Naval Base Ventura County, San Nicolas Island Erosion Control Program

Mesembryanthemum crystallinum impacts and habitat restoration

Final Report

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Cooperative Agreement Technical Representative: Michelle Cox, NAVFAC Southwest

Installation Representative: William Hoyer, Naval Base Ventura County

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Prepared By: The Santa Barbara Botanic Garden (SBBG)

Prepared For: William Hoyer, Installation Representative, Naval Base Ventura County

Under Contract to: Michelle Cox, Cooperative Agreement Technical Representative

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GLOSSARY

C_3 Carbon Fixation – One of three metabolic pathways for carbon fixation in photosynthesis, along with C_4 and CAM. This process converts carbon dioxide and ribulose bisphosphate into 3-phosphoglycerate. C_3 plants tend to thrive in areas where sunlight intensity and temperatures are moderate, and groundwater is plentiful.

CAM Photosynthesis – Crassulacean Acid Metabolism (CAM) is one of three metabolic pathways for carbon fixation in photosynthesis, along with C_3 and C_4. It evolved in some plants as an adaptation to arid conditions. In this pathway, the stomata in the leaves remain shut during the day to reduce evapotranspiration, but open at night to collect carbon dioxide which is stored for use in photosynthesis during the day.

Composition – The assemblage of species, subspecies, and other taxa found in an area.

Cover (Absolute) – Absolute plant cover is how much of the ground is covered by plants, regardless of the overlap of different species that may be present.

Cover (Relative) – The percent of ground covered by an individual taxon in an assemblage. The sum of the relative cover, or total relative cover, can exceed the absolute plant cover in an area due to spatial overlap between taxa.

Detritivore – An organism that obtains nutrients by consuming detritus (decomposing plant and animal parts as well as feces). By doing so, these organisms contribute to decomposition and the cycle of nutrients. In this study, we have broadened the category of detritivore to include fungivores.

Ecosystem – A community made up of both living organisms and nonliving components such as air, water, and mineral soil.

Ecosystem Function – The capacity of natural processes and components to provide goods and services that satisfy human needs, either directly or indirectly.

Electrical Conductivity (EC) – Salts that dissolve in water break into positively and negatively charged ions. Conductivity is the ability of water to conduct an electrical current, and dissolved ions such as sodium, calcium, and potassium are the conductors.

Feeding Guild – A guild is any group of species that exploit the same resources, or that exploit different resources in related ways. Arthropod feeding guilds include herbivores, detritivores, and predators.

Functional (bio)diversity – A component of biodiversity that generally concerns the range of things that organisms do in communities and ecosystems. It can provide a link between the individual organisms and the functions they perform within greater ecosystems.

Fungivore – An organism that consumes fungi.

Grow-Kill Technique – A habitat restoration technique that aims to deplete an undesired seedbank by watering to stimulate germination of the unwanted species, then control of that species.

Herbivore – An organism that consumes plants.

Parasitoid – An organism that lives in close association with its host at the host's expense, and which eventually kills it. Strategies range from living inside the host, to paralyzing the host and living outside it. Hosts can include other parasitoids, resulting in hyperparasitism.

Pollinator – An organism that moves pollen from the male anther of a flower to the female stigma, thus fertilizing the ovules and enabling seed and fruit production.

Predator – An organism that kills and eats another (live) organism, its prey.

Pre-emergent Herbicide – A chemical that kills weeds as they germinate (sprout) from seeds.

Resilience – The amount of disturbance that an ecosystem can withstand without changing self-organized processes and structures.

Species Diversity – An index that accounts for both the number of different species in a community as well as their evenness (how equal the abundances of those taxa are). For two communities with the same number of taxa, the community with the greater evenness will have higher diversity, as each of those taxa are better represented.

Species Richness – The number of species in an assemblage.

ABSTRACT

Invasive, non-native species are one of the top threats to biological diversity, and a major driver of global change. Insects and other arthropods are excellent indicators of the impacts of plant invasions, as well as the effectiveness of habitat restoration efforts. We investigated the impacts of *Mesembryanthemum crystallinum* invasion on arthropod abundance, richness, composition, feeding guilds, and functional diversity via impacts on plant diversity, native plant cover, and soil characteristics at three sites on San Nicolas Island, California. We then investigated several techniques to regain this plant diversity and native plant cover.

In 2x2 meter plots, we compared a more labor-intensive approach (grow-kill) with a less intensive approach (herbicide), and compared these treatments to both control and native comparison plots. Both treatments were also used in combination with hydro-seeding of native plant seed. We surveyed terrestrial arthropods using pitfall traps in April 2016, and plants using visual cover estimates in April 2016, 2017, and 2018. We identified all arthropods except for spiders and mites to the family level, then assigned them to “morphospecies”, which were tracked across samples using high-resolution z-stacked images. We added 8 then 12 gallons of water to the grow-kill plots each month between October 2016 and January 2017, and controlled emerging *Mesembryanthemum* through a combination of hand pulling and hoeing. Herbicide was applied in early February, and hydroseeding performed in mid-February using a Turbo Turf HS-50-M portable hydroseeder.

For two of three sites studied (Buckwheat Badlands and Caliche Plateau), both plant and arthropod diversity were significantly (or near-significantly) lower in *Mesembryanthemum*-dominated plots. Native plant cover and soil moisture were the most significant explanatory variables for arthropod richness at those two sites. At the third site (Stilted Dunes), both plant and arthropod richness were significantly *higher* in *Mesembryanthemum* plots. At that site, the best explanatory variable for arthropod richness was plant litter cover. Despite these differing plant/arthropod diversity responses at the different sites, arthropod composition was consistently altered by *Mesembryanthemum* invasion at all three sites. Indicator Species for *Mesembryanthemum* plots were primarily detritivores such as springtails (Collembola) and barklice (Psocoptera), as well an herbivorous mealybug (Pseudococcidae). A large increase in arthropod abundance found in *Mesembryanthemum* plots at both Buckwheat Badlands and Stilted Dunes was due in large part to an increase in these taxa. In contrast, Indicator Species for Native comparison plots included all flies (Diptera), beetles (Coleoptera), ants (Formicidae: Hymenoptera) and moths (Lepidoptera), as well as all but one wasp (Hymenoptera) and true bug (Hemiptera). The increase in abundance of detritivores and herbivores, and sometimes parasitoids, combined with a decrease in nectar/pollen feeders and omnivores at some sites, led to reduced functional diversity at both the Buckwheat Badlands and Stilted Dunes sites. It is noteworthy that either species richness or functional diversity (or both) was reduced in *Mesembryanthemum* plots at all three study sites. This has important, negative implications for ecosystem functions, stability, and resilience to global environmental change on the island, and habitat restoration will be critical.

In our restoration experiment, herbicide application appears to have achieved the greatest reduction of *Mesembryanthemum* cover in our plots. However grow-kill plots supported higher plant species richness and native plant cover of the two treatments. Herbicide could not be applied as selectively as hoeing, and the negative effect of herbicide on plant richness persisted into 2018. As of April 2018 (1 years and 2 months following treatment), there was not yet any significant effect of hydroseeding. Seedling growth observed in April 2017 perished in the subsequent drought, and very few annuals (including *Mesembryanthemum*) were observed in April 2018 monitoring. Hydroseeded material is still evident in our plots, however, and could still germinate and grow in a favorable weather year. But drought will be an ongoing concern for restoration programs that utilize seeding. Recommendations are provided for future restoration efforts going forward.

INTRODUCTION

Biological diversity provides resilience and stability in an ecosystem, via the variety of responses that different species have to annual variation and disturbance (Gunderson 2000; Hautier et al. 2015). Invasive, non-native species are one of the top three threats to this biological diversity, and are a major driver of global change (Mack et al. 2000; Millennium Ecosystem Assessment 2005). Invasive plants, in particular alter disturbance regimes, nutrient cycles, the physical environment, and fluxes of both materials and energy (Mack and D'Antonio 1998; Liao et al. 2008; Ehrenfeld 2010). Understanding the impacts of plant invasions can help to guide the conservation and restoration of diverse, functional ecosystems (Lodge 1993, McMahon et al. 2006).

Insects and other arthropods are excellent indicators of the impacts of plant invasions and habitat restoration, because they respond quickly, sensitively, and locally to environmental changes (Kremen et al. 1993), and perform key ecosystem functions. Arthropods in different feeding guilds can be directly linked to such functions, including decomposition (via detritivores, fungivores, and scavengers), regulation of food and fuel production as well as soil retention and carbon sequestration (herbivores), pest control (predators and parasitoids), and pollination (nectar & pollen feeders). Any impacts on arthropod abundance, diversity, and composition thus have implications for entire food webs (Gullan & Cranston 2005). Feeding guild impacts can be investigated individually, but their cumulative diversity is also an important indicator. Functional Diversity is an excellent predictor of ecosystem function (Cadotte et al. 2011, Gagic et al. 2015), and appears to be even more important than species richness in buffering the negative effects of global environmental change (Valencia et al. 2015; Liu & Wang 2018). Thus Functional Diversity should be incorporated into conservation decision making and habitat restoration efforts (Cadotte et al. 2011).

We investigated the impacts of *Mesembryanthemum crystallinum* invasion on arthropod abundance, richness, composition, feeding guilds, and functional diversity via impacts on plant diversity and native plant cover on San Nicolas Island (SNI), California. We then investigated several techniques to regain this plant diversity and native plant cover, and thus support higher trophic levels starting with terrestrial arthropods, which are an important food source for two rare vertebrate taxa: Island foxes (*Urocyon littoralis*) and Island night lizards (*Xantusia riversiana*).

Background

Mesembryanthemum crystallinum (hereafter MECR), or crystalline iceplant, is an annual South African plant that is invasive along southern California's coast and Channel Islands. It was already reported as abundant on SNI by 1898 (Junak 2008). It accumulates salts and releases them into the soil upon its death, thereby creating a detrimental osmotic environment correlated with reduced numbers of grassland seedlings (Vivrette & Muller 1977). It is also able to spread and form high soil cover, and has been associated with a decrease in both native plant species richness (Williams & Williams 1984) and annual pasture production (Kloot 1983). These changes in biodiversity and soil salinity are likely to impact the terrestrial arthropod community, however this has not been studied.

MECR is highly adaptable, able to switch its photosynthetic mechanism from C_3 photosynthesis to CAM to conserve water in response to increased salinity and drought (Adams et al. 1998; Winter and Holtum 2014). Its seeds are also likely relatively long-lived; seeds of the closely related *Mesembryanthemum nodiflorum* remain viable at least 32 years (Gutterman and Gendler 2005). Further, MECR grows well in the saline environment that it creates, whereas many native plants do not; this creates a positive feedback for MECR dominance. Clearly, this is a critical yet difficult weed to manage. MECR has invaded the California coast from the San Francisco Bay area south to the border with Mexico (including all eight of the Channel Islands), and effective habitat restoration techniques are needed to regain the biological diversity and ecosystem function that has likely been lost in those areas.

The U.S. Navy is interested in learning more about the impacts of MECR on SNI, and restoring diverse native habitat to benefit the natural resources there. Given the large extent of MECR invasion on the island, the methods used need to be both efficient and cost-effective at a large scale. We conducted a study to learn more about the impacts of MECR on soil salinity, plant cover and diversity, and invertebrate assemblages on SNI. We also conducted a greenhouse study to determine if there is enough native component in the seed bank on SNI to advise against use of a pre-emergent herbicide, which would have the advantage of treating the MECR soil seed bank as well as above-ground living plants. Following these studies, we conducted a habitat restoration experiment which compared a more labor-intensive approach (grow-kill) with a less intensive approach (herbicide). The grow-kill technique entails multiple watering events and removal of germinated MECR, and attempts to stimulate germination of the MECR seed bank to achieve greater long-term control of this weed. On Santa Barbara Island, D'Antonio et al. (1992) found that salts could be pulled back out of the soil by harvesting MECR prior to it dying. We reasoned that our grow-kill technique would have the dual benefits of leaching salts from the soil surface via repeated watering, while also pulling salts out of the soil through MECR's biotic mechanism, thus re-creating a more hospitable environment for germination of other plant species. Both treatments were also used in combination with hydro-seeding of native plant seed, and compared to plots without seed addition, to restore native plant cover and diversity and provide resistance to re-invasion. Seeding was chosen over growing and planting container stock because it is much less resource-intensive, albeit dependent on rainfall (which can be highly variable), and the tackifier and mulch used when hydroseeding are expected to be critical in the windy, eroded environment of SNI.

Through our studies, we asked the following specific questions:

- What is the effect of MECR on soil salinity and pH levels on SNI?
- Does the soil seed bank contain a significant native species component that would make use of a pre-emergent herbicide ill-advised?
- How are plant species richness and native plant cover affected by MECR invasion?
- How do arthropod assemblages (abundance, richness, composition, feeding guilds, and

functional diversity) differ between native- and MECR-dominated plots, and along a gradient of MECR invasion?

- How do two MECR removal techniques (grow-kill, herbicide) combined with hydroseeding of native plants affect MECR abundance/loss, plant species richness and native plant cover?

We expected to find that MECR would increase soil salinity levels on San Nicolas Island as elsewhere, and that plant species richness and native plant cover would be decreased by MECR invasion. We also expected that arthropod richness and functional diversity would be lower in MECR plots, and that composition would be significantly different. However, because plant invasions tend to increase the mass of both living and dead plant material (Holdredge and Bertness 2011; Topp et al. 2008; Moron et al. 2009) and that can allow expansion of selected arthropod populations, we expected that arthropod abundance would be increased by MECR invasion.

METHODS

Study Site and Plot Setup

San Nicolas Island is 58 square kilometers in size, and lies 98 km southwest of the city of Ventura (Junak 2008). The low-lying island (maximum elevation 277 meters) is dominated by a broad central mesa, rimmed by sandstone ledges, coastal terraces, and beaches (Junek 2008). The prevailing northwest wind averages 26 kilometers per hour, and annual precipitation is 21 cm (Junak 2008). The most common soil types on the island include rock outcrops, Vizcapoint severely eroded land complexes, dune land, and Vizcapoint sandy loam (USDA 1985). The predominant vegetation communities on the island include (in order of decreasing area) Coastal Scrub, Barren or Sparse, Grassland, *Coreopsis* Scrub, and Stabilized Dune (Halvorson et al. 1996). MECR is a component of most of these plant communities (Junak 2008). In 2014, a total of 105 acres were mapped as being dominated by "*Carpobrotus edulis* or *other Ice Plants*" (HDR 2014). This is 0.42 square kilometers, or 0.7% of the island. Of ten plant communities found on San Nicolas Island, MECR-dominated scrub is tied for the lowest number of total plant species (11); this is in contrast to a mean of 31.3, and maximum value of 59 (Halvorson et al. 1996).

At each of three sites across San Nicolas Island, chosen for a combination of extensive MECR invasion, accessibility, and habitat diversity, we set up six 2x2 meter plots each of the following treatments (42 plots at each site, 126 plots total):

- Grow-kill MECR with hydroseeding
- Grow-kill MECR, without hydroseeding
- Herbicide MECR with hydroseeding
- Herbicide MECR, without hydroseeding
- No MECR treatment, with hydroseeding
- No MECR treatment, without hydroseeding
- Native-dominated control

Denise Knapp (SBBG Director of Conservation) and Chris Garoutte (SBBG Conservation Technician), together with William Hoyer, randomly located the northeastern corners of our plots in November 2015. We GPS'ed those corners, and marked them with found materials from the island (wooden stakes, PVC or metal pipe). At that time, we collected approximately 0.04 square meters of soil from the center of a 1x1 meter sub-plot placed in the northeastern quadrant for use in seed germination trials. This method kept the sample to the top two inches of soil, and was the maximum weight that we could get on the plane that is the only means of visitor transportation to and from the island.

After setting up the experimental plots, it became obvious that we needed plots with less MECR and more native cover for comparison. These were established in April 2016. We sought the nearest native-dominated patches available, which in all cases were located on the fringes of the invaded area. These native patches were typically found in shallow drainages. Two hypotheses for why this might be are: 1) topsoil containing native seeds eroded into what used to be deeper drainages, or 2) natives do better in areas with slightly more moisture.

Our three sites are shown in **Figure 1** and their locations are as follows:

1) Buckwheat Badlands (BB), 33.221/ -119.449

2) Stilted Dunes (SD), 33.261/ -119.554

3) Caliche Plateau (CP), 33.247/ -119.544

Figure 1. The Stilted Dunes (SD), Caliche Plateau (CP), and Buckwheat Badlands (BB) study locations on San Nicolas Island.

Buckwheat Badlands (BB: **Figure 2**) is located at the southeastern corner of the island just above Daytona Beach. The silty soils are erosive and this site shows evidence of human disturbance, including an old road and metal rubbish. MECR is by far the dominant plant (with an average 58% cover), but occasional associates include *Suaeda taxifolia*, *Crassula connata*, *Salsola tragus*, and *Plantago ovata*. The nearest native-dominated habitat is coastal scrub dominated by the San Nicolas Island endemic *Eriogonum grande* var. *timorum*, *Isocoma menziesii*, *Lomatium insulare*, and *Bromus madritensis*. There, MECR has an average of 5% cover.

Figure 2. The Buckwheat Badlands site, San Nicolas Island.

Caliche Plateau (CP: **Figure 3**) is located in the mid-western half of the island just below the E-W trending ridge that bisects the island. It contains coastal scrub habitat dominated by *Isocoma menziesii* in addition to MECR, and as the name implies, the soil is covered with calcium carbonate deposits (caliche), likely exposed by the extensive erosion that the island has experienced (Junak 2008). Plant associates include *Astragalus traskiae*, *Lomatium insulare*, *Lepidium lasiocarpum*, *Crassula connata*, and *Bromus madritensis*. MECR has an average of 58% cover in our experimental plots, and 3% in our nearby native plots.

Figure 3. The Caliche Plateau site, San Nicolas Island.

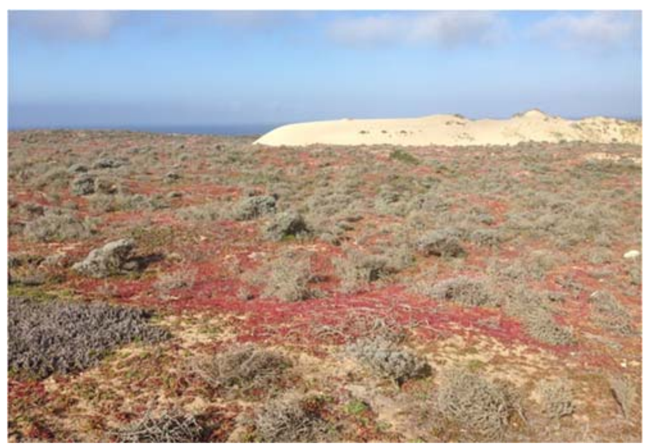

Figure 4. The Stilted Dunes site, San Nicolas Island.

Stilted Dunes (**Figure 4**) is located on the sandy, far western slope of the island. The backdune scrub habitat there contains such natives as *Lupinus arboreus*, *Acmispon argophyllus*, *Astragalus traskiae*, *Abronia umbellata*, and *Ambrosia chamissonis*, along with non-native annuals including *Erodium cicutarium* and *Bromus madritensis*. MECR has an average 60% cover in our experimental plots, and 1% cover in our nearby native plots.

Seed Bank Study

Chris Garoutte and SBBG Plant Propagation Manager Heather Wehnau set up the soil seed bank study in January of 2016 at the Santa Barbara Botanic Garden greenhouse, which is covered with fine mesh but otherwise open to the sun and wind. Soil samples were added to 4" pots already half full with potting soil. Each pot was labeled with the plot ID using plastic pot tags, and the pots were watered regularly to keep the soil moist. Every 2-5 days, Chris counted and recorded any plants that were mature enough to identify and then removed them from the pot. Plants were grown up as long as necessary to facilitate their identification to species rank.

Pitfall Trapping

Terrestrial arthropods were surveyed by Denise Knapp and Chris Garoutte using pitfall traps. We buried 540 mL plastic deli cups (11.5 cm diameter, 7 cm height) in the approximate center of each 2x2 m plot, being careful to ensure that the lip of the cup was as smooth with the soil surface as possible. Once all cups were installed, we filled each approximately half full with soapy water (2 drops blue Dawn dish liquid to 1 liter of water). These were left open for 45.5-48 hours to collect ground-dwelling invertebrates. The cups were then pulled and the contents poured into containers for sieving with a fine mesh coffee filter into vials with 70% ethanol.

Arthropod Identification

All arthropods except for spiders (Araneae) and mites (Acari) were identified to Family level then assigned a hypothesized species based on morphological characteristics ("morphospecies"; Oliver & Beattie 1996), taking into account the most important features for identification of each group. Consulting ecologist Fritz Light performed the vast majority of this work. Most arthropod taxa were identified following Triplehorn and Johnson (2005), but identifications of Coleoptera also followed Arnett and Thomas (2001) and Arnett et al. (2002), while Diptera ID's followed McAlpine et al. (1981, 1987), and isopods followed Smith and Carlton (1975). High-resolution images of each morphospecies were taken with a Leica M125 dissection microscope equipped with "z-stacking" technology, which montages many images together to achieve one photograph that is in focus throughout the insect's highly 3-dimensional body. In this way we were able to assess and track morphospecies across vials of arthropods, which are not conducive to re-examination. Photos of difficult taxa were posted onto https://bugguide.net to enlist the help of entomological specialists worldwide with identification.

Feeding guild was assigned to each arthropod family using the same references above. Fungivores, scavengers, and detritivores were combined into the single category of detritivore. Abundances for each guild were then used to calculate Functional Diversity for each plot using the Shannon diversity index (H'; Krebs 1998).

Vegetation Surveys

Vegetation surveys were performed in April of 2016, 2017, and 2018 by Denise Knapp, typically along with either Chris Garoutte or Conservation Technician Alena Leonatti. We visually estimated cover for each plant taxon found within our 1x1 m subplots. Computer generated diagrams representing different levels of cover (produced by the California Native Plant Society) were used as training guides before undertaking the work to avoid over- or under-estimation. When possible, two surveyors worked together, estimating cover independently and then coming to an agreement. Species cover estimates were combined to produce an estimate of total relative cover; we also assessed absolute cover in the field. Using these data, we also calculated plant species richness and native plant cover.

Soil Analyses

We collected soil in April 2016, then again in May 2017, for soil electroconductivity, pH, and texture analyses in our lab. We combined three subsamples taken with a trowel from the top inch of soil. All soils analyses were conducted by SBBG Conservation Technician Stephanie Calloway.

We used the New South Wales Department of Sustainable Natural Resources protocols (2018) to measure electrical conductivity (EC; an indicator of salinity) and pH. A 1:5 soil:water suspension was prepared by weighing 10 g air dry soil into a bottle and adding 50 mL deionized water. This mixture was mechanically agitated at 15 rpm for 1 hour to dissolve soluble salts. An Oakton PC 10 pH/conductivity/temperature meter was calibrated using the manufacturer's KCl reference solution, rinsed, and used to perform the measurements. To assess salinity before (2016) and after (2017) grow-kill treatments in comparison to control plots which did not receive weed treatments, electroconductivity in 2016 was subtracted from 2017.

Soil texture was assessed using the "feel method" (USDA – NRCS 2018) on five randomly chosen plots from each treatment. Soil moisture was assessed by Denise Knapp and Alena Leonatti in May 2017 by averaging four measurements, taken in each corner of the plot with a Field Scout TDR 300 soil moisture meter (Spectrum Technologies, Aurora IL).

MECR Control

Denise Knapp and Alena Leonatti visited the island in October 2016 to begin the grow-kill treatments. Navy archaeologist Lisa Thomas accompanied us to the Buckwheat Badlands site to ensure that cultural resources were not at risk. At that time, we labeled each of our plot markers with colored duct tape to indicate our treatments. We flagged three corners of our 2x2 meter plots, then used 2-gallon watering cans to ensure that we applied a consistent amount of water to each of our plots. We determined at that time that 8 gallons saturated the soil to a degree at which we thought it would enhance *Mesembryanthemum* germination. We used a 60-gallon AquaTank water bladder together with a variety of plastic receptacles to fill the watering cans.

Denise and Alena visited the island each month between October 2016 and January 2017 to continue the grow-kill treatments. Before January, the few seedlings we observed were easily controlled by hand pulling, making hoeing or raking unnecessary and allowing us to disturb the soil as little as possible. Because we saw little germination either inside or outside the plots during those months, we increased our water quantity to 12 gallons per plot in December, applied over two days which resulted in three days of saturation.

With the greater than average rain that had fallen earlier in the month, no watering was necessary in January, and there was a thick carpet of *Mesembryanthemum* seedlings. This germination was likely also related to both rainfall and temperature cues. We used a hoe to remove these seedlings, and removed the densest clumps from the plots in order to avoid this barrier inhibiting the germination of other taxa.

Conservation Technician Alena Leonatti visited the island on February 2 to direct herbicide treatments performed by Kevin Thompson of Channel Islands Restoration (CIR). Due to the heavy fog and potential diluting effect it may have, Kevin used 2.5% glyphosate, which is slightly higher than the normal rate (2%). The spraying was performed successfully. At the same time, Alena hoed *Mesembryanthemum* in the appropriate plots.

Hydroseeding

Seed was collected from the general vicinity of each of our study sites on three separate visits between May 23 and July 12. All site visit dates are provided in **Appendix Table 1**. Seed was collected from 20 different native plant taxa that were found in enough abundance, and in the right condition, to collect. Collection date and location, cleaned weight, and site application information are provided in **Table 1**.

Denise Knapp, Alena Leonatti, and SBBG Gardener Robert Carrillo visited the island from February 14-16, 2017 to perform the hydroseeding, with the help of William Hoyer and Northern Arizona University (NAU) biological soil crust experts Anita Antoninka, and Peter Chuckran. Seed was applied at a rate of 0.008 lbs/square meter (=0.55-0.57 lbs/site total) together with paper mulch and tackifier using a Turbo Turf HS-50-M portable hydroseeder (Turbo Technologies Inc., Beaver Falls, PA). M-Binder tackifier was applied at a rate of 100-200 lbs/acre, and Nature's Own paper fiber mulch was applied at a rate of 1,500 lbs/acre. Paper mulch was chosen over wood mulch both because it is required for our portable model, and because it creates a "paper mâché" over the soil which seals in moisture and provides better seed to soil contact.

Statistical Analyses

For all comparative tests with two samples, Student's t-tests were used for data that met the assumptions of this test, as it is more powerful than non-parametric tests. Wilcoxon/Kruskal-Wallis rank sums tests were used for data that were not distributed normally (non-parametric). In order to determine the most significant explanatory variables for arthropod richness and functional diversity results, multiple regression analyses were performed comparing MECR cover, plant species richness, native plant cover, litter cover, and soil moisture.

For tests comparing experimental MECR restoration treatments, ANOVA analyses were used for normally distributed data with approximately equal variances, then pairs compared using a Tukey-Kramer HSD test, which presents a familywise error rate (it corrects for the greater probability of getting a significant result when performing multiple tests). When data were not distributed normally, Wilcoxon/Kruskal-Wallis tests were used to compare multiple samples, then pairs were compared using the Steel-Dwass method, which corrects for multiple tests. These corrections result in a conservative interpretation of statistical significance when compared to any given pairwise comparison in isolation. The above analyses were all performed in JMP version 13.0 (Statistical Analysis Software, Cary, North Carolina).

Non-Metric Multidimensional Scaling was used to visualize differences in the relative abundances of arthropod taxa across plots and plot type (*Mesembryanthemum*-dominated, native-dominated). The effects of plot type on arthropod community composition was assessed quantitatively using the Multi-response Permutation Procedure (MRPP) (Mielke and Berry 2001). Sorenson (Bray-Curtis) distance measures were used for both of these analyses. In addition, Indicator Species Analysis was used to determine the morphospecies associated with the two plot types. Dufrêne and Legendre's (1997) method, which combines information on the concentration of species abundance in a group and the faithfulness of its occurrence in that group. All of these multivariate analyses were performed using PCOrd software, version 7 (McCune and Mefford 1999).

Results are considered statistically significant when the probability that there is no difference between the means is five percent ($p=0.05$) or less. In other words, we reject the null hypothesis that there is no difference between the means. Asterisks are used to indicate statistical significance at the $p \leq 0.05$ (*), 0.01 (**), and 0.001 (***) levels. For p values between 0.05 and 0.10, this is considered a statistical trend, and indicated with a †.

RESULTS

Soils Analyses (2016)

Results for salinity and pH tests are presented in **Table 2**. Electroconductivity was significantly greater in native plots at the Caliche Plateau site, but was not significantly different between treatments at the other two sites. The Buckwheat Badlands and Caliche Plateau sites had significantly higher pH in the MECR plots, while differences were not significant at Stilted Dunes.

Soil texture for randomly selected representatives of each plot type are presented in **Table 3**. Soil texture differed slightly between the three sites, with Buckwheat Badlands generally silty loam, Caliche Plateau loamy sand, and Stilted Dunes loamy sand/sand.

