Vegetation Monitoring Program Review for Channel Islands National Park

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Executive Summary

A scientific panel met December 5-6, 2000, for a technical review of the Channel Islands National Park long-term vegetation monitoring program. The program is one of four National Park Service prototype monitoring programs, and it serves as a model for others. The panel reviewed the program in detail, evaluated performance relative to original goals, and recommended revised program goals. Specific comments, discussion and suggestions for improving the program are presented in the review document.

Channel Islands National Park has one of the best long-term plant community monitoring programs in the National Park Service. The program provides managers and the scientific community with an invaluable tool for understanding vegetation change. It has national and international value, and every effort should be made to preserve and continue the monitoring. Some mid-course adjustment is needed in the underlying sample design to better capture critical information for monitoring the changes in the vegetation with release from grazing. Finally, the vegetation monitoring has been reduced in effectiveness by unpredictable and declining funding since its inception. The program could be greatly increased in value for management if funding was stable, predictable and modestly increased over current levels.

The original monitoring plan calls for a combination of transect monitoring for analysis of trends within plant communities, and periodic vegetation mapping to look at changes in plant distribution across island landscapes. The transect data collection protocol is well implemented, providing within–community trend information with a high degree of statistical accuracy. However the protocol for periodic vegetation mapping was not implemented, so the program does not provide important, complementary information about landscape-wide changes in community boundaries. This is a significant shortfall for vegetation recovery monitoring. Periodic vegetation mapping should be done using remote sensing imagery combined with extensive plot-based field sampling to look at vegetation change.

Invasive plant and rare plant monitoring protocols need to be added to the program to make it more sensitive to immediate management needs. Objectives should be to provide basic information on the distribution and abundance of invasive and rare plants, and on spots for weed introduction and corridors for weed invasion on each island. Demographic monitoring is necessary to determine population trend of listed rare plants. These protocols can build on a weed and rare plant spatial database already developed by U.S. Geological Survey-Biological Resources Division and National Park Service work on the islands.

It may be possible to streamline field data collection and reporting to provide time for additional invasive and rare plant monitoring. Vegetation mapping will probably require additional, cyclic funding. Streamlining is possible because the park now has a 15-year baseline for assessing vegetation change on three islands. During this sample period vegetation was tracked through wet years and an extended drought, allowing for analysis of trend and pattern across the wide range of climatic variability characteristic of Mediterranean systems. These data should be used to investigate what information is lost by sampling fewer transects each year.

Possible streamlining techniques include sampling certain slowly-changing communities less frequently; sampling fewer points per transect, or sampling only a core set of transects on each island annually, with the remainder sampled every 3-5 years.

A report summarizing monitoring results 1984-1996 was prepared in 1998. However, reporting from the vegetation monitoring program has been limited. As a consequence, the program has low visibility and has been of little direct value to managers. The review committee finds that it imperative that the monitoring botanist's work load be adjusted so that monitoring data are analyzed and a report on the results is issued annually. A major impediment to reporting has been the backlog of unedited data from the early years and the lack of consistent computer programming support for data handling. The backlog is nearly cleared, but the level of data management support has decreased. The program needs to improve data handling and reporting efficiency, and ensure that adequate support for data collection, management and analysis is available to take advantage of the many potential benefits of the program.

Introduction

Channel Islands National Park implemented a biological monitoring program in the late 1980's, with long-term funding through the National Park Service (NPS) Inventory and Monitoring program. Twelve different monitoring protocols were designed to describe communities and populations and track long-term trends in terrestrial and marine systems of the park. Protocols that have been implemented address vegetation, landbirds, small mammals, herpetofauna, seabirds, rocky intertidal systems, kelp forests, beaches and sandy lagoons, and weather. Between 5 and 15 years of data have been collected using these protocols, and some subject areas have sufficient information for trend analysis. An important component of the Channel Islands monitoring program is periodic review of the data, to determine whether adjustments in sampling techniques, study design or data handling could improve the program. A group of scientists reviewed the kelp forest program in 1996, and the landbird, vegetation, seabird, and rocky intertidal programs are being reviewed in 2000.

A technical review of the vegetation monitoring program was held by the USGS-BRD Channel Islands Field Station on December 5-6, 2000. The group used the Terrestrial Vegetation Monitoring Handbook for Anacapa, Santa Barbara and San Miguel Islands (Halvorson et al 1988), the Terrestrial Vegetation Monitoring 1984-1995 Report (Johnson 1998), and data summaries and trend analyses (McEachern, Geissler Appendices A through D) as background for discussion. Meeting participants were:

Dr. Steve Acker – National Park Service, Pacific West Region, Seattle, WA
Sarah Chaney – Channel Islands National Park, Ventura, CA
Katie Chess – USGS-Biological Resources Division, Channel Islands Field Station, Ventura, CA
Ronilee Clark – California Dept. of Parks and Recreation, San Diego, CA
Tim Coonan – Channel Islands National Park, Ventura, CA
Kate Faulkner – Channel Islands National Park, Ventura, CA
Dr. Paul Geissler - USGS-Biological Resources Division, Biology Science Staff, Laurel, MD
Dr. William Halvorson – USGS-Biological Resources Division, Univ. of Arizona, Tucson, AZ
Steve Junak – Santa Barbara Botanic Garden, Santa Barbara, CA
Dr. Todd Keeler - Wolf – California Dept. of Fish and Game, Sacramento, CA
Denise Knapp – Catalina Conservancy, Avalon, Catalina Island, CA
Dr. Lyndal Laughrin – UC Reserve, Santa Cruz Island, UCSB, Santa Barbara, CA
Jim Lenihan – U.S. Forest Service, Oregon State University, Corvallis, OR
Dr. Kathryn McEachern – USGS-Biological Resources Division, Channel Islands, Ventura, CA
Dr. Bob Peet – University of North Carolina, Chapel Hill, N.C.
Dirk Rodriguez – Channel Islands National Park, Ventura, CA
Peter Schuyler – Catalina Conservancy, Avalon, Catalina Island, CA

Review objectives were to:

1. Evaluate Channel Islands vegetation monitoring program performance relative to its original, design goals.
2. Recommend program modifications to address current management needs, increase scientific understanding of Channel Islands ecosystems, and take advantage of new technology.

