# PRISSM Project Description

Partnership of Regional Institutions for Sage Scrub Monitoring

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Updated September 15, 2017

## 1. Summary

The Partnership of Regional Institutions for Sage Scrub Monitoring (PRISSM) is focused on building stronger collaborations among biologists and educators to gather key biological information required for effective management and preservation of biodiversity throughout Southern California. Since 2014, PRISSM has been working to design and implement bio-monitoring programs in endangered California sage scrub (CSS) fragments (see Rundell 2007 for a description of the ecosystem). PRISSM's programmatic goals are to: (1) build collaboration among natural area/reserve/biological field station directors/managers tasked with managing CSS fragments and among the researchers that study this ecosystem; and (2) design and implement bio-monitoring programs that support and enhance current and future research in CSS throughout Southern California. Currently, collaborating institutions have developed and implemented protocols for monitoring diversity and phenology of CSS plants, invertebrates, birds and vertebrates (e.g., mammals, reptiles amphibians as well as birds). A heavy emphasis is on designing practical bio-monitoring protocols given the limited resources available at most institutions that manage CSS systems. In addition, priority was placed on developing common taxonomic focus and methodology so data among fragments could be comparable and contribute to a larger understanding of the CSS ecosystem. This document summarizes the needs for regional monitoring of the CSS system and protocols that are currently being used. We anticipate that this process will develop as a long-term, dynamic and inclusive program; i.e., we welcome new collaborators. To learn more about the program, download data and example datasheets, and find contact information of current collaborators, please visit our website at www.PRISSM.org. Contact any contributor to learn ways to become involved.

## 2. Problem Statement

CSS is a vegetation type distributed over/across the coastal slopes and basins of Southern California where the mean annual rainfall averages 450 to 250 mm a year (Barbour & Major 1977). It is characterized primarily by dominant drought-deciduous shrubs (e.g., *Artemisia californica*) and scattered small-stature trees, with a few evergreen shrubs (Mooney 1977, Rundel & Gustafson 2005, Rundell 2007). Drought-deciduous CSS shrub species lose much of their foliage during the hot, dry summer months, and resume growth in the winter and spring, during and immediately following the rainy season (Mooney 1977).

The CSS ecosystem is listed as endangered (85-98% lost) by the USGS (Noss et al. 1995), and as critically endangered by the World Wildlife Fund (Ricketts 1999). CSS has been heavily impacted by human land use in southern California, with existing stands thought to be reduced to less than 10% of their original distribution (Westman 1981, Rundel 2007). Unfortunately, much of the remaining CSS is degraded, requiring restoration efforts (Burger et al. 2003), and found in small isolated patches that are typically long and narrow, increasing the impact of edge effects (Alberts et al.1993, Soulé et al. 1988 Suarez et al. 1998, Bolger et al. 2000). Although CSS vegetation contains some 50 widespread shrub and subshrub species, more than half its approximately 550 understory herbs are relatively restricted in range and/or are rare, and 200+ CSS herbs are listed as species of conservation concern (Bowler 1990). Among animals, 11 mammal, 26 bird and 10 reptile species inhabiting CSS are listed as threatened or endangered, making this ecosystem a conservation priority in California (Davis et al. 1994, Keeley & Swift 1995, Feldman & Jonas, 2000, Riordan & Rundel 2009).

CSS fragments are threatened by a myriad of interacting threats, including climate change, non-native plant and animal species, nitrogen deposition, and increased disturbance and development (Suarez et al. 1998, Holoway 2005, Wolkovich et al. 2010, Riordan & Rundel 2014). However, few efforts have been made to establish long-term monitoring protocols that could be used to assess changes in the CSS ecosystem. This is largely because the agencies and colleges and universities that manage many of the remaining CSS fragments are understaffed. When bio-monitoring programs are undertaken, the focus is often on just one or a few taxa, depending on the expertise of the director/manager. Piecemeal approaches to bio-monitoring means that conservation and biodiversity managers are not equipped with critical information to make informed decisions concerning the management and preservation of biodiversity in CSS across Southern California.

**3. PRISSM Goals for CSS Monitoring**

Stronger networks and collaboration among biologists and educators are necessary to address the lack of key biological information in the few, remaining CSS fragments. Since June 2014, PRISSM has been conducting workshops to bring together local experts and initiated bio-monitoring programs in endangered CSS fragments to begin filling these gaps in knowledge. Our programmatic goals are to: (1) build collaboration among reserve/biological field station directors tasked with managing CSS fragments and among the researchers that study this ecosystem; and (2) design and implement bio-monitoring programs that will support and enhance current and future research in CSS throughout Southern California. Currently, we have protocols for monitoring plant, invertebrate, bird, and mammal composition/richness and phenology. In addition, we identified goals for monitoring abiotic aspects of the various fragments.