Table 1. Native plant seed used for hydroseeding on San Nicolas Island, February 2016

Species	Date collected	Total per species (g)
Stilted Dunes (SD)		
Abronia maritima	June 2016	0.10
Abronia umbellata	June 2016	2.10
Achillea millefolium	June 2016	9.10
Amblyopappus pusillus	June 2016	16.70
Astragalus traskiae	May, June 2016	60.20
Calystegia macrostegia	July 2016	19.90
Daucus pusillus	June 2016	31.00
Isocoma menziesii	May, June, July 2016	67.00
Lepidium lasiocarpum lasiocarpum	June 2016	4.60
Leptosyne gigantea	June 2016	5.60
Lotus argophyllus	June 2016	9.80
Lupinus albifrons douglasii	May, June 2016	17.80
Malacothrix foliosa polycephala	May 2016	0.20
Spergularia macrotheca	June 2016	6.50
	Sum (g)	**250.60**
	Sum (lb)	**0.55**
Buckwheat Badlands (BB)		
Achillea millefolium	June, July 2016	35.10
Amblyopappus pusillus	June 2016	27.20
Dudleya virens insularis	July 2016	16.00
Eriogonum grande var. timorum	May, June 2016	93.90
Isocoma menziesii	June, July 2016	49.30
Leptosyne gigantea	May, June 2016	16.80
Lomatium insulare	June 2016	0.20
Plantago ovata	June 2016	9.80
	Sum (g)	**248.30**
	Sum (lb)	**0.55**
Caliche Plateau (CP)		
Achillea millefolium	June, July 2016	34.50
Calystegia macrostegia	July 2016	0.20
Deinandra clementina	July 2016	25.00
Dudleya virens insularis	July 2016	11.90
Gnaphalium palustre	July 2016	0.50
Isocoma menziesii	July 2016	75.50
Lepidium lasiocarpum lasiocarpum	June 2016	14.20
Leptosyne gigantea	May 2016	2.80
Lomatium insulare	June 2016	78.80
Oligomeris linifolia	June 2016	15.00
Malacothrix foliosa polycephala	May, June 2016	0.80
	Sum (g)	**259.20**
	Sum (lb)	**0.57**

Table 2. Soil salinity (as measured by electroconductivity (EC), in µS/cm) and pH differences between MECR and native plots. Statistically significant results are in bold. Asterisks are used to indicate statistical significance at the $p \leq 0.05$ (*), 0.01 (**), and 0.001 (***) levels.

Metric and Site	**MECR mean (stand. error)**	**NTV mean (stand. error)**	**Statistical Test**	**Test Statistic**	**Statistical Significance**
EC – site BB	436.9 ± 51.9	326.5 ± 35.6	Wilcoxon	Chi Square = 0.37	p = 0.544
EC – site CP	273.2 ± 21.3	506.6 ± 103.0	Wilcoxon	Chi Square = 5.06	**p = 0.024***
EC – site SD	284.5 ± 29.3	238.9 ± 30.3	Wilcoxon	Chi Square = 0.03	p = 0.857
pH – site BB	8.96 ± 0.07	8.44 ± 0.19	Student's t	t = -2.57	**p = 0.039***
pH – site CP	9.01 ± 0.06	8.62 ± 0.09	Student's t	t = -3.53	**p = 0.005****
pH – site SD	8.65 ± 0.06	8.82 ± 0.10	Student's t	t = 1.36	p = .207

Table 3. Soil texture obtained using the "feel method", by site on San Nicolas Island.

Buckwheat Badlands (BB)			
Treatment	**Texture**	**Percentage 1**	**Percentage 2**
MECR	Silt-Loam/Loam	80% Silt	20% Sand
MECR	Silt-Loam/Loam	80% Silt	20% Sand
MECR	Silt-Loam/Loam	80% Silt	20% Sand
MECR	Silt-Loam/Loam	80% Silt	20% Sand
MECR	Loamy Sand	70% Sand	30% Other
NTV	Silt-Loam/Loam	80% Silt	20% Sand
NTV	Loamy Sand	70% Sand	30% Other
NTV	Silt-Loam/Loam	80% Silt	20% Sand
NTV	Silt-Loam/Loam	80% Silt	20% Sand
NTV	Loamy Sand	70% Sand	30% Other
Caliche Plateau (CP)			
Treatment	**Texture**	**Percentage 1**	**Percentage 2**
MECR	Loamy Sand	80% Sand	20% other
MECR	Loamy Sand	80% Sand	20% other
MECR	Loamy Sand	80% Sand	20% other
MECR	Loamy Sand	80% Sand	20% other
MECR	Loamy Sand	80% Sand	20% other
NTV	Loamy Sand	80% Sand	20% other
NTV	Loamy Sand	80% Sand	20% other
NTV	Loamy Sand	80% Sand	20% other
NTV	Loamy Sand	80% Sand	20% other
NTV	Loamy Sand	80% Sand	20% other

Stilted Dunes (SD)			
Treatment	**Texture**	**Percentage 1**	**Percentage 2**
MECR	Loamy Sand	85% Sand	15% other
MECR	Loamy Sand	85% Sand	15% other
MECR	Loamy Sand	85% Sand	15% other
MECR	Loamy Sand	85% Sand	15% other
MECR	Sand	90% Sand	10% other
NTV	Loamy sand	85% Sand	15% Other
NTV	Loamy sand	85% Sand	15% Other
NTV	Sand	90% Sand	10% Other
NTV	Sand	90% Sand	10% Other
NTV	Sand	90% Sand	10% Other

Seed Bank Study

The results of the seed bank study are summarized in **Figures 5, 6, and 7** below. Plot-specific results are provided in **Appendix Tables 3, 4, and 5**. *Mesembryanthemum crystallinum* was by far the most abundant species at all sites, with between 399 and 1447 individuals. There were, however, many other species present (13 at Buckwheat Badlands, 20 at Caliche Plateau, and 15 at Stilted Dunes). Native species made up roughly half of the species at each site, with 7 at Buckwheat Badlands, 13 at Caliche Plateau, and at least 9 at Stilted Dunes. Especially abundant natives include *Crassula connata*, *Malacothrix foliosa*, *Astragalus traskiae*, and *Amblyopappus pusillus*.

Our Horticulture Department retained some of these plants for the grounds. These include *Abronia umbellata* (Accession #16-170), *Acmispon argophyllus* (16-171), *Ambrosia chamissonis* (16-172), *Astragalus traskiae* (16-173), *Isocoma menziesii* (16-261), *Lupinus albifrons* (16-174), and *Achillea millefolium* (16-301).

Plant Assemblages

Differences in plant species richness and native plant cover are presented in **Figures 8 and 9** below. Plant species richness was significantly higher in native-dominated plots at Buckwheat Badlands, and there was a statistical trend for the same at Caliche Plateau. There was no statistically significant difference in plant species richness at the Stilted Dunes site, however. There were an average of 6.8 species in native plots vs. 2.4 species in MECR plots at Buckwheat Badlands; these numbers are 8.3 vs. 6.3 at Caliche Plateau and 5.7 vs. 4.9 at Stilted Dunes.

Native plant cover was significantly greater in native-dominated plots than in plots containing MECR at all sites (by design); this difference was most significant at the Buckwheat Badlands and Stilted Dunes sites. Buckwheat Badlands had the least native cover in the MECR plots (average 0.5%), followed by the Stilted Dunes site (7.9%) then Caliche Plateau (19.2%).

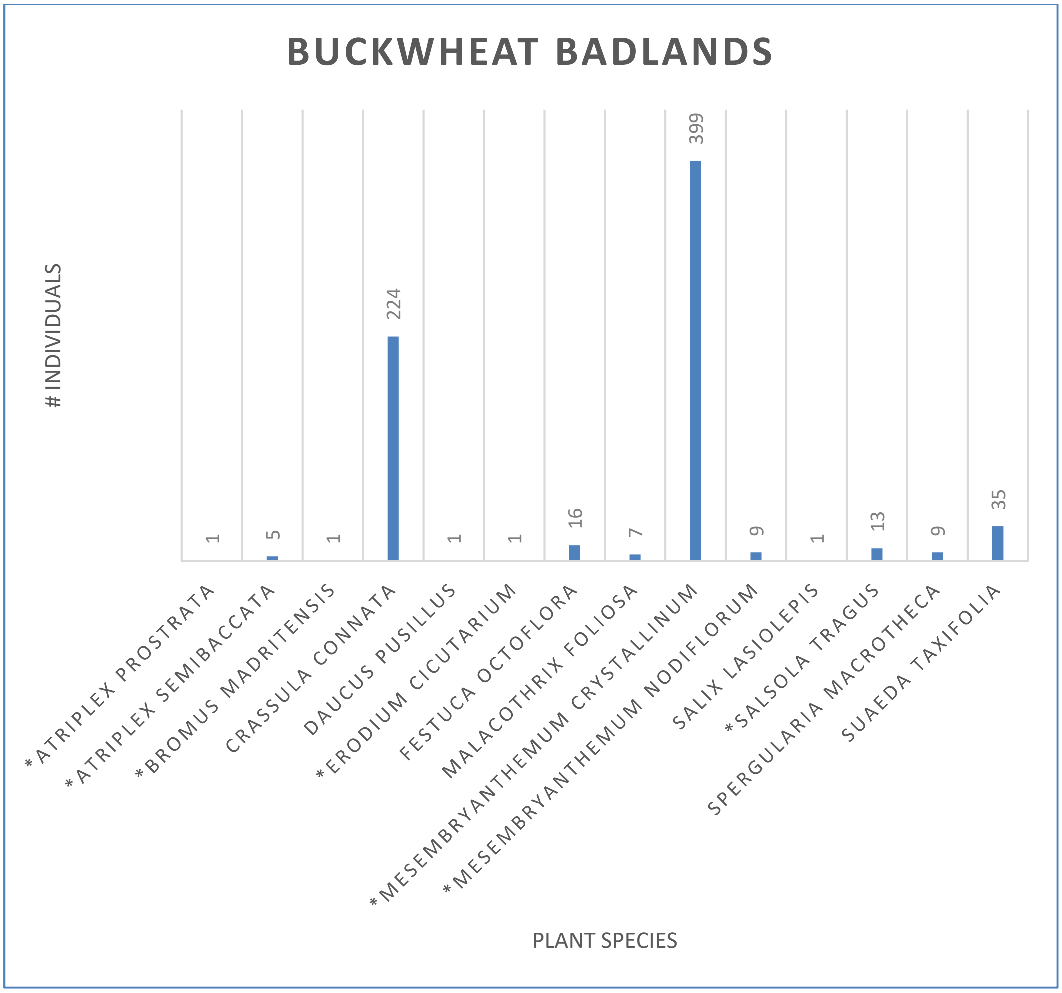

Figure 5. Results from a soil seedbank study at the Buckwheat Badlands site in 2016. Non-native taxa are indicated with asterisks.

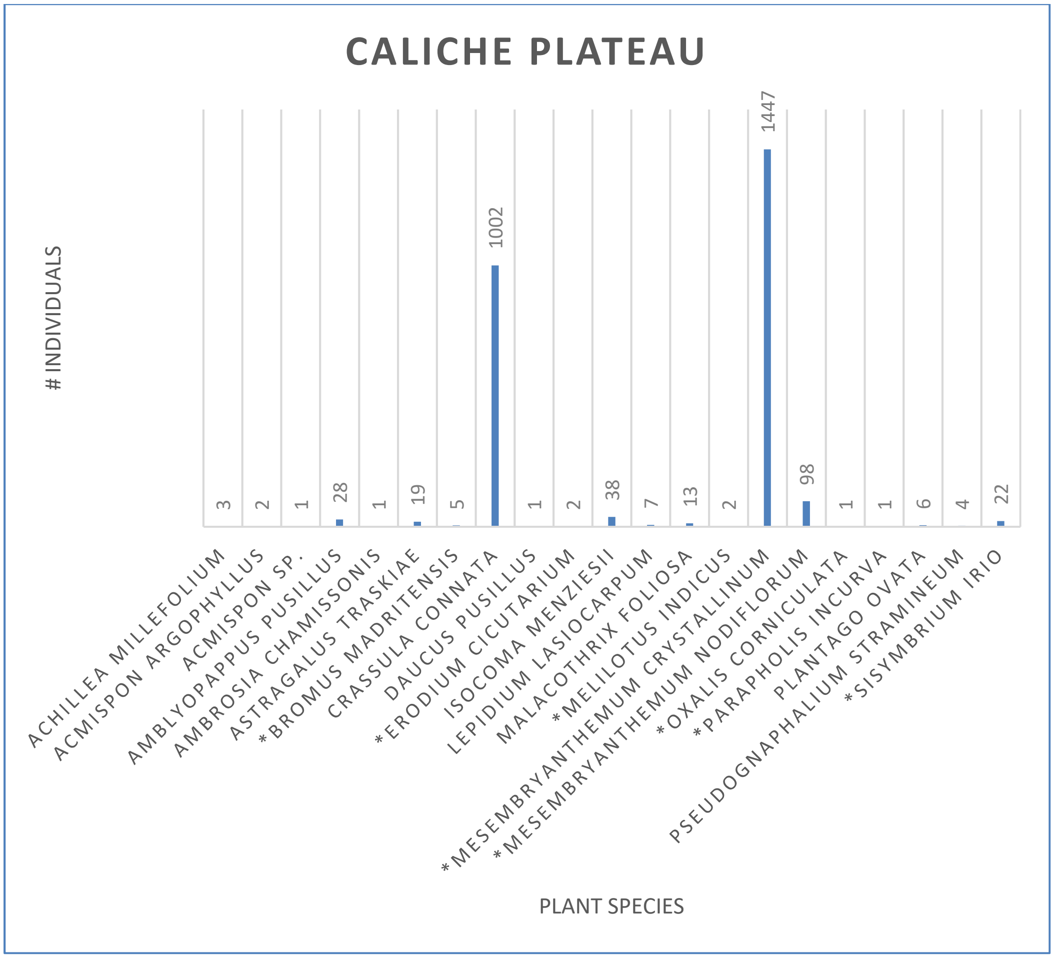

Figure 6. Results from a soil seedbank study at the Caliche Plateau site in 2016. Non-native taxa are indicated with asterisks.

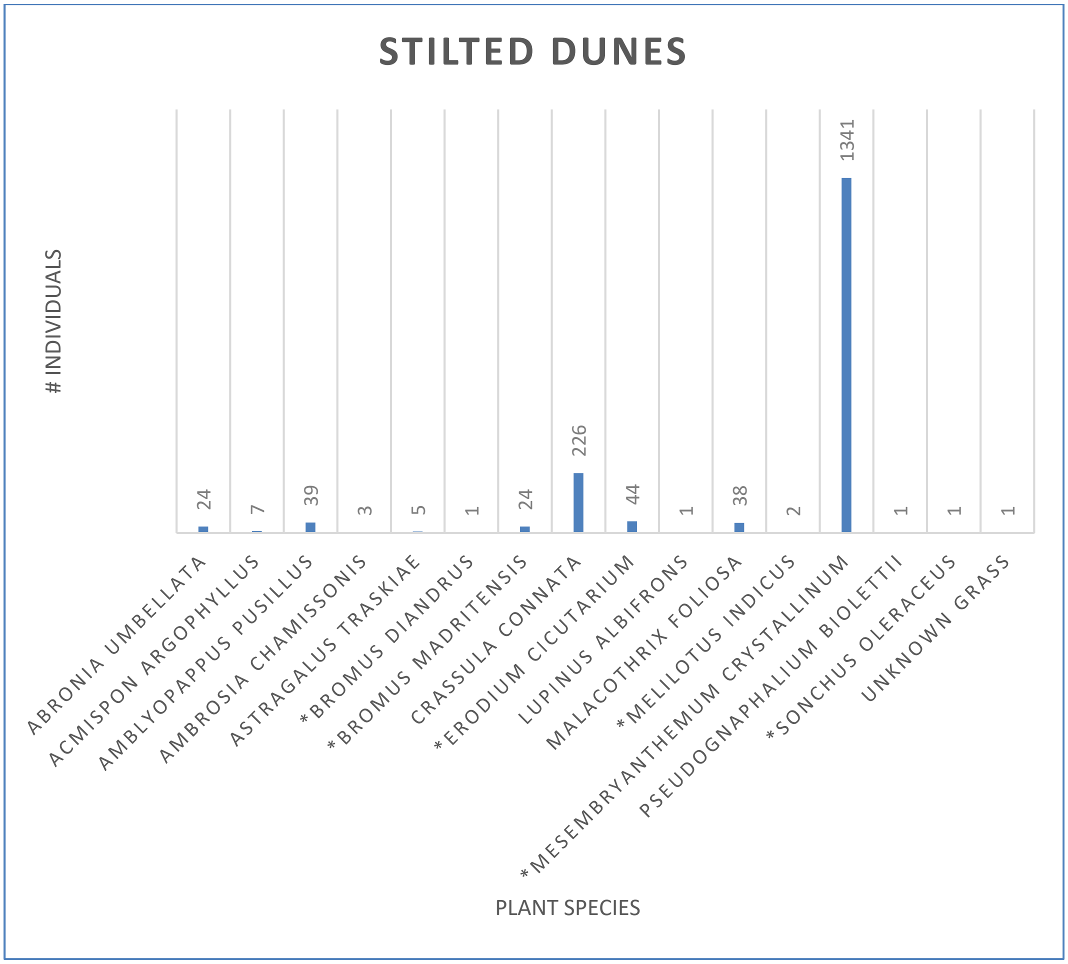

Figure 7. Results from a soil seedbank study at the Stilted Dunes site in 2016. Non-native taxa are indicated with asterisks.

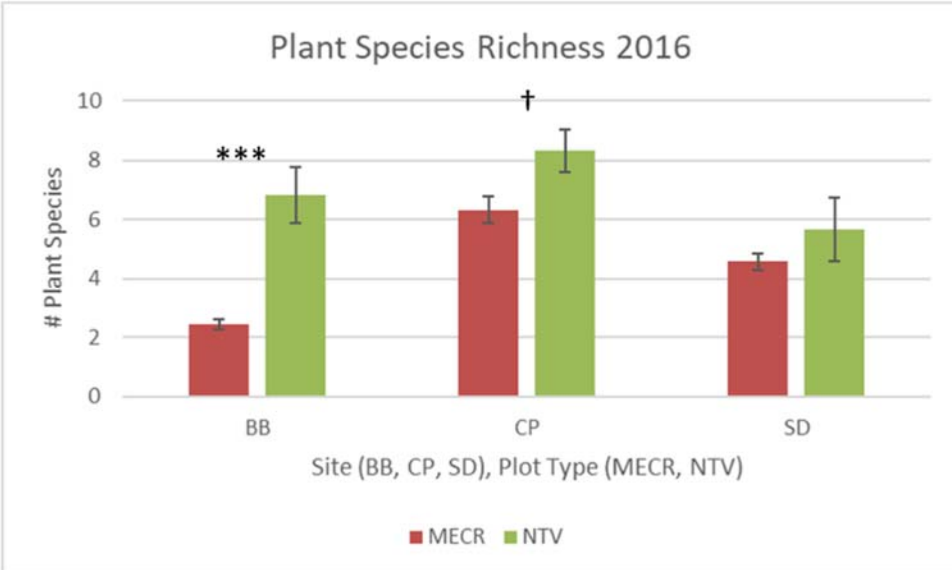

Figure 8. Plant species richness in 2016 by site and plot type on San Nicolas Island. Wilcoxon non-parametric tests were used. MECR = *Mesembryanthemum crystallinum*, NTV = Native. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

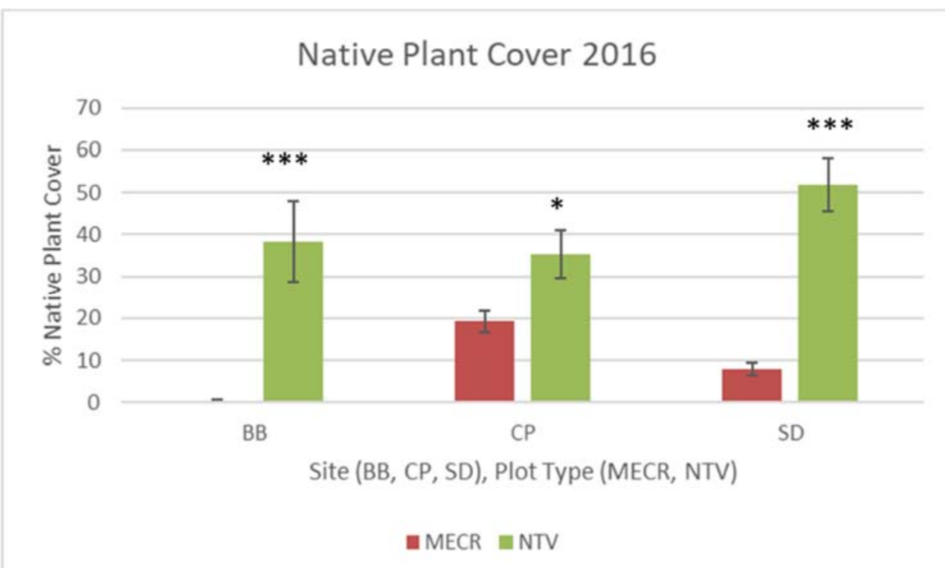

Figure 9. Native plant cover in 2016 by site and plot type on San Nicolas Island. Wilcoxon non-parametric tests were used. MECR = *Mesembryanthemum crystallinum*, NTV = Native. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

Arthropod Abundance and Morphospecies Richness

A total of 11,048 arthropod individuals, in 78 families and 192 morphospecies were assessed (**Appendix Table 6**). Arthropod abundance data are presented in **Figure 10.** As hypothesized, abundance was significantly greater in the MECR plots at both the Buckwheat Badlands and Stilted Dunes sites. There was no significant difference in arthropod abundance between treatments at the Caliche Plateau site. At the Buckwheat Badlands site this represents a 230% increase, from an average of 125 individuals in Native plots to 285 individuals in MECR plots, whereas at Stilted Dunes this represents a 210% increase, from an average of 69 to 33 individuals. The Buckwheat Badlands site had higher overall arthropod abundance than the other two sites.

Arthropod richness data are presented in **Figure 11**. At both the Buckwheat Badlands and Caliche Plateau sites, richness was significantly greater in the Native plots, whereas at the Stilted Dunes site, richness was significantly greater in the MECR plots. At the Buckwheat Badlands site this represents a 144% increase, from an average of 20.4 morphospecies in the MECR plots to an average of 29.3 morphospecies in the Native plots. At the Caliche Plateau site, this represents a 130% increase, from an average of 13.4 morphospecies in the MECR plots to an average of 17.7 morphospecies in the Native plots. In contrast, MECR plots had an average of 20.7 morphospecies at the Stilted Dunes site, a 123% increase from the Native plots which had an average of 16.8 morphospecies.

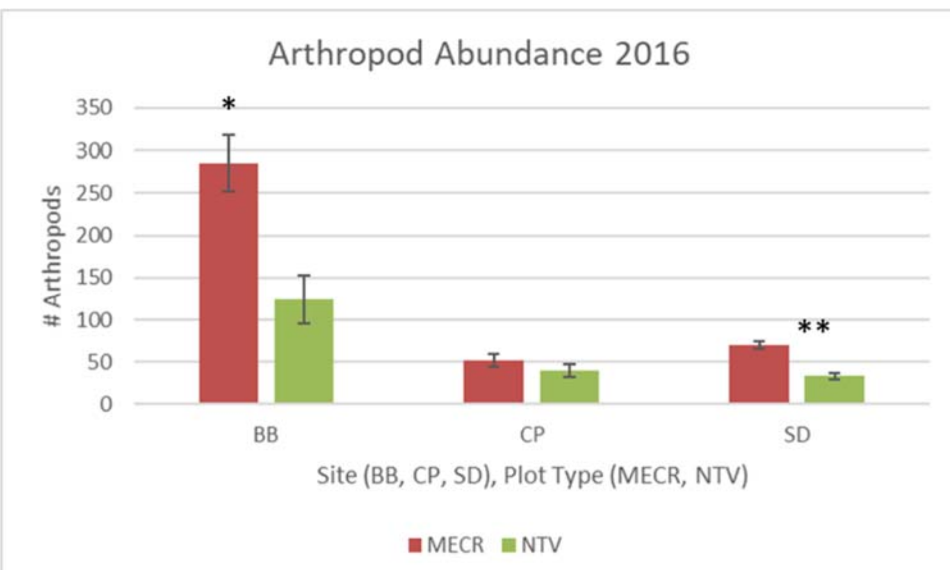

Figure 10. Arthropod abundance in 2016 by site and plot type on San Nicolas Island. Wilcoxon non-parametric tests were used. MECR = *Mesembryanthemum crystallinum*, NTV = Native. Asterisks are used to indicate statistical significance at the $p \leq 0.05$ (*), 0.01 (**), and 0.001 (***) levels.

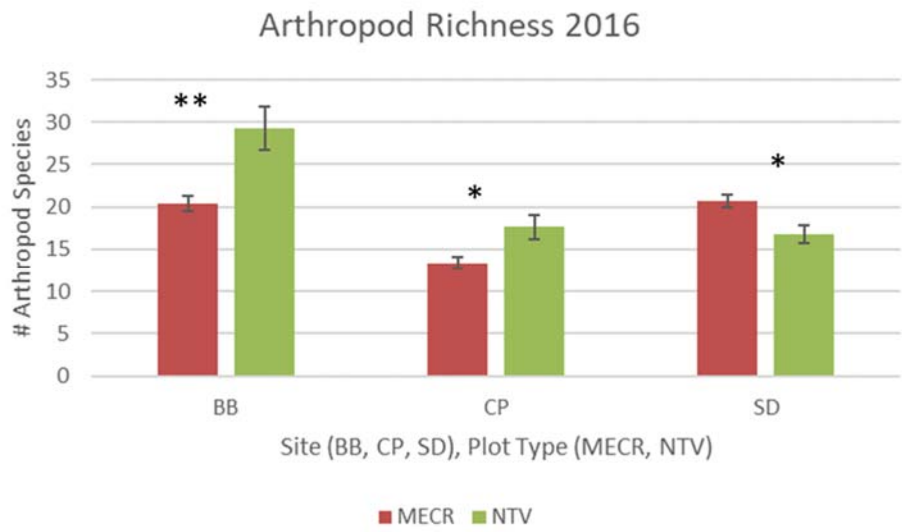

Figure 11. Arthropod species richness in 2016 by site and plot type on San Nicolas Island. Students t-tests were used. MECR = *Mesembryanthemum crystallinum*, NTV = Native. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

Results from multiple regression analyses on arthropod richness to determine the best explanatory variables are presented in **Tables 4, 5, and 6**. Results varied at each of the sites. At Buckwheat Badlands, native plant cover was statistically significant, with a respectable r^2 value (0.54, which quantifies the proportion of variation in the response that is explained). At Caliche Plateau, soil moisture was statistically significant, however the r^2 value (0.24) was less impressive. At Stilted Dunes, plant litter cover was the most significant variable, with an even smaller r^2 (0.22).

Table 4. Explanatory variable parameter estimates for **arthropod richness**, **Buckwheat Badlands**, San Nicolas Island, 2016. Results of a multiple linear regression. Whole model Rsquare = 0.54, p=0.006. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

	Slope	Std Error	t Ratio	Prob > |t|
***Mesembryanthemum* cover**	-0.02	0.05	-0.31	0.76
Plant Species Richness	0.19	0.61	0.31	0.76
Native Plant Cover	0.20	0.07	2.70	**0.01***
Plant Litter Cover	-0.03	0.02	-1.40	0.18
Soil Moisture	-0.51	0.53	-0.97	0.34

Table 5. Explanatory variable parameter estimates for **arthropod richness**, **Caliche Plateau**, San Nicolas Island, 2016. Results of a multiple linear regression. Whole model Rsquare = 0.24, p=0.09. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

	Slope	Std Error	t Ratio	Prob > |t|
***Mesembryanthemum* cover**	-0.04	0.03	-1.38	0.18
Plant Species Richness	-0.07	0.32	-0.21	0.83
Native Plant Cover	-0.06	0.05	-1.21	0.23
Plant Litter Cover	0.01	0.02	0.31	0.76
Soil Moisture	0.81	0.33	2.48	**0.02***

Table 6. Explanatory variable parameter estimates for **arthropod richness**, **Stilted Dunes**, San Nicolas Island, 2016. Results of a multiple linear regression. Whole model Rsquare =0.22, p=0.12. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

	Slope	Std Error	t Ratio	Prob > |t|
***Mesembryanthemum* cover**	0.03	0.05	0.64	0.53
Plant Species Richness	0.31	0.45	0.69	0.50
Native Plant Cover	-0.04	0.06	-0.60	0.56
Plant Litter Cover	0.07	0.03	2.49	**0.02***
Soil Moisture	-4.80	2.96	-1.62	0.11

Arthropod Composition

Arthropod composition differences are shown in **Figures 12-14**. As the separation of different colored points shows, and the MRPP values confirm, composition was significantly different between plot types at all three sites. Vectors also indicate the strong influence of MECR cover vs. Native Cover in these two types of plots.

Indicator Species results are presented in **Figures 15-20**. At Buckwheat Badlands, five arthropod morphospecies across three Orders were statistically significant indicators of MECR plots (**Figure 15**), whereas twelve different morphospecies across five Orders were representative of native-dominated plots (**Figure 16**). At Caliche Plateau, two morphospecies in two Orders were significant indicators of MECR plots (**Figure 17**), whereas ten morphospecies in four Orders were representative of native-dominated plots (**Figure 18**). At Stilted Dunes, four arthropod morphospecies across three Orders were significant indicators of MECR dominated plots (**Figure 19**), whereas five morphospecies in two Orders were significant indicators of native-dominated plots (**Figure 20**).

