The Center for Natural Lands Management-San Diego:
Coastal Sage Scrub Monitoring Plan
(Revised in 2013)

Objective: Track the changes in structure and composition of the coastal sage scrub (CSS) community.

a. Use data to evaluate the structure and composition of the CSS vegetation community and its correlation to predictions of vegetation changes based on theories postulated by ecological and threats models.
b. Use data to evaluate changes or trends in "populations", presence/absence and/or occupied/unoccupied habitat of sensitive animal species, primarily the coastal California gnatcatcher (*Polioptila californica californica*)(CAGN).
c. Use data to evaluate changes in species richness.
d. Use data to evaluate changes over time from a baseline vegetation pattern.
e. Use data to guide vegetation management decisions (i.e. non-native plant removal, rare species range increases/introductions).

Background of Need:

The Center for Natural Lands Management (CNLM) manages several thousand acres of CSS in San Diego County. These areas host many threatened, endangered and sensitive plant and wildlife species, provide for wildlife movement and are some of the last remaining stands of CSS in coastal San Diego. These areas were also specifically designated as important areas to conserve under the regional Habitat Conservation Planning (HCP) conservation efforts.

As a result, the CNLM needs to be able to evaluate recruitment and vigor of this vegetation community over time to guide management decisions and to evaluate changes in plant and animal communities. This monitoring will also provide an opportunity to evaluate theorized predictions of changes in vegetation communities resulting from urbanization, non-native species invasion, climate change, increased edge, altered fire regime and fragmentation (to name a few).

Background of Ecological Model and Threats

CSS is a fire-adapted vegetation community with fires occurring naturally, but most severely under the extreme Santa Ana heat and winds of late summer and fall and during drought conditions. During these conditions there would generally be a "complete burn" where all above ground vegetation within the fire's path would be consumed. After such a fire, herbaceous plants (fire followers), which are known to sprout after fires, would dominate the landscape for a few years. Over time (3-5 years) the shrub lands would regain their dominance, and after 5-10 years a mature assemblage of plants and wildlife would again be found on site (Dallman 1998).

The fire frequency in CSS is as frequent as chaparral due to the volatile oils and resins that occur in CSS plants. The plants, such as white sagebrush (*Saliva apiana*), are able to resprout after a fire or produce many seedlings from the dormant seed bank that lies in the soil. Seed germination of some species may also be stimulated by fire (Holland and Keil 1995, Dallman 1998). However, if the fire frequency and intensity are too great, plants in the CSS community, such as black sage (*Salvia mellifera*) and California sagebrush (*Artemisia californica*) are permanently killed and can no longer regenerate, slowly converting the CSS community to a non-native, annual grassland (Southwest Division, Naval Facilities Engineering Command 1998).

Each CNLM preserve in San Diego has a different fire history and a different predicted fire future. For example, most of the Rancho La Costa (RLC) Habitat Conservation Area (HCA) burned in the Harmony Grove fire in October of 1996, while the Manchester HCA has not burned (except two very small fires) in its entirety since 1917. Prior to 1917 no data are recorded, so it is uncertain as to when the last significant fire event occurred in the Manchester HCA.

Regardless of fire history and the current vegetation characteristics, there are many realized or potential threats to the integrity of the CSS vegetation community (See RLC Habitat Management Plan CSS Ecological Model and Threats Section (CNLM 2005) that need to be evaluated including:

1. What is the effect of an altered fire regime at each HCA?
2. What is the potential effect of global climate change?
3. What are the effects of urban edge?
4. What are the effects of fragmentation and isolation?
5. What are the effects of altered wildlife usage patterns?

The answers to these threats questions lead to other questions that are associated with effects on ecological processes and patterns, such as:

1. Are the variables investigated representing a threat?
2. At what spatial scale are the variables representing a threat?
3. How do the effects of the threats listed above effect the distribution and abundance of sensitive plant and wildlife species?
4. How do the threats listed above effect the distribution of non-sensitive plants and animals?
5. How do the effects of each threat alter ecological processes?
6. How do the various measured factors interact?