Specific questions asked of the panel included:

1) Does the program fulfill its original, design goals? Should the goals (and program) be amended to reflect current knowledge?
2) Are the data adequate to show important patterns in the vegetation - temporally and spatially?
3) Should the field sample design and field methods be modified, and if so, how?
4) Do the data have adequate statistical power to show trends reliably?
5) Are the vegetation maps adequate for each island?
6) Is data management efficient, archival good?
7) Is annual reporting effective in communicating monitoring results to management and others?
8) Are there ways to better integrate the vegetation data with other long-term monitoring data collected on the islands (eg, small mammals, landbirds, etc)?

The team reviewed the program relative to its original goals, provided amended goals, recommended sample design and protocol adjustments to make the program more cohesive across all islands, and discussed changes specific to the sample design on each of the five park islands. Results will be used by the National Park Service to develop an updated vegetation monitoring program protocol for Channel Islands National Park.

Vegetation monitoring program overview

The first comprehensive natural resources study of the Channel Islands National Park was completed in 1979 (Powers et al 1979), when the park was Channel Islands National Monument and consisted of consisted of just Anacapa, Santa Barbara and San Miguel Islands. Vegetation maps showing dominant communities were made in the 1979 study using 1:24,000 scale color infrared aerial photographs, with some field checking for floristic accuracy. Plant community monitoring began in 1984, with the establishment of permanent point-line intercept transects on Anacapa, Santa Barbara and San Miguel Islands (Table 1). Semi-quantitative community relevé data were collected on Santa Barbara and San Miguel Islands as a check on the accuracy of the 1979 maps before transects were installed. With a few minor exceptions the 1979 maps were accepted as accurate, and they were used as the basis for transect establishment. Transects were placed subjectively across the three islands, with the objective of representing typical examples of the vegetation.

Santa Rosa Island was added to Channel Islands National Park in 1987, the easternmost 10% of Santa Cruz was added in 1990, and the isthmus portion of Santa Cruz in 2001. Long-range plans call for the Park to acquire other portions of Santa Cruz Island in the upcoming decades. Vegetation sampling began in 1990 on Santa Rosa Island and in 1998 on the eastern end of Santa Cruz. The Nature Conservancy (TNC) implemented a vegetation monitoring program on the western 90% of Santa Cruz Island from 1991 to 1995, but TNC funding for continued sampling has been cut. Vegetation mapping from aerial photographs and relevé sampling were done on both Santa Rosa and Santa Cruz Islands to describe plant community distribution and composition and adjust the maps before transects were installed (1988 images for Santa Rosa and 1996 for Santa Cruz). Santa Rosa Island transects were installed subjectively, stratified by island topography, to represent examples of the major plant communities in their best condition on the island, away from community boundaries (Halvorson personal communication). Santa Cruz Island east end transect locations were chosen by a stratified random method (McEachern 1998), with stratification based on topography.

Data have been collected annually since transect establishment on each island with the exception of 1991 and 1992, when funding was not available. The Channel Islands National Park Inventory and Monitoring Program was formally funded in 1992. The program is managed by a full-time botanist; with field assistance in some years by seasonally employed technicians, student conservation association interns, unpaid volunteers, or by cooperative agreement with the Santa Barbara Botanic Garden. Funding for the entire Channel Islands Inventory and Monitoring Program has remained flat since its inception. Also, funds have been diverted from the program at times to support short-term needs in other program areas. Such flat and fluctuating funding results in a real decrease in support over the years so that the amount of effort devoted to data collection, processing and reporting has declined since 1992. There has been fluctuation in financial allocation among the 12 field protocols across the years in an attempt to adjust for declining funds. Thus, the level of financial support for the vegetation program has been inconsistent and declining, and transect resampling has varied among years. Additionally, the resource base in need of monitoring has increased with the acquisition of new land on Santa Cruz Island, but there are no new funds for monitoring.

The vegetation transect data are managed in an MS-Access database environment along with data from the other monitoring programs at Channel Islands National Park. For this program review data were mainly aggregated by life form within exotic and native plant groups, and averaged by community or across whole islands to show general patterns and trends (Appendixes A through D). MS-Access and Excel (1997), Systat (2000) and PC-Ord (1999) software were all used in these analyses.

All of the California Channel Islands were used as open range for livestock, beginning in the late 1800's. The park islands were heavily grazed by sheep, cattle, deer, elk, rabbits, donkeys, horses and pigs in the past, and feral animals remain on Santa Rosa and Santa Cruz Islands. Each island has its own unique grazing history. The effects of this land use are apparent in the vegetation today. Channel Islands plant communities are dominated by exotic species: nearly 25% of the flora and 50% of the land cover is alien to southern California. Eurasian Mediterranean grasses are the largest plant group in nearly every sampled community. The native scrub cover that once dominated the islands has been generally replaced by alien annual grassland. Annual exotic species have invaded the understories of the remaining remnant native shrub and tree stands. Recovery is expected to proceed in two main ways: through increases in native plant canopy and understory cover within stands, and by expansion of natives from their patchy refugia into the grassland matrix.