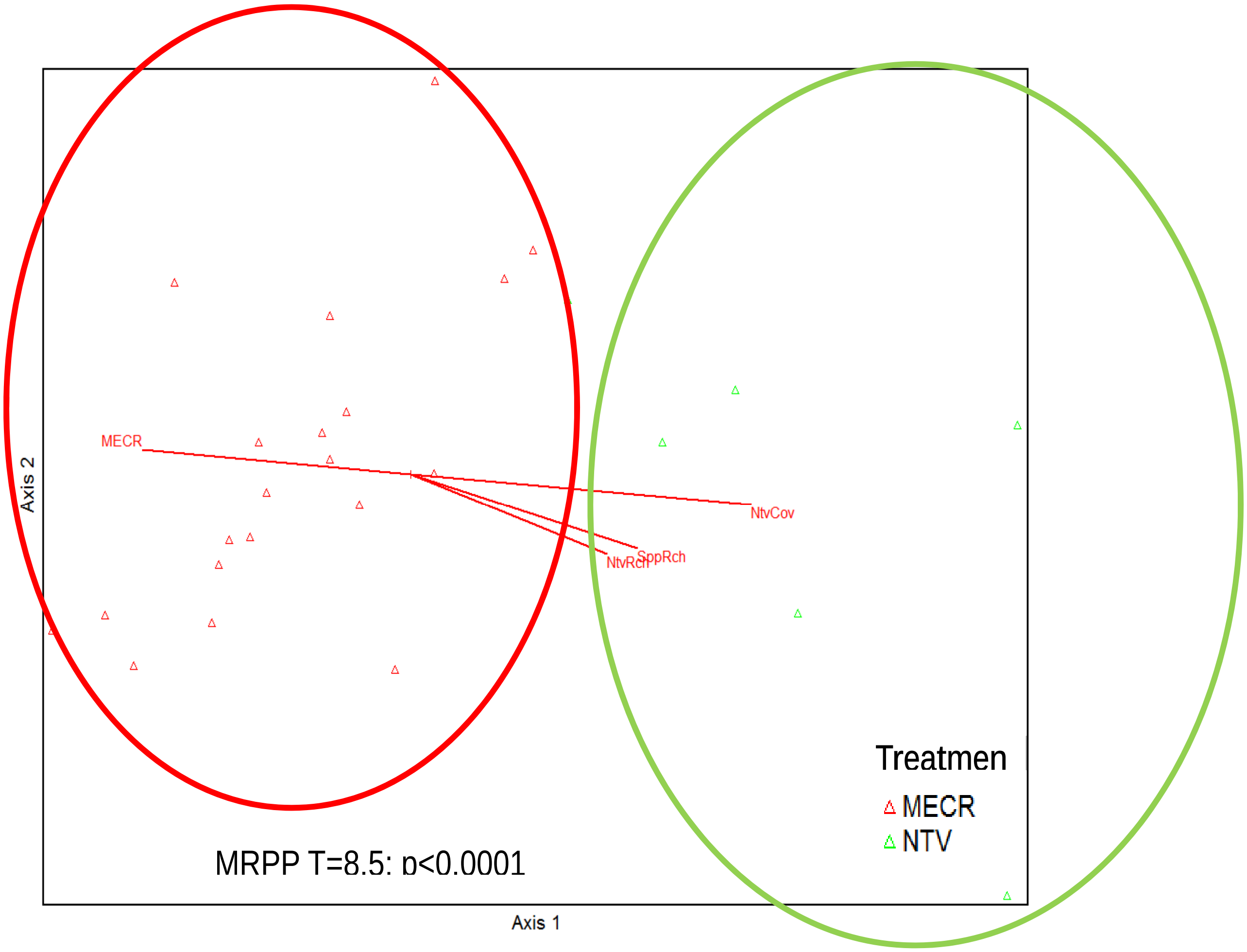

Figure 12. Arthropod composition differences between MECR (*Mesembryanthemum crystallinum*) and native- (NTV) dominated plots at Buckwheat Badlands, San Nicolas Island in 2016. Non-metric multi-dimensional scaling was used. Vectors show the influence of MECR cover, Native Cover (NtvCov), Plant Species Richness (SppRch), and Native Plant Richness (NtvRch). Circles indicate the extent of the multi-dimensional points.

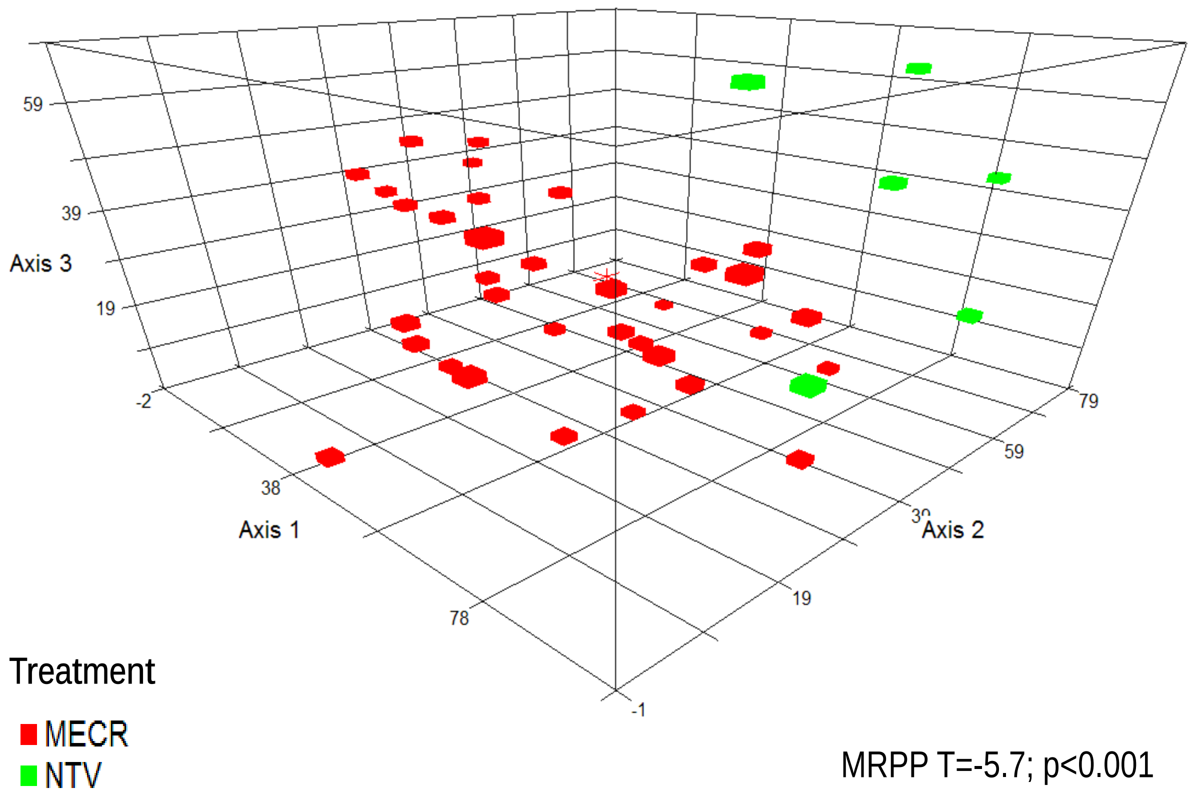

Figure 13. Arthropod composition differences between MECR and native-dominated plots at Caliche Plateau San Nicolas Island, 2016. Non-metric multi-dimensional scaling was used. Red marks are *Mesembryanthemum crystallinum* plots (MECR), blue are native (NTV).

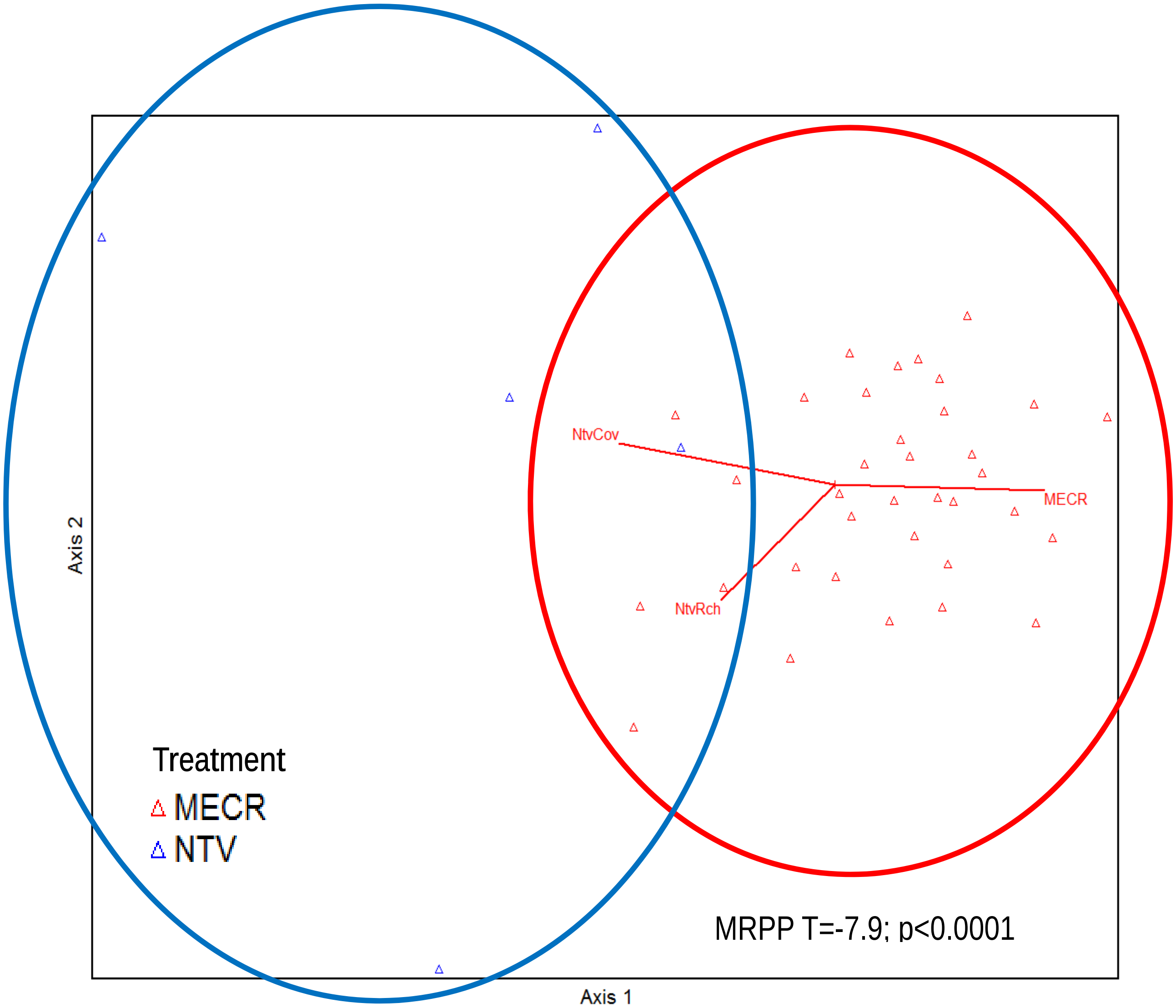

Figure 14. Arthropod composition differences between MECR (*Mesembryanthemum crystallinum*) and native-dominated (NTV) plots at Stilted Dunes, San Nicolas Island, 2016. Non-metric multi-dimensional scaling was used. Vectors indicate the influence of native cover (NtvCov), native richness (NtvRch), and MECR cover. Circles indicate the extent of the multi-dimensional points.

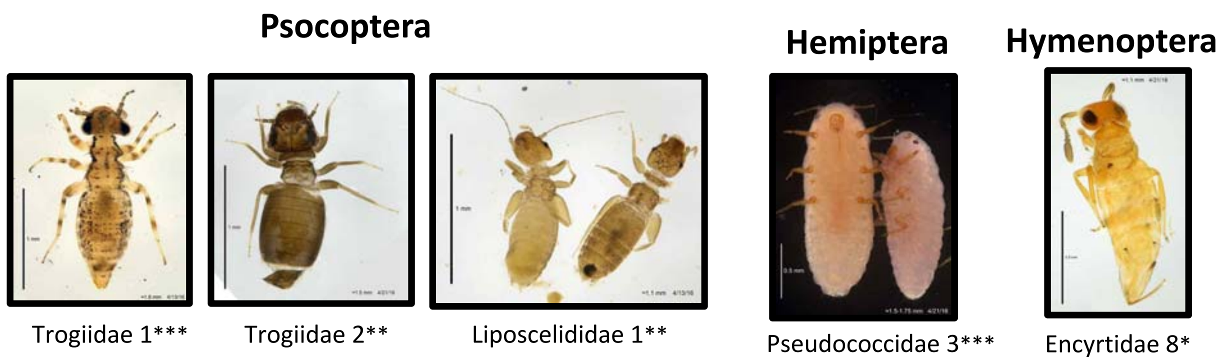

Figure 15. Arthropod Indicator Species images for MECR plots at Buckwheat Badlands, San Nicolas Island. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

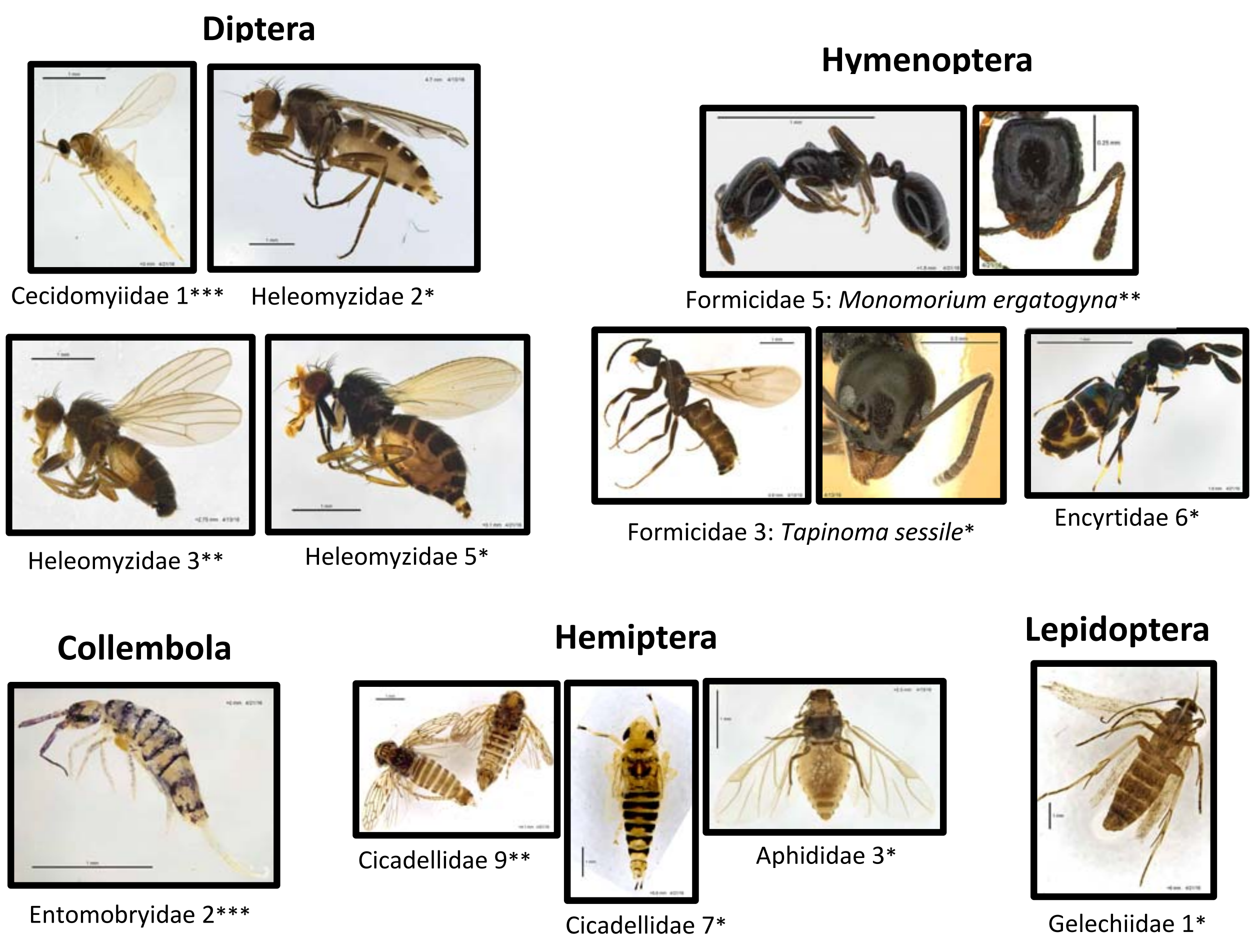

Figure 16. Arthropod Indicator Species images for native plots at Buckwheat Badlands, San Nicolas Island. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

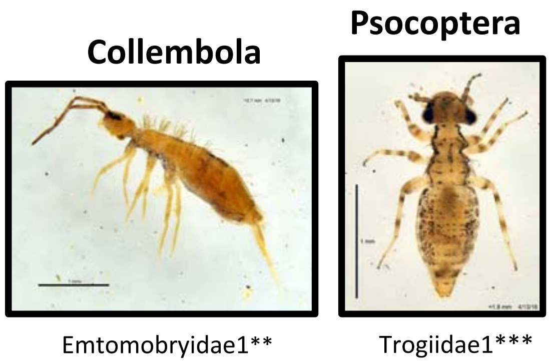

Figure 17. Arthropod Indicator Species images for MECR plots at Caliche Plateau, San Nicolas Island. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

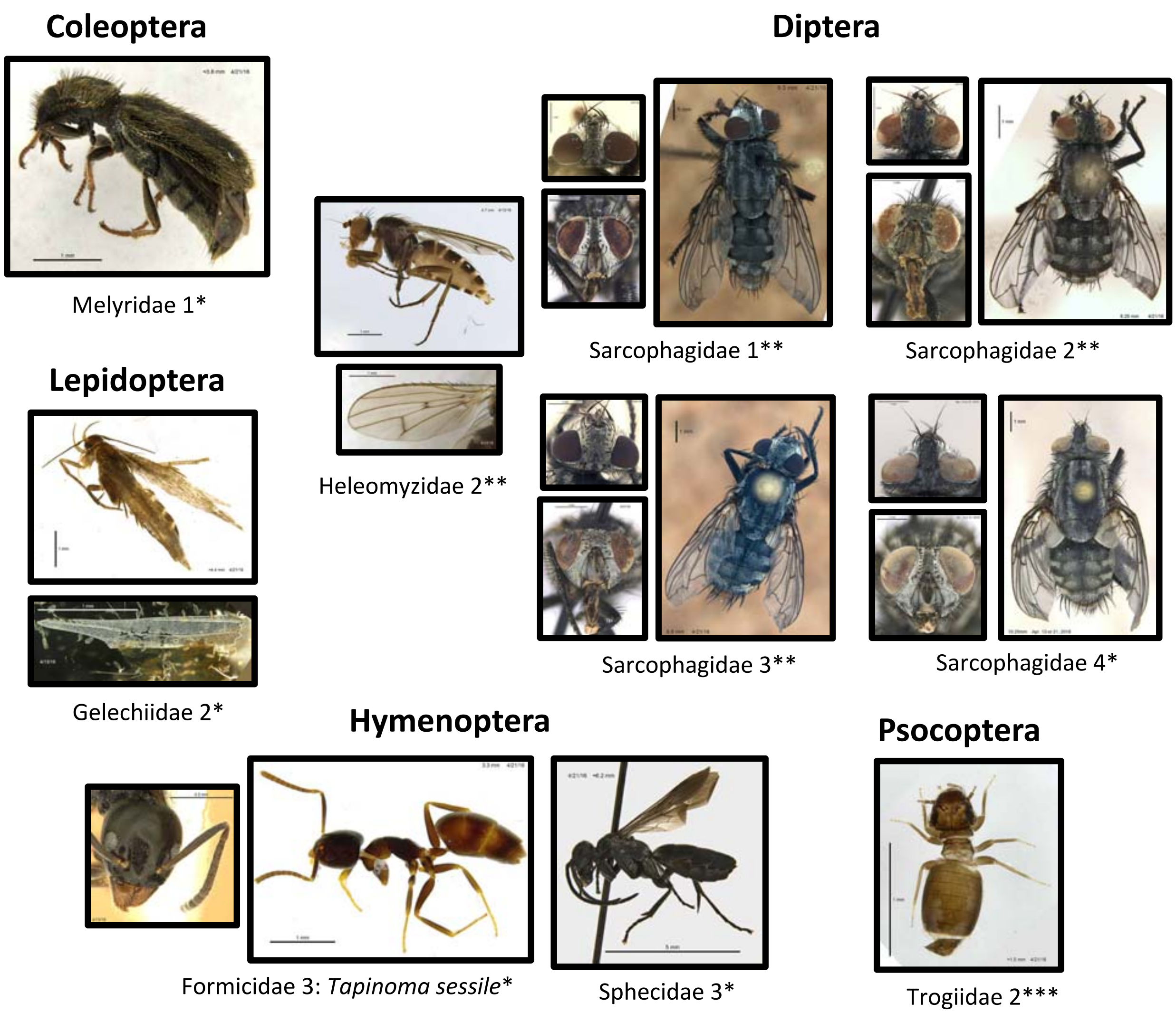

Figure 18. Arthropod Indicator Species images for Native plots at Caliche Plateau, San Nicolas Island. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

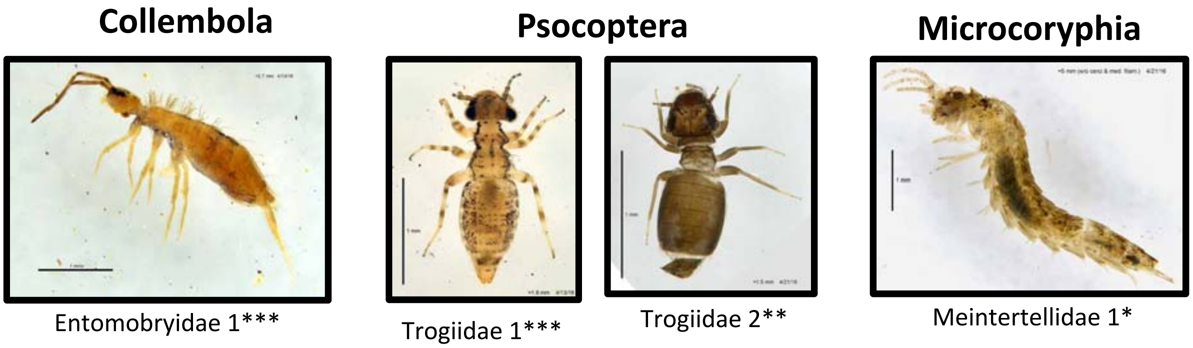

Figure 19. Arthropod Indicator Species images for MECR plots at Stilted Dunes, San Nicolas Island. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

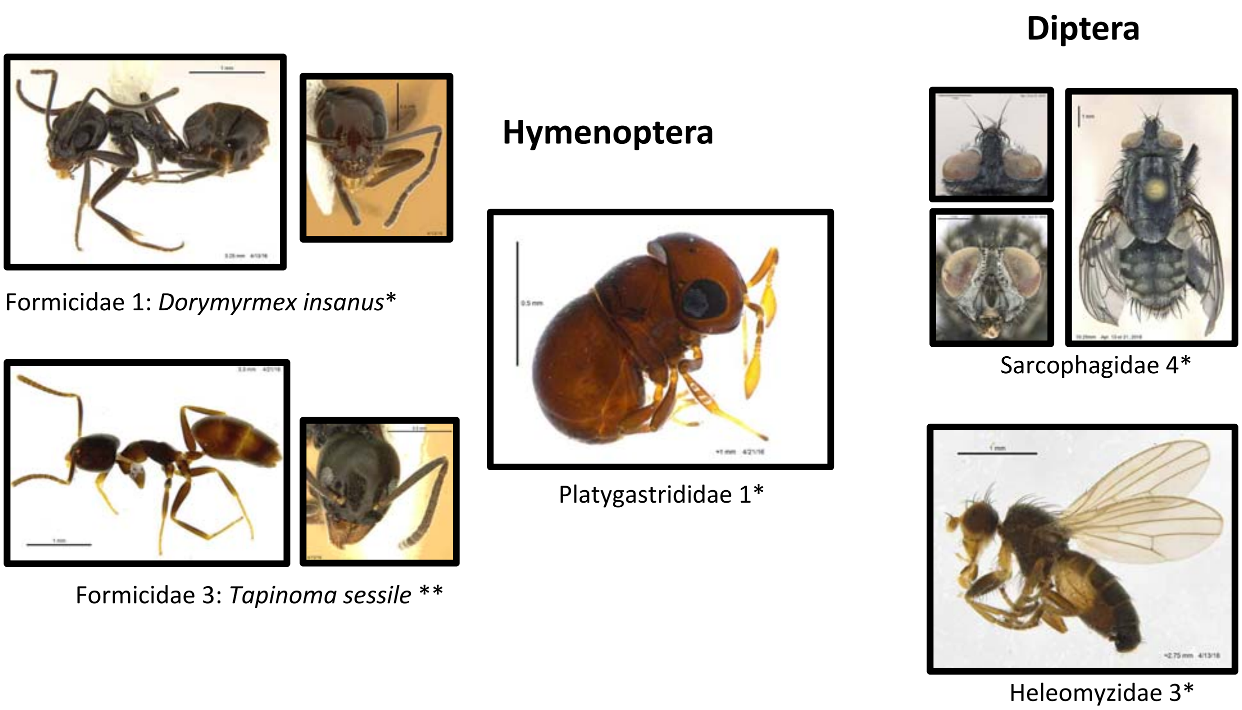

Figure 20. Arthropod Indicator Species images for Native plots at Stilted Dunes, San Nicolas Island. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

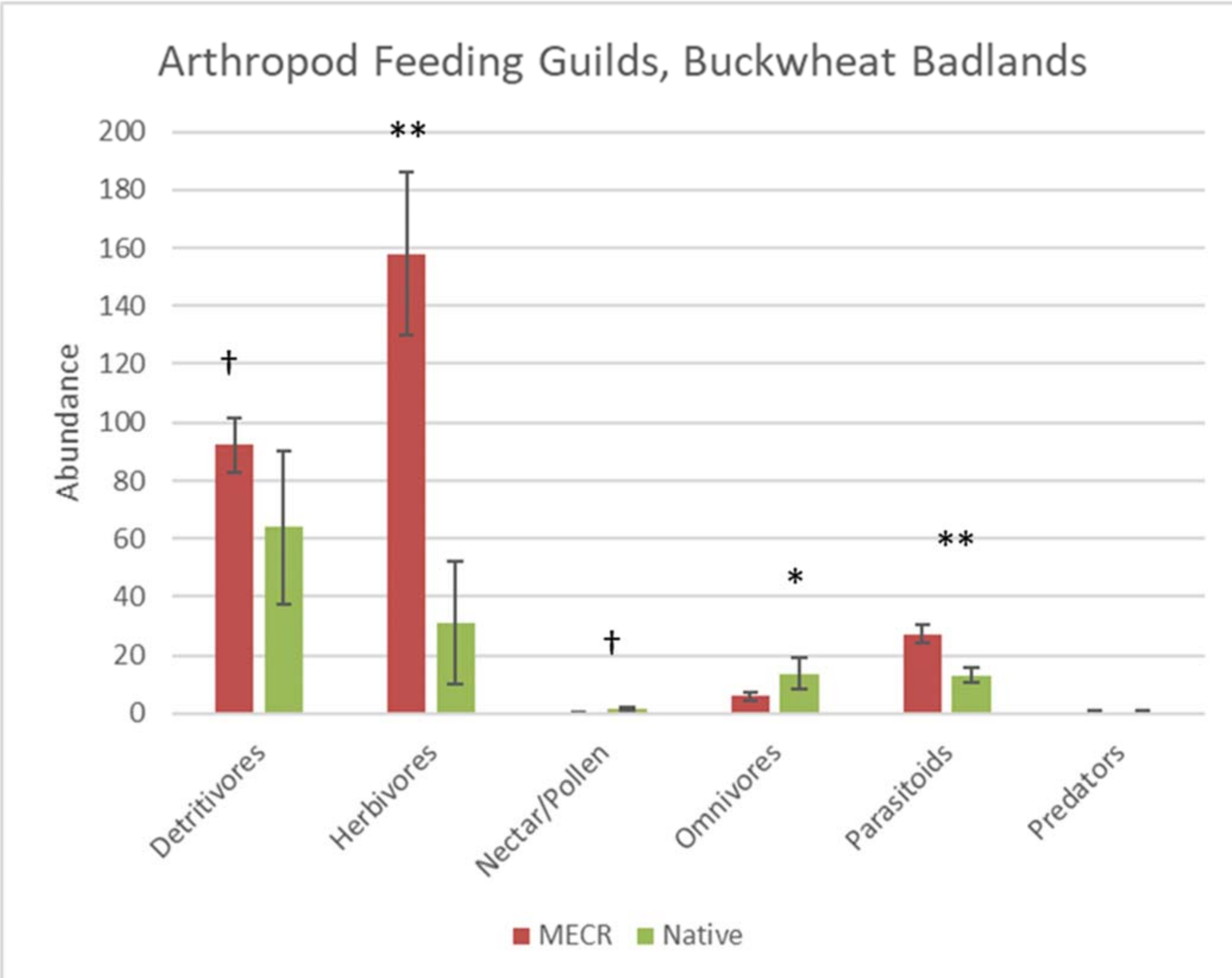

Figure 21. Arthropod feeding guild differences at Buckwheat Badlands, San Nicolas Island. Asterisks are used to indicate statistical significance at the $p \leq 0.05$ (*), 0.01 (**), and 0.001 (***) levels. For p values between 0.05 and 0.10, this is considered a statistical trend, and indicated with a †. MECR = *Mesembryanthemum crystallinum*, NTV = Native.

