# Population monitoring and habitat restoration for Cassin's Auklets at Scorpion Rock and Prince Island, Channel Islands National Park, California: 2007–2008


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Photo above: View looking west toward Scorpion Rock on 24 September 2008, the day of the initial native out-planting effort.

Cover photo: Volunteer restoration horticulturists work to out-plant Scorpion Rock with native flora during September 2008.

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# EXECUTIVE SUMMARY

In 2007 and 2008, population monitoring of Cassin's Auklet (*Ptychoramphus aleuticus*) continued at Scorpion Rock (Santa Cruz Island) and at Prince Island (San Miguel Island), California. Baseline, pre-restoration vegetation cover was quantified at Scorpion Rock. An experimental design to test the efficacy of exotic vegetation control and native out-plantings was established. This experiment is intended to reveal the effects of introduced plants on the burrowing habitat of Cassin's Auklet and physical alteration of soil parameters caused primarily by invasive Crystalline Ice Plant (*Mesembryanthemum crystallinum*). This experiment significantly contributes also to the overall project goal to eradicate exotic vegetation on Scorpion Rock. Artificial nest sites at Prince Island and Scorpion Rock (originally installed in 1984, 1999–2000) were replaced with a new design intended to improve nesting microhabitats for sites used for long-term monitoring and ecological research. Information from 2007 and 2008 monitoring is intended to be used by the Montrose Settlements Restoration Program Trustee Council and Channel Islands National Park to: a) refine and best inform habitat restoration plans for Cassin's Auklets at Scorpion Rocks, and possibly other areas in the future; and b) maintain long-term monitoring programs for Cassin's Auklet at Scorpion Rock and Prince Island for measuring population changes resulting from restoration actions and other natural and anthropogenic factors.

Herein, we describe Cassin's Auklet monitoring that occurred between March and August 2007 and February and July 2008 on Scorpion Rock and Prince Island. Monitoring activities included estimation of breeding population size at Scorpion Rock, and reproductive success at Scorpion Rock and Prince Island. Also described are results from artificial burrow temperature monitoring, pre-restoration vegetation composition and cover surveys, pre-restoration soil composition and chemistry sampling, and Phase I restoration out-planting in 2008.

In 2008, auklet hatching on Prince Island occurred from 22 April to 24 June (63 day period, mean hatching date 6 May ± 10 SD days). In 2008, hatching on Scorpion Rock occurred from 26 April to 20 May (24 day period, mean hatching date 11 May ± 11 SD days). On Prince Island, occupancy among artificial sites increased from 60% in 2006, to 88% in 2007, and 100% in 2008. Breeding success on Prince Island was zero in 2007 and 70% in 2008. On Scorpion Rock, occupancy was less than at Prince Island, but showed a similar increasing trend from 6% in 2006, to 11% in 2007, and 60% in 2008. Breeding success on Scorpion Rock was zero in 2006 and 2007, and 30% in 2008. In 2007 and 2008, there were an estimated total 28 and 62 breeding birds, respectively on Scorpion Rock. An unknown number (likely fewer than 20) of auklets breed on the adjacent Little Scorpion Rock. In 2007 and 2008, we deployed 16 archival temperature recorders within auklet nest sites (artificial and natural sites) on Prince Island and Scorpion Rock. Among burrow categories, there was more variability in maximum temperatures. Natural burrows on Prince Island had the lowest maximum temperatures at 21.4 °C in 2007 and 27.4 °C in 2008. In both years, greatest maximum temperatures were recorded in AB sites on Prince Island, with sites in 2008 displaying slightly warmer maximum temperatures on average.

We designed a randomized block analyses of variance (ANOVA) experiment to assess the efficacy of exotic vegetation control, native re-vegetation, and the effect of these treatments on soil quality. The removal/control portion of this experiment constitutes 21% (900 of 4,300 $m^2$) of

the total estimated vegetative area of Scorpion Rock (excluding the eastern gully, the southwest corner, and the southern bench areas). To prepare for native outplanting, seeds for this project were collected on Scorpion Rock and SCI and grown in an on-island nursery facility. The nursery is located in the central valley on SCI adjacent to the University of California (UC) Reserve. A water storage and delivery system was established for Scorpion Rock prior to the fall 2008 outplanting. Composed of 17 55-gal and two 135-gal *Fold-a-Tank* collapsible water storage containers (1,200 gal total). Prior to restoration, on 15 April 2008, 96 ± 6% of the vegetative cover within vegetation restoration study plots on Scorpion Rock was composed of seven exotic species, mostly vegetative and desiccated *M. crystallinum*, 63% cover), Cheeseweed (*Malva parviflora*), 14% cover), Nettle-leaf Goosefoot (*Chenopodium murale*), 17%), and Brome Grass (*Bromus diandrus*) and Foxtail (*Hordeum murinum*; together <1%). Out-planting density in the non-experimental areas was similar to that used in the experimental plots (approximately 1 plant $m^{-2}$). In addition to the species used in the experimental plots, we planted additional Lemonadeberry (*Rhus integrifolia*), Island Morning Glory (*Calystegia m. macrostegia*), and *S. taxifolia.*

Key recommendations include: (a) continued quantification of vegetation and soil parameters that affect auklet nesting habitat on Scorpion; (b) exotic plant control and experimentally-guided restoration of native plants that will improve nesting habitat for auklets and potentially Xantus's Murrelet (*Synthliboramphus hypoleucus*); (c) addressing soil stabilization in lower drainage area on Scorpion Rock; and (d) development of outreach and education to inform Park and Sanctuary visitors of the importance of preserving and enhancing seabird habitat on Scorpion Rock and other locations throughout the Channel Islands National Park. Provided additional funding is made available, comprehensive monitoring of reproductive success, adult survival, and diet of Cassin's Auklets and Catch Per Unit Effort (CPUE) and mark-recapture banding for Ashy Storm-Petrels (*Oceanodroma homochroa*) should be continued at Prince Island in order to provide a reference comparison to evaluate restoration success for Cassin's Auklets and Ashy Storm-Petrels at Scorpion Rock, Orizaba Rock, and other locations throughout the Channel Islands National Park.

## INTRODUCTION

Islands within Channel Islands National Park (CINP) provide essential nesting habitat for seabirds including Ashy Storm-Petrel (*Oceanodroma homochroa*), Cassin's Auklet (*Ptychoramphus a. aleuticus*), and Xantus's Murrelet (*Synthliboramphus hypoleucus*). These species also depend upon marine prey resources (especially euphausiids and larval/juvenile fishes) throughout surrounding waters of the southern California Current System (CCS) including several west coast National Marine Sanctuaries and Marine Protected Areas (Whitworth *et al*. 2000, Mason *et al*. 2004, Adams *et al*. 2004a,b, Adams & Takekawa 2008, USGS *unpubl. data*). Off southern California, several studies indicate that Cassin's Auklet has declined 50–60% (Carter *et al.* 1992 [colony-based assessment of breeding birds], Hyrenbach & Veit 2003 [at-sea density estimates], Mason *et al*. 2004 [at-sea density estimates]), coincident with changes in zooplankton community structure (McGowan *et al.* 1998, Peterson & Schwing 2003). With the onset of strong and prolonged La Niña ocean conditions in 1999, prey (*e.g.*, rockfish, euphausiids; Peterson & Schwing 2003) and predator populations responded rapidly to enhanced productivity in the southern CCS (Adams 2004). In contrast, conditions during 2004 through 2007 were characterized by anomalously warm ocean waters, low productivity, and delayed upwelling. These conditions are thought to be partly responsible for several seabird mortality events and dramatic breeding failure in some species (*e.g.*, Cassin's Auklets from California to British Columbia; Sydeman *et al.* 2006, Jahncke *et al.* 2008).

*Cassin's Auklet*— Cassin's Auklet ranges from Alaska to northern Baja California, Mexico. Although the species is abundant in portions of its overall range (*i.e.*, British Columbia) it is recognized by the California Department of Fish & Game as a Bird Species of Special Concern (BSSC; Adams 2008; **Fig. 1**). The vast majority of the statewide population in 1989–91 occurred at three colonies: South Farallon Islands National Wildlife Refuge (Farallon NWR, San Francisco County; 68%), Prince Island and Castle Rock (CINP, Santa Barbara County; 16%), and Castle Rock (Castle Rock NWR, Del Norte County; 10%; Carter *et al.* 1992, Adams 2008). Within the CINP, the largest colonies occur on Prince Island (8,922 birds in 1991) and Castle Rock (2,614 birds in 1991), both off San Miguel Island (Carter *et al.* 1992). Cassin's Auklets nest on other small islands scattered throughout the northern Channel Islands (unless noted otherwise, numbers of birds from Table 35 in Carter *et al.* 1992): Point Bennett (20) and Harris Point to Cuyler Harbor ("Hare Rock," 28) in San Miguel Island area; Diablo Rocks (28), Sppit (AKA Orizaba Rock;10 estimated by Hunt *et al.* 1979 in June 1977, 0 found in May 1991 by Carter *et al.* 1992), Scorpion Rocks (546), Willows Anchorage Rocks (10), and Gull Island (132) in Santa Cruz Island area; and Santa Barbara Island (132), Shag Rock (2), and Sutil Island (122) in Santa Barbara Island area. A maximum estimate of 120 (probably fewer) birds nested on Scorpion Rocks in 2000 (J. Adams, *unpubl. data*).

Cassin's Auklet was monitored on Prince Island, off San Miguel Island, and on Scorpion Rock, off Santa Cruz Island (SCI), intermittently from 1975 to 1997. In 1975–76, University of California Irvine studied population size, reproductive success, and diet at Prince Island (Hunt *et al.* 1979, 1980). Beginning in 1985, the CINP seabird monitoring program monitored reproductive success, breeding phenology, and adult survival at Prince Island (Lewis *et al.* 1988, Ingram 1992, Ingram & Jory-Carter 1997, CINP, *unpubl. data*). In 1991, Humboldt State University estimated population size at Prince Island and Scorpion Rocks (Carter *et al.* 1992). In

1998–99, Point Reyes Bird Observatory (PRBO) studied reproductive success and diet at Prince Island (PRBO, *unpubl. data*). From 1999 to 2001, monitoring and research efforts were conducted annually by USGS and Humboldt State University. Research and monitoring during 1999–2001 were enhanced through the addition of 84 new artificial burrows on Prince Island and Scorpion Rock (Adams *et al*. 2000, Ackerman *et al*. 2004, Adams *et al*. 2004a, 2004b, Adams *et al. in press*). Lower-level monitoring efforts by USGS also continued annually from 2002–06.

In 2007 and 2008, the U.S. Geological Survey, Western Ecological Research Center (USGS-WERC), with assistance from collaborators, continued efforts to maintain long-term studies of Cassin's Auklets on Prince Island and Scorpion Rock for the purpose of evaluating success of Montrose Settlements Restoration Plan (MSRP 2005) restoration actions. Herein, we summarize data and activities from visits to Scorpion Rock and Prince Island during spring to summer, 2007 and 2008. Specifically, we report on: (1) condition and occupancy among nest sites, clutch initiation, hatching success, fledging success, and overall breeding success among artificial Cassin's Auklet burrows at both colonies (we also summarize auklet reproductive success information from previous research and monitoring efforts during 2006); (2) replacement of existing temporary and dilapidated artificial Cassin's Auklet nesting sites at Prince Island and Scorpion Rock, (3) temperature patterns among artificial and natural Cassin's Auklet burrow sites on Prince Island and Scorpion Rock, (4) experimental vegetation restoration treatments and native out-planting on Scorpion Rock, and (5) soil chemistry on Scorpion Rock.

## STUDY SITE, ACTIVITIES, AND METHODS

<u>*Site descriptions*</u>— Scorpion Rocks (34º05′N, 119º30′W, <1 ha, 15 m elevation), consist of two small islets (Scorpion Rock and Little Scorpion Rock) and two small rock pinnacles located off the northeast end of Santa Cruz Island (SCI) in close proximity to the Scorpion Ranch and the CINP campground. The two larger islets provide important nesting habitat for Cassin's Auklet, Xantus's Murrelet, Ashy Storm-Petrel, Pigeon Guillemot (*Cepphus columba*), Pelagic Cormorant (*Phalacrocorax pelagicus*), and Western Gull (*Larus occidentalis*). The largest of the islets, Scorpion Rock (**Fig. 2**), also provides important roosting habitat (and occasional, historical nesting habitat) for Brown Pelican (*Pelecanus occidentalis*), and roosting habitat for Brandt's Cormorant (*Phalacrocorax penicillatus*). Little Scorpion Rock (hereafter Little Scorpion), is surrounded by steep, friable volcanic sides—and is essentially inaccessible. Little Scorpion is well vegetated with native species including mature Giant Coreopsis (*Coreopsis gigantea*)[a], Cliff Aster (*Malacothrix saxatilis)*, and Sea Blite (*Suaeda taxifolia)*. Scorpion Rock is geomorphically much different in structure than Little Scorpion. Scorpion Rock is saddle-shaped, and slopes upward from the southeast to a highpoint, above cliff-edges that drop to the water along the west to northwest sides. Along with portions of the southern slope, the top, middle portion of Scorpion Rock has a substantial layer of loamy, guanogenic soil that in 2007 supported seven native plant species (**Table 1**). Scorpion Rocks was at one time free from non-native, invasive plants. The earliest (only) known plant species list was compiled by Philbrick and Cummings in 1977 (**Table 1**).

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[a] All plant species are referred to upon first occurrence in the text by their full Common Name (*Genus species*); all references following the first occurrence in the text are *G. species*. Please see tables for reference.

The vegetated soil on Scorpion Rock provides burrowing habitat for nesting Cassin's Auklets. The first estimates of the numbers of burrow and crevice nesting seabirds indicate that in 1991, 546 Cassin's Auklets nested mostly in earthen burrows (Carter *et al.* 1992). In 2000, a maximum of 120 birds (probably fewer) occurred there (Adams 2008). Non-native, invasive Crystalline Ice Plant (*Mesembryanthemum crystallinum*: **Fig. 3**) currently poses the most significant threat to native plants, soil chemistry (increased soil salinity through time), and the viability of the Cassin's Auklet colony on Scorpion Rock. Dense mats of vegetative *M. crystallinum* can prevent auklets from accessing their burrows and the soil, thereby exposing birds to an increased risk of predation from Western Gull and Barn Owl (*Tyto alba*; J. Adams *unpubl. data & pers. obs.*). Seasonal desiccation of this annual weed releases concentrated salts to the soil; over time, soil salinity increases and potentially can prevent recolonization by certain native plants.

Prince Island (34º05′N, 120º20′W; 16 ha, 90 m elevation), located 2 km north of San Miguel Island, is a steep-sided island flanked with loose soils, boulders, and many rocky crevices. During the spring and summer, surrounding waters are seasonally enriched by coastal upwelling primarily north of Point Conception; flow is partially directed into and recirculated within the Santa Barbara Channel (Harms and Winant 1998). In contrast, Scorpion Rock is sheltered by the mainland from prevailing northwesterly winds during the spring and summer, and oceanographic influence from upwelling is more variable than at Prince Island. During the spring and summer, ocean conditions near Scorpion Rock generally are warmer and more stratified, whereas waters off Prince Island are cooler and more mixed.

*Artificial burrow replacement*— In the spring of 2007, a sample of the existing nest boxes (installed by USGS in 2000 & 2001; **Fig. 4**) were replaced with a new design (n = 5 on Scorpion Rock and n = 5 on Prince Island). New artificial burrows were constructed from 8-inch diameter landscape irrigation control valve cover (ICV) boxes (Carson Industries Model #809-4, green HDPE, **Fig. 5**). These ICV boxes were fit to a 0.5 m length of flexible corrugated ADS irrigation pipe to form a burrow-nest chamber unit. The ICV box and ADS flex pipe then were set into the ground and back filled such that the locking lid is level and 1.75 in above the ground surface. In August and September 2007, after breeding colony attendance by adults had ceased, we replaced the remaining USGS temporary artificial burrows on Scorpion Rock (N = 35) and Prince Island (N = 47). In addition, we replaced wooden CINP nest boxes (a.k.a., South Boxes [SBO] that were installed in 1984) on the southeast side of Prince Island (N = 25; **Fig. 6**).

*Cassin's Auklet monitoring*— In 2007 and 2008, USGS continued seabird monitoring efforts by collecting nest occupancy, reproductive success, and chick growth data, and banding of adult Cassin's Auklets captured at Scorpion Rock and Prince Island colonies. In 2007, we also obtained digital recordings of auklet vocalizations and provided these to L. Harvey (CINP) for use in play-back systems to be deployed on Santa Barbara Island in 2009. In 2007 and 2008, we assessed nesting activity for Cassin's Auklet among artificial nest boxes and artificial burrows on Prince Island and among artificial burrows on Scorpion Rock. Generally, we visited nest sites periodically throughout each nesting season (January through July). Although frequent visits to these colonies are desirable, logistic constraints limit the number of repeat visits to colonies. Colonies generally are visited approximately every two-weeks, weather permitting. We currently use artificial burrows for monitoring auklet occupancy and reproductive effort following methods detailed in Adams *et al*. (2004a). The use and evaluation of artificial nesting habitat for

auklets provides the necessary background for the evaluation, implementation, and monitoring of such structures during future restoration actions. Percent occupancy refers to the number of nest sites with evidence that they were visited by auklets (*e.g.*, sign of digging or trammeling, guano, or feathers) divided by the total number of sites and expressed as a percentage; clutch initiation is the total number of sites where an egg was laid; hatching success is the total number of eggs that hatched divided by the number of eggs laid; fledging success is the total number of chicks assumed to have fledged divided by number of hatched; and breeding success is the total number of fledged chicks divided by the number of eggs laid.

We measured chick mass (± 1.0 g) with 100- or 300-g spring scales, and maximum flattened wing length (±1.0 mm) with a ruler. If we did not observe the hatching date, we estimated chick age using the linear relationship between wing length and age calculated from a subset of our data that included chicks with known hatching dates (chick age in days = (FWC – 14.68)/2.25; $n = 64$, $r^2 = 0.93$, Adams et al. 2004a). We also used this equation to estimate hatching date by subtracting the chick's estimated age from the date on which the wing chord was measured. We calculated a "chick condition index" CCI as mass/wing-length among mostly feathered to fully feathered, pre fledging chicks. This value has not yet been related to chick survival or any other independent measure (*i.e.*, diet composition, blood values, etc.) but is reported here and is intended to be compared with similar values, and potentially other independent measures, during future studies.

Historic banding efforts used size 3 inkaloy bands (*e.g.*, prefix 1313- supplied under BBL Permit 22911 [Takekawa, USGS] and Permit 22539 [Martin, CINP]) from the USGS Bird Banding Laboratory (BBL), Patuxent, MD. BBL currently does not have any of this type of band remaining in inventory and in 2007 supplied size 3 hard metal bands (*e.g.*, prefix 1643- ) as replacements for the inklaloy bands. We ceased banding adults in 2008 after depleting our remaining 1313- bands, and when we first observed a 1643- band that would have potentially been too tight. Upon subsequent comparison, we determined that the internal diameter of the new hard metal bands was slightly smaller than the previously used and appropriately sized inkaloy bands. Because of potential risks associated with the smaller bands, we assumed precaution and did not attempt to band chicks in 2008. A request has been made to the BBL to evaluate this issue for future banding efforts[b].

*Nest site temperature*— In 2007 and 2008, we deployed 16 archival temperature recorders (ATRs; iButton DS1920, Maxim Integrated Products, Dallas Semiconductor, Dallas, TX) within auklet nest sites (artificial and natural sites) on Prince Island and Scorpion Rock. In 2007, ATRs were affixed to small hardwood blocks (10×10×2 cm) which were placed into the nest chambers of artificial burrows (Prince Island and Scorpion Rock) and approximately 0.75 m into natural burrows (Prince Island only). ATRs were pre-programmed to record temperature (°C) every 10 min continuously while deployed. In 2008, the hardwood blocks were replaced with plastic stakes that held the ATRs. Stakes with ATRs were inserted in the artificial burrow nest chambers approximately 5 cm above ground and to the side of the chamber ~10 cm from where the entrance tunnel meets the nest chamber. For natural burrow sites on Prince Island in 2008, ATRs were placed on the floor of the burrow approximately 0.75 m from the entrance (*i.e.*, similar to

[b] In 2009, CINP located 400 inkaloy 1313- bands, 200 of these (1313-80001 to 1313-80100 and 1313-90001 to 1313-90100) were provided to USGS for continued banding efforts in 2009.

placement of blocks in 2007). On subsequent visits after ATRs were deployed, we recorded whether the ATR had been buried or disturbed by visiting auklets. For analyses we used only data from ATRs that remained unburied and undisturbed.

*Native plant propagation*— To assist in plant palette selection for the re-vegetation effort, reference sites on Little Scorpion and SCI were examined and available historical information was collected. Coastal bluff plant communities on SCI and Little Scorpion Rock were evaluated to develop appropriate species assemblages for the restoration effort. Plant species were chosen that would provide quality habitat for nesting seabirds, had the ability to compete with the invasive species currently occupying the site, and could aid with soil stabilization. Herbarium records and collection notes from the Santa Barbara Botanic Garden (SBBG) were researched to help discern which species were present historically. Field notes from a collection trip to Scorpion Rocks conducted by Ralph Philbrick of the SBBG in August 1977 provided insight into species that were present then (**Table 1**).

Seeds for this project were collected on Scorpion Rock and SCI and grown in an on-island nursery facility (**Table 2**). The nursery is located in the central valley on SCI adjacent to the University of California (UC) Reserve. Seed collection trips for the 2008 growing season took place on: 10–11 October 2007, 8 January 2008, and 11–12 February 2008. Due to varying phenology among selected plant species, seeds also were collected opportunistically during monitoring and site restoration trips throughout the year (March–December 2008). All seeds were collected from source materials as close to Scorpion Rock as possible.

Plants were propagated from seeds sown on 12 January, 16 February, and 11 March 2008 in the SCI nursery facility (**Table 3**). Seeds were sown in a sterile Sunshine #5 sterile planting mix contained in 14×16×3.5 in wooden flats. Seedlings were transplanted into either 3.5 in nursery containers or D-27 tubes and held in these containers until the out planting date. The soil medium used for transplanting was a Sunshine #4 and #5 sterile planting mix. Plant propagation and nursery maintenance was managed by Growing Solutions (GS) and MSRP staff; several volunteer efforts (including groups from Santa Barbara City College, Santa Barbara High School, and Patagonia Inc.) assisted throughout the year.

The farther plants are grown from Scorpion Rock (*i.e.*, the mainland), the greater the potential for unwanted pest introductions. Plants, therefore, were grown in an on-island nursery to reduce logistical issues of plant transport and control for unwanted species introductions. Plants were regularly inspected for pests and overall health. Sterile soil medium and nursery containers (*e.g.*, pots, soil containers) were used to help reduce the potential for unwanted weed and pathogen introductions. Before transport from the nursery, all plants were inspected and fully submersed in water to examine for unwanted pests, specifically ants and aphids.

During the course of the growing season ants were noted around and in the nursery facility. Due to the presence of Argentine ants (*Linepithema humile)* on SCI, dialogue with CINP, UC Reserve, The Nature Conservancy (TNC), GS and UC Santa Barbara (UCSB) researchers was initiated to troubleshoot this issue. Monitoring within the nursery site was undertaken and samples of the ants were collected and identified with the help of the Santa Barbara Museum of Natural History (SBMNH) and Dr. Adrian Wenner (UCSB). Samples of ants occurring on

Scorpion Rock also were collected for identification. A recent Argentine ant survey on SCI showed no Argentine ants present in or near the nursery site (CINP and TNC *unpubl. data* 2009), however their range has extended slightly farther east from the UC reserve footprint towards the nursery (Coastal Restoration Consultants *pers. comm.* 2009). The ants identified within the nursery area and on Scorpion Rock were all native species: *Monomorium ergatogyna* and *Camponotus spp.* (identification to species is difficult and there are 7 species of this genus native to Santa Cruz Island; A. Wenner *pers. comm.* 2008). Ongoing monitoring of the nursery site is being conducted throughout the 2009 growing season.

*Scorpion Rock restoration site preparation*— A water storage and delivery system was established for Scorpion Rock prior to the fall 2008 outplanting. Initially ten 72-gal and two 135-gal *Fold-a-Tank* collapsible water storage containers were transported to the site. After developing multiple leaks in most containers caused by deer mouse (*Peromyscus maniculatus santacruzae*) damage, we replaced the water bladders with clean, 55-gal steel drums. A total of 17 drums and two collapsible tanks (1,200 gal total) comprise current water storage on Scorpion Rock (**Fig. 7**). Filling the tanks was accomplished by pumping water from four, 500-gal storage containers supplied by the CINP vessel *Ocean Ranger* through approximately 500 ft of 1.5 in fire hose. The hose diameter was reduced on Scorpion Rock into multiple lengths of 0.75-in garden hose to facilitate filling multiple containers simultaneously.

*Weather monitoring*— A small weather station (HOBO microstation #MAN-H21-002, Onset Computer Corporation, Bourne, MA) was installed prior to out-planting to record temperature, relative humidity, and rainfall. The station was mounted approximately 1 m from the ground surface to a metal post driven into the ground. Data were recorded every 3 min from 8 October 2008 to 12 December 2008 and every 30 min from 12 to 31 December 2008. Herein we report daily minimum and maximum temperature (°C), average daily percent relative humidity (%RH), and total daily rainfall (mm).

*Vegetation restoration study plots: a design for control and removal of non-native vegetation and for establishing base-line vegetation composition and percent cover*— We designed a randomized block analyses of variance (ANOVA) experiment to assess the efficacy of exotic vegetation control, native re-vegetation, and the effect of these treatments on soil quality (**Figs. 8–9**). This design was composed of 6, 15×15-m plots. Each plot contained 3, 5×5-m treatments (*control*, *manual removal + native out-planting*, and *desiccant + native out-planting*. Each treatment was replicated 3 times within each plot. Each control treatment was left unmodified, and each of the two removal treatments had the same out-planting regimen. In future analyses, effects of plots in ANOVAs will be blocked to control for potential inter-plot variability in environmental/soil conditions. The removal/control portion of this experiment constitutes 21% (900 of 4,300 $m^2$) of the total estimated vegetative area of Scorpion Rock (excluding the eastern gully, the southwest corner, and the southern bench areas). On 15 April 2008, we measured the initial pre-treatment vegetation composition and percent cover for each of the 54, 5×5-m treatment sub-plots. Within each sub-plot we measured the percent cover for each plant species, desiccated *M. crystallinum*, rock, bare soil, and presence of an artificial burrow. We used rope and or transect tapes to isolate each 5×5-m sub-plots and then used a 1×1-m reference quadrat to estimate percent cover for each species. If a species was present, but represented <1% cover we assigned a value of 1% so that its presence would be recorded. Total percent cover summed to

100% for each sub-plot. All plots were quantified by JA and DM. The remaining 79% of the vegetated portion of Scorpion Rock (*i.e.*, outside the experimental plots) was out-planted with natives on 22–24 September 2008 (see section below).

During 22–24 September 2008, native out-planting regimens consisted of randomly distributed (within 25 $m^2$ treatment sub-plots) assemblages of seven pre-determined species (**Fig. 9**). Species included a combination of plant forms (*i.e.*, mat-forming ground cover and mounding perennials). Species include: Alkalai Heath (*Frankenia salina*), *C. gigantea*, Island Buckwheat (*Eriogonum grande*), Santa Cruz Island Buckwheat (*E. arborescens*), California Saltbrush (*Atriplex californica*), Brewer's Saltbrush (*A. lentiformis breweri*), and *M. saxitalis* var. *implicate* (**Table 3**). For each 5×5-m sub-plot, there were 25, 1×1-m cells, each of which was planted with one member of this species assemblage (**Fig. 9**, **Appendix 1**). The out-plantings were in 3.5–4-in containers or dee cells (D-27). The target out-planting totals per species were: *F. salina* = 432 plants, *C. gigantea* = 180 plants, *E. grande* = 72 plants, *E. arborescens* = 72 plants, *Atriplex californica* = 36 plants, *A. lentiformis* = 36 plants, and *M. saxatilis* var. *implicate* = 72 plants. One infill planting to supplement for plants within experimental plots that exhibited early mortality was conducted 16–17 November, utilizing available species within the remaining palette (**Table 3**).

<u>*Non-experimental restoration out-planting*</u>— Vegetated areas outside the six experimental plots (~3,400 $m^2$) were supplemented with native out-planting according to remaining nursery plant availability (**Table 3**). Focal areas for non-experimental out-planting include the head and adjacent upslope margin of the eastern gully (**Fig. 10**), the southwestern corner area (**Figs. 11, 12**), and the southern bench of Scorpion Rock (**Fig. 12**). During May–June 2008, *M. crystallinum* was removed from the southwestern corner area. Out-planting density in the non-experimental areas was similar to that used in the experimental plots (approximately 1 plant $m^{-2}$). In addition to the species used in the experimental plots, we planted additional Lemonadeberry (*Rhus integrifolia*), Island Morning Glory (*Calystegia m. macrostegia*), and *S. taxifolia* (**Table 3**). Before out-planting, the southern bench along the southern perimeter was sparsely vegetated with *M. saxatilis* var. *implicate* and *F. salina.* We supplemented these natives with additional plants of these two species and also *R. integrifolia, S. taxifolia,* and *C. macrostegia.* The eastern upslope and drainage area were planted with California Sagebrush (*Artemisia californica*) and Giant Rye Grass (*Leymus condensatus*) to provide soil stability and slow water movement over this hardpan area. Areas between plots and the main drainage also were planted with available native species. Infill planting in non-experimental plot areas was conducted 16–17 November 2008 in locations that displayed relatively greater early mortality.

<u>*Soil chemistry*</u>— On 12 August 2008 we collected 3 sub-samples each ~500 ml (surface to 20 cm depth) from each treatment sub-plot (n = 162 samples, 54 treatment sub-plots, 6 plots). Sub-samples were collected using a metal bulb-core-planter and a hand trowel and were mixed to form one composite soil sample per sub-plot from each of the three sub-plot treatments (n = 54 total). Soil samples were analyzed by A&L Western Agricultural Laboratories, Modesto, CA. Parameters included organic matter, estimated nitrogen release, phosphorus (weak Bray and sodium bicarbonate-P), extractable cations (potassium, magnesium, calcium, and sodium), hydrogen, sulfate-S, soil pH, cation exchange capacity and percent cation saturation (computed), saturation percentage, soluble salts, sodium, calcium, magnesium, chloride, boron, carbonate,

bicarbonate, pH, sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP). Herein we report mean values for parameters among the three sub-plot treatments and among the six experimental plots. We tested for pre-vegetation control differences for major nutrients N (ppm) and P (ppm), percent organic material, and soluble salts (soil conductivity: mmhos $cm^{-1}$) among sub-plots (treatments), and plots using ANOVA. Values collected in 2008 are intended for comparison and further analysis to measure the effects of invasive plant removal and native re-vegetation on soil chemistry following repeat soil sampling in August 2011.

## RESULTS

*Cassin's Auklet artificial burrow replacement*— From 27 to 30 August 2007, and on 9 October 2007 we removed 45 of 47 temporary artificial burrows from the southeast slope of Prince Island. Two sites (AB28 and AB47) were not modified because sites were situated in rocky outcrops that were not amenable to replacement using the new Carson VCB design. We also removed all 25 existing plywood nest boxes from the southeast slope (SBO sites) and retrofit the existing plank structure with 2×12 and 2×4 untreated redwood retainers to hold soil surrounding new artificial burrows (SBO01 – SBO25) and soil down-slope below the new burrow entrances. We replaced all temporary artificial nest sites on Scorpion Rock (N = 35) on 11 October 2007. Nest-site locations on Prince Island and Scorpion Rocks were mapped and are provided in **Appendix 2**.

