43.721\ln(x) - 14.352$; ($R^2 = 0.30$).

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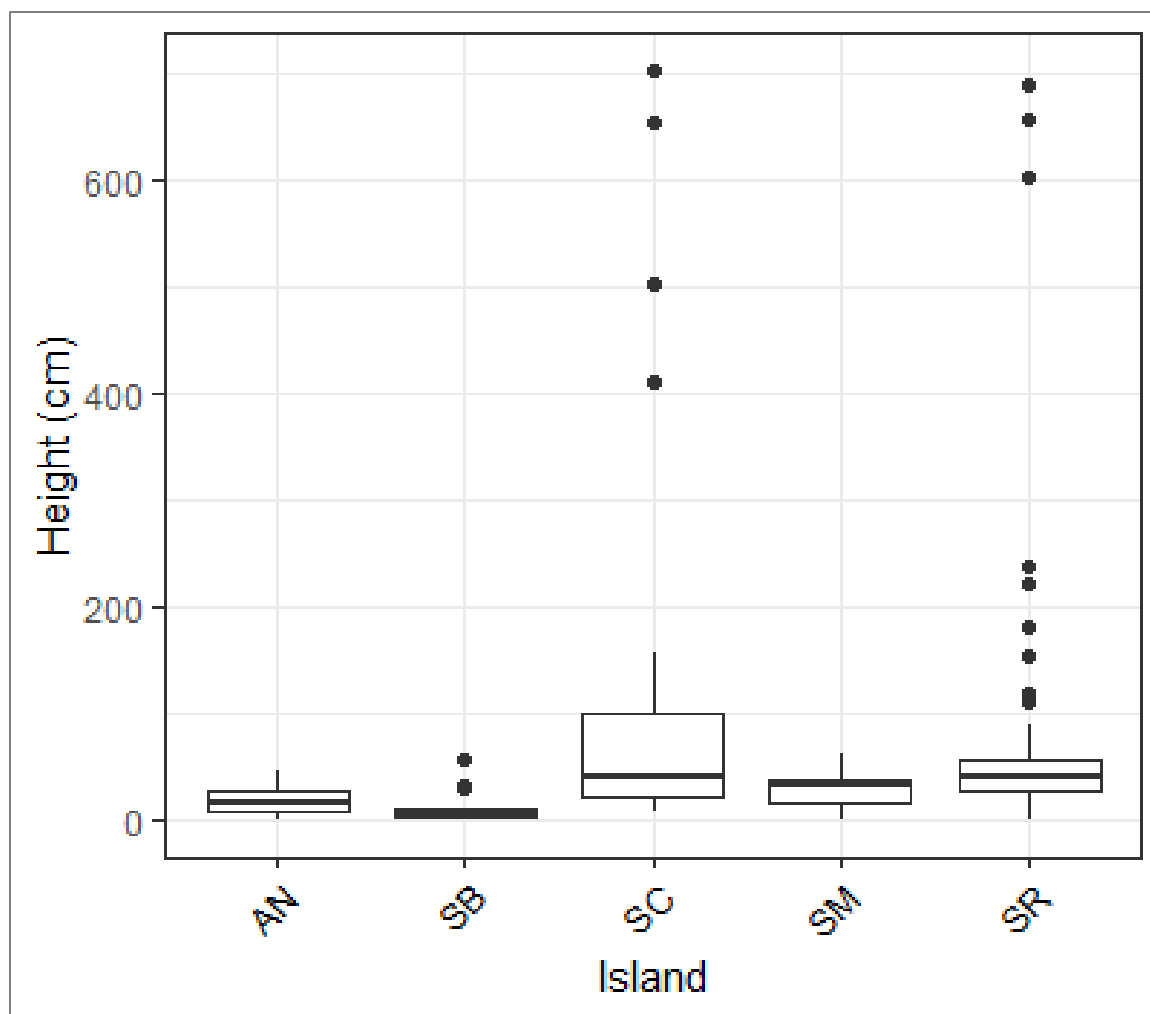


Figure 5. Boxplot illustrating median vegetation height compared among islands for 143 transects surveyed at Channel Islands National Park in 2023. Values include unvegetated points recorded as 0 cm height. AN = Anacapa Island, SB = Santa Barbara Island, SC = Santa Cruz Island, SM = San Miguel Island, SR = Santa Rosa Island.