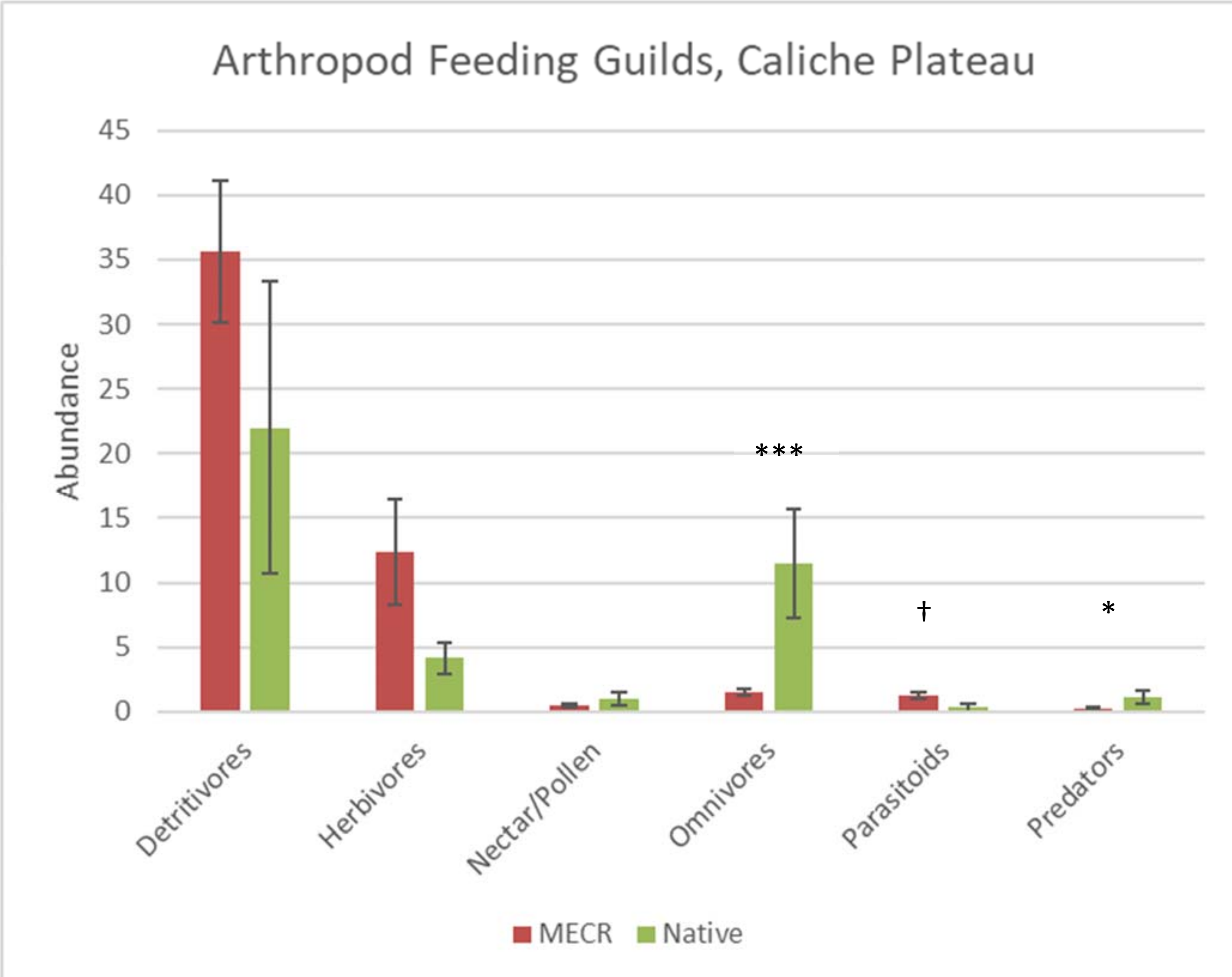

Figure 22. Arthropod feeding guild differences at Caliche Plateau, San Nicolas Island. Asterisks are used to indicate statistical significance at the $p \leq 0.05$ (*), 0.01 (**), and 0.001 (***) levels. For p values between 0.05 and 0.10, this is considered a statistical trend, and indicated with a †. MECR = *Mesembryanthemum crystallinum*, NTV = Native.

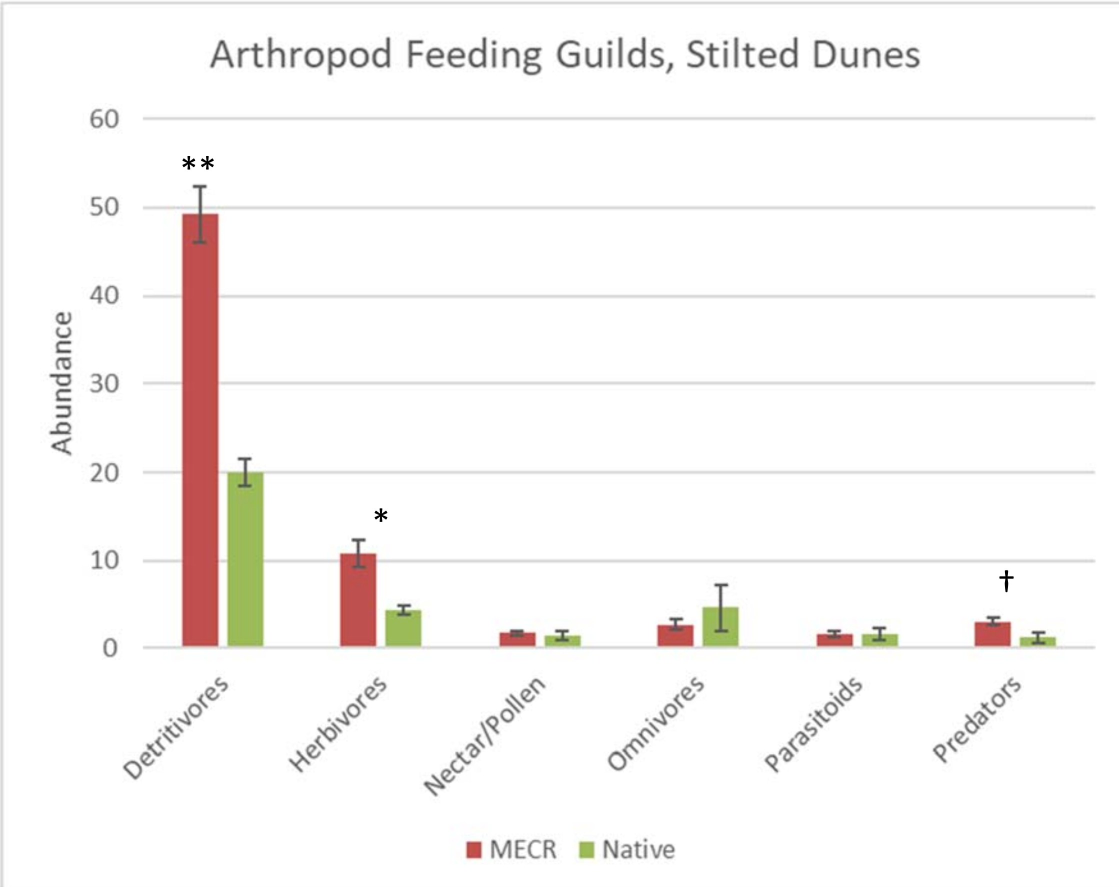

Figure 23. Arthropod feeding guild differences at Stilted Dunes, San Nicolas Island. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels. For p values between 0.05 and 0.10, this is considered a statistical trend, and indicated with a †. MECR = *Mesembryanthemum crystallinum*, NTV = Native.

Arthropod feeding guild differences at the three different sites are presented in **Figures 21-23**. Buckwheat Badlands exhibited, for MECR plots, higher detritivore (†), herbivore, and parasitoid numbers, and lower numbers of nectar/pollen consumers (†) and omnivores. Caliche Plateau exhibited, for MECR plots, significantly fewer omnivores and predators but more parasitoids (†). Stilted Dunes on the other hand exhibited, for MECR plots, more detritivores, herbivores, and predators (†).

Arthropod functional diversity differences are presented in **Figure 24**. Native plots had significantly greater functional diversity at both the Buckwheat Badlands and Stilted Dunes sites; differences were not statistically significant at the Caliche Plateau site. Potential explanatory variables were assessed using multiple regression analysis and are presented in **Tables 7-9**. The most significant variable explored were MECR cover and soil moisture at Buckwheat Badlands, MECR cover and native plant cover at Caliche Plateau, and plant species richness at Stilted Dunes.

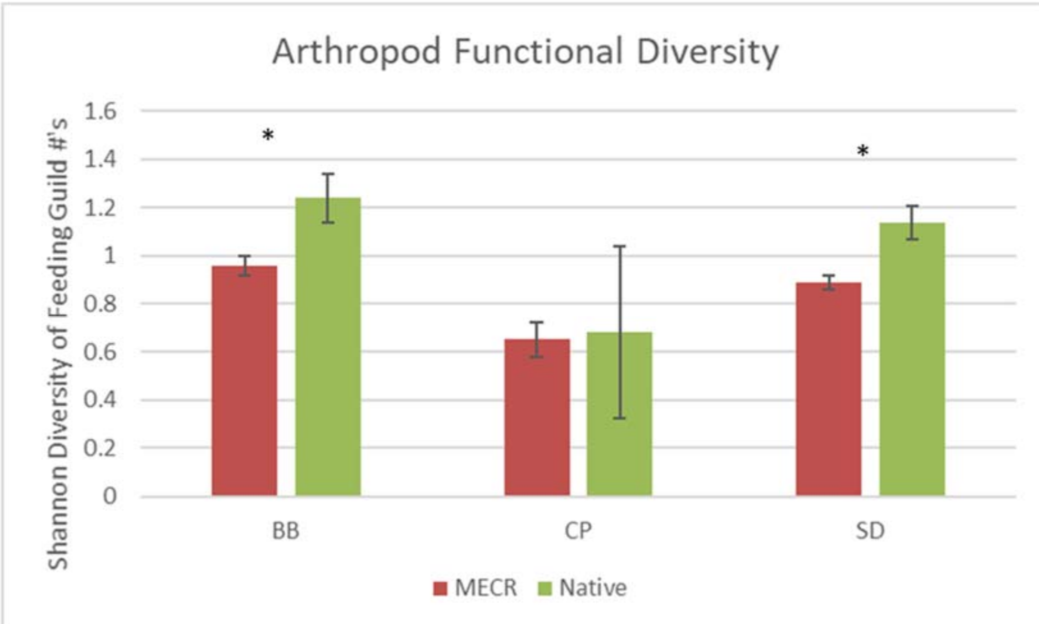

Figure 24. Arthropod functional diversity in 2016 by site and plot type on San Nicolas Island. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels. MECR = *Mesembryanthemum crystallinum*, NTV = Native.

Table 7. Explanatory variable parameter estimates for **arthropod functional diversity**, **Buckwheat Badlands**, San Nicolas Island, 2016. Results of a multiple linear regression. Whole model Rsquare = 0.55, p=0.004. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

	Slope	Std Error	t Ratio	Prob > |t|
***Mesembryanthemum* cover**	-0.008	0.002	-3.79	**0.001****
Plant Species Richness	-0.01	0.02	-0.57	0.58
Native Plant Cover	-0.002	0.003	-1.03	0.31
Plant Litter Cover	0.001	0.001	1.58	0.13
Soil Moisture	-0.04	0.02	-2.26	**0.04***

Table 8. Explanatory variable parameter estimates for **arthropod functional diversity**, **Caliche Plateau**, San Nicolas Island, 2016. Results of a multiple linear regression. Whole model Rsquare = 0.27, p=0.06. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels.

	Slope	Std Error	t Ratio	Prob > |t|
***Mesembryanthemum* cover**	-0.01	0.003	-3.23	**0.003****
Plant Species Richness	-0.03	0.03	-1.07	0.29
Native Plant Cover	-0.01	0.005	-2.10	**0.04***
Plant Litter Cover	0.002	0.002	0.99	0.33
Soil Moisture	0.05	0.03	1.62	0.12

Table 9. Explanatory variable parameter estimates for **arthropod functional diversity**, **Stilted Dunes**, San Nicolas Island, 2016. Results of a multiple linear regression. Whole model Rsquare =0.17, p=0.28. Asterisks are used to indicate statistical significance at the p ≤ 0.05 (*), 0.01 (**), and 0.001 (***) levels. For p values between 0.05 and 0.10, this is considered a statistical trend, and indicated with a †.

	Slope	Std Error	t Ratio	Prob > |t|
***Mesembryanthemum* cover**	-0.00	0.00	-0.14	0.89
Plant Species Richness	0.04	0.02	1.67	**0.10†**
Native Plant Cover	0.002	0.003	0.81	0.42
Plant Litter Cover	0.002	0.001	1.21	0.23
Soil Moisture	-0.09	0.15	-0.62	0.54

Mesembryanthemum control (2016-2017)

Data for MECR cover loss between 2016 and 2017 are presented in **Figure 25**. Each site had slightly different patterns, which are presented by site below.

Buckwheat Badlands

At Buckwheat Badlands, the greatest loss in MECR cover between 2016 and 2017 was found in herbicided plots (both hydroseeded and not). Grow-kill plots, which had some MECR re-growth following the 2016 treatments, displayed no significant change, whereas control plots gained MECR cover. Statistically significant differences were found when both types of herbicide plots were compared with Control and Grow-kill treatments of both kinds.

Caliche Plateau

The greatest loss in MECR cover between 2016 and 2017 at Caliche Plateau was found in herbicided plots (both hydroseeded and not), followed by grow-kill plots. Control plots gained MECR cover. Statistically significant differences were found between herbicided plots of both kinds and control plots of both kinds, between grow-kill plots without hydroseeding and control plots of both kinds, and between grow-kill plots that were hydroseeded and control plots that were hydroseeded.

Stilted Dunes

At Stilted Dunes, the greatest loss in MECR cover between 2016 and 2017 was found in herbicided plots (both hydroseeded and not), followed by grow-kill plots. The Stilted Dunes site behaved differently from the two other sites in that both control plot types also lost an average of 14% MECR cover (for hydroseeded plots) and 27% MECR cover (for plots that were not hydroseeded). Native plots were significantly different from all other treatments except for control with hydroseeding. In addition, both types of herbicided plots were significantly different from both types of control plots, and grow-kill plots without hydroseeding were significantly different from control plots with hydroseeding.

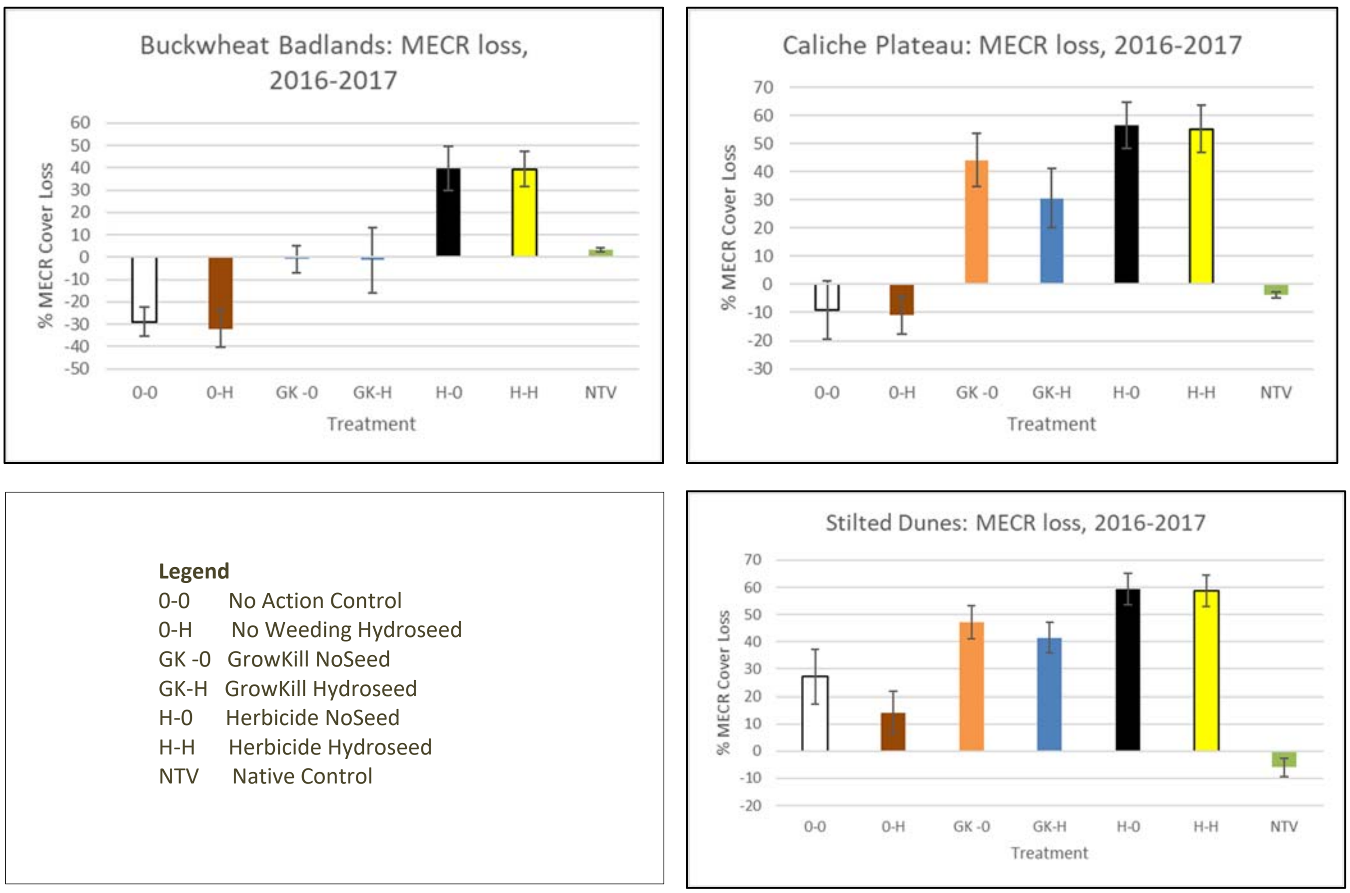

Figure 25. *Mesembryanthemum* cover loss between 2016 and 2017 by site and treatment on San Nicolas Island. Comparisons of pairs were made with Tukeys HSD tests. Negative numbers indicate *Mesembryanthemum* cover gain. Statistical differences are too complicated to represent in the graph, and are discussed in the text.

MECR cover (2018)

Data for MECR cover in 2018 are presented in **Figure 26**. At the Buckwheat Badlands site, the lowest MECR cover was found in herbicided plots and those with no weed control. At the Caliche Plateau site, the lowest MECR cover was found in native plots and those with no weed control. At the Stilted Dunes site, native plots and those with no weed control again had low MECR cover, but grow-kill plots with no hydroseeding also had low MECR cover. The greatest MECR cover was found in grow-kill plots at both Buckwheat Badlands and Caliche Plateau, but at Stilted Dunes was found in herbicided plots, both with and without hydroseeding.

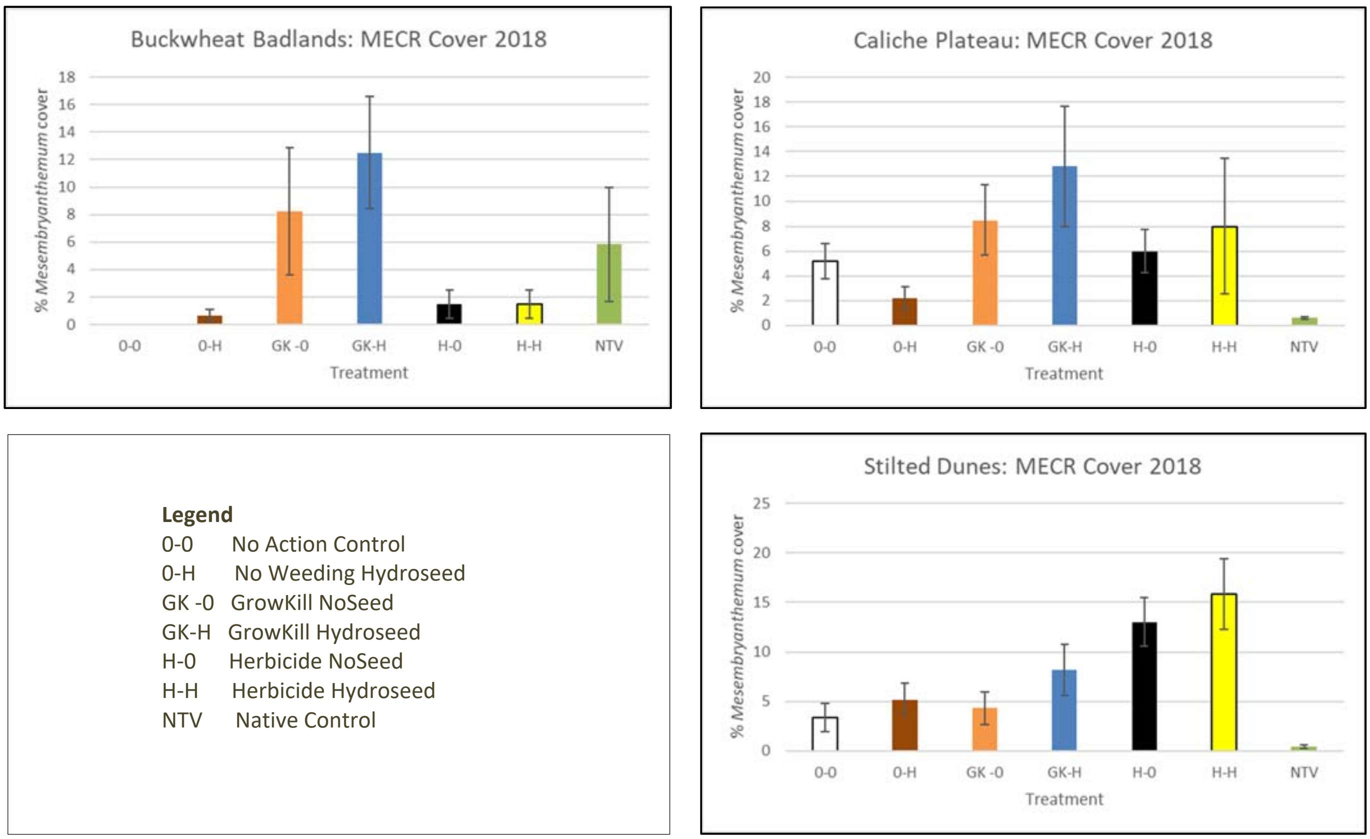

Figure 26. *Mesembryanthemum* cover in 2018 by site and treatment on San Nicolas Island. Comparisons between pairs were made with non-parametric Steel-Dwass tests. Statistical differences are too complicated to represent in the graph, and are discussed in the text.

High variability in the experimental treatment plots and corrections for multiple pairwise comparisons limited the number of statistically significant differences between treatments in 2018. There were no differences significant at the $p \leq 0.05$ level, but there were some statistical trends, including native plots lower than the other three treatments without hydroseeding at Caliche Plateau, and native plots lower than all other treatments except for control plots without hydroseeding at Stilted Dunes.

Plant Species Richness

Species richness comparisons for 2017 are presented in **Figure 27**. At Buckwheat Badlands, grow-kill plots with hydroseeding supported the highest plant species richness of all our experimental treatments. This difference was only significant when compared with herbicided plots without hydroseeding, which had the lowest plant species richness of all treatments. Native plots had higher plant species richness than all plot treatments except for grow-kill with hydroseeding. Caliche Plateau and Stilted Dunes had similar patterns to each other, with mean plant species richness similar for all treatments except for both types of herbicide plots, which supported significantly lower plant species richness than all other treatments.

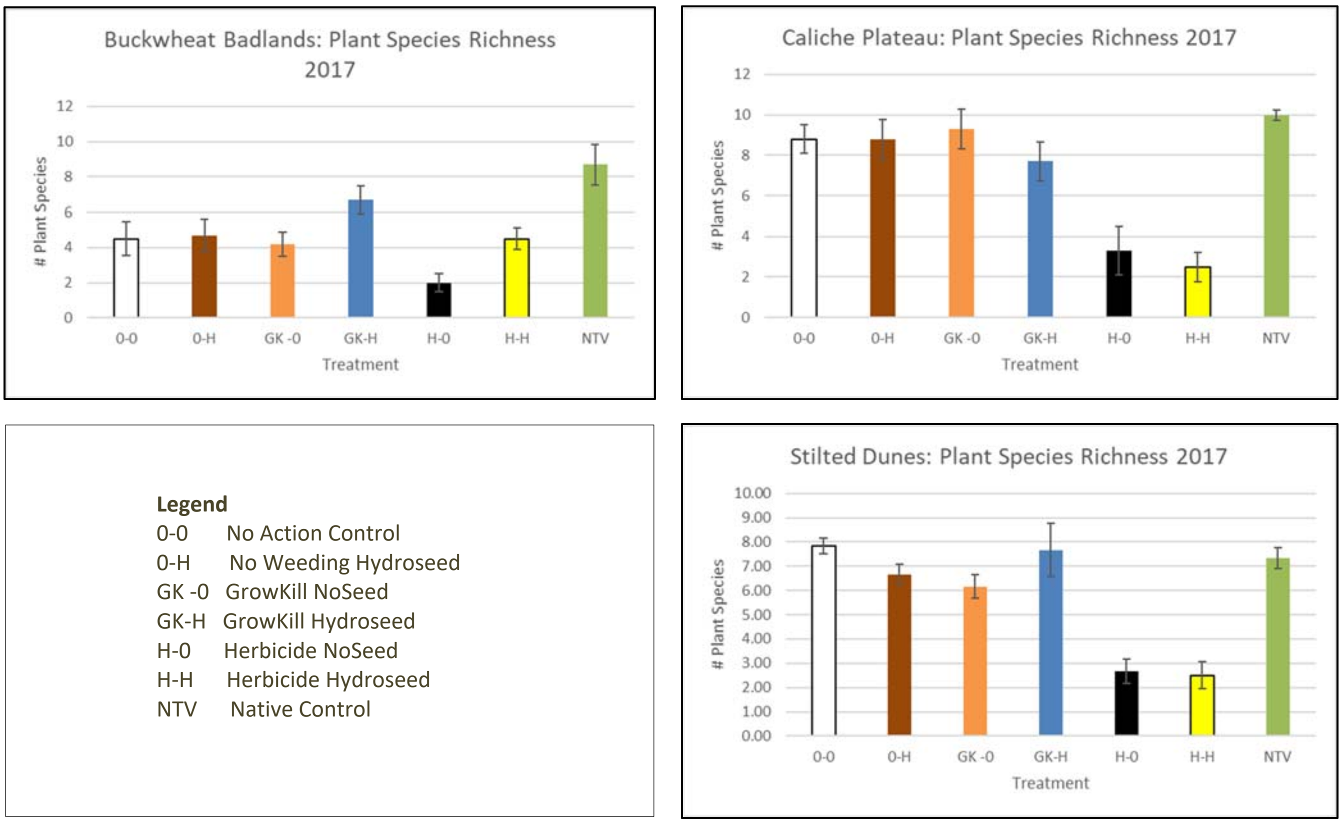

Figure 27. Plant species richness in 2017 by site and treatment on San Nicolas Island. Comparisons of pairs were made with Tukeys HSD tests. Statistical differences are too complicated to represent in the graph, and are discussed in the text.

Species richness comparisons for 2018 are presented in **Figure 28**. In general, grow-kill plots had as high or higher plant species richness than other experimental treatments. At the Buckwheat Badlands site, native plots had significantly higher species richness than all other treatments, but no other differences were statistically significant. At the Caliche Plateau site, grow-kill/hydroseed plots had significantly higher species richness than both types of control and both types of herbicide plots. Grow-kill plots without hydroseeding also had significantly higher species richness than herbicide plots without hydroseeding. Control plots without hydroseeding had significantly higher species richness than herbicide plots without hydroseeding, and richness in native plots was significantly greater than both herbicide/no hydroseed and control/hydroseed plots. There were no significant differences in species richness between treatments at the Stilted Dunes site.

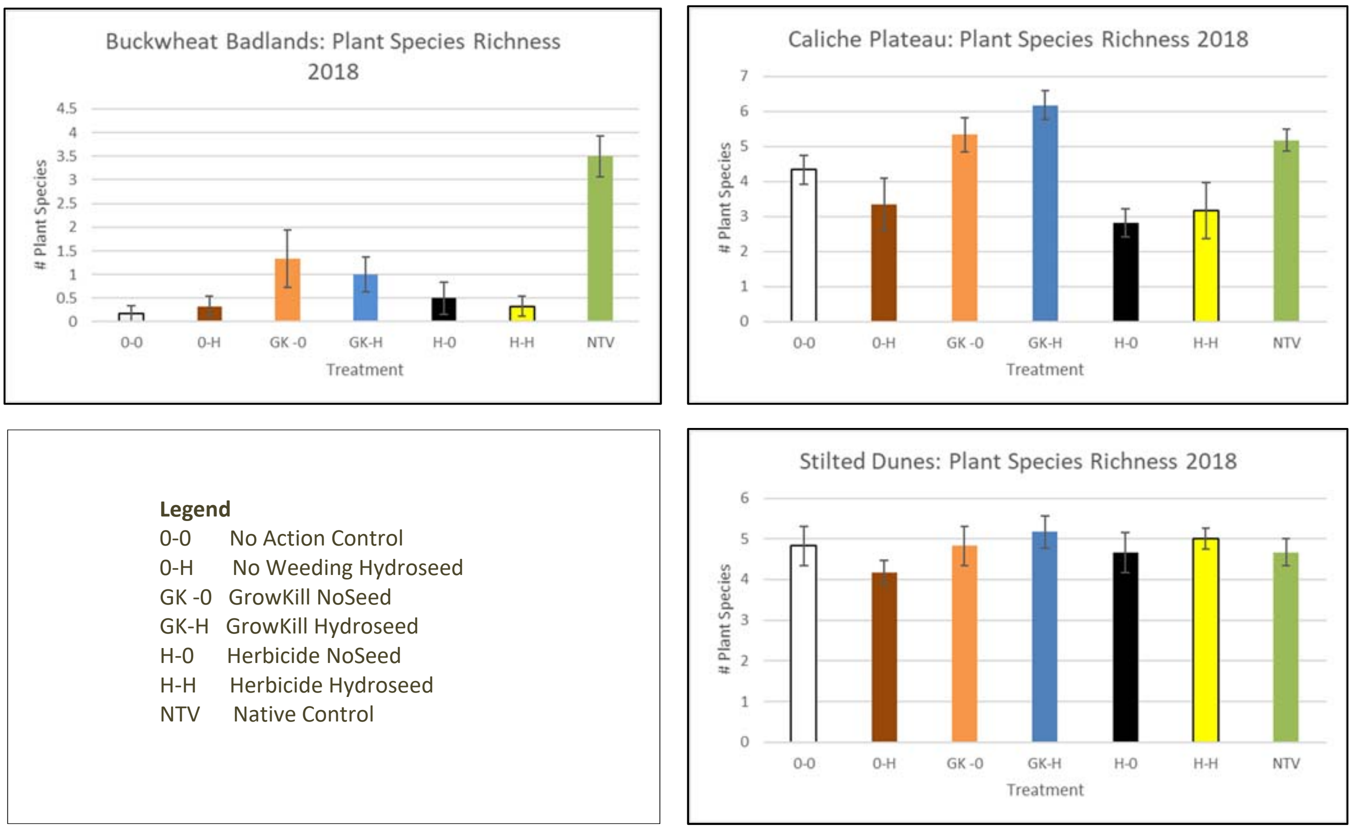

Figure 28. Plant species richness in 2018 by site and treatment on San Nicolas Island. Comparisons between pairs were made with non-parametric Steel-Dwass tests. Statistical differences are too complicated to represent in the graph, and are discussed in the text.