*Cassin's Auklet reproductive effort*— Currently, there are 35 artificial Cassin's Auklet burrows (AB sites) on Scorpion Rock, and in 2007 we located an additional 18 natural burrow sites (**Fig. 13**). Natural burrows are extremely fragile and the contents of these are not accessible, therefore we were only able to note occupancy (*i.e.*, signs including digging, foot prints, and feathers). Whereas egg-laying among Cassin's Auklets could not be directly verified on Prince Island in 2006, observations in the following spring (March 2007) indicated substantial egg abandonment had occurred with no evidence of hatching. Of the 18 total natural burrows on Scorpion Rock in 2007, 10 were occupied (in 2 of 10 we observed eggs, one of which was later abandoned); the remaining 8 sites were not occupied (2 of 8 collapsed during the 2007 season). In 2008, we monitored all 18 sites marked in 2007 and added one additional new site. Of the 19 total natural burrow sites in 2008, 5 appeared active, 3 were not active, and the remaining 10 sites had collapsed or had disappeared. In 2007 and 2008, we could not determine hatching or fledging among natural burrow sites. Occupancy among AB sites increased at Scorpion Rock from 6% in 2006, to 11% in 2007, and 60% in 2008 (**Table 4**). Auklets failed to lay eggs in 2006 and 2007 at Scorpion Rocks. In 2008, clutches were initiated in 29% of artificial nest sites, hatching success was 50%, and of eggs that hatched, 60% fledged chicks (**Table 4**). Ultimately breeding success in 2008 was 30% (**Table 4**). In 2007 and 2008, based on nest site occupancy among AB sites and natural burrows, we estimate a maximum breeding population of 28 and 62 birds, respectively on Scorpion Rock (values reflect double the number of occupied nest sites).

On Prince Island, there currently are 47 haphazardly-distributed AB sites (AB01–AB48; AB44 does not exist) and a single cluster of 25 uniformly-spaced artificial burrows that replaced the existing CINP southeast boxes (SBO01–SBO25; **Appendix 3**). Therefore, a total of 67 sites were monitored in 2007 and 72 sites were monitored in 2008. We report reproductive success

parameters for AB and SBO sites on Prince Island separately because we found differences in a previous study that likely resulted from breeding history and location differences between these two groups (Ackerman *et al.* 2004). Occupancy among AB sites increased at Prince Island from 60% in 2006, to 88% in 2007, and 100% in 2008 (**Table 4**). Auklets at Prince Island initiated clutches in 24% (2006), 38% (2007), and 100% (2008) of available AB sites (**Table 4**). Auklets at Prince Island, however, failed to hatch eggs in 2006 and 2007. In 2008, hatching success was 77%, and of eggs that hatched, 92% fledged chicks (**Table 4**). Ultimately breeding success among AB sites at Prince Island in 2008 was 70% (**Table 4**).

Occupancy among CINP boxes (SBO sites) at Prince Island (2006 & 2007) and new artificial burrows installed in 2008 to replace the CINP boxes (referred to in all years as SBO sites) displayed a similar trend as found among the AB sites. Occupancy among SBO sites increased at Prince Island from 36% in 2006, to 52% in 2007, and 100% in 2008 (**Table 5**). Auklets initiated clutches in 24% (2006), 20% (2007), and 48% (2008) of available Prince Island SBO sites (**Table 5**). Auklets in SBO sites on Prince Island also failed to hatch eggs in 2006 and 2007. In 2008, hatching success was 83%, and of eggs that hatched, 90% fledged chicks (**Table 5**). Ultimately breeding success among new SBO sites at Prince Island in 2008 was 36% (**Table 5**).

*Cassin's Auklet chick growth*—No chicks survived to fledge in 2007. We did not measure chicks often enough to calculate accurate growth rates among individuals during the linear growth phase, however, we estimated a "chick condition index" (CCI: mass/wing length for mostly to fully feathered chicks) that may prove useful when compared to past or future data. CCI at Prince Island was 1.16 ± 0.03 S.E. (n = 30). We did not measure any chicks at Scorpion Rocks that were mostly to fully feathered.

*Nest site temperature*— Because we intended to maximize our ability to measure variability among the diversity of nest sites on Prince Island and Scorpion Rock, a limited number of ATRs and low sample sizes among burrow categories precluded statistical analyses. During 2007 and 2008, we recorded continuous temperatures for 28 ± 9 days primarily between late May and late June in 25 sites on Prince Island (2007 and 2008; **Table 6**) and Scorpion Rock (2007 only; **Table 6**). The absolute minimum (maximum) burrow temperatures averaged from 13.2 to 16.0 °C (21.4 to 34.3 °C) according to nest site category (AB sites, SBO sites, or natural burrows; **Table 6**, **Fig. 14**). Among burrow categories, there was more variability in maximum temperatures (**Fig. 14**). Natural burrows on Prince Island had the lowest maximum temperatures at 21.4 °C in 2007 and 27.4 °C in 2008. In both years, greatest maximum temperatures were recorded in AB sites on Prince Island, with sites in 2008 displaying slightly warmer maximum temperatures on average (**Fig. 14**). Natural burrows on Prince Island displayed the least daily temperature variability (average daily SD ~1.0 °C), followed by newly replaced (2008) SBO sites on Prince Island (average daily SD ~1.6 °C), and AB sites on Scorpion Rock and Prince Island (average daily SD = 2.3 to 2.4 °C; **Fig. 14**).

*Western Gulls on Scorpion Rock*— Western Gulls continued to nest on Scorpion Rock in 2007 and 2008. On 1 June 2008, 21 nests were counted and 6 of 21 had initiated hatching. One nest contained one egg, 6 nests contained two eggs/chicks, and 14 nests contained three eggs/chicks. We were not able to estimate hatching success or fledging success in 2008. In 2008, we continued to count the remains of depredated/scavenged Western Gulls. On 6 March we counted

remains from two sub-adults; on 15 April we counted the remains from 4 adults and 4 juveniles, and 12 August we counted remains from 2 hatch-year gulls.

Vegetation restoration study plots— On 15 April 2008, 96 ± 6% of the vegetative cover within vegetation restoration study plots on Scorpion Rock was composed of seven exotic species, mostly vegetative and desiccated *M. crystallinum*, 63% cover), Cheeseweed (*Malva parviflora*), 14% cover), Nettle-leaf Goosefoot (*Chenopodium murale*), 17%), and Brome Grass (*Bromus diandrus*) and Foxtail (*Hordeum murinum*; together <1%; **Table 7, Figs. 15–20**). In addition, there was an isolated patch of Kikuyu Grass (*Pennisetum clandestinum*) located along the southwestern edge of Scorpion Rock outside the survey area. Seven native plant species were present (including *S. taxifolia* which was not encountered within the survey area; **Table 7**). For vegetative *M. crystallinum*, plots located on the south-facing slope (plots 1–4) had significantly greater cover than north-facing plots (plots 5–6; ANOVA, $F_{5,48\,(0.05)} = 16.75$, $P < 0.0001$, Tukey's post-hoc multiple comparisons $P < 0.005$, **Fig. 21a**). For desiccated *M. crystallinum*, we observed the opposite trend (with the exception of plot 1); south-facing plots (plots 2–4) had significantly less desiccated *M. crystallinum* cover than the two north facing plots and plot 1 (ANOVA, $F_{5,48\,(0.05)} = 6.06$, $P < 0.0001$, Tukey's post-hoc multiple comparisons $P < 0.05$, **Fig. 21b**). Percent cover of introduced *C. murale* was different between plots 3 and 6 (ANOVA, $F_{5,45\,(0.05)} = 3.91$, $P = 0.005$, Tukey's post-hoc multiple comparison $P = 0.002$, **Fig. 21c**). There were no differences in percent cover for *M. crystallinum*, desiccated *M. crystallinum*, or *C. murale* among treatment sub-pots within plots (ANOVAs $P > 0.05$).

Experimental removal (*manual removal + native out-planting* treatment) was initiated on 5–6 May and 1–2 June 2008. We removed, by hand-pulling, non-native vegetation (primarily *M. crystallinum*) from 18 sub-plots. When removed *M. crystallinum* was fully vegetative and removed entirely from each sub-plot to prevent releasing its salt load back into the soil upon desiccation. Total removal of *M. crystallinum* left soils unprotected against rain and wind, therefore we covered bare ground among *manual removal + native out-planting* treatments with BioNet[c] erosion control material (**Fig. 22**). Out-planting within experimental treatment sub-plots was conducted from 22–24 September 2008 (an annotated slideshow documenting restoration out planting can be viewed online at http://birdmam.mlml.calstate.edu/jalbum/ ). Infill planting conducted on 16–17 November within the experimental plots replaced 46 plants within plots 1–3 and 5 (**Table 3**). This represented about a 5% replacement of plants, with the highest mortality recorded in the eastern-most plots 1 and 5.

Soil chemistry— Complete soil chemistry analyses reports are provided in **Appendix 4**. Major nutrients, soil composition, and soil chemistry varied throughout the experimental plots on Scorpion Rock (**Tables 8**, **9**). On 12 August 2008 we found significant differences in phosphorus concentration among plots (ANOVA: $F_{5,36} = 4.364$, $P = 0.003$, **Fig. 23a**) Maximum phosphorus concentration occurred in plots 1–4 (range in mean [P] = 254.1–265.0 $\mu g\ g^{-1}$) and the least amount of phosphorus occurred in plot 6 (182.1 ± 12.7 $\mu g\ g^{-1}$ S.E.). There were no significant

[c] C125BN™ Double Net Coconut Blanket (North American Green http://www.bionetblankets.com/products.php ) features a 100% coconut fiber matrix stitched with biodegradable thread between leno woven jute top netting and woven jute bottom netting. It is ideal for use in applications where vegetation will require 18 to 24 months for establishment, on slopes with a 1:1 or steeper gradient, and in high-flow channels, stream banks or shorelines.

differences among sub-plot treatments (mean $[NO_3]$ = 183.7 ± 13.0 μg $g^{-1}$ S.E., $F_{2,36}$ = 0.982, $P$ = 0.385) and the interaction was not significant ($P$ = 0.982). We found no significant differences in nitrate concentration among plots or sub-plot treatments (ANOVA: $F_{5,36}$ = 2.302, $P$ = 0.065, $F_{2,36}$ = 0.519, $P$ = 0.600; **Fig. 23b**) and the interaction was not significant ($P$ = 0.300). We found no significant differences in percent organic matter (arcsine transformed) among plots or sub-plot treatments (ANOVA: $F_{5,36}$ = 1.438, $P$ = 0.234, $F_{2,36}$ = 1.328, $P$ = 0.278) and the interaction was not significant ($P$ = 0.989). We found no significant differences in pH among plots or sub-plot treatments (ANOVA: $F_{5,36}$ = 1.557, $P$ = 0.197, $F_{2,36}$ = 0.589, $P$ = 0.560; **Fig. 23c**) and the interaction was not significant ($P$ = 0.467). We found no significant differences in soluble salts (conductivity: mmhos $cm^{-1}$) among plots or sub-plot treatments (ANOVA: $F_{5,36}$ = 1.941, $P$ = 0.112, $F_{2,36}$ = 0.422, $P$ = 0.659) and the interaction was not significant ($P$ = 0.794).

*Non-experimental out-planting*— Vegetated areas outside experimental plots also were out-planted with a variety of native species from 22–24 September 2008 (13 species, 825 plants; **Table 3**). Although it is too early to discern overall survivorship and many plants can be forced into dormancy by stress, plants on the eastern portion and exposed edges of Scorpion Rock appeared to have experienced greater mortality than those within interior locations. Approximate estimates of the non-experimental areas indicate a loss of at least 20% of the out-planted individuals. Early mortality seemed to affect all planted species with no particular species suffering the majority of the loss. Infill planting on 16–17 November replaced 35 plants in the eastern most section above the gulley and along the southern bench. This represents about a 4% replacement, however overall mortality likely will be greater. Locations in the interior of Scorpion Rock (*i.e.*, the southwestern corner and out-planted strips between experimental plots) had less plant mortality than the exposed areas (i.e., the east side, south bench, and western edge). Mouse damage also accounted for some plant loss, most notably *S. taxifolia*, *Atriplex californica* and *C. gigantea*. The *S. taxifolia* planted on the southern bench was completely defoliated, as were most *Atriplex californica* in the experimental plots. Several *C. gigantea* were girdled or gnawed substantially enough to cause complete mortality or loss of the main plant stem.

*Watering*— Plants were watered by hand during the out-planting effort 22–25 September and subsequently were watered approximately weekly through the end of November 2008. Watering dates post-out-planting included: 28 September, 7–8 October, 17 October, 21–23 October, 27 October, 7 November, 11 November, 16–17 November, 19 November and 25 November. Hand watering ceased after the first significant rainfall of 46.96 mm occurred (25–27 November 2008). There were a total of five water deliveries during fall. The first supply (approximately 450 gallons) was used for the initial out-planting effort. The next three water deliveries (totaling ~3,600 gal) were used entirely for watering the plants. Approximately 900 gal were cached for future use.

*Weather conditions monitored on Scorpion Rock*— Minimum and maximum daily temperatures were more variable during October through mid-November and then decreased in late November through December (**Fig. 24**). Warm events (max temperatures exceeding 25° C) occurred 5 times, and lasted from 2 to 6 days. Maximum recorded temperatures exceeded 30° C on four days: 15, 22–23 October and 16 November (**Fig. 24**). Daily average relative humidity varied throughout October to December 2008 (Fig. 19). Lowest %RH coincided with periods of greatest

maximum daily temperatures, and measurable rainfall (31 October, 1–2, 4, 25–27 November, and 15–18, 22, 24–25 December) coincided with periods when %RH generally exceeded 70% (**Fig. 25**)

## DISCUSSION

*Cassin's Auklet reproductive success and chick growth 2006–2008*— From 2006 to 2008, Cassin's Auklets on Scorpion Rock and Prince Island displayed parallel increasing trends in percent occupancy and percent of occupied sites where pairs initiated clutches. Whereas auklets at both sites failed to produce chicks in 2006 and 2007, 2008 marked a return to successful reproduction at both colonies, likely resulting from increased availability of sufficient zooplankton prey within the foraging range of provisioning parent auklets. Breeding success at Scorpion Rock remained relatively low (30%) compared with Prince Island (70%). We examined breeding success within the newly replaced CINP sites (SBO sites) separately because the pre-existing sites may have been functionally less available to auklets (*e.g.*, before 2008 when entrances were elevated >20 cm from the ground and nestboxes were fully exposed to direct sun; **Fig. 6**). Clutch initiation among SBO sites on Prince Island was less than half that in the AB sites that have been maintained and occupied to some degree continuously since 2000. During the first year after replacement, the new SBO sites revealed 100% occupancy. We expect that the percent of clutch initiation among the SBO sites will increase in the future as these sites now are fully buried with entrances at ground level—conditions likely attractive to prospecting auklets and beneficial for pre-fledging chicks. Furthermore, once established, new or young breeding pairs may continue to occupy these breeding sites for multiple years with the likelihood that reproductive success will increase with increasing adult experience, enhanced chick survival, and recruitment. Future success, however, is contingent on sufficient prey availability during the winter non-breeding period and near the colonies during the summer.

*Artificial burrow replacement*— The new artificial burrow (AB) design has three distinct benefits over the previous temporary burrow sites installed on Scorpion Rock and Prince Island during 2000 and 2001: (1) the lids can not be dislodged by gulls, roosting pelicans, or the wind and thus provide the auklets with a more stable nest site; (2) unlike the previous nursery container design, the new design is open at the bottom ensuring that auklets are nesting on dirt/rock which is the case in natural burrows; and (3) the open bottom facilitates drainage and gas exchange thereby contributing to a more natural nesting environment. Furthermore, this new design is less conspicuous than the previous artificial burrows. The 25 CINP nest boxes and 4×12 in plank on the northeast side of Prince Island (*i.e.*, NBO sites) currently are in a state of disrepair and have been historically difficult or impossible to monitor safely. These NBO sites remain, and pose no significant threat to nesting auklets or the environment and are not currently scheduled for removal. On Scorpion Rock, artificial burrows provide critical nesting habitat for auklets that may still experience hindered access to soil (due to erosion control materials and remaining *M. crystallinum*). Given 100% occupancy and high fledging success (90–92%) among replaced AB sites and new SBO sites on Prince Island in 2008, these new sites appear suitable for continued long-term monitoring efforts, provided continued annual maintenance efforts (*i.e.*, clear entrances and nest chambers of blocking debris, modify lids, *etc.*). Despite excellent results thus far among artificial burrows, the current design could be improved. First, on several occasions

auklets have burrowed out of the nesting chamber making it difficult or impossible to determine contents (J. Adams & D. Mazurkeiwicz *pers. obs.* 2009). In most cases, the burrows where auklets tunneled beyond the nesting chamber were closed off and backfilled prior to egg-laying. To ensure that auklets do not tunnel beyond the nest chambers, one solution would be to add a 2–3 inch layer of gravel mixed with dirt (collected on site) to the chamber floor. Second, although the lids of the burrow chambers were originally painted white to reflect solar heating, the painted surface (smooth HDPE) has shown to form a poor bond with the plastic enamel originally used. To better ensure that lids can better reflect heat and best insulate chambers, lids should be retro-fitted with painted HardieBacker® 500 cement board or pre-cast concrete valve box covers. Both these improvements should be accomplished after the nesting season (August-September 2009) or before nesting is initiated (January 2010).

In 2007 and 2008, we observed for the first time artificial burrows designed for Cassin's Auklets on Prince Island that were occupied by Xantus's Murrelets. In 2007, site AB28 was occupied by a murrelet after 18 June as evidenced by a post-hatched (based on examination of shell membrane) eggshell fragment found on 27 August. Earlier in the season this site was occupied by auklets who abandoned incubation by 22 May. In 2008, this site was again occupied by auklets between 6 March and 6 May with a scavenged egg found on 28 May. On 12 and 28 June this site contained a single abandoned murrelet egg. A second site (AB34) was occupied by incubating auklets between 6 March and 6 May (failed to hatch their egg), and then for an unknown period after 12 June by an incubating murrelet. Successful breeding by murrelets at AB34 was not determined, but will be assessed based on return visits in March 2009. Both sites with murrelets were located on the steep, east-facing slope of Prince Island approximately 10 to 15 m above the waterline. Occupation and reproductive attempt within these sites indicate that with appropriate design considerations, Xantus's Murrelets will use artificial nest sites. In fact, several artificial sites placed on Santa Barbara Island in 1999 (Wolf et al. 1999) were used by murrelets since 2007 (L. Harvey *unpubl. data*). Attempts to attract murrelets to artificial nest sites may facilitate restoration actions or may facilitate annual monitoring of reproduction for this species.

Evaluation of adaptive management actions and restoration success for auklets at Scorpion Rock (and at other sites in the CINP) will require a continued assessment of the inherent variability in reproductive effort and subsequent success among Cassin's Auklet at Scorpion Rock and Prince Island colonies. Prince Island, the largest auklet colony in southern California, serves as a reference (*i.e.*, control-comparison) to evaluate interannual trends in population response to variable oceanographically linked prey availability. Differences in reproductive effort and ultimately, chick growth and reproductive success among auklets nesting at Prince Island and Scorpion Rock likely reflect differences in foraging conditions experienced by provisioning adults at each colony (Adams *et al*. 2004b).

*<u>Cassin's Auklet nest site temperatures</u>*— Given the limited accessibility of natural burrow sites on Prince Island, it is difficult to install temperature loggers in the actual nest chambers as was possible among artificial nest sites. Natural burrow sites displayed lower maximum temperatures and lower daily variability in temperature compared with AB sites. There were no apparent differences among the minimum temperatures recorded among the different sites (AB sites, SBO sites, and natural burrows); however, variability among daily minimum temperatures appeared

lesser among natural burrow sites. The slightly lower maximum temperatures recorded among the newly replaced SBO sites compared with the artificial burrow sites likely resulted from these being more insulated from solar heating resulting from better soil coverage. Although we did not investigate the effect of temperature maxima or variability on chick growth and development, successful reproductive output among auklets inhabiting artificial sites indicates that temperatures experienced by nesting auklets did not appreciably impact breeding success. Average maximum burrow temperatures (27.4–34.3 °C) are approximately equivalent to temperatures measured by time-depth-recorders attached to adults while attending nest sites during night (J. Adams *unpubl. data*). The slightly elevated maximum temperatures in 2008 may reflect elevated burrow temperatures among sites occupied by adults and chicks (sites were empty during 2007 after auklets failed to breed). The maximum temperature recorded in artificial burrow AB07 (36.7 °C) resulted from this site's unique exposed location. Future visits should ensure that all artificial nest sites are well insulated from direct sun. We will conduct additional temperature logger deployments among artificial nest sites on Prince Island and Scorpion Rock during 2010, following vegetation restoration on Scorpion Rock and additional suggested modifications to artificial burrow lids.

*Restoration experimental plots*— Baseline (pre-restoration) vegetative cover among plots was dominated by vegetative *M. crystallinum,* desiccated *M. crystallinum* and *C. murale.* Significant differences in the percent cover of vegetative *vs*. dessicated *M. crystallinum* indicates that conditions for growth of this species in plots 5 and 6 (north facing) differ from those in plots 1–4 (south facing). Although there is less *C. murale* in plot 6, this species appears less sensitive with respect to location. In a pre-restoration state and given the relative homogeneity of pH levels and soluble salts across plots, we suggest that compositional differences relate to exposure to sun, perhaps to nutrient levels (*i.e*., phosphorous levels are less in plots 5 and 6, likely due to the propensity for Brown Pelicans to roost within or in proximity to plots 1–4), or some combination of unknown factors. We expect that salinity levels should decrease (in comparison with control treatments) after *M. crystallinum* is removed from plots. *M. parviflora* also comprises a greater proportion of the non-native vegetation coverage in north-facing plots 5 and 6 compared with plots on the south facing slope (plots 1–4). Because *M. crystallinum* is very sensitive to shading, early growth of *M. parviflora* and/or *C. murale* in 2008 may have prevented significant vegetative growth in the former species. The relative consistency across both plots and experimental sub-plots among major nutrients (N, P) and soil condition (pH, %OM, and soluble salts) reflects uniform conditions that existed on Scorpion Rock before *M. crystallinum* was manually removed in 2008. In order to measure the effect of *M. crystallinum* on the soil condition, recruitment of native vegetation, and interannual variability in the response of *M. crystallinum* to fluctuating environmental conditions—remaining control plots (*i.e*., totaling 450 $m^2$ or 10% of the total vegetated cover on Scorpion Rock) should be retained until summer–fall 2010, and then restored, based on information gathered regarding the best combination of native plant species with the greatest effect on *M. crystallinum* and natural auklet recruitment associated with restored native plants.

After completing baseline vegetation surveys, greater than 800 $m^2$ of vegetative *M. crystallinum* was removed from experimental sub-plot treatments and adjacent non-experimental areas. BioNet erosion control material was not needed within spray plots, because out-planting

occurred within existing pre-treatment desiccated vegetation. We decided that the desiccated vegetation would provide protection against erosion during winter rain events.

<u>*Outplanting status*</u>— The conditions during fall 2008 were particularly challenging for the establishment of the plants on Scorpion Rock. High temperatures, low humidity, minimal soil moisture and frequent Santa Ana conditions into late November made for harsh transplanting conditions. These factors probably contributed to the higher rate of mortality observed on the eastern exposed side of the Rock and southern edges (D. Mazurkiewicz *pers. obs.*). Mouse damage and subsequent plant mortality accounted for the loss of some plants, most notably those that were succulent or had accessible moisture (*C. gigantea*, *S. taxifolia*, and *Atriplex californica*). Available food resources for the mice population were at a minimum at this time of the year (late summer–early fall) and some of the out plantings were consumed or damaged. Whereas a later planting date could have alleviated some of these issues, logistical constraints and sea conditions could also have easily prevented the out-planting effort. The current estimates of plant mortality rates (20–30%) are within acceptable levels for ultimate restoration success. Frequent fall watering was necessary to keep the plants alive and was also an asset to allow deeper moisture penetration when the first significant rain arrived. Post storm soil probing on 30 December 2009 showed soil moisture at 20–25 cm depths near planted locations.

Rains in November and December 2008 brought relief to the new plantings; however, it has also exposed some of the issues with weed species on the rock (**Fig. 26**). Due to the non-native seed bank present, weed control will need to be continued frequently throughout the site. Eradication of invasive plants within the 18 control sub-plots (*i.e.*, 450 $m^2$ or 10% of the total vegetated area) should wait until summer–fall 2010; the benefits of retaining the control plots will provide needed insight into the control of these non-native species. Evaluation of the biological and physical impact of *M. crystallinum* on Scorpion Rock would not be possible without maintaining and tracking the control sub-plots. The rainfall that has occurred to date has underscored the need to further address the erosion issues in the eastern gully area on Scorpion Rock (**Fig. 27**).

<u>*Soil chemistry*</u>— We hypothesize that active removal of *M. crystallinum* and restoration of native perennials will alter soil chemistry. The soil conditions present on Scorpion Rock are determined by constant exposure to salty air, high deposition of acidic and nutrient-rich Brown Pelican guano, and net positive salination from the annual cycle of growth–salt-concentration–salt-dumping (upon desiccation), from the island's formerly dominant *M. crystallinum* cover. Soil salinity, pH, and nutrient loading likely influence the ability of certain native plant species to persist and recruit successfully. Physical qualities of the soil such as hydration and compaction also are important factors that can impact certain native plant recruitment and the ability of auklets to excavate effective, stable burrows for nesting. These physical soil attributes likely are modified by vegetation. For example, emergent vegetation promotes fog-drip thereby increasing soil hydration during the summer; root growth increases soil permeability and hydration, and reduces compaction. Roots also hold soil and reduce the potential for erosion, thereby increasing the stability and persistence of subterranean auklet burrows.

<u>*Cassin's Auklet on Scorpion Rock*</u>— With the removal in 2008 of more than 800 $m^2$ of vegetative *M. crystallinum* within and outside experimental restoration plots, auklet nesting habitat disturbance on Scorpion Rock from this non-native, invasive weed now poses a reduced

threat to prospecting and breeding adult auklets. Early prospecting among auklets visiting Scorpion Rock in December–January 2009, before peak vegetation occurred, combined with the continuation of weed suppression in spring 2009, also may have lessened the potential effects of *M. crystallinum* on auklets. During the past several years, thick vegetative growth of this weed has completely overtopped burrows and appears to prevent auklets from accessing the soil surface, existing natural burrows, and entrances to artificial burrows. Evidence of depredation in March 2006 (auklet heads and wing sets) may have resulted from Peregrine Falcon (*Falco peregrinus*) returning to the island after catching auklets at sea (J. Adams *pers. obs.*), or from Barn Owls taking individuals that attended the colony at night. Auklets can seek refuge from their nocturnal predators if they can rapidly access non-obstructed burrow entrances. The early arrival of auklets in 2009, combined with continuing weed suppression, may have allowed prospecting auklets to successfully excavate burrows before *M. crystallinum* achieved significant vegetative growth.

Long-term monitoring of individual nest sites is rare; both time series analyses and before-after impact/restoration analyses greatly benefit from continuous data without gaps. Continuing information regarding breeding effort, occupancy, nesting success, diet, predation, adult survival, sub-adult recruitment, and nesting habitat modification are important management priorities for CINP. Continued research in 2009 and beyond is essential because such efforts precede full implementation of planned restoration actions on Scorpion Rock and Santa Barbara Island to enhance nesting habitat for auklets and murrelets (*e.g.*, provide improved nesting habitat, control and eradicate invasive plants, and restore native and endemic vegetation). Successful restoration of seabirds by resource managers (*i.e.*, CINP and Montrose Trustees) can be achieved by improving nesting habitat and increasing reproductive output and survival. These actions also will benefit the Scorpion Rock nesting-island ecosystem. With support from collaborators, previous USGS data and renewed 2009 cooperative studies will provide ability to document, monitor, and evaluate continuing restoration actions—and overall restoration success.

Adams (2008) identified several conservation and restoration actions for Cassin's Auklets in California. Future efforts (2009–2011) to restore and evaluate auklet habitat and native plant community structure on Scorpion Rock likely will benefit if research and management staff:

(1) Maintain current efforts to quantify breeding biology parameters for Cassin's Auklets at Prince Island and Scorpion Rock with visits throughout the breeding season. An attempt should be made to space visits such that nest sites are monitored at no greater than 2-week intervals. Parameters include: breeding phenology, site occupancy, clutch initiation, hatching success, and fledging success. Additional archived information includes chick growth, and adult condition, and re-sighting of banded individuals over time which is required for estimating survival and breeding histories;

(2) Improve capability to monitor natural auklet burrows on Prince Island and Scorpion Rock through the use of video burrow scopes. Improve the capacity for more non-invasive techniques for monitoring recapture events using Radio Frequency ID (*e.g.*, subcutaneous PIT tags) that can be scanned without accessing the nest chamber or handling adult birds. A switch to this technology would alleviate the need to locate the appropriately sized bands which are currently not available from the USGS Bird Banding Laboratory.

(3) Evaluate thermal (Parish 1990) and/or chemical weed control as an inexpensive, non-labor-intensive method to prevent rapid, extensive vegetative growth of *M. crystallinum* during the late winter–early spring 2009. Thermal techniques are ideally suited for Scorpion Rock. Native vegetation can be marked in advance and therefore protected during treatment. Thermal techniques deplete the seed bank without disrupting the fragile soil layer which could easily be disturbed by manual pulling of weeds and subsequently facilitate rapid loss of top soil by eolian or hydrologic erosion;

(4) Continue to supplement Scorpion Rock in 2009–2010 with native vegetation (propagated locally from local seeds collected on adjacent rocks or mainland Santa Cruz Island) and continue to use sterile cover vegetation or material as needed to facilitate native recovery, prevent erosion, and improve soil condition (*i.e.*, moisture retention) to benefit burrowing alcids;

(5) Further develop outreach and education to inform CINP, CINMS, and recreational concession personnel (*e.g.*, Island Packers, kayak companies) of the importance of preserving and enhancing seabird habitat on Scorpion Rock. These people can then better inform the tens of thousands of visiting public who come to Santa Cruz Island each summer about unique and important seabirds and habitats within CINP and CINMS; and

(6) Develop methods to prevent the reintroduction of additional weeds to Scorpion Rock by researchers, restoration personnel, and resource managers.

(7) Initiate restoration of experimental control plots using best methods developed in **Phase I** beginning in summer–fall 2010 after final vegetation surveys and soil chemistry sampling (August 2010).

(8) Conduct post-restoration plot mainance and vegetation surveys for 2–3 years following outplanting completion (2011–2013).

(9) Continue Cassin's Auklet monitoring at Scorpion Rock and Prince Island for a minimum of 3 years after restoration completion (2014) to assess ultimate success of the Montrose Restoration Program.

*Ashy Storm-Petrel on Scorpion Rock*— Ashy Storm-Petrel is a difficult species to monitor. Although thought to nest throughout the Channel Islands primarily in inaccessible cliff areas, talus slopes, and sea caves, current monitoring of reproductive success is restricted to several accessible sea caves along the northern side of Santa Cruz Island. Whereas continued monitoring of focal nests at Orizaba Rock and in sea caves is important, maintaining mistnet and mark-recapture studies will provide additional independent information related to the status of the species within the CINP. Mist-netting efforts should continue within the Channel Islands for several reasons: (1) at most sites, nests are difficult to find or impossible to access. Mist-net capture-recapture is one of the only effective methods for assessing population size and trends over time (Carter *et al*. 1992; Sydeman *et al*. 1998). (2) At present, no nests are accessible on Scorpion Rocks to monitor and mist-net monitoring is the only method available for measuring population fluctuations (*i.e.*, changes from restoration actions). (3) Mist netting data are directly comparable to similar, continuous and long-term studies at Farallon Islands, and thereby provide insight to potentially contrasting trends across the species' range. (4) Catch Per Unit Effort

(CPUE) provides an independent, robust metric related to colony area attendance patterns both within seasons and across multiple years, and therefore may be useful for future trend analyses and as a covariate to explain variability in nesting success. (5) Capture of individuals provides the opportunity to assess individual's body condition (*i.e.*, mass scaled to body size, feather condition, proportion of non-breeders, *etc*.). (6) Information from mist-netting can inform and help evaluate social attraction for restoration enhancement (*i.e.*, sex-specific attraction to broadcast vocalizations). And (7), mark-recapture analyses eventually can be used to estimate sub-adult/adult survival—the most important demographic parameter influencing population growth (lambda) among long-lived, slowly maturing, and low-fecundity seabirds.