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Table 2. Vegetation height and count of transects surveyed within each community at Channel Islands National Park in 2023. Values include unvegetated points recorded as 0 cm height.

Community	Mean Canopy Height (cm)	Transect (count)
<i>Baccharis</i> Scrub	47.0	6
Barren	0.0	1
Boxthorn Scrub	1.0	1
Cactus Scrub	6.1	1
Caliche Scrub	3.1	3
Coastal Bluff Scrub	6.1	2

Table 2 (continued). Vegetation height and count of transects surveyed within each community at Channel Islands National Park in 2023. Values include unvegetated points recorded as 0 cm height.

Community	Mean Canopy Height (cm)	Transect (count)
Coastal Marsh	37.8	2
Coastal Sage Scrub	43.3	21
Coastal Scrub	15.4	9
Coastal Scrub (open)	60.7	1
Coastal Strand	6.5	1
Coreopsis Scrub	28.0	7
Fennel	49.5	2
Herbaceous Scrub (generic)	19.1	5
Island Chaparral	73.5	10
Lupine Scrub	28.6	1
<i>Lyonothamnus</i> Grove	538.2	3
Mixed Woodland	309.4	4
Oak Woodland	655.6	2
Riparian	81.5	6
Santa Cruz Island Pine	110.3	1
Seablite Scrub	1.5	2
Shrub Savannah	72.0	3
Torrey Pine Woodland	355.4	2
Valley/Foothill Grassland	29.7	38
Valley/Foothill Grassland - annual	31.6	5
Valley/Foothill Grassland - perennial	26.6	4

Plant cover comparisons (Figure 6) revealed that total plant cover was higher on SR and SM than SB, AN, or SC (Conover-Iman test, $p \leq 0.008$ for each comparison). Perennial plant cover was higher on SC, SR, and SM than SB or AN ($p \leq 0.003$), and native plant cover was higher on SC, SR, and SM than SB or AN ($p \leq 0.012$).

