A Shared Vision for the Survey of California Vegetation

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California State University Northridge

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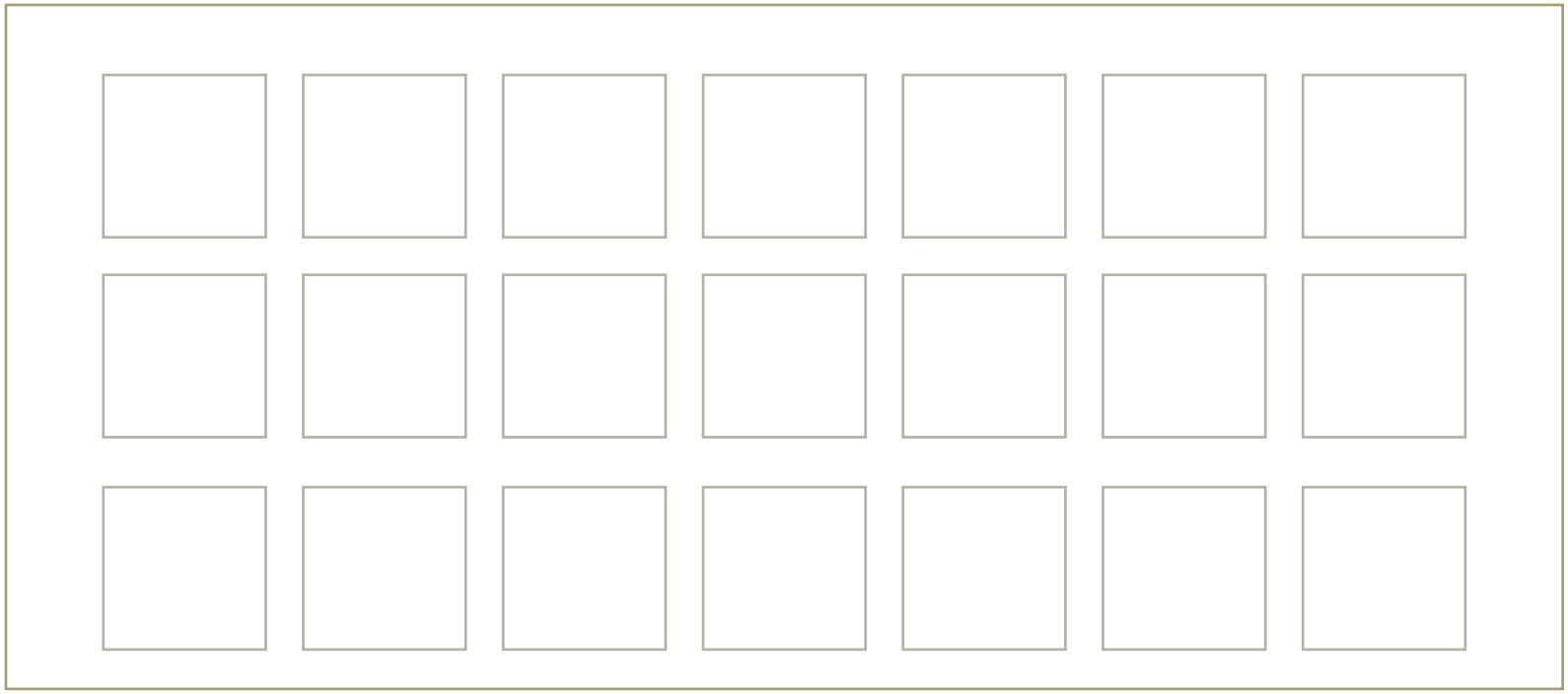
Endorsements



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EXECUTIVE SUMMARY

Survey of California Vegetation — A primary tool for natural resource management

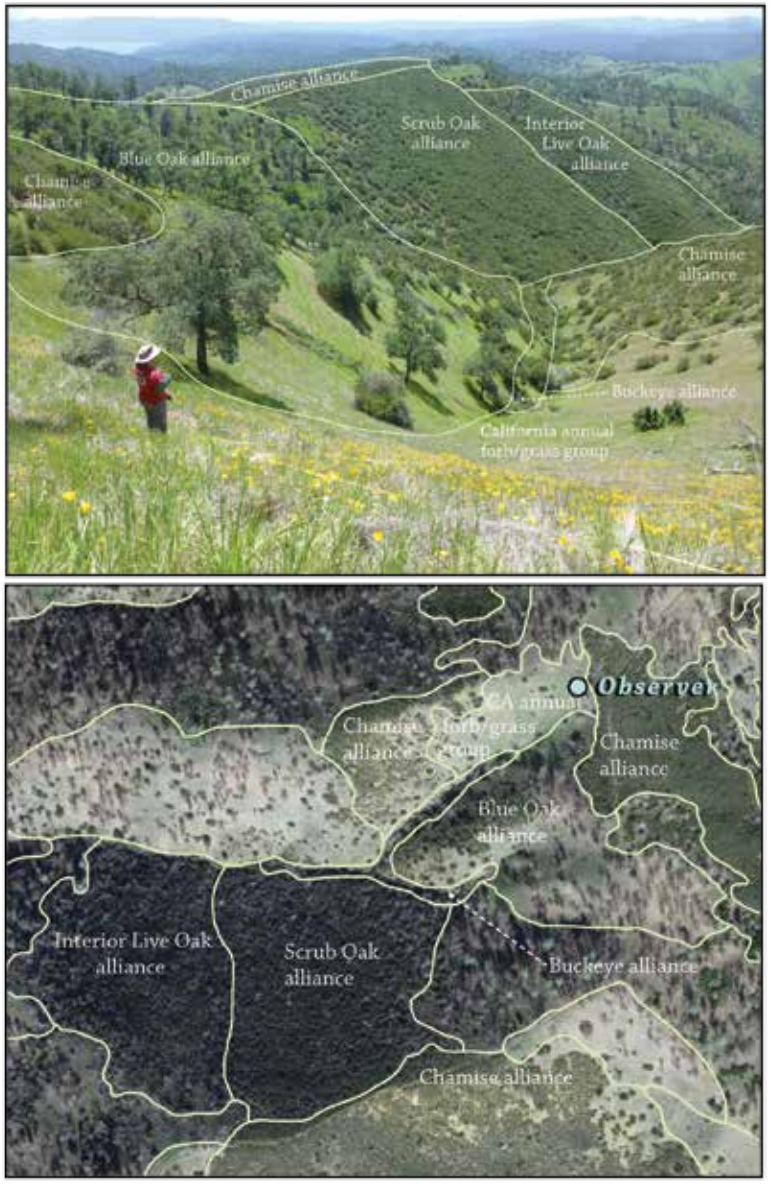
California needs a comprehensive, high-resolution, statewide vegetation map, created in compliance with the Survey of California Vegetation (SCV) standards. Natural resource data users have confirmed that a high-resolution digital map of California's vegetation is one of the top data requirements for the state. This study was initiated to document the wide variety of applications that already benefit from SCV-compliant maps and to show the advantages that can be obtained if the entire state were to be mapped to that level.

This report describes the Survey of California Vegetation and then presents results from two studies: (1) a vegetation map user study and (2) a benefit–cost analysis. Together they offer strong evidence of the demand for, and benefits of, a statewide SCV dataset. The findings are based on the results of an online survey targeting the vegetation Geographic Information System (GIS) user community, as well as personal interviews with individuals from state and federal agencies, nonprofit organizations, and private firms.

The Survey of California Vegetation

The Survey of California Vegetation (SCV) is a framework that sets the standards for vegetation surveying, classification, and mapping in California.

- The SCV surveying standards define the protocols for field collection of detailed vegetation data and environmental information.
- The SCV classification standards conform to the National Vegetation Classification System and international standards, and categorize California vegetation types into a hierarchy.
- The SCV mapping standards specify the size of the vegetation polygons, the map scale, vegetation cover classes, and other mapping conventions.
- Each SCV mapped polygon is labeled with the vegetation type, and also includes multiple attributes such as the cover of trees, shrubs and herbs; the diameter of conifer and hardwood trees; the degree of human disturbance and invasion by non-native species; and other regionally specific attributes.
- Each SCV map is verified by a quantified Accuracy Assessment process to assure consistent quality and avoid uncertainty as to the reliability of the data.



The great flexibility built into the classification and the maps enables dependable evaluation of a variety of biological and environmental resources, from species habitat to timber management to carbon sequestration.

The Survey of California Vegetation was developed by the California Department of Fish and Wildlife's Vegetation Classification and Mapping Program (VegCAMP) and the California Native Plant Society's Vegetation Program in association with an interagency vegetation group. VegCAMP has supervised or served in an advisory role in the mapping and classification of approximately 42 percent of California to SCV standards, but the effort is incomplete in many critical areas. The proposed expansion of SCV standards to the rest of the state will provide the type of digital map that GIS users require.

Example of SCV classification and mapping from Observer point of view. The vegetation polygons labeled in the map can be seen in the photo as they appear in the field. The photo was taken at the point marked on the map, looking southwest.

Vegetation Map User Study

Vegetation map users state that a high-resolution digital map of California's vegetation is one of the top data requirements for the state.

The vegetation map user study was conducted in two parts: an online survey and personal interviews. The online survey inventoried the needs of 48 existing and potential users of vegetation data. In addition, personal interviews were conducted with more than 20 individuals from organizations and agencies across the state. During these interviews, current applications of SCV data were explored in detail, and the resulting efficiencies and cost savings were clearly documented.

Vegetation map users state that a high-resolution digital map of California's vegetation is one of the top data requirements for the state. Map users report that they experience substantial time and cost savings when they can use SCV datasets rather than older, less detailed map products. For example, the California Coastal Commission uses SCV-compliant data in Southern California to help evaluate development proposals in the Santa Monica Mountains and in Orange County. Sensitive habitats can be located on the map and those areas can be avoided without costly and time-consuming field visits.

The National Park Service, U.S. Geological Survey, and Ventura County Fire Department all use SCV datasets to aid in fire fuel analysis and post-fire modeling. The detailed vegetation attributes, such as tree canopy height and shrub density, contribute to models that predict which areas will burn intensely and how a fire might spread. Post-fire habitat can also be modeled with the high level of detail provided by SCV data.

Survey respondents indicate that the superior quality of SCV data enhances scientific research. The Sierra Nevada Conservancy is planning to conduct a study using fine-scale vegetation data as a baseline for a climate change adaptation interface. The Sonoma County Agricultural Preservation and Open Space District is planning to use its SCV data to assist with tasks such as predicting and measuring carbon sequestration rates.

Many users confirm that there is significant demand for SCV data in regions where mapping has not yet begun. For example, the American River Conservancy would find an SCV-compliant map very useful for its work in the high-elevation meadows of the Sierra Nevada. The coarse-resolution vegetation data that is available for this area is not sufficient for conservation planning, parcel acquisition, or assessment of development impacts.

Benefit–Cost Analysis

Costs of producing a statewide SCV dataset include field surveying, vegetation classification, mapping, and assessment of the accuracy of the final map. The cost to map the remaining 58 percent of California to SCV standards ranges from $45 to $75 million, depending upon the magnitude of the cost savings that can be implemented. Significant cost savings can be realized by mapping the remainder of the state in a single coordinated effort, rather than in the opportunistic, but fragmented, fashion that is currently employed. Economies of scale resulting from shared overhead and distributed training costs will substantially decrease the average cost per acre of map production.

Technological innovations in the field of GIS, such as automated map interpretation, higher-resolution imaging, and the use of drones and remote imagery sensors will also contribute to future cost reductions.

Benefits can be subdivided into three different types: measurable monetary, difficult-to-quantify monetary, and intangible nonmonetary. However, this benefit–cost analysis was based solely on easily measurable monetary benefits. Several cost and benefit scenarios were considered in this analysis and all produce positive net benefits. Depending on the scenario, the return on monetary investment ranges from 15 percent to more than 550 percent. Based exclusively on expected monetary savings, the high-resolution SCV map of California will return benefits above and beyond its cost.

Return on investment is even greater when difficult-to-quantify and intangible benefits are considered. The proposed statewide SCV map will yield significant savings to users. These include a reduction in the number of permitting and zoning errors due to incomplete habitat knowledge, increased project productivity, and more ecologically sound preservation of natural resources. Although these savings could not be quantified in the benefit–cost analysis, they are a significant factor when assessing the value of a statewide SCV map.

The Compelling Need to Complete the Statewide Map

Approximately 42 percent of the state has already been mapped to the high SCV-level standards. The remainder of the state should be mapped for the following reasons:

- An SCV map is more than just a map of vegetation; it includes a wide variety of detailed biological and environmental data.
- An SCV map with its detailed attribute data provides the single best surrogate for wildlife habitat.
- Conservation efforts are enhanced by the detail that accompanies these maps; the best locations for reserves and wildlife areas can be chosen.
- Global climate change effects on the state's natural landscapes can be studied by monitoring and modeling the patterns of vegetation change over time.
- Detailed fire management planning and modeling is possible due to the accurate, fine-scale fuel maps that can be created.
- Invasive species can be more easily located and controlled.
- Urban development and transportation routing can be planned to avoid environmentally sensitive areas and reduce costly mitigation.
- Environmental review processes are streamlined, leading to reduction in the time required to complete environmental assessments and decreasing the possibility of costly litigation.

All of these benefits, and more, have been realized by the users of existing SCV-compliant maps and data.

Conclusion and Goal

The preponderance of evidence strongly supports the completion of a comprehensive, statewide, high-resolution, digital vegetation map. A large and diverse set of scientists, public agencies, and private firms will experience many map-related benefits. The economic analysis shows that from a fiscal perspective, the benefits outweigh the costs under a variety of scenarios. Even the most conservative estimates show positive net benefits. Moreover, if the numerous nonmonetary benefits to the public could be quantified and included in the analysis, the arguments for supporting the vegetation map would only grow stronger.

We believe that a well-justified goal is to produce a completed SCV-compliant vegetation map of California by 2020. In order to achieve this very important goal, we need the support of the diverse organizations and agencies that will benefit most from the high resolution, proven accuracy, and detailed data that comprise this map.

INTRODUCTION

California's Need for a High-Resolution Vegetation Map

The completion of a statewide, high-resolution vegetation map is crucial for effectively managing California's natural resources and for fostering conservation of those resources; without it, the government entities tasked with these responsibilities cannot operate efficiently. Over the past two decades, the demand for a detailed vegetation map of California has been established among government agencies and councils, researchers, and experts in various fields. Through a series of statewide data forums conducted for the California Geospatial Framework Data Plan (Baker et al., 2006), California state and local agency Geographic Information System (GIS) users have identified a statewide, high-resolution digital vegetation map as one of their top framework data requirements. In fact, of the top 11 geospatial framework data needs identified by these users, vegetation mapping addresses all or a portion of four.