Predictions

<u>Fire</u>. We predict that as a result of fragmentation, complete burns of preserves are now less likely and that there will be fewer, smaller fires resulting in a mosaic of CSS with various age structures.

Global Climate Change. We predict that rainfall patterns will change (likely decrease) over the next 100 years resulting in a lengthening of the fire season, increased frequency of lightening fires, increased frequency of drought, and areas burned. We predict:

1. Possible regime shifts (altered abundance and recruitment patterns in various native vegetation assemblages)
2. Altered invasion severity of exotic species due to changes from native-adapted variations in weather phenomena
3. Lowered native seedling survival of species due to changes from native-adapted variations in weather phenomena
4. Lowered seed and/or clonal production of future generations due to changes from native-adapted variations in weather phenomena
5. Negative interactions between native wildlife and changes resulting from the above mentioned predictions in vegetative cover

Habitat Fragmentation and Urban Edge. We predict that habitat fragmentation will reduce plant diversity and migration and/or genetic exchange between plant populations. This could affect the CSS community by reducing vigor within populations and eventually leading to extinctions of specific plant species. Habitat fragmentation has resulted in an increase of urban edge on all our preserves. We predict that this will result in increased pressures from non-native plant species, illegal vegetation clearing, dumping, erosion, and other threats that will change the vegetation structure and composition.

Monitoring Methodology

Approximately fifty plots will be established inside three of our preserves, and the number per preserve allocated by the amount of acreage currently occupied by CSS in each preserve. These plots will be placed in a stratified random manner across our preserves. Stratification will take into account:

1. Size of preserve
2. Slope and aspect
3. Distance from preserve edge/urban edge
4. Presence or absence of CAGN or San Diego horned lizard (*Phrynosoma coronatum blainvillii*)
5. Fire history

Plot Design and Setup 2009 - 2013

The original plot design was based on the Whittaker nested vegetation sampling design as in Stohlgren et al. 1995. The design of the Whittaker nested vegetation sampling plot deviated from that described in Stohlgren et al. 1995 by not including the 12 smaller 1-square meter rectangles. The dimensions of the modified Whittaker nested vegetation sampling macroplot was 50 meters long by 20 meters wide. Originally, three smaller nested plots were placed inside the sampling macroplot, the largest of these three was 20 meters long and 5 meters wide, placed in the center of the sampling macroplot, with the long axis corresponding to that of the macroplot. The two other nested plots were at opposite corners of the sampling macroplot, and were 5 by 2 meters in length, again with the long axis corresponding to that of the sampling macroplot. The long axis of the modified Whittaker plots was set to cross the environmental gradient present at the sampling macroplot location. Sampling was carried out for both continuous variables (percent cover by species) and non-parametric and semi-continuous variables (count of dead shrubs, species richness).

The sampling macroplot design was modified in 2011 after data analyses revealed that less area could be sampled within each macroplot. It was found that saturation, or that area where adding more area to a species search area only slowly adds further species, is reached at roughly 25-30 square meters. The two, 5 by 2 meter nested plots were deleted from the sampling effort and the 5 by 20 meter center, nested quadrat was reduced in size to 2 by 20 meters. During 2013, this sampling frame was redesigned entirely, and in order to achieve a per-plot replication of species richness, CNLM dispersed 1.9x1.9 meter quadrats at all corners of both the larger macroplot, and at the outside corners of the original 5x20 meter sampling frame, for a total of eight quadrats per css plot. This method should account for more dispersed area, and as Figure 1 suggests, will achieve saturation at most plots at some point between 10 meters and 28.9 square meters of survey area. This latest change in sampling design should remain unchanged in future years, since it maximizes the original shape of each plot, is replicated, and reduces sampling effort as much as is practicable.

We obtained shrub counts in our nested subplots and in the macroplot during our first year of sampling (N = 17 macroplots), and found that any counting inside subplots and the macroplot, in addition to noting species richness cannot be supported on our HCA endowments. Collecting species richness in these subplots is the most time-consuming portion of each visit.

