Title

Building Climate Resilience of Urban Waters, Ecosystems, and Communities

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Building Climate Resilience of Urban Waters, Ecosystems, and Communities

Final Report for State Coastal Conservancy submitted by Ocean Discovery Institute in partnership with California Sea Grant and San Diego Canyonlands

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Manzanita Canyon restoration plot MU12 before planting in May 2016 (left), and 6 months after planting in May 2018 (right).

Summary
Climate change preparation should include water quality improvement and conservation measures, particularly in urban ecosystems. The project site, Manzanita Canyon, is located in the heart of a "disadvantaged" community in San Diego, California. In urban watersheds such as this, ecosystems provide services disproportionate to their size, yet are also highly vulnerable to climate change hazards because of the heavy reliance on services and the relatively degraded state. This two-year project improved water quality and climate resilience of an urban ecosystem and an underserved community by engaging 2,253 community members in stewardship activities; restoring 7.56 acres of native coastal scrub ecosystem, including planting, maintaining and monitoring 1,536 natives; and removing 22 metric tons (758 m^3) of invasive plants and trash. Findings from this project formed the basis of the following stewardship recommendations:

1. **Community engagement** was most effective when community-based leaders or organizations were involved in the motivation and recruitment of volunteers. Further, local recruitment was effective, with 64% of volunteer effort contributed by neighbors, and 59% of effort contributed by youth (through clubs and schools.)
2. **Trash cleanup efforts** should be focused on areas of illegal dumping and abandoned homeless camps, with added effort near storm drains during the rainy season. Solutions closer to the source of these inputs are also needed, such as improved social and housing programs for the homeless; stricter enforcement and education surrounding illegal dumping; expansion of free

large-item curbside pickup and drop-off location services; improved clean street strategies (e.g., more efficient street sweeping, neighborhood-driven litter reduction and cleanup strategies); and collaboration with businesses and industry to improve incentives for reducing use of common trash items, especially plastics.

3. **Establishment of native plants** requires not only native plantings, but also invasive plant removal, and slope stabilization measures (e.g., closing renegade trails, use of erosion control barriers). Planting in diverse clusters that include nearby well-established plant species; and watering, weeding and fencing, especially in times of drought, should decrease planting mortality due to stress, competition and herbivory.
4. **Ecosystem restoration** takes time. After two years of restoration efforts, restored plant communities and substrates were on a trajectory of resembling reference plots, but were still significantly different. Continued maintenance such as weeding and watering should facilitate system development as native plantings establish and grow, and increasingly confer benefits such as provision of year-round complex habitat, reduction of fire fuel (annual plants), and resistance and resilience of the community to fire and drought.

This project strengthened the climate resilience of this urban community and section of watershed by alleviating common urban stresses, namely non-native plant cover and trash pollution, known to increase the vulnerability of an area to climate change impacts, such as increased intensity and frequency of fire, drought, and flooding that results from more intense but less frequent storms. Removal of 138 m^3 (13 metric tons) of trash from urban waterways improved channel flow thereby reducing risk of flooding, and reduced risk of contamination on site and downstream. Removal of 620 m^3 (8.62 metric tons) of invasive plant material reduced risk of wildfire, by reducing fire fuel levels, and lessened competition with fire- and drought-resistant natives. Planting of 1,537 native perennials, totaling 73 m^3 of native plant biomass by the end of the project, increased the ecosystem's carbon storage capacity, and added the complex and stable habitat that is associated with plants that have diverse morphologies, perennial life cycles, and evolved resistance to drought and fire. Further, community engagement not only provided needed help, but also increased public awareness of the value of and threats to local coastal ecosystems, and the ways in which everyday actions, such as planting natives and picking up trash, can influence the health of our environment now and into the future.

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Introduction

Climate change is already impacting water security, the reliable supply and quality of water, through generally warmer temperatures, more intense, scouring storms and runoff, and increasing demands for clean water (Vörösmarty et al. 2000, Whitehead et al. 2009). The types and magnitude of effects that climate change has on water security varies with other environmental stressors, such as pollution (Whitehead et al. 2009). Therefore, climate change preparation should include water quality improvement and conservation measures, particularly in urban ecosystems where water resource demands are high yet water and ecosystem quality is low. A network of coastal canyons and seasonal streams provide some degree of the usual array of ecosystem services, and also serve as the stormwater system for San Diego, connecting the highly urbanized city and its contaminants to the ocean. These canyons therefore provide services disproportionate to their size, yet are highly vulnerable to the hazards that come with climate change because of the reliance on their services and their relatively degraded state.

The project site. Manzanita Canyon, is located in the heart of a highly-urbanized, high poverty, “disadvantaged” (DWR 2015) community in the middle of the City of San Diego (32.737°, -117.106°). These communities have been identified as “vulnerable to climate change impacts” (Pacific Institute 2012) and the canyons that characterize the geography of this area are part of the Chollas Creek sub-watershed, labeled one of the most impaired waterbodies in San Diego County (Anderson et al. 2012), indicating that action is needed to increase resiliency of both the urban community and the ecosystem. These canyons are blighted by many of the challenges common in urban areas: introduced plant invasions; degraded, un-vegetated, and eroded slopes; trash accumulations and illegal dumping; homeless encampments; and high-volume storm water flows. Each challenge leaves this ecosystem and the water that passes through it even more vulnerable to the climate change impacts of increased fire intensity and frequency, increasing temperatures, and more intense but less frequent storm events (Cayan et al. 2008, Messner et al. 2008, Mastrandrea et al. 2011, Diez et al. 2012). These impacts further decrease ecosystem condition and water quality, such as through increased runoff, erosion and contaminant inputs, and therefore further increase vulnerability (e.g., Westerling and Bryant 2008, Keeley et al. 2011, Sandel and Dangremond 2011).

Removal of trash and debris from canyons. Land based trash, in particular plastic, is pervasive in watersheds and ocean ecosystems around the world (Rochman 2013). The infiltration of urban trash into and throughout watersheds occurs via stormwater systems and littering. San Diego’s seasonal precipitation patterns result in dry season accumulations and then tremendous pulses of the accumulated trash and contaminants into coastal watersheds with rain events (Miller-Cassman et al. 2016, Talley et al. 2016). Trash is not just unsightly but carries with environmental risks such as entanglement, ingestion and, as with plastics, binding of other contaminants in the environment (Wilcox et al. 2015). Timely removal of trash may also reduce the risk of materials breaking into smaller pieces (i.e., micro-trash; Talley et al. in prep) making them even more likely to be ingested, transported, photodegraded into composite contaminants, and /or to bind to other contaminants in the environment (e.g., Mato et al. 2001, Ross and Birnbaum 2010, Rochman 2013). The highest accumulations of trash in these canyons tend to occur next to storm drains and at illegal dumping sites, and after large rain events that follow dry spells (Miller-Cassman et al. 2016, Talley et al. 2016).

Re-establishment of healthy, diverse native plant communities. Removal of invasive, introduced annual and fast-growing perennial species and the addition of a diversity of native perennials, which are adapted to the drought and fire conditions in this region, will improve water quality by reducing erosion, debris inputs and risk of fire. A persistent, diverse native plant community will also improve climate change resilience of the ecosystem such as more reliable wildlife habitat, reduced heat island effects, and increased carbon storage potential. In addition, closing and vegetating bare slopes and renegade trails will further reduce erosion and increase water quality, and can be achieved through simple fencing (e.g., placing cut vegetation), signage redirecting users to approved trail locations and promotion within the community. At least 9 trails have already been approved for permanent closure by the City and San Diego Canyonlands and others that meet one of the City's trail closure criteria (e.g., contributing to erosion) can be added to the list with prior written approval by the Open Space Division. Enhancement of the canyons has also been shown to decrease occurrences of illegal dumping and encampments, which will further reduce contaminant inputs, risk of flood and fire, and improve safety.

This multi-benefit project sustainably improved water quality, and the climate resilience of urban ecosystems and an underserved community through urban native greening, invasive plant and trash removal, and the engagement and education of the community and local decision makers.

Goal & Objectives
The goal of this multi-benefit project was to sustainably improve water quality, and the climate resilience of urban ecosystems and an underserved community through urban native greening, invasive plant and trash removal, and the engagement and education of the community and local decision makers
This goal was met through the following five specific objectives:

1. Assess the amount of involvement of the community
2. Assess the amount and types of trash removed that would have traveled or been trapped between San Diego's urban center and San Diego Bay
3. Restore and assess the progress of restoration actions over 7.56 acres of urban watershed ecosystem, including renegade trail closures, removal of invasive plants, and native plantings.
4. Determine the environmental influences on rates of native planting survival and growth
5. Assess the effects of restoration on plant communities and substrate conditions throughout the canyon.

Methods
Tracking community volunteers and their efforts. Numbers and zip codes of community volunteers, amounts of trash and invasive plants removed, other maintenance activities (e.g., watering) were conducted during weekly and biannual (spring and fall) organized community events, and by independent community members, mostly canyon neighbors, contributing

throughout each week year-round. Partners and community members reported, at a minimum, the location, general types, weight and volume of trash and weeds removed during each visit to the canyon.