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## LITERATURE CITED

Ackerman J.T., J. Adams, J.Y. Takekawa, H.R. Carter, D.L. Whitworth, S.H. Newman, R.T. Golightly, and D.L. Orthmeyer. 2004. Effects of radio transmitters on repro-ductive performance of Cassin's Auklets. Wildlife Society Bulletin 32: 1229–1241.

Adams, J. 2008. Cassin's Auklet (*Ptychoramphus aleuticus*). *In*: W.D. Shuford, and T. Gardali (Eds.). California Bird Species of Special Concern.2006: a ranked assessment of species,

subspecies, and distinct populations of birds of immediate conservation concern in California. Studies in Western Birds 1.

Adams, J. 2004. Foraging ecology and reproductive biology of Cassin's Auklet *Ptychoramphus a. aleuticus* in the California Channel Islands. Unpublished M.Sc. thesis, Moss Landing Marine Laboratories, Moss Landing, California; and San Francisco State University, San Francisco, California

Adams, J. and Takekawa, J. Y. 2008. At-sea distribution of radio-marked Ashy Storm-Petrels *Oceanodroma homochroa* captured on the California Channel Islands. *Marine Ornithology* 36:9–17.

Adams, J., J.Y. Takekawa, and H.R. Carter. 2004a. Stable foraging areas and variable chick diets: Insight to ocean variability and reproductive success of Cassin's Auklet in the California Channel Islands, 1999–2001. Can. J. Zool. 82: 1578–1595.

Adams, J., J.Y. Takekawa, and H.R. Carter. 2004b. Foraging distance and home range of Cassin's Auklets nesting at two colonies in the California Channel Islands. Condor 106: 618–637..

Adams, J., J.Y. Takekawa, and H.R. Carter. 2000. Foraging distribution and movement patterns of Cassin's Auklets nesting at Prince Island, California, in 2000. Pages 88–117 *In*: D.L. Orthmeyer, H.R. Carter, J.Y. Takekawa, and R.T. Golightly (Eds.). At-sea distribution of seabirds and marine mammals in the Southern California Bight. Unpublished progress report, U.S. Geological Survey, Western Ecological Research Center, Dixon and Vallejo, California; and Humboldt State University, Department of Wildlife, Arcata, California.

Adams, J., J.Y. Takekawa, H.R. Carter, and J. Yee. *In press*. Factors influencing the at-sea distribution of Cassin's Auklets (*Ptychoramphus aleuticus*) breeding among the Channel Islands, California. *The Auk*.

Carter, H.R., G.J. McChesney, D.L. Jaques, C.S. Strong, M.W. Parker, J.E. Takekawa, D.L. Jory, and D.L. Whitworth. 1992. Breeding populations of seabirds in California, 1989–1991. Volume I – Population Estimates. Unpublished draft final report, U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Dixon, California.

Harms, S., and C. D. Winant. 1998. Characteristic patterns of the circulation in the Santa Barbara Channel. Journal of Geophysical Research 103:3041–3065.

Hunt, G.L., Jr., R.L. Pitman, M. Naughton, K. Winnet, A. Newman, P.R. Kelly, and K. T. Briggs. 1979. Summary of marine mammal and seabird surveys of the Southern California Bight area 1975–1978. Volume III: investigators reports. Part III. Seabirds. Book II. Reproductive ecology and foraging habits of breeding seabirds. Unpublished report, University of California, Institute of Marine Sciences, Santa Cruz, California.

Hunt, G.L., Jr., R.L. Pitman, and H.L. Jones. 1980. Distribution and abundance of seabirds breeding on the California Channel Islands. Pages 443–459 *In*: D.M. Power (Ed.). The California Islands: proceedings of a multidisciplinary symposium. Santa Barbara Museum of Natural History, Santa Barbara, California.

Hyrenbach, K.D., and R.R. Veit. 2003. Ocean warming and seabird communities of the southern California Current System (1987–98): response at multiple temporal scales. Deep-Sea Research II 50(14–16): 2537.

Ingram, T. 1992. Seabird monitoring in Channel Islands National Park, 1990. Unpublished report, Channel Islands National Park Natural Resource Report CHIS-92-001, Ventura, California.

Ingram, T., and D. Jory-Carter. 1997. Seabird monitoring, Channel Islands national Park, 1991–1992. Unpublished report, Channel Islands National Park Technical Report 96-08, Ventura, California.

Jahncke, J., B.L. Saenz, C.L. Abraham, C. Rintoul, R.W. Bradley, W.J. Sydeman. 2008. Ecosystem responses to short-term climate variability in the Gulf of the Farallones, California. Progress in oceanography 77:182-193

Lewis, D.B., and F. Gress. 1988. Seabird monitoring in the Channel Islands National Park, 1986. Unpublished report, Channel Islands National Park Natural Science Report 88–002, Ventura, California.

Mason, JW, GJ McChesney, WR McIver, HR Carter, JY Takekawa, RT Golightly, JT Ackerman, DL Orthmeyer, W Perry, JL Yee, MO Pierson, and MD McCrary. 2004. At-sea Distribution and abundance of seabirds off southern California: a 20-year comparison. Studies in Avian Biology No. 33: 101 pp.

McGowan, J.A., D.R. Cayan, and L.M. Dorman. 1998. Climate-ocean variability and ecosystem response in the northeast Pacific. Science 281: 210–217.

Montrose Settlements Restoration Program. 2005. Final restoration plan and programmatic environmental impact statement, and environmental impact report. Unpublished report, Montrose Settlements Restoration Program, National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, National Park Service, California Department of Fish and Game, California Department of Parks and Recreation, and California State Lands Commission.

Peterson, W.T., and F.B. Schwing. 2003. A new climate regime in the northeast Pacific Ocean. Geophys. Res. Let. 30(17): 1896.

Parish, S. 1990. A review of non-chemical weed control techniques. Biological Agriculture and Horticulture 7: 117–137.

Sydeman, W.J., Bradley, R.W., Warzybok, P., Abraham, C.L., Jahncke, J., Hyrenbach, K.D., Kousky, V., Hipfner, J.M., Ohman, M.D., 2006. Planktivorous auklet (Ptychoramphus aleuticus) responses to the anomaly of 2005 in the California Current. Geophysical Research Letters 33, L22S09. doi:10.1029/2006GL026736.

Sydeman W.J., N. Nur, E.B. McLaren, and G.J. McChesney. 1998. Status and trends of the Ashy Storm-Petrel on Southeast Farallon Island, California, based upon capture-recapture analyses. Condor 100: 438–447.

Whitworth, D. L., J. Y. Takekawa, H. R. Carter, S. H. Newman, T. W. Keeney, and P. R. Kelly. 2000. At-sea distribution of Xantus's murrelets (*Synthliboramphus hypoleucus*) in the Southern California Bight. *Ibis* 142: 268-279.

Wolf, S., Roth, J. E., Sydeman, W. J., and P. L. Martin. 1999. Population Size, Phenology And Productivity Of Seabirds On Santa Barbara Island, 1999. Unpublished technical report #CHIS 00-02 to Channel Islands National Park.

## TABLES

**Table 1.** Species list of native and non-native plants known to occur on Scorpion Rocks, on adjacent mainland, and including native species propagated in the UC Reserve nursery on Santa Cruz Island. Plant species used in restoration out-planting on Scorpion Rock are indicated in **bold**.

| Common name | Scientific name[1,*] | Alpha Code | Native? | Propagated? |
|---|---|---|---|---|
| **Giant Coreopsis** | ***Coreopsis gigantea*[1,*,†]** | **COGI** | **Yes** | **Yes** |
| **Lemonade Berry** | ***Rhus integrifolia*[1,*,†]** | **RHIN** | **Yes** | **Yes** |
| **Island Buckwheat** | ***Erigonum grande*** | **ERGR** | **Yes** | **Yes** |
| **Santa Cruz Island Buckwheat** | ***Erigonum arborescens*** | **ERAR** | **Yes** | **Yes** |
| **Cliff Aster** | ***Malacothrix saxatilis* var. *implicata*[1,*,†]** | **MASA** | **Yes** | **Yes** |
| Seaside Daisy | *Erigon glaucus*[†] | ERGL | Yes | No |
| Emory's Rock Daisy | *Perityle emoryi*[†] | PEEM | Yes | No |
| Succulent Lupine | *Lupinus succulentus*[1] | LUSU (LUSP) | Yes | No |
| Alkali Heath | *Frankenia salina*[1,*,†] | FRSA | Yes | Yes |
| Soap Root | *Chenopodium californicum*[1] | CHCA | Yes | Yes |
| Nettle-leaf Goosefoot | *Chenopodium murale*[1,*,†] | CHMU | No | — |
| Goosefoot | *Chenopodium ambrosioides* (?)[1] | CHAM (CHSP-SM) | No | — |
| **Island Morning Glory** | ***Calystegia macrostegia*[1,*,†]** | **CAMA** | **Yes** | **Yes** |
| Wild Cucumber | *Marah macrocarpus*[†] | MAMA | Yes | No |
| Crystalline Iceplant | *Mesembryanthemum crystallinum*[1,†] | MECR | No | — |
| Sow Thistle | *Sonchus spp.* [†] | SOSP | No | — |
| Brome Grass | *Bromus diandrus*[1] | BRDI | No | — |
| Foxtail/Barley | *Hordeum murinum*[1] | HOMU | No | — |
| Kikuyu Grass | *Pennisetum clandestinum*[1] | PECL | No | — |
| Filaree | *Erodium botrys*[1] | ERBO | No | — |
| Cheeseweed | *Malva parviflora*[1] | MAPA(MALV) | No | — |
| **Sea Blite** | ***Suaeda taxifolia*[1,*,†]** | **SUTA** | **Yes** | **Yes** |
| **Brewer's Saltbush** | ***Atriplex lentiformis breweri**[†]** | **ATLE** | **Yes** | **Yes** |
| **California Saltbush** | ***Atriplex californica*[*,†]** | **ATCA** | **Yes** | **Yes** |
| Australian Saltbrush | *Atriplex semibaccata*[†] | ATSE | No | — |
| **Giant Rye Grass** | ***Leymus condensatus**[†]** | **LECO** | **Yes** | **Yes** |
| **California Sagebrush** | ***Artemisia californica*[2]** | **ARCA** | **Yes** | **Yes** |
| **Yarrow** | ***Achillea millefolium*[2]** | **ACMI** | **Yes** | **Yes** |
| Green's Dudleya | *Dudleya greenei*[†] | DUGR | Yes | No |

[1] Recorded on Scorpion Rock in 2008.
* Recorded on Scorpion Rock by Philbrick & Cummings in Junak *et al.* 1995.
[2] Recorded on adjacent mainland area – no record from Scorpion Rock, propagated in GS Nursery.
[†] Recorded on Scorpion Rocks by Ralph Philbrick (SBBG) 21 August 1977.

**Table 2.** Species sown for the Scorpion Rock Restoration Project. Seeds for this project were collected on SCI and grown in the UC Reserve nursery facility.

| CODE | Botanical Name | Common Name | Source |
|---|---|---|---|
| ACMI | *Achillea millefolium* | Yarrow | Scorpion Bluffs |
| ARCA | *Artemisia californica* | California Sagebrush | Scorpion |
| ATCA | *Atriplex californica* | California Saltbush | Scorpion |
| ATLE | *Atriplex lentiformis* | Quailbush | Yellow Banks |
| CAMA | *Calystegia macrostegia* | Island Morning-glory | Scorpion |
| COGI | *Coreopsis gigantean* | Giant Coreopsis | Pelican trail |
| COGI | *Coreopsis gigantean* | Giant Coreopsis | Scorpion |
| ERAB | *Eriogonum arborescens* | SCI Buckwheat | Scorpion |
| ERGR | *Eriogonum grande* | Island Buckwheat | Scorpion |
| FRSA | *Frankenia salina* | Alkali Heath | Scorpion |
| LECO | *Leymus condensatus* | Giant Rye Grass | Scorpion |
| LODE | *Lotus dendroides* | Island Deerweed | Scorpion |
| MASA | *Malacothrix saxitilis* var. *implicata* | Cliff Malacothrix | Yellow Banks/Scorpion Ranch |
| RHIN | *Rhus integrifolia* | Lemonadeberry | Scorpion Ranch |
| SUTA | *Suaeda taxifolia* | Sea Blite | Scorpion Ranch |

**Table 3.** Native plant species propagated in the UC Reserve nursery on Santa Cruz Island. Included are total numbers grown for initial plantings in both experimental plots and non-experimental areas. Also shown are total numbers and species used for infill in both experimental plots and in non-experimental areas.

| | | **Experimental Plots** | | **Non-experimental Areas** | | | |
|---|---|---|---|---|---|---|---|
| **Native Out-planting Species** | | **Initial Plantings** | **Infill Plantings** | | **Initial Plantings** | **Infill Plantings** | |
| **Scientific Name** | **Common Name** | **3.5–4" pot** | **Mixed Containers** | **Tree Tube** | **2, 3.5–4" Pot** | **Mixed Containers** | **Totals** |
| *Achillea millefolium* | Yarrow | | | | 27 | 5 | **32** |
| *Artemesia californica* | California Sagebrush | | 4 | 40 | 32 | 36 | **112** |
| *Atriplex californica* | California Saltbush | 36 | | | 12 | | **48** |
| *Atriplex lentiformis* | Quailbush | 36 | 11 | | 84 | 13 | **144** |
| *Calystegia macrostegia* | Island Morning-glory | | | 4 | | 5 | **9** |
| *Chenopodium californicum* | Soaproot | | | 20 | | | **20** |
| *Coreopsis gigantea* | Giant Coreopsis | 180 | 7 | 147 | 54 | 44 | **432** |
| *Erigonum grande* | Island Buckwheat | 72 | 13 | | 163 | 41 | **289** |
| *Erigonum arborescens* | SCI Buckwheat | 72 | 4 | | 20 | | **96** |
| *Frankenia salina* | Alkali Heath | 432 | 3 | | 67 | | **502** |
| *Leymus condensatus* | Giant Rye Grass | | | 60 | | 20 | **80** |
| *Malacothrix saxatilis* | Cliff Malacothrix | 72 | 4 | | 84 | | **160** |
| *Rhus integrifolia* | Lemonadeberry | | | 53 | | 7 | **60** |
| *Suaeda taxifolia* | Sea Blite | | | | 90 | 22 | **112** |
| | **Totals** | **900** | **46** | **324** | **633** | **192** | **2096** |
| | | | | | Total planted Sept 2008 | | **1811** |
| | | | | | Remaining for infill (Nov-March) | | **285** |
| | | | | | Planted for infill (Nov-March) | | **192** |
| | | | | | Nursery mortality | | **-93** |
| | | | | | **Total out-planted 2008-09** | | **2003** |

**Table 4.** Summary of breeding effort parameters for Cassin's Auklets nesting within artificial burrows on Prince Island and Scorpion Rock in 2006, 2007, and 2008. Results from southeastern Prince Island CINP SBO sites are reported separately in **Table 5**. Values in parentheses are actual numbers observed.

| | **Prince Island** | | | **Scorpion Rock** | | |
|---|---|---|---|---|---|---|
| | **2006[a]** | **2007** | **2008** | **2006** | **2007** | **2008** |
| # Sites | 42 | 42 | 47 | 35 | 35 | 35 |
| % occupied | 60% (25) | 88% (37) | 100% (47) | 6% (2) | 11% (4) | 60% (21) |
| % initiated (egg laid) | 24% (10) | 38% (16) | 100% (47) | 0 | 0 | 29% (10) |
| Hatching success (eggs hatched / eggs laid) | 0 | 0 | 77% (36) | — | 0 | 50% (5) |
| Fledging success (chicks fledged / eggs hatched) | — | — | 92% (33) | — | 0 | 60% (3) |
| Breeding success (chicks fledged / eggs laid) | 0 | 0 | 70% (33) | 0 | 0 | 30% (3) |

[a] Estimates of percent occupancy and initiation in 2006 at Prince Island are based on very limited observations during this year and the documentation of abandoned eggs on 15 March 2007 (these likely were laid during the 2006 season). Furthermore, 6 of the 42 sites observed in 2006 had nest chamber lids that were dislodged or blown off completely; therefore, occupancy and initiation estimates should be interpreted accordingly.

**Table 5.** Summary of breeding effort parameters for Cassin's Auklets nesting within CINP Southeast Boxes (SBO) on Prince Island (2006, 2007, and 2008). Values in parentheses are actual numbers observed.

| | **Prince Island** | | |
|---|---|---|---|
| | **2006[a]** | **2007[a]** | **2008** |
| # Sites | 25 | 25 | 25 |
| % Occupied | 36% (9) | 52% (13) | 100% (25) |
| % Initiated (egg laid) | 24% (6) | 20% (5) | 48% (12) |
| Hatching success (eggs hatched / eggs laid) | 0 | 0 | 83% (10) |
| Fledging success (chicks fledged / eggs hatched) | — | — | 90% (9) |
| Breeding success (chicks fledged / eggs laid) | 0 | 0 | 36% (9) |

[a] Values in 2006 and 2007 are from original nest boxes installed by CINP in 1984. 2008 values are from new artificial burrow sites that replaced the park boxes during late-summer 2007. Estimates of percent occupancy and initiation in 2006 at Prince Island are based on very limited observations during this year and the documentation of abandoned eggs on 15 March 2007 (these likely were laid during the 2006 season). Furthermore, 2 of the 25 sites observed in 2006 had nest chamber lids that were dislodged or blown off completely; therefore, occupancy and initiation estimates should be interpreted accordingly.

**Table 6.** Nest site temperature recorded among natural, artificial, and SBO sites on Prince Island (2007, 2008) and among artificial burrows on Scorpion Rock (2007). Shown are island, site, ATR number, analysis period, minimum temperature (°C), maximum temperature (°C), and the average daily SD of temperature (°C), and variance in the average SD of temperature (in parentheses).

| Island | Site | ATR | Analysis Period | Min | Max | Ave Daily SD (variance) | Comments |
|---|---|---|---|---|---|---|---|
| Prince | AB03 | TL3741 | 5/23/07–6/17/07 | 13.6 | 30.2 | 3.4 (0.9) | buried/reset on 4/24, 5/22; OK on 6/18 |
| Prince | AB10 | TL3A41 | 4/10/07–5/21/07 | — | — | — | partially buried on 5/22, buried on 6/18 |
| Prince | AB12 | TL3141 | 5/23/07–6/17/07 | 14.2 | 28.2 | 2.3 (0.5) | Buried on 5/22; OK on 6/18 |
| Prince | AB15 | TL1241 | 5/23/07–6/17/07 | 14.2 | 28.7 | 2.9 (0.4) | Buried 4/24, OK 5/22, 6/18 |
| Prince | AB20 | TLDF41 | 4/10/07–4/23/07 | 10.7 | 32.2 | 4.9 (1.0) | OK |
| Prince | NB11 | TL1541 | 5/23/07–6/17/07 | 16.2 | 21.2 | 2.3 (0.5) | OK 5/22, 6/18 |
| Prince | NB629 | TL2D41 | 5/23/07–6/17/07 | 15.1 | 18.6 | 0.5 (0.01) | Buried 4/24, OK 5/22, 6/18 |
| Prince | NB634 | TL7641 | 5/23/07–6/17/07 | 14.7 | 19.2 | 0.6 (0.01) | Kicked out 4/24, OK 5/22, 6/18 |
| Prince | NB716 | TLAC41 | 4/10/07–6/17/07 | 12.6 | 26.6 | 0.4 (0.1) | OK 5/22 |
| Scorpion | AB03 | TL 4841 | 5/22/07–6/18/07 | 13.6 | 24.6 | 2.2 (0.4) | Empty OK |
| Scorpion | AB11 | TL F241 | 5/22/07–6/18/07 | 13.6 | 27.6 | 2.3 (0.6) | Empty, buried 5/21, OK 6/19 |
| Scorpion | AB12 | TL 4041 | 5/22/07–6/18/07 | 13.6 | 31.6 | 2.0 (0.4) | Empty |
| Scorpion | AB33 | TLB441 | 5/22/07–6/18/07 | 13.1 | 28.2 | 2.6 (0.6) | Empty, partly buried 5/21, OK 6/19 |
| Scorpion | AB36 | TLFE41 | 5/22/07–6/18/07 | 13.2 | 25.2 | 2.4 (0.4) | Empty OK |
| Scorpion | AB39 | TLA341 | 4/26/07–5/6/07 | — | — | — | Empty, partly buried 5/6, buried 5/21, 6/19 |
| Prince | AB37 | TL3141 | 5/30/08–6/27/08 | 15.2 | 34.2 | 2.1 (0.5) | MGC on 5/29 |
| Prince | AB39 | TL4041 | 5/30/08–6/27/08 | 15.6 | 33.1 | 2.1 (0.5) | LGC on 5/29 |
| Prince | AB41 | TL4841 | 5/30/08–6/27/08 | 16.1 | 33.1 | 1.8 (0.5) | SGC on 5/29 |
| Prince | AB07 | TL3A41 | 5/30/08–6/27/08 | 13.2 | 36.7 | 3.4 (0.9) | Dead NHC on 5/28 |
| Prince | NB01 | TL2D41 | 5/30/08–6/27/08 | 15.1 | 23.6 | 0.3 (0.03) | |
| Prince | NB629 | TL9341 | 5/30/08–6/27/08 | 14.2 | 29.7 | 0.7 (0.06) | |
| Prince | NB634 | TLDF41 | 5/30/08–6/27/08 | 14.7 | 23.7 | 0.5 (0.03) | |
| Prince | NB710 | TL3741 | 5/30/08–6/27/08 | 13.6 | 32.7 | 1.4 (0.7) | |
| Prince | NB716 | TLAC41 | 5/30/08–not recovered | — | — | — | not recovered |
| Prince | SBO01 | TLF241 | 5/30/08–6/27/08 | 17.1 | 29.6 | 1.1 (0.2) | MGC |
| Prince | SBO03 | TL1241 | 5/30/08–6/27/08 | 17.2 | 30.7 | 1.5 (0.2) | LDC |
| Prince | SBO05 | TLFE41 | 5/30/08–6/27/08 | 16.7 | 28.2 | 1.3 (0.2) | empty |
| Prince | SBO13 | TL1541 | 5/30/08–6/27/08 | 15.2 | 31.7 | 2.0 (0.4) | Empty |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Prince | SBO19 | TLA941 | 5/30/08–6/27/08 | 14.1 | 31.7 | 1.8 (0.3) | MDC |
| Prince | SBO23 | TL7641 | 5/30/08–6/27/08 | 15.7 | 31.2 | 1.7 (0.3) | MGC |

**Table 7**. Percent cover of native (bold type) and non-native vegetation among experimental restoration plots on Scorpion Rock before restoration. Shown are plot number, treatment type (A = control, B = manual removal + outplanting, C = desicant spray + outplanting) and plant species (BRDI, Bromus diandrus; CAMA, Calystegia macrostegia; CHCA, Chenopodium californicum; CHSP, Chenopodium murale; CHSP-SM also C. murale; COGI, Coreopsis gigantea; DESMES, dessicated Mesembryanthemum crystallinum; FRSA, Frankenia salina; HORD, Hordeum murinum; LUSP, Lupinus succulentus; MALV, Malva parviflora; MASA, Malacothrix saxatilis var. implicata; MECR, Mesembryanthemum crystallinum). Total percent cover less than 100% reflects the presence of soil, rock, and artificial nest boxes (cover values not shown).

| | | **Plant Species** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Plot** | **Treatment** | BRDI | **CAMA** | **CHCA** | CHSP | CHSP-SM | **COGI** | DESMES | **FRSA** | HORD | **LUSP** | MALV | **MASA** | MECR | **Total** |
| 1 | A | 0 | 0 | 0 | 16 | 0 | 0 | 48 | 0 | 0 | 0 | 4 | 0 | 28 | 96 |
| | B | 0 | 0 | 0 | 18 | 0 | 0 | 47 | 0 | 0 | 0 | 6 | 0 | 25 | 96 |
| | C | 0 | 0 | 0 | 7 | 0 | 0 | 47 | 0 | 0 | 0 | 4 | 0 | 33 | 92 |
| 2 | A | 0 | 0 | 0 | 14 | 0 | 0 | 24 | 0 | 0 | 0 | 6 | 1 | 54 | 99 |
| | B | 0 | 0 | 0 | 10 | 0 | 0 | 22 | 0 | 0 | 0 | 7 | 0 | 59 | 99 |
| | C | 0 | 0 | 0 | 23 | 0 | 0 | 27 | 0 | 1 | 0 | 4 | 0 | 44 | 99 |
| 3 | A | 0 | 0 | 1 | 31 | 0 | 1 | 23 | 0 | 1 | 0 | 1 | 0 | 42 | 99 |
| | B | 0 | 0 | 0 | 30 | 1 | 0 | 20 | 0 | 0 | 0 | 7 | 0 | 41 | 99 |
| | C | 0 | 0 | 0 | 31 | 3 | 0 | 16 | 1 | 2 | 0 | 6 | 0 | 41 | 100 |
| 4 | A | 2 | 27 | 0 | 8 | 1 | 0 | 22 | 2 | 4 | 0 | 6 | 0 | 27 | 99 |
| | B | 0 | 6 | 3 | 16 | 1 | 0 | 10 | 6 | 9 | 0 | 9 | 0 | 38 | 98 |
| | C | 1 | 0 | 3 | 8 | 1 | 0 | 24 | 5 | 9 | 0 | 8 | 0 | 39 | 97 |
| 5 | A | 0 | 0 | 0 | 22 | 0 | 1 | 56 | 0 | 0 | 0 | 13 | 0 | 5 | 96 |
| | B | 0 | 0 | 0 | 23 | 0 | 1 | 48 | 0 | 0 | 0 | 21 | 0 | 4 | 97 |
| | C | 0 | 0 | 0 | 18 | 0 | 1 | 50 | 0 | 0 | 0 | 24 | 0 | 2 | 96 |
| 6 | A | 0 | 0 | 0 | 9 | 0 | 1 | 41 | 0 | 2 | 0 | 41 | 0 | 3 | 97 |
| | B | 0 | 0 | 0 | 5 | 0 | 2 | 45 | 0 | 1 | 0 | 44 | 0 | 2 | 99 |
| | C | 0 | 0 | 0 | 7 | 1 | 1 | 55 | 0 | 0 | 0 | 29 | 0 | 5 | 98 |

**Table 8.** Soil chemistry (major nutrients, composition, & chemistry) among experimental plots on Scorpion Rock 12 August 2008 including: Phosphorous (P), Nitrogen ($NO_3$), percent organic matter (OM), estimated nitrogen release (ENR), soil pH, and soluble salts (electrical conductivity [EC]). Sample size per plot: *n* = 9, total sample size: N = 54. Values are mean (S.E.).

| | Major Nutrients, Composition, & Chemistry | | | | | |
|---|---|---|---|---|---|---|
| **Plot** | **P (µg g$^{-1}$)** | **$NO_3$ (µg g$^{-1}$)** | **OM (%)** | **ENR** | **pH** | **EC (mmhos cm$^{-1}$)** |
| 1 | 265.0 (12.0) | 242.5 (43.9) | 7.3 (1.0) | 44.5 (2.0) | 4.5 (0.1) | 4.0 (0.4) |
| 2 | 254.1 (19.2) | 153.7 (31.1) | 7.4 (0.2) | 44.7 (0.4) | 4.7 (0.1) | 2.7 (0.3) |
| 3 | 259.6 (6.3) | 141.9 (26.6) | 6.6 (0.3) | 43.2 (0.7) | 4.6 (0.1) | 2.6 (0.4) |
| 4 | 264.5 (18.4) | 142.7 (18.2) | 7.8 (0.7) | 45.7 (1.3) | 4.8 (0.1) | 3.0 (0.4) |
| 5 | 203.0 (21.3) | 190.4 (27.5) | 6.5 (0.5) | 42.9 (0.9) | 4.6 (0.1) | 3.1 (0.3) |
| 6 | 182.1 (12.7) | 231.2 (27.0) | 6.0 (0.3) | 42.0 (0.5) | 4.7 (0.1) | 3.5 (0.4) |
| **Total** | 238.2 (7.6) | 183.7 (13.0) | 6.9 (0.2) | 43.8 (0.5) | 4.7 (0.04) | 3.1 (0.2) |

**Table 9.** Soil chemistry (Cations and micronutrients, µg g$^{-1}$) among experimental plots on Scorpion Rock 12 August 2008 including: potassium (K), magnesium (Mg), calcium (Ca), sodium (Na), sulfur (S), zinc (Zn), manganese (Mn), iron (Fe), copper (Cu), and boron (B). Sample size per plot: *n* = 9, total sample size: N = 54. Values are mean (S.E.).

| | Soil Cations | | | | Soil Micronutrients | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Plot** | **K** | **Mg** | **Ca** | **Na** | **S** | **Zn** | **Mn** | **Fe** | **Cu** | **B** |
| 1 | 1405.8 (88.8) | 228.5 (34.5) | 1129.1 (71.0) | 278.9 (13.9) | 106.7 (16.4) | 6.6 (1.7) | 8.4 (2.0) | 90.5 (11.3) | 0.6 (0.06) | 0.8 (0.03) |
| 2 | 1447.4 (83.8) | 162.2 (15.7) | 1182.0 (95.2) | 212.6 (31.8) | 87.9 (11.9) | 5.4 (0.9) | 14.9 (1.6) | 102.0 (4.8) | 0.5 (0.05) | 0.8 (0.04) |
| 3 | 1608.6 (75.3) | 163.0 (8.8) | 1160.4 (72.1) | 294.8 (41.3) | 95.8 (11.7) | 4.0 (0.8) | 17.0 (1.1) | 98.8 (5.4) | 0.5 (0.06) | 0.7 (0.04) |
| 4 | 1498.1 (58.5) | 190.1 (14.2) | 1520.6 (129.7) | 217.6 (32.7) | 118.4 (14.9) | 5.6 (0.9) | 19.4 (2.4) | 88.0 (6.1) | 0.5 (0.05) | 0.7 (0.05) |
| 5 | 1858.7 (129.2) | 191.1 (22.8) | 1002.1 (65.5) | 469.1 (42.3) | 62.3 (9.5) | 3.1 (0.5) | 16.9 (2.5) | 107.3 (3.9) | 0.7 (0.1) | 0.9 (0.03) |
| 6 | 2223.0 (88.9) | 241.2 (22.3) | 1182.1 (64.0) | 567.5 (68.1) | 70.7 (8.5) | 2.8 (0.3) | 22.1 (3.4) | 98.2 (4.3) | 0.7 (0.03) | 0.8 (0.08) |
| Total | 1673.6 (52.7) | 196.0 (9.3) | 1196.0 (39.9) | 340.1 (24.4) | 90.3 (5.5) | 4.6 (0.4) | 16.5 (1.1) | 97.5 (2.7) | 0.6 (0.03) | 0.7 (0.02) |

# FIGURES

**Figure 1.** Cassin's Auklet outside rock crevice nesting site on Prince Island.

**Figure 2.** West-facing aerial photo (16 April 2004) of Scorpion Rocks and adjacent mainland Santa Cruz Island (north is oriented toward the right).