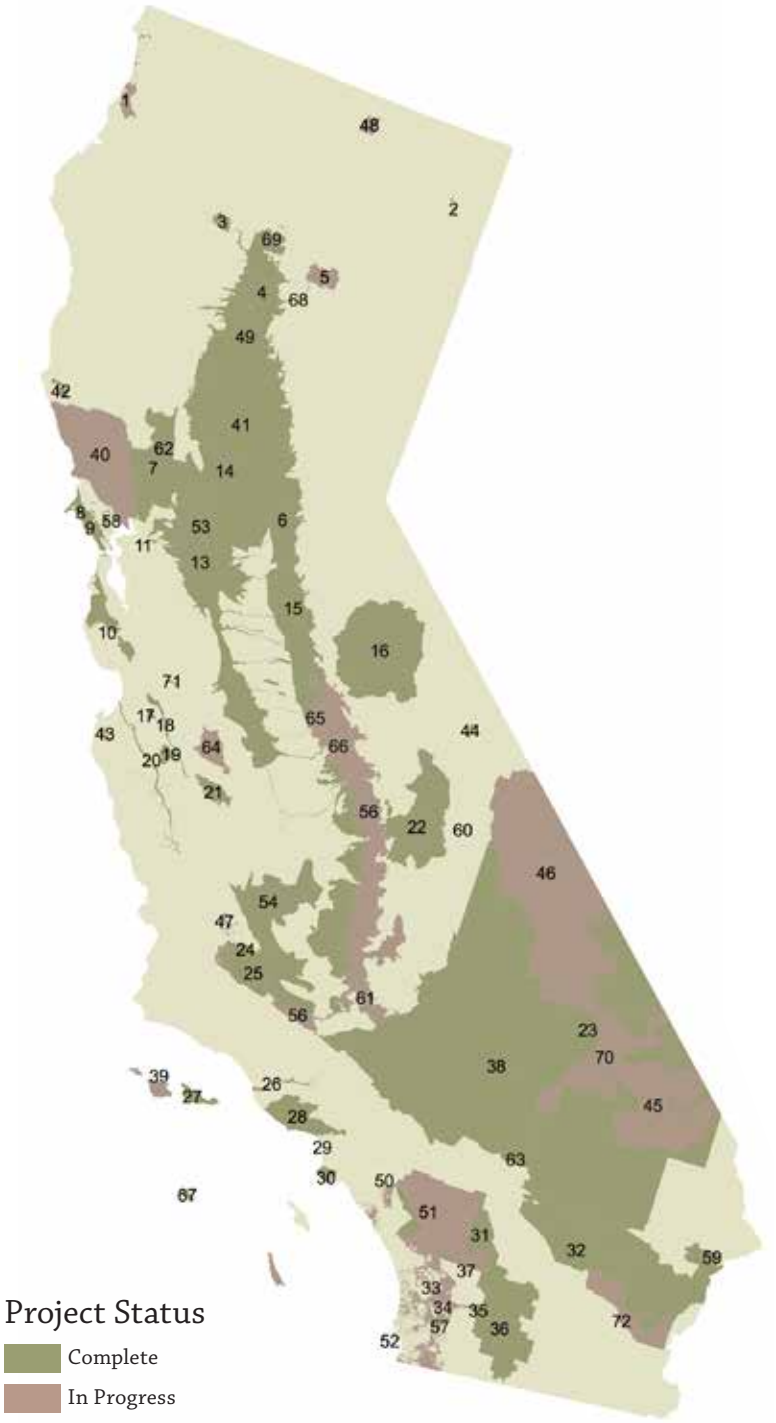
A statewide map is in demand because vegetation is often considered the single best surrogate for habitat and ecosystems, and as such, it addresses several statewide and local needs. According to the Data Plan, a vegetation map consistent across all types of land ownership is deemed critical for assessing current conditions, monitoring long-term changes, and determining land management options. Although other statewide vegetation maps currently exist and are often sufficient for multi-region or statewide broad-spectrum uses, they are inadequate for numerous other applications as discussed in this report.

This report describes the Survey of California Vegetation, a framework for standardized vegetation classification and mapping in the state. It presents data on the utility of the SCV for natural resource management and many other applications, and provides a benefit–cost analysis demonstrating that cost savings and better decision making can be achieved by completion of a statewide map. To date, 42 percent of the state has been mapped to the standards set in the SCV (Figure 1), but additional funding is needed to complete the task for the rest of California.

What is the Survey of California Vegetation?

The Survey of California Vegetation (SCV) is a framework that sets the standards for vegetation surveying, classification, and mapping in California.

- The SCV survey standards provide protocols for the collection of detailed vegetation data, including plant species and percent cover, structure (such as the height and diameter of dominant trees), and environmental information (such as slope, aspect, and soil texture).
- The SCV classification standards conform to the National Vegetation Classification System (NVCS) and international standards, and categorize species into a hierarchy; for instance the "Californian Broadleaf Forest and Woodland Group" contains the "Blue Oak Alliance" which contains the "Blue Oak-Valley Oak Association."



1 Redwood National Park
2 Pine Creek and Fitzhugh Creek Wildlife Areas
3 Whiskeytown-Shasta National Recreation Area
4 Lassen Foothills
5 Lassen National Park
6 Sierra Nevada Foothills – North
7 Napa County and Blue Ridge Berryessa
8 Point Reyes National Seashore and Golden Gate National Recreation Area
9 Marin Municipal Water District
10 Midpeninsula Regional Open Space District and Peninsula Open Space Trust Lands
11 John Muir National Historic Site
12 Suisun Marsh
13 Sacramento–San Joaquin River Delta
14 Central Valley Riparian Project and Eastern Sacramento Valley
15 Peoria Wildlife Area
16 Yosemite National Park
17 Gabilan Ranch
18 San Benito River
19 Pinnacles National Monument
20 Salinas River
21 Clear Creek Management Area
22 Sequoia and Kings Canyon National Parks
23 Central Mojave Desert
24 Carrizo Plain Ecological Reserve
25 Carrizo Plain National Monument
26 Santa Clara River Parkway
27 Santa Cruz Island
28 Santa Monica Mountains National Recreation Area
29 Ballona Wetlands
30 Palos Verdes
31 Western Riverside County
32 Joshua Tree National Park
33 Western San Diego County
34 San Dieguito River Parkway
35 San Felipe Valley Wildlife Area
36 Anza-Borrego State Park
37 Oak Grove Unit of San Felipe Valley Wildlife Area
38 Vegetation Map in Support of the Desert Renewable Energy Conservation Plan
39 Channel Islands
40 Sonoma County
41 Eastern Sacramento Valley Natural Vegetation
42 Garcia River
43 Santa Lucia Preserve
44 Fish Slough Area of Critical Environmental Concern and Ecological Reserve
45 Mojave Desert National Preserve
46 Death Valley National Park
47 Carrizo Plain Mitigation Area and Tule Elk Range
48 Lava Beds National Monument
49 West Sacramento Valley Natural Vegetation
50 Orange County
51 Western Riverside County Remap
52 Cabrillo National Monument
53 Liberty Island Remap
54 Southwest San Joaquin Valley Habitat Linkage
56 Southern Sierra Nevada Foothills
57 Cañada de San Vicente Ecological Reserve
58 Marin County Open Space District Lands
59 Desert Renewable Energy Conservation Plan Rice Valley Extension
60 Manzanar National Historic Site
61 High-Speed Rail Corridor
62 Knoxville Wildlife Area
63 Johnson Valley Integrated Mapping
64 Ciervo Panoche North
65 Southern Sierra Nevada Foothills
66 McKenzie Preserve at Table Mountain
67 San Nicolas Island
68 Mill Creek
69 Cow Creek
70 Desert Renewable Energy Conservation Plan Silurian Valley Soda Mountains Extension
71 Cañada de los Osos Ecological Reserve
72 Desert Renewable Energy Conservation Plan Chuckwalla Bench Extension

FIGURE 1
Vegetation mapping projects completed to the standards of the Survey of California Vegetation

- The SCV mapping standards specify the size of the vegetation polygons (the Minimum Mapping Unit), which may be as small as ½ acre for wetlands and other special plant communities, the vegetation cover classes, and other mapping conventions.
- Each SCV mapped polygon is labeled with the vegetation type, and also includes multiple attributes such as the cover of trees, shrubs and herbs; the diameter of conifer and hardwood trees; and the degree of disturbance, invasion by non-native species, roadedness, and other regionally specific attributes.
- Each SCV map is verified by a quantified Accuracy Assessment process to assure consistent quality and avoid uncertainty as to the reliability of the data.

The production of an SCV dataset includes the development of a defensible data-driven classification, the creation of tested, accurate map products derived from that classification, and revisions to both the classification and the map products as conditions change.
The SCV extends well beyond the standard hard-copy map labeled with simple vegetation types. An SCV map is a digital dataset, produced using GIS software. Map users can view and interact with the spatial information (the mapped polygons) as well as the vegetation and environmental information associated with each polygon (Figures 2 and 3).

The great flexibility built into the classification and the mapped units enables dependable evaluation of a variety of biological and environmental resources.

Attribute *	*Value*
Map Unit	*Quercus douglasii* / grass Association
Heterogeneity	Low, less than 5% heterogeneous
Conifer Cover	<1%
Hardwood Cover	30–40%
Total Tree Cover	30–40%
Tree DBH	11–24"
Shrub Cover	1–10%
Herbaceous Cover	10–40%
Exotics	Medium
Roadedness	Medium
Fire Evidence	No
Other Impacts	None
Acres	166
Method ID	Photo-interpretation
Confidence	High
Rare	No
NVCS Name	*Quercus douglasii* / grass
Hierarchy Level	Association
NVCS Alliance	*Quercus douglasii*
NVCS Group	Californian broadleaf forest and woodland
NVCS Macrogroup	California Forest and Woodland
CalVeg Name	Blue Oak
CWHR Type	Blue Oak Woodland
* Attributes are defined in Appendix C	

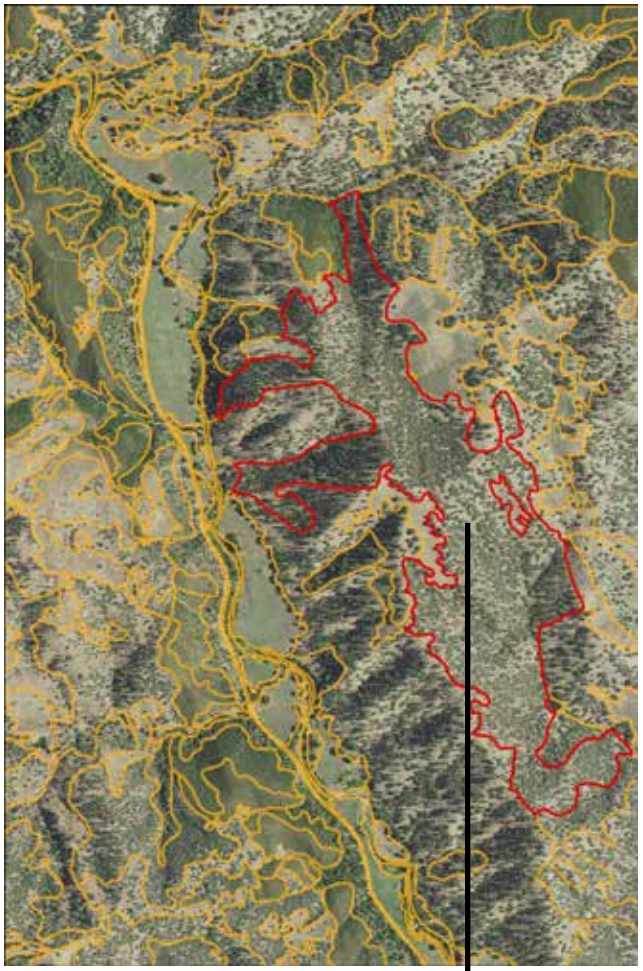


FIGURE 2

Example of an SCV GIS layer derived from detailed aerial imagery and field samples. This map shows vegetation polygons drawn over aerial imagery. The finely detailed polygons are delineated based on type of vegetation and value of vegetation cover. The table on the left shows some of the robust attributes associated with the SCV polygon outlined in red.

FIGURE 3

This map shows a different view of the same polygons as drawn in Figure 2. The fine level of detail is maintained in this map, but the polygons are color-coded by vegetation type, without regard to cover, illustrating the flexibility of the SCV and the ability to aggregate data to serve various purposes.

The Survey of California Vegetation as the State Standard

In 2000, the Memorandum of Understanding for Cooperative Vegetation and Habitat Mapping and Classification (MOU) identified shortcomings in existing vegetation GIS datasets and established the need to develop mapping standards, integrate existing data into those standards, and initiate a coordinated regional mapping project (California Biodiversity Council, 2000). This MOU was developed by representatives from five state agencies, seven federal agencies, and four universities. In response to the MOU, the California Department of Fish and Wildlife's Vegetation Classification and Mapping Program (VegCAMP) and the Vegetation Program of the California Native Plant Society (CNPS) began development of the vegetation survey protocols, classification and mapping standards, and accuracy assessment processes that would later comprise the Survey of California Vegetation framework.

In 2007, state legislation identified the California Department of Fish and Wildlife (CDFW), in consultation with interested stakeholders, as the lead agency to develop vegetation mapping and classification standards for California, and called for the mapping standards to be consistent with those developed by the Federal Geographic Data Committee. It further stipulated that CDFW should devise "mechanisms for integrating new map products that meet the standard into a cohesive database with the intent of eventually completing statewide coverage" (Senate Bill No. 85, Chaptered 2007 as Section 1940 of the Fish and Game Code).

The Memorandum of Understanding for Cooperative Vegetation and Habitat Mapping and Classification was developed by representatives from five state agencies, seven federal agencies, and four universities:

- *California Department of Forestry and Fire Protection*
- *California Department of Fish and Wildlife*
- *California Department of Pesticide Regulation*
- *California Department of Water Resources*
- *California Department of Transportation*
- *United States Forest Service*
- *Bureau of Land Management*
- *United States Geological Survey*
- *United States Fish and Wildlife Service*
- *National Park Service*
- *United States Bureau of Reclamation*
- *Natural Resources Conservation Service*
- *University of California, Davis*
- *University of California, Riverside*
- *California State University, San Diego*
- *California State University, Humboldt*

The SCV incorporates all of the elements mandated by the MOU and Senate Bill No. 85. The current state vegetation classification is embodied in The Manual of California Vegetation (Sawyer et al., 2009), and data collection protocols, mapping standards, and accuracy assessment procedures are documented and available to all vegetation mappers through VegCAMP.

VegCAMP's Role in the Survey of California Vegetation

VegCAMP leadership is essential to the completion of the SCV map of California. VegCAMP coordinates the efforts of the numerous firms and agencies that survey vegetation and produce maps, trains participants in the surveying and mapping processes, assists with vegetation classification in currently unmapped areas, implements quality control procedures, and initiates updates to the standards as necessary. VegCAMP involvement is critical to the success of this endeavor and will ensure that the completed map complies with all SCV standards.

What Can the Survey of California Vegetation Provide to the State?