Trash assessments. Trash and debris were removed from across the whole canyon throughout each year by the project team and community volunteers during organized events and informal visits to the canyon. Team members and neighbors reported the location, volume and weight of all material removed, and often provided a qualitative assessment of the types of trash removed. These data were totaled to create assessments of the amounts of trash removed within canyon regions and across the whole canyon.

In Spring and Fall of each year, one 30 – 35 m trash transect was established on the floor of the canyon at the head (upstream end), middle-reach, and downstream end of the canyon (for a total of 3 transects per date X 5 sampling dates). The width of each transect was defined by the width of the creek bed (to bank-full levels, range of 2-5 m width). All mesotrash (2 – 50 cm length) in each transect area was collected and sorted by material type (plastic, metal, wood, natural fiber cloth, paper, other- usually ceramics and lumber). Total weight and volume of each material type were measured. Plastics were then further sorted into use categories (e.g., bags, wrappers & packaging, single use containers, fragments & pieces) and counted. Percent composition of each material and use category was calculated.

Trail closures. Renegade trails were identified and mapped in the first year of the project. Trail closures occurred opportunistically in both years of the project as large plant material (e.g., cut up fallen tree, brush) became available in close proximity to a renegade trail (Figure 1). Occasionally, cactus or the native woody plantings, if the trail was in a restoration plot, were also planted in trails to discourage use. Brush, woody natives and/or cactus were placed in and across renegade trails in one to several locations, depending upon length of the trail, to block access. Total length of closed trails was calculated using Google Earth with trail GIS layer overlays.

Figure. 1. Renegade trail closure using pruned limbs from nearby maintenance activities placed at the head of a trail leading down a steep slope.

Invasive plant removal. Both introduced annual herbaceous plants and, less frequently, woody perennial plants were removed throughout the canyon over the two-year project. The type (herbaceous, woody), state (green, dry), total weight and volume of the plant material were measured at the end of each event. All herbaceous plant weights and volumes were converted to dry weights by collecting and measuring wet (green) six samples of commonly targeted introduced forbs (e.g., mustard, radish) and grasses. Plant material was placed in large paper bags and dried in hot, dry outdoor conditions to mimic drying in the field. Weights and volumes were measured again when plants were about half dry (half green and brown), and when completely dry (all brown; no further loss of weight). Wet to partially dry and wet to completely dry conversion factors for weight and volume were calculated and used. Resulting conversion factors were compared to values reported in on-line studies and were confirmed to be within range of most reported values. Wet (green) woody plant material was converted to dry weight and volume using conversion factors reported on-line for the particular species of interest or closely related taxa. For example, average of values for several species of *Eucalyptus* were used to convert values the species removed from the canyon, *E. cladocalyx,* for which data could not be found.)

Native plantings. Before the start of this project in early 2016, 22 restoration polygons (hereafter "plots") were established throughout Manzanita Canyon (Figure 2) and a planting palette for each plot was defined based on a combination of criteria, including existing established species, species that are generally common in San Diego canyon ecosystems but that had undergone decline in this canyon, and City regulations (e.g., adherence to Brush Management Zones near residences so that utilities could be maintained). Six nearby reference plots were also established that were similar in topography to the six restoration plots to which they were paired (Figure 2).

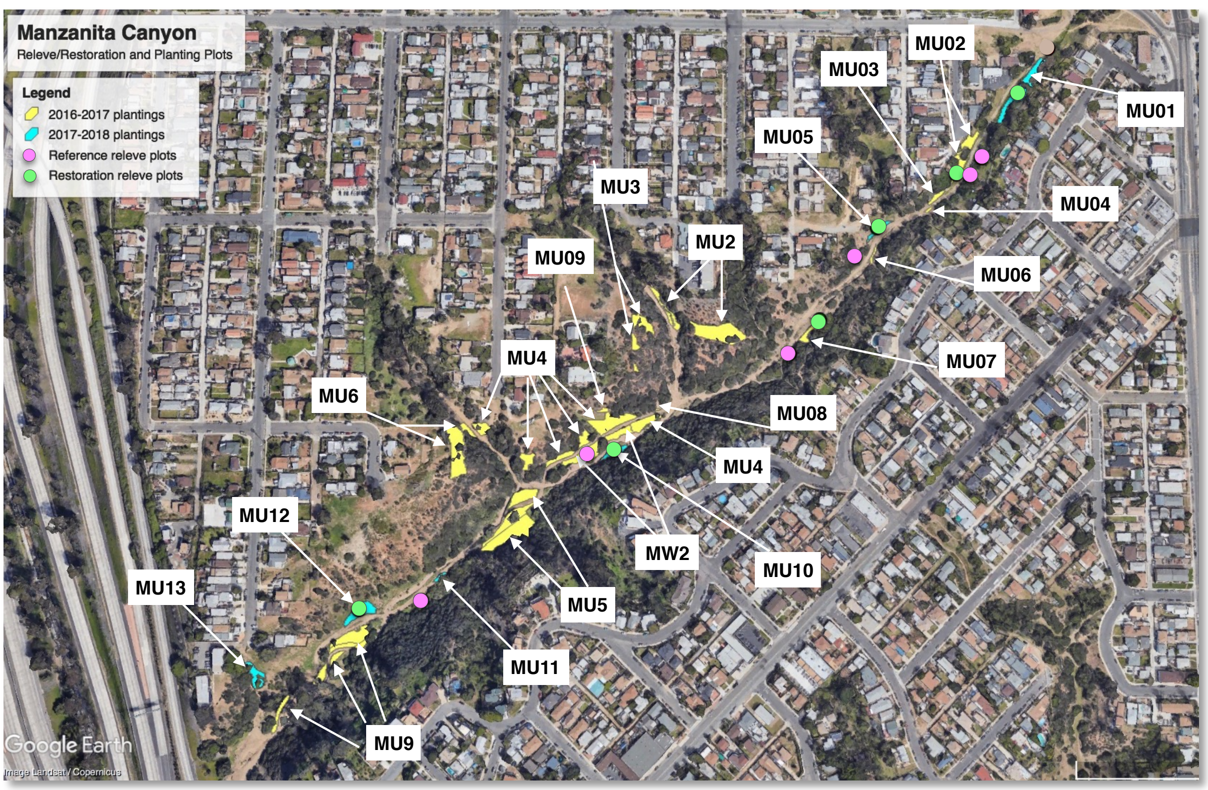

Figure 2. The restoration plots (polygons), and paired restoration-reference plot Relevé survey locations in the 1-km long Manzanita Canyon, San Diego, California. Plots were surveyed between October 2016 – May 2018. Note that MU4 was treated as two plots, one on the canyon floor (coastal sage scrub) and the other along a slope of mixed coastal sage scrub & southern oak chaparral.

A total of 1537 native perennial plants were planted during late 2016-early 2017 (716 plants over 16 plots) and late 2017-early 2018 (820 plants over 6 plots) (Figure 2). Each planting was marked with two bamboo garden stakes (Figure 3) and, for the first 2-3 months, surrounded by a plastic cylinder (Figure 4) to prevent herbivory. The restoration plots varied in area, species planted, and numbers of plantings (Appendix 1).

Figure. 3. A planted *Trichostema lanotum* marked with two bamboo garden stakes in plot MU13, May 2018.

Planting Growth and Survival. At least 10% of each planting species in each plot were tagged for monthly measurements of growth. Throughout October 2016- February 2017 (year-1 plantings) and October 2017-May 2018 (year-2 plantings), basal stem diameter of each tagged plant was measured using a caliper placed at the soil surface level. The volume of the tagged plants was measured by measuring height the tallest point of the plant, length at the widest diameter of the plant, and width of the diameter perpendicular to length.

All plantings were assessed monthly for survival, mortality and, in some cases, whether they were missing (e.g., loss by vandalism, deterioration of standing dead stems). When a plant went missing, an exhaustive search was conducted in the plot and around the perimeter to find the missing stem, the bamboo stakes and/or the empty planting pit. At the end of project, we assumed all missing plants to be dead. A "live" plant was defined as a plant with any visible green on the aboveground portion. Some of the species used were drought deciduous, with summer dormancy making the plant appear dead for several months. If a plant 'greened-up' again in the fall, the survival numbers for that plot throughout the summer were adjusted to reflect added survival.

Plant community and substrate monitoring. Plant community structure (abundance, diversity, composition), and substrate cover of the six paired restoration and reference plots (Figure 1) were monitored in April/May of each year (2016, 2017, 2018) using the *Combined Relevé and Vegetation Rapid Assessment Protocol* (hereafter Relevé; CNPS 2014) within a 100m^2 plot size. Plant abundance was measured as %cover and diversity was calculated using Simpson's Index of Diversity (1-D), which reflects the probability that two individuals randomly selected from a sample will belong to different species (i.e., 0= no diversity, 1= 100% chance of being different.)

Weather data. Weather data were collected hourly from a weather station at the head of the canyon and made available at weathercurrents.com. Data collected included wind speed, temperature, humidity, rainfall, and dew point. These data were averaged or summed daily and then averaged for the month-long period between plant monitoring surveys (i.e., sampling month).