**Figure 3.** Experimental study plot (grid is 5×5 m) showing dominant pre-restoration cover of Crystalline Ice Plant (*Mesembryanthemum crystallinum*; pale green) and Nettle-leaf Goosefoot (*Chenopodium murale*; darker green, erect vegetation).

**Figure 4.** USGS temporary artificial burrows were originally installed at Scorpion Rock and Prince Island in 2000 and 2001. The nesting chamber shown here on Scorpion Rock was constructed with a 3-gal nursery container fitted with a plywood lid and attached to a ADS flex-pipe burrow. Dominant vegetation here is desiccated *M. crystallinum* with emergent, green *C. murale*.


**Figure 5.** Newly replaced artificial burrows in 2007 (shown here on Prince Island) were constructed from 8-in diameter landscape irrigation control valve cover (ICV) boxes (Carson Industries Model #809-4, green HDPE). Chambers were fit to a 0.75-m section of ADS flex-pipe and backfilled to minimize solar heating.

**Figure 6.** In fall of 2007, we replaced wooden CINP nest boxes (top; a.k.a., South Boxes [SBO]) that were installed in 1984 on the southeast side of Prince Island with the Carson ICV design backfilled with soil held in place with redwood retainers.

**Figure 7.** Water was stored on Scorpion Rock using clean 55-gal water storage drums aligned along the central drainage of the island. Coco fiber waddles were contoured into the central drainage to slow erosive waterflow and trap sediment.

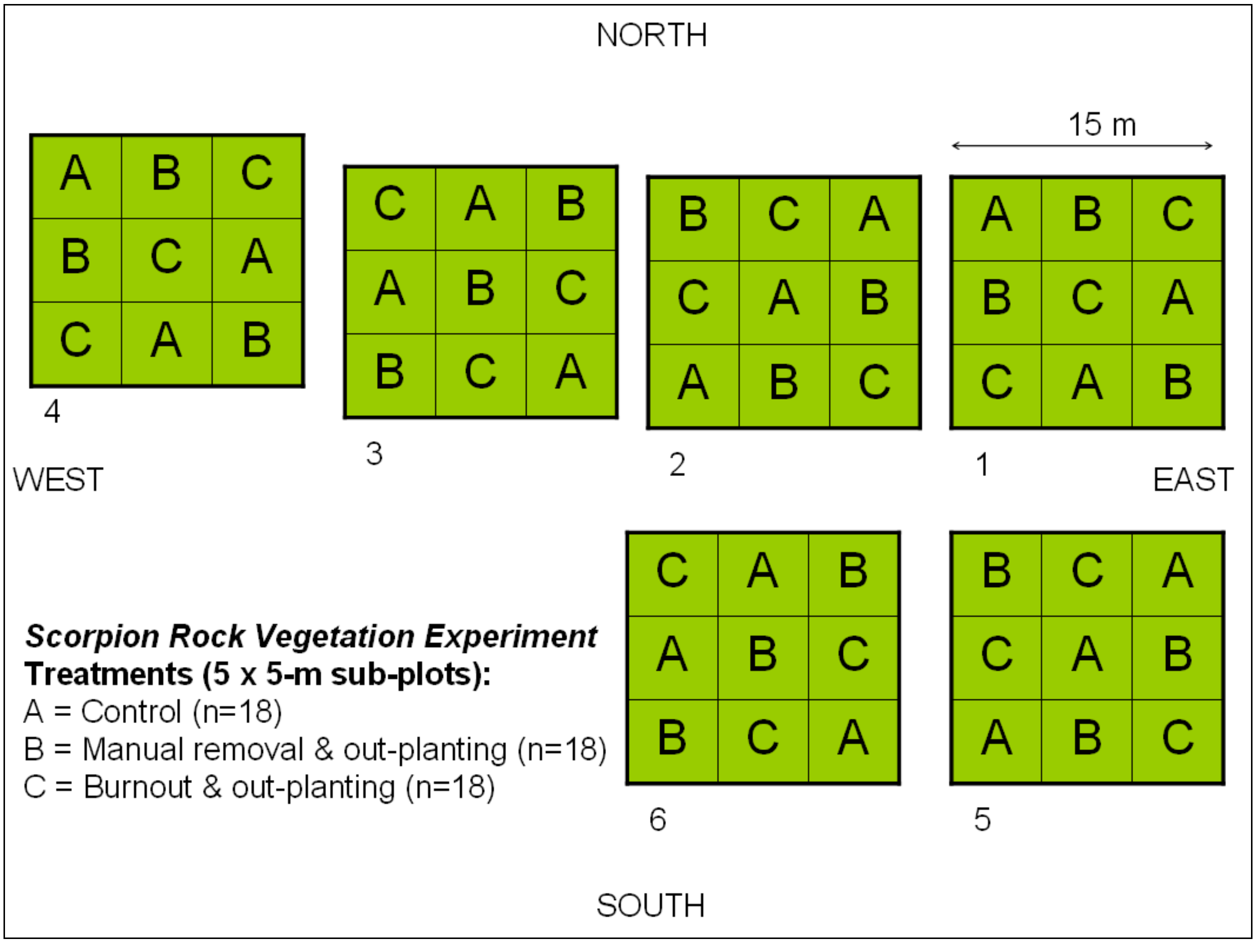


**Figure 8.** We designed a randomized block analyses of variance (ANOVA) experiment to assess the efficacy of exotic vegetation control, native re-vegetation, and the effect of these treatments on soil chemistry. This design was composed of 6, 15×15-m plots. Each plot contained 3, 5×5-m treatments (*control* [A], *manual removal + native out-planting* [B], and *desiccant + native out-planting* [C]). Each treatment was replicated 3 times within each plot.

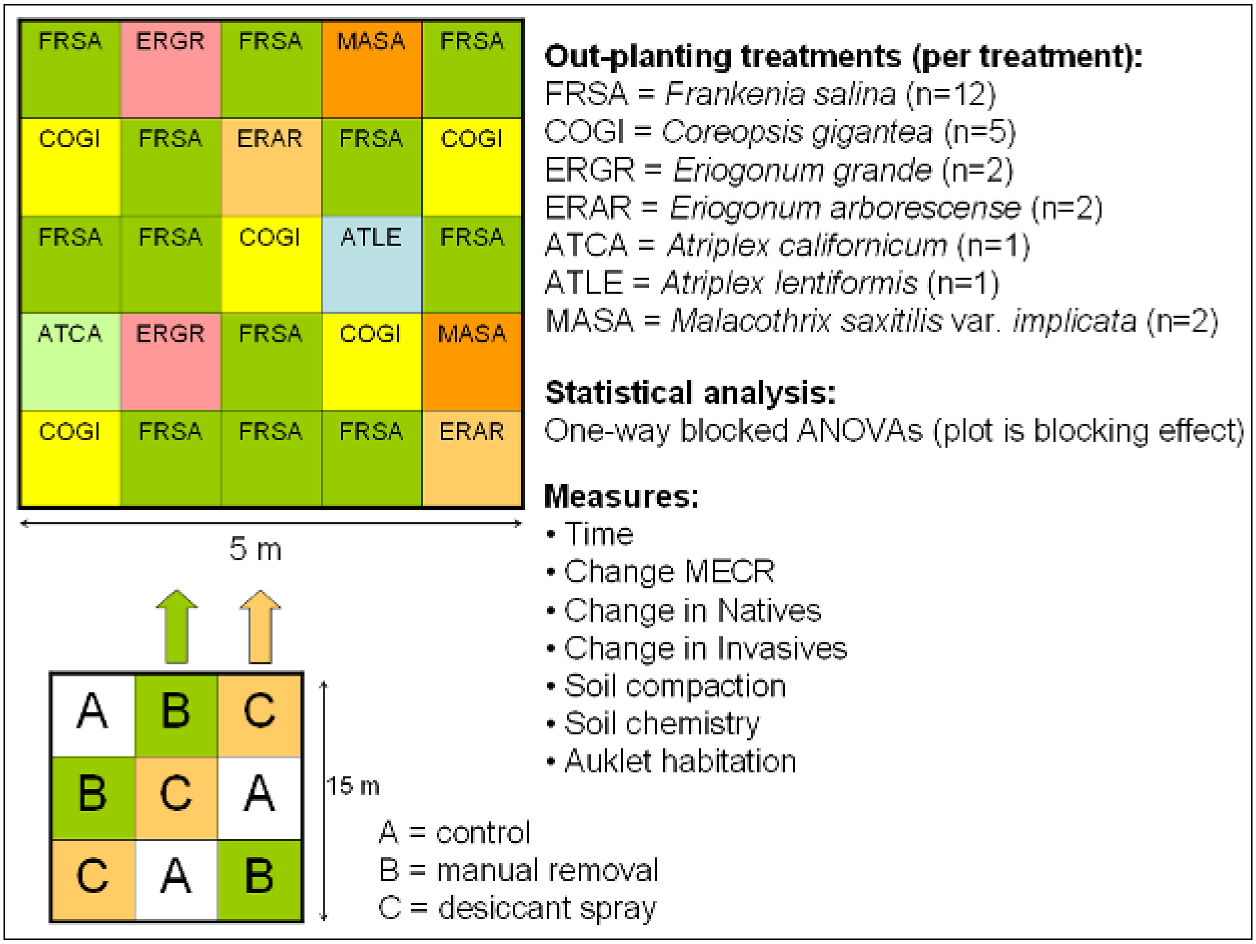


**Figure 9.** Native out-planting regimens consisted of randomly distributed (within 25 m$^2$ treatment sub-plots) assemblages of seven pre-determined species. Species included a combination of plant forms (*i.e.*, mat-forming ground cover and mounding perennials); species include: *Frankenia salina*, *Coreopsis gigantea*, *Eriogonum grande*, *E. arborescens*, *Atriplex californica*, *A. lentiformis, and M. saxitalis saxatilis* var. *implicate*.

**Figure 10.** Eastern gully area of Scorpion Rock on 25 April 2007. This area is the most subjected to winter erosion. Greatest amounts of soil are lost at the head where calving occurs during heavy winter rains. We are working to stabilize this erosion and to revegetate the steep sides and upslope areas with native perennials.

**Figure 11.** View looking toward the east over the central southwestern corner area of Scorpion Rock on 25 March 2006. Foreground shows remnant Lemonade Berry (*Rhus integrifolia*) skeletons to the left of a large native stand of Island Morning Glory (*Calystegia macrostegia*). Crystalline Ice Plant (*Mesembryanthemum crystallinum*) and Nettle-leaf Goosefoot (*Chenopodium murale*) are vegetative after winter rains. Cheeseweed (*Malva parviflora*) from the previous summer is fully desiccated (erect light-colored sticks, especially prevalent on the north-facing slope).

**Figure 12.** View looking east across the southwest corner and southern bench area of Scorpion Rock on 25 March 2006. Foreground shows a large native stand of Island Morning Glory (*Calystegia macrostegia*) flanked by emergent Crystalline Ice Plant (*Mesembryanthemum crystallinum*). Prior to restoration, the southwest corner and bench areas were dominated by introduced grasses, *M. crystallinum*, *C. murale*, and *M. parviflora*. These areas were targeted as non-experimental outplanting areas and in 2008 were subjected to weed control and native outplanting.

**Figure 13.** A natural Cassin's Auklet burrow in a stand of native Alkalai Heath (*Frankenia Salina*) on Scorpion Rock.

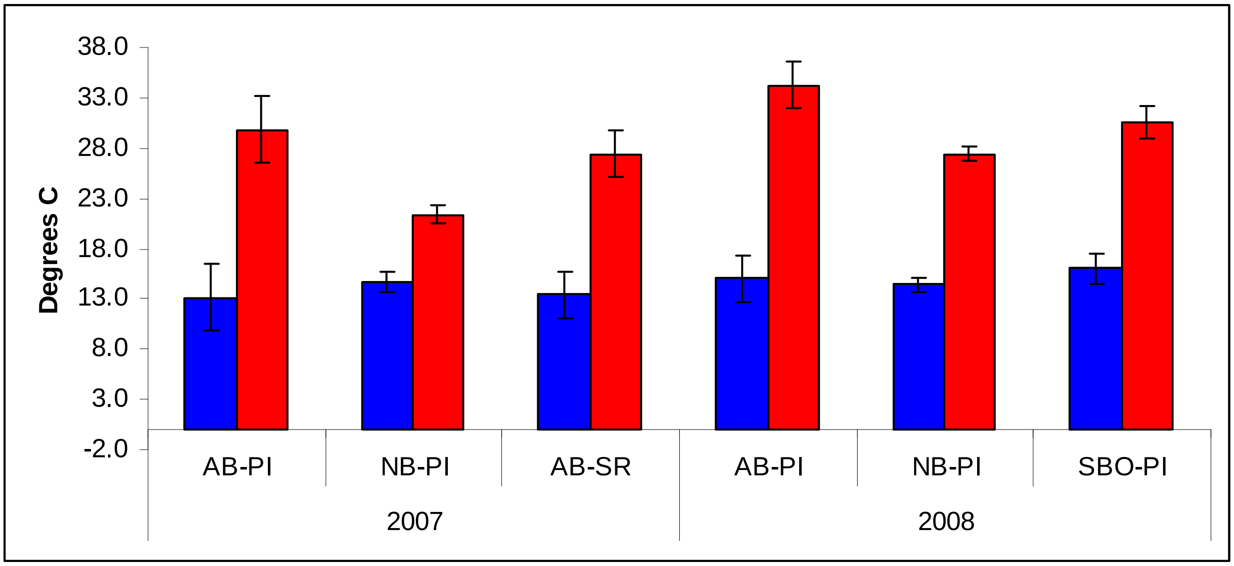


**Figure 14**. Average minimum (blue bars) and maximum (red bars) burrow temperatures recorded within Cassin's Auklet nest sites on Scorpion Rock and Prince Island during 2007 and 2008. Categories include artificial burrows on Prince Island (AB-PI: 2007, n = 4; 2008, n = 4), Natural burrows on Prince Island (NB-PI: 2007, n = 4; 2008, n = 4), artificial burrows on Scorpion Rock (AB-SR: 2007, n = 5), and newly designed southeast boxes on Prince Island (SBO-PI: 2008, n = 6). Error bars indicate the average daily SD of temperature for each nest site category, and do not reflect the error distributions of either minimum or maximum temperatures.

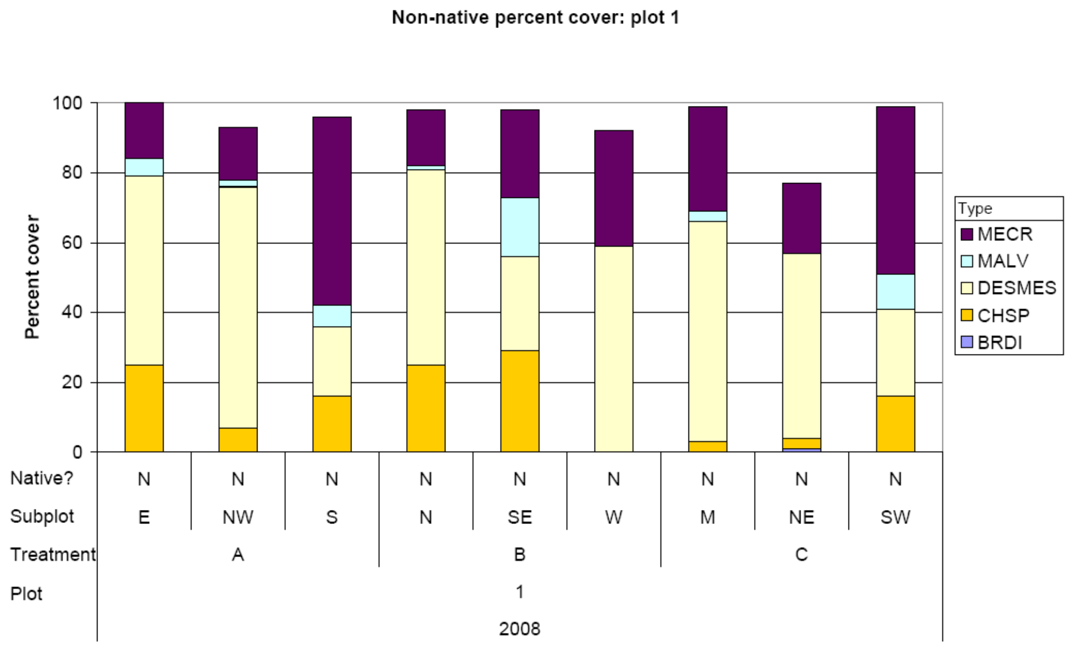


**Figure 15.** Pre-restoration percent cover of non-native vegetation according to sub-plots within experimental plot 1 on Scorpion Rock. Treatments include control (A), manual removal + native out-planting (B), and desiccant spray + native out-planting (C).

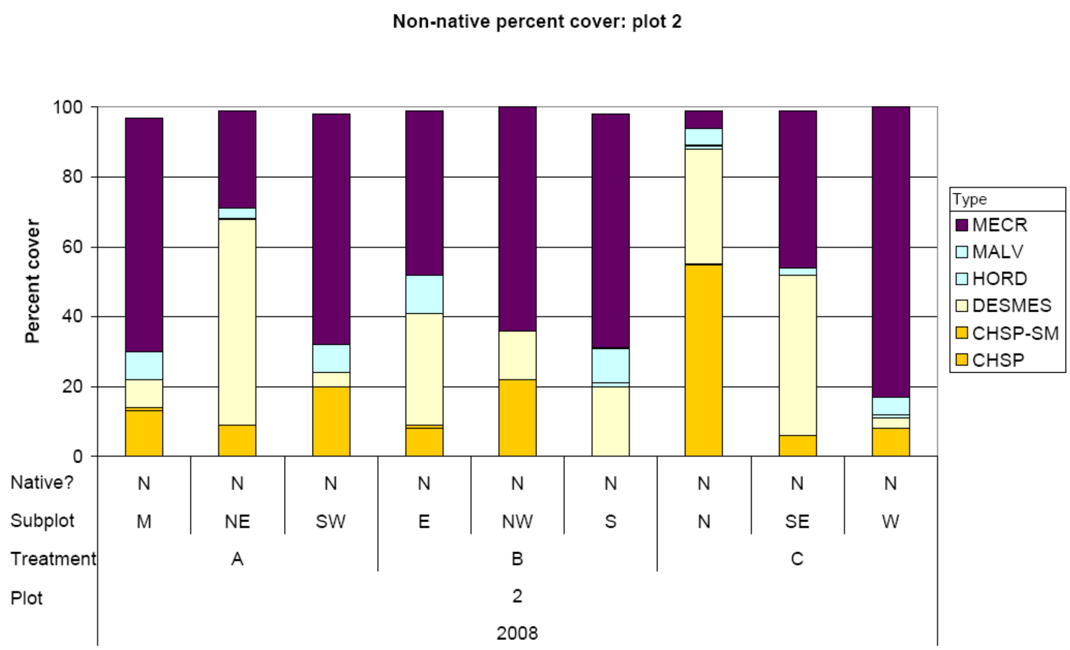


**Figure 16.** Pre-restoration percent cover of non-native vegetation according to sub-plots within experimental plot 2 on Scorpion Rock. Treatments include control (A), manual removal + native out-planting (B), and desiccant spray + native out-planting (C).

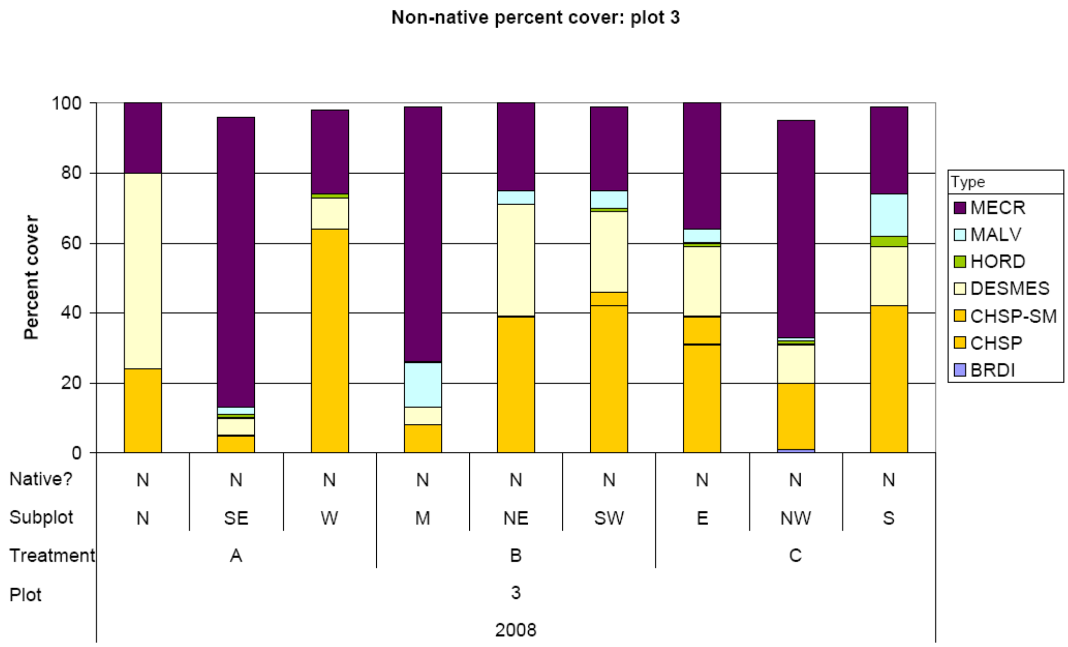


**Figure 17.** Pre-restoration percent cover of non-native vegetation according to sub-plots within experimental plot 3 on Scorpion Rock. Treatments include control (A), manual removal + native out-planting (B), and desiccant spray + native out-planting (C).

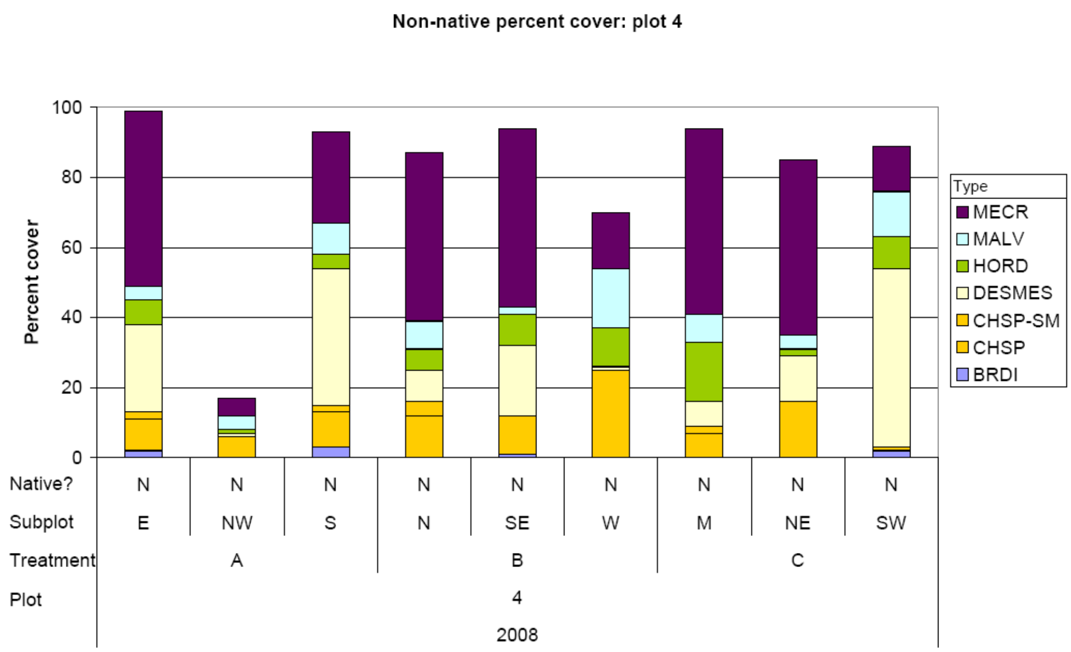


**Figure 18.** Pre-restoration percent cover of non-native vegetation according to sub-plots within experimental plot 4 on Scorpion Rock. Treatments include control (A), manual removal + native out-planting (B), and desiccant spray + native out-planting (C).

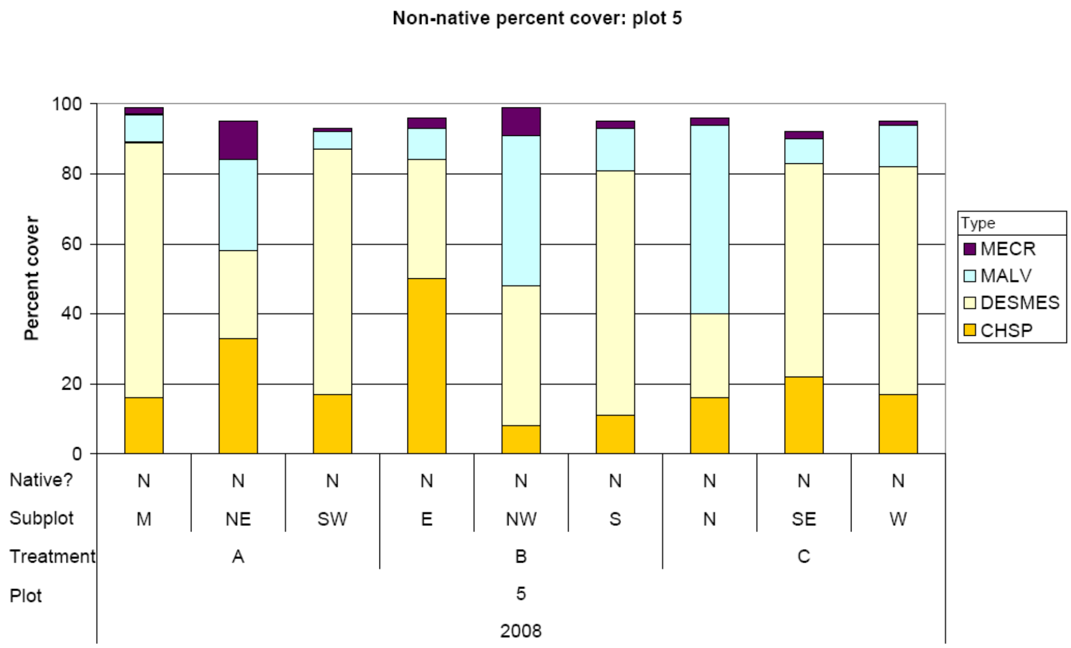


**Figure 19.** Pre-restoration percent cover of non-native vegetation according to sub-plots within experimental plot 5 on Scorpion Rock. Treatments include control (A), manual removal + native out-planting (B), and desiccant spray + native out-planting (C).

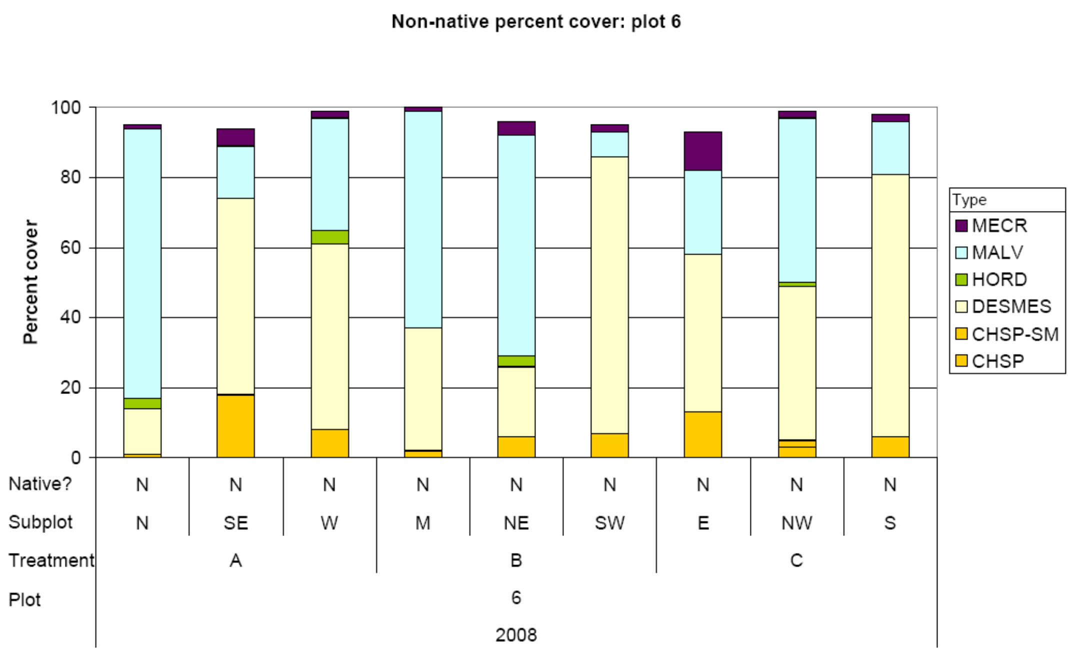


**Figure 20.** Pre-restoration percent cover of non-native vegetation according to sub-plots within experimental plot 6 on Scorpion Rock. Treatments include control (A), manual removal + native out-planting (B), and desiccant spray + native out-planting (C).

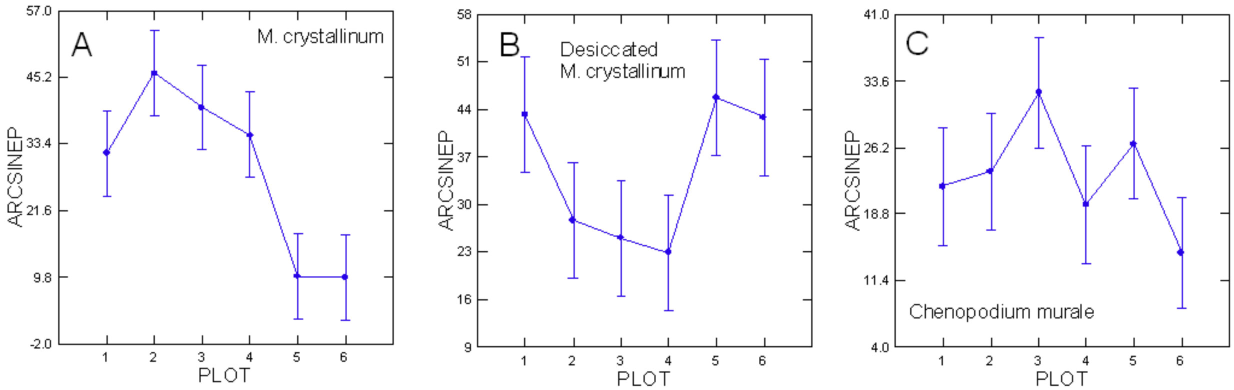


**Figure 21.** Differences among plots in proportional cover (arcsine transformed values) for the three most dominant forms invasive plant cover in 2008: *Mesembryanthemum crystallinum* (A), desiccated *M. crystallinum* (B), and *Chenopodium murale* (C).

**Figure 22.** Total removal of *M. crystallinum* left soils unprotected against rain and wind (middle and upper right), therefore we covered bare ground among *manual removal + native out-planting* treatments with BioNet erosion control material (lower left). Photo taken 13 August 2008.

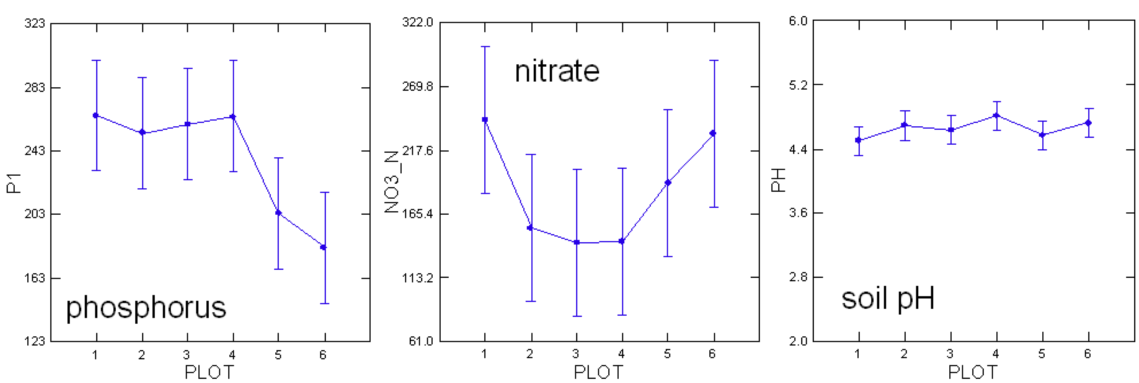


**Figure 23.** Differences among plots in major nutrients (phosphorus, nitrate) and soil pH within experimental vegetation plots on Scorpion Rock on 12 August 2008.