The transect data show slight increases in average combined cover of all native plants and in several individual native shrub and grass species in some communities (Appendix A). There is a pronounced effect of weather on plant cover. Vegetation cover fluctuates with growing season precipitation (Figure 1), and natives tend to increase in relative dominance in drier years. Repeated measures analysis of variance tests for differences within and among early and late periods of the 1984-2000 monitoring program, and high and low precipitation years, indicate that some of these trends are significant at the 90% confidence level (Appendix B). Change is occurring most rapidly on San Miguel Island, where trends were significant for all plant groups tested. One program design goal was to show long-term trends with a 90% chance of detecting 40% change at the 10% significance level. Table 2 shows levels of power detection for several vegetation parameters, and detailed analysis results are included in Appendix B. The data are adequate to have a 90% chance of detecting a change of 40% or more in mean cover between early and late periods in several plant groups and in a few species across whole islands

(Appendix 1). Tests show similar power for average native plant cover within some communities on Anacapa, Santa Barbara, San Miguel and Santa Rosa Islands.

Classification and ordination analyses contrasting the first and last three complete years in the data sets from San Miguel and Santa Barbara Island (1984-1986 vs. 1997-1999) show that transects generally remain in the same community groups across years (Appendix C). However, some transects have diverged slightly from others in the same community in species composition and relative abundance over the years. This pattern is especially pronounced on Santa Barbara Island and among the *Coreopsis gigantea* and *Isocoma menziesii* dominated transects on San Miguel. These analysis of variance and classification/ordination results suggest that directional change is occurring in floristic composition and cover across the years as a background to weather-induced fluctuations. For the most part, the change seen on these two islands is toward increased native plant cover, a positive sign of system recovery.

Field botanists report observations of apparently young native shrubs in grasslands on nearly every island (Junak, Chaney, McEachern, Chess, Wilken, Rodriguez, personal communication), both at shrubland-grassland ecotones and in scattered locations away from ecotones. Grassland transect data do not show such rapid native invasion, as most grassland transects were purposefully located away from community boundaries. Repeated landscape-scale mapping coupled with relevé -type sampling is needed to capture change in dominant species across boundaries. Periodic mapping (every five years) using low-altitude aerial photography and field sampling is part of the vegetation monitoring protocol. Repeated mapping has not been done, so there is no systematic or quantitative way to place a pattern or rate on these field observations with monitoring program data.

Review team comments on the existing program

<u>Original program goals</u>

The original goals of the Channel Islands vegetation monitoring program (Halvorson et al 1988) were to:

1. Describe important plant communities of the islands,
2. Document levels of natural variability,
3. Show long-term trends with a 90% chance of detecting 40% change at the 10% significance level, and
4. Identify patterns and rates of change among plant communities.

These goals were very broadly stated. A main hypothesis driving program design was that communities would change as they recover from nearly a century of grazing; but that natural variability in plant cover driven by weather fluctuations might mask that change. A major objective was to provide a design that facilitated separation of weather-induced “natural” fluctuation from more “directional” recovery in response to grazing release (Halvorson personal communication).

The vegetation monitoring program was not designed to provide information on distribution, abundance or trends in rare taxa or invasive species. Hindsight shows that such information is needed by management to better direct restoration and recovery efforts. The new goals and program design should include a rare plant and invasive plant monitoring component. Similarly, recent advances in relational database design and spatial data analysis make it possible to interface the various terrestrial monitoring programs of the park. A critical component of any new sample design should be co-location or co-referencing of vegetation sample sites with those from other protocols for an integrated approach to ecosystem analysis on the islands.

Evaluation of the current program against original goals

Goal 1: Describe important plant communities of the islands.

The transect data describe the major plant communities, and some of the important minor ones, of the islands. The transect data excel in allowing repeatable measurement over many years of the dominant species in the major communities. The relevé data provide a more extensive baseline survey of the islands, and they may capture some of the more infrequent plants not sampled in the transect method. However, the relevé s are not permanently marked and exrtensive, island-wide relevé sampling has not been repeated. The original vegetation maps and relevé s made for each island (1979 for Anacapa, Santa Barbara and San Miguel Islands), 1990 for Santa Rosa Island and 1998 for Santa Cruz Island) capture most of the major communities, and can serve as a baseline for judging subsequent change in species composition and distribution of those communities. The following caveats need to be kept in mind when using the transect data:

1. The semi-subjective location of transects on all but the east end of Santa Cruz Island casts doubt on the strict statistical validity of island-wide inferences made from the data. However, most transects were established with at least a random component, using topography as the basis for stratification. If the constraint of subjectivity is always recognized when using the data, ecological inference can be made. For example, the transect data may not detect the expansion of shrubs into grassland because the transects were purposefully placed away from community boundaries.

2. The transects were established to complement repeated community mapping accompanied by relevé plot sampling for a holistic view of vegetation change. The dual transect sample-plus-mapping protocol was designed to test the hypothesis that directional change would occur in rebound from grazing, both within and among plant communities. Since only part of the protocol has been implemented, only part of the picture of grazing recovery is available. This causes a heavy reliance on the transect data that were not envisioned as stand alone samples when the program was designed.