One Hobo pendant temperature and light logger was placed in each of the six paired restoration and reference plots used for Relevé, and three nearby local built urban areas to collect canyon and urban data. Although the intent was to collect data from paired restoration and reference plots throughout the canyon, vandalism of the loggers resulted in the loss of most loggers so data from remaining loggers were averaged and used to supplement the weather station data.

Figure 4. Project team members, Nina Venuti, Blanka Lederer & Charles Adams next to recently planted plot MU02 revealing blue cylinders placed over new plantings to deter herbivory; Feb 2017.

Canyon variables. The distance from the head of the canyon, elevation, and slope were calculated for each plot (plot centroid) using Google Earth.

Data analyses. Descriptive statistics were calculated for all types of data collected, and were the only statistics used to summarize the community volunteer data, trash totals, trail closure data, and the invasive plant removal totals.

Differences in planting survival and growth between plots and planting species after the first year were tested using one-way ANOVA (N=15 year-1 restoration plots). Due to the different types of species in each plot, two-way ANOVA could not be used. Relationships between planting %survival and growth (after one year and monthly measures) and weather variables (e.g., temperature, humidity, light, dew point, canyon slope, slope aspect, distance from the head of the canyon) were tested with forward, stepwise multiple regressions. All univariate statistical tests were run in JMP 13.

Changes in plant community structure and substrate composition between restoration and reference plots and across years were tested using non-metric multidimensional scaling, analysis of similarity (ANOSIM) and similarity percentage analysis (SIMPER) in Primer statistical software (Clarke and Gorley 2015).

Comparisons of plant and substrate composition were visualized using non-metric multidimensional scaling (nMDS) on the Bray Curtis similarity indices of standardized, log (x+1) transformed data (Clarke 1993, Clarke and Gorley 2015). Six different random starting points with up to 1,000 steps were used. The stress values from the six runs were examined for stability to determine whether a global solution had been found. Only analyses with stress values of <0.2 were used; stress is a measure of how well the solution (in this case the two-dimensional MDS plots) represents the multidimensional distances between the data. Clarke (1993) suggests values <0.1 are good and <0.2 are useful.

Significance testing for differences in plant and substrate composition between plot types (restoration or reference) and years was performed using an analysis of similarity (ANOSIM) procedure on the Bray Curtis similarity matrices. This is a randomized permutation test based on rank similarities of samples (Clark 1993). Analyses of dissimilarities in plant and substrate composition found between plots and years, and the particular items/species contributing to the dissimilarity, were carried out using SIMPER (Clarke 1993). The SIMPER results specify which variables (plant species or substrate features) are responsible for the ANOSIM results by comparing the average abundances of each plant species or substrate feature between each year and plot type. The average dissimilarity of samples between year-plot groups is computed and then broken down into contributions from each. Those variables or items with high average terms relative to the standard deviation are important in the differentiation of assemblages.

Results and Discussion

Community involvement

Over the two-year project period (May 2016 – May 2018), 2,253 individuals participated in restoration and cleanup efforts totaling 2,583 volunteer days (usually ~3 hours/day). These efforts totaled 7,749 volunteer hours (2,583 volunteer days X 3 hrs/day) at an estimated value of $89,114 in help received ($11.50 San Diego minimum wage X 7,749 hours). Residents of the neighboring community, City Heights, contributed 63.7% of the volunteer effort (1,645 volunteer days), and 58.5% of the effort (1,510 volunteer days) was completed by youth (Figure 5). Most volunteers (83%, 2,147 individuals) only participated once, and 4% (106 individuals) repeatedly participated at an average of 4.1 times over the two years (range: 2-58 times). Besides participation by individuals, a total of 33 groups helped organize volunteers to work in the Canyon, including non-profits, community groups, faith-based groups, local businesses (Figure 6), K-12 schools and the Navy.

Figure 5. Two kids from the City Heights community participating in the spring 2018 Creek to Bay Cleanup at Manzanita Canyon. Photo: Dennis Wood.

Figure 6. Group from a local business participating in the April 2018 Creek to Bay Cleanup at Manzanita Canyon. Photo: Dennis Wood.

Effective community engagement occurred in three general ways. First, there was high volunteer turn out when restoration and cleanup events coincided with organized regional cleanup efforts, such as the annual spring "Creek to Bay Cleanup" and annual fall "Coastal Cleanup Day." Second, many volunteers were engaged by connecting with groups that have educational or philanthropic missions, such as classes from local K-16 schools, science or community service organizations, faith-based groups, and local business with community-service team building activities (Figure 6). These organizations, except for businesses, tended to repeatedly participate even if many of the individual members would only come once to a few times. Lastly, local community activists, although few, were effective at recruiting and leading many of the other community volunteers throughout the year at informal events. Again, the community activists would repeatedly participate while the volunteers they recruited would come once to a few times per year.

Trash accumulations

Canyon-wide trash. Over the two-year long project, roughly 12.95 metric tons of trash and debris (137.5 m^3) were removed from the canyon by the project team and community volunteers. Included were bags of mesotrash and an assortment of large items, mostly commonly furniture (e.g., couches, chairs, mattresses, headboards, desks), household items (e.g., fans, lamps, carpets, suitcases, mirrors, microwave ovens, toilets, a tub, a water heater), and shopping carts and strollers (e.g., Figure 7).

Figure 7. A typical example of large trash items found throughout Manzanita Canyon; pictured here are folding chairs and table, gas stove, suitcase, kids pool, broom, clothes, and a bag with trash and blankets found on 09 March 2017 at the base of Jamie's Way access trail.

Trash by canyon region. In general, trash accumulations were greatest at the upstream end of the canyon ("upper canyon") and decreased with distance downstream (Figure 8). The highest abundance of trash was removed from the side canyons and access trails in the upper half of the canyon (Figure 8); roughly 0.54 kg/m^2 (5.9 L/m^2) of trash was removed from Cooper Canyon (Figure 8) with illegal dumping the likely main source based on the items found, such as car engines, furniture, and cement. Jamie's Way, which also serves as an access trail into the canyon, was cleared of 1.1 kg/m^2 (16.2 L/m^2) of trash (Figure 8), with likely sources from homeless encampments based on common items found, such as cookware, bedding, camping gear (e.g., Figure 7). The ridge at the upper canyon, including Manzanita Gathering Place and the access trail leading into the canyon, was cleaned of 1.0 kg/m^2 (8.2 L/m^2) of trash, with homeless and illegal dumping as likely sources based on common items, including shopping carts, furniture, and bedding. On the canyon floor, the upper end of the canyon accumulated the greatest amount of trash (0.42 kg/m^2; 5.0 L/m^2; Figure 7) due to storm drain inputs and illegal dumping based on items found (e.g., loose trash downstream of the storm drain, abandoned mattresses and furniture by the entrance).

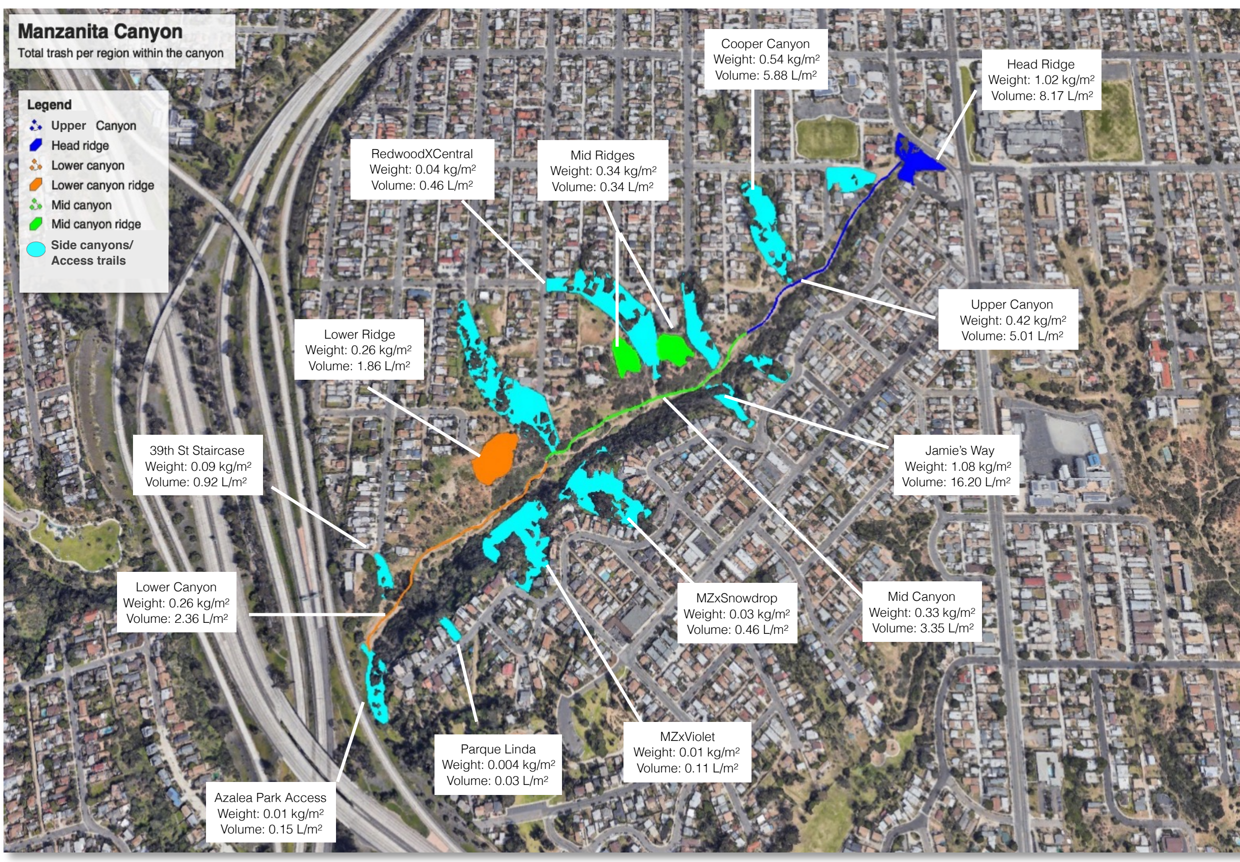

Figure 8. Regions within the 1-km long Manzanita Canyon with total trash removed from May 2016-May 2018.