<u>Native Plant Cover</u>

Native plant cover data for 2017 are presented in **Figure 29**. Caliche Plateau exhibited the highest native cover overall in experimental plots, two months following hydro-seeding. High variability and corrections for multiple pairwise comparisons limited the number of statistically significant differences, however in general grow-kill plots had greater native cover than herbicided plots, while control plots were variable, with sometimes less native plant cover than grow-kill plots (Stilted Dunes), sometimes similar native cover to those plots (Buckwheat Badlands), and sometimes more native plant cover than grow-kill plots (Caliche Plateau). At the Buckwheat Badlands site, there were no statistically significant differences at the p ≤ 0.05 level, although there was a statistical trend for all native plots to have greater native cover than all of the experimental plots. Results were similar at the Caliche Plateau site except the only statistical trends were between native plots and both herbicide treatments as well as grow-kill/no hydroseed. At Stilted Dunes, the only statistical trend was between native and herbicide/hydroseed plots.

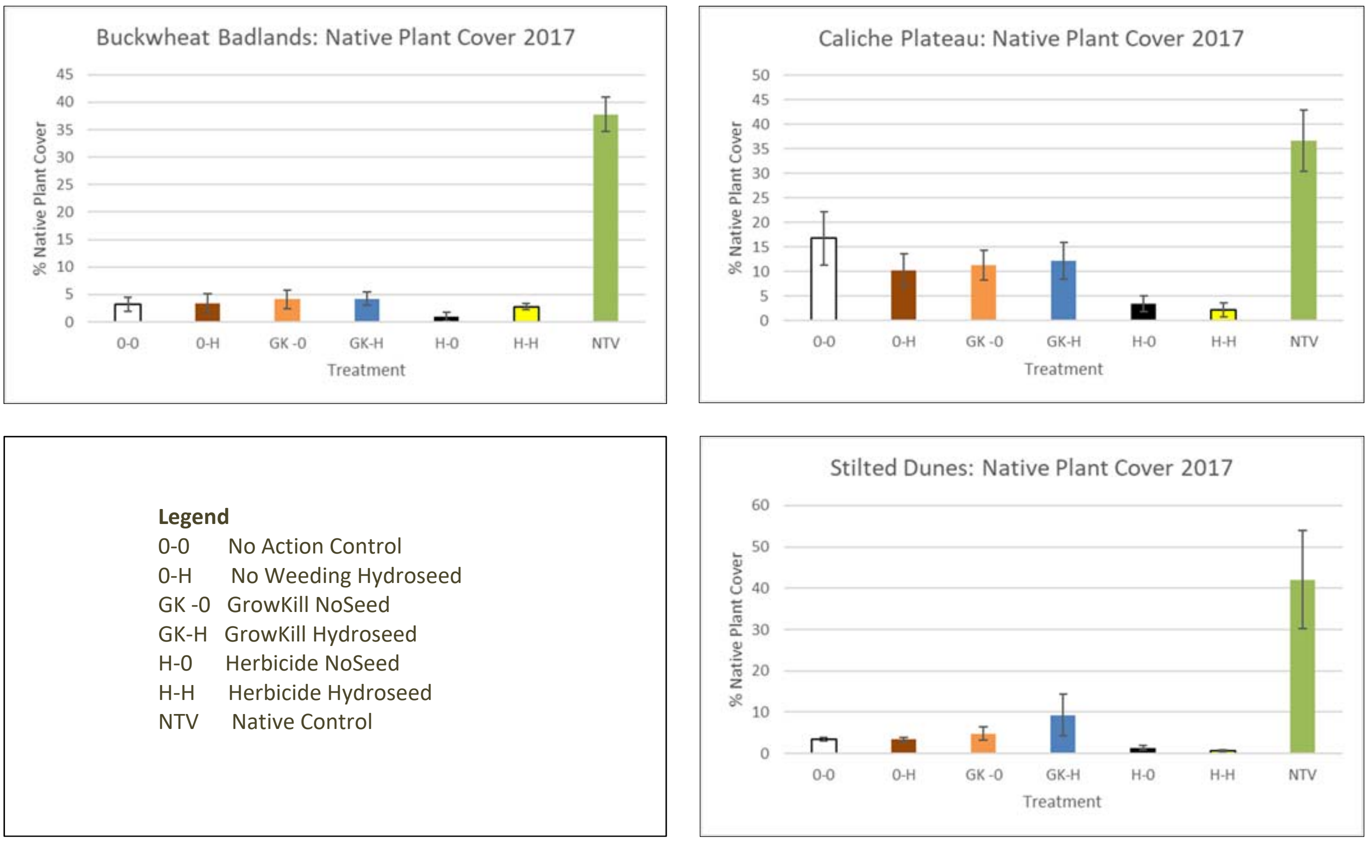

Figure 29. Native plant cover in 2017 by site and treatment on San Nicolas Island. Comparisons between pairs were made with non-parametric Steel-Dwass tests. Statistical differences are too complicated to represent in the graph, and are discussed in the text.

Native plant cover data for 2018 are presented in **Figure 30**. Overall, Stilted Dunes plots supported the greatest native cover, followed by Caliche Plateau then Buckwheat Badlands, which had very little native cover. Each site had slightly different patterns across treatments, and results are discussed separately by site below.

Buckwheat Badlands

Native plots had an average of 28% native cover in 2018 at the Buckwheat Badlands site, whereas the highest native cover in the different treatments was 2.8% (in plots that were herbicided but not hydroseeded). Native cover was significantly greater in the native plots than all other treatments; no other differences were significant.

Caliche Plateau

At the Caliche Plateau site, native plots had an average of 40% native cover in 2018; this was at least 200% that of the experimental treatment with the next greatest native cover (controls with no weed treatment or hydroseeding). There, the only statistically significant differences were between native plots and both herbicided treatments, as well as controls with hydroseeding.

Stilted Dunes

At the Stilted Dunes site, native plots had an average of 43% native cover in 2018, less than 1% greater than the native cover in grow-kill/hydroseed plots, and not significantly different from any of the other treatments, in large part due to high variability. Plots that were treated by grow-kill then hydroseeded had significantly greater native cover than both types of herbicided plots at the Stilted Dunes site, however, as did no weed treatment/hydroseed vs. herbicide not hydroseed.

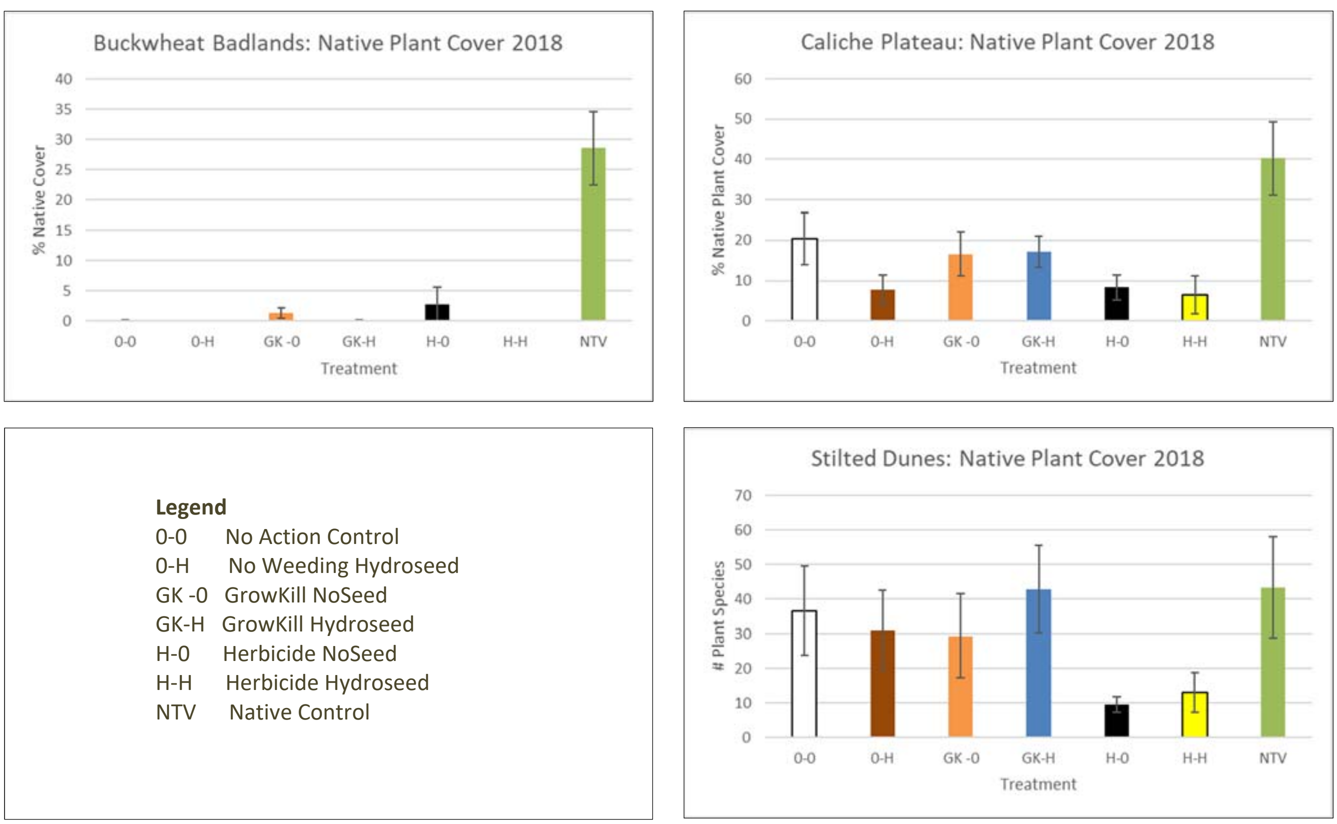

Figure 30. Native plant cover in 2018 by site and treatment on San Nicolas Island. Comparisons between pairs were made with non-parametric Steel-Dwass tests. Statistical differences are too complicated to represent in the graph, and are discussed in the text.

Soils Analyses (2017)

Soil salinity differences between 2016 and 2017 are presented in **Table 10.** Only grow-kill and control treatments were compared, to determine the effectiveness of watering to leach salts out of the soil. None of the differences between treatments was statistically significant.

Table 10. Soil salinity differences between grow-kill and control plots, 2016-2017, by site on San Nicolas Island. Wilcoxon tests were used. None of the differences were statistically significant.

Site	Grow-Kill mean (stand. error)	Control mean (stand. error)	Test Statistic	Significance
Buckwheat Badlands	-323.2 ± 87.4	-217.1 ± 71.1	Chi Square = 1.07	p =0.30
Caliche Plateau	-187.2 ± 50.6	-212.7 ± 46.6	Chi Square = 0.007	p =0.93
Stilted Dunes	-121.0 ± 52.7	-177.7 ± 50.2	Chi Square = 0.35	p =0.55

DISCUSSION

MECR impacts

Although there is ample evidence that non-native plant invasions have negative effects on arthropod diversity (van Hengstum et al. 2014, Knapp 2014), most studies have concentrated on a limited group of arthropods, with few considering the impacts of plant invasions on entire arthropod assemblages performing many functional and trophic roles (Bezemer et al. 2014). Analyses of invasive plant impacts on entire arthropod assemblages, such as we provide here, will help us to understand the mechanisms for the effects of plant invasions on entire communities (Levine et al. 2003).

For two of three sites studied, both plant and arthropod diversity were significantly (or near-significantly) lower in MECR-dominated plots. Several studies have linked declines in arthropod abundance and diversity to decreasing plant diversity (e.g., Schooler et al. 2009; Spyreas et al. 2010; Almeida-Neto et al. 2011), and those variables are significantly, positively correlated at Buckwheat Badlands in our study (but not at the other two sites). The most significant explanatory variable at Buckwheat Badlands, however, was native plant cover, followed by soil moisture. Buckwheat Badlands had the lowest native plant cover of all the sites, associated with the dense MECR invasion there. Perhaps native plant cover was an important pre-condition for plant species richness. The most important explanatory variable for arthropod species richness at the Caliche Plateau site was soil moisture. Abiotic variables such as plant litter, temperature, and moisture (all to some degree related) are important to arthropod assemblages

(Potts et al. 2003, Wolkovitch 2010, Price 2011). At that site, MECR- and native-dominated areas were more integrated, and the difference in native plant cover less strong.

The Stilted Dunes site exhibited greater plant and arthropod richness in MECR plots. At that site, the best explanatory variable was plant litter cover. The Stilted Dunes site, in addition to supporting a more unique plant assemblage than the other two, had lower soil moisture overall, likely related to the slightly coarser soils without a caliche hardpan. There, plant litter contributes somewhat to greater soil moisture in addition to serving as an additional food source for detritivores. Structural habitat complexity is also important for arthropod diversity, related to more hiding places from natural enemies as well as more enhanced prey capture (Brose 2003; Langellotto and Denno 2004). This variable was not measured, but would enhance future studies.

Despite differing plant/arthropod diversity responses at the different sites, arthropod composition was consistently altered by MECR invasion at all three sites. The number of Indicator Species (which are representative of one treatment and not the other) was much greater in the Native plots at both Buckwheat Badlands and Caliche Plateau, where MECR plots were only 29 and 17 percent of the total number of Indicator Species, respectively. Further, all Diptera (fly), Coleoptera (beetle), and Lepidoptera (in this case, moth) Indicators were found in Native plots, as were all but one Hymenoptera (ants and wasps) and Hemiptera (true bug) Indicator. Psocoptera (bark louse) Indicators were mostly found in MECR plots, as was the one Microcoryphia (bristletail), whereas Collembola (springtails) were split 50/50. In general, Indicator Species for Native plots are larger in size than those for MECR plots, suggesting that arthropod biomass is likely to be negatively impacted as well.

We found a large increase in arthropod abundance in MECR plots at both the Buckwheat Badlands and Stilted Dunes sites, due in large part to detritivores such as Collembola and Psocoptera, and herbivores such as mealybugs (Pseudococcidae). The increase in abundance of those groups seems to have driven a decrease in evenness among the feeding guilds, and consequently reduced functional diversity. ***It is noteworthy that, at all three of the sites, either species richness or functional diversity (or both) was lower in MECR-dominated plots.***

The most significant explanatory variables for functional diversity at Buckwheat Badlands were MECR cover and soil moisture. The heavy MECR invasion at that site seems to have driven an increase in herbivorous and detritivorous arthropods that are able to use it as a resource, and the parasitoids that are supported by those, but the elevated abundance for those feeding guilds combined with a reduction in other feeding guilds such as nectar/pollen feeders and omnivores has resulted in reduced functional diversity. At Caliche Plateau, fewer feeding guilds were significantly different, and consequently functional diversity was not significantly affected. However at Stilted Dunes, as with Buckwheat Badlands, detritivores and herbivores were significantly increased, as were predators, driving an imbalance that reduced the functional diversity.

Results for each of the different feeding guilds examined are discussed further, in turn, below.

Herbivores

Among arthropod feeding guilds, herbivores (particularly specialized herbivores) are often most negatively affected by introduced plants, because they have adapted to tolerate the chemical and physical defenses of native plants (Proches et al. 2008; Hartley et al. 2010). Invasive plant species with greater phylogenetic distance to resident native species can be underutilized by invertebrate herbivores (Strong et al. 1984; Harvey et al. 2012), particularly specialists (Almeida-Neto et al. 2011) which may avoid this novel plant due to differences from native plants in characteristics such as nutritional quality, chemical composition, and architecture (Strong et al. 1984; Kuhnle and Muller 2009). This has the potential be a particularly acute problem for *Mesembryanthemum* as there are only two native members of the plant family Aizoaceae in California (it is taxonomically isolated), and none of them are found on San Nicolas Island. A number of herbivores were Indicator Species for the Native plots, including two leafhopper (Cicadellidae) morphs and one aphid (Aphididae) morph. Furthermore, two twirler moth (Gelechiidae) morphs were associated with Native plots, which could be due to either their preferences as a nectar feeding adult or to the host plant preferences of their larvae. Herbivore impacts are moderated with increasing time since establishment (Kennedy and Southwood 1984; Harvey et al. 2013), which is substantial in the case of *Mesembryanthemum* (nearly 120 years). This has likely facilitated the herbivores, such as mealybugs (Pseudococcidae) that are more abundant in MECR plots.

Detritivores

Areas with high densities of invasive plants often have dense plant litter produced over successive growth cycles (Holdredge and Bertness 2011; Topp et al. 2008; Moron et al. 2009), related to the rapid growth rates of many invasive species (Grotkopp et al. 2010). This provides a ready resource for arthropods that are able to utilize it, and several types of Collembola and Psocoptera seem to be thriving in MECR habitat.

Nectar/Pollen feeders (pollinators)

Nectar/pollen consumers and omnivores were both reduced in MECR plots, at both the Buckwheat Badlands and Caliche Plateau sites. Because flower feeders vary greatly in their specialization for specific plants (Johnson and Steiner 2000), their abundances can either increase, when generalists track the often large, abundant, and showy flowers of invaders (Traveset and Richardson 2006, Bjerknes et al. 2007) or decrease, as invasive plants reduce the diversity of native plants used by specialists (Valtonen et al. 2006; Moron et al. 2009). Overall, pollinator richness is typically lower on exotic than native plants (Knapp 2014), and that is what we found here. Flower feeders in our study were primarily several types of moths (**Appendix Table 6**).

Omnivores

Omnivores were significantly lower in MECR plots at both Buckwheat Badlands and Caliche Plateau, and although not statistically significant, at Stilted Dunes they were on average about 50% as abundant as in Native plots. The omnivores collected in the course of our study included Sarcophagidae (flesh flies), Melyridae (soft-winged flower beetles), Gryllacrididae (raspy crickets), and several types of Formicidae (ants). We should note that while many Sarcophagidae larvae are parasites, the adults of this family feed on a variety of resources, including nectar, animal fluids, and other organic substances, and we therefore classified the adults as omnivores. The Orders of these insects (Diptera, Coleoptera, Orthoptera, and Hymenoptera) are all food items of Island Foxes (Cypher et al. 2011), as discussed later in this document.

Predators & Parasitoids

Parasitoids were more abundant in MECR plots at both Buckwheat Badlands and Caliche Plateau. Interestingly, at the Buckwheat Badlands site both Pseudococcidae 3 and Encyrtidae 8 were Indicator Species for MECR plots; many Encyrtidae attack scales and mealybugs (R. Zuparko, Essig Museum of Entomology, personal communication). Parasitoids, which are more specialized to their hosts than predators (Price et al. 2011, Welch et al. 2012), benefit from a greater diversity of prey, but the greater parasitoid abundance found here is likely driven by the abundance of their host.

Predator results were variable; they were more abundant in MECR plots at Stilted Dunes, but less abundant in MECR plots at Caliche Plateau. Because the effects of plant diversity dampen with increasing trophic level, predators as well as parasitoids are less affected by changes in plant diversity than herbivores (Scherber et al. 2010). A review by Knapp (2014) revealed equivocal relationships between predator and parasitoid richness and invasive plants, with nearly equal numbers finding lower and higher species richness in invaded habitats.

Diet analysis via scat sorting revealed that Island foxes eat Jerusalem crickets (*Stenopalmatus* spp.), silk-spinning sand crickets (*Cnemotettix* spp.), earwigs (*Forficula auricularia*), cockroaches (Blattidae) and unspecified insects in the orders Coleoptera, Diptera, Hymenoptera, Lepidoptera, and Odonata (Cypher et al 2011). Indicator Species in the Orders Coleoptera, Diptera, Hymenoptera, and Lepidoptera were found exclusively in Native plots, with the exception of one parasitic wasp. ***This suggests that MECR impacts on arthropods is impacting fox nutrition.*** Further diet analysis using DNA barcoding will enable more resolved taxonomic identification, and may reveal additional smaller, softer-bodied groups that the foxes are eating. SBBG is starting this work on San Clemente Island in 2019/2020.

The morphospecies photos posted online have attracted attention from a global network of entomologists that are providing identifications for their (typically narrow) taxonomic group of interest. It has even led to the discovery of a whole new genus (and thus species as well) of parasitic wasp in the family Encyrtidae. Dr. Zuparko at the Essig Museum of Entomology requested and examined our specimen of Encyrtidae 7, and although the male specimen is not enough for a formal description, he feels confident that this it represents a new genus to science. This provides support for our novel application of the morphospecies technique, which utilizes ecologists/generalist entomologists to coarsely identify and image a wide variety of arthropods and get an ecological question answered, then taps into entomological specialist expertise via modern online tools to facilitate further identification and description of new taxa. This is a win-win for both biodiversity exploration and habitat restoration.

Restoration experiment

While MECR was by far the most abundant plant species in the seed bank at all three sites, there were between 7 and 13 native plant species present as well, including rare endemics such as *Astragalus traskiae* and *Malacothrix foliosa*. Given that the abundance of these taxa cumulatively is dwarfed by the numbers of MECR seeds, it could be argued that it is easier to kill the entire seed bank then put the desired species back. However, genetic diversity is also a key component of biodiversity and provides further resilience to environmental change, and on an island such as SNI that is relatively depauperate in native plant cover, we chose to proceed with our restoration experiment without using a pre-emergent herbicide.

The statistical penalty when comparing seven different treatments, combined with moderate to high variability, rendered few differences statistically significant. This does not mean that they are not ecologically significant, however. For the purposes of this discussion, when error bars to not overlap, those differences are considered ecologically significant.

For the most part, herbicide appears to have achieved the greatest reduction of MECR cover in our plots, in addition to having the advantage of being the more cost-effective and scalable technique. Grow-kill plots had more MECR re-growth between 2016 and 2017 (especially at Buckwheat Badlands), likely facilitated by the disturbance of hoeing. This pattern was sustained at two of the three sites in 2018, but disrupted at the Stilted Dunes site where herbicided plots had the greatest MECR cover (perhaps related to a light rain that fell briefly after application). As a comparison, control plots gained MECR cover at two of three sites between 2016 and 2017, a rather wet rainfall year (but lost cover at Stilted Dunes). But then, in 2018 control plots had the *lowest* MECR cover of all treatments at both Buckwheat Badlands and Stilted Dunes. The extremely low rainfall that year hindered growth of everything, but this result is surprising.

Grow-kill plots had the advantage, on the other hand, of supporting higher plant species richness than herbicide plots (at least at two of the sites), which is the goal of this project – and begets arthropod diversity. In 2017, herbicide plots had lower plant species richness than all other treatments, so this control technique seems to have also thwarted natives, at least for that year. At the Caliche Plateau and Stilted Dunes sites, plant species richness in grow-kill plots actually rivaled that of the native plots both in 2017 and 2018. MECR was not associated with reduced plant richness at Stilted Dunes in the first place, and there was also no difference between any of the treatments there.

Native plant cover, as with species richness, was lowest in herbicide plots in 2017, and similarly higher for other experimental treatments that year. In 2018, results varied quite a bit by site, with Buckwheat Badlands supporting very low native plant cover across all treatments, and Caliche Plateau and Stilted Dunes sustaining the patterns of 2017 (but with Stilted Dunes treatments supporting much higher native plant cover overall, similar to native plots). Buckwheat Badlands had extremely low native plant cover in the experimental treatment area to start with, so this pattern was simply continued – but the experimental MECR plots gained an impressive amount of cover at the Stilted Dunes site, overtaking Caliche Plateau's lead in native cover from 2016.

The negative herbicide effects seem to have continued into 2018 for both species richness and native plant cover. The challenge with herbicide as a treatment, if the goal is to get native growth following, is that the dead MECR remains, physically blocking germination and growth of any native species waiting in the seed bank (but also blocking its own germination). Further, when hydro-seeding natives, little of the material makes contact with the soil surface.

Unfortunately, as of April 2018 (1 year and 2 months following treatment), there was not yet any significant effect (statistical *or* ecological) of hydro-seeding. In April 2017, we saw promising seedling growth, and hoped that more would germinate the following fall with the onset of rain. But that rain didn't come (the 2017-218 rainfall year was extremely dry), and those seedlings for the most part perished. As of April 2018, the hydroseed material was still evident in the plots, and it is possible that there will still be germination and growth in the 2018-2019 rainfall season, given sufficient rainfall. This climatic uncertainty is the drawback to seeding-based restoration programs.

Much time and expense goes into collecting seed from island wildlands, cleaning and preparing that seed, and then applying it. But drought, precipitation extremes, and warmer temperatures are all occurring at accelerated rates (IPCC 2014), making the success of seeding programs equally variable. Even more worrisome, invasive species will likely be favored over natives (Sandel and Dangremond 2012), particularly such adaptable species as MECR. Barring a fortunate combination of our seed application's persistence and a favorable rain year soon, other strategies will need to be adopted to restore diverse, native habitat in MECR-dominated areas on the San Nicolas Island landscape.

Container plantings followed by irrigation are being implemented successfully on San Nicolas Island in accessible, high-priority locations from which seed will likely disperse on prevailing winds. This technique is less scalable, however, and more difficult to accomplish in more remote locations. But these sites will be excellent places for seed collection in the future, which will continue to get easier and easier as more habitat is restored. One option is to collect native seed for restoration purposes every year, but only apply it when it is clear that it will be a good rainfall year (although an extremely dry year following application could still thwart these efforts).

The portable hydroseeding technique holds promise, despite seeding programs being susceptible to drought years. Bulk-collecting seed from production fields and other restoration areas, then applying in years when rainfall is looking to be abundant, could be a successful strategy. The challenge for this is that it doesn't mesh well with the standard short-term nature of funding and contracts. With flexible three-year contracts, however, it could work. In this study, we've learned that some sites, like Stilted Dunes, are not as negatively impacted as others, which will help to prioritize future restoration efforts.

Biological control, or the introduction of a novel herbivore to control invasive plant populations, is an important tool in conservation management (Caltagirone 1981), and with the extensive testing required in the United States, is now safer than ever (Sheppard et al. 2005). This may be the best option for MECR control on San Nicolas Island. In this case, the taxonomic isolation of MECR is an advantage, as it will be easier to find a low-risk biological control agent. Further, the island's remoteness would buffer the project from unintended consequences. Before such a program was implemented, however, an action plan for native revegetation must be in place.

Problems encountered and form of resolution

One of our April pitfall traps (SD37) was disturbed by (presumably) a fox. Much more catastrophically, nearly half (15 of 36) of the Buckwheat Badlands experimental plots were completely filled with sediment at the end of the two days, thus yielding no data. This did not happen at the other two sites, and has not happened in any of our previous pitfall trapping experiences; we believe that a combination of finer, more erosive soils at that site and high winds are responsible. Luckily, enough samples were intact to enable a robust comparison between MECR and native-dominated plots at that site. Samples that were usable had a larger than usual amount of debris, requiring pre-separation of arthropods, and greatly increasing the time required.

In order to compensate for traps that were silted in at Buckwheat Badlands, and to capture later insect stages which may give a greater opportunity to define *Mesembryanthemum* impacts, pitfall traps were re-sampled on a voluntary basis from June 7-10 for two sites (Stilted Dunes and Buckwheat Badlands), Given the great amount of work that was required to identify and image the April samples, these samples have not been processed and identified, but could be a useful data set for the Navy.

On-island car rental personnel were sometimes absent, which delayed our start of work for as much as four hours. This is highly significant on a two or three day visit. We worked longer days and made return visits to compensate. Some days, there were issues with our reservation that we were not made aware of by Navy personnel and we were unable to obtain a vehicle; we are grateful to Bill Hoyer and anonymous Navy personnel for their assistance on those days.

On some visits, we would encounter road closures due to either operations or barge arrival. On those visits, we adjusted our schedules the best we could to get all of the work done.

Weight limits on the plane, as well as limits in what types of articles could be brought aboard (i.e. no garden implements, no ethanol), made advance planning and flexibility necessary. We were glad that return flights are often more flexible with weight, and are grateful to both Channel Islands Restoration

for sharing their equipment, and to Bill Hoyer for helping us to gather found materials for marking our plots. We are also grateful to Valerie Vartanian for facilitating our barge shipments.

Passes were often not available at the pass office in Port Hueneme when they should have been, making for some exciting mornings and days, and some thwarted visits. We are grateful to Bill Hoyer, Martin Ruane, and Valerie Vartanian for assisting the best they could.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Mesembryanthemum is on the balance having a significant negative impact on the plant and arthropod communities of San Nicolas Island. All three of our study sites exhibited significant differences in arthropod composition, in favor of tiny detritivores and herbivores in a few Orders, and at the detriment of many larger arthropods in a variety of Orders. Those losing Orders are known food sources for Island Foxes, which are thus likely negatively impacted by *Mesembryanthemum* as well. Results varied by site, with some positive effects at the dune scrub dominated Stilted Dunes site, but at all sites, either arthropod species richness, functional richness, or both were negatively affected.

Habitat restoration efforts can typically regain lost invertebrate diversity (Knapp 2014), even after only $\leq$ one year for some groups (Waltz & Covington 2004; Kaiser-Bunbury et al. 2009; Lomov et al. 2010). While our treatments successfully reduced *Mesembryanthemum* cover, regaining plant species diversity and cover is made more difficult by extreme variation in rainfall and frequent drought. We suggest a combination of continued restoration using irrigated container plantings, combined with further efforts for hydroseeding, and pursuit of biological control. The effort will be worth it, as the biodiversity that is gained will then provide the islands resistance to invasion, resilience to disturbance, and adaptation to future environments.

Persistence, flexibility, and adaptation were keys to the success of this project. Work on military bases is always challenging, as is island work; this project was both. In addition, the arthropod work took longer than expected, but through it we fully discovered what valuable tools z-stacked images and online image-sharing can be, and we are pleased that our work is furthering the invertebrate biodiversity knowledge for the island. For future projects, it will be useful to pre-sort the specimens into different Orders and other groups of interest, for more efficient ID as well as ready sharing with interested entomologists.