**4. Questions Bio-Monitoring Programs Should Address in CSS**

PRISSM recognizes that long-term baselines and species inventories associated with bio-monitoring efforts are critical if we intend to address some of the unprecedented environmental challenges that threaten this ecosystem and our region (e.g., climate change, habitat loss, introduced species, biodiversity loss, and increased addition of nutrients). In addition, monitoring biodiversity in isolated CSS patches can provide insights to study both theoretical and applied questions relating to the effects of fragmentation and urbanization on biodiversity. Questions that implementation of a regional bio-monitoring program could facilitate include:

1. How will anthropogenic changes (increasing temperatures, changes in the hydrological cycle, increased nitrogen deposition, etc.) influence diversity and community composition in the CSS ecosystem?
2. How do biotic communities differ among patches within the CSS ecosystem? How do communities change along latitudinal (north to south) and coast- interior gradients? What abiotic and biotic factors influence these patterns?
3. Does Island Biogeography Theory (MacArthur & Wilson 1967) explain most of the variation in species richness, or are there other factors (e.g. subsurface water, local geology, edge effects) that influence diversity among CSS fragments?
4. What are the distributions of non-native, nuisance/pest and disease species, and how fast are these species spreading through the region?
5. What impacts do different types of disturbances (fire) and stressors (drought, toxins, N-deposition, edge effects) have on CSS communities? Are CSS communities resilient to these disturbances? How frequent are these disturbances?
6. How do patterns of regeneration (native and non-native) change over time? How do various factors influence regeneration? How might this inform restoration efforts?
7. What species require conservation recognition and what are appropriate criteria for targeted management plans or other types of intervention?
8. How will human encroachment and disturbance influence diversity in CSS ecosystems? What political actions could assist or hinder conservation efforts in the region?

These bio-monitoring programs may also contribute to larger regional and national/continental programs. For instance, the California Phenology Program is currently only monitoring one CSS plant species (*Eriogonum fasciculatum*), and the National Ecological Observation Network and the Long-Term Ecological Research Network project do not have a site in Southern California or in the CSS ecosystem.

## 5. Bio-monitoring Protocols

Bio-monitoring protocols were developed to document and assess changes in diversity and phenology of four distinct taxonomic groups: plants, invertebrates, birds, and mammals. Protocols were developed based on two criteria: (1) that they collect data in a way that can reveal changes in the biota at both the patch and regional levels; and (2) that they are practical (i.e., they could be implemented with the resources at most institutions). Monitoring of abiotic components are also being conducted at most sites, but methods are largely dependent upon the institution.

Datasheets for each bio-monitoring component, previous year's data, as well as, other resources can be found on the PRISSM website.

### *5.A. Monitoring Abiotic Characteristics*

Rising concentrations of greenhouse gases in the atmosphere are leading to increasing global temperatures and changes in the hydrological cycle (IPCC, 2013). Because such abiotic changes are impacting the distribution of biota across the planet (Parmesan 2006, Chen et al. 2011) and are predicted to influence the distribution of CSS plant species (Riordan & Rundell 2009), bio-monitoring programs must incorporate climate monitoring to identify changes in climate that might be driving observed biotic changes. As such, monitoring of abiotic characteristics is critical to identifying primary factors that influence / shape current differences in community composition and diversity among CSS sites. PRISSM has identified multiple abiotic parameters that would complement biological monitoring efforts. These can be separated into two categories based on type of dataset: (1) dynamic datasets that require constant monitoring and often are associated with a weather station (e.g., air and ground temperature, relative humidity, precipitation, rates and type N-deposition), and (2) static datasets, which only need to be collected once but are critical to understanding relationships among sites (e.g., topography, soil type). Because the legacy of land use is also known to influence the structure of CSS communities, it is recommended that managers of CSS fragments document (to the best of their ability) past disturbances and/or land use regimes. Implementations of different aspects of the abiotic monitoring depend on the financial ability and expertise at each institution. As such, we suggest that each field station develop their own strategy for consolidating the information they currently have and develop a stagey for enhancing their abiotic descriptions. All detail provided will be made accessible on our website (www.prissm.org).