3. The point-line intercept method typically under-samples the infrequent plants in the community. As a result, the data emphasize trends in dominant species. However, in some cases the rarer species may show a more immediate response to weather, threats or perturbations. If the sample method consistently misses those species, important information may also be missing that could be used to judge trends or patterns. This drawback was recognized during the design phase. Nevertheless, the point-line intercept method was chosen because it is quick to implement in the field, and robust to inter-observer biases.

4. There is a wide variety of community names used among the five park islands (and, among all California Channel Islands). Some communities may in fact be sufficiently similar to one another across islands that they can be named the same.

5. There is inconsistency between the vegetation mapping and the communities that are sampled with transects on Anacapa, Santa Barbara and San Miguel Islands (Appendix D). The field sample design on these islands was implemented in several stages between 1979 and 1984, and there is poor documentation of the methodology used in each stage. Particularly, the lack of information on how maps were made and how communities were defined on Anacapa, Santa Barbara and San Miguel Islands limits the inferences that can be made. Following is a review of how the samples were designed, to the best recollection of several panel members who worked with Channel Islands National Park to set up the monitoring program on various islands.

   Anacapa, Santa Barbara and San Miguel Islands (William Halvorson, Steve Junak, Jim Lenihan; personal communication):
   Vegetation maps were made in 1978-1979 for Anacapa, Santa Barbara and San Miguel Islands as part of a general natural resources inventory (Powers et al 1979) using 1978 1:24,000 color infrared photography. Map units were spot-checked in the field, and they were described by listing the major species. Line intercept cover data were recorded in 1979 in a few locations on the three islands, but they were not used as the basis for an extensive, quantitative description of the communities. Relevés were read and classified on San Miguel (Lenihan 1983) and Santa Barbara Islands in 1983 and 1984 respectively, to better describe the vegetation mapped in 1979. The relevé data were used to locate transects on Santa Barbara in areas typical of the map unit. The relevé data were used to adjust community boundaries on San Miguel prior to sample location. The adjustments largely involved merging smaller map units, and renaming some map units to reflect a different understanding of the vegetation. Probably the newer understanding represented simply a different ecological view of the vegetation, rather than a real difference driven by succession on the ground. Subsequent San Miguel mapping (Halvorson et al 1991) refined the original 1979 map using digital scanning methods, but without additional field work beyond the transect monitoring. It is still unclear exactly how transects were established on Anacapa, but some of them probably were done with reference to the 1979 map unit descriptions, and others were not (e.g. island iceplant). Relevé data were not collected in association with sample design on any of the Anacapa Island islets.

   Santa Rosa Island (Ronnie Clark, William Halvorson; personal com.) and Santa Cruz Island (Kathryn McEachern, personal com.)
   The Santa Rosa Island and Santa Cruz Island vegetation maps were made by drafting plant community boundaries on aerial photos, and adjusting them on the basis of aerial and ground reconnaissance surveys. Relevés were located by stratified random means, and the number sampled was roughly proportional to the area occupied by each map unit on the draft map. The relevé data were classified, and map units were adjusted to reflect the classification. On both islands, the adjustments involved mapping new units that appeared as significant variations of a larger community. These new maps were spot-checked on the ground for accuracy with no further data collection. On Santa Rosa Island, transects were chosen that represented typical examples of the mapped plant community in the least trampled and fragmented condition. Locations were stratified by topography so that samples were scattered across the island, and areas difficult to access

(more than one to two hours of walking time from a road or dangerous to access) were screened out. On the east end of Santa Cruz Island, inaccessible and dangerous locations were screened out, the island was stratified by watershed, and sample locations were chosen at random.

Goal 2: *Document levels of natural variability*

The 15 years of data from Anacapa, Santa Barbara and San Miguel Islands sample through years of high and low rainfall, including a season of nearly double the average annual precipitation, (1985-1986), a protracted drought (1987-1992) and an el Nino event (1995-1996) (Figure 1). The Santa Rosa sampling began during the drought and continued through the high rainfall of the mid- and late-1990's. Vegetation cover (Appendix A) fluctuates directly with precipitation, and some of these fluctuations are statistically significant at the 90% confidence level when comparing high and low rainfall years (Table 2, Appendix B). The data capture natural fluctuations related to weather with a high degree of precision because the monitoring was done nearly annually through those years. It might be possible to sample at a less frequent interval on the three original park islands, now that this long run of baseline data is available to inform any interpretations of successional change as a background to natural fluctuation.

Goal 3: Show long-term trends with a 90% chance of detecting 40% change at the 10% significance level.

This goal is vague about what trends are of interest to the program, and over what time-frames. As a result, the data were explored to test levels of power actually achieved for the entire period sampled on each island, for single species, species life-form guilds, and native and exotic vegetation by life-form guild and combined across life forms (Table 2, Appendix B). Power was also tested for indices of species richness and diversity, total vegetation cover, bare ground and vegetation height. Trends shown in Table 2 were tested by combining transects across all community types within each island. Monthly average precipitation was used as a covariate in the analyses, and significance levels are reported for data adjusted to remove the effect of variation in rainfall.

The data are adequate to show long-term trends with a 90% chance of detecting at least a 40% change in sample means at the 10% significance level for several vegetation parameters. The differences between mean values that can be detected with this power range from 8 to 32% for plant cover data grouped by all natives, all exotics, native grasses, exotic grasses, native shrubs, native herbs, and exotic herbs. For this test the data were summarized across 15 years on Anacapa, Santa Barbara, and San Miguel Islands, and across 8 years for Santa Rosa Island.