<u>Current Plot Design (2013)</u>

Beginning and end points are marked on GIS for each set of points representing the upper segment of each plot. This upper segment is where point-intercept readings are carried out, along with height measures every other point at 1 meter intervals, added as of 2013.

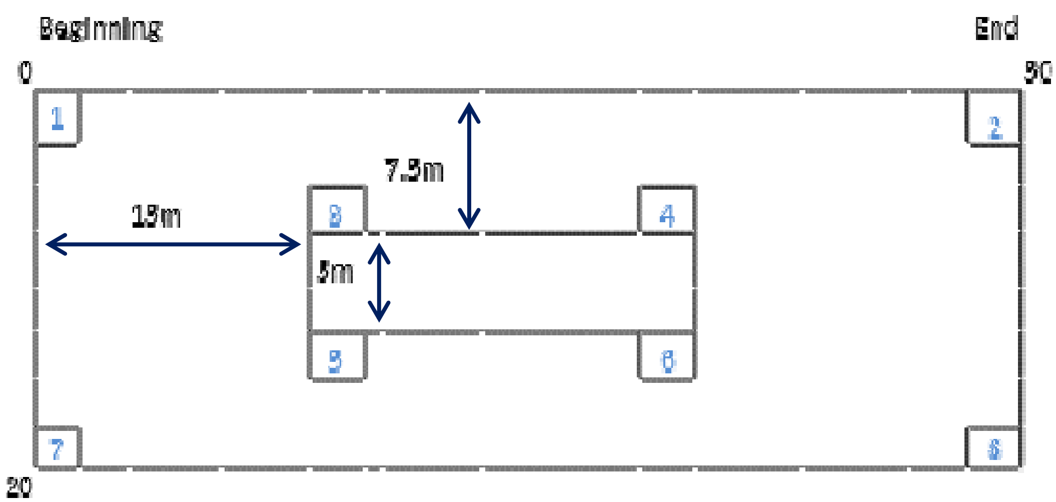

Figure 1. CSS plot design with dimesions and landmark distances. All inside and outside corners were marked in the field during plot setup. Species richness quadrats are numbered in blue, and the shapes represented here are not exact. Each richness quadrat is 1.9 x 1.9 meters.

Point Intercept Data (Percent Cover)

Percent cover by species was gathered by running a metric measuring tape along the upper border of each macroplot. The point-intercept transects were standardized to read hits at half meter intervals, thus generating 99 "hits" along the long (50 meter) side of the macroplot. Living plants were counted as a point or "hit," if a 1.5 millimeter dowel is intersected in the vertical plane by the living tissue of a plant. At each half meter, data pertaining to bare ground, rock, or litter incident with the dowel was also collected. Occasionally, dead shrubs may be counted as "hits" along the line, since they were read the first few years of this study, and can provide good comparisons from previous years of live cover data.

The point-intercept transect measures will provide a method of quantifying change in abundance by species and edaphic cover that may also tie into species richness changes observed within the richness quadrats. For instance, non-native grasses and/or litter cover changes may be predictive as explanatory variables in a multi-factorial analysis of the response variables mortality or species decline. Other variables that may be tied into a model explaining the measured pattern may include regional rainfall totals for the season and/or seasonal temperature averages, slope and aspect of macroplots, fire history, and the presence or absence of animal herbivory.

Investigations by researchers who measure css regularly reveal that 50 meter transects are optimal, and CNLM is further optimizing the measurement by totaling 99 points per transect. Douglas Deutschaman's Management and Monitoring Group at San Diego State University (SDSU MMG) regularly monitor css plots using 50-meter point-intercept transects at whole-meter intervals. This alone provides a robust measurement of cover by functional group. Setup and species richness are the most time consuming portions of this effort, and adding an additional 50 points to the protocol does not add considerable time to each survey. CNLM may investigate whether performing point-intercept at 50 meters on the whole-meter interval will negatively affect any further analyses, but has not done so yet.