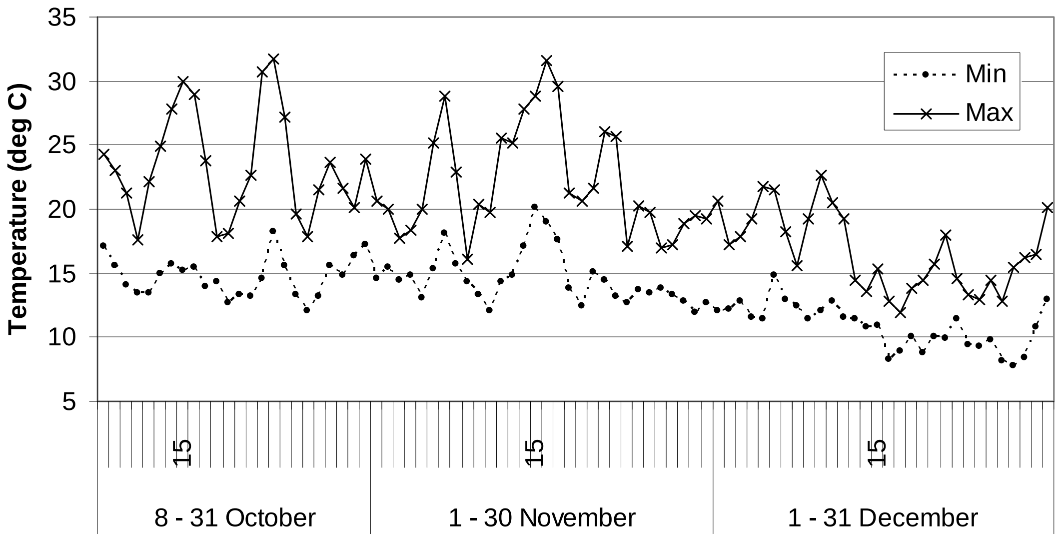


**Figure 24.** Daily minimum (dots with broken line) and maximum (Xs with solid line) temperatures (°C) recorded on Scorpion Rock (8 October through 31 December 2008).

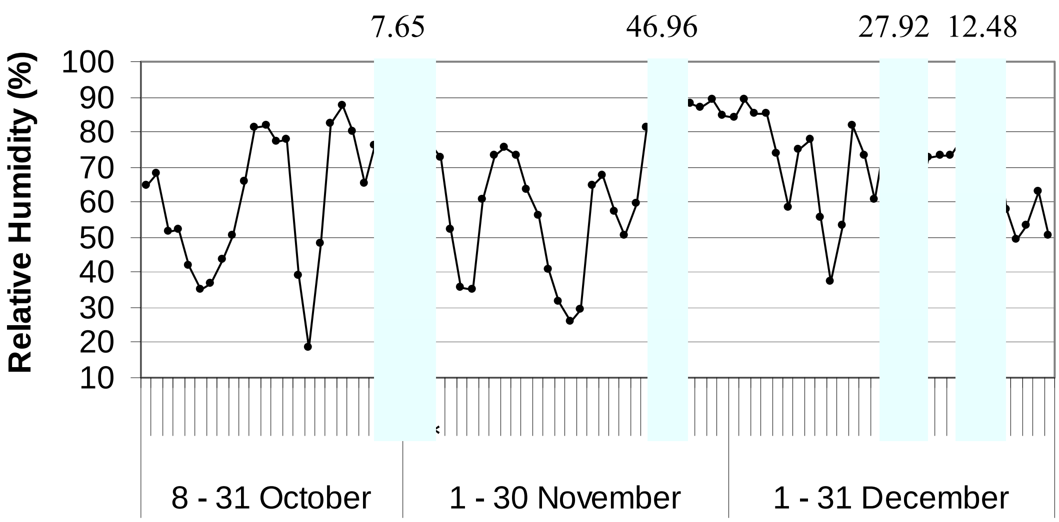


**Figure 25.** Percent relative humidity (%RH) and rainfall (mm, total amount indicted above graph during rainfall events [blue shading] recorded on Scorpion Rock from 8 October through 31 December 2008.

**Figure 26.** Rains in November and December 2008 brought relief to the new plantings; however, it has also exposed some of the issues with weed species on the rock. A carpet of Cheeseweed (*Malva parviflora*) seedlings germinating and pushing through desiccated Crystalline Ice Plant (*Mesembryanthemum crystallinum*) after winter rains. Managing the exotic seedbank will require a continuous effort in future years until sufficient native cover is established and the seedbank is depleted through germination and subsequent control.

**Figure 27.** The rainfall that has occurred to date has underscored the need to further address the erosion issues on the eastern gulley area on Scorpion Rock. Shown here are braiding and erosion on the southeastern side of gulley after rains. Native out-plantings in this area and in the area upslope should help to reduce future erosion during the winter.

# Appendix 1: Scorpion Rock Native Out-planting Schedule

# Scorpion Rock Native Out-planting Schedule


Josh Adams[1], David Mazurkiewicz[2], and Laurie Harvey[3]

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[3] Channel Islands National Park, 1901 Spinnaker Drive Ventura, CA 93001, laurie_harvey@nps.gov


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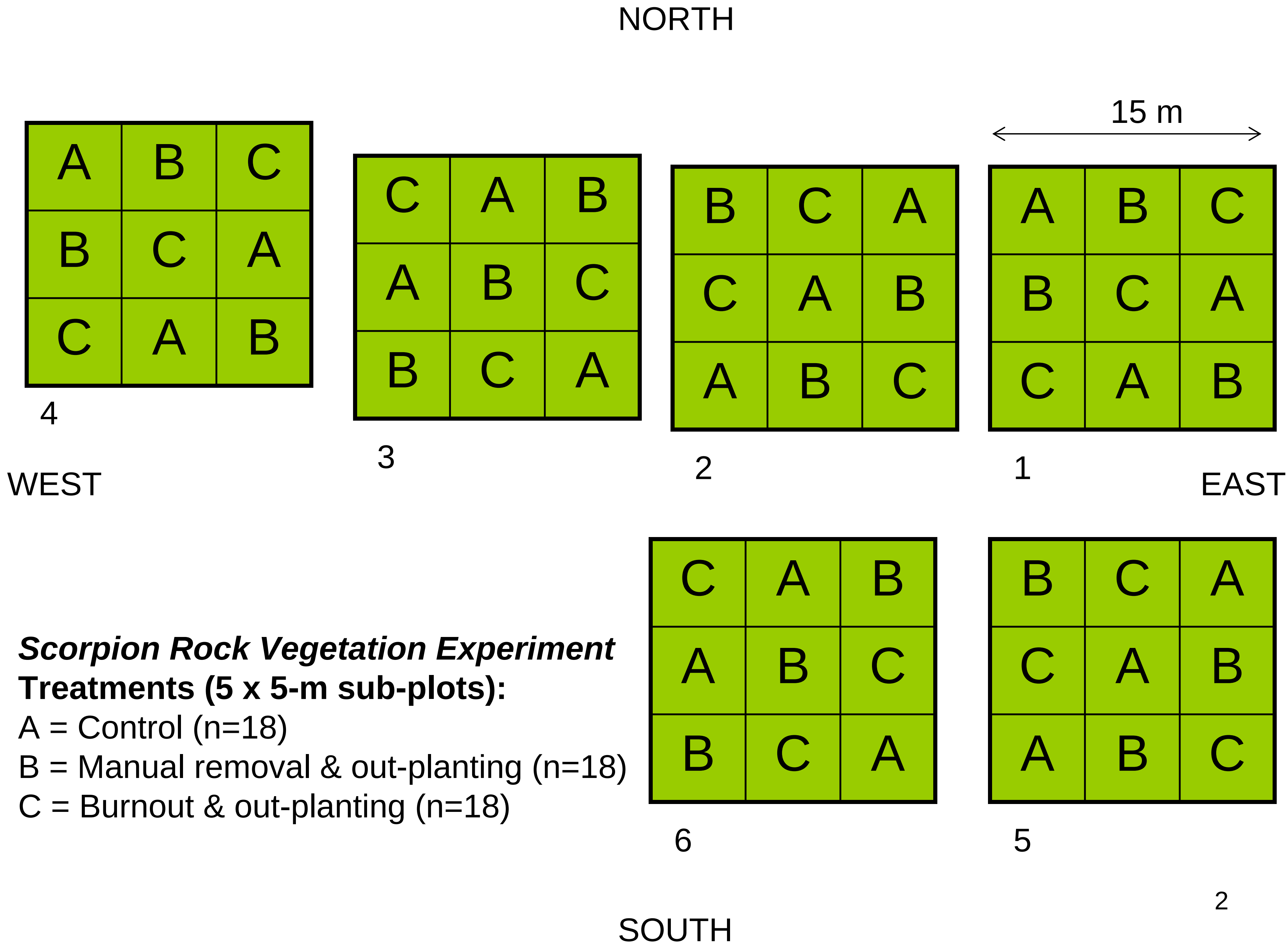

NORTH
15 m
A B C
B C A
C A B
4
C A B
A B C
B C A
3
B C A
C A B
A B C
2
A B C
B C A
C A B
1
WEST
EAST
C A B
A B C
B C A
6
B C A
C A B
A B C
5
SOUTH
***Scorpion Rock Vegetation Experiment***
**Treatments (5 x 5-m sub-plots):**
A = Control (n=18)
B = Manual removal & out-planting (n=18)
C = Burnout & out-planting (n=18)

| | | | | |
|---|---|---|---|---|
| ERGR | ATLE | MASA | FRSA | COGI |
| FRSA | ERAR | FRSA | FRSA | COGI |
| FRSA | FRSA | FRSA | COGI | FRSA |
| FRSA | ATCA | ERAR | MASA | COGI |
| FRSA | FRSA | COGI | FRSA | ERGR |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 1 – B - N

| | | | | |
|---|---|---|---|---|
| 3 | 6 | 7 | 1 | 2 |
| 1 | 4 | 1 | 1 | 2 |
| 1 | 1 | 1 | 2 | 1 |
| 1 | 5 | 4 | 7 | 2 |
| 1 | 1 | 2 | 1 | 3 |

| | | |
|---|---|---|
| A | B | C |
| B | C | A |
| C | A | B |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| ERAR | COGI | ATLE | FRSA | FRSA |
| ATCA | FRSA | FRSA | FRSA | FRSA |
| FRSA | FRSA | FRSA | COGI | MASA |
| FRSA | COGI | COGI | ERGR | MASA |
| ERGR | COGI | ERAR | FRSA | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 1 – C - NE

| | | | | |
|---|---|---|---|---|
| 4 | 2 | 6 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 2 | 7 |
| 1 | 2 | 2 | 3 | 7 |
| 3 | 2 | 4 | 1 | 1 |

| | | |
|---|---|---|
| A | B | C |
| B | C | A |
| C | A | B |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| MASA | FRSA | COGI | FRSA | COGI |
| FRSA | ERGR | ERGR | FRSA | FRSA |
| FRSA | COGI | COGI | FRSA | ERAR |
| FRSA | ERAR | FRSA | FRSA | FRSA |
| ATLE | FRSA | MASA | COGI | ATCA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 1 – B - W

| | | | | |
|---|---|---|---|---|
| 7 | 1 | 2 | 1 | 2 |
| 1 | 3 | 3 | 1 | 1 |
| 1 | 2 | 2 | 1 | 4 |
| 1 | 4 | 1 | 1 | 1 |
| 6 | 1 | 7 | 2 | 5 |

| | | |
|---|---|---|
| A | B | C |
| B | C | A |
| C | A | B |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| ERGR | FRSA | FRSA | ERGR | COGI |
| ERAR | MASA | FRSA | FRSA | FRSA |
| FRSA | ATLE | FRSA | ERAR | COGI |
| FRSA | FRSA | ATCA | FRSA | COGI |
| FRSA | FRSA | MASA | COGI | COGI |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 1 – C - M

| | | | | |
|---|---|---|---|---|
| 3 | 1 | 1 | 3 | 2 |
| 4 | 7 | 1 | 1 | 1 |
| 1 | 6 | 1 | 4 | 2 |
| 1 | 1 | 5 | 1 | 2 |
| 1 | 1 | 7 | 2 | 2 |

| | | |
|---|---|---|
| A | B | C |
| B | C | A |
| C | A | B |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| COGI | FRSA | FRSA | FRSA | FRSA |
| FRSA | FRSA | FRSA | ATLE | FRSA |
| COGI | ERGR | ERAR | MASA | FRSA |
| COGI | MASA | FRSA | ERGR | FRSA |
| ATCA | ERAR | FRSA | COGI | COGI |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 1 – C - SW

| | | | | |
|---|---|---|---|---|
| 2 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 6 | 1 |
| 2 | 3 | 4 | 7 | 1 |
| 2 | 7 | 1 | 3 | 1 |
| 5 | 4 | 1 | 2 | 2 |

| | | |
|---|---|---|
| A | B | C |
| B | C | A |
| C | A | B |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| COGI | ERGR | COGI | FRSA | ERAR |
| FRSA | FRSA | ERAR | FRSA | COGI |
| FRSA | FRSA | FRSA | FRSA | FRSA |
| COGI | MASA | FRSA | FRSA | MASA |
| COGI | ATCA | ERGR | ATLE | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 1 – B - SE

| | | | | |
|---|---|---|---|---|
| 2 | 3 | 2 | 1 | 4 |
| 1 | 1 | 4 | 1 | 2 |
| 1 | 1 | 1 | 1 | 1 |
| 2 | 7 | 1 | 1 | 7 |
| 2 | 5 | 3 | 6 | 1 |

| | | |
|---|---|---|
| A | B | C |
| B | C | A |
| C | A | B |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| ERAR | COGI | COGI | ERAR | FRSA |
| MASA | FRSA | FRSA | MASA | FRSA |
| ATCA | ERGR | FRSA | COGI | FRSA |
| FRSA | ATLE | FRSA | FRSA | ERGR |
| COGI | FRSA | COGI | FRSA | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

## PLOT 2 – B - NW

| | | |
|---|---|---|
| B | C | A |
| C | A | B |
| A | B | C |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| 4 | 2 | 2 | 4 | 1 |
| 7 | 1 | 1 | 7 | 1 |
| 5 | 3 | 1 | 2 | 1 |
| 1 | 6 | 1 | 1 | 3 |
| 2 | 1 | 2 | 1 | 1 |

| | | | | |
|---|---|---|---|---|
| COGI | MASA | FRSA | COGI | COGI |
| FRSA | FRSA | ERAR | ERGR | FRSA |
| FRSA | COGI | FRSA | FRSA | FRSA |
| ERGR | ATCA | ERAR | FRSA | ATLE |
| FRSA | COGI | MASA | FRSA | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 2 – C - N

| | | | | |
|---|---|---|---|---|
| 2 | 7 | 1 | 2 | 2 |
| 1 | 1 | 4 | 3 | 1 |
| 1 | 2 | 1 | 1 | 1 |
| 3 | 5 | 4 | 1 | 6 |
| 1 | 2 | 7 | 1 | 1 |

| | | |
|---|---|---|
| B | C | A |
| C | A | B |
| A | B | C |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | FRSA | FRSA | MASA | FRSA |
| ERAR | FRSA | COGI | ERGR | FRSA |
| FRSA | COGI | FRSA | COGI | FRSA |
| ERAR | FRSA | FRSA | ERGR | ATCA |
| FRSA | COGI | COGI | MASA | ATLE |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 2 – C - W

| | | | | |
|---|---|---|---|---|
| 1 | 1 | 1 | 7 | 1 |
| 4 | 1 | 2 | 3 | 1 |
| 1 | 2 | 1 | 2 | 1 |
| 4 | 1 | 1 | 3 | 5 |
| 1 | 2 | 2 | 7 | 6 |

| | | |
|---|---|---|
| B | C | A |
| C | A | B |
| A | B | C |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| MASA | FRSA | FRSA | ERAR | FRSA |
| MASA | FRSA | COGI | COGI | FRSA |
| COGI | FRSA | FRSA | FRSA | ATLE |
| FRSA | FRSA | ERAR | COGI | FRSA |
| ERGR | ERGR | FRSA | ATCA | COGI |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 2 – B - E

| | | | | |
|---|---|---|---|---|
| 7 | 1 | 1 | 4 | 1 |
| 7 | 1 | 2 | 2 | 1 |
| 2 | 1 | 1 | 1 | 6 |
| 1 | 1 | 4 | 2 | 1 |
| 3 | 3 | 1 | 5 | 2 |

| | | |
|---|---|---|
| B | C | A |
| C | A | B |
| A | B | C |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | FRSA | MASA | FRSA | FRSA |
| FRSA | ERGR | COGI | FRSA | ERAR |
| COGI | COGI | ATCA | FRSA | FRSA |
| ERAR | MASA | COGI | FRSA | FRSA |
| FRSA | ERGR | ATLE | FRSA | COGI |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 2 – B - S

| | | | | |
|---|---|---|---|---|
| 1 | 1 | 7 | 1 | 1 |
| 1 | 3 | 2 | 1 | 4 |
| 2 | 2 | 5 | 1 | 1 |
| 4 | 7 | 2 | 1 | 1 |
| 1 | 3 | 6 | 1 | 2 |

| | | |
|---|---|---|
| B | C | A |
| C | A | B |
| A | B | C |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | ATCA | FRSA | FRSA | FRSA |
| ATLE | ERGR | FRSA | FRSA | COGI |
| MASA | FRSA | FRSA | ERGR | MASA |
| FRSA | COGI | COGI | FRSA | COGI |
| FRSA | ERAR | ERAR | COGI | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 2 – C - SE

| | | | | |
|---|---|---|---|---|
| 1 | 5 | 1 | 1 | 1 |
| 6 | 3 | 1 | 1 | 2 |
| 7 | 1 | 1 | 3 | 7 |
| 1 | 2 | 2 | 1 | 2 |
| 1 | 4 | 4 | 2 | 1 |

| | | |
|---|---|---|
| B | C | A |
| C | A | B |
| A | B | C |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | ERGR | MASA | FRSA | FRSA |
| COGI | ATLE | FRSA | FRSA | FRSA |
| ERGR | COGI | FRSA | FRSA | FRSA |
| FRSA | COGI | COGI | ERAR | ATCA |
| FRSA | COGI | FRSA | MASA | ERAR |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 3 – C - NW

| | | | | |
|---|---|---|---|---|
| 1 | 3 | 7 | 1 | 1 |
| 2 | 6 | 1 | 1 | 1 |
| 3 | 2 | 1 | 1 | 1 |
| 1 | 2 | 2 | 4 | 5 |
| 1 | 2 | 1 | 7 | 4 |

| | | |
|---|---|---|
| C | A | B |
| A | B | C |
| B | C | A |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | MASA | COGI | MASA | FRSA |
| FRSA | FRSA | FRSA | FRSA | ATLE |
| ERAR | ATCA | FRSA | FRSA | ERAR |
| COGI | FRSA | COGI | COGI | ERGR |
| FRSA | COGI | ERGR | FRSA | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 3 – B - NE

| | | | | |
|---|---|---|---|---|
| 1 | 7 | 2 | 7 | 1 |
| 1 | 1 | 1 | 1 | 6 |
| 4 | 5 | 1 | 1 | 4 |
| 2 | 1 | 2 | 2 | 3 |
| 1 | 2 | 3 | 1 | 1 |

| | | |
|---|---|---|
| C | A | B |
| A | B | C |
| B | C | A |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| ATCA | FRSA | COGI | FRSA | ERAR |
| ATLE | FRSA | ERGR | FRSA | MASA |
| FRSA | COGI | FRSA | FRSA | FRSA |
| MASA | ERGR | FRSA | ERAR | FRSA |
| COGI | COGI | FRSA | COGI | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 3 – B - M

| | | | | |
|---|---|---|---|---|
| 5 | 1 | 2 | 1 | 4 |
| 6 | 1 | 3 | 1 | 7 |
| 1 | 2 | 1 | 1 | 1 |
| 7 | 3 | 1 | 4 | 1 |
| 2 | 2 | 1 | 2 | 1 |

| | | |
|---|---|---|
| C | A | B |
| A | B | C |
| B | C | A |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| ERGR | MASA | FRSA | ERAR | FRSA |
| FRSA | FRSA | ERAR | FRSA | COGI |
| COGI | ERGR | MASA | FRSA | FRSA |
| COGI | COGI | FRSA | COGI | FRSA |
| ATLE | FRSA | ATCA | FRSA | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 3 – C - E

| | | | | |
|---|---|---|---|---|
| 3 | 7 | 1 | 4 | 1 |
| 1 | 1 | 4 | 1 | 2 |
| 2 | 3 | 7 | 1 | 1 |
| 2 | 2 | 1 | 2 | 1 |
| 6 | 1 | 5 | 1 | 1 |

| | | |
|---|---|---|
| C | A | B |
| A | B | C |
| B | C | A |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | FRSA | COGI | COGI | FRSA |
| COGI | FRSA | FRSA | ERAR | FRSA |
| MASA | FRSA | COGI | FRSA | FRSA |
| MASA | ERGR | COGI | FRSA | FRSA |
| ERGR | ATLE | ERAR | ATCA | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 3 – B - SW

| | | | | |
|---|---|---|---|---|
| 1 | 1 | 2 | 2 | 1 |
| 2 | 1 | 1 | 4 | 1 |
| 7 | 1 | 2 | 1 | 1 |
| 7 | 3 | 2 | 1 | 1 |
| 3 | 6 | 4 | 5 | 1 |

| | | |
|---|---|---|
| C | A | B |
| A | B | C |
| B | C | A |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | FRSA | COGI | ERAR | ERGR |
| ERAR | FRSA | FRSA | FRSA | FRSA |
| COGI | FRSA | FRSA | ERGR | FRSA |
| MASA | COGI | MASA | COGI | FRSA |
| FRSA | COGI | ATLE | FRSA | ATCA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 3 – C - S

| | | | | |
|---|---|---|---|---|
| 1 | 1 | 2 | 4 | 3 |
| 4 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 3 | 1 |
| 7 | 2 | 7 | 2 | 1 |
| 1 | 2 | 6 | 1 | 5 |

| | | |
|---|---|---|
| C | A | B |
| A | B | C |
| B | C | A |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | ATCA | FRSA | ERGR | FRSA |
| FRSA | ERAR | FRSA | COGI | COGI |
| MASA | ATLE | FRSA | FRSA | MASA |
| FRSA | FRSA | COGI | COGI | ERGR |
| FRSA | COGI | FRSA | ERAR | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 4 – B - N

| | | | | |
|---|---|---|---|---|
| 1 | 5 | 1 | 3 | 1 |
| 1 | 4 | 1 | 2 | 2 |
| 7 | 6 | 1 | 1 | 7 |
| 1 | 1 | 2 | 2 | 3 |
| 1 | 2 | 1 | 4 | 1 |

| | | |
|---|---|---|
| A | **B** | C |
| B | C | A |
| C | A | B |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| COGI | COGI | COGI | FRSA | ERGR |
| ATCA | FRSA | FRSA | FRSA | FRSA |
| MASA | FRSA | MASA | FRSA | FRSA |
| ERAR | FRSA | FRSA | COGI | ATLE |
| ERAR | FRSA | FRSA | ERGR | COGI |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 4 – C - NE

| | | | | |
|---|---|---|---|---|
| 2 | 2 | 2 | 1 | 3 |
| 5 | 1 | 1 | 1 | 1 |
| 7 | 1 | 7 | 1 | 1 |
| 4 | 1 | 1 | 2 | 6 |
| 4 | 1 | 1 | 3 | 2 |

| | | |
|---|---|---|
| A | B | C |
| B | C | A |
| C | A | B |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | COGI | FRSA | ERAR | FRSA |
| ERGR | ATLE | FRSA | ATCA | COGI |
| COGI | COGI | FRSA | FRSA | COGI |
| MASA | FRSA | ERAR | MASA | FRSA |
| FRSA | FRSA | FRSA | ERGR | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 4 – B - W

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 1 | 4 | 1 |
| 3 | 6 | 1 | 5 | 2 |
| 2 | 2 | 1 | 1 | 2 |
| 7 | 1 | 4 | 7 | 1 |
| 1 | 1 | 1 | 3 | 1 |

| | | |
|---|---|---|
| A | B | C |
| B | C | A |
| C | A | B |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| ERGR | MASA | FRSA | FRSA | FRSA |
| FRSA | FRSA | FRSA | FRSA | ATLE |
| FRSA | ATCA | FRSA | COGI | COGI |
| FRSA | ERGR | FRSA | ERGR | COGI |
| MASA | ERAR | COGI | COGI | FRSA |

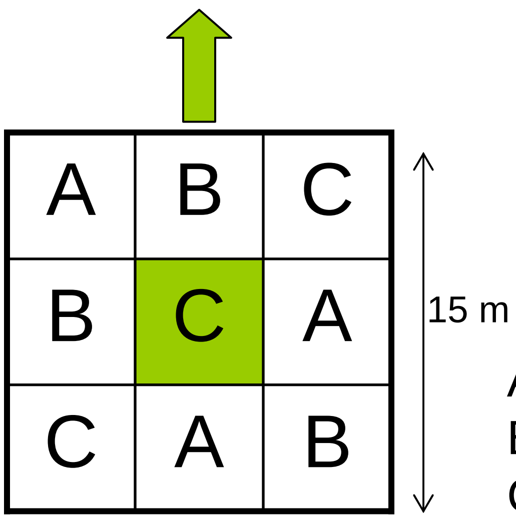
5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 4 – C - M

| | | | | |
|---|---|---|---|---|
| 4 | 7 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 6 |
| 1 | 5 | 1 | 2 | 2 |
| 1 | 3 | 1 | 3 | 2 |
| 7 | 4 | 2 | 2 | 1 |




A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| ATCA | MASA | FRSA | COGI | FRSA |
| COGI | FRSA | FRSA | MASA | FRSA |
| FRSA | COGI | COGI | ERGR | ERAR |
| ERGR | FRSA | FRSA | ERGR | ERAR |
| MASA | FRSA | FRSA | FRSA | ERAR |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 4 – C - SW

| | | | | |
|---|---|---|---|---|
| 5 | 7 | 1 | 2 | 1 |
| 2 | 1 | 1 | 6 | 1 |
| 1 | 2 | 2 | 3 | 4 |
| 3 | 1 | 1 | 1 | 2 |
| 7 | 1 | 1 | 1 | 4 |

| | | |
|---|---|---|
| A | B | C |
| B | C | A |
| C | A | B |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| ERGR | COGI | FRSA | MASA | FRSA |
| FRSA | FRSA | COGI | FRSA | MASA |
| COGI | FRSA | ATCA | FRSA | FRSA |
| FRSA | FRSA | FRSA | ERGR | COGI |
| FRSA | ERAR | ATLE | ERAR | COGI |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 4 – B - SE

| | | |
|---|---|---|
| A | B | C |
| B | C | A |
| C | A | B |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| 3 | 2 | 1 | 7 | 1 |
| 1 | 1 | 2 | 1 | 7 |
| 2 | 1 | 5 | 1 | 1 |
| 1 | 1 | 1 | 3 | 2 |
| 1 | 4 | 6 | 4 | 2 |

| | | | | |
|---|---|---|---|---|
| FRSA | COGI | COGI | ATLE | FRSA |
| ATCA | MASA | FRSA | FRSA | FRSA |
| FRSA | COGI | FRSA | COGI | FRSA |
| ERAR | FRSA | FRSA | FRSA | COGI |
| ERAR | ERGR | FRSA | MASA | ERGR |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 5 – B - NW

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 2 | 6 | 1 |
| 5 | 7 | 1 | 1 | 1 |
| 1 | 2 | 1 | 2 | 1 |
| 3 | 1 | 1 | 1 | 2 |
| 4 | 3 | 1 | 7 | 4 |

| | | |
|---|---|---|
| B | C | A |
| C | A | B |
| A | B | C |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | FRSA | FRSA | COGI | COGI |
| FRSA | FRSA | COGI | FRSA | ERAR |
| FRSA | ERAR | ERGR | COGI | COGI |
| FRSA | ERGR | FRSA | MASA | FRSA |
| FRSA | ATLE | ATCA | MASA | FRSA |

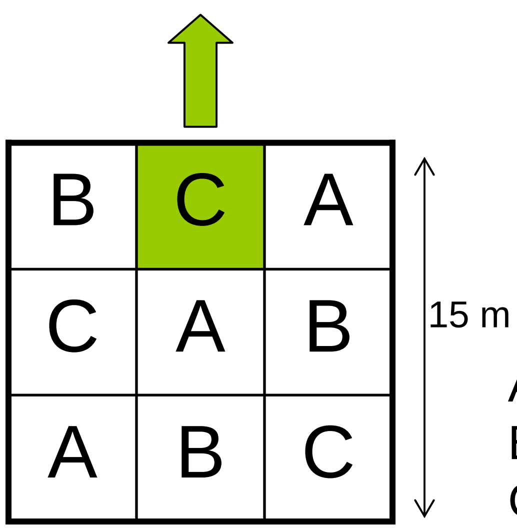
5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 5 – C - N

| | | | | |
|---|---|---|---|---|
| 1 | 1 | 1 | 2 | 2 |
| 1 | 1 | 2 | 1 | 4 |
| 1 | 4 | 3 | 2 | 2 |
| 1 | 3 | 1 | 7 | 1 |
| 1 | 6 | 5 | 7 | 1 |




A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | ERGR | COGI | COGI | FRSA |
| ATLE | COGI | FRSA | COGI | ATCA |
| FRSA | FRSA | FRSA | FRSA | MASA |
| FRSA | ERGR | FRSA | FRSA | MASA |
| ERAR | FRSA | COGI | ERAR | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 5 – C - W

| | | | | |
|---|---|---|---|---|
| 1 | 3 | 2 | 2 | 1 |
| 6 | 2 | 1 | 2 | 5 |
| 1 | 1 | 1 | 1 | 7 |
| 1 | 3 | 1 | 1 | 7 |
| 4 | 1 | 2 | 4 | 1 |

| | | |
|---|---|---|
| B | C | A |
| C | A | B |
| A | B | C |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | ATCA | FRSA | ERGR | FRSA |
| FRSA | ERAR | FRSA | COGI | COGI |
| MASA | ATLE | FRSA | FRSA | MASA |
| FRSA | FRSA | COGI | COGI | ERGR |
| FRSA | COGI | FRSA | ERAR | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 5 – B - E

| | | | | |
|---|---|---|---|---|
| 1 | 5 | 1 | 3 | 1 |
| 1 | 4 | 1 | 2 | 2 |
| 7 | 6 | 1 | 1 | 7 |
| 1 | 1 | 2 | 2 | 3 |
| 1 | 2 | 1 | 4 | 1 |

| | | |
|---|---|---|
| B | C | A |
| C | A | B |
| A | B | C |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| ERGR | COGI | ATLE | COGI | FRSA |
| COGI | FRSA | ERAR | FRSA | FRSA |
| FRSA | FRSA | FRSA | FRSA | ERGR |
| FRSA | FRSA | COGI | ERAR | COGI |
| MASA | MASA | FRSA | ATCA | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 5 – B - S

| | | | | |
|---|---|---|---|---|
| 3 | 2 | 6 | 2 | 1 |
| 2 | 1 | 4 | 1 | 1 |
| 1 | 1 | 1 | 1 | 3 |
| 1 | 1 | 2 | 4 | 2 |
| 7 | 7 | 1 | 5 | 1 |

| | | |
|---|---|---|
| B | C | A |
| C | A | B |
| A | B | C |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | ATLE | FRSA | FRSA | FRSA |
| FRSA | ERAR | ERAR | FRSA | FRSA |
| COGI | MASA | FRSA | ERGR | FRSA |
| FRSA | COGI | FRSA | FRSA | COGI |
| MASA | COGI | ATCA | COGI | ERGR |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 5 – C - SE

| | | | | |
|---|---|---|---|---|
| 1 | 6 | 1 | 1 | 1 |
| 1 | 4 | 4 | 1 | 1 |
| 2 | 7 | 1 | 3 | 1 |
| 1 | 2 | 1 | 1 | 2 |
| 7 | 2 | 5 | 2 | 3 |

| | | |
|---|---|---|
| B | C | A |
| C | A | B |
| A | B | C |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | COGI | ATLE | FRSA | COGI |
| FRSA | FRSA | FRSA | FRSA | ERGR |
| ATCA | FRSA | MASA | COGI | COGI |
| ERAR | FRSA | COGI | MASA | ERGR |
| FRSA | FRSA | ERAR | FRSA | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 6 – C - NW