Additionally, the data are adequate to detect mean differences ranging from 7 to 33% with the same power for species richness and diversity, total vegetation hits, bare ground and average tallest plant height. The same level of confidence is reached for cover of several dominant plant species on several islands, including *Coreopsis gigantea, Baccharis pilularis, Isocoma menziesii, Nasella pulchra, Artemisia californica, and Lycium californicum*. Exceptions where the 40% minimum change detection goal was not met are bare ground on Anacapa (99% change detectable), native grass and exotic herbs on Santa Barbara (50% and 41% difference, respectively), and average height on Santa Rosa (44% difference).

Preliminary power analyses indicate that power is similarly good for native plant cover within plant communities on the islands. The major constraint on statistical confidence occurs at the within-community level when few transects represent the community (Table 1), or when data are missing for some years because of logistical problems. If the number of transects or the frequency of sampling is reduced, by design or by further reductions in financial support for the program, power may be reduced also. It is important to reduce effort in a balanced way so that loss of statistical power is minimized.

Goal 4: Identify patterns and rates of change among plant communities.

Classification and ordination analyses were done for Santa Barbara and San Miguel Islands. The first three years of transect data (1984-1986) were contrasted with the last three (1997-1999) to investigate relationships among the transects and to investigate whether directional community change associated with post-grazing recovery may be apparent in the data (Appendix C). The classification and ordination results, along with the trend and power analyses, indicate that the data can show rates and patterns of change in generalized vegetation parameters, both among communities and across whole islands. There are several limitations to the data, however, resulting from the sample design and the failure to implement the mapping protocol.

1. Some communities are represented by only one or two transects, and change is most difficult to assess in them because of small sample size. Transects in these communities have not been sampled in some years because of logistical constraints. In such cases, trends are nearly impossible to detect because patterns are obscured by the effect of missing information (e.g. coastal sage scrub on Anacapa Island).

2. Because the vegetation mapping protocol was not implemented, it is impossible to document or assess rates of change in community spatial pattern or species movement among communities. This is a real problem, since field observations indicate that change is occurring across the landscape that is not captured in the monitoring program. Additionally, plant communities occupying relatively little acreage on the islands are not sampled by the transects. Change in these communities remains unknown without periodic mapping along with extensive relevé sampling to describe the mapped communities.

3. Methods for the initial community mapping on Anacapa, Santa Barbara and San Miguel Islands are poorly documented, so repeat mapping cannot be made using the same methods and assumptions as the original effort. Inferences about change are limited by a lack of methodological information.

Recommendations for future monitoring

<u>Amended program goals</u>

The panel recommends the following amended Channel Islands National Park vegetation monitoring program goals, stated as general overarching reasons for having a monitoring program, and specific objectives for achieving those goals.

Overarching goals for the Channel Islands vegetation monitoring program

1. Identify long-term trends in biodiversity, both within communities and across the landscape.
2. Detect threats to the vegetation (e.g., weed invasions, loss of important native species).
3. Inform management staff of progress in recovery of degraded systems and developing threats to biodiversity.

Specific, operational Channel Islands vegetation monitoring program goals
Restated 1988 goals (italics indicate more specific wording than the original goals included):

1. Describe *and document the composition and distribution of* important plant communities of the islands.
2. Document levels of variability *in community composition, species frequency and cover as related to climatic variation*.
3. Document long-term trends (*decadal) in plant community composition. Document change over time in native and exotic plant cover and abundance, total vegetation cover and bare ground, and dominant species across the islands and within major plant communities.* The data should have a 90% probability of detecting a 40% change *in cover* at the 10% significance level over a decade.
4. Identify patterns and rates of change in community boundaries over time: map community boundaries and conduct relevé sampling to document community composition every five years to show change.

Proposed additions:

5. Identify patterns in the distribution and abundance of invasive species over time: map and estimate density or cover every three to five years to show change.
6. Identify trends both in sparse and rare (Federally and California listed taxa, Federal and California "watch" taxa, and plants deemed sensitive by NPS) plants of the islands. Map and count or estimate abundance in populations for several successive years to establish levels of normal annual variation. Thereafter, the sample interval might be increased to reduce effort while following trends. The best sample interval should be chosen on a species-by species basis, based on levels of variation seen in the baseline data.
7. Link change in vegetation to change in other components of the Channel Islands Inventory and monitoring program, particularly landbirds, small mammals, invertebrates and weather.
8. Report results annually for managers and scientists in a detailed technical report and executive summary, and in shorter stand-alone descriptions of significant or interesting findings for managers, interpreters and the public.

<u>New program design</u>

The panel recommends that Channel Islands National Park revise the vegetation monitoring program to correct problems with the current transect sample design. The mapping protocol already designed as part of the program should be implemented, using new technology. A new invasive exotic plant and rare native plant monitoring component should be included in the program. Ideally, such modifications would be made with increased funding for additional staff and logistical support. The Park should seek funding to fully implement the mapping component of the program, and add invasive and rare plant monitoring.

Realistically, funding is unlikely to appear in the short-term, so the challenge is to design an interim program addressing current program shortfalls with the same amount of effort as in the past. It may be possible to reduce the number of transects sampled in the field each year, freeing time for invasive and rare plant work. However, time cannot realistically opened up for vegetation mapping, nor is the expertise available in-house to do the work. Therefore, vegetation mapping will most likely require additional, cyclic funding. Recommendations for program design are presented below - first as generalized protocol adjustments that should be applied over all islands, and then as specific, additional, suggestions for each island.