Species Richness

Species richness was originally gathered inside the three, nested subplots located inside each macroplot; however, as discussed above, in 2011, species richness was only collected in the nested center quadrat that was reduced in size from 5 by 20 meters to 2 by 20 meters. Each species occurring within the subplot was recorded. Plants were identified to species and subspecies whenever possible. Initial studies informed the reduction in the richness quadrat size, and further informed the changes implemented during the 2013 field season (Figure 2).

CNLM changed design of species richness data collection in order to account for species richness variation on a per-quadrat basis. Eight plots are dispersed throughout the css plots (Figure 1) in an effort to maximize site heterogeneity, and to attain yearly average richness values. Figure 2 indicates, as did previous investigations, that a leveling off of additional species occurs on most plots upon reaching 20 square meters of total search area. These data are not nested within consecutively larger quadrats, but are summed by adding separate quadrat areas and species with each quadrat. This is an imperfect method of generating species area curves, but illustrative nonetheless of the range of values needed to maximize search effort. Most plots reach saturation before 28.9 square meters of total search area.

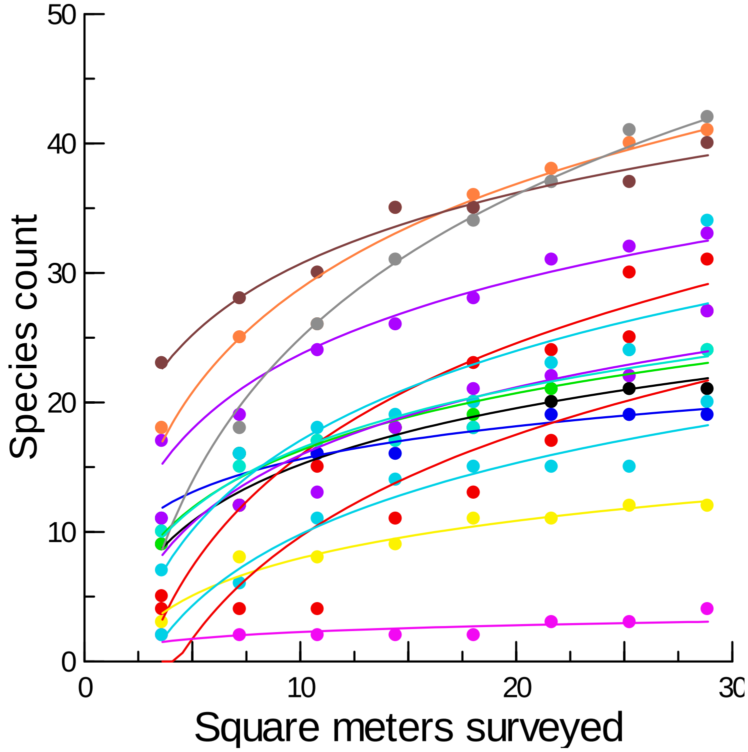

Figure 2. Species area curves for 15 long-term css monitoring plots in Carlsbad, California, measured during winter-spring 2013. Species richness was collected in 1.9 x 1.9 meter quadrats dispersed throughout each css plot for a total area of 28.9 square meters sampled for plant species richness. Best fit lines follow a logarithmic pattern.

<u>Shrub Height</u>

During 2013, CNLM began measuring tallest shrub height at every whole-meter interval. This will provide a measure of canopy height that may inform managers of animal usage patterns, development or senescence of vegetation over time. This measurement should continue for the foreseeable future until researchers (SDSU MMG included) find that cover by species correlates sufficiently with height to make shrub height a non-useful measure.

Sampling intensity

CNLM met with Dr. Douglas Deutschman to inquire into methods of maximizing our return from our effort. We could not afford to monitor more than approximately 20 macroplots per year. Also, the effects of trampling could mislead our conclusions about trend over time if we re-visited the same sites every year over the course of many years. It is necessary to capture the yearly variation in conditions such as rainfall and temperature, and thus we knew that many replicates would be needed in order to capture meaningful patterns.