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 6 | 1 | 2 |
| 1 | 1 | 1 | 1 | 3 |
| 5 | 1 | 7 | 2 | 2 |
| 4 | 1 | 2 | 7 | 3 |
| 1 | 1 | 4 | 1 | 1 |

| | | |
|---|---|---|
| C | A | B |
| A | B | C |
| B | C | A |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| COGI | ERAR | FRSA | FRSA | COGI |
| FRSA | FRSA | ATCA | ERGR | FRSA |
| FRSA | FRSA | ERGR | COGI | ERAR |
| COGI | COGI | FRSA | FRSA | FRSA |
| FRSA | MASA | ATLE | FRSA | MASA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 6 – B - NE

| | | | | |
|---|---|---|---|---|
| 2 | 4 | 1 | 1 | 2 |
| 1 | 1 | 5 | 3 | 1 |
| 1 | 1 | 3 | 2 | 4 |
| 2 | 2 | 1 | 1 | 1 |
| 1 | 7 | 6 | 1 | 7 |

| | | |
|---|---|---|
| C | A | B |
| A | B | C |
| B | C | A |

15 m

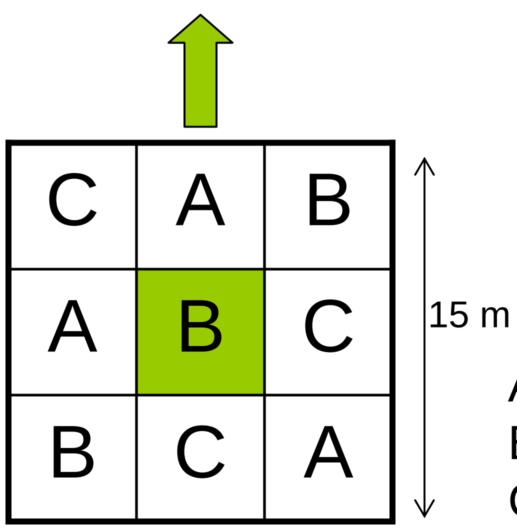
A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| COGI | FRSA | MASA | FRSA | FRSA |
| FRSA | COGI | ERAR | ATCA | COGI |
| FRSA | ATLE | FRSA | FRSA | COGI |
| FRSA | FRSA | FRSA | ERGR | ERAR |
| MASA | ERGR | COGI | FRSA | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)




A = control
B = manual removal
C = desiccant spray

# PLOT 6 – B - M

| | | | | |
|---|---|---|---|---|
| 2 | 1 | 7 | 1 | 1 |
| 1 | 2 | 4 | 5 | 2 |
| 1 | 6 | 1 | 1 | 2 |
| 1 | 1 | 1 | 3 | 4 |
| 7 | 3 | 2 | 1 | 1 |

| | | | | |
|---|---|---|---|---|
| COGI | FRSA | FRSA | COGI | FRSA |
| ERGR | FRSA | FRSA | FRSA | MASA |
| ERGR | COGI | ERAR | FRSA | FRSA |
| COGI | ATLE | ERAR | COGI | ATCA |
| FRSA | MASA | FRSA | FRSA | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 6 – C - E

| | | | | |
|---|---|---|---|---|
| 2 | 1 | 1 | 2 | 1 |
| 3 | 1 | 1 | 1 | 7 |
| 3 | 2 | 4 | 1 | 1 |
| 2 | 6 | 4 | 2 | 5 |
| 1 | 7 | 1 | 1 | 1 |

| | | |
|---|---|---|
| C | A | B |
| A | B | C |
| B | C | A |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| ERAR | FRSA | COGI | FRSA | FRSA |
| COGI | ERAR | FRSA | ERGR | FRSA |
| COGI | FRSA | COGI | FRSA | FRSA |
| FRSA | FRSA | ATLE | COGI | ERAR |
| MASA | FRSA | ATCA | MASA | FRSA |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 6 – B - SW

| | | | | |
|---|---|---|---|---|
| 3 | 1 | 2 | 1 | 1 |
| 2 | 4 | 1 | 3 | 1 |
| 2 | 1 | 2 | 1 | 1 |
| 1 | 1 | 6 | 2 | 4 |
| 7 | 1 | 5 | 7 | 1 |

| | | |
|---|---|---|
| C | A | B |
| A | B | C |
| B | C | A |

15 m

A = control
B = manual removal
C = desiccant spray

| | | | | |
|---|---|---|---|---|
| FRSA | ERGR | COGI | ERGR | ATCA |
| COGI | FRSA | FRSA | FRSA | ERAR |
| ATLE | MASA | FRSA | COGI | COGI |
| COGI | FRSA | FRSA | FRSA | FRSA |
| FRSA | FRSA | FRSA | MASA | ERAR |

5 m

**Out-planting treatments (per treatment):**

1. FRSA = *Frankenia salina* (n=12)
2. COGI = *Coreopsis gigantea* (n=5)
3. ERGR = *Eriogonum grande* (n=2)
4. ERAR = *Eriogonum arborescense* (n=2)
5. ATCA = *Atriplex californicum* (n=1)
6. ATLE = *Atriplex lentiformis* (n=1)
7. MASA = *Malacothrix saxitilis* var. *implicata* (n=2)

# PLOT 6 – C - S

| | | | | |
|---|---|---|---|---|
| 1 | 3 | 2 | 3 | 5 |
| 2 | 1 | 1 | 1 | 4 |
| 6 | 7 | 1 | 2 | 2 |
| 2 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 7 | 4 |

| | | |
|---|---|---|
| C | A | B |
| A | B | C |
| B | C | A |

15 m

A = control
B = manual removal
C = desiccant spray

# Appendix 2: Cassin's Auklet Artificial Burrow Replacement

**To:** Channel Islands National Park, Montrose Settlement Restoration Plan Trustees

**From:** Josh Adams, USGS WERC

**Subject:** ***27–30 August 2007 Trip Report: Replacement of artificial nesting sites for Cassin's Auklet on Prince Island***

**Update:** 5 September 2007

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*Background*— The Cassin's Auklet (*Ptychoramphus aleuticus*, Family Alcidae) is a jay-sized (~160 g) diving seabird. Islands within the Channel Islands National Park (CINP) provide essential nesting habitat for Cassin's Auklet. This species also depends upon marine prey resources abundant within surrounding waters including several west coast National Marine Sanctuaries. To facilitate long-term monitoring of adult survival, breeding effort, and annual reproductive success, the CINP installed 50 artificial plywood nest boxes for Cassin's Auklet in 1984. Boxes were set in two lines and covered with 36-foot long 4 x 12 planking. One row of boxes is located on the southeast facing slope and the second row is located on the northeast slope. In 2000 and 2001, to enhance monitoring and facilitate foraging ecology studies (Adams et al. 2004a, b), USGS added an additional 48 temporary artificial burrows (plywood covered nursery containers with 4-in ADS flex pipe entrances) among several clusters located on the southeast slope of Prince Island. After 23 years, the southeast boxes had been exposed to erosion and entrances were suspended approximately 12-in above grade. In summer 2007 USGS received permission to replace the existing artificial nest sites (southeast CINP boxes, N=25 and USGS artificial burrows, N=48) with new, more durable structures consisting of landscape valve cover boxes (Carson VCB) fitted with 4-in ADS flex pipe entrances. Permission also was granted to remove the existing nest boxes from the northeast slope of Prince Island.

*Progress update*— From 27 to 30 August 2007, Adams and Phillips removed 45 of 48 temporary artificial burrows from the southeast slope of Prince Island. Two sites (AB28 and AB47) were left as is because sites were situated in rocky outcrops that were not amenable to replacement using the new Carson VCB design. We also removed all 25 existing plywood nest boxes from the southeast slope and retrofit the existing plank structure with 2x12 and 2x4 retainers to hold soil surrounding new artificial burrows and the down-slope area surrounding the new burrow entrances (see photos). Due to time constraints, we were able to replace 9 of 25 artificial burrows. We temporarily installed 24 feet of 2x12 retainer to hold soil in place until we return to replace the remaining 16 CINP sites. Additionally, we will add 3 more artificial burrow sites to bring the total to 50. We still plan to remove the existing boxes and planking located on the northeast slope.

****** Additional trip required ****** Completion of proposed tasks (replacement of existing artificial nest sites at Prince and Scorpion, and removal of CINP nest boxes and planking on northeast slope of Prince will require two more days at sea (one full day at Prince Island and one full day at Scorpion Rock).

*Acknowledgments*— Restoration of seabirds in the Channel Islands National Park is funded by the Montrose Settlement Restoration Plan Trustees (Annie Little, USFWS and Jennifer Boyce, NOAA). We wish to thank many people who helped: Assistance with permitting was provided by K. Faulkner, D. Richards, L. Harvey, and I. Williams. Transportation was provided by Ron Fairbanks who captained the *Miss Devin*. E. Phillips (MLML) provided excellent field support. Equipment was provided by MLML and USGS. This permitted research activity was conducted under the authority of the CINP seabird monitoring program review.

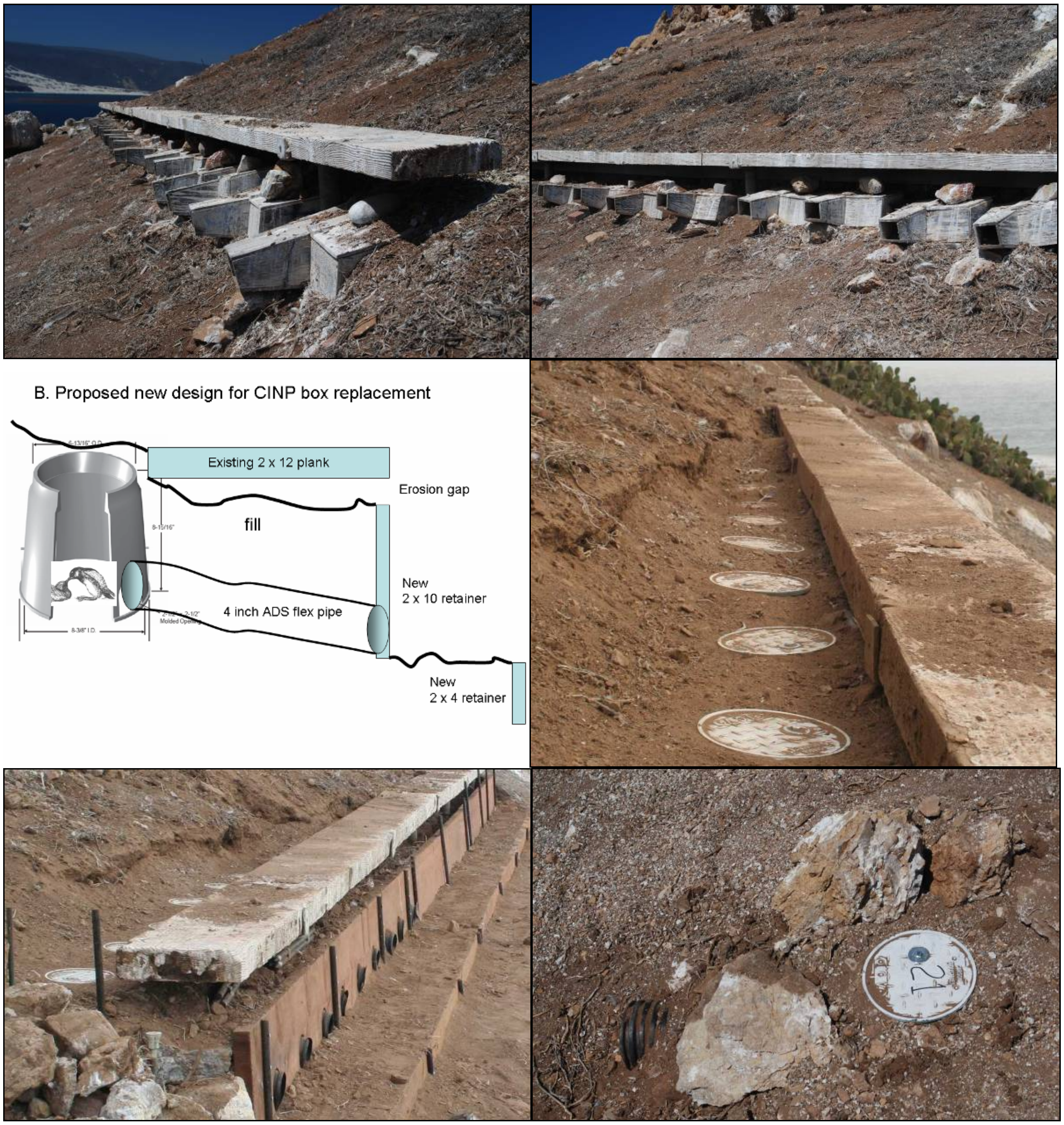


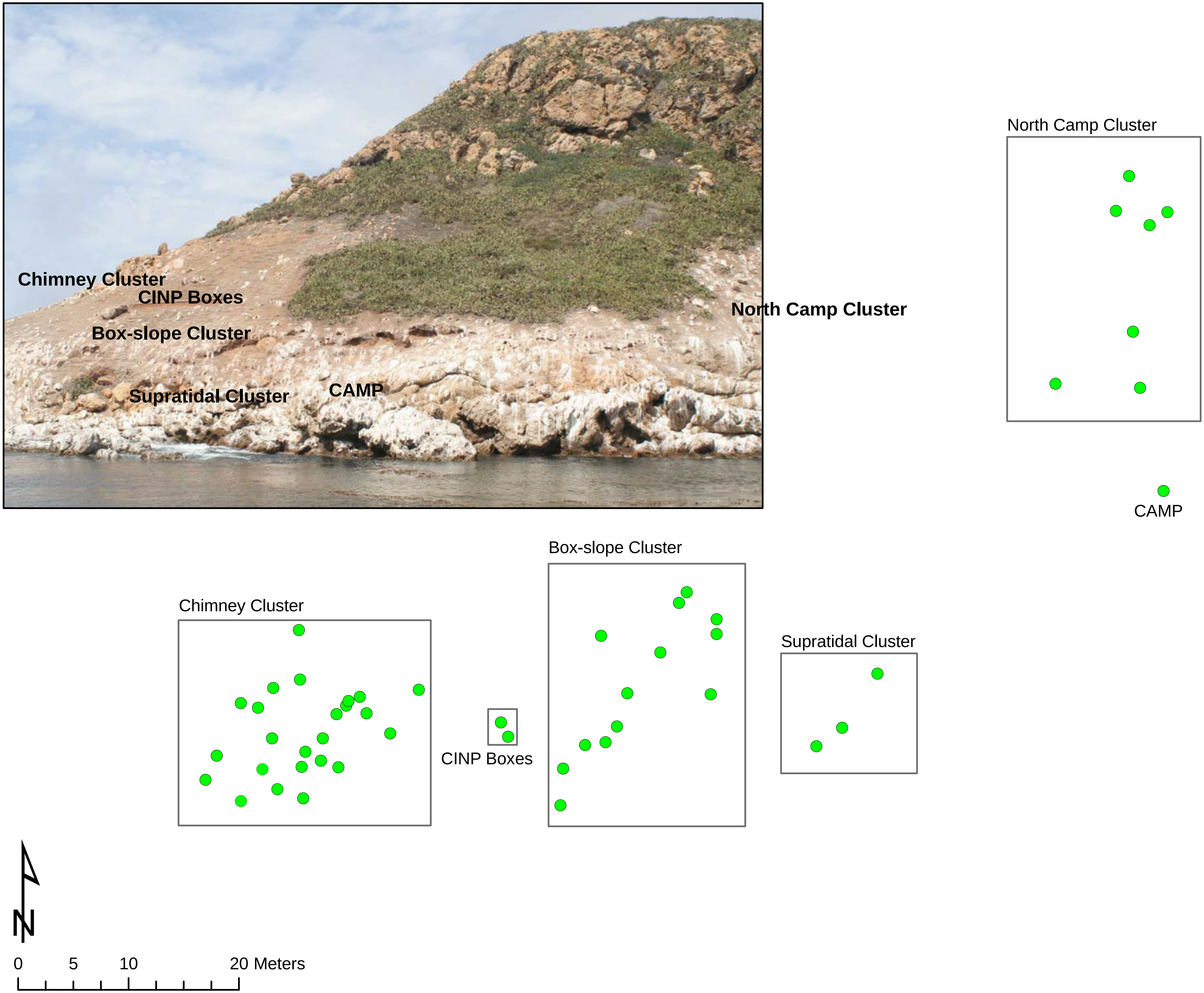

**Figure 1.** From top left to bottom right: the first image shows the southeast CINP auklet nest boxes before removal on 27 August 2007, note that boxes are near fully exposed to the morning and early afternoon sun, second image shows view of CINP boxes from downslope, note the suspended entrances and lack of structure to trap and hold soil at entrance level, the third image shows schematic proposed for new artifical burrow replacement, the forth image shows new Carson VCB artificial burrows set behind existing plank structure, the fifth image shows the new replacement burrows installed (9 of 25) with 2x4 retainer to trap and hold soil 12-in in front of new burrow entrances, and the sixth image shows a newly replaced artificial burrow (1 of 50) located on the southeast slope of Prince Island.

*Literature Cited*—Adams, J., J. Y. Takekawa, and H. R. Carter. 2004a. Foraging distance and home range of Cassin's Auklets nesting in the California Channel Islands. Condor 106:618–637.; Adams, J., J. Y. Takekawa, and H. R. Carter. 2004b. Cassin's Auklet (*Ptychoramphus aleuticus*) foraging during variable ocean conditions suggests transport mediated changes in zoo- and ichthyoplankton availability off California. Can. J. Zool. 82:1578–1595.

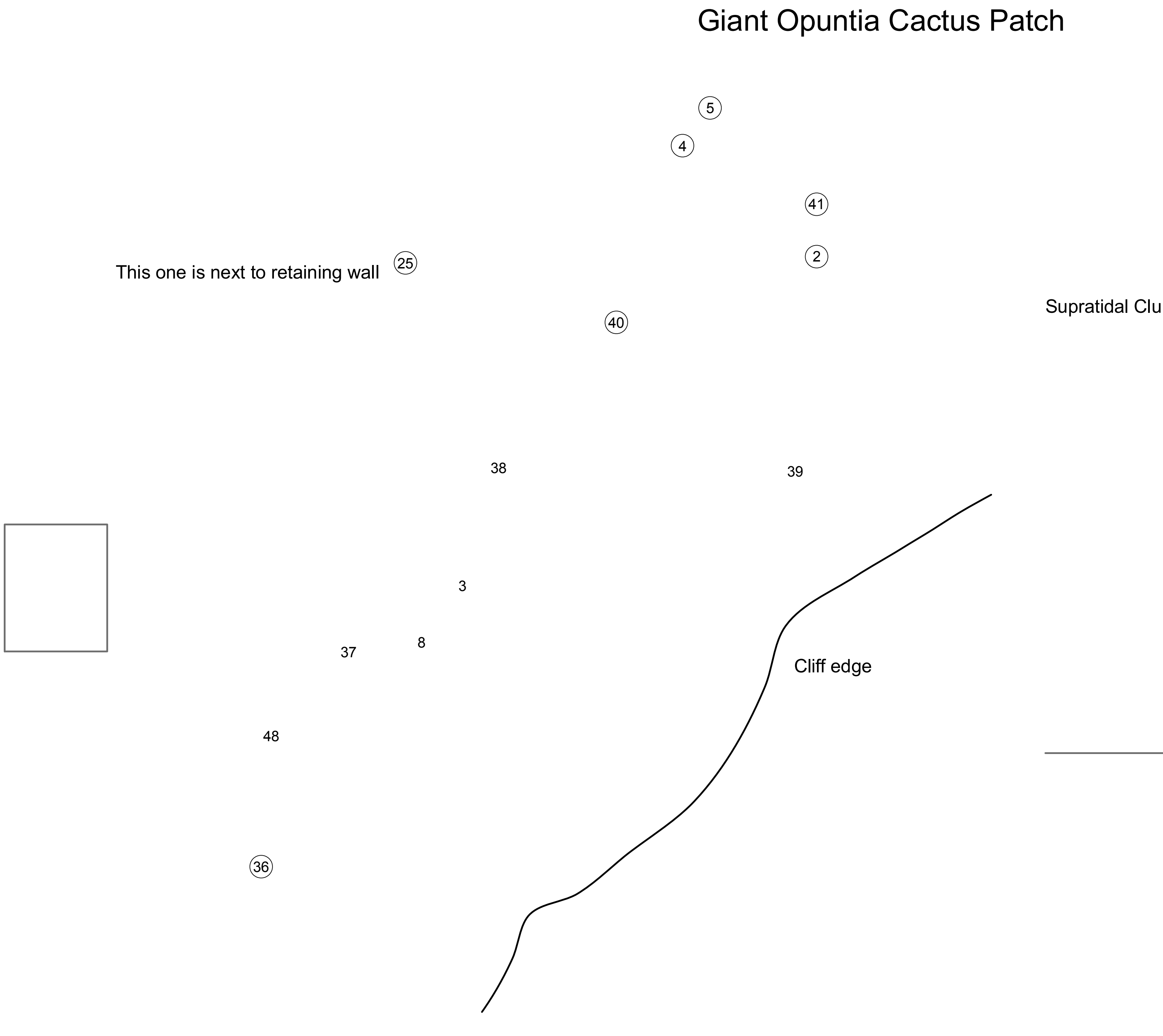
**Data herein are preliminary and subject to revision – do not cite or distribute without permission**

**For more information, please contact:** Josh Adams, USGS-WERC, 831-771-4138, josh_adams@usgs.gov

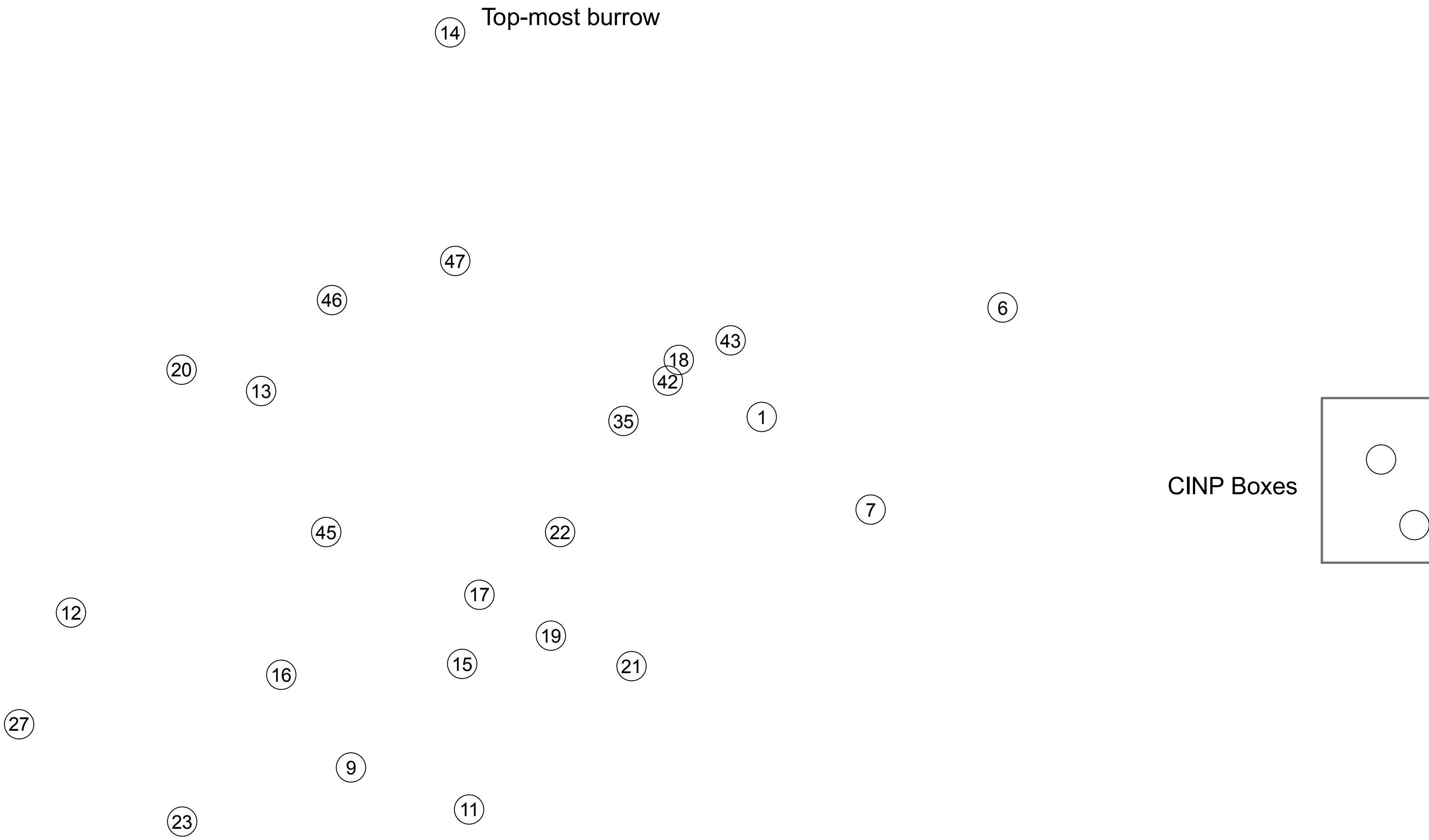
# Appendix 3: Cassin’s Auklet Nest Sites on Prince Island and Scorpion Rock


Chimney Cluster
CINP Boxes
Box-slope Cluster
Supratidal Cluster
CAMP
North Camp Cluster
North Camp Cluster
CAMP
Box-slope Cluster
Chimney Cluster
CINP Boxes
Supratidal Cluster
N
0
5
10
20 Meters