### *5.B. Plant Diversity*

Perennial shrubs and annual herbs form the foundation of CSS habitat (structure and food). Monitoring both perennial shrubs and annual plants is critical because diversity and abundance of shrubs tend to respond slowly to many stressors, whereas annual plants show large response to inter-annual variation in climate. Focusing on perennial and annual plant species, should allow us to determine how both short-term stressors influence plant diversity and abundance and identify shifts associated with climate change and other disturbances.

The plant diversity protocol was designed to annually record percent cover, species composition and species richness at sampling sites within CSS fragments. Sampling will be conducted in spring when most annual plants are flowering. To standardize our data across CSS fragments, we intend to conduct surveys between mid-March and mid- April beginning in spring 2017.While peaks in annual diversity likely vary considerably among season and location (coastal vs. inland sites), we have chosen this timeframe because most annual plants have been found to be flowering at sites (inland CSS) currently participating in the PRISSM program.

While site managers will decide the level of effort that is feasible, we recommend that each CSS fragment run a minimum of three transects in various locations. One should be in the area with the most intact CSS habitat. A second transect is recommended to be run in a different plant habitat type (e.g., non-native grassland or Chaparral) if one exists adjacent to the CSS fragment. Additional transects should focus on CSS and chose sites based on the needs of the respective institution/site. With increased resources, we recommend increasing the number of transects and focusing efforts on CSS habitats. Additional transects should only be done if managers can commit the effort to survey the sites over multiple years.

Permanent transects are 40 m long. Location of the beginning and the end of each transect should be staked and GPS locations recorded. It is recommended that photographs be taken at the beginning point of each transect each year prior to conducting the plant survey. Plant surveys combine multiple approaches. First, researchers will mark the species present, the number of times each species touches, and the maximum height of each species at every meter along the transect using the point intercept method to provide an estimate of both basal and canopy cover. To standardize data, point intercept data should be collected using a pole that is ¾ inches (~1.9 cm) in diameter. A PVC pole with 10 cm heights marked on the pole to 2 m is most often used. Previous work suggests that point intercept data are more precise than those taken via visual cover estimates (Godinez-Alvarez et al. 2009), and are especially appropriate for studies in chaparral (Bauer 1943). Also, point-intercept methods are easy to teach, and more objective and repeatable than visual cover estimates when carried out by multiple observers (Elzinga et al. 2009). Following the point intercept method data collection, 1 $m^2$ quadrats will be placed every 2 m along each transect. In each quadrat, all species are identified to better record species richness of annuals. Starting in 2017, all quadrats were placed on the right side of the transect, e.g., the side that is on the researher's right looking from the beginning of the transect to the end of the transect to standardize the area surveyed each year. Following quadrat measurements, researchers will record all additional species not recorded using previous methods within 5 m on either side of the transect line. This last step will allow us to make comparisons to surveys conducted by the CNPS (https://www.cnps.org/cnps/vegetation/pdf/rapid_assessment_protocol.pdf) using the rapid protocol. Identifications of all plants should be to species. When individuals cannot be identified to species, individuals should be identified to lowest taxonomic level, photographed and flagged for expert identification. Since species identification may require flower morphology, individual plants may need to be tracked and collaboration with experts within the network will be utilized.

### *5.C. Plant Phenology*

Phenology is the study of cyclic and seasonal natural phenomena in relation to climate and plant and animal life. Climate warming and changes in precipitation have already impacted the life cycles of many species (Kimball et al. 2010, Crimmins et al. 2011), such as the timing of flowering and the emergence of insects, both of which are strongly correlated with temperature or other climatic cues (Bale et al. 2002, Crimmins et al. 2009, 2011, Strange & Ayres 2010). As a consequence, phenology may be a leading indicator of climate change impacts.