In addition to providing a consistent and accurate vegetation classification system across all regions of California, the SCV methodology will produce vegetation maps and data in a standard format. Because it will cover the entire state, SCV data will allow various agencies and organizations to communicate about environmental issues in a common language. This vegetation data framework will have a wide variety of applied uses; fire modeling and fuel mapping on U.S. Forest Service lands, and identification of wetland environments throughout the Sacramento–San Joaquin River Delta are just two examples.

Other potential applications of SCV data include:

- Wildlife and plant conservation
- Development planning
- Hydrology and watershed assessments
- Fire management
- Invasive species monitoring and control
- Detection of landscape level changes resulting from climate change
- Environmental assessments
- Transportation planning
- Prioritization of land acquisitions for wildlife reserves and protected areas
- Predicting and measuring carbon sequestration levels and carbon release rates

When applied to these efforts, the SCV map will increase operational efficiencies, provide quantifiable cost reductions, and offer additional intrinsic benefits. The completed, statewide SCV dataset will enable broad analysis with far-reaching application.

What Makes the Survey of California Vegetation Unique?

The completed SCV map will address several problems of existing statewide vegetation maps: low resolution/level of detail, limited on-the-ground validation, restricted spatial extent, and variable classification systems and standards. The limited on-the-ground

validation that has been completed for these other maps reduces the quality of the data to some degree. "There is no statewide vegetation dataset that meets the accuracy and precision needs of a variety of map users" (California Biodiversity Council, 2000).

The most recent statewide vegetation map, the 2008 California remapping for the National Gap Analysis Program of the U.S. Geological Survey's Land Cover Data Set, version 2 (GAP), has a spatial resolution that is considered by many to be too coarse for site-specific or even regional work. This vegetation map is part of a national project and was intentionally produced at a coarse scale to show national trends. The coarse scale allowed the map to be completed more quickly and at lower cost than would be possible with a high-resolution map, but detail was sacrificed (Figure 4). The 30-meter pixel size doesn't permit mapping of small, patchy vegetation types, such as environmentally important sensitive habitats, and small wetlands and riparian areas. In addition, the GAP map does not represent the finer floristic levels of the classification hierarchy, limiting its use for many projects.

The California Department of Forestry and Fire Protection's (CAL FIRE) Fire and Resource Assessment Program (FRAP) has produced a statewide "Multi-Source Vegetation" map for the purpose of monitoring forests and rangelands in California. FRAP started with U.S. Forest Service (USFS) maps of California, which were developed to map and evaluate forest, woodland, and shrubland landscapes for productivity and fuels assessment. Although these maps were state of the art when developed in the 1980s and 1990s, and have proven highly valuable for their original purposes, they have several qualities that limit their usefulness for other applications, which have become critical in recent years. The USFS maps use the Calveg classification system, which does not translate uniformly to the NVCS hierarchy. Automated methods were primarily used to create maps on satellite imagery that had approximately 30-meter pixels, resulting in coarse-resolution polygons. As with the GAP map, with such large pixels, many fine-scale vegetation features, such as wetlands, were too small to include in the map. Additionally, because the USFS maps are focused on forested areas and rangelands, they do not cover the entire state (Figure 5).

FIGURE 4
Comparison of GAP layer and SCV layer

In an effort to address these issues, FRAP compiled the "best" vegetation maps from across the state into a single GIS layer, the FRAP Multi-Source Vegetation Map. In some parts of the state, these were the original USFS Calveg-based maps. In other areas, they were highly detailed SCV-compliant maps. When no other vegetation data was available, FRAP incorporated coarse-level GAP maps. The data from all these disparate maps was then crosswalked into yet another classification system, the California Wildlife Habitat Relationships (CWHR). Although the FRAP map completely covers California, it is an amalgamation of different mapping methods, scales, resolutions, attribute detail, and classification systems.

Survey of California Vegetation data reflects vegetation information at a higher resolution than either the GAP map or much of the FRAP map. The imagery used for SCV maps typically has a resolution of 1- to 3-foot pixels, so very detailed vegetation polygons can be drawn, with correspondingly detailed vegetation and environmental data (Figure 6). As a result of rigorous field sampling, consistent vegetation classification, adherence to standardized mapping conventions, and evaluated accuracy assessments, the SCV map is more reliable and more accurate than the GAP map and the non-SCV portions of the FRAP map. When needed, the detail available in both the

FIGURE 5
Extent of California mapped by the U.S. Forest Service using Calveg classifications, as of 2014

spatial features and the descriptive attributes can be aggregated, or generalized, so that the dataset becomes customizable to any scale and supports a wide range of uses. The SCV's accurate and consistent vegetation mapping methodology can generate a standardized, high-resolution vegetation dataset for all regions of California; it will be readily accessible and scalable, and will serve both the public and private domains.

It is important to note that although the GAP dataset and much of the FRAP dataset do not contain the fine level of detail required by many users, they do satisfy the specific objectives of the agencies and organizations responsible for producing them.

Benefits of the Survey of California Vegetation

Completion of a statewide SCV map will provide tangible and quantifiable benefits, as well as an array of intangible benefits. Agencies such as the California Department of Fish and Wildlife, California Department of Transportation (Caltrans), California Department of Water Resources (DWR), and U.S. Bureau of Land Management (BLM) will be well equipped to preserve and protect our state's natural resources in an efficient manner. Nonprofit organizations and private individuals will be able to use the data to offer conservation planning or mitigation options. As a result, the reduction of habitat degradation, a key intrinsic and intangible benefit that the SCV dataset offers, will be provided to the general public. The SCV map layer will also provide critical data to national and international programs for broad-level analyses related to issues such

FIGURE 6

Individual patches of juniper woodland represented on the ground (defined by yellow lines) are often represented individually in SCV maps as a result of the typically small Minimum Mapping Unit. The view at the right is a vegetation map on a 1:6000 scale aerial photograph that shows the juniper woodland polygons depicted on the ground photograph on the left. Blue polygons are not viewable from the field perspective. Line of sight is defined by a red line in both images.

as global climate change. Cooperation across agencies and borders can help broaden the scope of conservation efforts far beyond current undertakings.

This report provides examples of tangible and quantifiable benefits by highlighting existing applications of SCV data. This report also provides estimates of the dollar value of future benefits and examples of cost savings the completed map will provide.

Research Methods and Overview of Findings

Because of the relatively large upfront costs of collecting, classifying, and mapping vegetation data, it is important to conduct a comprehensive study to justify this expense for completing the SCV map of California. This report details the results of such a study and addresses the following topics: case studies illustrating the improved efficiency and efficacy of government processes when SCV data is utilized; demand for high-resolution vegetation map datasets among GIS users; and a benefit–cost analysis for completing SCV-compliant mapping throughout California.

Researchers (including GIS specialists and an economist) conducted an online survey and in-person and teleconference interviews with representatives of numerous agencies and organizations around the state and country. The online survey inventoried the needs of 48 existing and potential users of vegetation data, and concluded that there is significant demand for high-resolution vegetation data among the user community. Through in-person and teleconference interviews, researchers documented case studies illustrating applications of such data and the subsequent efficiencies and cost savings. Results strongly support the fact that a statewide SCV dataset will save time and resources, and allow users to achieve results they might not otherwise have been able to achieve with coarser-scale or outdated maps. Analysis of the collected research provided a synthesis of tangible and intangible returns on investment (ROI). Tangible returns include both quantitative and qualitative benefits. Quantitative benefits were identified via the analysis of time and cost savings, and the development of ROI models.

VALUE OF THE SURVEY OF CALIFORNIA VEGETATION

Who Uses the Survey of California Vegetation?

The Survey of California Vegetation (SCV) has numerous applications for a wide range of agencies and organizations throughout the state. Since vegetation data is often regarded as a key baseline for environmental analyses, various projects can benefit from a high-resolution, standardized vegetation dataset aligned with the state classification standards (Baker et al., 2006). An SCV-compliant map increases the efficiency of government agencies, jurisdictional units, nonprofit organizations, and various other entities. An online User Community Survey and over 20 personal interviews, as discussed further in this report, identified many current applications of SCV data. These applications include development and planning, environmental assessment, transportation, wildlife and plant conservation, natural resources management, invasive species monitoring and eradication, water resource management and flood control, prioritization of land acquisitions, fire control, public safety, climate change studies, and agriculture. High-resolution vegetation datasets are also being used in academia for research and educational purposes, as the quality and depth of information in the dataset is a valuable teaching tool. These are the current uses of SCV data, but the GIS user community is quick to find new applications. This section describes the experiences of many organizations that depend on high-quality SCV data, explores the advantages that a complete statewide implementation of the SCV will provide, and discusses the implications of the User Community Survey.

An online User Community Survey and personal interviews identified many current applications of SCV data, including:

- *Environmental assessment*
- *Wildlife and plant conservation*
- *Natural resources management*
- *Fire control*
- *Invasive species monitoring and eradication*
- *Water resource management and flood control*
- *Development and planning*
- *Transportation*
- *Prioritization of land acquisitions*
- *Public safety*
- *Climate change studies*
- *Agriculture*

Climate Change

High-resolution vegetation data can be used as a monitoring tool to detect landscape-level alterations due to climate change. SCV datasets detect details in species composition in both the mapping and the field sampling, enabling more precise tracking of change than is possible with more generalized maps or field data. The detailed information in an SCV dataset can also be used to help model potential changes in vegetation as the climate changes, thus helping to predict how wildlife might migrate as a result.

Sonoma County Agricultural Preservation and Open Space District

The Sonoma County Agricultural Preservation and Open Space District has begun creating an SCV dataset of the region as part of its climate change and adaptation project initiatives. This dataset will assist with tasks such as predicting and measuring carbon sequestration rates, and generating carbon sequestration and greenhouse gas emission assessments under different land use scenarios. According to Tom Robinson, the Conservation Planner for the district, fine-scale land cover data is critical for developing an informed climate change adaption plan (Tom Robinson, personal communication, November 13, 2013).

Sierra Nevada Conservancy; Department of Integrative Biology at University of California, Berkeley

The Sierra Nevada Conservancy is planning to conduct a study using fine-scale vegetation data as a baseline for a climate change adaptation interface. According to researchers, high-resolution vegetation data allows the user to better measure changes in community at the association level. David Ackerly, Professor and Researcher at the Department of Integrative Biology at UC Berkeley, indicates that high-resolution data is useful for analyzing the possible outcomes of climate change in a landscape with varying topographic features. It helps project how vegetation will move when variables such as slope and aspect are changed. For example, vegetation data can allow a researcher to answer questions such as "will a vegetation species move from one side of the hill to another?" In short, high-resolution data allows more detailed climate analyses to be conducted than low-resolution data (David Ackerly, personal communication, March 4, 2014).

Northwest Hydraulic Consultants

High-resolution vegetation data can be used to predict potential flood impacts due to sea level rise. Northwest Hydraulic Consultants used SCV data to conduct a Federal Emergency Management Agency (FEMA) Coastal Flood Hazard survey. According to the GIS manager of this company, it was necessary to know vegetation type and coverage at a detailed level for this study. The SCV dataset was a vital source of information for some of the analyses pertaining to this project (Dawn Lasprugato, personal communication, September 16, 2013).

Wildlife and Plant Conservation

High-resolution vegetation data is a valuable tool for natural resources management, improving the decision-making process regarding conservation issues. The use of a high-resolution vegetation dataset can enhance and inform various conservation projects, including population dynamics studies, species distribution modeling, reserve design decisions, genetic sampling, and prioritization of conservation efforts.

California Energy Commission

Detailed vegetation data serves as a resource to inform wildlife reserve design. Such data is used extensively in the Desert Renewable Energy Conservation Plan (DRECP), a multi-agency program developed through a collaborative effort between the California Energy Commission, California Department of Fish and Wildlife, U.S. Bureau of Land Management, and U.S. Fish and Wildlife Service, and managed by the California Energy Commission. The program's purpose is to provide effective protection and conservation of desert ecosystems while allowing the appropriate development of renewable energy projects. Prior to the 2013 completion of an SCV dataset for the Mohave Desert region, an adequately detailed vegetation layer for this area did not exist; DRECP management had to base many of its decisions upon coarse-resolution, generalized geospatial data. This data was heavily criticized by independent science advisors, who predicted that the plan was likely to fail unless a high-resolution vegetation dataset could be utilized. Their report made the following recommendation: "Invest in completing a seamless, up-to-date, high-resolution, hierarchical vegetation (or land-cover) map as soon as possible to support conservation planning, renewable energy facility siting, and conservation analyses. The lack of a comprehensive and dependable land-cover base map—which is an essential data layer for spatially explicit models, maps, and analyses—is a key information gap faced by the plan. This hinders the ability to reasonably predict the plan's effects on target species and communities and to locate appropriate conservation and mitigation actions" (DRECP Independent Science Advisors, 2010). The newly created, high-resolution vegetation dataset has enhanced the plan by enabling DRECP to identify locally rare plant locations and sensitive wildlife habitats, and to consider rare vegetation types in reserve design (Misa Milliron, personal communication, October 11, 2013).

National Park Service

According to the National Park Service staff at the Santa Monica Mountains National Recreation Area, high-resolution vegetation data is useful for determining potential collection locations for genetic sampling of uncommon and rare species. The data is used to create predictive maps of species distributions, allowing the biologists to narrow their searches when conducting field work. Additionally, this high-resolution data is a critical component of their inventory and monitoring program for various plant and wildlife species in the park (John Tiszler, Denise Kamradt, Tony Valois, and Martha Witter, personal communication, September 16, 2013).

WILDLIFE AND PLANT CONSERVATION

California Department of Fish and Wildlife

One key aspect of conserving viable wildlife populations is maintaining connections between patches of habitat, which are commonly fragmented by human development, roads, and various forms of land conversion. The CDFW Data and Technology Division used SCV data to better understand habitat connectivity across the Northern Sierra Nevada Foothills ecoregion. They identified 30 focal species, such as bobcat, black bear, and mountain lion, which were representative of the wildlife in the study region. Then they identified "landscape blocks" in the study area, representing protected lands that provide core habitat areas for the focal species. The purpose of the study was to model linkages between these landscape blocks. They used species-specific data in conjunction with SCV data to develop habitat suitability models for the focal species; the models were then used to identify core habitat patches for each species. With this data, they could identify least-cost corridors linking core habitat patches in the landscape blocks. The habitat corridors and habitat patches for the 30 focal species were combined to build a linkage that would permit wildlife movement between each pair of neighboring landscape blocks. The resulting linkage network identified areas of high habitat suitability as well as areas of conservation concern such as barriers to movement and movement bottlenecks. The CDFW Data and Technology Division believes that this network will be useful for local and regional land use planning, land use decision making, and conservation and habitat acquisition planning for state and local governments and conservation organizations (Melanie Gogol-Prokurat, personal communication, May 29, 2014).

Bay Area Open Space Council; Creekside Center for Earth Observation

Another advantage of high-resolution vegetation data is its ability to detect encroachment of certain plant species into new areas. Analysis of coarse vegetation data is incapable of detecting such encroachment, as it only captures general vegetation types. According to the Bay Area Open Space Council and the Creekside Center for Earth Observation, a fine-scale vegetation map can provide a solid indicator of the progression of vegetation species within a community over time (Stu Weiss and Ryan Branciforte, personal communication, November 13, 2013).