This is a rich dataset with which much more can be done. It would be useful to investigate selected insect groups that are abundant, diverse, and play important functional roles (such as ants [Mauda et al. 2018] or Collembola [Vandewalle et al. 2010]) and investigate their relationships to habitat characteristics. Similarly, relationships to environmental variables could be investigated for all feeding guilds. Furthermore, when the invertebrate fauna is better known for SNI, confirmed species-level identifications would allow for native/non-native status to be determined for each of these taxa, and for feeding guilds to be parsed out more finely, and thus enhance the findings here.

Arthropod specimens are currently housed at SBBG. The Santa Barbara Museum of Natural History is interested in housing the beetle specimens, but is less interested in receiving the vials of ethanol containing mixed specimens of other Orders. Ideally, specimens would be sorted by order and distributed to interested taxonomic specialists. This would require additional work and funding, however.

REFERENCES

Adams, P., et al. (1998). Growth and development of *Mesembryanthemum crystallinum* (Aizoaceae). New Phytologist **138**(2): 171-190.

Almeida-Neto, M., et al. (2011). Phytophagous insect fauna tracks host plant responses to exotic grass invasion. Oecologia **165**(4): 1051-1062.

Arnett, J., Ross H. and M. C. Thomas (2001). American Beetles, Vol. 1: Archostemata, Myxophaga, Adephaga, Polyphaga: Staphyliniformia. Boca Raton, FL, CRC Press. **1:** 443.

Arnett, J., Ross H., et al., Eds. (2002). American Beetles, Vol. 2: Polyphaga: Scarabaeoidea through Curculionoidea. Boca Raton, FL, CRC Press.

Bezemer, T. M., et al. (2014). Response of native insect communities to invasive plants. Annual Review of Entomology, Vol 59, 2014. M. R. Berenbaum. **59:** 119-141.

Bjerknes, A. L., et al. (2007). Do alien plant invasions really affect pollination success in native plant species? Biological Conservation **138**(1-2): 1-12.

Brose, U. (2003). Bottom-up control of carabid beetle communities in early successional wetlands: mediated by vegetation structure or plant diversity? Oecologia **135**: 407-413.

Cadotte, M. W. (2011). The new diversity: management gains through insights into the functional diversity of communities. Journal of Applied Ecology **48**(5): 1067-1069.

Caltagirone, L.E. (1981). Landmark examples in classical biological control. Annual Review of Entomology 26: 213-232.

Cypher, B.L., A.Y. Madrid, C.L. Van Horn Job, E. Kelly, S.W.R. Harrison, and T.L. Westall. 2011. Resource exploitation by island foxes: Implications for conservation. Unpublished report P0850004 prepared for the California Department of Fish and Game, San Diego, CA.

D'Antonio, C. M., et al. (1992). Restoration of denuded areas and iceplant areas on Santa Barbara Island, Channel Islands National Park, Cooperative National Park Resources Studies Unit. University of California at Davis Institute of Ecology, Davis, CA.

Dufrêne, M. and P. Legendre. 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. Ecological Monographs 61: 53-73.

Ehrenfeld, J. G. (2010). Ecosystem Consequences of Biological Invasions. Annual Review of Ecology, Evolution, and Systematics, Vol 41. **41:** 59-80.

Gagic, V., et al. (2015). Functional identity and diversity of animals predict ecosystem functioning better than species-based indices. Proceedings of the Royal Society B-Biological Sciences **282**(1801).

Grotkopp, E., et al. (2010). Assessing potential invasiveness of woody horticultural plant species using seedling growth rate traits. Journal of Applied Ecology **47**(6): 1320-1328.

Gullan, P. J. and P. S. Cranston (2005). The insects: An outline of entomology. Malden, MA, Blackwell Publishing Ltd.

Gunderson, L.H. (2000). Ecological resilience – in theory and application. Annual Review of Ecology and Systematics **31**:425-439.

Gutterman, Y. and T. Gendler (2005). Annual rhythm of germination of seeds of *Mesembryanthemum nodiflorum* 32 years after collection. Seed Science Research **15**(3): 249-253.

Halvorson, W.L., S.A. Junak, C. Schwemm, and T. Keeney. (1996). Plant communities of San Nicolas Island, California. Technical Report No. 55. University of Arizona: Tucson, AZ.

Hartley, M. K., et al. (2010). Comparisons of arthropod assemblages on an invasive and native trees: abundance, diversity and damage. Arthropod-Plant Interactions **4**(4): 237-245.

Harvey, K. J., et al. (2012). Australian family ties: does a lack of relatives help invasive plants escape natural enemies? Biological Invasions **14**(11): 2423-2434.

Harvey, K. J., et al. (2013). Does time since introduction influence enemy release of an invasive weed? Oecologia **173**(2): 493-506.

Hautier, Y., D. Tilman, F. Isbell, E.W. Seabloom, E.T. Borer, and P.B. Reich. (2015). Anthropogenic environmental changes affect ecosystem stability via biodiversity. Science 348(6232): 336-340.

HDR. (2014). Vegetation classification and mapping, Naval Base Ventura County, San Nicolas Island, California. Prepared by HDR for Naval Facilities Engineering Command Southwest.

Holdredge, C. and M. D. Bertness (2011). Litter legacy increases the competitive advantage of invasive Phragmites australis in New England wetlands. Biological Invasions **13**(2): 423-433.

IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Johnson, S. D. and K. E. Steiner (2000). Generalization versus specialization in plant pollination systems. Trends in Ecology & Evolution **15**(4): 140-143.

Junak, S. (2008). A flora of San Nicolas Island, California. Santa Barbara Botanic Garden, Santa Barbara, CA.

Kaiser-Bunbury, C. N., et al. (2009). Community structure of pollination webs of Mauritian heathland habitats. Perspectives in Plant Ecology Evolution and Systematics **11**(4): 241-254.

Kennedy, C. E. J. and T. R. E. Southwood (1984). The number of species of insects associated with British trees - a re-analysis. Journal of Animal Ecology **53**(2): 455-478.

Kloot, P. M. (1983). The role of common iceplant (*Mesembryanthemum crystallinum*) in the deterioration of medic pasture. Australian Journal of Ecology **8**(3): 301-306.

Knapp, D. A. (2014). Effects of an exotic plant invasion on arthropod assemblages. Ecology, Evolution, and Marine Biology. Santa Barbara, CA, University of California, Santa Barbara. Ph.D. dissertation: 187 pages.

Krebs, C. J. (1998). Ecological methodology (2nd edition). San Francisco, CA, Benjamin Cummings.

Kremen, C., et al. (1993). Terrestrial arthropod assemblages: Their use in conservation planning. Conservation Biology **7**(4): 796-808.

Kuhnle, A. and C. Muller (2009). Differing acceptance of familiar and unfamiliar plant species by an oligophagous beetle. Entomologia Experimentalis Et Applicata **131**(2): 189-199.

Levine, J. M., et al. (2003). Mechanisms underlying the impacts of exotic plant invasions. Proceedings of the Royal Society of London B **270**: 775-781.

Liao, C., et al. (2008). Altered ecosystem carbon and nitrogen cycles by plant invasion: a meta-analysis. New Phytologist **177**: 706-714.

Liu, X. and H. Wang (2018). Contrasting patterns and drivers in taxonomic versus functional diversity, and community assembly of aquatic plants in subtropical lakes. Biodiversity and Conservation **27**(12): 3103-3118.

Lodge, D. M. (1993). Biological invasions: Lessons for ecology. TRENDS in Ecology and Evolution **8**(4): 133-137.

Lomov, B., et al. (2010). Pollination and plant reproductive success in restored urban landscapes dominated by a pervasive exotic pollinator. Landscape and Urban Planning **96**(4): 232-239.

Mack, R. N., et al. (2000). Biotic invasions: Causes, epidemiology, global consequences, and control. Ecological Applications **10**(3): 689-710.

Mack, M. C. and C. M. D'Antonio (1998). Impacts of biological invasions on disturbance regimes. TRENDS in Ecology and Evolution **13**(5): 195-198.

Mauda, E. V., et al. (2018). Changes in landuse alter ant diversity, assemblage composition and dominant functional groups in African savannas. Biodiversity and Conservation **27**(4): 947-965.

McAlpine JF, Peterson BV, Shewell GE, Teskey HJ, Vockeroth JR, Wood DM (eds) (1981) Manual of Nearctic Diptera, Volume 1. Canadian Government Publishing Centre, Quebec, Canada

McAlpine JF, Peterson BV, Shewell GE, Teskey HJ, Vockeroth JR, Wood DM (eds) (1987) Manual of Nearctic Diptera, Volume 2. Canadian Government Publishing Centre, Quebec, Canada

McCune, B., Mefford, M.J., (1999). Multivariate analysis of ecological data, version 4.25. MjM Software, Gleneden Beach, Oregon.

McMahon SM, Cadotte MW, Fukami T (2006) Tracking the tractable: using invasions to guide the exploration of conceptual ecology. In: Cadotte MW, McMahon SM, Fukami T (eds) Conceptual ecology and invasion biology. Springer, Netherlands, pp. 3-14

Mielke, P.W., Berry, K.J., (2001). Permutation methods: A distance function approach. Springer Series in Statistics. 344 p.

Millennium Ecosystem Assessment (2005). Ecosystems and human well-being: Synthesis. Washington, D.C., Island Press.

Moron, D., et al. (2009). Wild pollinator communities are negatively affected by invasion of alien goldenrods in grassland landscapes. Biological Conservation **142**(7): 1322-1332.

New South Wales Department of Sustainable Natural Resources. (Accessed September 2018). Soil survey standard test method: Electrical conductivity. Available at: https://www.environment.nsw.gov.au/resources/soils/testmethods/ec.pdf

Oliver, I. and A. J. Beattie (1996). Invertebrate morphospecies as surrogates for species: A case study. Conservation Biology **10**(1): 99-109.

Potts, S. G., et al. (2003). Linking bees and flowers: How do floral communities structure pollinator communities? Ecology (Washington D C) **84**(10): 2628-2642.

Price, P. W., et al. (2011). Insect ecology : Behavior, populations and communities. Cambridge, Cambridge University Press.

Proches, S., et al. (2008). Herbivores, but not other insects, are scarce on alien plants. Austral Ecology **33**(5): 691-700.

Sandel, B. and E.M. Dangremond (2012). Climate change and the invasion of California by grasses. Global Change Biology **18**(1): 277-289.

Scherber, C., et al. (2010). Bottom-up effects of plant diversity on multitrophic interactions in a biodiversity experiment. Nature **468**(7323): 553-556.

Schooler, S. S., et al. (2009). Negative per capita effects of two invasive plants, Lythrum salicaria and Phalaris arundinacea, on the moth diversity of wetland communities. Bulletin of Entomological Research **99**(3): 229-243.

Sheppard, A.W., R.D. van Klinken, and T.A. Heard. (2005). Scientific advances in the analysis of direct risks of weed biological control agents to nontarget plants. Biological Control **35**: 215-226.

Smith, R. I. and J. T. Carlton, Eds. (1975). Light's manual: Intertidal invertebrates of the central California coast. Berkeley, CA, University of California Press.

Strong, D. R., et al. (1984). Insects on plants: Community patterns and mechanisms. Cambridge, Massachusetts, Harvard University Press.

Spyreas, G., et al. (2010). Biological consequences of invasion by reed canary grass (Phalaris arundinacea). Biological Invasions **12**(5): 1253-1267.

Topp, W., et al. (2008). Response of ground-dwelling beetle (Coleoptera) assemblages to giant knotweed (Reynoutria spp.) invasion. Biological Invasions **10**(4): 381-390.

Traveset, A. and D. M. Richardson (2006). Biological invasions as disruptors of plant reproductive mutualisms. Trends in Ecology & Evolution **21**(4): 208-216.

Triplehorn, C. A. and N. F. Johnson (2005). Borror and DeLong's introduction to the study of insects. Belmont, CA, Thomson Brooks/Cole.

U.S. Department of Agriculture. (1985). Soil survey of Channel Islands area, California: San Nicolas Island part. Interim Report. USDA Soil Conservation Service, National Cooperative Soil Survey, Washington, D.C. 248 pp.

U.S. Department of Agriculture, Natural Resources Conservation Service. (Accessed September 2018.) Guide to texture by feel. Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054311

Valencia, E., et al. (2015). Functional diversity enhances the resistance of ecosystem multifunctionality to aridity in Mediterranean drylands. New Phytologist **206**(2): 660-671.

Valtonen, A., et al. (2006). Flora and lepidoptera fauna adversely affected by invasive Lupinus polyphyllus along road verges. Biological Conservation **133**(3): 389-396.

Vandewalle, M., et al. (2010). Functional traits as indicators of biodiversity response to land use changes across ecosystems and organisms. Biodiversity and Conservation **19**(10): 2921-2947.

van Hengstum, T., et al. (2014). Impact of plant invasions on local arthropod communities: a meta-analysis. Journal of Ecology **102**(1): 4-11.

Vivrette, N. J. and C. H. Muller (1977). Mechanism of invasion and dominance of coastal grassland by *Mesembryanthemum crystallinum*. Ecological Monographs **47**(3): 301-318.

Waltz, A. E. M. and W. W. Covington (2004). Ecological restoration treatments increase butterfly richness and abundance: Mechanisms of response. Restoration Ecology **12**(1): 85-96.

Welch, K. D., et al. (2012). The role of generalist predators in terrestrial food webs: Lessons for agricultural pest management. Biodiversity and insect pests key issues for sustainable management. G. Gurr, W. S. D., S. W. E. and R. D. M. Y. Chichester, West Sussex, UK; Hoboken, NJ, John Wiley & Sons**:** 41-56.

Williams, W. T. and J. A. Williams (1984). 10 years of vegetation change on the coastal strand at Morro Bay, California. Bulletin of the Torrey Botanical Club **111**(2): 145-152.

Winter, K. and J. A. M. Holtum (2014). Facultative crassulacean acid metabolism (CAM) plants: powerful tools for unravelling the functional elements of CAM photosynthesis. Journal of Experimental Botany **65**(13): 3425-3441.

Wolkovich, E. M. (2010). Nonnative grass litter enhances grazing arthropod assemblages by increasing native shrub growth. Ecology (Washington D C) **91**(3): 756-766.

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APPENDIX

Denise Knapp and Chris Garoutte submitted an abstract for the 2016 California Islands Symposium in July 2016, reporting on results from the subset of plots that had been processed at that time. This was presented in November of that year, and the abstract follows:

IMPACTS OF MESEMBRYANTHEMUM CRYSTALLINUM ON THE PLANT AND ARTHROPOD DIVERSITY OF SAN NICOLAS ISLAND

Knapp, Denise A. and C.S. Garoutte

Santa Barbara Botanic Garden

Crystalline iceplant (*Mesembryanthemum crystallinum*) is an invasive weed from South Africa that was recorded as abundant on San Nicolas Island as early as 1898. It is known to accumulate salts on the soil surface and forms high ground cover throughout the island, but the resulting impacts to plant and arthropod communities have not been quantified. In April 2016, we gathered baseline plant and arthropod biodiversity data prior to initiating experimental restoration treatments. We performed pitfall trapping and visual plant cover surveys in a series of 42 2x2 meter plots in each of three locations on the island. We found that results differed among the three sites, with significant negative effects of *Mesembryanthemum* on both plant and arthropod richness at two sites (plants 65% and 23% lower, p=0.005 and 0.042 respectively; arthropods 38% and 35% lower, p=0.002 and 0.010 respectively), and the third site displaying no difference in plant richness but somewhat greater arthropod richness in *Mesembryanthemum* plots (19% greater, p = 0.06). Furthermore, we found a strong negative correlation between *Mesembryanthemum* cover and both plant and arthropod richness at the first two sites (Pearson's r = -0.61 and -0.49 for plants, -0.76 and 0.70 for arthropods). The site with fewer differences is dune sand, which supports sparser vegetation and may leach salts more readily. In future work, we will investigate soil texture and salinity as well as differences in arthropod composition, particularly those taxa known as preferred food sources for island foxes. Then in fall 2016, we will apply two *Mesembryanthemum* reduction treatments (grow-kill, which should leach any salts, and herbicide, which is more cost-effective) and hydroseed native plants in a portion of those plots.

Appendix Table 1. Island visit dates, staff, and purpose.

Date(s)	Staff	Purpose
November 23-25, 2015	Knapp, Garoutte	Plot setup
April 11-13, 2016	Knapp, Garoutte	Vegetation monitoring, arthropod sampling
April 19-21, 2016	Knapp	Finish vegetation monitoring, arthropod sampling
May 23, 2016	Garoutte	Seed collection
June 7-10, 2016	Garoutte	Arthropod re-sampling (in case needed), seed collection
July 11-12	Knapp	Seed collection
October 12-14, 2016	Knapp, Leonatti	Grow-kill weed treatments
November 9-10, 2016	Knapp, Leonatti	Grow-kill weed treatments
December 5-6, 2016	Knapp, Leonatti	Grow-kill treatments
January 18-19, 2017	Knapp, Leonatti	Grow-kill treatments
February 2, 2017	Leonatti, Thompson (CIR)	Herbicide treatments
February 14-16, 2017	Knapp, Leonatti, Carrillo	Hydroseeding
April 24-25, 2017	Knapp, Leonatti	Vegetation monitoring
May 22-23, 2017	Knapp, Leonatti	Soil sampling for follow-up electroconductivity, soil moisture measurements
April 16-18, 2018	Knapp	Vegetation monitoring

Appendix Table 2. Inventory of all equipment and supplies ≤ $5,000 purchased under this agreement

Item	Cost	Company	Date	Whereabouts
Turbo Turf HS-50-M portable hydroseeder with extra 50 ft hose	$2,480.66	Turbo Technologies Inc.	August 2016	Currently on SNI.
Field Scout TDR 300 Soil Moisture Meter	Navy contract paid $500 of $1,232	Spectrum Technologies, Inc.	May 2017	At SBBG.
Aluminum tags and flags for plot delineation	Navy contract paid $300 of $350.83	Ben Meadows	February 2016	These have been used.
Aquatank for water storage/delivery	$141.96	Amazon.com	September 2016	At SBBG.
1x 50 lb bag of M-Binder, 3x50 lb bags of Nature's Own paper fiber mulch	$81	S&S Seed	November 2016	Remainder is on SNI.
Colored duct tape for plot delineation and watering cans for grow-kill	$65.64	Home Depot	October 2016	Watering cans are at SBBG, duct tape has been used.
Herbicide, surfactant, and blue dye for MECR treatment	$11.20	via Channel Islands Restoration	February 2017	These have been used.

Appendix Table 3. Results of the Soil Seed Bank Study, San Nicolas Island, Site BB (Buckwheat Badlands)

Plant Species	Plots (and abundance)
Atriplex prostrata	BB15 (1)
Atriplex semibaccata	BB8 (5)
Bromus madritensis	BB32 (1)
Crassula connata	BB2 (11), BB4 (21), BB5 (14), BB6 (1), BB7 (1), BB10 (2), BB11 (7), BB12 (47), BB13 (1), BB14 (3), BB17 (4), BB18 (7), BB19 (1), BB25 (1), BB27 (27), BB28 (56), BB30 (2), BB33 (2), BB34 (13), BB36 (3)
Daucus pusillus	BB12 (1)
Erodium cicutarium	BB28 (1)
Festuca octoflora	BB5 (1), BB27 (1), BB28 (14)
Malacothrix foliosa	BB22 (3), BB30 (1), BB31 (1), BB32 (1), BB34 (1)
Mesembryanthemum crystallinum	BB1 (10), BB2 (9), BB5 (3), BB6 (10), BB7 (1), BB8 (5), BB9 (11), BB11 (9), BB12 (6), BB13 (4), BB14 (1), BB16 (28), BB17 (1), BB18 (5), BB19 (1), BB20 (1), BB21 (2), BB22 (90), BB24 (2), BB25 (10), BB26 (16), BB27 (2), BB28 (16), BB29 (5), BB29 (12), BB30 (24), BB31 (50), BB32 (20), BB33 (4), BB34 (34), BB35 (4), BB36 (3)
Mesembryanthemum nodiflorum	BB4 (3), BB6 (1), BB9 (1), BB20 (1), BB23 (1), BB28 (2)
Salix lasiolepis	BB35 (1)
Salsola tragus	BB13 (13)
Spergularia macrotheca	BB4 (4), BB6 (2), BB7 (1), BB30 (1), BB32 (1)
Suaeda taxifolia	BB22 (13), BB24 (3), BB25 (1), BB26 (18)

Appendix Table 4. Results of the Soil Seed Bank Study, San Nicolas Island, Site CP (Caliche Plateau)

Plant Species	**Plots (and abundance)**
Achillea millefolium	CP10 (1), CP11 (2)
Acmispon argophyllus	CP2 (1), CP34 (1)
Acmispon sp.	CP13 (1)
Amblyopappus pusillus	CP5 (1), CP9 (4), CP10 (1), CP15 (3), CP29 (19)
Ambrosia chamissonis	CP20 (1)
Astragalus traskiae	CP5 (1), CP11 (1), CP14 (1), CP16 (1), CP20 (1), CP21 (2), CP23 (1), CP24 (1), CP30 (1), CP31 (5), CP33 (2), CP34 (2)
Bromus madritensis	CP13 (3), CP21 (1), CP34 (1)
Crassula connata	CP1 (4), CP3 (26), CP4 (25), CP7 (202), CP8 (1), CP9 (1), CP10 (300), CP12 (27), CP15 (5), CP16 (2), CP19 (59), CP20 (48), CP21 (17), CP22 (2), CP23 (5), CP24 (2), CP25 (71), CP26 (144), CP27 (12), CP28 (3), CP30 (3), CP31 (4), CP33 (1), CP34 (36), CP35 (2)
Daucus pusillus	CP11 (1)
Erodium cicutarium	CP23 (2)
Isocoma menziesii	CP2 (1), CP17 (1), CP22 (34), CP26 (2)
Lepidium lasiocarpum	CP1 (1), CP2 (5), CP32 (1)
Malacothrix foliosa	CP6 (2), CP20 (1), CP23 (1), CP24 (2), CP27 (3), CP28 (3), CP34 (1)
Melilotus indicus	CP20 (2)
Mesembryanthemum crystallinum	CP1 (54), CP2 (36), CP3 (19), CP4 (7), CP5 (36), CP6 (43), CP7 (6), CP8 (108), CP9 (38), CP10 (3), CP12 (35), CP13 (125), CP14 (110), CP15 (20), CP16 (7), CP18 (32), CP19 (65), CP20 (16), CP21 (44), CP23 (156), CP24 (85), CP25 (22), CP26 (28), CP27 (25), CP28 (59), CP29 (34), CP30 (5), CP31 (122), CP32 (43), CP33 (12), CP34 (32), CP35 (3), CP36 (17)
Mesembryanthemum nodiflorum	CP5 (32), CP6 (1), CP9 (1), CP12 (1), CP15 (24), CP16 (1), CP17 (32), CP19 (2), CP20 (1), CP22 (2), CP31 (1)
Oxalis corniculata	CP30 (1)
Parapholis incurve	CP17 (1)
Plantago ovata	CP3 (1), CP7 (5)
Pseudognaphalium stramineum	CP5 (1), CP17 (2), CP24 (1)
Sisymbrium irio	CP22 (22)

Appendix Table 5. Results of the Soil Seed Bank Study, San Nicolas Island, Site SD (Stilted Dunes)

Plant Species	Plots (and abundance)
Abronia umbellata	SD2 (2), SD8 (1), SD14 (3), SD19 (13), SD25 (1), SD29 (3), SD34 (1)
Acmispon argophyllus	SD4 (2), SD5 (2), SD19 (1) SD20 (2)
Amblyopappus pusillus	SD3 (1), SD4 (3), SD6 (2), SD11 (4), SD16 (2), SD18 (10), SD20 (7), SD22 (1), SD25 (1), SD26 (1), SD28 (5), SD34 (1), SD35 (1)
Ambrosia chamissonis	SD9 (1), SD22 (1), SD23 (1)
Astragalus traskiae	SD6 (3), SD8 (2)
Bromus diandrus	SD31 (1)
Bromus madritensis	SD3 (1), SD5 (1), SD11 (1), SD13 (12), SD25 (1), SD26 (1), SD34 (7)
Crassula connata	SD1 (24), SD3 (2), SD4 (1), SD6 (4), SD12 (1), SD13 (79), SD15 (4), SD18 (1), SD19 (1), SD22 (4), SD27 (16), SD28 (9), SD29 (7), SD30 (4), SD31 (42), SD32 (15), SD33 (12)
Erodium cicutarium	SD1 (1), SD4 (9), SD5 (1), SD6 (1), SD7 (3), SD13 (1), SD14 (1), SD16 (2), SD17 (1), SD18 (3), SD19 (2), SD21 (1), SD22 (5), SD25 (2), SD26 (2), SD28 (2), SD29 (6), SD30 (1)
Lupinus albifrons	SD19 (1)
Malacothrix foliosa	SD4 (5), SD6 (1), SD8 (1), SD9 (1), SD10 (2), SD12 (1), SD14 (15), SD17 (1), SD18 (1), SD20 (1), SD24 (1), SD28 (7), SD34 (1)
Melilotus indicus	SD32 (2)
Mesembryanthemum crystallinum	SD1 (114), SD2 (87), SD3 (29), SD4 (34), SD5 (4), SD6 (76), SD7 (13), SD8 (7), SD10 (25), SD11 (32), SD12 (1), SD13 (8), SD16 (2), SD17 (59), SD18 (37), SD19 (9), SD20 (27), SD21 (70), SD22 (70), SD23 (59), SD24 (2), SD25 (6), SD26 (48), SD27 (3), SD28 (74), SD29 (1), SD30 (158), SD31 (10), SD32 (8), SD33 (61), SD34 (39), SD35 (148), SD36 (20)
Pseudognaphalium biolettii	SD21 (1)
Sonchus oleraceus	SD2 (1)
Unknown grass	SD14 (1)

Appendix Table 6. Arthropods of the *Mesembryanthemum* Impacts Study, 2016, San Nicolas Island

Sp	Fam	Order	Taxon	Function	Morph	Morph detail	Determined by
1	1	Coleoptera	Byrrhidae	Herbivore	m1		Matt Gimmel, SBMNH
2	2	Coleoptera	Carabidae	Predator	m1	Amara (poss. A. insularis)	"Aaron Hunt", "Curt Harden" BugGuide.net
3	3	Coleoptera	Coccinellidae	Predator	m1	Nephus sordidus	"Blaine Mathison", "James Bailey" BugGuide.net
4		Coleoptera	Coccinellidae	Predator	m2	Prob. Coccinella septempunctata	"Alice Abela", BugGuide.net
5	4	Coleoptera	Curculionidae	Herbivore	m1	Trigonoscuta sp.	Matt Gimmel, SBMNH
6		Coleoptera	Curculionidae	Herbivore	m2		Matt Gimmel, SBMNH; Rolf Aalbu, CA Acad. Sci.
7	5	Coleoptera	Latridiidae	Fungivore	m1	Poss. Melanophthalma casta	"v belov", BugGuide.net; F. Light
8		Coleoptera	Latridiidae	Fungivore	m2	Metophthalmus (poss. Parvicollis Le Conte)	"Wolfgang Rucker" (via "v belov", BugGuide.net)
9	6	Coleoptera	Melyridae	Omnivore	m1	Trichochrous sp.	Matt Gimmel, SBMNH
10	7	Coleoptera	Mordellidae	Herbivore	m1		Matt Gimmel, SBMNH
11	8	Coleoptera	Staphylinidae	Predator	m1	Aleocharinae	Matt Gimmel, SBMNH
12		Coleoptera	Staphylinidae	Predator	m2	Poss. Oxypoda sp.	Matt Gimmel, SBMNH
13		Coleoptera	Staphylinidae	Predator	mL1	Larva	Matt Gimmel, SBMNH
14	9	Coleoptera	Tenebrionidae	Scavenger/detritivore	m1	Apsena grossa	Rolf Aalbu, CA Acad. Sci.; Fritz Light (Gen./sp.)
15		Coleoptera	Tenebrionidae	Scavenger/detritivore	m2	Coelus sp.	Rolf Aalbu, CA Acad. Sci.
15		Coleoptera	Tenebrionidae	Scavenger/detritivore	m2	Coelus pacificus	Rolf Aalbu, CA Acad. Sci.; Fritz Light (Gen./sp.)
16		Coleoptera	Tenebrionidae	Scavenger/detritivore	m3	Eleodes sp.	Rolf Aalbu, CA Acad. Sci.
16		Coleoptera	Tenebrionidae	Scavenger/detritivore	m3	Eleodes acuticaudus	Rolf Aalbu, CA Acad. Sci.; Fritz Light (Gen./sp.)
17		Coleoptera	Tenebrionidae	Scavenger/detritivore	m4	Eusattus robustus	Rolf Aalbu, CA Acad. Sci.; Fritz Light (Gen./sp.)
18		Coleoptera	Tenebrionidae	Scavenger/detritivore	m5	Alaudes singularis Horn	Rolf Aalbu, CA Acad. Sci.
19		Coleoptera	Unknown		mUL1	Larva	Matt Gimmel, SBMNH; Rolf Aalbu, CA Acad. Sci.
20	10	Coleoptera	Zopheridae	Scavenger/detritivore	m1	Rhagodera sp.	"v belov", BugGuide.net, "Nathan Lord", BugGuide.net