The plant phenology protocol is designed to monitor phonological patterns of common CSS plant species on a weekly basis beginning in November and ending at the end of June every year. While surveys may need to be conducted longer in coastal sites, flowering of all plant species in inland CSS, except white sage is completed by June. Also, human resources are low after June at most institutions limiting the ability to compile complete data sets. Plant species were chosen because they were commonly found at a large portion of the CSS fragments and they represent important resources for animals, particularly butterflies (see section 4.D.). The five species of plants chosen for phenological monitoring include: California sagebrush (*Artemisia californica*), White Sage (*Salvia apiana*), California buckwheat (*Eriogonum fasciculatum*), California thistle (*Cirsium occidentale*), and royal penstemon (*Penstemon spectabilis*). We also recommend that yerba santa (*Eriodictyon trichocalyx* or *Eriodictyon crassifolium* depending on the site) and deerweed (*Lotus scoparius*) be monitored at sites when managers can expand their effort. Other species such as pinebush (*Ericameria pinifolia*) and scale-broom (*Lepidospartum squamatum*) are important in the CSS ecosystem since they flower later in the year and often are the only plants flowering in fall. However, allocating resources at many sites later in the summer and into the fall is logistically difficult, especially on a weekly basis for many CSS fragments. Only one of these species (*Eriogonum fasciculatum*) is monitored by the California Phenology Network. Increasing the number of CSS plants will increase our ability to detect changes. Future plans include understanding the phenology of non-native grasses.

To monitor the phenology of these plant species, six individuals of each species should be identified and tagged prior to November. It is fine to include only tose species present at a site and fewer than six individuals of a particular species depending on access and resources. Individuals should be widely distributed across each CSS fragment to effectively sample phenology in various micro-habitats. When possible, individuals are tracked for as many years as possible. If an individual dies during or between sampling seasons, a new individual should be chosen and given a new identifying code. Starting the first week in November and every week after until the beginning of July, researchers visit each individual plant and record characteristics identified. While our focus is on timing of flowering and floral resources, occasionally, we record other life-history characteristics: presence/abundance of functioning leaves, buds, flowers, and/or fruit.  For more detailed information on what needs to be recorded for each species, please download the data collection sheet and the plant phenology category description document from www.prissm.org.

PRISSM's objective is to understand how plant phenology varies within and among sites in CSS habitats. As such, our protocols are designed to assess the phenology of multiple individuals for each species at each site, with a focus on floral resources. Our protocol was not designed to comprehensively study the phenology of any one species. We have found that using our protocol takes a researcher approximately 2 hours, depending on the distance among individuals.

### *5.D. Invertebrate Diversity and Phenology*

Monitoring invertebrate communities in CSS fragments can be done using a variety of methods and can focus on a myriad of taxa. The criteria PRISSM used to identify a taxon for bio-monitoring of CSS included: (1) ease of identification to species, (2) ease of sampling using methods that do not include extensive processing efforts (e.g., pitfall traps), and (3) suitability of the group to engage broad public participation. Because of these criteria, PRISSM decided against monitoring some invertebrate groups that are commonly used in bio-monitoring programs: e.g., native bees which are hyper-diverse and difficult to identify to species, and ground-dwelling invertebrates (e.g., ants and carabid beetles) that typically require a taxonomic specialist and intensive processing to study. Instead, we decided to monitor butterfly diversity for four main reasons: (1) they engender excitement from students and the general public, (2) butterflies have been used as indicator species in multiple systems (Daily & Ehrlich 1996), despite it being unclear if patterns can be generalized across taxa (Ricketts et al. 2002), (3) there are good data on Southern California butterfly species, and many species are easy to distinguish from one another by sight, and (4) multiple sampling protocols exist that are similar to protocol designed by participants of the workshop. For example, the protocol for the Illinois Butterfly Monitoring Program (http://www.bfly.org/monitoring_guidelines.pdf) is almost identical to our approach.

Bio-monitoring protocols for butterflies were designed to collect data on butterfly phenology or relative densities throughout the season (the number of individuals recorded within an interval of space and/or time) and species richness. Over multiple years, we expect that this approach will provide an inventory of butterfly species at each site, and to allow researchers to identify habitat preferences.

Prior to implementation, managers/researchers need to establish a permanent census route (see Pollard 1977). The census route should travel through the main / major habitat types present, take advantage of existing paths, and be easy to locate and follow by all participants. The path chosen should take at least 1 hour and no more than 3 hours to complete. Transitions from one habitat type to another and from intact to degraded areas should be clearly delineated. These portions of the trail that are in different habitat types will be called transects. These transects will need to be defined *a-prioi* by the researchers (e.g., intact CSS, degraded CSS, non-native grassland, burned CSS, Chaparral). Classification of portions of the trail into different transects will require discussion by experts prior to surveys, and may require some plant surveys. Classification of a particular habitat type typically uses the minimum requirement that 25% or more of the plants detected along transect/s are typically associated with a particular habitat type (Sawyer and Keeler-Wolf 1995). If more than 25 % of plants are associated with two habitat types, this should be considered an ecotone. However, because much of Southern California has experienced some level of disturbance or invasion by exotic grasses (Keeley 2005, Wolkovich et al. 2010), plots are only considered to be non-native grassland if no other vegetation type constitutes 25% or more of the linear vegetation of a transect, typically using point-intercept method (see Matsuda et al. 2011). Using this system we can also classify CSS sites by level of non-native grass incursion using broad categories (non-native grassland, > 75% non-native grass; heavily degraded CSS, 75-50 % non-native grass; degraded CSS, 50-25 % non-native grass; intact CSS, < 25 % non-native grass).