AECOM

Population dynamics studies and species distribution modeling are commonly employed conservation techniques, both of which are enhanced by a high-resolution vegetation dataset. High-resolution vegetation data is used to estimate the populations of animal species that occur only in specific vegetation types or in habitats dominated by certain plant species. For example, AECOM uses an SCV dataset to estimate population densities of the federally listed endangered Arroyo Toad and the threatened California Gnatcatcher, both of which occur in a specific type of sage scrub habitat. The detailed vegetation data allows the biologists to determine the locations and extents of these habitat patches, thereby enabling them to estimate population densities for the toad and gnatcatcher (Jonathan Dunn and Tom Oberbauer, personal communication, November 18, 2013).

Dudek

The highly detailed classifications and the spatial accuracy of high-resolution vegetation data can enhance species distribution modeling. The biological consulting firm Dudek uses SCV data to create species distribution models that predict species occurrence over landscapes. These models are more accurate than models created from coarse-resolution data, resulting in more robust analyses (Wendy Worthey and Mike Howard, personal communication, April 3, 2014).

Conservation Biology Institute

The Conservation Biology Institute is a nonprofit organization that provides scientific expertise in support of the conservation and recovery of biological diversity. The institute uses SCV data to correlate vegetation types with rare animal species in San Diego County. Additionally, the organization uses SCV data to create an adaptive management strategy for endemic species (Patricia Gordon-Reedy, personal communication, November 4, 2013).

DEVELOPMENT AND PLANNING

Development and Planning

Fine-scale vegetation data is often regarded as a baseline for development and planning processes, which include county and city planning, infrastructure development, creation of recreation areas, and renewable energy development. The use of an SCV map can create efficiencies and facilitate better-informed decisions for such projects throughout the state.

California Coastal Commission

The California Coastal Commission uses an SCV dataset to guide policy for development and to evaluate development proposals in the Santa Monica Mountains. Sites with Environmentally Sensitive Habitat Area (ESHA) designations, which are unsuitable for development, can be identified by reference to the dataset. Commission staff can establish the locations of potential ESHA parcels prior to going out in the field, thereby reducing the amount of time spent in the field per project (Jonna Engel, personal communication, October 7, 2013).

The use of a detailed vegetation map can also help identify environmental violations or illegal resource extraction. The California Coastal Commission uses an SCV dataset to asses the resource impacts of development violations in the Santa Monica Mountains. By referring to the dataset, the Coastal Commission can tell which types of vegetation were removed from specific locations, and provide evidence that a species existed at a particular location prior to clearing (Jonna Engel, personal communication, October 7, 2013).

Los Angeles County Department of Regional Planning

SCV data helps to identify areas with Significant Environmental Resource Area designations or where there is a high likelihood of finding certain rare species. The Los Angeles County Department of Regional Planning used an SCV dataset to map habitat categories when it developed the implementation plan for the Santa Monica Mountains Local Coastal Program. The habitat categories help determine which regions should be completely protected and which areas require stringent development standards. Understanding that habitats are dynamic and can change over time, the Department of Regional Planning added a provision for updating the habitat maps on a regular basis (Josh Huntington and Chris Morneau, personal communication, October 28, 2013).

National Park Service

The National Park Service is an agency that has benefited from the increased detail of SCV-compliant datasets when creating visual displays. They have been able to create highly detailed and visually compelling maps that attest to the value of natural land, when that land is under consideration for development. The Park Service also uses these detailed maps in grant proposals when they must demonstrate the uniqueness of the habitat (John Tiszler et al., personal communication, September 16, 2013).

California Department of Fish and Wildlife

An SCV map provides fundamental information upon which the CDFW Lands Program management plans are based. "The high-resolution and highly attributed vegetation maps produced for our department's lands are used in developing the management plans that are required for each property, addressing issues such as invasive species removal, grazing management issues, and fuels management" (Teresa Le Blanc, personal communication, October 21, 2014).

PRIORITIZATION OF LAND ACQUISITIONS

Prioritization of Land Acquisitions

With detailed vegetation data, conservation agencies can obtain insight into which parcels of land to acquire based on the dominant vegetation type and other vegetation qualities. These agencies may want to acquire land with high conservation value or land that meets certain conservation objectives. Detailed vegetation data can help determine the presence of rare or special-status species, the level of disturbance of the habitat, the amount of vegetation on the land, and in some cases, the age of the vegetation (trees).

U.S. Bureau of Land Management

The U.S. Bureau of Land Management (BLM) uses SCV data for Eastern Riverside County to target acquisition areas for compensatory mitigation for solar projects. The data helps determine which areas may have suitable habitat for rare plant and wildlife species (e.g. Desert Tortoise). If this dataset were not available, BLM would have to rely upon the less-detailed GAP data, and would need to spend more time in the field to verify the suitability of the proposed mitigation land (Mark Massar, personal communication, April 4, 2014).

California Department of Fish and Wildlife

The California Department of Fish and Wildlife uses the SCV dataset for the San Felipe Valley Wildlife Area as the basis for analyzing the habitat of adjacent privately owned properties. These properties can then be prioritized for acquisition from willing sellers in future expansions of the Wildlife Area as specified in the Conceptual Area Protection Plan (Randy Botta, email correspondence, May 29, 2014)

Hydrology and Watershed Assessments

High-resolution vegetation data can be an insightful tool for conducting hydrology and watershed assessments. Detailed information on vegetation type, as well as attributes such as vegetation structure and level of disturbance, can provide knowledge regarding the quality of the watershed or the potential for watershed problems to occur.

National Park Service

The National Park Service uses an SCV dataset in the Santa Monica Mountains National Recreation Area to conduct watershed assessments, which help identify landslide hazards and debris flows for specific sites (John Tiszler et al., personal communication, September 16, 2013).

Sonoma County Agricultural Preservation and Open Space District

According to the staff at the Sonoma County Agricultural Preservation and Open Space District, high-resolution vegetation data provides good indicators of the quality of water in a watershed. Natural riparian vegetation contributes large wood for fish habitat, maintains low water temperature in streams by providing shade, and filters non-point source pollution from surrounding land before it can enter the streams. The SCV dataset reveals the presence or absence of riparian vegetation, demonstrating which areas are providing ecosystem services and where improvements to the ecosystem can be made. Additionally, the vegetation data serves as a surrogate for estimates of biodiversity, and displays the level of disturbance and human modification to the watershed (Tom Robinson, personal communication, November 13, 2013).

California Department of Water Resources

Setback levees are commonly installed for flood control along the Sacramento River and other rivers in the Central Valley. These levees are constructed at a set distance from the river channel in order to allow the river to occupy a portion of its original floodplain. The California Department of Water Resources (DWR) uses SCV data when determining where to install setback levees. According to DWR, the agricultural subtypes in the vegetation dataset are very useful in isolating different agriculture types such as orchards, alfalfa fields and vineyards (Stefan Lorenzato, personal communication, September 24, 2013).

FIRE ANALYSIS

Fire Analysis

High-resolution, detailed vegetation data allows users to conduct a wider range of analyses and are more accurate than coarse-resolution, generalized data. Several state and federal agencies use such data for a variety of fire analysis and management strategies.

National Park Service

The National Park Service uses SCV data in the Santa Monica Mountains National Recreation Area to conduct fire-effects and post-fire modeling. Post-fire modeling is a management tool that spatially predicts various effects of a fire, such as tree mortality or vegetation community change, based on different input variables. Vegetation attributes in the SCV dataset, such as canopy height and percent cover of species, provide detailed input variables that contribute to the refinement of a model. The National Park Service also uses the data for strategic planning to locate vegetation types where points of ignition generally occur. According to National Park Service staff, the very fine level of data that is present in this dataset is essential for conducting post-fire analyses (John Tiszler et al., personal communication, September 16, 2013).

U.S. Geological Survey

The U.S. Geological Survey (USGS) and the National Park Service staff at Yosemite National Park use the SCV dataset of that region extensively for fire-effects monitoring. The USGS uses the dataset to create a fire fuel-type map, which can be used as input to a model that predicts the spread of a fire. There are several different fuel-type classification models and the classifications have become more tailored as the understanding of fire behavior has grown. As the basis for the fuel map, a detailed vegetation map provides a more precise classification of fuel types and a more accurate model than coarse-resolution maps (Peggy Moore, personal communication, February 16, 2014).

Ventura County Fire Department

According to the Ventura County Fire Department, fine-scale vegetation data is helpful for determining specific areas to target for prescribed burns. Burn areas are selected based upon their fire history, local winds, and vegetation type. By looking at the vegetation data, they can target which areas they want to focus on and thus refine their prescription burn plan (Barbara Geringer, personal communication, January 27, 2014).

Invasive Species Monitoring and Control

Invasive plants are a pervasive problem in California, costing state and federal agencies at least $82 million per year in control, monitoring, and outreach efforts (California Invasive Plant Council, 2008). Several problematic species of noxious weeds can cause land degradation, erosion, disruptions to hydrologic regimes, and increased susceptibility to fire, and can often present public safety hazards. The negative impacts of invasive plants can be costly for individuals, state agencies, and the private sector. Such impacts include reduced property values, compromised farmland and reduced agricultural output, bluff and dune destabilization, and water loss. Vegetation maps have been employed as a tool for monitoring the spread of invasive plants and as an aid in the efforts to eradicate them. High-resolution vegetation data benefits these efforts more than low-resolution datasets.

California Department of Water Resources

Giant Reed (*Arundo donax*) is a noxious weed that has infested wetlands, river valleys, and coastal river drainages throughout California. California has spent more than $70 million on eradication efforts for Giant Reed alone (California Invasive Plant Council, 2011). High-resolution vegetation data enables effective monitoring and management of this species. The California Department of Water Resources utilizes an SCV dataset for Giant Reed eradication in the Sacramento–San Joaquin River Delta. The high spatial resolution of the dataset is useful for locating occurrences of the plant, allowing biologists to narrow and focus their control efforts (Stefan Lorenzato, personal communication, October 7, 2013).

U.S. Geological Survey

In most cases, invasive plants are associated with certain vegetation types. Detailed vegetation data is used to narrow down the possible areas in which these vegetation types could occur. The U.S. Geological Survey currently uses such data to develop exotic plant inventories, and to model and predict the potential spread of certain invasive species (Peggy Moore, personal communication, February 16, 2014).

Sierra Nevada Conservancy

High-resolution vegetation data portrays plant communities in which invasive species are dominant. The Sierra Nevada Conservancy, a California state agency, uses this information to measure the spread of dominant invasive species over time (Elizabeth van Wagtendonk, personal communication, January 21, 2014).

Environmental Assessments

Environmental assessments are an integral part of the property development process in California. They can be costly to perform, but they can be particularly costly, in fees and litigation costs, if they are not performed correctly. An SCV-compliant map can help reduce the costs and errors associated with environmental assessments.

California Energy Commission

When developers apply to the California Energy Commission (CEC) for permission to build renewable energy installations in the desert, they must go through the CEC's regulatory review process and comply with California Environmental Quality Act (CEQA) regulations. If the developers do not provide an accurate inventory of the site's environmental resources in the initial study, they might be required to conduct additional survey work. For example, according to Misa Milliron, Senior Biologist for the CEC, there have been cases where a developer had not accounted for the monsoonal rains in the desert and did not conduct late-season botanical surveys. These developers were then required to perform additional survey work to remedy this data inadequacy and address any potentially overlooked rare plant occurrences. The increased accuracy of SCV data helps identify sensitive resources by providing precise locations of microhabitats that have a high potential for supporting sensitive taxa. Developers can focus on those locations during their site assessment surveys and conduct detailed surveys for those rare taxa. With less-detailed vegetation data, developers may be required to conduct additional survey work to locate sensitive habitats, potentially prolonging the regulatory review process (Misa Milliron, personal communication, June 22, 2014).

Who Needs the Survey of California Vegetation?

Although a number of users enjoy the benefits of working with SCV datasets in their regions, this level of detail does not currently extend to cover the entire state. Consequently, many users have experienced a reduction in work output or have achieved less accurate results than would have been possible with high-resolution data. Some users who lack coverage in their areas were simply precluded from undertaking certain projects. Based on interviews with frequent users of vegetation GIS data, the following examples illustrate the demand for a comprehensive statewide vegetation layer adhering to SCV standards.

Sierra Nevada Conservancy

The Sierra Nevada conservancy works with SCV data in the areas where it is available. However, the conservancy expressed a need for a fine-scale vegetation dataset covering the 5,000- to 7,000-foot elevation range of the Sierra Nevada, where there is a significant amount of fire activity (Elizabeth van Wagtendonk, personal communication, January 21, 2014).

Ventura County Fire Department

The Ventura County Fire Department does not have an SCV map that covers the entire county and would like to acquire more precise vegetation classification information for use in fire analyses. An alliance-level classification system, part of an SCV dataset, would enhance efforts to determine locations for prescribed burns. With this data, the department would be able to identify locations with obligate seeders, plants such as ceanothus and manzanita, which have fire-activated seed banks that germinate and grow rapidly following a fire. Knowing the locations of obligate seeders would be helpful in determining target areas for prescribed burns by identifying which regions have not experienced a recent burn, yet might host a sufficient seed bank of such species (Barbara Geringer, personal communication, January 27, 2014).

American River Conservancy

SVC data does not cover the full extent of the region in which the American River Conservancy works. A representative of the conservancy indicated that the data would be particularly useful for high-elevation meadows in the Sierra Nevada, where the available coarse-resolution FRAP data is not sufficient for conservation planning, parcel acquisition, or assessment of development impacts. The projects that the conservancy undertakes in this area are very time consuming because they must interpret satellite imagery to create a map and cross-reference it with their on-ground knowledge of the area (Elena DeLacy, personal communication, November 1, 2013).

Multiple lawsuits regarding CEQA violations occur each year in California. Fine-scale vegetation datasets may help prevent errors leading to such lawsuits. For example, El Dorado County is in the process of re-creating its Oak Woodland Management Plan after CEQA violations were discovered. According to the American River Conservancy, the Oak Woodland Management Plan used USFS Calveg layers to identify "Important Oak Woodland Habitat." However, this layer underestimated the extent of the "Important Oak Woodland Habitat," since it did not accurately reflect the conditions on the

Many users of non-SCV datasets have experienced a reduction in work output or have achieved less accurate results than would have been possible with high-resolution data.

ground. An SCV dataset would contain detailed information concerning the age and species composition of oak woodlands and would be more likely to identify areas in need of protection. Thus El Dorado County would most likely have avoided the costly processes of litigation and re-implementation of the Management Plan (Elena DeLacy, personal communication, November 1, 2013).