Sp	Fam	Order	Taxon	Function	Morph	Morph detail	Determined by
21	11	Diptera	Anthomyiidae	Nectar/Pollen	m1		"John F. Carr", BugGuide.net
22	12	Diptera	Bombyliidae	Nectar/Pollen	m1	Conophorus sp.	"Bob Biagi", BugGuide.net
23	13	Diptera	Bombyliidae	Nectar/Pollen	m2	Lepidanthrax sp.	Andy Calderwood, Ventura Co. AgComm (Former SBMNH)
24	14	Diptera	Calliphoridae	Nectar/Pollen	m1		Fritz Light
25	15	Diptera	Cecidomyiidae	Scavenger/detritivore	m1		Fritz Light
26	16	Diptera	Chloropidae	Scavenger/detritivore	m1	Oscenellinae	"John F. Carr", BugGuide.net
27		Diptera	Chloropidae	Scavenger/detritivore	m2	Oscenellinae	"John F. Carr", BugGuide.net
28		Diptera	Chloropidae	Scavenger/detritivore	m3		Fritz Light
29		Diptera	Chloropidae	Scavenger/detritivore	m4		Fritz Light
30	17	Diptera	Dolichopodidae	Predator	m1		"John F. Carr", BugGuide.net
31		Diptera	Dolichopodidae	Predator	m2		"John F. Carr", BugGuide.net
32	18	Diptera	Ephydridae	Scavenger/detritivore	m1		"John F. Carr", BugGuide.net
33	19	Diptera	Heleomyzidae	Scavenger/detritivore	m1	Poss. Trixoscelis sp.?	"John F. Carr", BugGuide.net
34		Diptera	Heleomyzidae	Scavenger/detritivore	m2	Heleomyzini	"John F. Carr", BugGuide.net, "Robert Lord Zimlich", BugGuide.net
34		Diptera	Heleomyzidae	Scavenger/detritivore	m2		"John F. Carr", BugGuide.net
35		Diptera	Heleomyzidae	Scavenger/detritivore	m3		"John F. Carr", BugGuide.net
36		Diptera	Heleomyzidae	Scavenger/detritivore	m4		"John F. Carr", BugGuide.net
37		Diptera	Heleomyzidae	Scavenger/detritivore	m5	Poss. Trixoscelis sp?	"John F. Carr", BugGuide.net
38		Diptera	Heleomyzidae	Scavenger/detritivore	m6		"John F. Carr", BugGuide.net
39		Diptera	Heleomyzidae	Scavenger/detritivore	m7		"John F. Carr", BugGuide.net
40		Diptera	Heleomyzidae	Scavenger/detritivore	m8		"John F. Carr", BugGuide.net
41	20	Diptera	Phoridae	Scavenger/detritivore	m1		Fritz Light
42	21	Diptera	Sarcophagidae	Omnivore	m1		"John F. Carr", BugGuide.net
43		Diptera	Sarcophagidae	Omnivore	m2		"John F. Carr", BugGuide.net
44		Diptera	Sarcophagidae	Omnivore	m3		"John F. Carr", BugGuide.net
45		Diptera	Sarcophagidae	Omnivore	m4		"John F. Carr", BugGuide.net
46		Diptera	Sarcophagidae	Omnivore	m5		"John F. Carr", BugGuide.net
47		Diptera	Sarcophagidae	Omnivore	m6		"John F. Carr", BugGuide.net
48		Diptera	Sarcophagidae	Omnivore	m7		"John F. Carr", BugGuide.net

Sp	Fam	Order	Taxon	Function	Morph	Morph detail	Determined by
49		Diptera	Sarcophagidae	Omnivore	m8		"John F. Carr", BugGuide.net
50		Diptera	Sarcophagidae	Omnivore	m9		"John F. Carr", BugGuide.net
51		Diptera	Sarcophagidae	Omnivore	m10		Fritz Light
52		Diptera	Sarcophagidae	Omnivore	m11		Fritz Light
53		Diptera	Sarcophagidae	Omnivore	m12		Fritz Light
54		Diptera	Sarcophagidae	Omnivore	m13		Fritz Light
55		Diptera	Sarcophagidae	Omnivore	m14		Fritz Light
56		Diptera	Sarcophagidae	Omnivore	mL1		Martin Hauser, CDFA
57	22	Diptera	Sciaridae	Scavenger/detritivore	m1		Fritz Light
58		Diptera	Sciaridae	Scavenger/detritivore	m2		"John F. Carr", BugGuide.net
59	23	Diptera	Syrphidae	Nectar/Pollen	m1		Fritz Light
60		Diptera	Syrphidae	Nectar/Pollen	m2		Fritz Light
61		Diptera	Syrphidae	Nectar/Pollen	mL1	Larva: poss. Eupeodes vulceris	Fritz light
62	24	Diptera	Tachinidae	Nectar/Pollen	m1	Exoristinae	"John F. Carr", BugGuide.net
63		Diptera	Tachinidae	Nectar/Pollen	m2	Paradidyma sp.	"John F. Carr", BugGuide.net
64		Diptera	Tachinidae	Nectar/Pollen	m3	Nemorilla pyste	"John F. Carr", BugGuide.net
65	25	Diptera	Trixoscelididae	Herbivore	m1		Fritz Light
66	26	Entomobryomorpha	Entomobryidae	Scavenger/detritivore	m1	Poss. Entomobrya confusa or E. multifasciata	Fritz Light
67		Entomobryomorpha	Entomobryidae	Scavenger/detritivore	m2	Prob. Entomobrya atrocincta	Fritz Light
68	27	Hemiptera	Aleyrodidae	Herbivore	m1		Fritz Light
69	28	Hemiptera	Aphididae	Herbivore	m1	Pretty confident it's Aphis middletonii	"Ken Wogelmuth", BugGuide.net: Aphididae; Fritz Light: Genus/sp.
70		Hemiptera	Aphididae	Herbivore	m2		Fritz Light
71		Hemiptera	Aphididae	Herbivore	m3		"Kelsey J.R.P. Byers" (BugGuide.net): Aphididae.
72		Hemiptera	Aphididae	Herbivore	m4		Fritz Light
73		Hemiptera	Aphididae	Herbivore	m5		Fritz Light
74		Hemiptera	Aphididae	Herbivore	m6		Fritz Light
75		Hemiptera	Aphididae	Herbivore	m7		Fritz Light
76		Hemiptera	Aphididae	Herbivore	m8		"Kelsey J.R.P. Byers" (BugGuide.net): Aphididae.

Sp	Fam	Order	Taxon	Function	Morph	Morph detail	Determined by
77	29	Hemiptera	Cicadellidae	Herbivore	m01		Fritz Light
78		Hemiptera	Cicadellidae	Herbivore	m02		Fritz Light
79		Hemiptera	Cicadellidae	Herbivore	m03		Fritz Light
80		Hemiptera	Cicadellidae	Herbivore	m04		Fritz Light
81		Hemiptera	Cicadellidae	Herbivore	m05		Fritz Light
82		Hemiptera	Cicadellidae	Herbivore	m06		Fritz Light
83		Hemiptera	Cicadellidae	Herbivore	m07		Fritz Light
84		Hemiptera	Cicadellidae	Herbivore	m08		Fritz Light
85		Hemiptera	Cicadellidae	Herbivore	m09		Fritz Light
86		Hemiptera	Cicadellidae	Herbivore	m10		Fritz Light
87		Hemiptera	Cicadellidae	Herbivore	m11		Fritz Light
88		Hemiptera	Cicadellidae	Herbivore	m12		Fritz Light
89		Hemiptera	Cicadellidae	Herbivore	m13		Fritz Light
90	30	Hemiptera	Eriococcidae	Herbivore	m1	immature ♀	Natalie von Ellenrieder, CDFA
90		Hemiptera	Eriococcidae	Herbivore	m1	Immature ♀	Aaron Hunt (BugGuide.net), Fritz Light, Natalie von Ellenrieder, CDFA
91		Hemiptera	Eriococcidae	Herbivore	m2	Adult ♂	Aaron Hunt (BugGuide.net), Natalie von Ellenrieder, CDFA
92	31	Hemiptera	Geocoridae	Predator	m1		Fritz Light
93	32	Hemiptera	Lygaeidae	Herbivore	m1	Orsillinae, prob. Nysius sp.	"v belov", BugGuide.net; F. Light (sub-fam, genus)
94	33	Hemiptera	Margarodidae	Herbivore	m1		Aaron Hunt (BugGuide.net), Natalie von Ellenrieder, CDFA
95	34	Hemiptera	Miridae	Herbivore	m1		Fritz Light
96	35	Hemiptera	Pseudococcidae	Herbivore	m1	♀	Fritz Light, Natalie von Ellenrieder, CDFA
96		Hemiptera	Pseudococcidae	Herbivore	m1	Adult ♀	Fritz Light, Natalie von Ellenrieder, CDFA
97		Hemiptera	Pseudococcidae	Herbivore	m2	Adult ♂	Fritz Light, Natalie von Ellenrieder, CDFA
97		Hemiptera	Pseudococcidae	Herbivore	m2	Immature ♀	Fritz Light, Natalie von Ellenrieder, CDFA
98		Hemiptera	Pseudococcidae	Herbivore	m3	Adult	Aaron Hunt (BugGuide.net), Natalie von Ellenrieder, CDFA

Sp	Fam	Order	Taxon	Function	Morph	Morph detail	Determined by
99		Hemiptera	Pseudococcidae	Herbivore	m4	Adult ♀	Aaron Hunt (BugGuide.net), Natalie von Ellenrieder, CDFA
100	36	Hemiptera	Psyllidae	Herbivore	m1		Fritz Light
101	37	Hemiptera	Tropiduchidae	Herbivore	m1		Fritz Light
102	38	Hymenoptera	Aphelinidae	Parasitoid	m1		"Ross Hill", BugGuide.net
103	39	Hymenoptera	Apoidea	Nectar/Pollen	mUA1		Fritz Light
104	40	Hymenoptera	Bethylidae	Parasitoid	m1		Fritz Light
105		Hymenoptera	Bethylidae	Parasitoid	m2		"Ross Hill", BugGuide.net
106	41	Hymenoptera	Braconidae	Parasitoid	m1	Doryctinae	Katja Seltmann, CCBER
107		Hymenoptera	Braconidae	Parasitoid	m2		Katja Seltmann, CCBER
108		Hymenoptera	Braconidae	Parasitoid	m3	Aphidiinae, Aphidius sp.	Katja Seltmann, CCBER, "Ross Hill", BugGuide.net
109		Hymenoptera	Braconidae	Parasitoid	m4		Katja Seltmann, CCBER
110	42	Hymenoptera	Ceraphronidae	Parasitoid	m1		Fritz Light
111	43	Hymenoptera	Chalcididae	Parasitoid	m1		Fritz Light
112	44	Hymenoptera	Crabronidae	Predator	m1	Miscophus sp.	"John S. Ascher", BugGuide.net
113		Hymenoptera	Crabronidae	Predator	m2		Fritz Light
114	45	Hymenoptera	Encyrtidae	Parasitoid	m1	Aenasius	Fritz Light; Robert Zuparko (UCB Essig)
115		Hymenoptera	Encyrtidae	Parasitoid	m2	Metaphycus	Fritz Light; Robert Zuparko (UCB Essig)
116		Hymenoptera	Encyrtidae	Parasitoid	m3	Metaphycus	Fritz Light; Robert Zuparko (UCB Essig)
117		Hymenoptera	Encyrtidae	Parasitoid	m4	Acerophagus	Fritz Light; Robert Zuparko (UCB Essig)
118		Hymenoptera	Encyrtidae	Parasitoid	m5	Metanotalia maderensis	Fritz Light; Robert Zuparko (UCB Essig)
119		Hymenoptera	Encyrtidae	Parasitoid	m6	Holcencyrtus	Fritz Light; Robert Zuparko (UCB Essig)
120		Hymenoptera	Encyrtidae	Parasitoid	m7	**New genus and species**	Fritz Light; Robert Zuparko (UCB Essig); "John S. Ascher", BugGuide.net
121		Hymenoptera	Encyrtidae	Parasitoid	m8	Stemmatosteres apterus	"Chalcidbear", BugGuide.net; F.Light; Robert Zuparko (UCB Essig)
122	46	Hymenoptera	Eulophidae	Parasitoid	m1	Eulophidae ♀	"Ken Wogelmuth" (BugGuide.net)
123		Hymenoptera	Eulophidae	Parasitoid	m2	Eulophidae ♀	"Ken Wogelmuth" (BugGuide.net)

Sp	Fam	Order	Taxon	Function	Morph	Morph detail	Determined by
124	47	Hymenoptera	Eupelmidae	Parasitoid	m1		"Ross Hill", BugGuide.net
125	48	Hymenoptera	Formicidae	Scavenger/detritivore	m1	Dorymyrmex insanus	Fritz Light, David Holway (UCSD)
126		Hymenoptera	Formicidae	Omnivore	m2	Linepithema humile (Argentine ant)	"Ken Wogelmuth" (BugGuide.net); Fritz Light; David Holway (UCSD)
127		Hymenoptera	Formicidae	Scavenger/detritivore	m3	Tapinoma sessile, alate ♂	"Ken Wogelmuth" (BugGuide.net); Fritz Light; David Holway (UCSD)
128		Hymenoptera	Formicidae	Omnivore	m4	Aphaenogaster patruelis	"James C. Trager" (BugGuide.net); David Holway (UCSD)
129		Hymenoptera	Formicidae	Omnivore	m5	Monomorium ergatogyna	Fritz Light; David Holway (UCSD)
130	49	Hymenoptera	Halictidae	Nectar/Pollen	m1		Fritz Light
131	50	Hymenoptera	Mymaridae	Parasitoid	m1	Prob. Camptoptera sp.	Fritz Light
132		Hymenoptera	Mymaridae	Parasitoid	m2		"Ross Hill", BugGuide.net
133		Hymenoptera	Mymaridae	Parasitoid	m3		Fritz Light
134	51	Hymenoptera	Platygastridae	Parasitoid	m1	Baeus sp.	"Ross Hill", BugGuide.net
135	52	Hymenoptera	Pompilidae	Predator	m1		Fritz Light
136	53	Hymenoptera	Pteromalidae	Parasitoid	m1		Fritz Light
137	54	Hymenoptera	Signiphoridae	Parasitoid	m1		"Ross Hill", BugGuide.net
138		Hymenoptera	Signiphoridae	Parasitoid	m2		Fritz Light
139		Hymenoptera	Signiphoridae	Parasitoid	m3		"Ross Hill", BugGuide.net; "John S. Ascher", BugGuide.net
140	55	Hymenoptera	Sphecidae	Predator	m1	Prob. Podalonia mexicana	Fritz Light
141		Hymenoptera	Sphecidae	Predator	m2		Fritz Light
142		Hymenoptera	Sphecidae	Predator	m3		Fritz Light
143		Hymenoptera	Sphecidae	Predator	m4		Fritz Light
144	56	Hymenoptera	Tiphiidae	Parasitoid	m1	Prob. Brachycistidinae, *Brachycistus sp.* poss. *B. agama*.	Fritz Light
145		Hymenoptera	Tiphiidae	Parasitoid	m2		Fritz Light
146	57	Hymenoptera	Trichogrammatidae	Parasitoid	m1	Aphelinoidea (poss. plutella sp. group)	"Dr. Pinto" (via "Kyhl Austin", BugGuide.net)
147	58	Hymenoptera	Vespidae	Predator	m1	Eumeninae (looks like ♀ in Stenodynerus anormis-gp)	"Bob Biagi" (BugGuide.net)
148		Hymenoptera	Vespidae	Predator	m2	Eumeninae (looks like ♀ in Stenodynerus anormis-gp)	"Bob Biagi" (BugGuide.net)

Sp	Fam	Order	Taxon	Function	Morph	Morph detail	Determined by
149		Hymenoptera	Vespidae	Predator	m3	Eumeninae (looks like ♀ in Stenodynerus anormis-gp)	"John S. Ascher", BugGuide.net; Fritz Light
150	59	Isopoda	Cylisticidae	Scavenger/detritivore	m1	Cylisticus convexus	"Hisserdude", BugGuide.net
151		Isopoda	Cylisticidae	Scavenger/detritivore	m2		Fritz Light
152	60	Isopoda	Platyarthridae	Scavenger/detritivore	m1	Niambia capensis	"Hisserdude", BugGuide.net
153	61	Lepidoptera	Gelechiidae	Nectar/Pollen	m1		Fritz Light
154		Lepidoptera	Gelechiidae	Nectar/Pollen	m2		Fritz Light
155		Lepidoptera	Gelechiidae	Nectar/Pollen	m3		Fritz Light
156	62	Lepidoptera	Geometridae	Nectar/Pollen	m1		Fritz Light
157	63	Lepidoptera	Gracillaridae	Nectar/Pollen	m1		Fritz Light
158		Lepidoptera	Gracillariidae	Nectar/Pollen	m2		Fritz Light
159		Lepidoptera	Gracillariidae	Nectar/Pollen	m2		Fritz Light
160		Lepidoptera	Lepidoptera	Nectar/Pollen*	mUL1		Fritz Light
161		Lepidoptera	Lepidoptera	Nectar/Pollen*	mUL2		Fritz Light
162		Lepidoptera	Lepidoptera	Nectar/Pollen*	mUL3		"John S. Ascher" (BugGuide.net)
163		Lepidoptera	Lepidoptera	Nectar/Pollen*	mUL4		"John S. Ascher" (BugGuide.net)
164		Lepidoptera	Lepidoptera	Nectar/Pollen*	mUL5		Fritz Light
165		Lepidoptera	Lepidoptera	Nectar/Pollen*	mUL6		"Kyhl Austin" (BugGuide)
166	64	Lepidoptera	Tortricidae	Nectar/Pollen*	m1		Fritz Light
167		Lepidoptera	Tortricidae	Nectar/Pollen*	m2		Fritz Light
168	65	Microcoryphia	Machilidae	Scavenger/detritivore	m1	Poss. Neomachilis sp.	Fritz Light
169	66	Microcoryphia	Meinertellidae	Scavenger/detritivore	m1		Fritz Light
170		Microcoryphia	Meinertellidae	Scavenger/detritivore	m2		Fritz Light
171		Microcoryphia	Meinertellidae	Scavenger/detritivore	m3		Fritz Light
172	67	Neuroptera	Coniopterygidae	Predator	m1		Fritz Light
173	68	Neuroptera	Hemerobiidae	Predator	m1		Fritz Light
174	69	Orthoptera	Acrididae	Herbivore	m1	Oedipodinae: Conozoa nicola	"Alice Abela" (BugGuide.net)
175		Orthoptera	Acrididae	Herbivore	m2	Oedipodinae	"metrioptera" (BugGuide.net)
176	70	Orthoptera	Gryllacrididae	Omnivore	m1	Likely Cnemotettix sp.	Fritz Light
177	71	Psocodea	Ectopsocidae	Scavenger/detritivore	m1	Ectopsocus vachoni, ♂	Dr. Ed Mockford (Illinois State U.) via "Diane Young" (BugGuide.net)

Sp	Fam	Order	Taxon	Function	Morph	Morph detail	Determined by
177		Psocodea	Ectopsocidae	Scavenger/detritivore	m1	Looks like Ectopsocus vachoni, macropterous ♀	"Diane Young" (BugGuide.net):
178	72	Psocodea	Lachisillidae	Scavenger/detritivore	m1	Lachisilla pacifica	"Diane Young" (BugGuide.net)
179	73	Psocodea	Liposcelididae	Scavenger/detritivore	m1		Fritz Light
180	74	Psocodea	Psocidae	Herbivore	m1	Amphigerontia sp.	Dr. Ed Mockford (Illinois State U.) via "Diane Young" (BugGuide.net)
181		Psocodea	Psocodea		mUN1		"v. belov" (BugGuide.net); Fritz Light
182	75	Psocodea	Trogiidae	Detritivore	m1	Looks like Cerobasis sp., poss. C. guestfalica	Fritz Light
183		Psocodea	Trogiidae	Detritivore	m2	Looks like Lepinotus sp., poss. L. reticulatus	Fritz Light
184	76	Thysanoptera	Phlaeothripidae	Scavenger/detritivore	m1	Prob. Klambothrips (likely K. myopori)	Fritz Light
185		Thysanoptera	Phlaeothripidae	Scavenger/detritivore	m2	Poss. Compsothrips, Elaphothrips, or Megathrips sp.	Fritz Light
186		Thysanoptera	Phlaeothripidae	Scavenger/detritivore	m3		Fritz Light
187		Thysanoptera	Phlaeothripidae	Scavenger/detritivore	m4	Probably Compsothrips jacksoni	Fritz Light
188	77	Thysanoptera	Thripidae	Herbivore	m1	Prob. Frankliniella occidentalis, brown morph	Fritz Light
189		Thysanoptera	Thripidae	Herbivore	m2	Prob. Limothrips (looks like L. angulicornis)	Fritz Light
190		Thysanoptera	Thripidae	Herbivore	m3	Apterorthrips apteris	Fritz Light
191		Thysanoptera	Thripidae	Herbivore	m4	Limnothrips cerealium	Fritz Light
192	78	Zygentoma	Lepismatidae	Scavenger/detritivore	m1	Poss. Thermobia sp.	Fritz Light

*Although larval Lepidoptera are herbivores, adults may be ovipositing, and keeping adults and larvae together as nectar feeders is more revealing for the analyses here.

Appendix Table 7. Soil Data, San Nicolas Island *Mesembryanthemum* impacts study.

Plot	Type	Treatment	Treatment Description	EC (µs/cm) 4/20/16	EC (µs/cm) 5/22/17	pH 4/20/16	pH 5/22/17	%Moisture 5/22/17
BB01	MECR	H-0	Herbicide No Seed	371	133	8.93	9.13	1.3
BB02	MECR	GK-H	GrowKill Hydroseed	373	131.6	8.8	9.31	0.9
BB03	MECR	0-0	No Action Control	409	238	8.62	9.33	1.4
BB04	MECR	GK-H	GrowKill Hydroseed	238	136.6	9.09	9.16	1.5
BB05	MECR	H-0	Herbicide No Seed	302	131.7	8.72	9.26	1.8
BB06	MECR	0-H	No Weeding Hydroseed	299	220	8.92	8.94	3.3
BB07	MECR	H-H	Herbicide Hydroseed	373	141.5	9.03	9.05	1.1
BB08	MECR	H-H	Herbicide Hydroseed	361	161.9	9.26	8.85	2.0
BB09	MECR	H-0	Herbicide No Seed	329	169.1	9.17	9.38	1.6
BB10	MECR	0-H	No Weeding Hydroseed	282	243	9.39	9.37	2.0
BB11	MECR	GK-H	GrowKill Hydroseed	170.7	97.5	9.51	8.96	2.3
BB12	MECR	GK-0	GrowKill No Seed	162.2	145.9	9.34	8.63	2.2
BB13	MECR	0-H	No Weeding Hydroseed	282	190.2	9.22	9.45	1.6
BB14	MECR	0-H	No Weeding Hydroseed	170.9	208	9.58	9.54	2.9
BB15	MECR	0-0	No Action Control	241	140	9.33	9.12	2.2
BB16	MECR	GK-0	GrowKill NoSeed	127.3	145.2	9.12	9.55	9.0
BB17	MECR	H-H	Herbicide Hydroseed	424	189.1	8.84	9.74	1.6
BB18	MECR	0-H	No Weeding Hydroseed	217	184.3	9.15	9.53	1.4
BB19	MECR	0-0	No Action Control	219	186.9	9.28	9.45	2.7
BB20	MECR	GK-0	GrowKill No Seed	499	114.8	9.13	9.45	2.2
BB21	MECR	GK-H	GrowKill Hydroseed	253	76.2	9.3	9.45	1.4
BB22	MECR	GK-0	GrowKill No Seed	649	157	8.22	9.18	1.3
BB23	MECR	0-0	No Action Control	362	158.4	8.74	9.24	2.0
BB24	MECR	H-0	Herbicide No Seed	302	128.4	9.06	9.39	2.7
BB25	MECR	0-0	No Action Control	861	361	8.32	9.28	3.1
BB26	MECR	H-0	Herbicide No Seed	730	210	8.92	9.02	2.5
BB27	MECR	GK-H	GrowKill Hydroseed	924	127.6	8.07	9.16	3.7
BB28	MECR	GK-H	GrowKill Hydroseed	*	*	*	*	1.9

Plot	Type	Treatment	Treatment Description	EC (µs/cm) 4/20/16	EC (µs/cm) 5/22/17	pH 4/20/16	pH 5/22/17	%Moisture 5/22/17
BB29	MECR	H-H	Herbicide Hydroseed	*	*	*	*	0.5
BB30	MECR	H-H	Herbicide Hydroseed	274	128.2	9.43	9.3	0.0
BB31	MECR	0-0	No Action Control	543	322	9.05	9.47	2.1
BB32	MECR	H-0	Herbicide No Seed	351	143.6	7.69	8.72	0.7
BB33	MECR	GK-0	GrowKill No Seed	973	216	8.82	9.19	2.1
BB34	MECR	0-H	No Weeding Hydroseed	1631	302	9.46	9.48	3.2
BB35	MECR	GK-0	GrowKill No Seed	654	119.5	8.78	9.33	1.5
BB36	MECR	H-H	Herbicide Hydroseed	499	253	8.47	8.97	0.7
BB37	NTV	NTV	Native Control	265	83.2	8.13	8.9	2.8
BB38	NTV	NTV	Native Control	230	87.6	9.16	9.16	3.0
BB39	NTV	NTV	Native Control	482	194.4	7.91	8.37	6.0
BB40	NTV	NTV	Native Control	308	138.1	8.32	8.92	4.9
BB41	NTV	NTV	Native Control	344	175.5	8.25	9.13	5.0
BB42	NTV	NTV	Native Control	330	136.4	8.84	8.97	0.7
CP01	MECR	GK-0	GroKill No Seed	252	88.1	8.98	9.34	5.7
CP02	MECR	0-H	No Weeding Hydroseed	165.5	93.3	9.51	9.35	6.4
CP03	MECR	GK-H	GrowKill Hydroseed	208	104	9.23	9.23	6.3
CP04	MECR	0-0	No Action Control	218	102.2	9.57	9.22	8.4
CP05	MECR	GK-H	GrowKill Hydroseed	585	98.2	8.76	9.11	4.5
CP06	MECR	H-H	Herbicide Hydroseed	242	97.2	8.74	9.33	1
CP07	MECR	GK-H	GrowKill Hydroseed	643	96.5	8.83	9.3	1.1
CP08	MECR	0-0	No Action Control	385	136	8.83	9.23	2.1
CP09	MECR	H-0	Herbicide No Seed	181.8	106.8	9.18	9.22	5.3
CP10	MECR	H-0	Herbicide No Seed	188.5	107.2	9.06	9.19	12.2
CP11	MECR	GK-0	GroKill No Seed	152.3	238	9.09	8.5	11.9
CP12	MECR	GK-0	GroKill No Seed	158	107.6	9.38	9.19	5.1
CP13	MECR	0-H	No Weeding Hydroseed	312	93.2	8.5	9.34	1.9
CP14	MECR	H-H	Herbicide Hydroseed	*	*	*	*	0
CP15	MECR	0-0	No Action Control	322	135.6	8.94	9.42	3.6
CP16	MECR	H-0	Herbicide No Seed	378	120.4	8.54	9.23	1.6

Plot	Type	Treatment	Treatment Description	EC (µs/cm) 4/20/16	EC (µs/cm) 5/22/17	pH 4/20/16	pH 5/22/17	%Moisture 5/22/17
CP17	MECR	GK-0	GroKill No Seed	256	87.5	9.26	9.3	7.3
CP18	MECR	H-H	Herbicide Hydroseed	240	88.4	9.19	9.26	2
CP19	MECR	0-H	No Weeding Hydroseed	505	116.2	8.51	9.12	3.3
CP20	MECR	0-0	No Action Control	232	120.8	8.82	9.26	2.8
CP21	MECR	GK-H	GrowKill Hydroseed	177.2	104.6	9.1	9.22	6
CP22	MECR	H-H	Herbicide Hydroseed	246	98.2	9.31	9.53	1.7
CP23	MECR	GK-H	GrowKill Hydroseed	307	98.7	8.94	9.14	2.2
CP24	MECR	0-0	No Action Control	149.6	118.5	9.8	9.22	3
CP25	MECR	GK-0	GroKill No Seed	282	84.5	8.46	9.27	1.4
CP26	MECR	GK-H	GrowKill Hydroseed	299	92.1	8.74	9.13	1.1
CP27	MECR	H-H	Herbicide Hydroseed	215	79.3	9.04	9.39	2.3
CP28	MECR	GK-0	GroKill No Seed	229	102.4	8.79	9.26	2.1
CP29	MECR	H-0	Herbicide No Seed	521	123.8	8.65	9.2	1.8
CP30	MECR	0-H	No Weeding Hydroseed	131	101.4	9.3	9.17	2.3
CP31	MECR	0-H	No Weeding Hydroseed	165.4	93.4	9.8	9.36	3.9
CP32	MECR	0-H	No Weeding Hydroseed	169.8	87.3	9.03	9.21	3.3
CP33	MECR	H-0	Herbicide No Seed	362	109.2	8.5	9.31	2.8
CP34	MECR	H-H	Herbicide Hydroseed	198.3	98	9.03	9.31	1.6
CP35	MECR	H-0	Herbicide No Seed	293	119.2	8.45	9.16	0.4
CP36	MECR	0-0	No Action Control	194	123.6	9.32	9.38	2.8
CP37	NTV	NTV	Native Control	164.3	95.4	9.01	9.24	4.3
CP38	NTV	NTV	Native Control	931	123.5	8.45	8.95	3.5
CP39	NTV	NTV	Native Control	593	117.3	8.71	9.33	3.7
CP40	NTV	NTV	Native Control	499	146.3	8.63	9.07	4.4
CP41	NTV	NTV	Native Control	439	224	8.43	8.71	6.9
CP42	NTV	NTV	Native Control	413	131.3	8.5	9.08	3.1
SD01	MECR	MECR H-0	Herbicide No Seed	272	137.4	7.98	9.08	0.4
SD02	MECR	MECR-GK-H	GrowKill Hydroseed	186.8	86.2	8.85	9.15	0.5
SD03	MECR	MECR-0-H	No Weeding Hydroseed	973	118.3	7.74	9.07	0.0
SD04	MECR	MECR GK	GrowKill No Seed	160.1	154.6	9.38	9.06	1.2

Plot	Type	Treatment	Treatment Description	EC (µs/cm) 4/20/16	EC (µs/cm) 5/22/17	pH 4/20/16	pH 5/22/17	%Moisture 5/22/17
SD05	MECR	MECR-H-H	Herbicide Hydroseed	137.6	115.7	9.28	9.13	0.5
SD06	MECR	MECR GK	GrowKill No Seed	262	97.2	8.67	9.12	0.0
SD07	MECR	MECR GK	GrowKill No Seed	138	393	8.45	8.45	0.7
SD08	MECR	MECR GK	GrowKill No Seed	261	103.2	8.66	9.36	0.0
SD09	MECR	MECR-H-H	Herbicide Hydroseed	153.2	129.5	8.96	9.03	0.0
SD10	MECR	MECR-H-H	Herbicide Hydroseed	258	87.4	8.55	9.13	0.7
SD11	MECR	MECR H-0	Herbicide No Seed	408	115.3	8.58	9.15	0.5
SD12	MECR	MECR-GK-H	GrowKill Hydroseed	639	118.2	8.08	8.81	0.0
SD13	MECR	MECR-00	No Action Control	306	121.4	8.73	9.08	0.4
SD14	MECR	MECR-GK-H	GrowKill Hydroseed	266	115.3	8.59	9.19	0.0
SD15	MECR	MECR-H-H	Herbicide Hydroseed	237	94	8.81	9.36	0.0
SD16	MECR	MECR H-0	Herbicide No Seed	342	136.1	8.28	9.18	0.0
SD17	MECR	MECR-H-H	Herbicide Hydroseed	171.5	97.5	9.3	8.97	0.0
SD18	MECR	MECR-0-H	No Weeding Hydroseed	409	227	8.36	8.87	0.0
SD19	MECR	MECR-00	No Action Control	186.2	134.3	8.82	9.01	0.7
SD20	MECR	MECR H-0	Herbicide No Seed	232	123.6	8.55	9.05	0.0
SD21	MECR	MECR-0-H	No Weeding Hydroseed	269	123.5	8.48	9.16	0.0
SD22	MECR	MECR GK	GrowKill No Seed	151.8	95.4	8.86	9.23	0.4
SD23	MECR	MECR-00	No Action Control	720	221	8.19	9.14	0.0
SD24	MECR	MECR H-0	Herbicide No Seed	177.2	178.8	8.59	8.75	0.0
SD25	MECR	MECR-0-H	No Weeding Hydroseed	393	102	8.28	9.32	0.5
SD26	MECR	MECR-GK-H	GrowKill Hydroseed	404	88.1	8.75	9.04	0.4
SD27	MECR	MECR-00	No Action Control	266	91.8	8.82	9.32	0.0
SD28	MECR	MECR-GK-H	GrowKill Hydroseed	189.9	115.5	8.54	9.14	0.6
SD29	MECR	MECR-00	No Action Control	347	189.6	8.17	8.65	0.4
SD30	MECR	MECR-00	No Action Control	158.8	261	9.04	8.81	0.0
SD31	MECR	MECR H-0	Herbicide No Seed	280	102.5	8.68	9.06	0.6
SD32	MECR	MECR-H-H	Herbicide Hydroseed	191.2	117.8	8.72	8.86	0.4
SD33	MECR	MECR-0-H	No Weeding Hydroseed	134.7	151.7	8.96	9	0.0
SD34	MECR	MECR-GK-H	GrowKill Hydroseed	173.3	97.9	9.13	9.22	0.9

Plot	Type	Treatment	Treatment Description	EC (µs/cm) 4/20/16	EC (µs/cm) 5/22/17	pH 4/20/16	pH 5/22/17	%Moisture 5/22/17
SD35	MECR	MECR-0-H	No Weeding Hydroseed	195.4	151.4	9.06	9.19	0.0
SD36	MECR	MECR GK	GrowKill No Seed	192.2	107.2	8.51	9.15	0.0
SD37	NTV	NTV	Native Control	228	147.2	8.69	8.57	0.0
SD38	NTV	NTV	Native Control	248	103.5	8.69	8.82	0.0
SD39	NTV	NTV	Native Control	131.1	100.8	8.83	9.17	0.0
SD40	NTV	NTV	Native Control	286	160	8.47	8.74	0.4
SD41	NTV	NTV	Native Control	346	102.6	9.04	9.18	0.0
SD42	NTV	NTV	Native Control	194	86.2	9.17	9.3	0.0

Appendix Table 8. Arthropod & Plant Data, 2016 San Nicolas Island *Mesembryanthemum* impacts study.