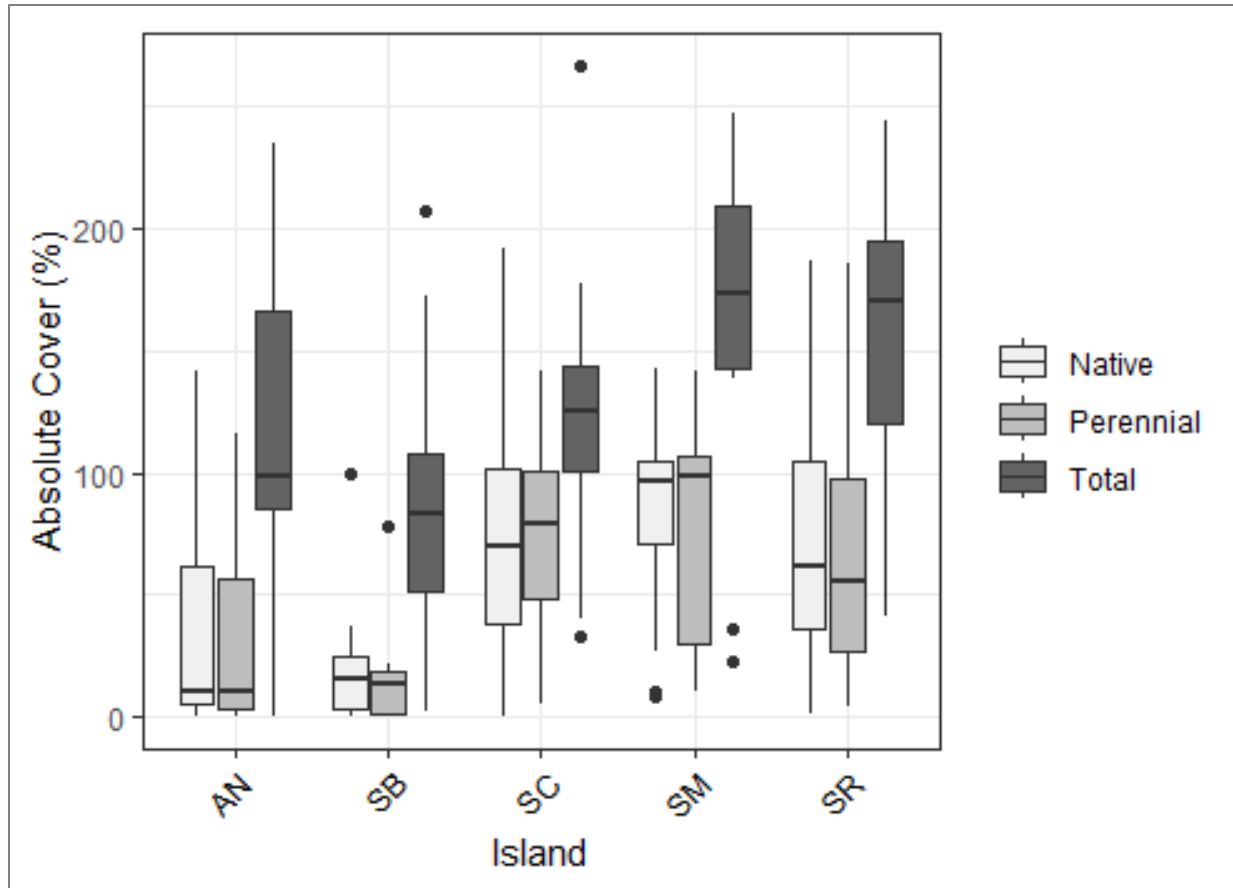


Figure 6. Boxplot illustrating percent cover of vegetation by nativity and longevity compared among islands for transects surveyed at Channel Islands National Park in 2023. “Total” includes native, nonnative, annual, and perennial plants.

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A striking result from this cover analysis was SB’s and AN’s very low native and perennial cover, especially relative to their much higher total cover. This result reflects large proportions of nonnative and annual plants, and suggests that recovery on the islands after browser/grazer removal could be slow compared to SC, SR, or SM. Soils, climate, seabirds, and the timing of surveys are all possible explanations for this pattern. The thin and clayey soils of SB may resist community change away from domination by nonnative annuals (McEachern et al. 2016). The south and easterly positions of SB and AN occupy a climate that offers less annual precipitation than SC, SR, or SM where a faster rate of woody vegetation recovery is likely facilitated by a wetter climate at these more northerly and westerly islands. For example, on SB the nonnative species *Hordeum murinum* (foxtail grass) and *Mesembryanthemum crystallinum* (crystalline iceplant) may switch dominance with the native shrub *Suaeda californica* (seablite) in patterns that are related to climate (Davidson et al. 2019). In addition, SB and AN support the largest nesting seabird colonies in the park. Western Gulls scrape small cup nests and line them with any nearby vegetation available (Schreiber 1970; Harper 1971), whereas Brown Pelicans construct large podium-like nests from a variety of plant material including forbs, grasses, and woody stems (Schreiber 1977; USFWS 1983). Interactions among these variables

may also play a role in the low plant cover at SB and AN. Low moisture availability at more southeasterly islands likely interacts with a combination of seabirds and soils on SB, and seabird abundance on AN, to further slow vegetation recovery. Finally, the late timing (September and October) of surveys at Middle and West AN likely captured lower overall cover, especially of herbs and drought-deciduous shrubs, which would have withered substantially with exposure to winds over the spring and dry summer seasons.

Shrub and Tree Density

The transition in land use from Native American habitation to animal ranching in the early 1800s resulted in a substantial reduction of woody and succulent plant communities, and the conversion of native shrubland to nonnative grassland and bare ground was particularly widespread (McEachern et al. 2016; Davidson et al. 2019). Comparing the density of woody vegetation at different developmental stages among islands can inform rates of recovery after removal of the ranched and feral animals. In 2023, the shrub protocol was implemented at 118 transects (Table 1). Among the four developmental stages considered, the highest shrub density at any individual transect was an outlying 29 seedlings/m² on SC (Table 3), with AN having no seedlings registered. The density of seedlings was higher on SB, SC, SR, and SM than AN (Conover-Iman test, $p \leq 0.019$ for each comparison). The results were similar for juvenile density, which was higher on SB, SC, and SM than AN, and also higher on SM than SC or SR ($p \leq 0.020$ for each comparison). For adult shrubs, the density was higher on SM than the other four islands ($p \leq 0.013$ for each comparison). Excepting the fact that AN had lower density of juveniles than SB, which could be due to the late survey timing at Middle and West AN, these results collectively point toward a higher rate of woody plant recovery for the more northwesterly islands, which may be attributable to favorable moisture conditions. This interpretation is consistent with the observation that north-facing slopes tend to be most amenable to vegetation recovery after the removal of ranched animals (Davidson et al. 2019). In addition, the higher density of adult shrubs on SM may be a product of the long recovery time since ranched animals were removed in the 1970s (McEachern et al. 2016).