Mesotrash composition. By volume, mesotrash was nearly always dominated by plastics (33-98%), whether across location in the canyon (upper, middle or lower end) or across season and year (Figure 9). Sporadically, the influence of illegal dumping was obvious with patchy occurrences of building and household materials (e.g., lumber, particle board, ceramics, bedding) (Figure 9).

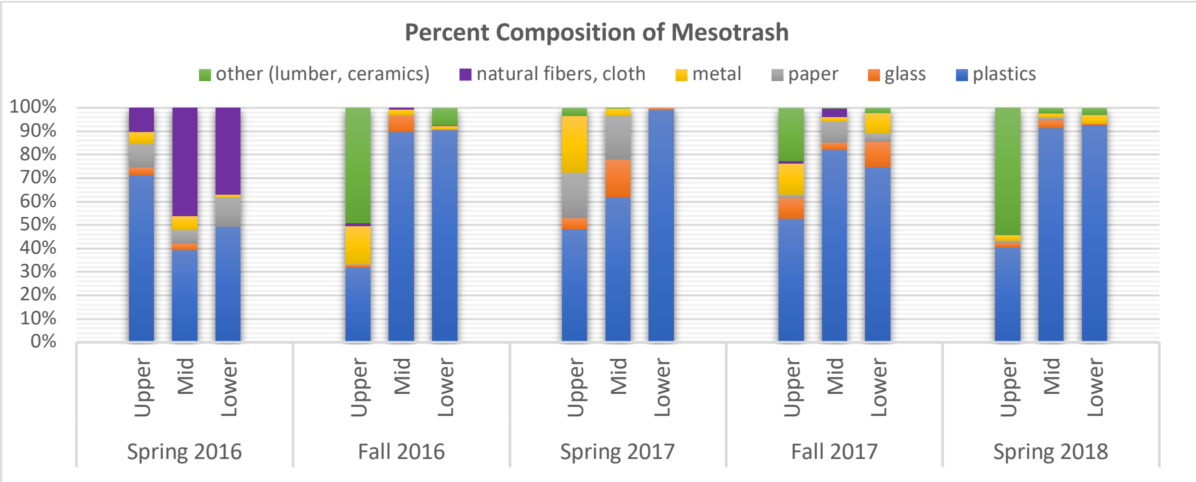

Figure 9. Percent composition by volume of mesotrash collected biannually along three transects located at the head (upstream), mid-reach (mid) and downstream end of Manzanita Canyon between Spring 2016- Spring 2018.

Mesoplastics composition. Mesoplastics were consistently, in space and time, numerically dominated by bags, packaging, and wrappers, comprising an average (±1SE) of 51±3% of all plastics (range of 30-70%; Figure 10). Also common were single-use containers and utensils (6-43% of mesoplastics), household items (e.g., cleaning solution jugs, pens, synthetic cloth/wipes, laminate, carpet fibers, broom bristles; 1-29%) and plastic fragments (1-23%) (Figure 10).

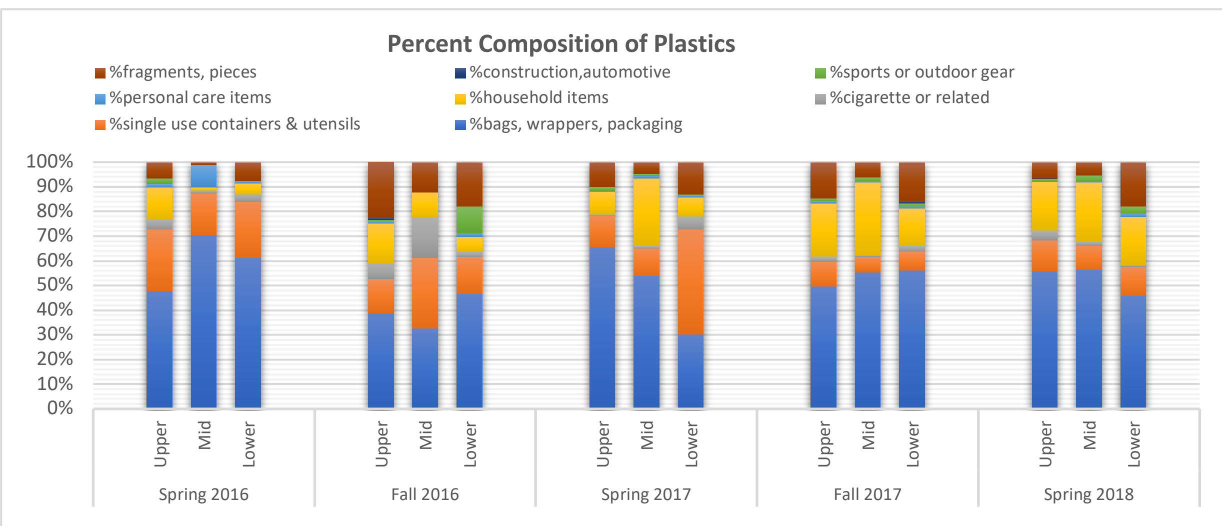

Figure 10. Percent composition by number of mesoplastics collected biannually along three transects located at the head (upstream), mid-reach (mid) and downstream end of Manzanita Canyon between Spring 2016- Spring 2018.

Trash lessons and recommendations. The sources of trash, based on the locations, types and amounts, include storm drain input, illegal dumping and homeless camps. The upper and middle of the canyon have storm drains nearby that shunt litter from streets into the canyon. Illegal dumping was most prevalent at the upper end and in side canyons where roads and alleys abut the canyon. Homeless camps were most common at the middle and lower end of the canyon and side canyons, where public foot traffic (i.e., public visibility) is lowest. The findings of this project formed the basis of the following recommendations:

1. Cleanup efforts should be focused in areas of illegal dumping and homeless camps, in cooperation with authorities and inhabitants, especially in obscured side canyons. Efforts on streets should occur year-round to prevent accumulations, and should be added by storm drain outfalls in the canyon after rains to prevent further movement of trash downstream. Priorities for cleanups should occur on a regional scale since most of San Diego's urban parks and open spaces are as trashed as Manzanita Canyon, or worse.
2. The City can contribute to reducing trash pollution through stricter enforcement of illegal dumping laws, and expansion of large-item pickup services and free drop-off locations. Making disposal of unwanted large items, such as furniture and mattresses, more convenient and free may reduce illegal dumping. Further, improved clean street strategies are needed. Trash that enters the canyons from storm drains originates from city streets where cleanups do not occur and street sweeping efforts do little to keep accumulations at bay.
3. Industry and businesses can play a role in reducing trash pollution by providing incentives for reductions or bans of single use bags, containers, packaging, wrappers, food containers and utensils. Use of compostable materials and incentives to encourage recycling, such as the bottle deposit, may be other solutions.
4. Much work is needed to educate the public and better understand the challenges communities face in stopping illegal dumping, reducing waste, participating in clean ups, and supporting regional strategies to help the homeless.

Restoration.

Renegade trail closures. Over the two-year project, approximately 645.3 linear meters of renegade trails were closed using brush (e.g., cut tree limbs, shrubs) and/or native woody restoration plantings. At the same time, use of established access points was encouraged through installation of stairways and railings, signage, and plantings. These trail closures, coupled with improvements to established access trails, seemed to deter opportunistic use of renegade trails (e.g., pedestrians seeking a short cut between the ridge and floor of the canyon). The closures did not, however, completely eliminate use of renegade trails providing access into encampment areas.