It is critical that the protocol for butterfly monitoring is strictly followed to provide comparable data on relative abundances among CSS fragments. We recommend that surveys be conducted between February through July when possible. Additional months can be added if additional resources are available. Each monthly census requires two individuals: (1) a monitor, who will be spotting and identifying butterfly species, and (2) a "blind" assistant who will be there only to record data. The assistant should not help the observer spot butterflies. The monitor should proceed at a steady pace throughout the plot. Surveys should initially be conducted between 9 AM and 3 PM. The beginning and end time of the survey should be recorded as should the times when the monitor transitions into different a transect (i.e., habitat types). When the monitor spots a butterfly, they should identify the species and record what plant species it is on or if it is in flight. In some instances, it might be necessary for the monitor to collect the individual for identification either in the field or further identification in the lab. In these instances, the assistant should record the time allocated to the collection of specimens, since this time is not spent observing butterflies. PRISSM recommends that when possible monitors photograph all individuals to confirm species identification We want to minimize collection of individuals as much as possible, so monitors will need to spend the appropriate time to familiarize themselves with the local butterfly fauna and practice photographing specimens. Butterflies only within 6 m of the census route should be identified and no effort should be made to record/capture species further than the 6 m from the trail.

*5.E. Bird Diversity and Phenology*

Monitoring of bird diversity and phenology can be done using a variety of methods, each with its own set of biases (see Bart & Earnest 2002 & Thompson 2002). We decided not to use point counts for three reasons. First, students, community members and interested researchers would require extensive training to learn the calls of the full diversity of birds. Second, extensive effort and training would be required to standardize data collection among observers in an effort to limit observer bias (lack of consistency among surveyors). Third, point counts are biased towards birds that are breeding (and therefore singing) but often miss the non-breeding bird residents and the migrants. Because of these concerns, we decided to conduct monthly surveys of the bird faunas using a similar approach designed to monitor butterfly diversity and phenology (Section 5.D.). Bird surveys will be conducted along a census trail which should run through all different habitat types. Different portions of the census trail will be broken into transects based on different habitat types and be clearly demarcated. The surveyor will identify observation points in each transect. The time at each observation point will be recorded as will all bird species observed. This approach should provide a good record of the bird species present annually in each CSS fragment and habitat preferences of different bird species, but will not provide a record of the relative abundances of the different species.

*5.F. Vertebrate Diversity and Phenology*

Monitoring vertebrate communities (e.g., mammals, birds, reptiles, etc) will provide many benefits to the CSS bio-monitoring program. Vertebrates more than any other taxonomic group engage the public's attention and support. In addition, many vertebrate species in CSS are listed as threatened or endangered (O'Leary 1990, Keeley & Swift, 1995). However, studying vertebrates, particularly mammals, involves extensive oversight (permits) and special training to capture and handle individuals safely.

To limit the need for extensive training and permits, we chose to design passive bio-monitoring protocols for vertebrates in CSS fragments using motion detector cameras. Bio-monitoring protocols for vertebrates will collect data on phenology and species richness at a CSS fragment. Over multiple years, a relatively complete species inventory of each CSS fragment should be complied.

Protocols require the use of a minimum of five motion detector cameras, although more are recommended. Cameras will be tied to stakes or trees approximately 30 cm above the ground in a conventional way so the lens face is perpendicular to the ground. This method will allow for the cameras to capture large mammals and smaller vertebrates (e.g., lizards) present at each site. Initially, we recommended that additional cameras be set according to a new protocol developed by Dustin Welbourne (see: http://theconversation.com/new-gadgets-are-opening-windows-on-reptiles-11322), e.g., face down (lens parallel with the ground). However, preliminary data has found that outward facing cameras collected more species including large carnivores present at each site not captured by downward facing cameras while also capturing most smaller species captured by downward facing cameras (Meyer and Karnovsky, unpublished). We have also found that outward facing cameras are especially good at capturing bird, reptile and amphibian diversity. Cameras will be placed at sites within each CSS fragment that span the variety of habitats. Each camera site will be categorized into habitat type using the approach provided in section 4.D. Cameras will be placed in the field for at least one week of every month from September through June. We have found that cameras, the date/time stamp in particular) often miss function during the hot summer months. At some sites and season, live trapping will occur concurrently with camera trapping. This will allow us to determine the relative efficacy of our method.