Dr. Deutschman suggested a “rotating panel” approach. This approach incorporates visiting a subsample of all macroplots on a yearly basis, ensuring to balance the replicates according to aspect and to spread these replicates across the landscape in order to capture variation in weather or rainfall that may take place across our sample region. It was suggested that we re-visit eight macroplots over the course of three years, while rotating 12 or more new macroplots over the course of the three years. Thus, after the third year of sampling, 45 plots have been visited, and the variation in measures among the eight re-visit macroplots can be compared to the rotating macroplots. In this manner we can judge if yearly re-visits are necessary in the long-term, or if more sites are needed each year.

For instance, one potential outcome is that the region in which we are sampling does not vary substantially in factors influenced by weather or disturbance, and that by stratifying sub-sampling across the region and visiting a subsample of the whole, we can adequately capture the variation in vegetative and species richness measures without overtaxing our annual budgets. Another potential outcome is that we will obtain substantial information from this rotating panel design to indicate how many more sites should be visited on a yearly basis to capture the yearly variation without visiting the entirety of our plots.

Analyses and sample size

CNLM again met with Dr. Deutschman in late 2011 to review data gathered over the course of the three consecutive years since collection began in 2009. Another meeting is scheduled for early December 2011 as of this writing. The considerations under his cognizance are how many plots are needed in order to gain x percent certainty that x change in particular vegetation functional group cover (exotic forbs, exotic grasses, etc.) while maintaining affordability of sampling effort. This is at face value a sliding scale scenario whereby the most sensitive measures (non-native grasses and native forbs) determine how precise our estimates should be, and affordability also helps determine the precision of both the percent change that is meaningful and the desired precision. The second meeting in December 2011 should help us further refine the most desirable yearly sample size for these most sensitive response variables. Based on power analyses based on the t statistics generated in the paired t tests, for the repeat plots that were performed for three consecutive years, it would appear that a minimum of 12 separate plots will need sampling every year, on a three or four year return interval. We are unsure at the moment how many to visit yearly, but will know soon. Table 1 below contains some basic statistics of a combination of the yearly repeat visit plots and the rotating plots also read, and thus totals to 60 plots altogether. Note that the variability of both exotic forbs and native grass cover relative to the other categories (the basic utility of the coefficient of variation) is much higher.

Table 1. Summary statistics for all plots 2009-2011, including repeat plots.

	Exotic forb	Exotic grass	Native forb	Native grass	Native shrub
N of Cases	60	60	60	60	60
Minimum	0	0	0	0	4
Maximum	42	62	56	29	87
Arithmetic Mean	6.767	12.7	9.75	4.4	45.567
Standard Deviation	11.115	12.163	10.042	6.559	19.793
Coefficient of Variation	1.643	0.958	1.03	1.491	0.434
Effect 20% of Mean	1.3534	2.54	1.95	0.88	9.1134

Table 2 (below) summarizes the number of plots needed annually to achieve a certain measure of change over time.

Table 2. Annual sample size needed to determine change over time for each group

	Exotic forb	Exotic grass	Native forb	Native grass	Native shrub
20 % of mean value	1.35	2.54	1.95	.88	9.11
Effect size desired	5%	5%	5%	5%	10%
Annual sample size needed to detect effect size	14	12	13	4	12

The basis for comparison in rotating sampling plots is necessarily a paired design whereby each unit gets compared to itself upon reaching the second return sampling event and thenceforth with every subsequent return. Each shape and corresponding color in Figure 1 below refers to a set of plots performed on each given year. The paired comparisons will take place between years, since variation in the measures performed thus far indicate that spatial variability among plots is much greater than year-to-year variability among plots. To put it another way, plots are very dissimilar to one-another in cover and representation of this cover by shrubs, grasses, and forbs, and these measures don’t change as much year-to-year as they do differ from one-another from site to site.

The set of plots visited annually may be determined by visiting the css dataset and finding out which plots were read during the year three years prior to the current date. For instance, CSS plot 24 was read during 2012, and will therefore need to be revisited during 2015.

Figure 3. rotating css plot analysis diagram. Each symbol represents a set of plots measured in a given year, repeating at regular intervals and analyzed using paired repeat measures methodology.