Invasive plant removal. Over the two-year project, 8.62 metric tons (620 m^3) of introduced plant material was removed from throughout the canyon (year-1: 5.23 mt, 530.2 m^3; year-2: 3.39 mt, 90.4 m^3). The removal of this plant material strengthens climate resiliency of the ecosystem in several ways. The risk of wildfire is reduced with the removal of dead, dried plant material (i.e., fire fuel), such as invasive annuals and eucalyptus. Reduction in this fuel also helps to break the positive feedback loop between invasive plant spread and increased fire intensity and frequency (Keeley et al. 2011, Diez et al. 2012). Sources of non-native propagules are also removed with removal of parent plants thereby reducing invasive plant persistence and spread. Finally, invasive plant removal reduces competition and encourages re-establishment of native plant communities, especially when coupled with native plantings. The common natives are perennial woody species that are drought- and fire-tolerant. Besides being better able to resist and recover from fire and drought, natives provide habitat services and maintain greater levels of habitat heterogeneity throughout the year.

Planting Survival and Growth After One Year

Survival After One Year. There was 50% survival of plants at one year after planting, ranging from 0% (MU08) to 90% (MU03) survival across the 16 plots (Figure 11).

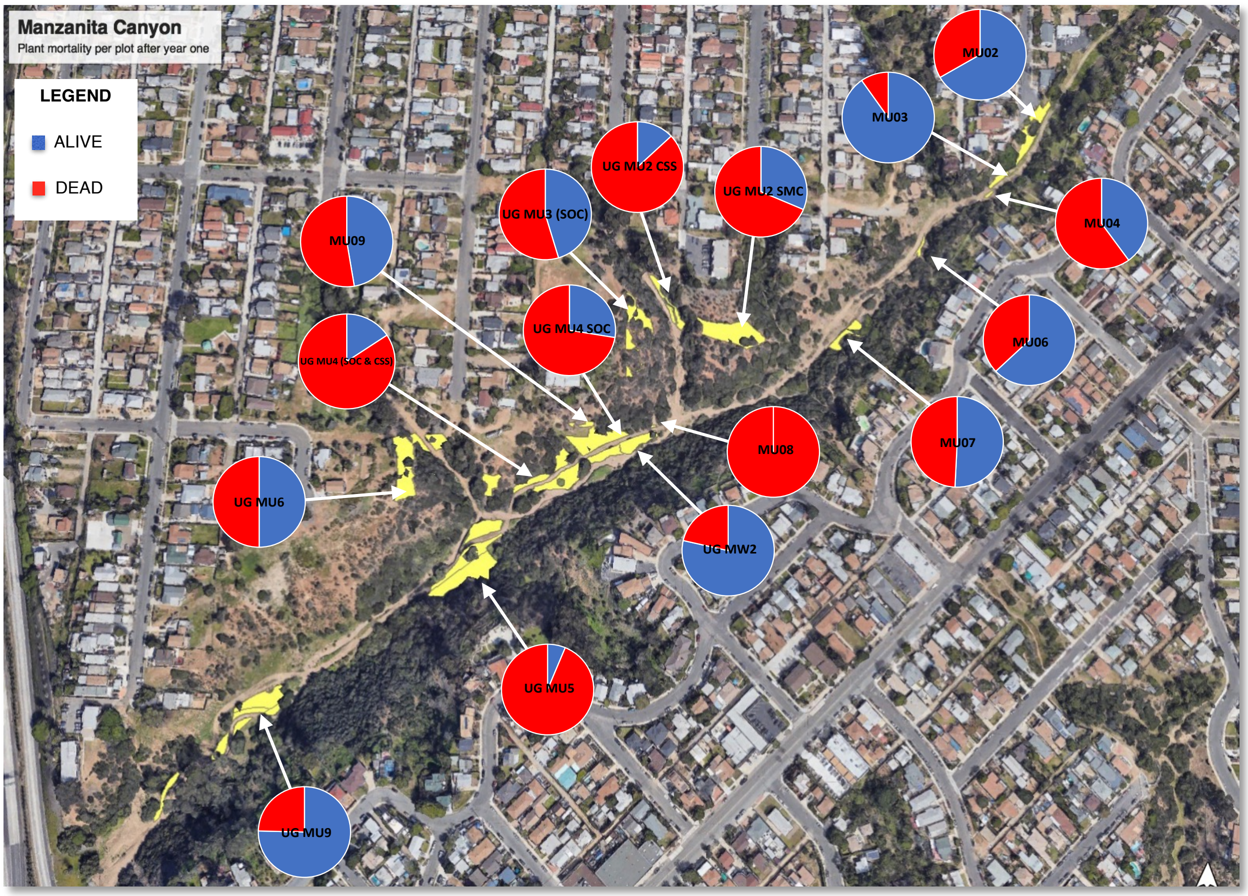

Figure. 11. Planting survival and mortality in the year-1 restoration plots of Manzanita Canyon. Natives were planted between October 2016-February 2017, and data were collected from Oct 2016-January 2018. N= 716 plants over 16 plots.

Monitoring of the year-2 plantings ended in May 2018 when planting survival rate was 81.1%. For comparison, survival of first year plantings in May 2017 was similar at 84.5%. A year-1 50% survival rate is not unusual survival for a coastal scrub restoration, especially with the absence of an irrigation system and the onset of drought. Similar overall mortality (30-56%) after one year has been observed in other coastal scrub restorations in the region (Bowler 2000, Boland and Winter 2016). Also, similar to this study, was the high variability in survival rates between species found in other studies. Bowler (2000) found that mortality rates ranging from 4% in *Artemisia californica* to 81% in *Lotus scoparius* (now *Acmispon glaber*), while mortality in this study ranged from 4% (*Ribes speciosum*) to 96% (*Ambrosia psilostachya*).

Despite the range in plot success, the one-year survival rate of the year-1 plantings did not differ significantly with plot (ANOVA p=0.25), likely due to the high variability in survival rates, numbers of plant species (1-12 species) and numbers of plantings (10-138 plantings per plot) in plots. Plots with the lowest survival (0-6%), tended to be those on slopes and/or along renegade trails, or along the channel, all areas subject to washouts and trampling (e.g., MU08, UG-MU5). However, none of the plot topographic variables tested (slope, elevation and distance from canyon head) were significantly correlated with survival at one year. Further, steeper exposed slopes tend to have higher exposure levels than flatter terrain and, therefore, lower planting survival rates (Kimball, et al. 2015). Trail closures and anchoring of large brush on steep slopes may help to reduce erosion, discourage trampling, and provide shade.

Survival rate for the year-1 plantings at one year differed between species (ANOVA, $p<0.001$, $F_{29,62}=4.1$, n=92) with the relatively narrowly distributed Nuttall's scrub oak (*Quercus dumosa*) and southern honeysuckle (*Lonicera subspicata*) being among the worst performing (0-5% survival); and more broadly distributed natives, such as western ragweed (*Ambrosia psilostachya*), sawtooth goldenbush (*Hazardia squarrosa*), Menzie's goldenbush (*Isocoma menziesii*) *,* California brittlebush (*Encelia californica*, and black sage (*Salvia mellifera*), among the best performing (92-100% survival).

Growth After One Year. Growth rate (% change in volume) of year-1 plantings after one year averaged 95±39%, ranging from -1% growth (yarrow (*Achillea millefolium*) in MU03) to 1569% (*I. menziesii* in MU06), yet growth did not significantly differ with plot or planting species (ANOVA, p=0.98 and p=0.91, respectively). Growth rates in plots over one year did tend to decrease with distance from the head of the canyon although not significant at p=0.05 ($R^2=0.28$, P=0.078, $F_{1,10}=3.84$, n=12 plots). By the end of the project, roughly 73m^3 of native plant biomass was added to the canyon (Figure 12), calculated as the year-end volume of natives planted in the first year [40.5 m^3 = 353 plants X average plant volume of 0.115 m^3], added to the project-end volume of natives planted in the second year [32.5 m^3 = 666 plants X average plant volume of 0.049m^3]. Native perennial plants, which are adapted to fire and drought, provide more resilience to climate change than introduced annual plants through longer-term carbon storage (Chapin 1980), and provision of year-round complex habitat (e.g., Kimball, et al. 2013).


Figure 12. Manzanita Canyon restoration plot MU02 in May 2016, before planting, and in April 2017, 3 months after planting.

Influences on planting survival and growth.

Monthly mortality rates of all species of year-1 plantings were weakly but significantly negatively correlated with maximum daily humidity over the first year (Table 1, Figure 13). Planting growth (% change in volume each month) was weakly but significantly positively correlated with total daily rainfall averaged over the month (Table 1, Figure 14). Growth, measured as change in stem basal diameter was weakly but significantly negatively correlated with daily maximum dew point averaged over the month (Table 1).