Table 3. Mean and maximum (max) shrub densities (count/m²) by developmental stage compared among islands in Channel Islands National Park in 2023. Minimum shrub densities were all zero.

Island	Seedling		Juvenile		Adult		Dead	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max
Anacapa	0.00	0.00	0.06	0.33	0.40	2.17	0.11	0.43
Santa Barbara	1.14	9.09	0.74	2.97	1.35	4.77	0.34	3.53
Santa Cruz	4.76	28.70	0.95	7.43	0.88	4.27	0.36	2.73
San Miguel	0.66	2.77	2.94	15.37	2.18	5.90	0.59	3.30
Santa Rosa	0.51	5.70	0.40	2.80	0.91	5.47	0.15	0.93

The tree protocol was implemented for 11 transects on SC and nine on SR (Table 1), a sample size that was deemed too small to warrant a comparative analysis of tree density for a single year. This,

combined with the high variability in tree density and basal area among transects and communities, makes these data better suited for an analysis of trends over the longer term.

Species Richness, Diversity, and Evenness

Species composition exerts a strong influence over susceptibility to invasion by nonnative plants (Hooper et al. 2005), and ecosystem productivity and stability are positively correlated with species richness, species evenness, and Shannon diversity (e.g., Naeem et al. 1994; Wilsey and Potvin 2000; Tilman et al. 2006). Therefore, diversity indices compared among plant communities can be useful tools in evaluating community and ecosystem recovery after environmental degradation, such as that caused by intensive browsing or overgrazing.

At CHIS in 2023, the most species-rich plant communities were on SR, with one transect (#011) in island chaparral supporting 58 taxa, and transects within mixed woodland and *Lyonothamnus* groves each supporting a mean of over 45 taxa (Figure 7). Coastal strand on SR supported just six taxa, and seablite scrub and valley/foothill grassland on SB each supported less than 10 taxa on average. A high proportion of native species was found in tree-dominated communities, including those featuring *Lyonothamnus*, Santa Cruz Island pine, and Torrey pine, whereas the smallest proportions were in barren, seablite scrub, and valley/foothill grassland communities. The lack of statistical replication for many of these communities constrains interpretation. However, valley/foothill grassland ($n = 38$) had consistently low proportions of native richness as well as relatively low overall richness. This community may have been highly susceptible to grazing in the past and may currently be resistant to passive recovery. Island chaparral ($n = 10$) and mixed woodland ($n = 4$), which exhibited higher ratios of native to nonnative species, may represent the other end of this spectrum.

Significant differences in species richness and Shannon diversity were detected among islands (Figure 8). Species richness was higher on SC, SR, and SM than SB or AN (Tukey's HSD, $p < 0.001$), but species evenness did not differ among islands (Conover-Iman test, $p = 0.060$). However, Shannon diversity was higher on SM than all other islands, higher on SR than SB or AN, and higher on SC than AN (Conover-Iman test, $p \leq 0.023$ for each comparison). Collectively, these diversity indices point toward a broader trend of decreasing ecosystem productivity and stability at drier more southeasterly islands. In particular, the consistently low species richness and Shannon diversity on SB and AN suggest that these most southeasterly and driest islands in the park may be the most resistant to passive recovery. High species richness is consistently associated with resistance to invasion by nonnative species in part because a range of species responses to environmental disturbance can stabilize ecosystem processes (Hooper et al. 2005). Indeed, both SB and AN exhibited low richness and Shannon diversity (Figure 8), with a relatively large proportional contribution from nonnative species (Figure 7).