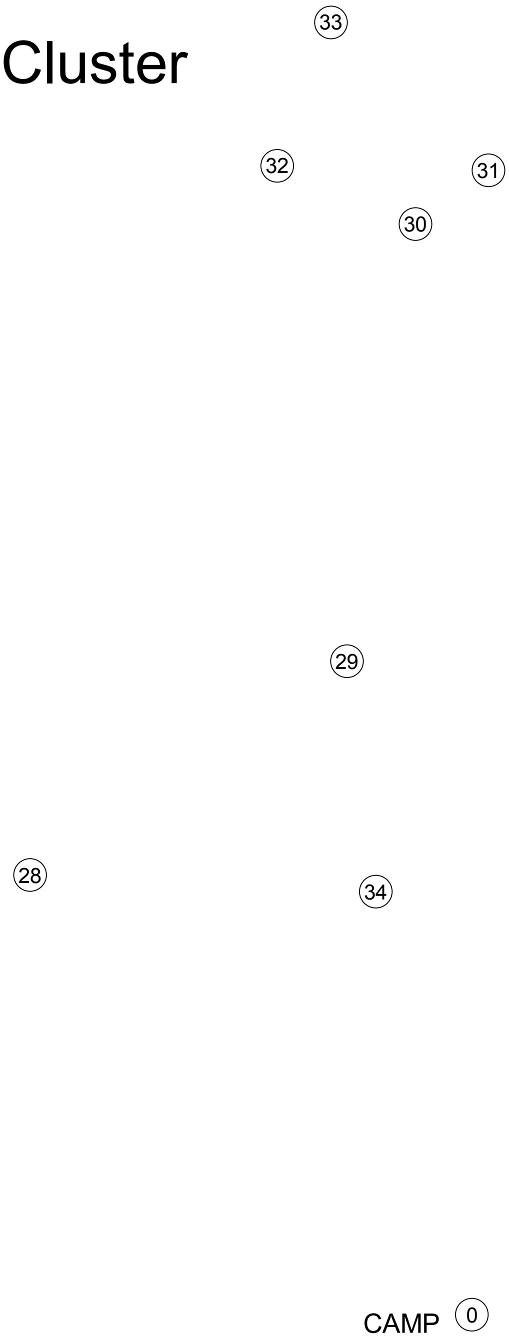
# Box-slope Cluster

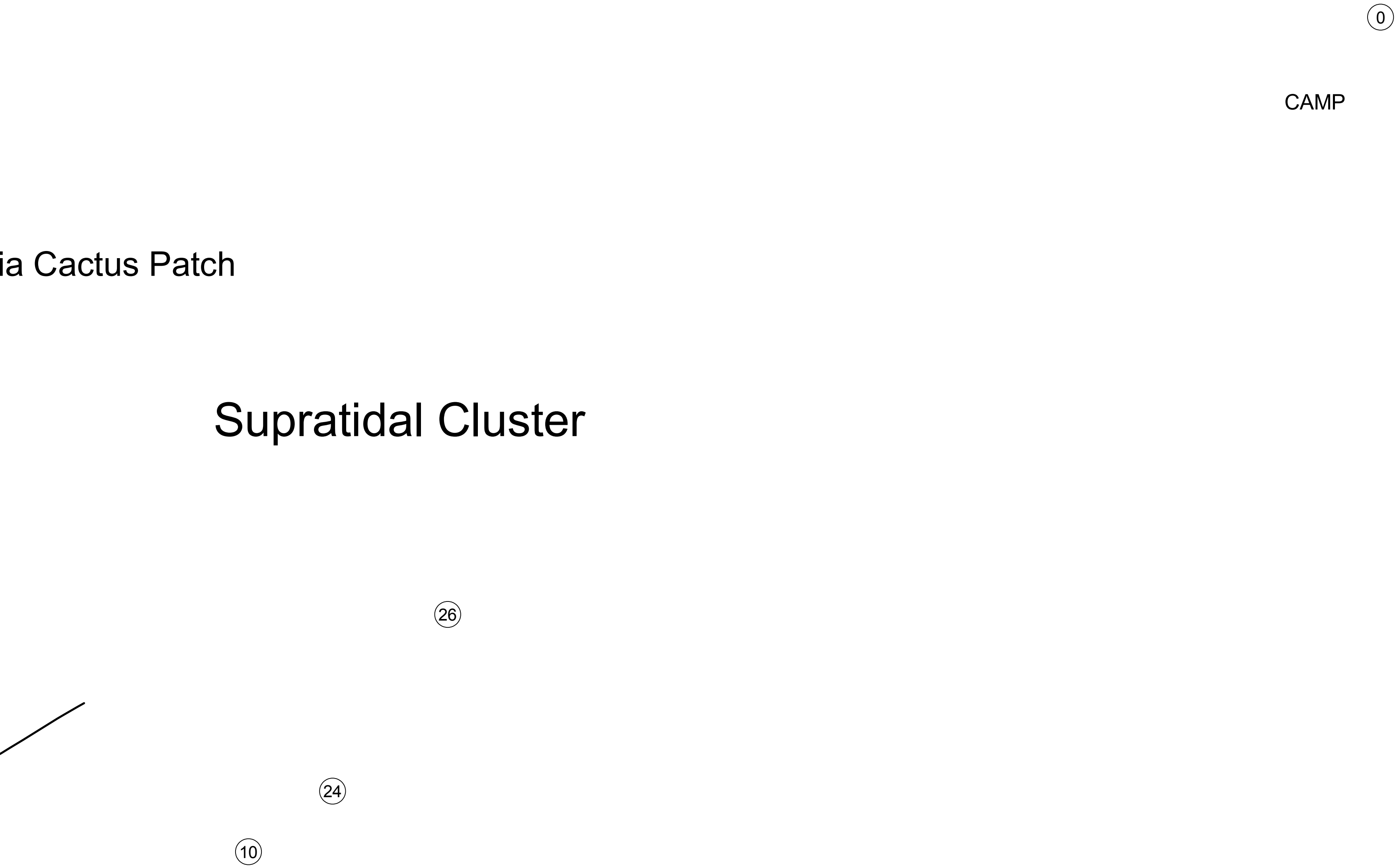


# Chimney Cluster

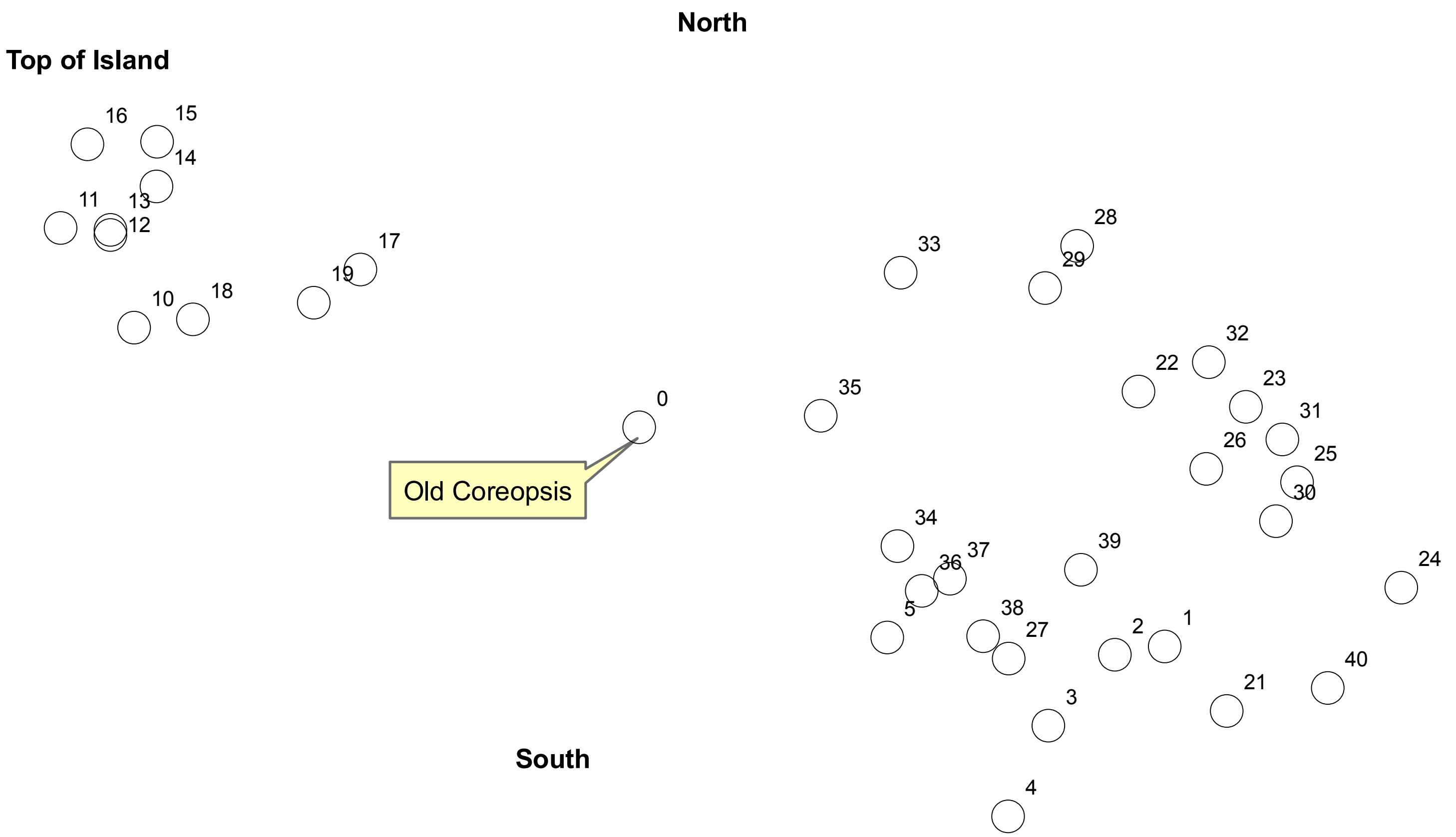


# North Camp Cluster




0
CAMP
ia Cactus Patch
Supratidal Cluster
26
24
10

# Scorpion Rock Artificial Burrow Locations



# Appendix 4: Soil Chemistry Analyses Reports

# A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 | MODESTO, CALIFORNIA 95351 | (209) 529-4080 | FAX (209) 529-4736


**REPORT NUMBER:** 08-232-050

**CLIENT NO:** 9999-D

**SEND TO:** USGS/MOSS LANDING MARINE LABS
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**SUBMITTED BY:** JOSH ADAMS

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL ANALYSIS REPORT

**PAGE:** 1

| SAMPLE ID | LAB NUMBER | Organic Matter * % Rating | Organic Matter ** ENR lbs/A | Phosphorus P1 (Weak Bray) **** * ppm | Phosphorus $NaHCO_3$-P (OlsenMethod) **** * ppm | Potassium K ***** * ppm | Magnesium Mg *** * ppm | Calcium Ca *** * ppm | Sodium Na *** * ppm | pH Soil pH | pH Buffer Index | Hydrogen H meq/100g | Cation Exchange Capacity C.E.C. meq/100g | PERCENT CATION SATURATION (COMPUTED) K % | Mg % | Ca % | H % | Na % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B5NW | 50930 | 7.9VH | 189 | 197VH | 187** | 1765VH | 119VL | 1005VL | 306M | 4.2 | 4.8 | 28.2 | 40.0 | 11.3 | 2.4 | 12.5 | 70.4 | 3.3 |
| C5W | 50931 | 5.1H | 133 | 135VH | 205** | 2350VH | 155VL | 849VL | 618H | 4.6 | 5.7 | 16.7 | 30.9 | 19.5 | 4.1 | 13.7 | 54.0 | 8.7 |
| A5SW | 50932 | 5.2H | 133 | 255VH | 251** | 2091VH | 257L | 953VL | 624H | 4.7 | 5.8 | 15.2 | 30.1 | 17.7 | 7.0 | 15.8 | 50.5 | 9.0 |
| B5S | 50933 | 5.3VH | 137 | 303VH | 363** | 1993VH | 292L | 1171VL | 513H | 4.7 | 5.7 | 15.9 | 31.5 | 16.2 | 7.6 | 18.6 | 50.5 | 7.1 |
| A5M | 50934 | 5.6VH | 141 | 255VH | 108** | 1907VH | 147VL | 944VL | 447H | 4.5 | 5.6 | 17.6 | 30.3 | 16.1 | 4.0 | 15.5 | 58.0 | 6.4 |

** NaHCO3-P unreliable at this soil pH

| SAMPLE NUMBER | Nitrogen $NO_3$-N ppm | Sulfur $SO_4$-S ppm | Zinc Zn ppm | Manganese Mn ppm | Iron Fe ppm | Copper Cu ppm | Boron B ppm | Excess Lime Rating | Soluble Salts mmhos/cm | Chloride Cl ppm | | PARTICLE SIZE ANALYSIS SAND % | SILT % | CLAY % | SOIL TEXTURE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B5NW | 137VH | 44VH | 4.3H | 6M | 126VH | 0.5L | 0.7M | L | 2.1H | | | | | | |
| C5W | 328VH | 46VH | 2.0M | 19H | 96VH | 0.7L | 0.7M | L | 4.2VH | | | | | | |
| A5SW | 173VH | 113VH | 1.8M | 11M | 122VH | 0.9M | 0.5L | L | 4.0H | | | | | | |
| B5S | 173VH | 57VH | 2.0M | 18H | 97VH | 0.9M | 0.7M | L | 2.9H | | | | | | |
| A5M | 325VH | 35H | 2.0M | 24H | 103VH | 0.7L | 0.6M | L | 3.7H | | | | | | |

* CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), AND VERY HIGH (VH).
** ENR - ESTIMATED NITROGEN RELEASE
*** MULTIPLY THE RESULTS IN ppm BY 2 TO CONVERT TO LBS. PER ACRE OF THE ELEMENTAL FORM
**** MULTIPLY THE RESULTS IN ppm BY 4.6 TO CONVERT TO LBS. PER ACRE $P_2O_5$
***** MULTIPLY THE RESULTS IN ppm BY 2.4 TO CONVERT TO LBS. PER ACRE $K_2O$
MOST SOILS WEIGH TWO (2) MILLION POUNDS (DRY WEIGHT) FOR AN ACRE OF SOIL 6-2/3 INCHES DEEP

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

Mike Buttress, CPAg
A & L WESTERN LABORATORIES, INC.

# A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 | MODESTO, CALIFORNIA 95351 | (209) 529-4080 | FAX (209) 529-4736

**REPORT NUMBER:** 08-232-050

**CLIENT NO:** 9999-D

**SEND TO:** USGS/MOSS LANDING MARINE LABS
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**SUBMITTED BY:** JOSH ADAMS

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL ANALYSIS REPORT



| SAMPLE ID | LAB NUMBER | Organic Matter * % Rating | Organic Matter ** ENR lbs/A | Phosphorus P1 (Weak Bray) **** * ppm | Phosphorus $NaHCO_3$-P (OlsenMethod) **** * ppm | Potassium K ***** * ppm | Magnesium Mg *** * ppm | Calcium Ca *** * ppm | Sodium Na *** * ppm | pH Soil pH | pH Buffer Index | Hydrogen H meq/100g | Cation Exchange Capacity C.E.C. meq/100g | PERCENT CATION SATURATION (COMPUTED) K % | Mg % | Ca % | H % | Na % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C5N | 50935 | 8.6VH | 201 | 235VH | 113** | 2009VH | 155VL | 1141VL | 542H | 4.3 | 4.9 | 28.1 | 42.5 | 12.1 | 3.0 | 13.4 | 66.0 | 5.5 |
| A5NE | 50936 | 7.9VH | 188 | 104VH | 111** | 964VH | 105L | 596VL | 259H | 4.7 | 6.3 | 7.6 | 15.0 | 16.4 | 5.7 | 19.8 | 50.5 | 7.5 |
| B5E | 50937 | 6.8VH | 166 | 186VH | 107** | 1663VH | 249L | 1138VL | 410H | 4.9 | 6.1 | 10.8 | 24.6 | 17.3 | 8.3 | 23.1 | 44.0 | 7.3 |
| C5SE | 50938 | 5.7VH | 145 | 164VH | 98** | 1986VH | 242L | 1222VL | 505H | 4.5 | 5.3 | 21.2 | 36.6 | 13.9 | 5.4 | 16.7 | 58.0 | 6.0 |

** NaHCO3-P unreliable at this soil pH

| SAMPLE NUMBER | Nitrogen $NO_3$-N ppm | Sulfur $SO_4$-S ppm | Zinc Zn ppm | Manganese Mn ppm | Iron Fe ppm | Copper Cu ppm | Boron B ppm | Excess Lime Rating | Soluble Salts mmhos/cm | Chloride Cl ppm | | PARTICLE SIZE ANALYSIS SAND % | SILT % | CLAY % | SOIL TEXTURE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C5N | 202VH | 64VH | 4.5H | 6M | 115VH | 0.5L | 0.5L | L | 3.1H | | | | | | |
| A5NE | 105VH | 37VH | 5.9H | 19H | 112VH | 0.8L | 0.8M | L | 2.3H | | | | | | |
| B5E | 127VH | 58VH | 3.7H | 19H | 102VH | 1.7H | 0.7M | L | 2.4H | | | | | | |
| C5SE | 142VH | 106VH | 2.0M | 28H | 94VH | 1.0M | 0.7M | L | 3.1H | | | | | | |

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# A & L WESTERN AGRICULTURAL LABORATORIES

**1311 WOODLAND AVE #1 | MODESTO, CALIFORNIA 95351 | (209) 529-4080 | FAX (209) 529-4736**


**REPORT NUMBER:** 08-232-049

**CLIENT NO:** 9999-D

**SEND TO:** USGS/MOSS LANDING MARINE LABS
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**SUBMITTED BY:** JOSH ADAMS

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL ANALYSIS REPORT

**PAGE:** 1

| SAMPLE ID | LAB NUMBER | Organic Matter * % Rating | Organic Matter ** ENR lbs/A | Phosphorus P1 (Weak Bray) **** * ppm | Phosphorus $NaHCO_3$-P (OlsenMethod) **** * ppm | Potassium K ***** * ppm | Magnesium Mg *** * ppm | Calcium Ca *** * ppm | Sodium Na *** * ppm | pH Soil pH | pH Buffer Index | Hydrogen H meq/100g | Cation Exchange Capacity C.E.C. meq/100g | PERCENT CATION SATURATION (COMPUTED) K % | Mg % | Ca % | H % | Na % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B4SE | 50921 | 6.9VH | 168 | 226VH | 216** | 1346VH | 210L | 1095VL | 232H | 5.2 | 6.4 | 6.1 | 17.8 | 19.4 | 9.7 | 30.7 | 34.5 | 5.7 |
| A4S | 50922 | 6.7VH | 165 | 252VH | 216** | 1739VH | 280L | 1322VL | 394H | 4.9 | 6.0 | 11.8 | 26.9 | 16.5 | 8.6 | 24.5 | 44.0 | 6.4 |
| C4SW | 50923 | 7.0VH | 170 | 300VH | 212** | 1575VH | 156VL | 1465VL | 232M | 4.5 | 5.5 | 18.8 | 32.4 | 12.4 | 3.9 | 22.5 | 58.0 | 3.1 |
| B4W | 50924 | 12.5VH | 280 | 324VH | 232** | 1328VH | 165VL | 2285VL | 114L | 4.7 | 5.6 | 17.0 | 33.6 | 10.1 | 4.0 | 33.9 | 50.5 | 1.5 |
| C4M | 50925 | 8.6VH | 201 | 331VH | 203** | 1563VH | 164VL | 1597VL | 272M | 4.7 | 5.8 | 14.8 | 29.3 | 13.7 | 4.6 | 27.2 | 50.5 | 4.0 |

** NaHCO3-P unreliable at this soil pH

| SAMPLE NUMBER | Nitrogen $NO_3$-N ppm | Sulfur $SO_4$-S ppm | Zinc Zn ppm | Manganese Mn ppm | Iron Fe ppm | Copper Cu ppm | Boron B ppm | Excess Lime Rating | Soluble Salts mmhos/cm | Chloride Cl ppm | | PARTICLE SIZE ANALYSIS SAND % | SILT % | CLAY % | SOIL TEXTURE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B4SE | 120VH | 181VH | 2.8M | 12M | 81VH | 0.3VL | 0.8M | L | 4.4VH | | | | | | |
| A4S | 159VH | 167VH | 3.2H | 20H | 91VH | 0.4L | 0.5L | L | 3.9H | | | | | | |
| C4SW | 105VH | 171VH | 4.5H | 15H | 85VH | 0.5L | 0.4L | L | 2.8H | | | | | | |
| B4W | 124VH | 101VH | 9.3VH | 11M | 79VH | 0.8L | 0.8M | L | 2.2H | | | | | | |
| C4M | 97VH | 65VH | 8.9VH | 12M | 100VH | 0.6L | 0.6M | L | 1.7M | | | | | | |

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**REPORT NUMBER:** 08-232-049

**CLIENT NO:** 9999-D

**SEND TO:** USGS/MOSS LANDING MARINE LABS
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**SUBMITTED BY:** JOSH ADAMS

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

# SOIL ANALYSIS REPORT



| SAMPLE ID | LAB NUMBER | Organic Matter * % Rating | Organic Matter ** ENR lbs/A | Phosphorus P1 (Weak Bray) **** * ppm | Phosphorus $NaHCO_3$-P (OlsenMethod) **** * ppm | Potassium K ***** * ppm | Magnesium Mg *** * ppm | Calcium Ca *** * ppm | Sodium Na *** * ppm | pH Soil pH | pH Buffer Index | Hydrogen H meq/100g | Cation Exchange Capacity C.E.C. meq/100g | PERCENT CATION SATURATION (COMPUTED) K % | Mg % | Ca % | H % | Na % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A4E | 50926 | 5.4VH | 138 | 169VH | 173** | 1433VH | 142L | 994VL | 107L | 4.6 | 6.0 | 12.0 | 22.3 | 16.4 | 5.2 | 22.2 | 54.0 | 2.1 |
| C4NE | 50927 | 7.3VH | 175 | 207VH | 184** | 1742VH | 212L | 1431VL | 312M | 4.6 | 5.6 | 17.3 | 31.9 | 13.9 | 5.5 | 22.4 | 54.0 | 4.2 |
| B4N | 50928 | 8.1VH | 192 | 276VH | 209** | 1248VH | 172VL | 1811VL | 124L | 4.7 | 5.8 | 14.5 | 28.7 | 11.1 | 4.9 | 31.5 | 50.5 | 1.9 |
| A4NW | 50929 | 8.1VH | 191 | 295VH | 169** | 1509VH | 210L | 1685L | 172M | 5.4 | 6.4 | 5.9 | 20.6 | 18.7 | 8.4 | 40.8 | 28.5 | 3.6 |

** NaHCO3-P unreliable at this soil pH

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A4E | 78VH | 62VH | 2.3M | 29H | 125VH | 0.4L | 0.6M | L | 1.7M | | | | | | |
| C4NE | 198VH | 112VH | 6.1VH | 27H | 97VH | 0.5L | 0.7M | L | 3.1H | | | | | | |
| B4N | 152VH | 113VH | 6.8VH | 24H | 72VH | 0.6L | 0.7M | L | 2.7H | | | | | | |
| A4NW | 252VH | 94VH | 6.8VH | 24H | 62VH | 0.6L | 0.8M | L | 4.4VH | | | | | | |

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1311 WOODLAND AVE #1 | MODESTO, CALIFORNIA 95351 | (209) 529-4080 | FAX (209) 529-4736

**REPORT NUMBER:** 08-232-048

**CLIENT NO:** 9999-D

**SEND TO:** USGS/MOSS LANDING MARINE LABS
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**SUBMITTED BY:** JOSH ADAMS

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

# SOIL ANALYSIS REPORT



| SAMPLE ID | LAB NUMBER | Organic Matter * % Rating | Organic Matter ** ENR lbs/A | Phosphorus P1 (Weak Bray) **** * ppm | Phosphorus $NaHCO_3$-P (OlsenMethod) **** * ppm | Potassium K ***** * ppm | Magnesium Mg *** * ppm | Calcium Ca *** * ppm | Sodium Na *** * ppm | pH Soil pH | pH Buffer Index | Hydrogen H meq/100g | Cation Exchange Capacity C.E.C. meq/100g | PERCENT CATION SATURATION (COMPUTED) K % | Mg % | Ca % | H % | Na % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B3SW | 50912 | 6.5VH | 159 | 269VH | 240** | 1385VH | 160VL | 1212VL | 249M | 4.5 | 5.7 | 16.6 | 28.5 | 12.4 | 4.6 | 21.2 | 58.0 | 3.8 |
| C3S | 50913 | 5.7VH | 144 | 226VH | 228** | 1629VH | 164L | 909VL | 223M | 4.6 | 5.9 | 12.9 | 24.0 | 17.4 | 5.6 | 18.9 | 54.0 | 4.0 |
| A3SE | 50914 | 6.6VH | 161 | 226VH | 240** | 1554VH | 138L | 1079VL | 133L | 4.8 | 6.2 | 9.8 | 20.9 | 19.0 | 5.4 | 25.8 | 47.0 | 2.8 |
| C3E | 50915 | 7.1VH | 172 | 271VH | 235** | 1455VH | 152VL | 1196VL | 252M | 4.4 | 5.5 | 19.6 | 31.7 | 11.8 | 3.9 | 18.8 | 62.0 | 3.5 |
| B3M | 50916 | 6.9VH | 168 | 273VH | 208** | 1773VH | 151L | 1317VL | 302H | 5.1 | 6.3 | 8.4 | 22.0 | 20.6 | 5.6 | 29.8 | 38.0 | 6.0 |

** NaHCO3-P unreliable at this soil pH

| SAMPLE NUMBER | Nitrogen $NO_3$-N ppm | Sulfur $SO_4$-S ppm | Zinc Zn ppm | Manganese Mn ppm | Iron Fe ppm | Copper Cu ppm | Boron B ppm | Excess Lime Rating | Soluble Salts mmhos/cm | Chloride Cl ppm | | PARTICLE SIZE ANALYSIS SAND % | SILT % | CLAY % | SOIL TEXTURE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B3SW | 84VH | 52VH | 3.2H | 13H | 95VH | 0.4L | 0.9M | L | 1.5M | | | | | | |
| C3S | 90VH | 89VH | 2.1M | 19H | 100VH | 0.3VL | 0.7M | L | 2.0M | | | | | | |
| A3SE | 45VH | 94VH | 3.8H | 21H | 114VH | 0.4L | 0.6M | L | 1.5M | | | | | | |
| C3E | 181VH | 83VH | 4.8H | 18H | 108VH | 0.4L | 0.8M | L | 3.1H | | | | | | |
| B3M | 110VH | 135VH | 2.7M | 12M | 64VH | 0.3VL | 0.6M | L | 2.5H | | | | | | |

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**REPORT NUMBER:** 08-232-048

**CLIENT NO:** 9999-D

**SEND TO:** USGS/MOSS LANDING MARINE LABS
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**SUBMITTED BY:** JOSH ADAMS

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

# SOIL ANALYSIS REPORT



| SAMPLE ID | LAB NUMBER | Organic Matter | | Phosphorus | | Potassium | Magnesium | Calcium | Sodium | pH | | Hydrogen | Cation Exchange Capacity | PERCENT CATION SATURATION (COMPUTED) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | * % Rating | ** ENR lbs/A | P1 (Weak Bray) **** * ppm | $NaHCO_3$-P (OlsenMethod) **** * ppm | K ***** * ppm | Mg *** * ppm | Ca *** * ppm | Na *** * ppm | Soil pH | Buffer Index | H meq/100g | C.E.C. meq/100g | K % | Mg % | Ca % | H % | Na % |
| A3W | 50917 | 5.9VH | 149 | 268VH | 184** | 1580VH | 154L | 1039VL | 335H | 4.7 | 6.0 | 12.2 | 24.1 | 16.7 | 5.2 | 21.5 | 50.5 | 6.0 |
| C3NW | 50918 | 5.9VH | 148 | 266VH | 195** | 2094VH | 226L | 1081VL | 573H | 4.6 | 5.6 | 17.7 | 32.8 | 16.3 | 5.7 | 16.4 | 54.0 | 7.6 |
| A3N | 50919 | 5.8VH | 147 | 267VH | 171** | 1352VH | 144L | 978VL | 227M | 4.6 | 6.0 | 12.3 | 22.8 | 15.1 | 5.2 | 21.4 | 54.0 | 4.3 |
| B3NE | 50920 | 8.9VH | 209 | 271VH | 196** | 1655VH | 179VL | 1632VL | 359M | 4.4 | 5.1 | 25.1 | 40.5 | 10.4 | 3.6 | 20.1 | 62.0 | 3.9 |

** NaHCO3-P unreliable at this soil pH

| SAMPLE NUMBER | Nitrogen $NO_3$-N ppm | Sulfur $SO_4$-S ppm | Zinc Zn ppm | Manganese Mn ppm | Iron Fe ppm | Copper Cu ppm | Boron B ppm | Excess Lime Rating | Soluble Salts mmhos/cm | Chloride Cl ppm | | PARTICLE SIZE ANALYSIS SAND % | SILT % | CLAY % | SOIL TEXTURE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A3W | 104VH | 58VH | 3.1H | 21H | 90VH | 0.4L | 0.5L | L | 1.4M | | | | | | |
| C3NW | 194VH | 163VH | 2.7M | 17H | 94VH | 0.8L | 0.6M | L | 4.4VH | | | | | | |
| A3N | 161VH | 83VH | 3.3H | 18H | 116VH | 0.5L | 0.5L | L | 3.1H | | | | | | |
| B3NE | 310VH | 106VH | 10.0VH | 14H | 109VH | 0.8L | 0.7M | L | 3.8H | | | | | | |

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**REPORT NUMBER:** 08-232-047

**CLIENT NO:** 9999-D

**SEND TO:** USGS/MOSS LANDING MARINE LAB
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**SUBMITTED BY:** JOSH ADAMS

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

# SOIL ANALYSIS REPORT



| SAMPLE ID | LAB NUMBER | Organic Matter | | Phosphorus | | Potassium | Magnesium | Calcium | Sodium | pH | | Hydrogen | Cation Exchange Capacity | PERCENT CATION SATURATION (COMPUTED) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | * % Rating | ** ENR lbs/A | P1 (Weak Bray) **** * ppm | $NaHCO_3$-P (OlsenMethod) **** * ppm | K ***** * ppm | Mg *** * ppm | Ca *** * ppm | Na *** * ppm | Soil pH | Buffer Index | H meq/100g | C.E.C. meq/100g | K % | Mg % | Ca % | H % | Na % |
| A2SW | 50903 | 6.9VH | 169 | 268VH | 103** | 1439VH | 141VL | 1009VL | 157L | 4.5 | 5.8 | 14.6 | 25.1 | 14.6 | 4.6 | 20.0 | 58.0 | 2.7 |
| B2S | 50904 | 7.0VH | 169 | 266VH | 189** | 1684VH | 225L | 1024VL | 423H | 4.9 | 6.1 | 10.3 | 23.4 | 18.4 | 7.9 | 21.8 | 44.0 | 7.9 |
| C2SE | 50905 | 6.9VH | 168 | 262VH | 191** | 1714VH | 164L | 1164VL | 184M | 5.2 | 6.4 | 6.5 | 18.8 | 23.3 | 7.2 | 30.8 | 34.5 | 4.3 |
| B2E | 50906 | 8.1VH | 191 | 276VH | 190** | 1604VH | 109VL | 908VL | 222L | 4.2 | 5.1 | 25.0 | 35.5 | 11.6 | 2.5 | 12.8 | 70.4 | 2.7 |
| A2M | 50907 | 8.4VH | 197 | 103VH | 188** | 1674VH | 166VL | 1476VL | 265M | 4.7 | 5.8 | 14.4 | 28.6 | 15.0 | 4.8 | 25.8 | 50.5 | 4.0 |

** NaHCO3-P unreliable at this soil pH

| SAMPLE NUMBER | Nitrogen $NO_3$-N ppm | Sulfur $SO_4$-S ppm | Zinc Zn ppm | Manganese Mn ppm | Iron Fe ppm | Copper Cu ppm | Boron B ppm | Excess Lime Rating | Soluble Salts mmhos/cm | Chloride Cl ppm | | PARTICLE SIZE ANALYSIS SAND % | SILT % | CLAY % | SOIL TEXTURE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A2SW | 63VH | 60VH | 3.3H | 19H | 107VH | 0.4L | 0.8M | L | 1.2M | | | | | | |
| B2S | 186VH | 163VH | 3.7H | 24H | 89VH | 0.4L | 0.8M | L | 4.1VH | | | | | | |
| C2SE | 108VH | 113VH | 4.2H | 12M | 99VH | 0.5L | 0.6M | L | 2.6H | | | | | | |
| B2E | 98VH | 60VH | 4.3H | 10M | 119VH | 0.5L | 0.7M | L | 2.0M | | | | | | |
| A2M | 210VH | 105VH | 10.4VH | 19H | 99VH | 0.8L | 1.0M | L | 3.2H | | | | | | |

* CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), AND VERY HIGH (VH).
** ENR - ESTIMATED NITROGEN RELEASE
*** MULTIPLY THE RESULTS IN ppm BY 2 TO CONVERT TO LBS. PER ACRE OF THE ELEMENTAL FORM
**** MULTIPLY THE RESULTS IN ppm BY 4.6 TO CONVERT TO LBS. PER ACRE $P_2O_5$
***** MULTIPLY THE RESULTS IN ppm BY 2.4 TO CONVERT TO LBS. PER ACRE $K_2O$
MOST SOILS WEIGH TWO (2) MILLION POUNDS (DRY WEIGHT) FOR AN ACRE OF SOIL 6-2/3 INCHES DEEP

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

M Buttress

Mike Buttress, CPAg
A & L WESTERN LABORATORIES, INC.

# A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 | MODESTO, CALIFORNIA 95351 | (209) 529-4080 | FAX (209) 529-4736

**REPORT NUMBER:** 08-232-047

**CLIENT NO:** 9999-D

**SEND TO:** USGS/MOSS LANDING MARINE LAB
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**SUBMITTED BY:** JOSH ADAMS

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL ANALYSIS REPORT



| SAMPLE ID | LAB NUMBER | Organic Matter * % Rating | Organic Matter ** ENR lbs/A | Phosphorus P1 (Weak Bray) **** * ppm | Phosphorus NaHCO3-P (OlsenMethod) **** * ppm | Potassium K ***** * ppm | Magnesium Mg *** * ppm | Calcium Ca *** * ppm | Sodium Na *** * ppm | pH Soil pH | pH Buffer Index | Hydrogen H meq/100g | Cation Exchange Capacity C.E.C. meq/100g | PERCENT CATION SATURATION (COMPUTED) K % | Mg % | Ca % | H % | Na % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C2W | 50908 | 7.0VH | 170 | 263VH | 207** | 985VH | 94L | 836VL | 77L | 4.9 | 6.4 | 6.1 | 13.9 | 18.1 | 5.6 | 30.0 | 44.0 | 2.4 |
| B2NW | 50909 | 6.7VH | 163 | 271VH | 224** | 1412VH | 159VL | 1076VL | 200L | 4.3 | 5.3 | 21.6 | 32.8 | 11.0 | 4.0 | 16.4 | 66.0 | 2.6 |
| C2N | 50910 | 8.1VH | 193 | 283VH | 234** | 1170VH | 164VL | 1565VL | 229M | 4.6 | 5.8 | 15.4 | 28.6 | 10.5 | 4.7 | 27.3 | 54.0 | 3.5 |
| A2NE | 50911 | 7.2VH | 174 | 295VH | 235** | 1344VH | 239L | 1580VL | 158L | 4.9 | 6.1 | 11.0 | 25.0 | 13.8 | 7.9 | 31.6 | 44.0 | 2.7 |

** NaHCO3-P unreliable at this soil pH

| SAMPLE NUMBER | Nitrogen $NO_3$-N ppm | Sulfur $SO_4$-S ppm | Zinc Zn ppm | Manganese Mn ppm | Iron Fe ppm | Copper Cu ppm | Boron B ppm | Excess Lime Rating | Soluble Salts mmhos/cm | Chloride Cl ppm | | PARTICLE SIZE ANALYSIS SAND % | SILT % | CLAY % | SOIL TEXTURE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C2W | 96VH | 73VH | 4.1H | 12M | 94VH | 0.4L | 0.7M | L | 2.0M | | | | | | |
| B2NW | 155VH | 94VH | 3.2H | 14H | 81VH | 0.3VL | 0.8M | L | 2.8H | | | | | | |
| C2N | 368VH | 73VH | 9.7VH | 14H | 103VH | 0.6L | 1.0M | L | 4.3VH | | | | | | |
| A2NE | 101VH | 49VH | 5.7H | 11M | 128VH | 0.5L | 0.8M | L | 2.0M | | | | | | |

* CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), AND VERY HIGH (VH).
** ENR - ESTIMATED NITROGEN RELEASE
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**** MULTIPLY THE RESULTS IN ppm BY 4.6 TO CONVERT TO LBS. PER ACRE $P_2O_5$
***** MULTIPLY THE RESULTS IN ppm BY 2.4 TO CONVERT TO LBS. PER ACRE $K_2O$
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M Buttress

Mike Buttress, CPAg
A & L WESTERN LABORATORIES, INC.