Several principles guided the development of the following recommendations for a new vegetation monitoring protocol at Channel Islands National Park:

1. The integrity of the existing data should be preserved for the long term: any changes must allow for continued use of the existing data set in long-term analyses.
2. Existing data should be further analyzed to determine the best methods for streamlining the field data collection effort.
3. The hypotheses and principals guiding the original protocol design should be honored and incorporated into any redesign.

Implement the vegetation mapping and relevé sampling protocol.

- Map plant communities along with extensive relevé sampling of all islands to verify the map. Any new or re-sampled relevés should be sampled in a way that meets the proposed national standards for vegetation plots.
- Re-survey and monument the previously sampled relevé s.
- For the new mapping program, investigate sources of remote imaging data, data processing systems, and field sampling techniques that capture the changes observed on the landscape by field botanists over the past two decades. Establish test areas in the field where observations show that change has occurred to determine which imaging has the level of resolution required. Investigate cost-sharing for image acquisition and processing with other agencies.
- Use a time-series of images from the past decade to test whether the recommended five-year interval is adequate to show change. A more frequent mapping interval might be appropriate for some islands.
- There are a few cases where a community is sampled by the transects, but not mapped (e.g., boxthorn scrub on Santa Barbara Island). In these cases, the community should be added to the 1979 map using the 1978 color infrared photos that were the basis for the 1979 maps. This new map should be used as a revision of the 1979 map, recognizing that there can be no ground-truthing for that community as it was in 1979.

Reduce the number of transects sampled each year on Anacapa, Santa Barbara and San Miguel Islands, and use the time gained to implement weed and rare plant monitoring.

- A decreased all-island sample interval might be appropriate for some transects on the three original park islands, since the 1984-2000 data can be used as a baseline for evaluating change across wet and dry years. The existing data set should be analyzed to see what information would be lost by sampling a core set of transects annually, supplemented by an all-island transect sample at three to five year intervals on the three islands. Specifically, the data should be used to explore how much variance there is from year to year, and whether trends at a core set of reference points could be used to predict climate effects on vegetation along less frequently studied transects.
- Successively delete transects from the existing data set to determine where the power for pattern detection falls to an unacceptable level when leaving transects out of the entire data set, and across intervals of 2,3, and 5 years when using the entire data set.
- Use the core group analytically to infer or predict change occurring in the time gaps on the periodically sampled transects. Use the periodic whole data set sample as a check on the accuracy of the predictions.

- The core should include transects sampled consistently in past years, represent the range of plant communities with high land cover on the islands, and include transects in areas of high special interest for management or science.
- Critically analyze this core-and-rotating-group scheme after one complete cycle of the sampling to verify that predictions can still be made with the data.

Wait at least five years after feral animal removal to reduce to a core group sample scheme on Santa Rosa and Santa Cruz Islands.

- Santa Rosa and the eastern end of Santa Cruz Island have just been released from cattle and sheep grazing, respectively. Deer and elk will be removed from Santa Rosa in the year 2011. The Isthmus portion of Santa Cruz has recently been acquired by the National Park Service, and plans are being developed for the eradication of feral pigs from the entire island. Vegetation change is expected to be fast for several years as these systems adjust to new post-grazing equilibria. Therefore, it is not advisable to drop to a core group plus periodic complete transect sample scheme on those islands for at least five years past feral animal removal.
- Use existing data to determine when it is appropriate to change to a more streamlined sample scheme.

Reduce the sample time per transect on all islands

- Investigate whether transect field effort can be reduced by sampling 50 points per transect rather than 100. Use the existing data to test whether sampling every 60 centimeters rather than every 30 centimeters results in a significant loss of information. Calculate species area curves to see how many species drop out of the data, estimate the power of the sample, and classify the data to see whether different community patterns result from any changes in species composition and cover.

Test whether sparse, infrequent species are under-sampled with the point-intercept method

- At the outset it was considered best to get more information on the most common species over larger areas than to use a more time-consuming and less robust method in order to pick up information shown by a few species on fewer transects. A test could be done now to assess whether the samples do in fact under-represent infrequent species, using the existing data as a baseline. This could be done by adding a 1-meter wide belt transect alongside the point-intercept line, and listing the species present in that belt that are not sampled along the line. If many additional species are recorded (eg, greater than 10% of the species known from that transect over the years), then an adjustment in methodology might be needed. Such an addition to the sample scheme will require more field and data processing time, so fewer transects can be sampled per year. The trade-off again needs to be evaluated: is it still important to sample more transects every year than it is to get more sensitive data on species along fewer transects?

Record shrub density and cover

- Get better information on woody plants by adding the woody plant monitoring protocol designed by McEachern (2000) every 3 to 5 years.

- The woody plant protocol was followed in 2000 on Santa Rosa and Santa Cruz. It should be implemented on the other islands in 2001. The 2000-2001 data can serve as a baseline for judging change.

Adjust community names for consistency with California and national standard descriptions

- Classify data across islands to determine which communities are sufficiently similar to one another to be named as the same plant association or series, using procedures and standards such as those described in Sawyer and Keeler-Wolf (1995).
- Classify island data with the nearest mainland allegories to see whether they are similar to any mainland communities at the association or series level. Key the island plant community nomenclature to a more widely used, uniform classification system, like the California Native Plant Society statewide system, or The Nature Conservancy – ABI system.
- Cross-walk current island community nomenclature with new names, and change plant community labels to the new system.