Conservation Biology Institute

The Conservation Biology Institute in San Diego County is collecting vegetation data for four current projects, as it lacked sufficiently detailed datasets. The institute expressed a need for more detailed maps in order to find vegetation correlates for rare species, to conduct climate change analyses, and to monitor and manage species at the preserve level. If a dataset meeting these requirements were available, they would save considerable time and money by eliminating the data collection and mapping processes (Patricia Gordon-Reedy, personal communication, November 4, 2013).

Strategic Growth Council

Mike McCoy, Executive Director of the Strategic Growth Council, indicated that a comprehensive high-resolution vegetation dataset would be extremely useful for the development of the proposed high-speed rail system (the Bakersfield to Palmdale stretch in particular). The developers could use the dataset to expedite the site selection process, eliminating areas that should be avoided and indicating those that need further examination, thus reducing the number of sites that need to be physically surveyed. According to the council, the interagency working group would like to expedite preparation for the high-speed rail by using a high-quality vegetation map (Mike McCoy, personal communication, October 24, 2013).

California Department of Transportation

If available, the California Department of Transportation (Caltrans) could employ a high-resolution dataset during the scoping process to calculate impacts from development at different potential work sites. With such data, they may not have to conduct scoping field studies for each project or spend time digitizing maps from aerial imagery (Ed Schefter, personal communication, March 20, 2014). Caltrans could utilize SCV data to assist with road alignment projects in order to avoid sensitive species or habitats, such as vernal pools. Caltrans is also developing an Environmentally Sensitive Area (ESA) database to help their workers avoid trampling sensitive species during routine maintenance. High-resolution vegetation data would be very helpful in the continued development of this database (Dana York, personal communication, February 13, 2014).

AECOM

While AECOM was creating the SCV-compliant map of San Diego County, they received several requests from individuals working on the Regional Transportation Plan, inquiring if the dataset would be

available soon. Lacking the dataset, these individuals were forced to piece together missing project data to produce vegetation information for the Transportation Plan using inefficient processes and imprecise assessments (Jonathan Dunn and Tom Oberbauer, personal communication, November 18, 2013).

GreenInfo Network; California Invasive Plant Council

GreenInfo Network believes that a fine-scale vegetation dataset would be beneficial for invasive species monitoring and management, as it would allow them to pick out the typical invasive plants associated with each vegetation alliance (Larry Orman, personal communication, November 11, 2013). Similarly, the California Invasive Plant Council indicated that if higher-resolution data were available statewide, it would be useful in helping them prioritize habitats for protection efforts (Dana Morowitz, personal communication, January 9, 2014).

Information Center of the Environment at University of California, Davis

According to the Information Center of the Environment at UC Davis, the fine-scale classification of SCV datasets would be very useful for the North Coast Mitigation Project on Highway 101. It could be beneficial for predicting the impact of the development project on the species and ecosystems in that area. Additionally, it could be valuable for looking at nitrate contamination in groundwater in riparian areas (Karen Beardsley and Patrick Huber, personal communication, October 7, 2013).

California Energy Commission

The California Energy Commission's (CEC) Research and Development division funds species-distribution modeling in various parts of the state, some of which do not have a high-resolution vegetation dataset available. According to the senior biologist of the CEC, the quality of these models would be enhanced by a detailed and comprehensive vegetation dataset (Misa Milliron, personal communication, October 11, 2013).

Agroecology Research Group at University of California, Berkeley

Houston Wilson, a Ph.D. candidate in the Agroecology Research Group at UC Berkeley, indicated that high-resolution vegetation data would be helpful for agricultural pest control efforts. Certain pest species, such as Anagrus wasps, often invade cropland and vineyards adjacent to natural vegetation, yet have only a few host plant species. High-resolution data is necessary to determine if these host species are present in the vicinity of an agricultural plot. Coarse-resolution maps present only a gross assessment of the natural vegetation types in the vicinity and do not permit the isolation of single species (Houston Wilson, personal communication, February 13, 2014).

The User Community Survey

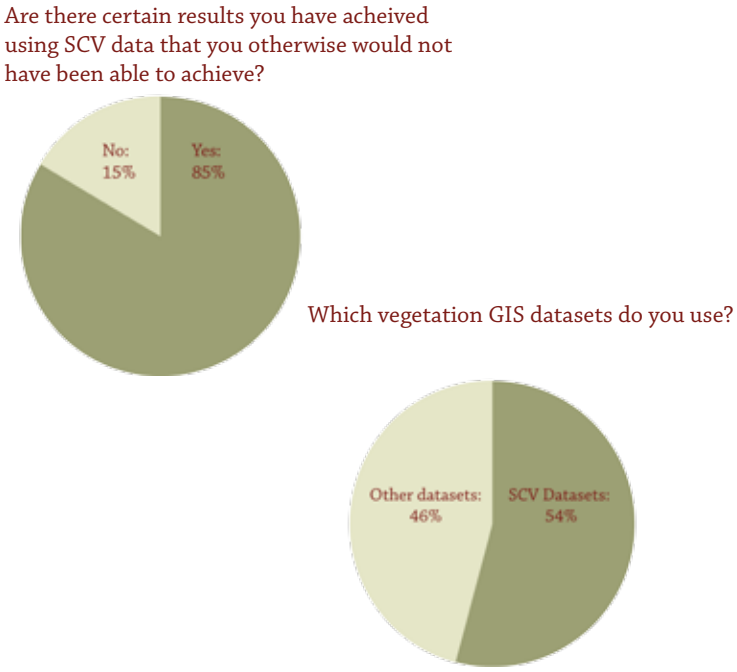
The detailed information acquired during personal interviews was augmented by an online survey that was presented to the current and potential vegetation GIS user community. Specifically, the survey sought to ascertain the various uses of SCV data, to determine user opinions regarding the utility and usefulness of the data, to identify dataset preferences, and to obtain information regarding the most important attributes contained within the dataset. A total of 48 individuals responded to the survey. Respondents represented various agencies and organizations, including state and federal agencies, private consultants, universities, and nonprofit organizations.

Users who did not have SCV data coverage in their region almost unanimously indicated that such data would be more useful to their organization than their current vegetation data and would result in a more efficient use of time.

The results of the User Community Survey provide a broad understanding of the overall need for a statewide SCV dataset by identifying users and determining how they use the dataset. SCV data was found to be used for more than a dozen different applications (Figure 7). The user survey conclusively found that SCV datasets were viewed as advantageous over other datasets, and provided a variety of benefits to users. Some of the main advantages cited by respondents include an increased confidence in the accuracy of the data, improved output and higher-quality final products, time efficiencies and monetary savings, and increased productivity (Figure 8).

Respondents were largely dissatisfied with other vegetation datasets, mentioning inadequate spatial resolution, obsolescence, inappropriate or unsuitable attributes for their purposes, and undesirable level of vegetation classification. Users who did not have SCV data coverage in their region almost unanimously indicated that such data would be more useful to their organization than their current vegetation data and would result in a more efficient use of time.

Please refer to Appendix A for detailed results of the online user survey.



Uses of SCV data

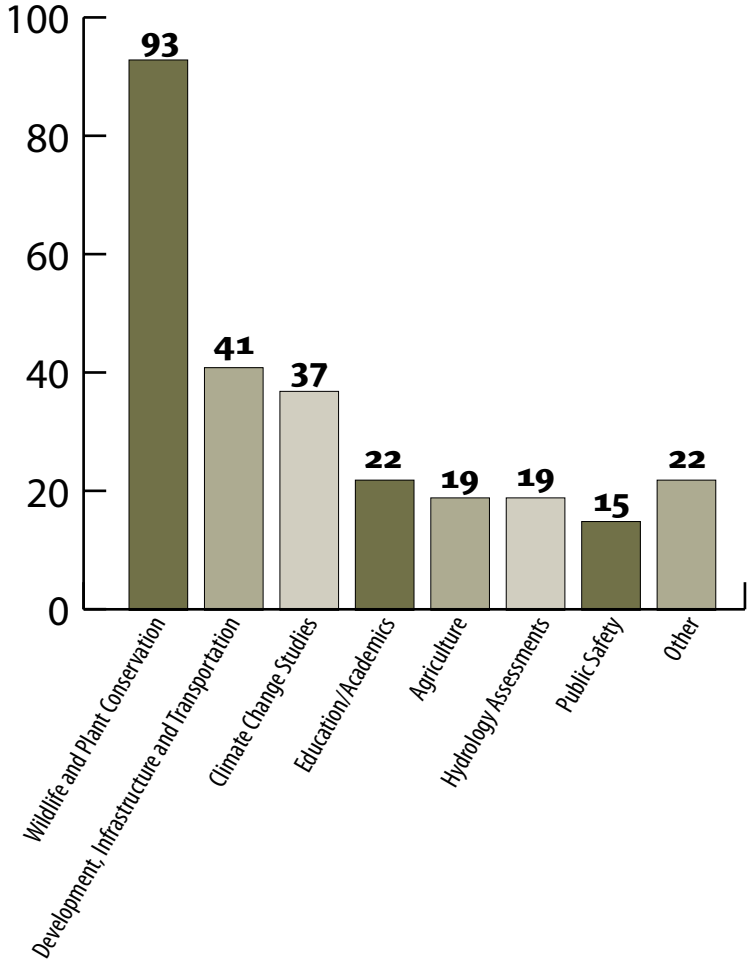


FIGURE 7

Survey resspondents were asked how they use SVC datasets and could choose as many categories as applied to them. This chart shows the percentage of users who chose each category.

Ways in which SCV data improves user success

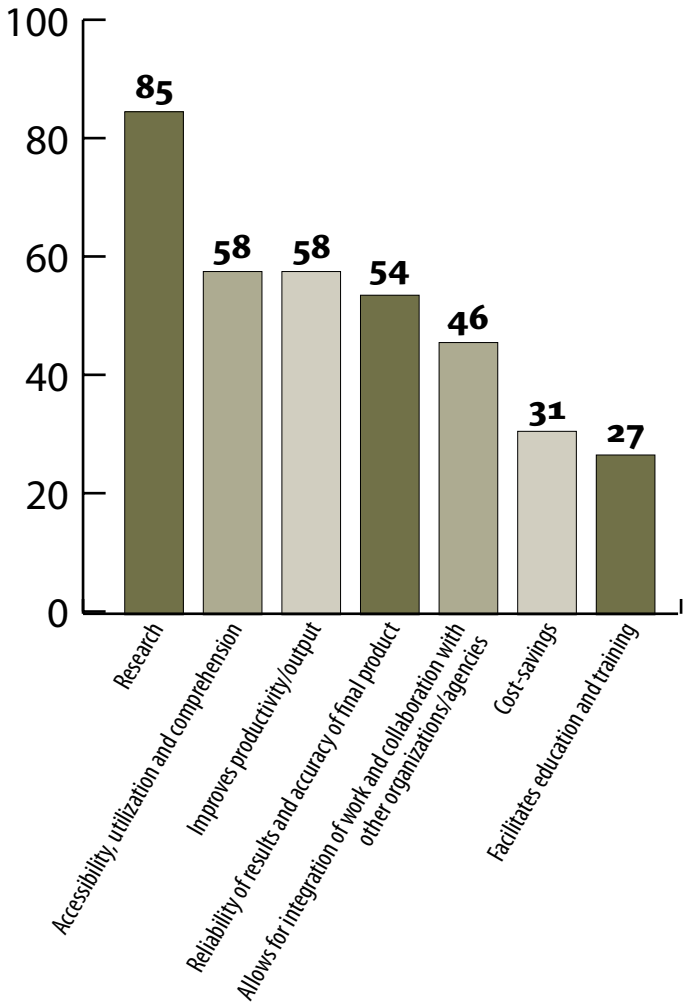


FIGURE 8

Survey resspondents were asked how SVC data improves the success of their projects and could choose as many categories as applied to them. This chart shows the percentage of users who chose each category.

ECONOMIC JUSTIFICATION

Basic Principles of Benefit–Cost Analysis

As the previous section demonstrates, there is strong demand for a statewide high-resolution vegetation map among public and private institutions in California, and the uses of the map are many. The statewide map is expected to yield significant economic benefits for its users. This section presents estimates of those benefits as well as cost estimates for producing the map. There is robust evidence that a statewide high-resolution vegetation map is a good investment for the State of California.

A standard procedure for evaluating the merits of public expenditures is benefit–cost analysis. Simply put, a high-resolution vegetation map is economically justified if its long-term benefits outweigh its cost. One fundamental challenge, however, is to identify, quantify, and monetize the potential benefits that will be realized by a wide variety of users over a period of several years.

Some map benefits may be straightforward to measure (e.g., labor cost savings for Los Angeles County), while others may be more elusive (e.g., the ability to make better decisions at Caltrans). For specificity, the benefits of a high-resolution vegetation map can be placed into one of three broad categories: 1) quantifiable benefits (such as increased work productivity, fewer site visits, etc.), 2) tangible but difficult-to-quantify benefits (such as enhancement of basic scientific research, more accurate information for decision making, or reduced impact to natural resources from land development), and 3) nonmonetary benefits (such as the preservation of plants and wildlife for their intrinsic value and public goodwill). The next section presents examples of some of these quantifiable benefits, difficult-to-quantify benefits, and intangible benefits. Only the quantifiable benefits can be monetized and used in a benefit–cost analysis, although benefits falling into categories 2 and 3 are valid and important.

If the quantifiable benefits exceed the costs, a high-resolution vegetation map is economically justifiable and would be a good investment. Many clear benefits of a statewide high-resolution map cannot be reliably estimated but, when combined with myriad intangible benefits, strengthen the argument for a statewide map. The next section presents a series of examples that demonstrate clear cost savings, which are then extrapolated statewide.

Benefit–Cost Analysis

In order to estimate a return on investment for producing a statewide dataset compliant with Survey of California Vegetation standards, it is first necessary to identify the estimated costs of completion. Bearing in mind that approximately 42 percent of the state has been previously mapped to SCV standards, costs are estimated for the remaining 58 percent of California. This section will provide the map completion cost range provided by VegCAMP and discuss how advances in mapping technology, increased knowledge and information, and improved productivity can be leveraged to bring completion costs closer to the lower end of the estimated range.

Explanation of Costs

VegCAMP estimated the range of mapping costs by assessing two different factors related to the cost of production: 1) the estimated extent of different vegetation life forms and land use types across California, and the historical and current per-acre cost of mapping, and 2) incorporation of revised mapping and classification methodologies that create time and cost efficiencies and increase productivity.

The principle costs of all vegetation mapping projects include field data collection, vegetation analysis and description development, field reconnaissance and map production, and assurance of map accuracy through application of the classification rules. The resulting product is affected by what is effectively mappable based on the limitations of time, cost, and the resolution of the imagery and other information sources.

Cost Scenarios

The three scenarios presented below identify the potential range of costs associated with SCV map completion for the unmapped areas of the state.