# A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 I MODESTO, CALIFORNIA 95351 I (209) 529-4080 I FAX (209) 529-4736


**REPORT NUMBER:** 08-232-046

**CLIENT NO:** 9999-D

**SEND TO:** USGS/MOSS LANDING MARINE LABS
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**SUBMITTED BY:** JOSH ADAMS

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL ANALYSIS REPORT



| SAMPLE ID | LAB NUMBER | Organic Matter * % Rating | Organic Matter ** ENR lbs/A | Phosphorus P1 (Weak Bray) **** * ppm | Phosphorus $NaHCO_3$-P (OlsenMethod) **** * ppm | Potassium K ***** * ppm | Magnesium Mg *** * ppm | Calcium Ca *** * ppm | Sodium Na *** * ppm | pH Soil pH | pH Buffer Index | Hydrogen H meq/100g | Cation Exchange Capacity C.E.C. meq/100g | PERCENT CATION SATURATION (COMPUTED) K % | Mg % | Ca % | H % | Na % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B1SE | 50894 | 14.4VH | 317 | 258VH | 215** | 892M | 171VL | 1508VL | 243L | 4.0 | 4.8 | 36.8 | 49.1 | 4.7 | 2.9 | 15.3 | 75.0 | 2.2 |
| A1E | 50895 | 7.1VH | 173 | 266VH | 213** | 1417VH | 148VL | 877VL | 263M | 4.2 | 5.1 | 24.7 | 35.0 | 10.3 | 3.5 | 12.5 | 70.4 | 3.3 |
| C1NE | 50896 | 6.1VH | 151 | 269VH | 196** | 1079VH | 304M | 1199VL | 236M | 5.0 | 6.2 | 8.5 | 20.8 | 13.3 | 12.0 | 28.8 | 41.0 | 4.9 |
| B1N | 50897 | 6.2VH | 154 | 290VH | 206** | 1409VH | 193VL | 1254VL | 268M | 4.4 | 5.4 | 20.6 | 33.2 | 10.9 | 4.8 | 18.9 | 62.0 | 3.5 |
| C1M | 50898 | 5.4VH | 138 | 319VH | 201** | 1523VH | 198L | 940VL | 315H | 4.6 | 5.9 | 13.6 | 25.2 | 15.5 | 6.5 | 18.6 | 54.0 | 5.4 |

** NaHCO3-P unreliable at this soil pH

| SAMPLE NUMBER | Nitrogen $NO_3$-N ppm | Sulfur $SO_4$-S ppm | Zinc Zn ppm | Manganese Mn ppm | Iron Fe ppm | Copper Cu ppm | Boron B ppm | Excess Lime Rating | Soluble Salts mmhos/cm | Chloride Cl ppm | | PARTICLE SIZE ANALYSIS SAND % | SILT % | CLAY % | SOIL TEXTURE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B1SE | 423VH | 76VH | 19.0VH | 10M | 107VH | 0.8L | 0.8M | L | 4.1VH | | | | | | |
| A1E | 142VH | 70VH | 8.0VH | 4M | 98VH | 0.4L | 0.6M | L | 2.9H | | | | | | |
| C1NE | 381VH | 156VH | 4.7H | 3M | 70VH | 0.5L | 0.9M | L | 5.4VH | | | | | | |
| B1N | 254VH | 88VH | 3.1H | 1VL | 36VH | 0.3VL | 0.8M | L | 3.5H | | | | | | |
| C1M | 132VH | 107VH | 4.4H | 8M | 138VH | 0.5L | 0.7M | L | 3.8H | | | | | | |

* CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), AND VERY HIGH (VH).
** ENR - ESTIMATED NITROGEN RELEASE
*** MULTIPLY THE RESULTS IN ppm BY 2 TO CONVERT TO LBS. PER ACRE OF THE ELEMENTAL FORM
**** MULTIPLY THE RESULTS IN ppm BY 4.6 TO CONVERT TO LBS. PER ACRE $P_2O_5$
***** MULTIPLY THE RESULTS IN ppm BY 2.4 TO CONVERT TO LBS. PER ACRE $K_2O$
MOST SOILS WEIGH TWO (2) MILLION POUNDS (DRY WEIGHT) FOR AN ACRE OF SOIL 6-2/3 INCHES DEEP

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

Mike Buttress, CPAg
A & L WESTERN LABORATORIES, INC.

# A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 | MODESTO, CALIFORNIA 95351 | (209) 529-4080 | FAX (209) 529-4736

**REPORT NUMBER:** 08-232-046

**CLIENT NO:** 9999-D

**SEND TO:** USGS/MOSS LANDING MARINE LABS
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**SUBMITTED BY:** JOSH ADAMS

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL ANALYSIS REPORT



| SAMPLE ID | LAB NUMBER | Organic Matter | | Phosphorus | | Potassium | Magnesium | Calcium | Sodium | pH | | Hydrogen | Cation Exchange Capacity | PERCENT CATION SATURATION (COMPUTED) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | * % Rating | ** ENR lbs/A | P1 (Weak Bray) **** * ppm | $NaHCO_3$-P (OlsenMethod) **** * ppm | K ***** * ppm | Mg *** * ppm | Ca *** * ppm | Na *** * ppm | Soil pH | Buffer Index | H meq/100g | C.E.C. meq/100g | K % | Mg % | Ca % | H % | Na % |
| A1S | 50899 | 8.1VH | 191 | 235VH | 172** | 1692VH | 134VL | 1018VL | 282M | 4.3 | 5.2 | 22.8 | 34.5 | 12.5 | 3.2 | 14.7 | 66.0 | 3.6 |
| C1SW | 50900 | 8.3VH | 196 | 194VH | 166** | 1542VH | 135VL | 1094VL | 238M | 4.4 | 5.5 | 18.8 | 30.4 | 13.0 | 3.7 | 18.0 | 62.0 | 3.4 |
| B1W | 50901 | 4.5H | 120 | 261VH | 134** | 1404VH | 392M | 929VL | 305H | 4.8 | 6.0 | 11.3 | 24.1 | 14.9 | 13.4 | 19.2 | 47.0 | 5.5 |
| A1NW | 50902 | 5.5VH | 139 | 292VH | 184** | 1694VH | 381M | 1343VL | 361H | 4.8 | 5.9 | 14.0 | 29.7 | 14.6 | 10.6 | 22.6 | 47.0 | 5.3 |

** NaHCO3-P unreliable at this soil pH

| SAMPLE NUMBER | Nitrogen $NO_3$-N ppm | Sulfur $SO_4$-S ppm | Zinc Zn ppm | Manganese Mn ppm | Iron Fe ppm | Copper Cu ppm | Boron B ppm | Excess Lime Rating | Soluble Salts mmhos/cm | Chloride Cl ppm | | PARTICLE SIZE ANALYSIS SAND % | SILT % | CLAY % | SOIL TEXTURE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1S | 112VH | 63VH | 6.3VH | 7M | 111VH | 0.9M | 0.7M | L | 2.8H | | | | | | |
| C1SW | 126VH | 69VH | 8.8VH | 14H | 126VH | 0.6L | 0.8M | L | 2.4H | | | | | | |
| B1W | 419VH | 121VH | 2.2M | 21H | 71VH | 0.5L | 0.7M | L | 6.2VH | | | | | | |
| A1NW | 194VH | 210VH | 3.3H | 8M | 57VH | 0.5L | 0.8M | L | 4.5VH | | | | | | |

* CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), AND VERY HIGH (VH).
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# A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 | MODESTO, CALIFORNIA 95351 | (209) 529-4080 | FAX (209) 529-4736

**REPORT NUMBER:** 08-232-051

**CLIENT NO:** 9999-D

**SEND TO:** USGS/NOSS LANDING MARINE LABS
5272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**SUBMITTED BY:** JOSH ADAMS

**GROWER:** PO#085WRSA0448

**DATE OF REPORT:** 08/27/08

# SOIL ANALYSIS REPORT



| SAMPLE ID | LAB NUMBER | Organic Matter * % Rating | Organic Matter ** ENR lbs/A | Phosphorus P1 (Weak Bray) **** * ppm | Phosphorus NaHCO3-P (OlsenMethod) **** * ppm | Potassium K ***** * ppm | Magnesium Mg *** * ppm | Calcium Ca *** * ppm | Sodium Na *** * ppm | pH Soil pH | pH Buffer Index | Hydrogen H meq/100g | Cation Exchange Capacity C.E.C. meq/100g | PERCENT CATION SATURATION (COMPUTED) K % | Mg % | Ca % | H % | Na % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C6NW | 50939 | 6.0VH | 149 | 128VH | 106** | 2290VH | 191L | 899VL | 406H | 4.7 | 5.9 | 13.9 | 27.6 | 21.2 | 5.7 | 16.2 | 50.5 | 6.4 |
| A6W | 50940 | 5.5VH | 141 | 192VH | 111** | 2230VH | 240L | 1479VL | 428H | 4.7 | 5.6 | 17.3 | 34.2 | 16.7 | 5.8 | 21.6 | 50.5 | 5.4 |
| B6SW | 50941 | 5.1H | 132 | 138VH | 110** | 2157VH | 264L | 1195VL | 914VH | 4.7 | 5.6 | 18.0 | 35.6 | 15.5 | 6.1 | 16.7 | 50.5 | 11.2 |
| C6S | 50942 | 5.4VH | 137 | 189VH | 119** | 2640VH | 229L | 998VL | 838VH | 4.8 | 5.8 | 15.3 | 32.6 | 20.7 | 5.8 | 15.3 | 47.0 | 11.2 |
| B6M | 50943 | 5.8VH | 146 | 204VH | 104** | 1975VH | 183VL | 1039VL | 453H | 4.4 | 5.3 | 22.4 | 36.1 | 14.0 | 4.2 | 14.4 | 62.0 | 5.5 |

** NaHCO3-P unreliable at this soil pH

| SAMPLE NUMBER | Nitrogen $NO_3$-N ppm | Sulfur $SO_4$-S ppm | Zinc Zn ppm | Manganese Mn ppm | Iron Fe ppm | Copper Cu ppm | Boron B ppm | Excess Lime Rating | Soluble Salts mmhos/cm | Chloride Cl ppm | | PARTICLE SIZE ANALYSIS SAND % | SILT % | CLAY % | SOIL TEXTURE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C6NW | 176VH | 73VH | 2.5M | 17H | 122VH | 0.6L | 0.3VL | L | 3.1H | | | | | | |
| A6W | 360VH | 61VH | 2.9M | 17H | 100VH | 0.6L | 0.8M | L | 3.8H | | | | | | |
| B6SW | 267VH | 127VH | 1.6M | 30H | 88VH | 0.6L | 0.7M | L | 5.1VH | | | | | | |
| C6S | 273VH | 75VH | 2.3M | 25H | 104VH | 0.7L | 0.9M | L | 3.9H | | | | | | |
| B6M | 149VH | 65VH | 2.0M | 14H | 97VH | 0.6L | 0.8M | L | 1.9M | | | | | | |

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# A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 | MODESTO, CALIFORNIA 95351 | (209) 529-4080 | FAX (209) 529-4736

**REPORT NUMBER:** 08-232-051

**CLIENT NO:** 9999-D

**SEND TO:** USGS/NOSS LANDING MARINE LABS
5272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**SUBMITTED BY:** JOSH ADAMS

**GROWER:** PO#085WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL ANALYSIS REPORT



| SAMPLE ID | LAB NUMBER | Organic Matter * % Rating | Organic Matter ** ENR lbs/A | Phosphorus P1 (Weak Bray) **** * ppm | Phosphorus $NaHCO_3$-P (OlsenMethod) **** * ppm | Potassium K ***** * ppm | Magnesium Mg *** * ppm | Calcium Ca *** * ppm | Sodium Na *** * ppm | pH Soil pH | pH Buffer Index | Hydrogen H meq/100g | Cation Exchange Capacity C.E.C. meq/100g | PERCENT CATION SATURATION (COMPUTED) K % | Mg % | Ca % | H % | Na % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A6N | 50944 | 6.7VH | 163 | 171VH | 113** | 2379VH | 222L | 1197VL | 470H | 4.6 | 5.5 | 18.7 | 34.6 | 17.6 | 5.3 | 17.3 | 54.0 | 5.9 |
| B6NE | 50945 | 7.6VH | 181 | 213VH | 112** | 1697VH | 188L | 1175VL | 365H | 4.7 | 5.9 | 13.6 | 26.9 | 16.1 | 5.7 | 21.8 | 50.5 | 5.9 |
| C6E | 50946 | 6.5VH | 160 | 248VH | 109** | 2269VH | 253L | 1208VL | 502H | 5.0 | 6.1 | 11.2 | 27.3 | 21.3 | 7.6 | 22.1 | 41.0 | 8.0 |
| A6SE | 50947 | 5.5VH | 140 | 157VH | 108** | 2370VH | 402L | 1449VL | 733H | 4.9 | 5.7 | 15.5 | 35.3 | 17.2 | 9.4 | 20.5 | 44.0 | 9.0 |

** NaHCO3-P unreliable at this soil pH

| SAMPLE NUMBER | Nitrogen $NO_3$-N ppm | Sulfur $SO_4$-S ppm | Zinc Zn ppm | Manganese Mn ppm | Iron Fe ppm | Copper Cu ppm | Boron B ppm | Excess Lime Rating | Soluble Salts mmhos/cm | Chloride Cl ppm | | PARTICLE SIZE ANALYSIS SAND % | SILT % | CLAY % | SOIL TEXTURE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A6N | 118VH | 41VH | 3.3H | 13H | 104VH | 0.5L | 0.8M | L | 2.1H | | | | | | |
| B6NE | 166VH | 51VH | 4.2H | 21H | 104VH | 0.8L | 1.1M | L | 3.0H | | | | | | |
| C6E | 278VH | 55VH | 3.8H | 17H | 90VH | 0.7L | 1.0M | L | 4.1VH | | | | | | |
| A6SE | 292VH | 88VH | 2.4M | 45VH | 76VH | 0.8L | 1.1M | L | 4.6VH | | | | | | |

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# A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 | MODESTO, CALIFORNIA 95351 | (209) 529-4080 | FAX (209) 529-4736


**REPORT NUMBER:** 08-232-050 **CLIENT:** 99999

**SUBMITTED BY:** JOSH ADAMS

**SEND TO:** USGS/MOSS LANDING MARINE LABS
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL SALINITY ANALYSIS REPORT

**PAGE:** 1

| Sample ID | Lab Number | SAR | ESP | Na meq/L | Ca meq/L | Mg meq/L | pH | $CO_3$ meq/L | $HCO_3$ meq/L | E.C. dS/m | Cl meq/L | B ppm | Saturation % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B5NW | 50930 | 4.4 | 4.9 | 7.5 | 4.3 | 1.6 | 4.2 | 0.0 | 0.9 | 2.1 | 0.6 | 0.4 | 60.0 |
| C5W | 50931 | 9.2 | 11.0 | 18.9 | 5.5 | 2.9 | 4.6 | 0.0 | 0.9 | 4.2 | 1.7 | 0.4 | 50.0 |
| A5SW | 50932 | 7.2 | 8.6 | 17.8 | 7.0 | 5.2 | 4.7 | 0.0 | 1.0 | 4.0 | 4.3 | 0.4 | 57.3 |
| B5S | 50933 | 5.4 | 6.3 | 14.2 | 8.7 | 5.0 | 4.7 | 0.0 | 0.8 | 2.9 | 2.1 | 0.4 | 53.5 |
| A5M | 50934 | 6.1 | 7.2 | 16.2 | 9.9 | 4.0 | 4.5 | 0.0 | 0.8 | 3.7 | 1.7 | 0.4 | 47.9 |
| C5N | 50935 | 6.3 | 7.4 | 13.9 | 7.1 | 2.7 | 4.3 | 0.0 | 0.9 | 3.1 | 2.1 | 0.4 | 61.1 |
| A5NE | 50936 | 6.4 | 7.5 | 12.3 | 4.9 | 2.5 | 4.7 | 0.0 | 0.9 | 2.3 | 2.1 | 0.4 | 67.6 |

**NOTES:**



Mike Buttress, CPAg
A & L WESTERN LABORATORIES, INC.

# A & L WESTERN AGRICULTURAL LABORATORIES

**1311 WOODLAND AVE #1 | MODESTO, CALIFORNIA 95351 | (209) 529-4080 | FAX (209) 529-4736**


**REPORT NUMBER:** 08-232-050 **CLIENT:** 99999

**SUBMITTED BY:** JOSH ADAMS

**SEND TO:** USGS/MOSS LANDING MARINE LABS
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL SALINITY ANALYSIS REPORT



| Sample ID | Lab Number | SAR | ESP | Na meq/L | Ca meq/L | Mg meq/L | pH | $CO_3$ meq/L | $HCO_3$ meq/L | E.C. dS/m | Cl meq/L | B ppm | Saturation % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B5E | 50937 | 4.8 | 5.5 | 11.1 | 6.9 | 3.9 | 4.9 | 0.0 | 1.2 | 204.0 | 2.1 | 0.4 | 12.8 |
| C5SE | 50938 | 5.0 | 5.8 | 13.0 | 9.0 | 4.4 | 4.5 | 0.0 | 0.8 | 3.1 | 3.4 | 0.3 | 71.9 |

**NOTES:**



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1311 WOODLAND AVE #1 | MODESTO, CALIFORNIA 95351 | (209) 529-4080 | FAX (209) 529-4736

**REPORT NUMBER:** 08-232-049 **CLIENT:** 99999

**SUBMITTED BY:** JOSH ADAMS

**SEND TO:** USGS/MOSS LANDING MARINE LABS
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL SALINITY ANALYSIS REPORT



| Sample ID | Lab Number | SAR | ESP | Na meq/L | Ca meq/L | Mg meq/L | pH | $CO_3$ meq/L | $HCO_3$ meq/L | E.C. dS/m | Cl meq/L | B ppm | Saturation % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B4SE | 50921 | 3.4 | 3.6 | 11.0 | 12.8 | 8.6 | 5.2 | 0.0 | 2.2 | 4.4 | 6.9 | 0.2 | 49.4 |
| A4S | 50922 | 4.3 | 4.9 | 13.7 | 12.2 | 7.8 | 4.9 | 0.0 | 1.7 | 3.9 | 8.3 | 0.3 | 57.3 |
| C4SW | 50923 | 2.5 | 2.4 | 7.6 | 13.6 | 4.3 | 4.5 | 0.0 | 1.2 | 2.8 | 4.7 | 0.3 | 54.9 |
| B4W | 50924 | 1.1 | 0.4 | 3.4 | 15.5 | 3.6 | 4.7 | 0.0 | 1.3 | 2.2 | 2.2 | 0.3 | 66.7 |
| C4M | 50925 | 3.1 | 3.2 | 7.0 | 8.0 | 2.5 | 4.7 | 0.0 | 1.0 | 1.7 | 2.0 | 0.4 | 64.1 |
| A4E | 50926 | 2.1 | 1.8 | 4.3 | 6.1 | 2.6 | 4.6 | 0.0 | 1.1 | 1.7 | 1.2 | 0.3 | 48.7 |
| C4NE | 50927 | 3.6 | 3.9 | 11.0 | 13.0 | 5.8 | 4.6 | 0.0 | 1.2 | 3.1 | 3.6 | 0.4 | 56.9 |

**NOTES:**



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8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL SALINITY ANALYSIS REPORT



| Sample ID | Lab Number | SAR | ESP | Na meq/L | Ca meq/L | Mg meq/L | pH | $CO_3$ meq/L | $HCO_3$ meq/L | E.C. dS/m | Cl meq/L | B ppm | Saturation % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B4N | 50928 | 1.4 | 0.8 | 4.7 | 18.2 | 4.9 | 4.7 | 0.0 | 1.2 | 2.7 | 3.0 | 0.3 | 60.3 |
| A4NW | 50929 | 2.2 | 1.9 | 5.4 | 8.8 | 3.5 | 5.4 | 0.0 | 1.6 | 4.4 | 2.5 | 0.2 | 70.0 |

**NOTES:**



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**REPORT NUMBER:** 08-232-048 **CLIENT:** 99999

**SUBMITTED BY:** JOSH ADAMS

**SEND TO:** USGS/MOSS LANDING MARINE LABS
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL SALINITY ANALYSIS REPORT



| Sample ID | Lab Number | SAR | ESP | Na meq/L | Ca meq/L | Mg meq/L | pH | $CO_3$ meq/L | $HCO_3$ meq/L | E.C. dS/m | Cl meq/L | B ppm | Saturation % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B3SW | 50912 | 3.5 | 3.8 | 7.6 | 6.7 | 2.5 | 4.5 | 0.0 | 1.0 | 1.5 | 1.8 | 0.3 | 44.6 |
| C3S | 50913 | 3.3 | 3.5 | 6.3 | 4.6 | 2.6 | 4.6 | 0.0 | 0.9 | 2.0 | 2.3 | 0.2 | 41.4 |
| A3SE | 50914 | 2.0 | 1.7 | 3.3 | 4.0 | 1.6 | 4.8 | 0.0 | 1.2 | 1.5 | 1.9 | 0.2 | 44.4 |
| C3E | 50915 | 3.0 | 3.1 | 8.4 | 11.6 | 4.2 | 4.4 | 0.0 | 1.0 | 3.1 | 2.3 | 0.2 | 51.2 |
| B3M | 50916 | 4.0 | 4.4 | 8.5 | 6.7 | 2.4 | 5.1 | 0.0 | 1.7 | 2.5 | 4.3 | 0.2 | 52.2 |
| A3W | 50917 | 5.1 | 5.9 | 10.2 | 5.4 | 2.6 | 4.7 | 0.0 | 1.1 | 1.4 | 2.2 | 0.3 | 46.0 |
| C3NW | 50918 | 6.7 | 7.9 | 21.7 | 13.0 | 8.1 | 4.6 | 0.0 | 1.4 | 4.4 | 8.2 | 0.3 | 45.2 |

**NOTES:**



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**SUBMITTED BY:** JOSH ADAMS

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8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL SALINITY ANALYSIS REPORT



| Sample ID | Lab Number | SAR | ESP | Na meq/L | Ca meq/L | Mg meq/L | pH | $CO_3$ meq/L | $HCO_3$ meq/L | E.C. dS/m | Cl meq/L | B ppm | Saturation % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A3N | 50919 | 3.2 | 3.3 | 8.7 | 10.7 | 4.5 | 4.6 | 0.0 | 1.1 | 3.1 | 3.6 | 0.2 | 47.6 |
| B3NE | 50920 | 3.0 | 3.0 | 11.7 | 24.0 | 6.8 | 4.4 | 0.0 | 1.3 | 3.8 | 3.6 | 0.4 | 62.7 |

**NOTES:**



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1311 WOODLAND AVE #1 | MODESTO, CALIFORNIA 95351 | (209) 529-4080 | FAX (209) 529-4736


**REPORT NUMBER:** 08-232-047 **CLIENT:** 99999

**SUBMITTED BY:** JOSH ADAMS

**SEND TO:** USGS/MOSS LANDING MARINE LAB
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL SALINITY ANALYSIS REPORT

**PAGE:** 1

| Sample ID | Lab Number | SAR | ESP | Na meq/L | Ca meq/L | Mg meq/L | pH | $CO_3$ meq/L | $HCO_3$ meq/L | E.C. dS/m | Cl meq/L | B ppm | Saturation % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A2SW | 50903 | 2.1 | 1.8 | 3.2 | 3.0 | 1.6 | 4.5 | 0.0 | 0.6 | 1.2 | 1.0 | 0.2 | 61.6 |
| B2S | 50904 | 4.6 | 5.3 | 11.2 | 7.0 | 4.9 | 4.9 | 0.0 | 1.3 | 4.1 | 3.6 | 0.2 | 65.2 |
| C2SE | 50905 | 2.7 | 2.7 | 4.8 | 4.1 | 2.1 | 5.2 | 0.0 | 0.9 | 2.6 | 2.8 | 0.2 | 85.3 |
| B2E | 50906 | 3.4 | 3.6 | 6.1 | 4.7 | 1.7 | 4.2 | 0.0 | 1.1 | 2.0 | 1.5 | 0.2 | 53.6 |
| A2M | 50907 | 2.7 | 2.7 | 7.7 | 12.4 | 3.8 | 4.7 | 0.0 | 1.1 | 3.2 | 2.9 | 0.3 | 58.2 |
| C2W | 50908 | 2.2 | 2.0 | 4.4 | 5.7 | 2.3 | 4.9 | 0.0 | 1.1 | 2.0 | 2.5 | 0.2 | 48.5 |
| B2NW | 50909 | 2.8 | 2.7 | 9.0 | 14.6 | 6.4 | 4.3 | 0.0 | 0.9 | 28.0 | 2.8 | 0.3 | 51.5 |

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**CLIENT:** 99999

**SUBMITTED BY:** JOSH ADAMS

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8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL SALINITY ANALYSIS REPORT



| Sample ID | Lab Number | SAR | ESP | Na meq/L | Ca meq/L | Mg meq/L | pH | $CO_3$ meq/L | $HCO_3$ meq/L | E.C. dS/m | Cl meq/L | B ppm | Saturation % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C2N | 50910 | 2.6 | 2.5 | 11.5 | 31.3 | 9.0 | 4.6 | 0.0 | 1.3 | 4.3 | 3.6 | 0.3 | 63.7 |
| A2NE | 50911 | 1.7 | 1.2 | 5.3 | 13.8 | 5.8 | 49.0 | 0.0 | 1.3 | 2.0 | 2.2 | 0.3 | 53.2 |

**NOTES:**



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**REPORT NUMBER:** 08-232-046 **CLIENT:** 99999

**SUBMITTED BY:** JOSH ADAMS

**SEND TO:** USGS/MOSS LANDING MARINE LABS
8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL SALINITY ANALYSIS REPORT



| Sample ID | Lab Number | SAR | ESP | Na meq/L | Ca meq/L | Mg meq/L | pH | $CO_3$ meq/L | $HCO_3$ meq/L | E.C. dS/m | Cl meq/L | B ppm | Saturation % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B1SE | 50894 | 2.2 | 1.9 | 10.0 | 33.4 | 8.7 | 4.0 | 0.0 | 0.4 | 4.1 | 3.4 | 0.3 | 84.6 |
| A1E | 50895 | 3.0 | 3.1 | 8.9 | 11.6 | 5.3 | 4.2 | 0.0 | 0.9 | 2.9 | 2.3 | 0.3 | 64.9 |
| C1NE | 50896 | 2.6 | 2.4 | 10.5 | 19.7 | 14.4 | 5.0 | 0.0 | 0.9 | 5.4 | 6.0 | 0.3 | 55.6 |
| B1N | 50897 | 2.7 | 2.6 | 10.1 | 20.8 | 8.1 | 4.4 | 0.0 | 0.8 | 3.5 | 4.3 | 0.3 | 59.1 |
| C1M | 50898 | 4.1 | 4.6 | 12.1 | 10.3 | 6.7 | 4.6 | 0.0 | 0.9 | 3.8 | 4.5 | 0.3 | 59.0 |
| A1S | 50899 | 3.8 | 4.2 | 7.7 | 5.6 | 2.5 | 4.3 | 0.0 | 0.7 | 2.8 | 2.0 | 0.3 | 72.1 |
| C1SW | 50900 | 3.0 | 3.1 | 6.9 | 7.3 | 3.0 | 4.4 | 0.0 | 0.6 | 2.4 | 1.5 | 0.3 | 78.1 |

**NOTES:**



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**SUBMITTED BY:** JOSH ADAMS

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8272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**GROWER:** PO#08WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL SALINITY ANALYSIS REPORT



| Sample ID | Lab Number | SAR | ESP | Na meq/L | Ca meq/L | Mg meq/L | pH | $CO_3$ meq/L | $HCO_3$ meq/L | E.C. dS/m | Cl meq/L | B ppm | Saturation % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B1W | 50901 | 3.3 | 3.4 | 12.6 | 12.4 | 17.1 | 4.8 | 0.0 | 0.9 | 6.2 | 3.9 | 0.3 | 53.9 |
| A1NW | 50902 | 2.9 | 3.0 | 10.7 | 13.8 | 12.6 | 4.8 | 0.0 | 0.9 | 4.5 | 5.6 | 0.2 | 59.1 |

**NOTES:**



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**1311 WOODLAND AVE #1 | MODESTO, CALIFORNIA 95351 | (209) 529-4080 | FAX (209) 529-4736**

**REPORT NUMBER:** 08-232-051 **CLIENT:** 99999

**SUBMITTED BY:** JOSH ADAMS

**SEND TO:** USGS/NOSS LANDING MARINE LABS
5272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**GROWER:** PO#085WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL SALINITY ANALYSIS REPORT

**PAGE:** 1

| Sample ID | Lab Number | SAR | ESP | Na meq/L | Ca meq/L | Mg meq/L | pH | $CO_3$ meq/L | $HCO_3$ meq/L | E.C. dS/m | Cl meq/L | B ppm | Saturation % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C6NW | 50939 | 5.7 | 6.6 | 11.1 | 4.9 | 2.8 | 4.7 | 0.0 | 0.8 | 3.1 | 1.4 | 0.3 | 47.5 |
| A6W | 50940 | 3.6 | 3.9 | 12.3 | 16.5 | 7.1 | 4.7 | 0.0 | 0.8 | 3.8 | 1.6 | 0.4 | 49.5 |
| B6SW | 50941 | 8.7 | 10.3 | 26.5 | 11.4 | 7.3 | 4.7 | 0.0 | 1.0 | 5.1 | 7.4 | 0.4 | 49.1 |
| C6S | 50942 | 9.3 | 11.1 | 17.7 | 4.3 | 2.8 | 4.8 | 0.0 | 0.9 | 3.9 | 3.1 | 0.4 | 54.9 |
| B6M | 50943 | 5.6 | 6.5 | 11.7 | 6.1 | 2.7 | 4.4 | 0.0 | 0.9 | 1.9 | 1.4 | 0.3 | 47.4 |
| A6N | 50944 | 4.9 | 5.6 | 7.2 | 2.9 | 1.4 | 4.6 | 0.0 | 0.9 | 2.1 | 0.8 | 0.3 | 54.2 |
| B6NE | 50945 | 4.4 | 5.0 | 9.7 | 6.6 | 3.0 | 4.7 | 0.0 | 1.0 | 3.0 | 1.4 | 0.4 | 61.0 |

**NOTES:**



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5272 MOSS LANDING RD
MOSS LANDING, CA 95039-

**GROWER:** PO#085WRSA0448

**DATE OF REPORT:** 08/27/08

## SOIL SALINITY ANALYSIS REPORT



| Sample ID | Lab Number | SAR | ESP | Na meq/L | Ca meq/L | Mg meq/L | pH | $CO_3$ meq/L | $HCO_3$ meq/L | E.C. dS/m | Cl meq/L | B ppm | Saturation % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C6E | 50946 | 5.4 | 6.3 | 13.6 | 8.0 | 4.8 | 5.0 | 0.0 | 1.0 | 4.1 | 2.1 | 0.4 | 60.1 |
| A6SE | 50947 | 6.1 | 7.2 | 21.1 | 13.4 | 10.2 | 4.9 | 0.0 | 1.1 | 4.6 | 6.3 | 0.5 | 55.2 |

**NOTES:**



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