## 6. Implementation

Implementation of all protocols at one CSS site is not required or expected to become a participant in PRISSM. Instead, we request that collaborating institutions decide what is reasonable for them based on resources and expertise, and expand the scope of their bio-monitoring program as resources and expertise change. To date, managers and researchers involved with three CSS fragments have begun implementation of CSS biomonitoring, and two additional institutions have committed to implementing some of the protocols when possible. In Table 1, we highlight the various protocols different agency/institutions have implemented.

**Table 1.** Implementation of bio-monitoring at five CSS fragments: Y = Yes, N= No, F = Future.

| CSS Site | Plant Diversity | Plant Phenology | Invertebrates | Birds | Vertebrates |
|---|---|---|---|---|---|
| Bernard Field Station | Y | Y | Y | Y | Y |
| Motte-Rimrock Reserve | N[1,2] | F | N | N | N[2,3] |
| Chaffey College | F | N[2] | N[2] | N[2] | N[2,3] |
| Voorhis Reserve | Y | Y | N[2] | N[2] | N[2,3] |
| N. Etiwanda Preserve | Y | Y | N[1,2] | N [1,2] | N[2,3] |

[1] lack of expertise at institution
[2] lack of required human effort (people with time and interest) to consistently conduct surveys
[3] lack of required funds to buy equipment

Table 1 also helps in identifying limiting factors that influence implementation of bio-monitoring programs broadly. The first limiting factor is that each agency/institution has only so many people with specific areas of expertise. In designing these protocols, we tried to limit how much expertise was required. Still, many people/institutions do not have the expertise and are apprehensive to conduct butterfly surveys. The second limiting factor is the human effort (people with the time and interest) to consistently conduct surveys based on the suggested frequency and dedication to manage the data. While data collection and management are easy for certain protocols, e.g., plant diversity, most of the others require sustained weekly or monthly efforts (plant phenology, bird and mammal monitoring). The initial perception for the plant phenology protocol, which involve weekly surveys, was that it requires too much effort. However, as it has been done and protocols have been refined, more institutions are incorporating this into their programs. The third limiting factor is access to funds. While cameras are not expensive, some institutions cannot allocate the $800 required to purchasing the 5 motion sensor cameras and supplies associated with the mammal monitoring protocols.

## 7. Broader Impacts

PRISSM bio-monitoring programs presented here will advance science discovery and understanding by building collaboration and cooperation among researches and land managers at various institutions throughout Southern California, many of which are less than 100 miles from each other. This connected network of researchers monitoring CSS at a regional/landscape level represents a new and critical contribution to understanding one of the most intrinsically rare and endangered ecosystems anywhere in the world. It is also especially significant in the context of a rapidly changing environment to better understand how both species and threats shift across the landscape. The main focus of this effort is to develop bio-monitoring programs and data archival/ management program to monitor biodiversity in the CSS ecosystem. Increased collaboration will facilitate communication and data sharing among researchers interested in Southern California ecosystems and enable new science and knowledge creation through universal access to data about the biota in Southern California and the environment that sustains it. These data and sampling efforts also provide valuable teaching opportunities for training students not only in field methods, but also in data analysis. In addition, data can spur new projects at the sites, serving as the baseline for comparisons.

We also expect that the development of bio-monitoring programs will directly and indirectly broaden opportunities for underrepresented groups and members of the larger community. Collaborating campuses include several federally identified Minority-Serving Institutions (e.g. California Polytechnic University, Pomona) and regional Community Colleges (e.g., Chaffey College and San Bernardino Valley College). Regional focused bio-monitoring projects and those at field stations close to campuses (e.g., the Bernard Field Station, Claremont Colleges; Voorhis Ecological Reserve, Cal Poly Pomona; and Chaffey College's Nature Preserve) broaden participation of individuals from lower socio-economic status because they reduce or eliminate travel costs that can often limit both faculty and student involvement. In addition, participants intend to incorporate bio-monitoring efforts into the science curriculum at participating institutions and involve interested community members as part of citizen science programs to provide relevant learning experiences and to engage everyone to become active participants in monitoring and preserving local biodiversity and connecting them to their home.

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