Archive original program materials

- Compile methodological descriptions, original relevé data and original transect data into an organized, retrievable system, and archive in a safe place.
- Compile a description of past vegetation mapping methods and materials for use in future mapping and analysis.

Implement invasive plant monitoring

- The objective of exotic plant monitoring is to provide information on distribution and abundance of weedy invasive species so that they can be controlled or eradicated before they become a threat to island resources.
- USGS-BRD and NPS have nearly completed a baseline inventory of weed distribution and abundance on all the park islands except the east end and isthmus of Santa Cruz (Chaney and McEachern 1999). This database should be used to guide development of a semi-quantitative relevé-type method for mapping and estimating abundance.
- Use the list of nearly 100 weedy species developed in the USGS/NPS study as the basis for weed monitoring.
- Map and estimate weed abundance by watershed on each island, so that the entirety of each island is surveyed over a minimum of a three-year period. Spatially distribute the mapping evenly across the island so that a watershed representing each ecological setting is surveyed in any one year. (It might be possible to survey all of Anacapa and Santa Barbara every three years instead of rotating through the island. The drawback is that such infrequent monitoring might miss a sudden weed explosion.)
- Identify areas where weeds are introduced, and corridors for spread, on each island, and visit them at least annually in the season when weeds are most likely to be identifiable.

Implement rare plant monitoring

- The objective of rare plant monitoring is to provide information on the distribution, abundance and condition of rare plant populations so that any threats can be identified for management.

- USGS-BRD has developed a rare plants spatial database that can be used to guide the further development of a rare plant monitoring program for Channel Islands National Park, including a list of plants considered rare or sensitive on the islands.
- Map and estimate rare plant abundance by watershed on each island by similar methods as for weedy species. Field surveys might be combined for the weeds and rare plants.
- Use the GIS to make spatial models from the base data that identify existing populations and potential habitats by watershed; direct searches primarily to those areas within watersheds, and secondarily to other areas.

Produce annual reports

- Produce an annual technical report that presents the annual data and describes the monitoring work. The report should contain updates to the monitoring manual, a log of activities, and a brief summary of the data with an evaluation of its implications. The report should be formatted so that it can be used independently as a "user's guide" update to the vegetation monitoring handbook. It should give details necessary for maintaining continuity among years and staff, including staff names and positions, time devoted to the various monitoring tasks, deviations from or changes to the protocols, problems (taxonomic and logistical), notes for future reference. The report should have a stand-alone non-technical executive summary that can be excerpted and distributed independently, describing findings and their significance for management.
- Produce 2-4 short notes annually for non-scientists describing program activities, observations, accomplishments, significant findings. The objective here is to increase park staff, management and public awareness of the program, and make it useful for education, interpretation, and management. The notes could be published in a variety of places, such as the Channel Islands newspaper or web site, Park Science, or interpretive bulletins.
- A major impediment to timely annual reporting has been the lack of dedicated technician and computer programmer time to assist with data entry, editing, quality checking, voucher processing, and computer programming. With the addition of weed and rare plant protocols, more support will be needed for data handling. Program managers should work to ensure that information management needs of the program are adequately supported, and the workload should be adjusted to ensure that annual reports are produced.

<u>Specific recommendations for individual islands</u>

Anacapa Island

- The sample design for Anacapa Island "lumps" the three islets. In fact, past land use, current management and vegetation succession are very different on the three islets. A new sample layout is needed that allows interpretation of vegetation condition on each islet separately for better feedback to management.
- Add transects to the total collection for the Anacapa islets, with the objective of selecting a minimum of three sample sites per community per islet. Transect locations should be chosen by a stratified random method, using the same strata as the original 1984 sample scheme if possible. These transects should all be sampled as a baseline before beginning a core sample with periodic whole island coverage scheme.
- Pelican nesting has prevented vegetation sampling on West Anacapa often during the 1984-2000 interval. The missing data from 1984-2000 make it impossible to get good trend information from the coastal sage scrub community.

- Additional, alternative transects should be chosen in the coastal sage scrub community on West Anacapa. When pelican nesting precludes sampling on transects representing that community, the alternative transects should be sampled for a complete design. Sample at least once in the fall when pelicans are not nesting, to get full coverage of the islet. Analyze the data to show similarities and contrasts among the full set of transects.
- Methods and assumptions for original vegetation mapping are particularly vague for Anacapa Island. People doing the original design work on Anacapa need to be contacted for information.
- Several communities are mapped that are not sampled, and several communities are sampled that are not mapped. When the samples do not reflect the mapping, it is impossible to make island-wide or even community-wide inferences from the data. A new sample and mapping scheme are urgently needed to make Anacapa Island monitoring more useful. New sampling is likely to require new imagery and fieldwork.

Santa Barbara Island

- The Santa Barbara sample design seems adequate to represent the full range of ecological conditions on the island, with two exceptions: a newly developing coastal sage scrub community on Signal Peak, and the seablite scrub on the west side of the island. Transects should be added for better coverage of these areas.
- Many field botanists have observed native shrub expansion from small patches into grassland. The transect monitoring scheme is not picking up this change. High resolution vegetation mapping is needed particularly urgently on Santa Barbara Island.
- Revise the 1979 map to add the boxthorn community that is being monitored.