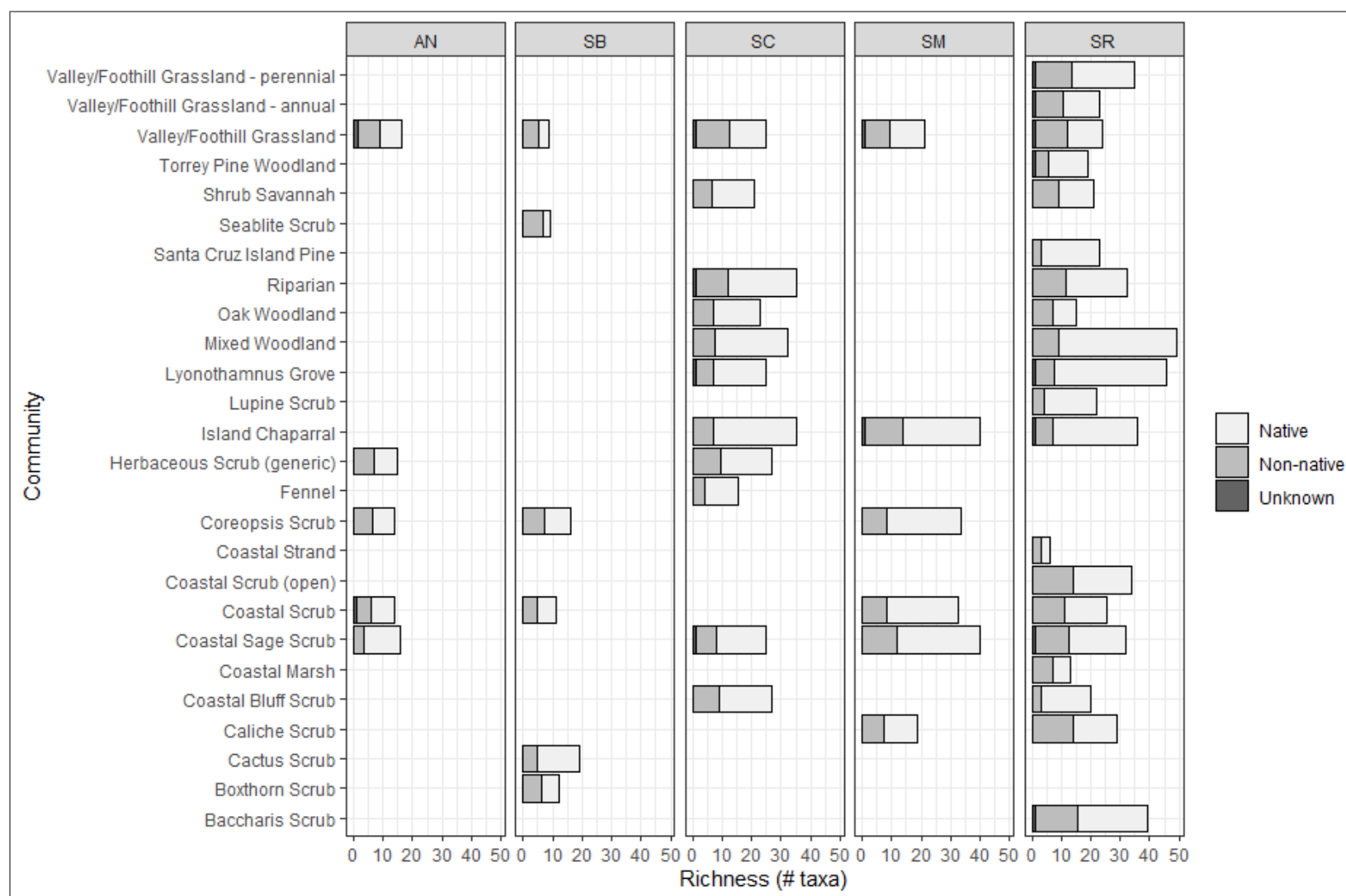


Figure 7. Richness of native and nonnative plants by community compared among islands for monitoring transects visited in 2023 at Channel Islands National Park. “Unknown” refers to species that could be native or nonnative because they were identified only to genus-level taxonomic resolution.