Plot ID	BSppRich	BAbun	BSppDiv	MECRCov	NtvPRich	PSppRich	RelPCov	NtvPCov
BB01	16	71	1.98710738	70	1	2	71	1
BB09	19	251	1.810856386	75	1	2	75	0.5
BB11	15	348	1.031619932	60	2	3	60	1
BB12	21	610	1.571949525	60	3	4	65	2
BB13	24	550	1.591959671	70	1	2	70	0.5
BB15	23	403	1.932870189	70	0	4	70	0
BB16	23	464	1.825534904	45	2	3	46	1.5
BB17	29	313	2.247516939	80	0	1	80	0
BB22	27	343	2.122218697	72	1	3	73	0.5
BB23	20	383	1.960017506	85	1	3	87	0.5
BB24	17	181	1.951320609	30	0	1	30	0
BB25	18	96	2.305948156	75	1	2	83	0.5
BB26	14	130	1.102176939	80	2	3	80	1
BB27	19	183	2.108201797	75	0	3	76	0
BB28	22	188	2.350510428	70	0	2	70	0
BB32	25	223	2.214858885	45	0	4	52	0
BB33	18	110	2.112599687	75	1	2	75	0.5
BB34	20	267	2.062322752	45	1	2	46	1
BB35	20	247	2.101834983	50	1	3	51	0.5
BB36	18	346	1.79298479	50	0	1	50	0
BB37	22	78	2.591449238	6	4	6	50	29
BB38	31	113	2.782425175	12	2	4	29	16
BB39	31	265	1.870171265	2	6	9	74	67.5
BB40	22	85	2.621107283	0.5	5	10	59	11
BB41	32	106	2.586991414	4	3	5	70	62
BB42	38	100	3.257395899	7	3	7	62	44
CP01	12	72	0.979646757	60	4	6	101	42
CP02	18	143	1.320801106	55	5	8	84	29
CP03	21	204	1.361220261	65	4	8	92	26.5
CP04	21	97	2.218225801	55	5	8	72	17
CP05	13	136	1.087301767	4	7	9	24	17.5
CP06	16	36	2.553237003	60	0	3	80	20
CP07	15	69	2.138684639	46	4	7	53	13.5
CP08	12	23	2.260936856	96	1	4	108	8
CP09	10	19	1.981096754	70	3	5	86	46.5
CP10	15	50	2.131708225	25	9	12	38	85.5
CP11	18	33	2.598464236	50	4	10	71	17.5

Plot ID	BSppRich	BAbun	BSppDiv	MECRCov	NtvPRich	PSppRich	RelPCov	NtvPCov
CP12	11	36	1.833079525	65	7	10	94	33
CP13	16	33	2.443365666	70	2	5	86	15.5
CP14	17	42	2.445141397	65	1	2	66	0.5
CP15	20	41	2.724073613	35	5	7	56	18
CP16	6	13	1.524707393	65	1	4	72	6
CP17	16	39	2.353858547	12	6	8	37	23
CP18	9	12	2.13833306	50	1	3	77	26
CP19	13	76	1.442050999	65	7	12	84	18.5
CP20	11	19	2.260233853	65	4	7	82	16.5
CP22	13	72	1.97831906	20	5	9	37	12.5
CP23	9	28	1.658365682	75	3	5	96	21
CP24	16	92	1.591012372	72	2	3	86	14
CP25	10	26	1.846856957	75	3	7	89	13.5
CP26	12	30	2.28604689	55	4	5	61	7
CP28	11	29	2.038752366	65	1	2	92	28
CP29	14	23	2.46149815	60	2	4	78	15.5
CP30	7	13	1.778233306	60	2	3	60	1.5
CP31	16	28	2.580522833	85	1	3	86	0.5
CP32	9	15	2.026229623	30	6	9	52	22.5
CP33	19	128	1.214156851	80	5	8	97	17
CP34	8	16	1.715263228	66	3	5	86	21
CP35	9	18	2.014122529	50	2	6	90	4.5
CP36	12	45	1.817683654	60	5	8	74	14.5
CP37	18	37	2.662445463	0.5	5	9	42	39.5
CP38	19	43	2.672704553	1	5	8	41	37.5
CP39	19	27	2.826944299	3	3	6	41	29.5
CP40	21	67	2.519935411		5	7	15	13.5
CP41	18	54	2.561906036	3	6	11	61	56.5
CP42	11	13	2.351673302	7	4	9	49	36
SD01	22	108	2.284340689	65	3	6	66	1.5
SD02	15	42	2.431922005	50	3	5	65	14.5
SD03	22	81	2.535903935	85	2	4	92	6.5
SD04	22	75	2.664221566	70	1	2	70	0.5
SD05	16	27	2.587038923	80	4	6	87	7
SD06	20	34	2.680113951	40	3	5	56	16
SD07	27	96	2.721634731	55	3	8	65	9.5
SD08	21	47	2.599020299	50	3	6	56	6
SD09	19	87	2.248783056	40	0	2	41	0
SD10	15	29	2.266886438	50	3	6	76	1.5
SD11	25	86	2.662796732	50	2	4	91	40.5

Plot ID	BSppRich	BAbun	BSppDiv	MECRCov	NtvPRich	PSppRich	RelPCov	NtvPCov
SD12	33	92	2.982786357	30	1	6	57	0.5
SD13	21	57	2.54351698	60	3	5	79	19
SD14	24	75	2.658084893	60	4	6	62	2
SD15	18	62	2.275710587	55	1	5	57	1
SD16	18	27	2.763014949	40	4	6	51	11
SD17	24	66	2.751077539	70	1	4	79	3
SD18	29	84	2.84449241	65	3	5	66	1.5
SD19	19	58	2.400548483	90	2	3	101	10.5
SD20	25	118	2.565114471	70	0	2	71	0
SD21	16	37	2.331060791	50	2	5	52	1
SD22	20	63	2.31015359	60	5	8	73	12.5
SD23	21	82	2.508482775	50	1	3	75	25
SD24	11	28	2.156727313	55	2	4	88	3
SD25	23	62	2.723067956	70	1	3	91	0.5
SD26	21	74	2.131017897	50	1	2	80	30
SD27	21	93	2.372615275	65	1	3	68	0.5
SD28	15	54	2.309824081	65	3	5	67	1.5
SD29	19	73	2.512257828	75	1	4	79	2
SD30	24	90	2.586335431	42	3	7	50	1.5
SD31	21	81	2.565876641	80	2	3	91	10.5
SD32	14	57	2.184299958	60	3	6	62	1.5
SD33	23	146	2.669300528	40	2	3	61	21
SD35	19	75	2.267239794	55	2	5	76	20.5
SD36	22	65	2.610975571	78	3	6	80	2
SD38	16	43	2.390710316	2	2	4	65	60
SD39	17	32	2.51181159	0.5	3	5	41	40
SD40	19	37	2.779805818	2	3	5	44	36
SD41	19	31	2.771927888	1	3	4	78	77.5
SD42	13	23	2.15516335	1	8	11	43	42

Appendix Table 9. Plant Data, 2017 San Nicolas Island *Mesembryanthemum* impacts study.

Plot	Type	Trtmt	MECR	SppRich	NtvRich	Litter Cov	Soil Cov	RelCov	AbsCov	NtvCov
BB01	MECR	H-0	3	3	2	15	85	4	4	1
BB02	MECR	GK-H	25	10	7	1	99	34	34	4
BB03	MECR	0-0	82	5	3	80	20	90	85	7.5
BB04	MECR	GK-H	82	5	3	0	100	84	84	1.5
BB05	MECR	H-0	30	4	3	10	90	35	35	5
BB06	MECR	0-H	98	5	2	100	0	101	98	1.5
BB07	MECR	H-H	4	4	3	15	85	6	6	2
BB08	MECR	H-H	8	5	4	12	98	11.5	11	3.5
BB09	MECR	H-0	52	1	0	10	90	52	52	0
BB10	MECR	0-H	97	3	1	100	0	98	98	0.5
BB11	MECR	GK-H	40	8	6	0	100	47	46	4
BB12	MECR	GK-0	40	4	2	2	98	51	49	9
BB13	MECR	0-H	80	6	3	95	5	94	93	11.5
BB14	MECR	0-H	97	6	3	10	90	100.5	98	2
BB15	MECR	0-0	85	4	2	30	70	87	85	1
BB16	MECR	GK-0	30	5	3	0	100	40	39	9.5
BB17	MECR	H-H	40	6	5	15	85	44.5	44	4.5
BB18	MECR	0-H	92	7	5	0	100	97.5	95	5
BB19	MECR	0-0	92	7	4	3	97	99.5	95	6
BB20	MECR	GK-0	37	5	2	0	100	46	45	3
BB21	MECR	GK-H	65	5	4	0	100	75	75	10
BB22	MECR	GK-0	78	6	3	0	100	80.5	80	1.5
BB23	MECR	0-0	96	7	4	80	20	102	96	4
BB24	MECR	H-0	12	1	0	10	90	12	80	0
BB25	MECR	0-0	97	1	0	97	3	97	97	0
BB26	MECR	H-0	7	1	0	35	65	7	7	0
BB27	MECR	GK-H	40	6	5	0	100	43	43	3
BB28	MECR	GK-H	63	6	4	0	100	66	65	2.5
BB29	MECR	H-H	18	4	3	40	60	20	20	2
BB30	MECR	H-H	35	6	4	10	90	39	38	3.5
BB31	MECR	0-0	97	3	1	95	5	98.5	98.5	0.5
BB32	MECR	H-0	13	2	0	20	80	14	14	0
BB33	MECR	GK-0	87	1	0	0	100	87	87	0
BB34	MECR	0-H	98	1	0	100	0	98	98	0
BB35	MECR	GK-0	55	4	3	0	100	56.5	56.5	1.5
BB36	MECR	H-H	3	2	1	40	60	4	4	1
BB37	NTV	NTV	2	12	6	10	90	48	43	41
BB38	NTV	NTV	8	8	4	3	97	42.5	41	32.5

Plot	Type	Trtmt	MECR	SppRich	NtvRich	Litter Cov	Soil Cov	RelCov	AbsCov	NtvCov
BB39	NTV	NTV	0	8	5	85	15	67.5	64	35
BB40	NTV	NTV	0	12	8	98	2	87	85	31
BB41	NTV	NTV	1	7	4	89	11	88.5	79	52
BB42	NTV	NTV	0	5	3	88	12	80	70	35
CP01	MECR	GK-0	6	0	0	0	0	0	0	6
CP02	MECR	0-H	72	0	0	0	0	0	0	22
CP03	MECR	GK-H	3	0	0	0	0	0	0	19.5
CP04	MECR	0-0	25	0	0	0	0	0	0	41
CP05	MECR	GK-H	4	0	0	0	0	0	0	23.5
CP06	MECR	H-H	1	0	0	0	0	0	0	0
CP07	MECR	GK-H	12	0	0	0	0	0	0	9.5
CP08	MECR	0-0	82	0	0	0	0	0	0	21
CP09	MECR	H-0	0.5	0	0	0	0	0	0	2
CP10	MECR	H-0	4	0	0	0	0	0	0	8.5
CP11	MECR	GK-0	30	0	0	0	0	0	0	17
CP12	MECR	GK-0	8	0	0	0	0	0	0	19.5
CP13	MECR	0-H	88	0	0	0	0	0	0	2.5
CP14	MECR	H-H	5	0	0	0	0	0	0	1
CP15	MECR	0-0	70	0	0	0	0	0	0	11.5
CP16	MECR	H-0	1	0	0	0	0	0	0	2
CP17	MECR	GK-0	2	0	0	0	0	0	0	17
CP18	MECR	H-H	4	0	0	0	0	0	0	3
CP19	MECR	0-H	60	0	0	0	0	0	0	8
CP20	MECR	0-0	93	0	0	0	0	0	0	6.5
CP21	MECR	GK-H	7	0	0	0	0	0	0	17
CP22	MECR	H-H	0	0	0	0	0	0	0	9
CP23	MECR	GK-H	55	0	0	0	0	0	0	1.5
CP24	MECR	0-0	88	0	0	0	0	0	0	4
CP25	MECR	GK-0	10	0	0	0	0	0	0	1.5
CP26	MECR	GK-H	45	0	0	0	0	0	0	2
CP27	MECR	H-H	0	0	0	0	0	0	0	0
CP28	MECR	GK-0	6	0	0	0	0	0	0	7
CP29	MECR	H-0	4	0	0	0	0	0	0	0
CP30	MECR	0-H	70	0	0	0	0	0	0	18.5
CP31	MECR	0-H	75	0	0	0	0	0	0	3.5
CP32	MECR	0-H	65	0	0	0	0	0	0	7
CP33	MECR	H-0	0.5	0	0	0	0	0	0	8.5
CP34	MECR	H-H		0	0	0	0	0	0	0.5
CP35	MECR	H-0	0.5	0	0	0	0	0	0	0
CP36	MECR	0-0	80	0	0	0	0	0	0	17

Plot	Type	Trtmt	MECR	SppRich	NtvRich	Litter Cov	Soil Cov	RelCov	AbsCov	NtvCov
CP37	MECR	NTV	4	0	0	0	0	0	0	50.5
CP38	NTV	NTV	5	0	0	0	0	0	0	23.5
CP39	NTV	NTV	5	0	0	0	0	0	0	19.5
CP40	NTV	NTV	1	0	0	0	0	0	0	26
CP41	NTV	NTV	7	0	0	0	0	0	0	46
CP42	NTV	NTV	15	0	0	0	0	0	0	54.5
SD01	MECR	H-0	3	0	3	0	0	0	0	1.5
SD02	MECR	GK-H	4	0	3	0	0	0	0	34
SD03	MECR	0-H	60	0	4	0	0	0	0	2.5
SD04	MECR	GK-0	7	0	4	0	0	0	0	3.5
SD05	MECR	H-H	0.5	0	3	0	0	0	0	1.5
SD06	MECR	GK-0	15	0	3	0	0	0	0	1.5
SD07	MECR	GK-0	11	0	2	0	0	0	0	1
SD08	MECR	GK-0	11	0	4	0	0	0	0	3.5
SD09	MECR	H-H	0	0	1	0	0	0	0	1
SD10	MECR	H-H	1	0	1	0	0	0	0	0.5
SD11	MECR	H-0	0.5	0	0	0	0	0	0	0
SD12	MECR	GK-H	12	0	2	0	0	0	0	2.5
SD13	MECR	0-0	37	0	6	0	0	0	0	4
SD14	MECR	GK-H	9	0	6	0	0	0	0	4
SD15	MECR	H-H	0	0	1	0	0	0	0	0.5
SD16	MECR	H-0	0	0	1	0	0	0	0	4
SD17	MECR	H-H	0.5	0	0	0	0	0	0	0
SD18	MECR	0-H	25	0	5	0	0	0	0	5.5
SD19	MECR	0-0	50	0	4	0	0	0	0	3
SD20	MECR	H-0	0	0	2	0	0	0	0	1
SD21	MECR	0-H	40	0	3	0	0	0	0	4
SD22	MECR	GK-0	12	0	5	0	0	0	0	10.5
SD23	MECR	0-0	55	0	5	0	0	0	0	2.5
SD24	MECR	H-0	0	0	2	0	0	0	0	1
SD25	MECR	0-H	55	0	4	0	0	0	0	2.5
SD26	MECR	GK-H	18	0	4	0	0	0	0	5.5
SD27	MECR	0-0	30	0	6	0	0	0	0	5.5
SD28	MECR	GK-H	18	0	8	0	0	0	0	7.5
SD29	MECR	0-0	12	0	3	0	0	0	0	2.5
SD30	MECR	0-0	35	0	4	0	0	0	0	3
SD31	MECR	H-0	0.5	0	2	0	0	0	0	1
SD32	MECR	H-H	0	0	2	0	0	0	0	1
SD33	MECR	0-H	55	0	5	0	0	0	0	4
SD34	MECR	GK-H	20	0	5	0	0	0	0	2.5

Plot	Type	Trtmt	MECR	SppRich	NtvRich	Litter Cov	Soil Cov	RelCov	AbsCov	NtvCov
SD35	MECR	0-H	45	0	3	0	0	0	0	2
SD36	MECR	GK-0	14	0	2	0	0	0	0	9
SD37	NTV	NTV	0	0	4	0	0	0	0	68
SD38	NTV	NTV	22	0	3	0	0	0	0	1.5
SD39	NTV	NTV	5	0	3	0	0	0	0	51
SD40	NTV	NTV	1	0	3	0	0	0	0	68.5
SD41	NTV	NTV	12	0	5	0	0	0	0	54
SD42	NTV	NTV	2	0	6	0	0	0	0	10.5

Appendix Table 10. Plant Data, 2018 San Nicolas Island *Mesembryanthemum* impacts study.

Plot ID	Type	Trtmt	MECR	Spp Rich	NtvRich	Litter Cov	Soil Cov	RelCov	AbsCov	NtvCov
BB01	MECR	H-0	6	2	1	10	90	20	20	14
BB02	MECR	GK-H	20	2	1	3	97	20	20	0.5
BB03	MECR	0-0	0	0	0	15	85	0	0	0
BB04	MECR	GK-H	0	0	0	0	100	0	0	0
BB05	MECR	H-0	0	0	0	45	55	0	0	0
BB06	MECR	0-H	0	0	0	97	3	0	0	0
BB07	MECR	H-H	0	0	0	8	92	0	0	0
BB08	MECR	H-H	25	1	0	40	60	25	25	0
BB09	MECR	H-0	3	1	0	60	40	3	3	0
BB10	MECR	0-H	2	1	0	95	5	2	2	0
BB11	MECR	GK-H	18	2	1	1	99	18	18	0.5
BB12	MECR	GK-0	15	2	1	3	97	18	18	3
BB13	MECR	0-H	2	1	0	88	12	2	2	0
BB14	MECR	0-H	0	0	0	50	50	0	0	0
BB15	MECR	0-0	0	0	0	60	40	0	0	0
BB16	MECR	GK-0	6	4	2	2	98	11	11	5
BB17	MECR	H-H	10	1	0	80	20	10	10	0
BB18	MECR	0-H	0	0	0	55	45	0	0	0
BB19	MECR	0-0	0	1	1	50	50	0	0	0.5
BB20	MECR	GK-0	0	0	0	5	95	0	0	0
BB21	MECR	GK-H	0	0	0	2	98	0	0	0
BB22	MECR	GK-0	28	1	0	0	100	28	28	0
BB23	MECR	0-0	0	0	0	90	10	0	0	0
BB24	MECR	H-0	0	0	0	25	75	0	0	0
BB25	MECR	0-0	0	0	0	100	0	0	0	0
BB26	MECR	H-0	0	0	0	25	75	0	0	0
BB27	MECR	GK-H	15	1	0	5	95	15	15	0

Plot ID	Type	Trtmt	MECR	Spp Rich	NtvRich	Litter Cov	Soil Cov	RelCov	AbsCov	NtvCov
BB28	MECR	GK-H	22	1	0	25	75	22	22	0
BB29	MECR	H-H	0	0	0	40	60	0	0	0
BB30	MECR	H-H	0	0	0	27	73	0	0	0
BB31	MECR	0-0	0	0	0	98	2	0	0	0
BB32	MECR	H-0	0	0	0	40	60	0	0	
BB33	MECR	GK-0	0	0	0	25	75	0	0	0
BB34	MECR	0-H	0	0	0	100	0	0	0	0
BB35	MECR	GK-0	0.5	1	0	5	95	0	0	0
BB36	MECR	H-H	0	0	0	50	50	0	0	0
BB37	NTV	NTV	0	4	4	50	50	35	35	35.5
BB38	NTV	NTV	1	3	2	5	95	14	14	13
BB39	NTV	NTV	0	3	2	95	5	46	46	46
BB40	NTV	NTV	0	5	5	90	10	14	14	14.5
BB41	NTV	NTV	0	4	3	96	4	43	43	43.5
BB42	NTV	NTV	0	2	2	95	5	19	19	19
CP01	MECR	GK-0	10	4	2	30	70	17	17	6
CP02	MECR	0-H	2	3	2	45	55	25	25	23
CP03	MECR	GK-H	2	6	2	10	90	30	30	25.05
CP04	MECR	0-0	4	6	4	50	50	44	44	39.05
CP05	MECR	GK-H	0	5	5	15	85	24	24	24.05
CP06	MECR	H-H	6	2	0	82	18	7	7	0
CP07	MECR	GK-H	25	8	6	1	99	31	31	6
CP08	MECR	0-0	12	4	1	96	4	29	29	15
CP09	MECR	H-0	10	3	1	50	50	14	14	4
CP10	MECR	H-0	2	4	3	50	50	21	21	19
CP11	MECR	GK-0	2	4	2	83	17	25	25	22.5
CP12	MECR	GK-0	10	6	3	40	60	51	51	40
CP13	MECR	0-H	0	0	0	90	10	0	0	0
CP14	MECR	H-H	1	2	1	75	25	1	1	0.5
CP15	MECR	0-0	5	4	2	25	75	11	11	5.5
CP16	MECR	H-0	12	2	1	70	30	21	21	9
CP17	MECR	GK-0	1	5	3	15	85	18	18	16.5
CP18	MECR	H-H	0	2	1	85	15	8	8	8
CP19	MECR	0-H	2	4	2	65	35	7	7	2.5
CP20	MECR	0-0	3	4	1	93	7	19	19	15
CP21	MECR	GK-H	7	6	4	15	85	36	36	27
CP22	MECR	H-H	2	7	3	35	65	33	33	29.5
CP23	MECR	GK-H	15	6	3	45	55	34	34	15
CP24	MECR	0-0	5	3	2	60	40	12	12	7
CP25	MECR	GK-0	8	6	3	85	15	28	28	3.5

Plot ID	Type	Trtmt	MECR	Spp Rich	NtvRich	Litter Cov	Soil Cov	RelCov	AbsCov	NtvCov
CP26	MECR	GK-H	28	6	3	22	78	35	35	6
CP27	MECR	H-H	4	3	0	8	92	5	5	0
CP28	MECR	GK-0	20	7	3	12	88	34	34	11
CP29	MECR	H-0	2	2	0	25	75	2	2	0
CP30	MECR	0-H	3	5	2	60	40	17	16	13
CP31	MECR	0-H	6	3	1	70	30	7	7	1
CP32	MECR	0-H	0	5	3	50	50	9	9	7.5
CP33	MECR	H-0	3	4	2	45	55	20	20	16
CP34	MECR	H-H	35	3	1	45	55	36	36	1
CP35	MECR	H-0	7	2	1	75	25	9	9	2
CP36	MECR	0-0	2	5	2	75	25	44	44	41
CP37	NTV	NTV	0.5	4	3	75	25	48	48	
CP38	NTV	NTV	0.5	6	3	80	20	34	33	32.5
CP39	NTV	NTV	0.5	5	2	92	8	50	50	48
CP40	NTV	NTV	0.5	5	3	30	70	40	40	38.5
CP41	NTV	NTV	0.5	5	3	98	2	70	70	68.5
CP42	NTV	NTV	1	6	3	97	3	16	16	13.5
SD01	MECR	H-0	18	4	1	93	7	24	24	0.5
SD02	MECR	GK-H	7	4	2	88	12	40	40	31
SD03	MECR	0-H	10	5	2	85	15	30	30	19
SD04	MECR	GK-0	1	5	2	90	10	85	85	80.5
SD05	MECR	H-H	18	5	2	30	70	46	46	26
SD06	MECR	GK-0	4	6	4	20	80	23	23	14
SD07	MECR	GK-0	5	4	2	35	65	27	27	20.5
SD08	MECR	GK-0	2	6	3	3	97	18	18	13
SD09	MECR	H-H	15	5	2	10	90	49	49	30
SD10	MECR	H-H	30	4	1	35	65	32	32	0.5
SD11	MECR	H-0	10	5	2	90	10	25	25	13
SD12	MECR	GK-H	5	5	2	60	40	22	22	8
SD13	MECR	0-0	6	6	3	45	55	40	40	34.5
SD14	MECR	GK-H	2	4	2	40	60	74	72	71
SD15	MECR	H-H	10	5	4	40	60	12	12	0.5
SD16	MECR	H-0	20	4	2	3	97	37	37	13
SD17	MECR	H-H	18	6	3	98	2	45	45	20.5
SD18	MECR	0-H	10	5	3	20	80	20	20	3
SD19	MECR	0-0	0	3	2	95	5	94	94	92
SD20	MECR	H-0	10	7	3	35	65	26	26	13
SD21	MECR	0-H	2	4	1	15	85	38	36	27
SD22	MECR	GK-0	12	3	0	15	85	15	15	0
SD23	MECR	0-0	2	4	2	92	8	38	38	35.5

Plot ID	Type	Trtmt	MECR	Spp Rich	NtvRich	Litter Cov	Soil Cov	RelCov	AbsCov	NtvCov
SD24	MECR	H-0	4	4	2	45	55	19	19	13
SD25	MECR	0-H	6	4	2	97	3	39	39	33
SD26	MECR	GK-H	20	6	2	20	80	47	47	22
SD27	MECR	0-0	9	5	2	20	80	56	55	45
SD28	MECR	GK-H	5	6	3	98	2	96	96	89
SD29	MECR	0-0	1	5	2	98	2	26	26	7
SD30	MECR	0-0	2	6	3	12	88	12	12	6
SD31	MECR	H-0	16	4	2	75	25	22	22	5
SD32	MECR	H-H	4	5	3	50	50	7	7	1
SD33	MECR	0-H	2	4	2	50	50	21	21	19
SD34	MECR	GK-H	10	6	3	15	85	48	48	36
SD35	MECR	0-H	1	3	1	20	80	87	87	85
SD36	MECR	GK-0	2	5	3	30	70	50	50	48
SD37	NTV	NTV	0	4	2	95	5	45	45	44
SD38	NTV	NTV	0.5	4	2	95	5	7	7	5.5
SD39	NTV	NTV	0	4	2	98	2	93	92	93
SD40	NTV	NTV	0.5	5	2	90	10	82	80	77
SD41	NTV	NTV	1	5	3	65	35	10	10	8.5
SD42	NTV	NTV	0.5	6	4	25	75	33	33	32