San Miguel Island

- There are 1979, 1984 and 1991 vegetation maps for San Miguel, each representing slightly different views of the vegetation. Original materials need to be consulted to determine the basis for the different community descriptions, the reasoning needs to be documented, and the map units need to be relabeled for consistency if the review shows this is warranted.
- Vegetation change is apparently occurring at a faster rate on San Miguel than on the other islands. Vegetation mapping needs to be done soon to capture expansion of shrub communities.
- There is a unique scrub community along the south side of the island that is not sampled. Transects should be added to document this community.

Santa Rosa Island

- Cattle were removed from Santa Rosa in 1998, so island ecosystems should be adjusting fairly rapidly to a new post-cattle equilibrium. The data do show significant increases in native grass (particularly *Nasella pulchra*) and native herbs 1998-2000. All of the transects on the island should be sampled through this period of rebound before reducing to a core sample subset. Annual sampling should continue for at least five years, and the data should be reviewed at that time to see whether the rate of change has slowed.
- An area on the central south side of Santa Rosa Island appears under represented in samples. Samples should be added there.

Santa Cruz Island

- Sheep were removed from the east end of Santa Cruz in 1999, and island vegetation appears to be undergoing a rapid rebound. Like Santa Rosa, sampling should continue annually for at least five more years. Any reduction in sample effort after five years should be based on an inspection of the data.
- The Nature Conservancy implemented a vegetation monitoring program on the western 90% of Santa Cruz Island. Those transects were sampled 1991 - 1995, but sampling is no longer supported by TNC. NPS should integrate these data into the vegetation monitoring program, and encourage and support continued monitoring efforts on this portion of the island.

Conclusions

Overall, the Channel Islands long-term vegetation monitoring program can serve as a good model for others in public and private agencies. Program design included transect data collection and periodic vegetation mapping to provide intensive and extensive views of vegetation change in relation to climate and succession following release from grazing. Long-term and consistent transect data collection is the strong point of the program. The transect data provide information on changes in dominant species in the most extensive and important plant communities of the islands. However, the protocol for vegetation mapping to provide information on change across island landscapes in community composition and plant distributions, has not been done. Thus, the Channel Islands vegetation monitoring program is only partially implemented. As a result, some changes apparent from field observations by island botanists are not captured or quantified by the monitoring program. Plant community mapping and relevé sampling to verify community composition should be done immediately and repeated periodically as a regular, recurring part of the vegetation monitoring program.

The transect data collection portion of the program performs well relative to its original goals, with a few exceptions. Specific adjustments to sample design are recommended for each island. Patterns and trends are evident in the data. Levels of power envisioned for the samples are achieved for some vegetation parameters averaged over whole islands, analyzed for trends over periods of 8 to 15 years. There may be ways to streamline field methods, sample design, data management for the original three park islands with the longest sample period (Anacapa, San Miguel and Santa Barbara Islands) so that time is available to implement new monitoring that fills gaps in the program. The transect data should be used to determine the best ways to reduce effort. Techniques could include collection of fewer data points per transect, and reducing annual sampling to a core set of transects, with sampling of the entire set occurring only periodically.

Semi-random sample design and the lack of clear information on how communities were defined for sample allocation limits island-wide inferences that can be made from the transect data. Original program design methods and materials should be clarified and archived. The original relevé data and the transect data should be classified to look for relationships among communities across islands, and community names should be assigned that are consistent across islands.

Annual reporting and communication of monitoring program results to managers was not explicitly stated as a program goal, although the major reason for monitoring is generally understood to be to provide information for use in land management planning. Eroding and inadequate financial support for the program has resulted in a data handling backlog, poor annual reporting, and a lack of good communication of monitoring results. A stronger focus on adequate program support and better reporting is essential to the program.

Finally, rare plant and exotic species monitoring is not part of the current vegetation monitoring program. However, information on the distribution and abundance of rare plants and invasive exotic species has emerged as an important ecological issue for Channel Islands National Park managers. Consistent monitoring data are needed to guide management for conservation of rare and sensitive native species and control of exotic invasives on the islands. Consequently, the monitoring program should incorporate a new rare and exotic plant component to address emerging management needs.

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Table 1. Communities and numbers of transects sampled on five islands, Channel Islands National Park

Community	AI	SBI	SMI	SRI	ESCI
Grassland	8	4	3	23	6
Coastal sage scrub	3	1	3	11	
Coreopsis scrub	3	7	3		
Sea cliff/coastal bluff scrub		3	1	3	2
Chaparral			4	6	5
Coastal dune scrub/coastal strand			1	2	
Caliche scrub			2	2	
Riparian				7	2
Perennial iceplant	2				
Boxthorn scrub		2			
Cactus scrub		3			
Seablite scrub		4			
Baccharis scrub				9	
Lupine scrub				3	
Coastal marsh				2	
Mixed woodland				7	
Oak (Q. tomentella) woodland				4	
Santa Cruz Island pine				2	
Torrey pine				5	
Oak (Q. agrifolia) woodland					1
Lyonothamnus groves					3
Disturbed scrub savanna					2

Appendix A

Figures A1-AJ: Trends in plant cover, 1984-2000

Appendix B

Trend analysis of Channel Islands National Park Vegetation data
(Paul Geissler, USGS-BRD, Laurel, MD)

Appendix C

Classification and ordination analyses contrasting the first and last three complete years in the data sets from San Miguel and Santa Barbara Island (1984-1986 vs. 1997-1999)

Appendix D

Communities mapped vs. communities that are sampled with transects on Anacapa, Santa Cruz, Santa Rosa, San Miguel and Santa Barbara Islands