Scenario	Cost
Low-Cost	$45,000,000
Mid-Cost	$56,000,000
High-Cost	$75,000,000

The high-cost scenario to complete the map is based on known current costs and efficiencies of scale. Economies of scale will help streamline the completion of the SCV map. It is less costly for one entity to produce a vegetation map for a geographic region than for multiple entities to produce several maps that comprise the region. Such cost savings stem from the sharing of overhead costs and the fact that the cost per acre decreases when mapping larger areas versus smaller ones. Economies of scale can best be attained if contracts can be established with a single mapping firm to produce maps in similar ecoregions. The amount of time required to complete the additional mapping can also be reduced by employing qualified vegetation mapping firms that have approved track records in meeting mapping accuracy standards.

Vegetation classification and mapping projects can take two or more years to complete using the current piecemeal approach, and accuracy assessment may take a similar amount of time. Economies of scale and reductions in map redundancy are quantifiable benefits of producing a single map. If funding continues for smaller areas on a project-by-project basis, the costs will be higher than the high-cost scenario.

The mid- and low-cost scenarios assume, to varying degrees, efficiencies that are being evaluated through recently completed, ongoing, or proposed projects, in addition to substantial economies of scale that are likely to fall into place once these refined efficiencies are implemented. Improved efficiencies are currently being explored using three basic avenues:

1) Greater reliance on automation
2) Reduced intensity classification and field effort
3) Improvements in technology

Automation

Automation (computer-modeled decisions on spatial delineation, typological, and structural attributes) can provide myriad time-saving benefits when compared to manual mapping on a polygon-by-polygon basis. For decades, there have been attempts to use computer analysis to improve upon the manual techniques of aerial photo interpretation of vegetation. Computer programs have been developed that analyze information in the spectral signatures of remote imagery and correlate those signatures with patterns of vegetation as described from field sampling sites. One of the limiting issues surrounding the application of automated methods was the lack of high-resolution imagery, but this imagery has recently become available. The Sonoma County Agricultural Preservation and Open Space District is beginning a vegetation map of the one-million-acre county that will rely on automated mapping; this map will serve as a test case for the entire state.

Reduced Intensity Classification and Field Effort

A reduced intensity classification and field effort approach will rely on existing SCV-compliant datasets to guide mapping efforts in a new area. The existing dataset will provide a well-developed, field-based vegetation classification and extensive map Accuracy Assessments (AAs). There are two scenarios for the methodology: building on existing knowledge and seed mapping.

The first scenario relies upon a vegetation classification and AA from a completed project, so substantial adjacent areas can be mapped without requiring significant additional data collection and analysis. More than 20 percent of the land mass has already been classified and mapped for 13 of the 18 ecoregions defined by Miles and Goudey (1997); these ecoregions are likely to be candidates for reduced intensity classification and accuracy assessment. Five of those ecoregions (Mojave Desert, Southeastern Great Basin, Sierra Nevada Foothills, Great Valley, Sonoran Desert) are more than 50 percent mapped already and are expected to need even less intensive classification and map accuracy efforts (Figure 9).

The second scenario applies to areas where little data collection or mapping has been completed. In those places, a representative "seed" map and classification area will be chosen for each ecoregion in the map range. The seed areas will be chosen to represent the full range of ecological settings of a given ecoregion and therefore encompass the vegetation types in it; they will span the diversity of vegetation in the map range, but will cover only a portion of the full area. The seed areas will be sampled, classified, mapped, and tested for accuracy at a high level. Once the seed areas are completed, the balance of the areas can be mapped at reduced costs, as in the first scenario. VegCAMP is currently beginning a pilot study of the seed mapping approach.

Improvements in Technology

Finally, cost reduction will undoubtedly come from improvements in technology such as advances in computer hardware and software, the availability of Unmanned Aircraft Systems (UAS, or drones), and new remote imagery sensors. VegCAMP is currently studying the use of UAS with the U.S. Geological Survey to collect very high-

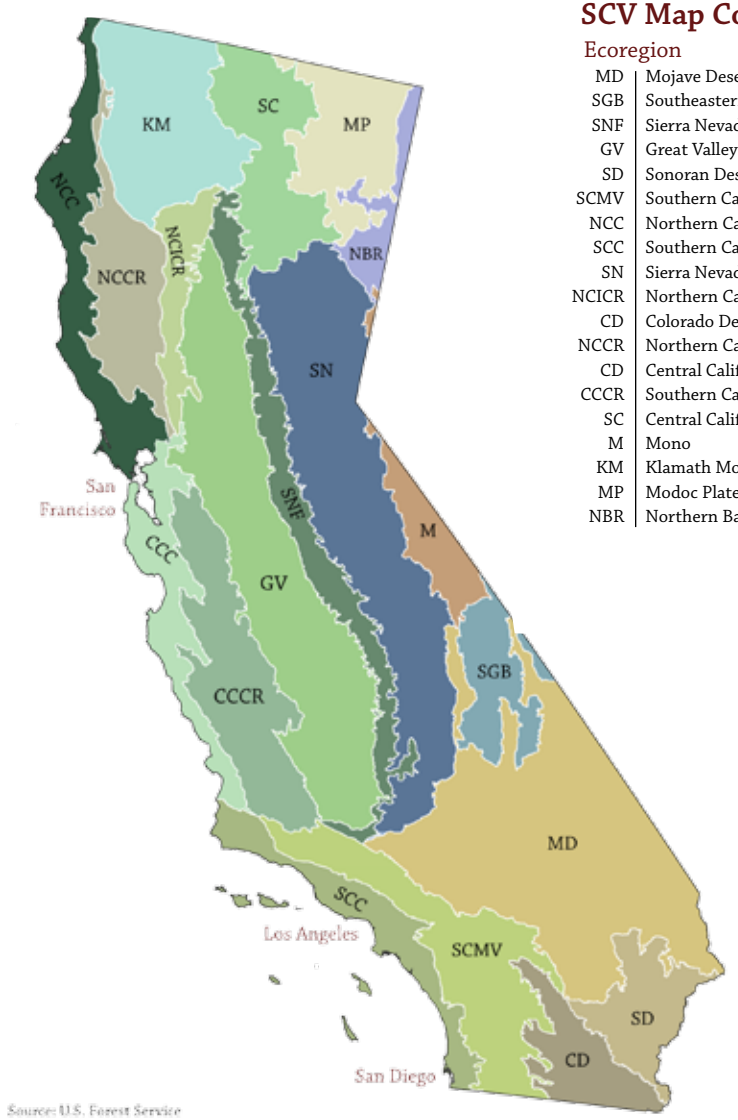
resolution imagery to save significant field effort in collecting accuracy assessment data.

Savings

Developing a high-resolution vegetation map for the State of California will benefit state, regional, and local economies by creating economic savings and benefits through multiple means. The identification of cost savings are best realized through real world experiences and lessons learned. Extensive user community interviews have identified robust examples of cost and time savings that would result from the development of a statewide SCV dataset. These savings have been grouped into three general categories: 1) Satisfying California Environmental Quality Act/National Environmental Policy Act requirements, 2) broad-scale projects, and 3) project-centered mapping.

Satisfying California Environmental Quality Act/National Environmental Policy Act Requirements

The process of satisfying California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) requirements is costly for both public and private entities, and this process occurs frequently and extensively throughout the state. The application of SCV data to regional/programmatic environmental assessments provides difficult-to-measure benefits, however the effects of using SCV data in site-specific assessments can be measured and will be used to illustrate savings and benefits.



SCV Map Completed by Ecoregion

Ecoregion		Percent Mapped
MD	Mojave Desert	89.9
SGB	Southeastern Great Basin	80.7
SNF	Sierra Nevada Foothills	58.6
GV	Great Valley	57.2
SD	Sonoran Desert	53.8
SCMV	Southern California Mountains and Valleys	34.4
NCC	Northern California Coast	30.5
SCC	Southern California Coast	21.9
SN	Sierra Nevada	18.4
NCICR	Northern California Interior Coast Ranges	16.2
CD	Colorado Desert	12.8
NCCR	Northern California Coast Ranges	10.8
CD	Central California Coast Ranges	10.5
CCCR	Southern Cascades	3.8
SC	Central California Coast	3.7
M	Mono	2.4
KM	Klamath Mountains	0.8
MP	Modoc Plateau	0.2
NBR	Northern Basin and Range	0.0

FIGURE 9
Ecoregions of the state, with percentage currently mapped

The CEQA process can be classified into several categories, each one involving multiple stages, such as the Initial Study and the development of an Environmental Impact Report (EIR) or Mitigated Negative Declaration. During the Initial Study stage and the development of a site-specific EIR, an environmental setting statement often utilizes a vegetation map to describe a site's natural features. When a sufficiently detailed map is not available, public agency planners or private companies (whoever is responsible for the EIR) may need to either utilize an in-house biologist/mapping specialist or hire an environmental consultant to survey the site in question and produce a map. Communications with environmental consultants indicated that if a vegetation dataset meeting SCV standards were available, their time spent on vegetation map preparation would be reduced.

Jennifer Holton of Streamscape Environmental produces vegetation maps that clients use for Initial Studies and for potential mitigation analysis research. She often starts with an existing vegetation map as a base, uses aerial photo interpretation and ground surveys to supplement and revise existing information, then edits the vegetation map as needed. She stated that the availability of a high-resolution dataset such as an SCV map could reduce time spent on these tasks by approximately 50 percent. As she works about ten hours per week editing and creating vegetation datasets, she assumes she would save about five hours per week. From a client's viewpoint, if she saved five hours per week, at $50 per hour, this would result in $250 per week of savings (Jennifer Holton, personal communication, 2014).

Jane Valerius of Jane Valerius Environmental Consulting also confirms that savings of up to 50 percent could be realized with the availability of an SCV dataset when creating and editing vegetation maps for use in site-specific EIR projects. Based on a billing rate of $115 per hour this could save anywhere from $230-$575 per week for her clients, which are typically small cities and towns, and local agencies such as Sonoma County Regional Parks (Jane Valerius, personal communication, 2014).

At Aspen Environmental Consultants, Scott White confirmed that they could save approximately 10 percent of the time required to produce an accurate vegetation map for a site-specific EIR by reducing the number of on the ground site visits (Scott White, personal communication, 2014).

According to AECOM, a biological consulting firm that has assisted in developing high-resolution vegetation datasets, small cities and other agencies without an in-house biologist often spend $100,000 on consultant contracts for CEQA-related assessments (Jonathan Dunn and Tom Oberbauer, personal communication, November 18, 2013). AECOM suggested that a high-resolution vegetation layer could eliminate the need for detailed mapping on a project-by-project basis (Michelle Fehrensen, personal communication, April 3, 2014).

Over 14,000 projects for which environmental documents (e.g. CEQA Initial Studies, Mitigated Negative Declarations, EIRs, and joint CEQA/NEPA Environmental Assessments and Environmental Impact

Statements) have been filed during the years 2007 through 2013 have addressed biological issues, according to the State Clearinghouse (Christine Rodriguez, personal communication, April 29, 2014). Many of these could be addressed more efficiently with fine-scale vegetation data such as the SCV provides. Of the 2,128 EIRs filed within this time frame, approximately 64 percent involved biological resources and would have benefited from SCV data. By reducing the number of periodic, piecemeal, and often overlapping mapping efforts required for large-scale environmental review processes, the statewide SCV map will result in significant savings for cities, counties, and other government agencies. Addressing this issue will assist in avoiding the redundant and inefficient use of public and private funds.

Broad-Scale Projects

The use of an SCV dataset can provide another significant benefit in the form of cost savings for broad-scale development and conservation projects. The state frequently spends a substantial amount of money in both the planning and permitting/reporting processes during the course of these projects, and SCV data can help reduce these costs.

Caltrans staff stated that enormous cost savings could be realized by limiting the time and scope of environmental impact analysis work required for sensitive large-scale projects such as road placement and realignment. For example, Caltrans staff can greatly reduce the amount of time they spend in the field for environmental analysis by guiding biologists directly toward resources of concern. Caltrans estimates it would reduce time spent in the field by about 200 hours per project per year, resulting in a savings of approximately $20,000 per project per year (Dana York, personal communication, 2014). Ed Schefter, another Caltrans staff member, estimated that the research dedicated to the vegetation aspect of a development project generally accounts for about 10 percent of the project's environmentally-related budget. Should the agency have access to a layer such as the SCV map, they might be 50 percent more efficient with their analysis, resulting in a 5 percent savings for environmentally related costs of the project (Ed Schefter, personal communication, March 20, 2014).

BLM staff hired Aspen Environmental Group to create a vegetation map for the Desert Harvest Solar Farm Project, a large solar project development on approximately 1,200 acres of desert habitat in Riverside County. Due to the absence of high-resolution, current, accurate vegetation data, Aspen Environmental had to create the map from scratch. According to both Scott White at Aspen Environmental Group and Mark Massar at BLM, the availability of a dataset such as the SCV could have potentially saved 50 percent of the mapping cost (Scott White and Mark Massar, personal communication, 2014). Frank McMenimen, Project Manager at the BLM Palm Springs office, stated that the cost of a special or standard biological/plant/wildlife survey such as this one averages between $1.8 and $2 million, which indicates that a potential savings of approximately $1 million could have been realized (Frank McMenimen, personal communication, 2014).

Even under the most conservative scenario, the quantifiable benefits of completion of the statewide SCV map are expected to exceed the costs of producing the classification and map. If the difficult-to-measure and nonmonetary benefits were included, the SCV's estimated value would be further strengthened.

The Desert Renewable Energy Conservation Plan (DRECP) required the development of a seamless vegetation map covering the extent of the project. For the first two years of the project, such a map did not exist, and needed to be stitched together from a variety of disparate, out-of-date and, in some cases, inaccurate sources with inconsistent resolutions and differing vegetation classification schemas. Planners and consultants spent hundreds of hours in discussions and map development, and expended a significant amount of money piecing together their best effort at a vegetation map that was eventually replaced by an SCV dataset.

Project-Centered Mapping

In the absence of a completed statewide SCV map, many regions in the state are left with inaccurate, generalized, and out-of-date vegetation data. As a result, agencies and organizations are often required to produce their own vegetation maps on a project-by-project basis. Often, these vegetation maps do not conform to state standards and at times they unintentionally overlap in extent, and may cost more to produce as well.

Jennifer Holton at Streamscape Environmental has worked on numerous site-specific vegetation mapping projects; within a four-month period, she worked on over ten vegetation mapping projects (personal communication, 2014). Staff at AECOM stated that they have worked on at least four broad-scale vegetation mapping projects (Jonathan Dunn, personal communication, 2014), and Scott White at Aspen Environmental estimates his company completes approximately ten vegetation mapping projects per year (personal communication, 2014). Individual map production requires significant oversight, enforcement of standards, and quality control. Should these estimates be extrapolated out to consultants and agencies across California, one can begin to envision the economic effect of the project-by-project mapping efforts that are occurring.

Net Benefits and Return on Investment

The statewide SCV map will produce monetary benefits to organizations and agencies across California. Benefits are presently being realized where SCV-compliant maps have been completed, but the level of current and future benefits is still uncertain. Over time, state agencies will gain experience with the maps and gather useful quantitative information, which will help to measure the various benefits of SCV datasets. Only after a suitable time period has elapsed will a thorough evaluation of the map's benefits be possible. Thus, the monetary value of benefits must be estimated and forecast into the future using conservative methods and assumptions.