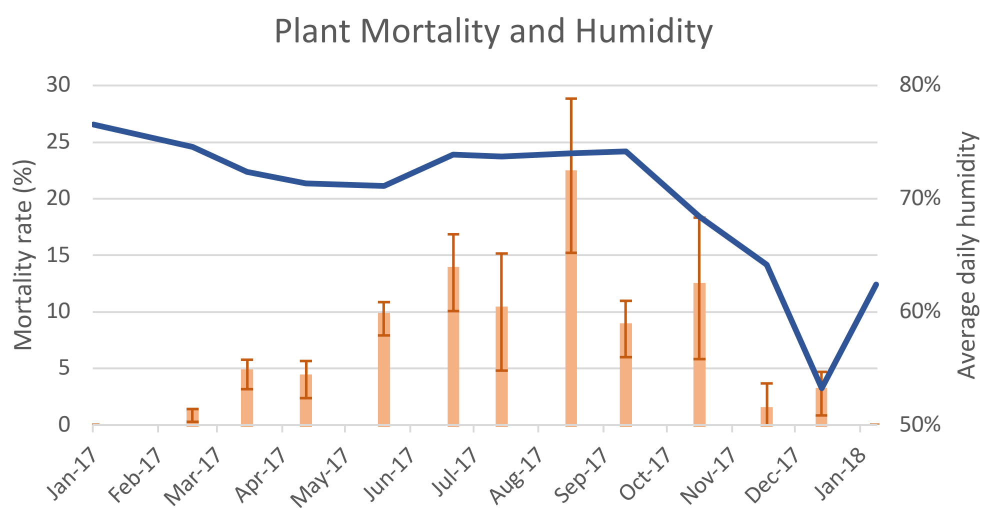

Figure 13. Native planting morality rate (% monthly change in mortality, orange bars) and average daily humidity (averaged within sampling month, blue line) throughout year-1 of the Manzanita Canyon restoration project. Humidity was the only variable tested that was correlated with monthly mortality rate (see text). N= 16 restoration plots.

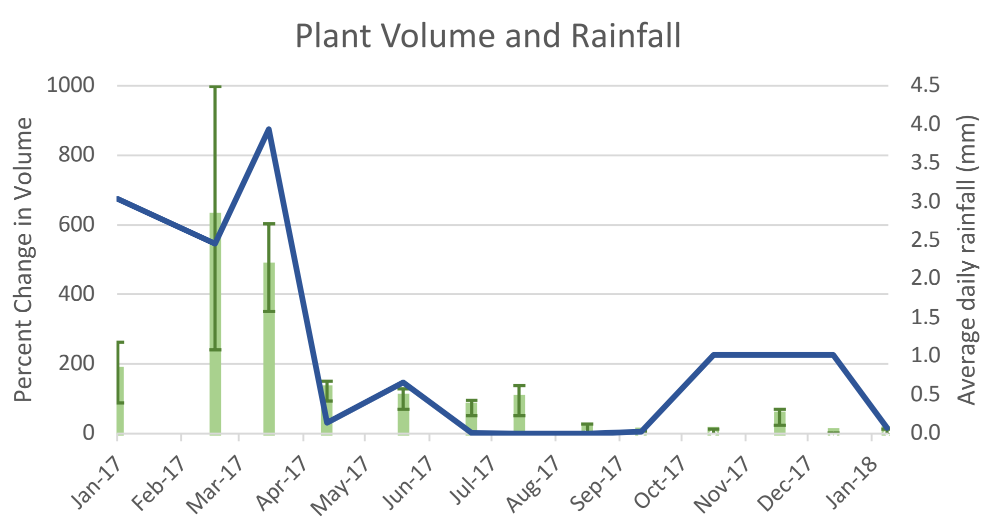

Figure 14. Native planting monthly growth rate (% monthly change in volume, green bars) and average daily rainfall (averaged within each sampling month, blue line). Average daily rainfall was the only variable tested that was correlated with planting growth (see text). N= 16 restoration plots.

The survival and growth of species, in particular those that are deciduous (e.g., *Ambrosia psilostachya*, *Artemisia californica, Artemisia dracunculus, Encelia californica, Ribes speciosum*), tended to mostly be positively correlated with cooler, moister weather conditions (Table 1). Evergreen species (e.g., *Ceanothus verrucosus, Quercus dumosa, Isocoma menziesii*) tended to also be correlated with location in the canyon (e.g., distance from head, elevation, or slope) (Table 1). In general, planting mortality rates tended to increase with higher elevation, farther distances down the canyon, and/or with increased slopes. Survival and/or growth of a few species was not correlated with any of the variables tested; this may likely have been due to the low numbers of plantings of some of those species (e.g., *Brickelia californica, Calystegia macrostegia, Eriophyllum confertiflorum, Trichostema lanatum*).

Other factors not measured in this study also likely contributed to the variability in planting survival and growth. For example, several species including *Isocoma menziesii* and *Artemesia californica* were subject to intense grazing by herbivores, such as bunnies, within the canyon. Fencing around exposed plants or plots, or using restoration cones for longer, may help to reduce grazing, as well as potentially reducing trampling and erosion.

Table 1. Results of forward stepwise multiple regressions testing relationships between the monthly %change in native planting mortality and growth, and environmental variables (see methods for variables measured.) Data are from November 2016 – October 2017. Legend: Temp = Temperature, Avg = Average, Cnyn = Canyon, Max = Maximum, Min = Minimum , Pt = Point; Orange highlight = deciduous species; green highlight = evergreen species; no highlight = can be deciduous or evergreen.

Response variable	R^2	P	F	n	df	Independent variable	+/-	r^2
All species of plantings								
%change in mortality	0.02	<0.001	13.8	816	1,814	Avg daily max humidity	-	n.a.
%change in canopy volume	0.06	<0.001	43.7	652	1,650	Avg daily rainfall	+	n.a.
%change in basal stem diameter	0.03	<0.001	14.3	647	1,645	Avg daily max dew pt	-	n.a.
Acmispon glaber								
%change in mortality	0.25	0.0004	14.8	47	46	Distance from cnyn head	+	
% change canopy volume		≥0.27				N.S.		
%change in basal stem diameter	0.23	0.0446	4.75	18	17	Hours of wind	+	
Ambrosia psilostachya								
%change in mortality		≥0.17				N.S.		
% change canopy volume	0.47	<0.0001	25.5	31	31	Total rain per day	+	
%change in basal stem diameter	0.16	0.0252	5.57	31	30	Max rain intensity	+	
Artemisia californica								
%change in mortality	0.95	0.0104	15.2	10	9	Max rain intensity Max temp Min temp Max dew-pt Min dew-pt	- - - + -	0.95 0.27 0.53 0.32 0.43
% change canopy volume	0.63	0.0061	13.6	10	9	Avg midnight humidity	-	
%change in basal stem diameter		≥0.20				N.S.		

Artemisia dracunculus								
%change in mortality		≥0.38				N.S.		
% change canopy volume	0.23	0.0036	9.85	35	34	Total rain per day	+	
%change in basal stem diameter	0.10	0.0577	3.87	35	34	Avg humidity per day	-	
Brickellia californica								
%change in mortality	0.18	0.0046	8.95	44	43	Max Temp	+	
% change canopy volume	0.37	0.0005	9.72	36	35	Max rain intensity Hours of rain	+ -	0.20 0.46
%change in basal stem diameter		≥0.29				N.S.		
Calystegia macrostegia								
%change in mortality		≥0.09				N.S.		
% change canopy volume	0.24	0.0152	6.94	24	23	Total rain per day	+	
%change in basal stem diameter		≥0.28				N.S.		
Encelia californica								
%change in mortality	0.10	0.013	6.53	62	61	Avg midday humidity	+	
% change canopy volume	0.46	<0.0001	20.9	52	51	Max rain intensity Hours of rain per day	+ -	0.38 0.50
%change in basal stem diameter	0.16	0.014	4.66	52	51	Max rain intensity Avg midday temp	- -	0.16 0.07
Eriophyllum confertiflorum								
%change in mortality	0.36	0.0146	5.32	22	21	Hours of wind Max Temp	+ +	0.23 0.36
% change canopy volume	0.48	0.0584	5.45	8	7	Max Humidity	+	
%change in basal stem diameter		≥0.15				N.S.		
Ribes speciosum								
%change in mortality	0.54	0.0001	19.5	36	35	Max humidity Avg midday light	- +	0.48 0.54
% change canopy volume	0.52	0.0001	37.2	36	35	Hours of rain	+	
%change in basal stem diameter		≥0.19				N.S.		
Solanum parishii								
%change in mortality	0.29	0.0197	4.68	26	25	Max light Slope	+ +	0.16 0.29
% change canopy volume	0.46	0.0403	3.69	17	16	Hours of rain Total rain per day Plot elevation	- + +	0.55 0.21 0.34
%change in basal stem diameter	0.73	0.0022	8.03	17	16	Max rain intensity Max temp Plot elevation Distance from cyn head	- - + +	0.39 0.57 0.21 0.73
Trichostema lanatum								
%change in mortality	0.14	0.0136	6.66	43	42	Slope	-	
% change canopy volume	0.45	<0.0001	32.4	41	40	Max rain intensity	+	
%change in basal stem diameter	0.12	0.0278	5.22	41	40	Avg mid-day temp	-	
Adenostoma fasciculatum								
%change in mortality		≥0.13				N.S.		
% change canopy		≥0.08				N.S.		