References

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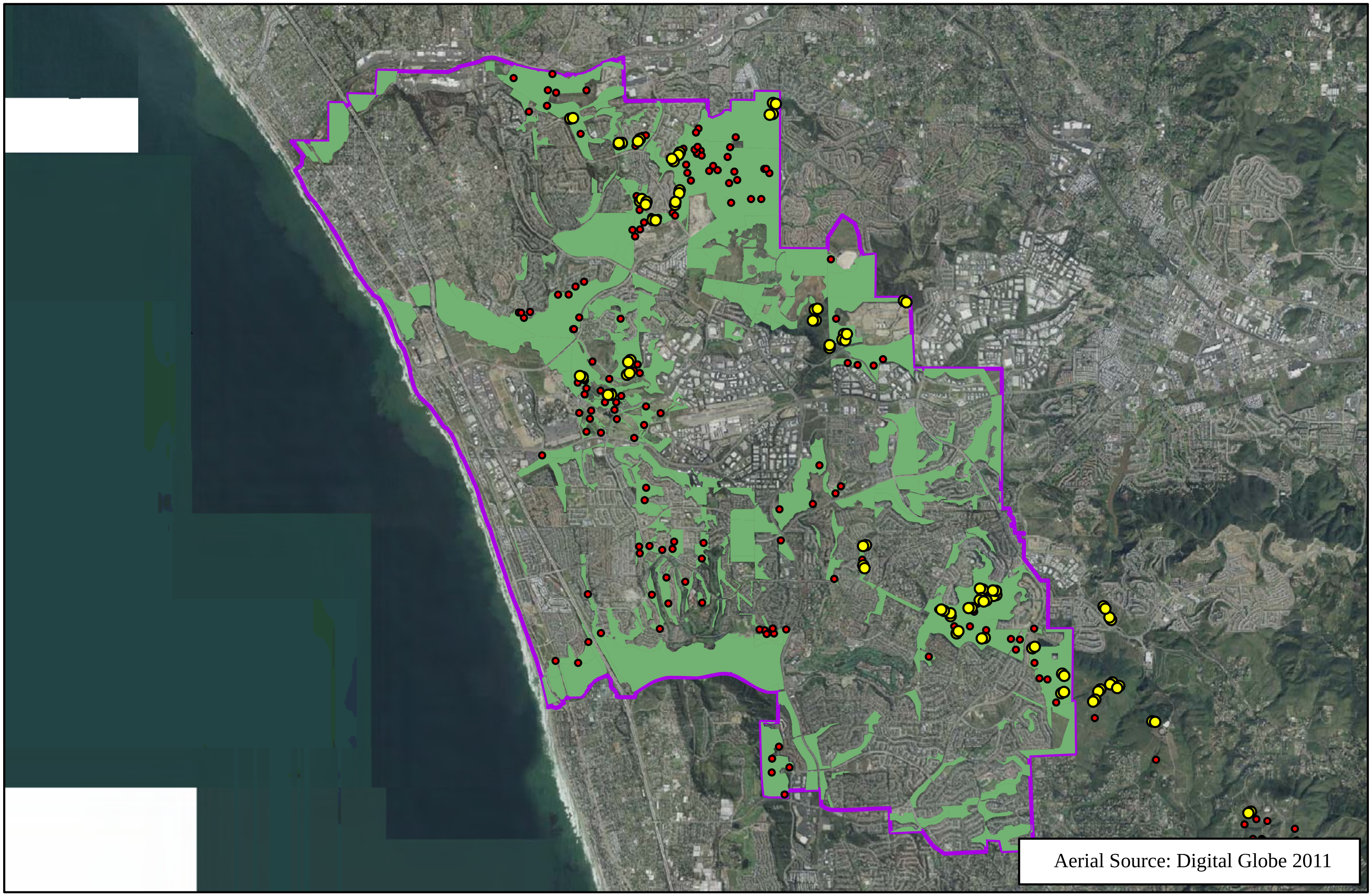

CSS Plots (yellow dots) CAGN (red dots)

Carlsbad

1,500 750 0 1,500 Meters

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