The benefits of the SCV will be widespread, and the estimates presented here reflect only a partial accounting of expected future benefits. Only the most easily quantified categories of benefits are considered. Nevertheless, even under the most conservative scenario, the quantifiable benefits of completion of the statewide SCV map are expected to exceed the costs of producing the classification and map. If the difficult-to-measure and nonmonetary benefits were included, the SCV's estimated value would be further strengthened.

As already mentioned, cost savings will account for a significant portion of the map's benefits. Examples of such cost savings include fewer site visits by biologists, increased efficiency of GIS users, and elimination of redundant and incompatible mapping efforts. Although these specific cost savings cannot be separately identified, they can be estimated using survey results and a set of reasonable assumptions. The estimated benefits of the SCV map depend on three key parameters:

1) The number of map users and the growth rate of users
2) The average hourly wage of map users
3) The number of annual hours the SCV map will save users

For example, one map user earning $50 an hour saving 100 hours per year translates into an annual benefit of $5,000. Extrapolating this calculation across all users over the lifetime of the SCV map yields the total estimated benefits of the map.

Values of the three key parameters are listed in Table 1, and are further separated by user type: public agency employees and private consultants. In addition, three sets of parameter values are considered: conservative, moderate, and optimistic. Using different sets of parameter values produces a sensitivity analysis, which shows how the estimates respond to changes in the values.

The moderate parameter values were derived from user surveys and other research. For public agencies, it is assumed that each state agency, city, and county has one SCV user, for a total of 707 users. Some of these entities may have more than one user and some may have none, but the parameter value represents a statewide average. The hourly wage for public users is the average wage across different levels of environmental planners and biologists in California. Finally, the number of hours saved per user is based on figures provided by Caltrans biologists.

TABLE 1

Benefit–cost analysis scenario assumptions

Public Agencies and Planners			
Parameter Values	**Users**	**Average Hourly Wage**	**Hours Saved per User**
Conservative	650	$25.00	150
Moderate	707	$50.00	175
Optimistic	750	$75.00	200
Private Consultants			
Parameter Values	**Users**	**Average Hourly Wage**	**Hours Saved per User**
Conservative	1,000	$50.00	90
Moderate	1,200	$85.00	100
Optimistic	1,400	$100.00	110

The number of private consultants is derived from four county-level lists of recommended CEQA consultants specializing in biology. San Diego, Riverside, Yolo, and Solano counties provided the lists, which were then extrapolated statewide. The average consultant wage and number of annual hours saved are based on interviews with two private consultants who use vegetation maps regularly.
The outcomes under the three different sets of parameter values (conservative, moderate, and optimistic) are based on a range of values for the three parameters mentioned above. There will inevitably be some variability in the estimated values of these parameters across agencies and locations, and the final estimated benefits represent an interval of likely outcomes. Thus the conservative estimates can be considered a lower bound to the benefits of the SCV map.

Three different cost estimates for completion of a statewide vegetation map to SCV standards were used (Table 2). The low-cost scenario implies that all of the most efficient cost-saving approaches and future technologies will be used for field data collection, classification, mapping, and accuracy assessments. The high-cost scenario would be based on no assumed economies of scale, as each project would involve its own unique classification and mapping effort. The mid-cost scenario would integrate methodologies from the other two scenarios.

It is necessary to account for the fact that the statewide SCV map will provide a stream of benefits (and costs) into the future. So when comparing benefits and costs that occur over many years, one must take into account the time value of money. In other words, a dollar received today is more valuable than a dollar received in the future because of uncertainty and the opportunity cost of investment. Converting the value of dollars received in the future into current dollars is called discounting and the procedure requires a discount rate. The discount rate measures the degree to which dollars received

TABLE 2

Financial outcomes across scenarios

Low-Cost Scenario ($45,000,000 completion cost)					
Parameter Values	**Benefits**	**Costs**	**Net Benefits**	**Benefit-Cost Ratio**	**Return on Investment**
Conservative	$72,756,623	$44,669,057	$31,087,566	1.75	75%
Moderate	$170,731,966	$41,669,057	$129,062,909	4.10	310%
Optimistic	$274,573,665	$41,669,057	$232,904,608	6.59	559%
Mid-Cost Scenario ($56,000,000 completion cost)					
Parameter Values	**Benefits**	**Costs**	**Net Benefits**	**Benefit-Cost Ratio**	**Return on Investment**
Conservative	$72,756,623	$51,854,827	$20,901,797	1.40	40%
Moderate	$170,731,966	$51,854,827	$118,877,140	3.29	229%
Optimistic	$274,573,665	$51,854,827	$222,718,838	5.30	430%
High-Cost Scenario ($75,000,000 completion cost)					
Parameter Values	**Benefits**	**Costs**	**Net Benefits**	**Benefit-Cost Ratio**	**Return on Investment**
Conservative	$72,756,623	$63,264,987	$9,491,636	1.15	15%
Moderate	$170,731,966	$63,264,987	$107,466,979	2.70	170%
Optimistic	$274,573,665	$63,264,987	$211,308,678	4.34	334%

Note: The completion costs for each scenario ($45, $56, and $75 million) are presented as nominal amounts. Completing a statewide map, however, is expected to take between 5 and 10 years, so some costs will be incurred in the future. Thus the estimated costs presented in column three of the above tables are discounted to 2014 dollars using an annual rate of 4 percent.

in the future are valued less than those received today and it is usually expressed as a percent. For this analysis the discount rate is set at an industry accepted standard of 4 percent. Finally, it is also assumed that the number of SCV users will grow at a rate of 3 percent annually and that maintenance costs will increase 2 percent annually.

There are several useful metrics for gauging the desirability of public projects like the completed SCV map of California. They are: 1) net benefits, 2) benefit–cost ratio, and 3) return on investment. The three measures are similar, but not equivalent, and the formulas are listed below. For simplicity it is assumed that the benefits and costs are measured in present dollars, i.e. they have been discounted.

Net Benefits = Benefits - Costs
Benefit–Cost Ratio = Benefits / Costs
Return on Investment = ((Benefits - Costs) / Costs) * 100

Table 2 presents the estimates for each of the three cost scenarios. The cost figures are those described earlier. In each of the cases, the benefits exceed the cost of producing the map; although under the conservative scenario, the net benefits are small but still positive. The moderate scenario, which used parameters based on the user community survey and other research, shows large returns; the benefits are more 2.5 times larger than the costs. The moderate scenario is considered to be the most likely outcome, as the associated parameter values are most strongly supported by the survey data and the interview responses. It is important to note that the scenarios identified below are based on unknown or hard-to-predict factors, hence the range in outcomes. These are not three different levels of work that could be funded, but rather an estimate as to potential returns on investment depending on cost and incorporation of efficiencies.

These estimates suggest that the benefits related to cost savings are large and exceed the map creation costs. Including other benefits that are difficult to quantify will further increase net benefits and return on investment.

Difficult-to-Measure and Nonmonetary Benefits

Survey of California Vegetation maps and data provide a variety of benefits to a wide range of agencies and organizations throughout the State of California. Some of these benefits, however, are inherently difficult to measure or are nonmonetary. Although such benefits cannot be measured in monetary terms, they do represent real value to the state.

Difficult-to-Measure Benefits

The statewide SCV map is expected to benefit California by reducing costs. Some costs, however, are difficult or impractical to measure. Vegetation map user survey results show that a host of organizations and agencies throughout the state will benefit from open access to a comprehensive, high-resolution dataset. Openly accessible data saves time by allowing organizations to utilize existing information resources (Transportation Research Board, 2004). For some projects,

Benefits

- *Foster collaboration and communication among agencies and organizations*
- *Reduce costs associated with consulting services*
- *Avoid redundant and overlapping mapping efforts*
- *Reduce errors in project planning and execution*
- *Reduce or avoid CEQA litigation*
- *Optimize resource management practices*
- *More efficiently utilize scarce resources and expedite processes*
- *Provide more accurate and reliable end products*
- *Support intrinsic value of California's wild flora and fauna*

especially ones that do not involve development, openly accessible data will eliminate the need to produce a detailed vegetation map. Since vegetation classification and mapping projects can take two or more years to complete using the current piecemeal approach, and subsequent accuracy assessments may take a similar amount of time, this could reduce the duration of a project by several years.

Collaboration among organization and agencies can be facilitated by a statewide high-resolution vegetation dataset. For example, Ventura County will be conducting an Environmentally Sensitive Habitat designation project in parts of the Santa Monica Mountains. Because Ventura County will be using SCV data for this area, they can collaborate with the California Coastal Commission, who has experience working with the dataset (Jonna Engel, personal communication, 2013). Ventura County will realize operational efficiencies and cost savings that they would not have received without this data. In addition, many local, regional, and state agencies are tasked with regional or landscape-level projects, often extending beyond their jurisdictions. Conserving species and landscapes, building habitat corridors, evaluating the relative importance of conservation sites, etc., all rely upon a seamless and standardized set of vegetation data (along with other seamless geographical data such as transportation infrastructure and conserved areas). SCV data facilitates coordination among agencies involved in such cross-jurisdictional projects, and will ultimately result in more efficient use of funds.

A statewide vegetation dataset can reduce redundant data collection and mapping, resulting in savings in cost and time (Transportation Research Board, 2004). Poor coordination between agencies results in unnecessary duplication of effort, higher costs, and products that cannot be readily used by others (California Biodiversity Council, 2000). Currently, communication between agencies during the mapping process is limited and public records of past surveys and mapping products are not readily available. SCV data is centralized and openly accessible, thereby eliminating unnecessary duplication in future mapping efforts.

Users of geospatial vegetation data have found that high-quality data can help reduce mistakes made in project planning and execution. It is difficult to estimate the cost of mistakes that would have occurred in the absence of a high-quality vegetation map, but they can be significant. For example, regulatory agencies may require an organization to completely reinstate a management plan, relocate infrastructure, or conduct various mitigation efforts if it finds that a mistake has been made that impacts the environment. Each year, approximately 25-30 CEQA-related lawsuits occur in California, often initiated due to erroneous information in environmental management plans and EIRs. An agency would incur substantial litigation costs if taken to court. Including a quantified accuracy assessment (an element of an SCV-compliant map) in management plans removes the debate surrounding data quality, and may prevent a CEQA-related lawsuit. Statewide SCV data will better inform management and

development practices, and will help many organizations avoid costly lawsuits in the future.

A statewide SCV map can also optimize natural resource management, as there are hundreds of government agencies tasked with managing and maintaining California's environmental resources. Statewide high-resolution vegetation data will clearly indicate locations of sensitive habitats and conservation efforts can be focused in those areas. With a comprehensive SCV dataset, many real cost savings will result from coordinated conservation practices and natural resource management. The state will save money as a result of a healthier environment. For example, decreased land degradation and improved invasive species control can reduce spending related to habitat restoration, erosion control, water quality management and agricultural pest control.

Nonmonetary Benefits

Some benefits of SCV data are inherently nonmonetary and occur as an indirect result of high-resolution mapping work. Chief among these benefits are the identification and preservation of natural resources and ecosystems, which many consider to be invaluable. SCV data will promote better management of natural resources and will help to preserve wildlife and wild lands for future generations. Additionally, SCV data will help to preserve and enhance the recreational value of these lands. Healthy, uncompromised landscapes attract outdoor enthusiasts, tourists, and families, promote healthy and active lifestyles, and set the stage for quality outdoor and environmental education programs.

A statewide SCV dataset will establish a common communication base among agencies and organizations. Shared data provides a basis for common understanding and decision making, giving each agency a greater awareness of the issues affecting other agencies (Transportation Research Board, 2004). The completed SCV map will give state agencies a "common language" for describing vegetation communities, resulting in less time spent interpreting and adapting disparate data. This common communication base can help streamline the many complicated stages of environmental review and regional conservation and mitigation planning processes, which require the collaboration of many agencies and individuals.

SCV data will promote better management of natural resources and will help to preserve wildlife and wild lands for future generations.

NEXT STEPS

Completion of the Survey of California Vegetation Map

Development of a process to expedite the completion of a statewide Survey of California Vegetation classification and map is a singularly important goal. The values of the methods and products discussed in this report can only be fully realized if the entire state is completed at the same resolution and accuracy. It is also important to develop this statewide dataset over a relatively short period of time since "currency" for statewide assessment is quickly changing due to development pressures and the effects of climate, fire, and other processes.

Based on our research, we emphasize that the rate of vegetation mapping should increase significantly for two reasons: 1) to serve the growing needs of vegetation map users, and 2) to ensure that the mapping already completed in over 42 percent of the state remains valid and useful. SCV-compliant vegetation mapping began in 1998, and mapping efficiencies in terms of acres mapped have doubled from the period 1998–2007 versus the period from 2007 to the present. This is primarily due to greater funding for projects with a more ecoregional approach, increasing economies of scale.

Mapping and Program Coordination

The Vegetation MOU, as discussed previously, recognizes that completion of a statewide vegetation dataset is best achieved on a regional basis through interagency cooperative efforts (California Biodiversity Council, 2000). Each ecoregion (Figure 9) will be mapped by experts who are familiar with the vegetation types and land management entities in that area, with the guidance and support of the contracting agencies. VegCAMP will provide training and technical advice, assistance with vegetation classification, and database stewardship. VegCAMP will also coordinate and oversee all of the various mapping efforts, ensuring the consistent high quality of the completed statewide map and data.

Collaboration

Although the SCV has been identified as the state standard, VegCAMP recognizes the need for other classification and mapping methodologies that support the goals of various stakeholders. VegCAMP is actively translating the SCV methodology to a wide range of classification systems, and has built a great degree of flexibility into the dataset. Broader vegetation types as well as crosswalks to other classification systems are, and can be, built into the data. VegCAMP acknowledges the advantages of collaboration with other agencies as a means for reducing costs, increasing efficiency, and leveraging limited funding. For example, VegCAMP is in discussions with the California Department of Forestry and Fire Protection (CAL FIRE) to explore a mechanism for collaboration that considers forestry issues and CAL FIRE objectives, as well as the numerous other applications for SCV data that were described in the case studies section. Both agencies are very interested in pursuing the most efficient and accurate way to perform regular updates of vegetation data in mountainous, forested ecosystems in a manner that leverages state funding efficiently and is useful to all users.

Maintenance

Once the statewide SCV map is complete, periodic update procedures will need to be established to maintain the currency of the dataset and to provide the ability to monitor and analyze statewide changes in vegetation. Discussions with CDFW staff and the SCV user community indicate that mapped areas may require updates every 10 to 20 years depending on ecoregion and natural community type, degree of development, rate and type of ecological change, and other relevant factors. For certain ecoregions, like much of the desert and higher mountains, the refresh rate would be reduced to a frequency of no greater than once every 15 or 20 years, while a few key areas may require more frequent updates. For example, Suisun Marsh is updated every three years with funding from DWR.