volume								
%change in basal stem diameter	0.19	0.0484	4.45	21	20	Avg light per day	-	
Ceanothus verrucosus								
%change in mortality		≥0.12				N.S.		
% change canopy volume	0.29	0.0044	6.45	35	34	Avg temp Slope	- -	0.20 0.29
%change in basal stem diameter		≥0.10				N.S.		
Eriogonum fasciculatum								
%change in mortality	0.56	0.012	10.3	10	9	Avg midday humidity	-	
% change canopy volume	0.92	0.0001	42.0	10	9	Max rain intensity Min temp	+ +	0.80 0.92
%change in basal stem diameter	0.86	0.001	21.6	10	9	Avg midday humidity Avg midday light	+ -	0.86 0.53
Hazardia squarrosa								
%change in mortality		≥0.43				N.S.		
% change canopy volume	0.12	0.025	5.40	42	41	Max temp	-	
%change in basal stem diameter		≥0.15				N.S.		
Isocoma manziesii								
%change in mortality	0.14	0.011	4.87	62	61	Plot elevation Distance from cnyn head	+ +	0.14 0.05
% change canopy volume	0.41	<0.0001	34.3	51	50	Total rain per day	+	
%change in basal stem diameter		≥0.10				N.S.		
Quercus dumosa								
%change in mortality	0.60	0.0001	13.2	30	29	Avg dew pt Avg light Distance from cnyn head	+ - -	0.47 0.60 0.54
% change canopy volume		≥0.19				N.S.		
%change in basal stem diameter	0.35	0.0137	5.36	23	22	Max temp Slope	- -	0.20 0.37
Rhamnus crocea								
%change in mortality		≥0.98				N. S.		
% change canopy volume		≥0.215				N.S.		
%change in basal stem diameter	0.75	0.0002	30.7	12	11	Avg mid-day humidity	-	
Achillea millefolium								
%change in mortality	0.17	0.0071	8.08	41	40	Max humidity	-	
% change canopy volume	0.21	0.0085	7.94	32	31	Total rain per day	+	
%change in basal stem diameter	0.11	0.069	3.59	30	29	Distance from cnyn head	+	

Change in canyon plant communities

Plant diversity (Simpson's Index of Diversity) was higher in the restoration plots than in the reference plots throughout the project (Table 2), likely due to the diversity of invasive annuals in the restoration plots. Diversity climbed slightly in the restoration plots through time (Table 2), which was not surprising given the addition of native species each year. Total percent plant cover in the restored plots remained at least half as much as was in the reference plots (Table 2), which were dominated by mature, perennial native shrubs.

Table 2. Average (±1SE) plant diversity (Simpson's Index of Diversity, 1-D) and total % plant cover in the restoration and reference plots of Manzanita Canyon. Data were collected in April-May of each year; n= 6 of each plot type.

	2016	2017	2018
Plant diversity			
Restoration	0.74 (±0.06)	0.78 (±0.04)	0.83 (±0.02)
Reference	0.55 (±0.06)	0.67 (±0.06)	0.62 (±0.07)
%Plant cover			
Restoration	36 (±12)	48 (±12)	36 (±9)
Reference	85 (±5)	90 (±9)	83 (±7)

The plant communities in the restoration and reference plots differed from each other within and across years. Plant community did not differ with time within the reference plots, but did differ in the restoration plots between 2016, before planting began, and 2018, after completion of planting (Figure 15, Table 3). [Note that in 2017, only half the restoration plots- MU02, MU07, MU10 were planted]. Plant communities within the restoration plots were less similar (more variable) than within reference sites in any given year (Table 3, diagonal); however, similarity in the restoration plots increased each year as the native plantings were completed (from 12% similarity in 2016 to 18% in 2018; Figure 15, Table 3).

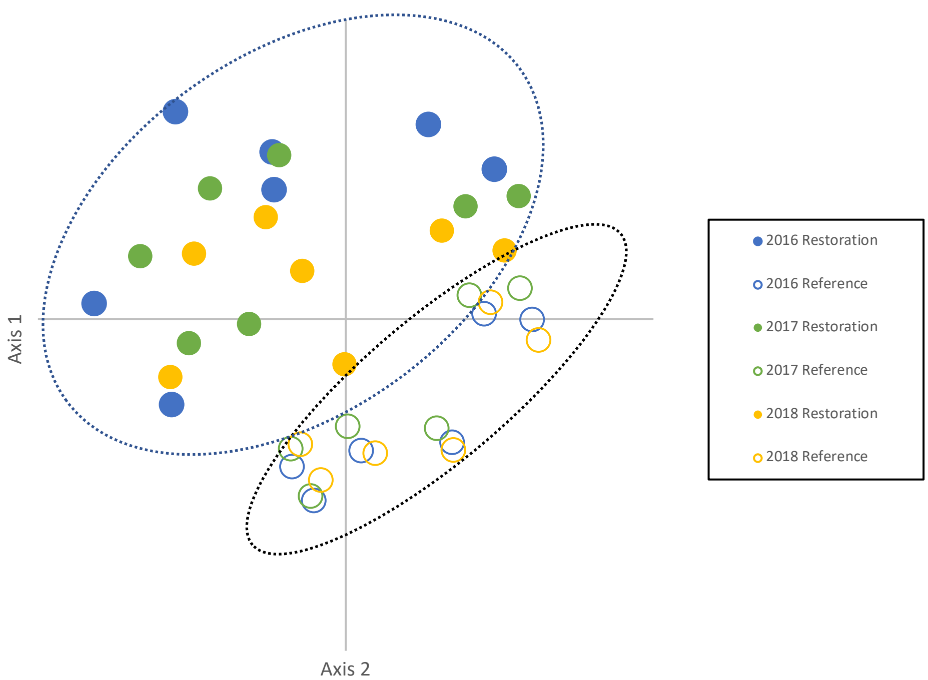

Figure 15. nMDS showing differences in the plant community composition of restored and reference plots of Manzanita Canyon from 2016-2018 (n=6 plots each, Stress=0.18).

Table 3. ANOSIM Global R= 0.25, P=0.001; pairwise p values appear above the diagonal with significant values (p≤0.06) in bold. SIMPER similarity percentages shown italicized on the diagonal and dissimilarity percentages shown below the diagonal for significant pairwise comparisons only. n= 6 restoration and reference plots each.

	2016 Restoration	2016 Reference	2017 Restoration	2017 Reference	2018 Restoration	2018 Reference
2016 Restoration	*12%*	**0.007**	0.595	**0.009**	**0.058**	**0.003**
2016 Reference	94%	*22%*	**0.002**	0.851	**0.008**	0.881
2017 Restoration	n.s.	93%	*14%*	**0.009**	0.438	**0.011**
2017 Reference	94%	n.s.	91%	*23%*	**0.010**	0.898
2018 Restoration	89%	89%	n.s.	88%	*18%*	**0.011**
2018 Reference	96%	n.s.	93%	n.s.	88%	*21%*

Plant community composition in the restoration and reference plots became more similar with time; from 94% different in 2016 before planting to 88% different after plantings were complete in 2018. The difference in restoration plot plant community between 2016 and 2018 was due to increased abundance of native plantings and a shift in abundant annual non-native plants (SIMPER variables explaining ≥75% of the variability between plots types within years). Plant communities differed between the restoration and reference plots each year due to lower abundance of native perennials and higher abundance of invasive annuals in the restoration compared with reference plots even after plantings were complete (SIMPER variables explaining ≥75% of the variability between plots types within years).

Change in substrate composition

There were differences in substrate composition between the restoration and reference plots within and across years, while substrate did not differ with time within the restoration or reference plots (Figure 16, Table 4).

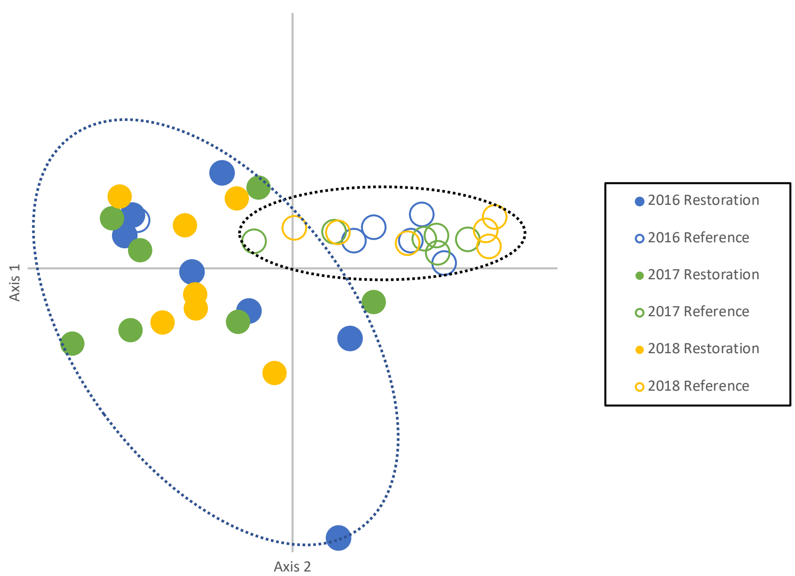

Figure 16. nMDS showing differences in the substrate composition of restored and reference plots of Manzanita Canyon from 2016-2018 (n=6 plots each, Stress=0.10). See methods for the variables assessed.