NPS

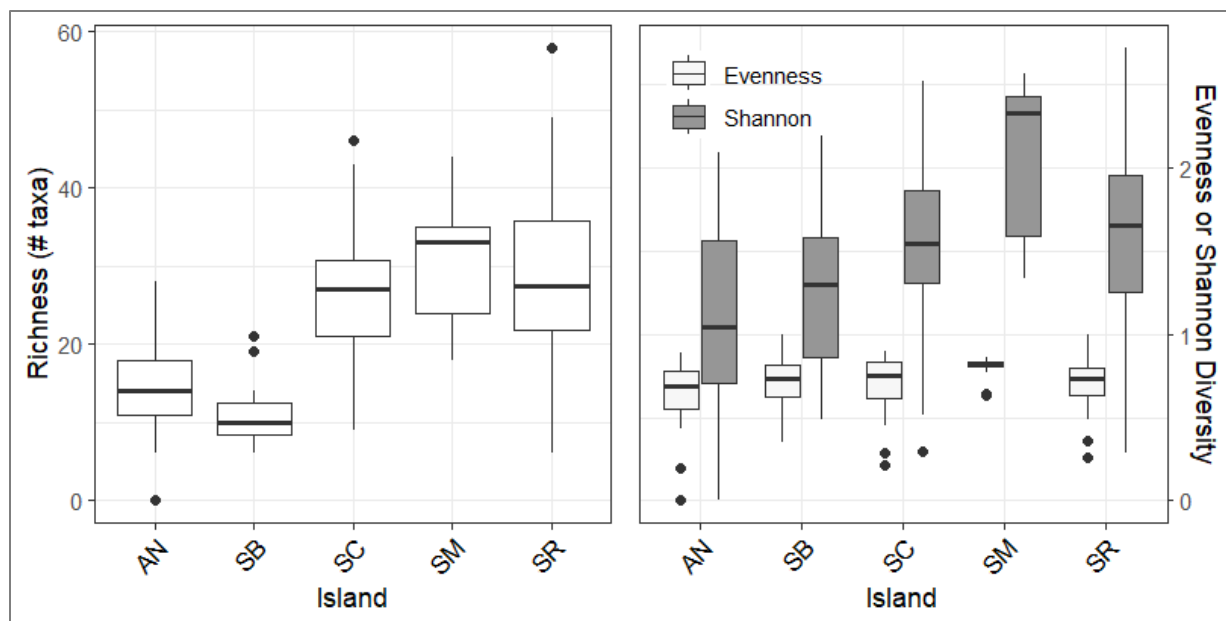


Figure 8. Boxplots illustrating indices of biodiversity compared among islands, for vegetation monitoring year 2023 at Channel Islands National Park.

NPS

Conclusions

Vegetation monitoring data collected from 143 transects in 2023 spanned all five of the Channel Islands National Park islands and included 27 different vegetation communities. A long-term decline in overall vegetation cover appeared starting in the mid-1990s, with a slight increase in 2023.

Absolute cover has been positively correlated with annual rainfall since vegetation monitoring began at the park in 1984, and the data from 2023 are consistent with this trend. Mean vegetation height was tallest on SC and SR owing to the presence of several tree-dominated communities there. The relatively high percent cover of native and perennial vegetation in more northwesterly parts of the park likely reflects a faster rate of woody vegetation recovery after browser and grazer removal on these wetter islands. Conversely, moisture limitation at more southeasterly islands may interact with a combination of seabirds and soils on SB, and seabird abundance on AN, to further slow vegetation recovery. The densities of seedling, juvenile, and adult shrubs were generally highest on more northwesterly islands, which may be attributable to favorable moisture conditions and indicative of a higher rate of vegetation recovery. Islands at more northwesterly positions tended to support higher species richness and Shannon diversity, consistent with a pattern of decreasing ecosystem productivity and stability at drier southeasterly islands. It is possible that patterns in cover, density, richness, and diversity along this moisture gradient may be artefactually inflated due to the late survey timing at Middle and West AN. Nonetheless, the results together suggest that moisture availability is a strong driver of the rate of vegetation recovery and indicate that SB and AN would benefit most from targeted restoration efforts.

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