Additional important features of a sustained SCV program include outreach, training, revisions to the standards by an update and review committee, and a centralized clearinghouse for storage and distribution of data. Once a statewide SCV dataset is produced, map updates and program maintenance can be conducted at a fraction of the original mapping cost.

Call for Support

This paper clearly demonstrates that there is broad demand for high-quality vegetation mapping. The case studies provide specific examples of how the use of this data improves organizational efficiency and decision making in all levels of government, nonprofit organizations, and the private sector. The number of organizations that have shared costs with CDFW on mapping projects provides further tangible evidence of the value of SCV data. In the last seven years, CDFW has more than doubled its own and Wildlife Conservation Board funds for the SCV mapping project by securing matching funds from other state, federal, and local agencies. These agencies valued the fine-scale vegetation data enough to contribute to the cost of mapping their high-priority areas.

In the last seven years, CDFW has more than doubled its own and Wildlife Conservation Board funds for the SCV mapping project by securing matching funds from other state, federal, and local agencies. These agencies valued the fine-scale vegetation data enough to contribute to the cost of mapping their high-priority areas.

The benefit–cost analysis shows a very healthy return on investment for dollars spent. However, it is the intangible value that comes from improved decision making that is the real payback. The value of avoiding the costly mitigation of sensitive species that may be necessary when development sites are chosen using less-precise data is difficult to quantify, but clearly very high. Species conservation, land use planning, land acquisition decisions and many other government activities can be greatly improved by having access to better data. In this light, spending on high-quality vegetation mapping can be considered an investment in government efficiency and efficacy, rather than a cost.

The goal is to complete mapping the remaining 58 percent of the state by 2020. In order to realize this goal, continued support from organizations and agencies that perceive benefits from this endeavor is imperative. As with any project of this size, funding must be procured in order to make this vision a reality. We now have the knowledge, experience, and technology to make such a bold vision possible. The sooner this important step is taken, the sooner the benefits can start to accrue for the State of California.

APPENDICES

Appendix A: Complete Results of Online User Survey

Number of users surveyed = 48

- 98% of respondents use vegetation geospatial data
- 52% of respondents use SCV datasets, while 46% use other vegetation geospatial datasets

Note that multiple options could be selected on the following questions, with the exception of the questions of prioritization.

Respondents Who Use Datasets Other Than SCV:

Twenty-two survey respondents use map datasets other than the SCV. Fifty-seven percent (57%) work with this data heavily and consistently, referring to themselves as "power users," whereas 43% refer to themselves as casual, occasional users.

There are a variety of map products available for California vegetation. Of the 22 respondents who use these other products:

- 76% use USFS Calveg
- 62% use USGS GAP land cover
- 48% use Holland
- 43% use CWHR
- 48% use other datasets

The respondents who utilize other datasets use them for the following purposes:

- 91% – wildlife and plant conservation, endangered species protection, or conservation planning
- 43% – development, infrastructure, or transportation
- 38% – climate change studies
- 24% – public safety (e.g. fire, backcountry conditions)
- 24% – hydrology assessments
- 10% – education/academics
- 5% – geological purposes
- 5% – agricultural purposes
- 5% – recreation
- 19% – other purposes (environmental assessments and permitting, vegetation management planning, wildfire analyses, state mapping projects)

Of the 22 respondents who use other datasets:

- 100% indicate that more comprehensive and finer resolution vegetation GIS data that follows state standards would be more useful to their organization
- 91% indicate that higher quality vegetation GIS data would save them or their organization time

Prioritization of vegetation GIS data characteristics (10 = most important, 5 = least important):

- Accuracy: 9.29
- Coverage: 9.29
- Vegetation attributes included in the dataset (e.g. percent cover, tree DBH, presence of rare species): 8.33
- Detailed classification of vegetation: 8.00
- Fine spatial resolution: 7.62
- Data derived from contemporary aerial imagery: 6.94
- Data derived significantly from field reconnaissance: 6.50
- Update/maintenance schedule: 6.43

Additional comments:

- "Easy to use, mobile app for field operations would be great."
- "[We] would use veg data more frequently and for higher use (e.g. greater cost/benefit) if it were better quality and higher resolution. For example, we could use geospatial data to make automated determinations of the need for field checking if we had reliable veg data. Project in developed area = no biological assessment = save $$."
- "Our area in Northeast California is poorly covered by this data type [high-resolution]. If better coverage were available, our usage would be more significant."
- "Accessibility of plot data is extremely important for my work and I usually find it difficult to obtain from completed projects funded by CDFW and CNPS. Names of map entities (alliances and the like) are 2nd order priorities to me."
- "The question about me being 'satisfied' with other veg data didn't seem that relevant. All data have uses, some are less satisfying than others to use, but when there are no alternatives I have to use them."
- "Thanks. I can think of many things, from an applied conservation research standpoint, to accomplish with this [SCV] data."
- "Vegetation mapping is an important part of community development, mitigation, and preservation. Most local governments do not have resources ($$) to map vegetation at fine scales. Additional resources from the state would improve local decision making greatly."

Respondents Who Use SCV Datasets:

Twenty-five survey respondents use SCV data. Forty-eight percent (48%) work with this data frequently and refer to themselves as "power users," whereas 52% use the data on an as-needed basis.

SCV datasets are used for many different purposes. Of the 25 respondents who use SCV data:

- 93% use it for wildlife and plant conservation, endangered species protection, or conservation planning
- 41% use it for development, infrastructure, or transportation
- 37% use it for climate change studies
- 22% use it for education/academics
- 19% use it for agricultural purposes
- 19% use it for hydrology assessments
- 15% use it for public safety (e.g. fire, backcountry conditions)
- 0% use it for geological purposes
- 22% use it for other purposes (connectivity analyses, developing map services for conservation groups, display/cartography, FEMA coastal flood hazard studies, regional planning, identifying impacts due to levee failures)

SCV data improves the success of the users' organizations/agencies. The percentage of users citing each dataset advantage is listed below:

- 85% – facilitates research: makes information more readily available, current, and reliable
- 58% – ease of accessibility, utilization, and comprehension
- 58% – improves productivity/output

- 54% – reliability of results: final product is serviceable and accurate
- 46% – allows for integration of work/collaboration with other institutions, agencies, or programs
- 31% – cost-savings
- 27% – facilitates education and training
- 4% – other
- 0% – SCV data does not improve organization's success

Of the 25 respondents who use SCV data, 89% were satisfied. The 11% who were not satisfied gave the following reasons:

- 67% – does not cover my project's region/area of interest
- 33% – needs of my project are not accurately contained in the data
- 33% – other: partially covers project area but needs more comprehensive coverage
- 0% – hard to interpret/too complicated

Prioritization of vegetation GIS data characteristics (10 = most important, 5 = least important):

- Accuracy: 8.85
- Coverage: 8.85
- Vegetation attributes included in the dataset (e.g. percent cover, tree DBH, presence of rare species): 8.70
- Detailed classification of vegetation: 8.54
- Fine spatial resolution: 8.27
- Data derived significantly from field reconnaissance: 7.71
- Data derived from contemporary aerial imagery: 6.40
- Update/maintenance schedule: 6.25

Eighty-five percent (85%) of respondents indicated that there are certain results they have achieved using SCV data that they otherwise would not have been able to achieve. Respondent comments on these results are listed below:

- "Analysis of landscape-scale vegetation pattern for the Yosemite region"
- "Conservation assessments with high resolution"
- "Desert Renewable Energy Conservation Plan (DRECP)"
- "Seamless standardized data has never existed in the past."
- "The data was utilized to define areas potentially restorable to oak woodland in Placer County."
- "Assessment of regional habitat loss, prioritizing potential restoration sites"
- "Modeling species distributions in the Mojave Desert"
- "Specific species info"
- "Doing our own field work for veg mapping would be cost-, time-, and skill-prohibitive, as I work in a fish bio lab."
- "The presence of a consistent vegetation data layer in areas where information was previously not available"
- "Info that we used might have been much broader, however using SCV will allow us to analyze projects on a much finer scale."
- "Where available, use of more standardized collection protocols for field data which has a variety of uses (veg assessments for the San Joaquin River Restoration Program, Delta area, etc.)."
- "Habitat suitability/quality mapping for endangered riparian brush rabbit. This work was based primarily on SCV data for the Delta and Central Valley riparian areas."

- "The finer-scale and more accurate data provided by SCV makes survey and assessment easier and more fluid."
- "Yes. I needed to know vegetation type and coverage at a detailed level. Performing this analysis from aerial imagery or site visits is time consuming and expensive. SCV is a vital source of data for some of the analysis that Northwest Hydraulic Consultants needs to perform."
- "We looked at different sea level rise scenarios and how land cover changes may affect wildlife populations."
- "Results are not actually only achievable using SCV, but certainly more accurate and fine-scale."
- "All other detailed veg data is based on raster analytical models and is significantly less accurate, less precise and less comprehensive."

Additional comments:

- "While no formal cost-benefit/business case was conducted we know that some GIS work would have been out of reach (due to cost) if SCV were not available."
- "Need 'one stop shopping', mosaicked datasets and consistent resolution data. This type of data keeps all sorts of research going, which is an economic benefit to the state."
- "Vegetation data was used in conjunction with soils data provided by NRCS [Natural Resources Conservation Service]. The work would not have been possible without both sources of data."
- "California-style field-based, vector output vegetation/ecosystem mapping needs to be done for the whole country. Maybe this is something we'll lead in just like we led in environment policy and law."

Appendix B: Acronyms, Agencies, and Glossary of Terms

Acronyms

Calveg

Classification and Assessment with Landsat of Visible Ecological Groupings, a classification system designed by the Pacific Southwest Region of the U.S. Forest Service to describe and map natural vegetation in the state. A single statewide map was produced in 1979. Since then, updates for large areas have been produced to describe the extent and condition of various land cover types, and the magnitude and cause of land cover changes.

CEQA

California Environmental Quality Act, a statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible

DRECP

Desert Renewable Energy Conservation Plan, a multi-agency plan with a goal of providing conservation of desert ecosystems while permitting development of renewable energy projects in the California deserts

EIR

Environmental Impact Report, a planning document under CEQA that describes the environmental impacts of a project, determines which impacts are significant, and describes alternatives to the project and mitigation measures

ESA

Environmentally Sensitive Area, as defined and used by California Department of Transportation

ESHA

Environmentally Sensitive Habitat Area, as defined under the California Coastal Act

FRAP

Fire Resource and Assessment Program, a program of the California Department of Forestry and Fire Protection that assesses the amount and extent of California's forests and rangelands, analyzes their conditions, and identifies alternative management and policy guidelines

GAP

National Gap Analysis Program of the U.S. Geological Survey's Land Cover Data Set, version 2. The California Gap land cover mapping project was completed in December of 2008. The final report can be found here: http://gap.uidaho.edu/index.php/ca-land-cover.

GIS

Geographic Information System, a system to capture, store, and analyze spatial information

NEPA

National Environmental Policy Act, a law that requires federal agencies to consider and disclose the environmental impacts of their proposed actions and reasonable alternatives to those actions

NVCS

National Vegetation Classification System, a set of standards for classifying existing vegetation cover and its associated information for the United States

SCV

Survey of California Vegetation, a framework for fine-scale vegetation classification and digital vegetation map production in California

Agencies and Organizations

BLM

U.S. Department of Interior Bureau of Land Management

CAL FIRE

California Department of Forestry and Fire Protection

Caltrans

California Department of Transportation

CDFW

California Department of Fish and Wildlife

CEC

California Energy Commission

CNPS

California Native Plant Society

DWR

California Department of Water Resources

USGS

United States Geological Survey

VegCAMP

CDFW's Vegetation Classification and Mapping Program

Terms

Alliance

The second level of classification (above Association) in the NVCS hierarchy. Many SCV-compliant maps are delineated to this level.

Association

The finest level of classification in the NVCS hierarchy. SCV-compliant maps are delineated to this level whenever possible.

Layer

A spatial dataset, such as vegetation, which can be analyzed in GIS in combination with one or more additional datasets (layers), such as protected areas or transportation corridors.

Appendix C: Mapping Attributes for Standard Survey of California Vegetation GIS Products

The list below provides a brief explanation of map attributes for SCV standard products. Depending upon the individual map project requirements these may be augmented with additional variables specific to project needs.

NVCS Name/NVCS Level

The standardized name and level of the vegetation description used in the National Vegetation Classification System

Map Unit

The name for a category in a vegetation map; it can represent a vegetation type (e.g., alliance or association), an unvegetated type, or non-natural vegetation such as agricultural crops

Conifer Cover

Percent bird's-eye cover of conifers within a vegetation stand, broken into cover classes

Hardwood Cover

Percent bird's-eye cover of hardwoods within a vegetation stand, broken into cover classes

Total Tree Cover

Percent bird's-eye cover of all trees (including Joshua Trees) within a vegetation stand, broken into cover classes

Tree DBH

The diameter at breast height (DBH) of the trees within the polygon, using California Wildlife Habitat Relationships classes

Shrub Cover

Percent bird's-eye cover of shrubs within a vegetation stand, broken into cover classes

Herbaceous Cover

Percent cover of herbaceous plants within a vegetation stand, broken into cover classes

Heterogeneity

The measure of uniformity of the vegetation type, cover class, and size class within the polygon; a low heterogeneity is desirable

Exotics

Level of impact by exotic invasive species, broken into three categories

Roadedness

Level of impact by paved and unpaved roads, OHV trails, railroads, etc., broken into three categories

Development

Level of impact by structures (buildings, tanks, paved parking lots, trailers, utility and mining structures), broken into three categories

Anthropogenic Alteration

Level of impact on vegetation by anthropogenic clearing through tillage, scraping, grazing, etc., broken into three categories

Fire Evidence

Yes, No, or Unknown, depending upon observed signs of previous fire; fire evidence can include dead snags and burn marks on trees and shrubs

Other Impacts

Impacts observable in the imagery, such as: OHV activity, disking/grading, development, erosion/runoff, and ungulate Trails

Land Use

Human use of land such as agriculture or urban development; if a polygon is designated as a land use type or the polygon represents a vegetated stand with a land use area within it, then a land use code is assigned to the polygon

Method ID

Identifies either the type of field data used to support the vegetation type decision for that polygon or if the polygon was attributed based on photo interpretation

Confidence

The level of confidence of the photointerpreter in correctly identifying the vegetation type and attribute values of the polygon: Low, Medium, or High

Rare

Rarity of the vegetation type: Yes if the alliance or association has a state rank of S1-S3, No otherwise

Calveg Name/Calveg Code

A crosswalk to the Calveg classification system

CWHR Type/CWHR Code

A crosswalk to the California Wildlife Habitat Relationships system

Global Rank/State Rank

The global/state rarity rank of the plant community mapped (only for alliances and associations)

NVCS Macrogroup/Group/Alliance

The standardized name for each hierarchical level as defined in the National Vegetation Classification System

Ecological Systems

A crosswalk to the ecological system as defined by the NatureServe Unique Identifier for each polygon

Acres and Hectares

GIS-calculated area measurements of each mapped polygon

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