Substrate conditions within restoration plots were less similar (more variable) than within reference sites in any given year (Figure 15, Table 4). Substrate composition between restoration and reference plots was 34-39% different (Table 4) due to a less cover by litter, and greater cover of exposed fine sediment and coarse material (gravel and cobble) in the restoration compared with reference plots. Restoration plots also had a higher cover of basal stem area in 2016 and 2017 due to the often-high density of annual invasive plants (SIMPER variables explaining ≥75% of the variability between plots types within years).

Table 4. ANOSIM Global R= 0.29, P=0.001; pairwise p values appear above the diagonal with significant values (p≤0.06) in bold. SIMPER similarity percentages shown italicized on the diagonal and dissimilarity percentages shown below the diagonal for significant pairwise comparisons only. n= 6 restoration and reference plots each.

	2016 Restoration	2016 Reference	2017 Restoration	2017 Reference	2018 Restoration	2018 Reference
2016 Restoration	*67%*	**0.038**	0.848	**0.006**	0.931	**0.004**
2016 Reference	34%	*79%*	**0.031**	0.461	**0.006**	0.368
2017 Restoration	n.s.	34%	*72%*	**0.013**	0.354	**0.007**
2017 Reference	36%	n.s.	35%	*84%*	**0.001**	0.760
2018 Restoration	n.s.	34%	n.s.	35%	*78%*	**0.001**
2018 Reference	39%	n.s.	39%	n.s.	39%	*83%*

Restoration takes time. The development time needed for restoration sites to resemble and function like reference ecosystems can take decades (Jones and Schmitz 2009). Although the plant community structure and substrate composition of the Manzanita restoration plots differed from the reference plots at the end of the two-year project, the trajectory of development was encouraging. The restoration plots became increasingly similar to the reference plots with completion of plantings. As native plantings continue to establish and grow, they should help to reduce invasive annual cover, through competition, and facilitate soil development, through shading and organic inputs. Continued maintenance, such as weeding and watering, should help with restoration plot development.

Restoration recommendations. The findings of this two-year study revealed many lessons about ecosystem restoration, which formed the basis of the following recommendations.

1. Increase watering during late summer/early fall and into early winter during drought (Stratton 2009).
2. Increase erosion control and closure of renegade trails on planted slopes to reduce incidence of washouts, trampling and erosion.
3. Use a planting palette that matches established plant species in areas lacking obvious causes of mortality (e.g.,coyote bush, rock rose on canyon ridges).
4. Keep cones on bunnies' favorite species, especially when conditions are dry and food gets scarce.
5. More regularly weed in cones during drought to reduce water competition (Gordon and Rice 2000).

6. In future efforts, consider & allocate resources for:
    a. Expanding use of mulch to maintain soil moisture and enhance microbial activity conducive to natives (Zink and Allen 1998, Talley and Dayton 2014); include composting of weeds on site and use as mulch.
    b. Planting in diverse clumps in open areas and denuded soils for partial shade, mycorrhizal inoculation and/or stabilization (Padilla and Pugnaire 2006, Byers et al. 2006).

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Appendix 1. The planting date, plot, species and numbers of native perennials planted in the restoration plots of Manzanita Canyon during the project period spanning fall 2016-winter 2018. The plants in each plot were monitored for survival and growth for one year following their planting date.

Project year	Date planted	Plot	Species	Total planted
Year-1	11/12/16	UG MU9	*Artemisia dracunculus*	65
	12/07/16	UG MU2 (SMC)	*Ceanothus verrucosus*	15
			Quercus dumosa	20
	12/10/16	UG MU2 (CSS)	*Ribes speciosum*	23
	12/10/16	UG MW2	*Artemisia dracunculus*	28
	12/10/16	UG MU4 (SOC)	*Adenostoma fasciculatum*	9
			Ceanothus verrucosus	20
	12/10/16	UG MU4 (CSS, SOC)	*Ribes speciosum*	51
	12/14/16	UG MU6	*Ceanothus verrucosus*	40
	12/31/16	UG MU3 (SOC)	*Adenostoma fasciculatum*	4
			Artemisia californica	10
			Encelia californica	7
			Eriogonum fasciculatum	16
			Hazardia squarrosa	13
			Isocoma menziesii	12
			Quercus dumosa	18
			Rhamnus crocea	6
	01/14/17	MU02	*Achillea millefolium*	9
			Acmispon glaber	9
			Ambrosia psilostachia	29
			Brickellia californica	3
			Calystegia macrostegia	9
			Encelia californica	18
			Eriophyllum confertifolium	14
			Hazardia squarrosa	14
			Isocoma menziesii	13
			Ribes speciosum	3
			Solanum parishii	3
			Trichostema lanatum	14
	01/25/17	MU03	*Achillea millefolium*	2
			Acmispon glaber	3
			Ambrosia psilostachia	6
			Artemisia dracunculus	3
			Brickellia californica	1
			Calystegia macrostegia	4
			Encelia californica	6
			Epilobium canum	3
			Hazardia squarrosa	3
			Isocoma menziesii	6
			Solanum parishii	1
			Trichostema lanatum	3
	01/25/17	MU04	*Achillea millefolium*	1

			Acmispon glaber	1
			Brickellia californica	1
			Calystegia macrostegia	1
			Encelia californica	1
			Eriophyllum confertifolium	1
			Hazardia squarrosa	1
			Isocoma menziesii	1
			Solanum parishii	1
			Trichostema lanatum	1
	01/25/17	MU06	*Achillea millefolium*	1
			Acmispon glaber	2
			Ambrosia psilostachia	4
			Artemisia dracunculus	2
			Brickellia californica	1
			Calystegia macrostegia	2
			Encelia californica	4
			Epilobium canum	2
			Eriophyllum confertifolium	2
			Isocoma menziesii	4
			Solanum parishii	1
			Trichostema lanatum	2
	02/08/17	UG MU5	*Ribes speciosum*	48
	02/11/17	MU07	*Adenostoma fasciculatum*	5
			Ceanothus verrucosus	4
			Helianthemum scoparium	5
			Heteromeles arbutifolia	8
			Lonicera subspicata	4
			Malacothamnus fasciculatus	6
			Malosma laurina	6
			Prunus illicifolia	2
			Quercus dumosa	8
			Rhamnus crocea	4
			Rhus integrifolia	2
			Salvia mellifera	9
			Sambucus nigra	1
			Yucca whipplei	1
	02/15/17	MU08	*Helianthemum scoparium*	5
			Quercus dumosa	6
	02/15/17	MU09	*Achillea millefolium*	1
			Acmispon glaber	3
			Adenostoma fasciculatum	4
			Brickellia californica	1
			Calystegia macrostegia	1
			Encelia californica	3
			Hazardia squarrosa	1
			Isocoma menziesii	2
			Solanum parishii	1

			Trichostema lanatum	2
Year-1 Total:				716
Year-2	10/14/17	MU10	*Artemisia douglasiana*	10
			Artemisia dracunculus	5
			Baccharis salicifolia	5
			Epilobium canum	8
			Muhlenbergia rigens	5
			Rosa californica	19
			Sambucus nigra	2
	10/14/17	MU11	*Achillea millefolium*	1
			Acmispon glaber	1
			Artemisia californica	2
			Asclepias fascicularis	6
			Brickellia californica	1
			Calystegia macrostegia	1
			Encelia californica	2
			Epilobium canum	1
			Eriogonum fasciculatum	9
			Isocoma menziesii	1
			Mimulis auranticus	1
			Pseudognaphalium californica	2
			Salvia mellifera	2
			Trichostema lanatum	1
	11/11&18/17	MU12	*Achillea millefolium*	11
			Acmispon glaber	11
			Artemesia californica	11
			Asclepias fascicularis	20
			Brickellia californica	11
			Calystegia macrostegia	7
			Ceanothus verrucosus	15
			Encelia californica	23
			Epilobium canum	11
			Eriogonum fasciculatum	34
			Isocoma menziesii	11
			Isomeris arborea	15
			Mimulis auranticus	11
			Pseudognaphalium californica	20
			Ribes speciosum	7
			Salvia mellifera	11
			Trichostema lanatum	11
	12/09/17	MU13	*Achillea millefolium*	5
			Acmispon glaber	5
			Brickellia californica	2
			Calystegia macrostegia	5
			Encelia californica	11
			Hazardia squarrosa	5

			Isocoma menziesii	8
			Pseudognaphalium californica	15
			Ribes speciosum	1
			Trichostema lanatum	10
	01/20/18	MU01	*Achillea millefolium*	38
			Acmispon glaber	30
			Ambrosia psilostachia	60
			Brickellia californica	4
			Calystegia macrostegia	19
			Encelia californica	60
			Epilobium canum	30
			Isocoma menziesii	60
			Pseudognaphalium californica	54
			Ribes speciosum	3
			Trichostema lanatum	30
	2/10/18	MU05	*Achillea millefolium*	3
			Acmispon glaber	3
			Brickellia californica	4
			Calystegia macrostegia	3
			Encelia californica	5
			Hazardia squarrosa	3
			Isocoma menziesii	3
			Pseudognaphalium californica	7
			Ribes speciosum	4
			Trichostema lanatum	5
			Year-2 Total:	820
			Project Total:	**1536**