Population monitoring and habitat restoration for Cassin's Auklets at Scorpion Rock and Prince Island, Channel Islands National Park, California: 2009–2011

Josh Adams[1], David Mazurkiewicz[2,3], A. Laurie Harvey [4]

[1] U.S. Geological Survey, Western Ecological Research Center
Pacific Science Center
400 Natural Bridges Drive
Santa Cruz, California 95060 USA
josh_adams@usgs.gov

[2] Montrose Settlements Restoration Program
Channel Islands National Park
1901 Spinnaker Drive
Ventura, California 93001 USA

[3] Channel Islands National Park
1901 Spinnaker Drive
Ventura, California 93001 USA

[4] Sutil Conservation Ecology
30 Buena Vista Avenue
Fairfax, California 94930 USA

Report prepared for:
Montrose Settlements Restoration Program Trustee Council
Channel Islands National Park
Channel Islands National Marine Sanctuary

Interim Data Summary Report, 17 March 2014

Photo above: Aerial photo of Scorpion Rock 13 April 2009 showing patchwork of experimental monitoring plots (5 × 5 m each). Photo by: Helen Sofaer.

Cover photo: Cassin's Auklet resting at night on Prince Island, Channel Islands National Park. Photo by: Josh Adams, USGS.

Disclaimer: This study was funded, in part, by the U.S. Department of the Interior, U.S. Department of Fish and Wildlife (USFWS), Ventura, CA, through Intragovernmental FWS Agreement Number 81430-8-H002 with the U.S. Geological Survey, Western Ecological Research Center. This report has been technically reviewed by USFWS. This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information is provided on the condition that neither the U.S. Geological Survey nor the U.S. Government may be held liable for any damages resulting from the authorized or unauthorized use of this information. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Suggested Citation: Adams, J., D. Mazurkiewicz and A.L. Harvey 2014. Population monitoring and habitat restoration for Cassin's Auklets at Scorpion Rock and Prince Island, Channel Islands National Park, California: 2009–2011. Interim Data Summary Report. U.S. Geological Survey, Western Ecological Research Center, Santa Cruz Field Station, Pacific Coastal Marine Science Center, Santa Cruz, California and Channel Islands National Park, Ventura, California. Unpublished interim data summary report to the Montrose Settlement Restoration Project Trustee Council. 29 pages, 9 tables, 11 figures, and 2 Appendices.

EXECUTIVE SUMMARY

In 2009 through 2011, population monitoring and native plant habitat restoration to preserve and enhance Cassin's Auklet (*Ptychoramphus aleuticus*) continued within the Channel Islands National Park (CINP) at Scorpion Rock (Santa Cruz Island) and at Prince Island (San Miguel Island), California. Post-restoration vegetation cover was quantified at Scorpion Rock. An experimental design to test the efficacy of exotic vegetation control and native out-plantings was implemented in 2008 – 2010, but treatments (desiccant spray *vs*. manual removal) were discontinued because native recruitment within cleared areas made spraying unfeasible. Control plots (*i.e.*, no removal and no out-planting) remained in place through August 2010 to evaluate change in native vegetation and soil chemistry within restoration treatment plots. This experiment was intended to reveal the effects of introduced plants *vs*. native plants on the burrowing habitat of Cassin's Auklet and recovery from previous physical alteration of soil parameters caused primarily by invasive Crystalline Ice Plant (*Mesembryanthemum crystallinum*). The removal/control monitoring plots constitute 31% (1,350 of 4,300 m^2) of the total estimated vegetative area of Scorpion Rock; restoration also was implemented in nonexperimental areas increasing the total restored area to include the majority of the vegetated surface of the island. Information from 2009 – 2011 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 continuous, annual monitoring programs for Cassin's Auklet at Scorpion Rock and Prince Island to measure population changes and variability in reproductive success resulting from restoration actions and other natural and anthropogenic factors.

We monitored Cassin's Auklet's between February and July of 2009, 2010, and 2011 on Scorpion Rock and Prince Island. Herein, we present results documenting post-restoration vegetation composition and percent cover changes of the plant community on Scorpion Rock resulting from restoration out-plantings and weed control. Auklet monitoring activities included estimation of breeding population size at Scorpion Rock and reproductive success at Scorpion Rock and Prince Island. In 2009, 2010, and 2011, based on nest site occupancy among artificial burrow sites and natural burrows on Scorpion Rock, we estimated maximum breeding population varied with 58, 50, and 48 birds in each year, respectively. Restoration monitoring included evaluation of exotic vegetation control, native re-vegetation, and changes to soil quality. To continue native out-planting in 2012 and beyond, we continued to collect native seed on Scorpion Rock and Santa Cruz Island for continued propagation in on-island nursery facilities, including a new nursery facility constructed at Scorpion Ranch (historic corral site) during 2010.

From 2008 – 2011, vegetative cover within vegetation restoration study plots on Scorpion Rock changed dramatically from 94% invasive weeds (6 exotic species) in 2008 to 12% invasive weeds (5 exotic species) in 2011. Change from 2008 to 2011 was driven by decreases in percent cover among three invasive weeds: *M. crystallinum*, (vegetative and desiccated combined: 62% to 7% cover), Cheeseweed (*Malva parviflora*; 13% to <1% cover), and Nettle-leaf Goosefoot (*Chenopodium murale*; 17% to <1%). Native plant richness increased from 6 species to 17 species, with percent cover of native plant species increasing 12-fold: from <4% in 2008 to 48% in 2011. Increase in native percent cover was dominated by Giant Coreopsis (*Leptosyne*

gigantea; < 0.5% to 32% cover), Alklai Heath (*Frankenia salina*; <1% to 3% cover, California Sage (*Artemesia californica*; 0 to 2% cover) and Brewer's Saltbush (*Atriplex lentiformis*; 0 to 2% cover). Out-planting density in non-experimental areas was similar to 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*), Sea Blite (*Suaeda taxifolia*), Coastal Sunflower (*Encelia californica*), and Prickly Pear Cactus (*Opuntia littoralis*, and *O. oricola*).

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 Scripps's Murrelet (*Synthliboramphus scrippsi*), and (c) 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.

Post-restoration establishment of Giant Coreopsis (*Leptosyne gigantea*) and California Sagebrush (*Artemisia californica*) in the foreground and flagging to designate additional restoration outplanting. Photo by: Montrose Settlement Restoration Project/NPS.

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 Scripps'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) which now include 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 by 50–60% during recent decades (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 spring 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). The CCS returned to La Niña conditions during spring 2007 (*i.e.*, more vigorous upwelling during the spring), but responses in ecosystem productivity were inconsistent (McClatchie *et al*. 2008). Conditions off southern California from 2008 – 2011 remained highly variable, oscillating between La Niña- and El Niño-like conditions (McClatchie *et al*. 2009, Bjorkstedt *et al*. 2010, Bjorkstedt *et al*. 2011). Furthermore, Sydeman *et al*. (*in press*), reported a long term decline (1987 – 2011) in the abundances of certain key forage fishes and a variable response and community reorganization in abundance among key krill species, especially within the northern Channel Islands region of the southern California Bight; the authors attribute decreases in the densities of certain seabirds – including Cassin's Auklet – to these changes in the prey base.

FOCAL SPECIES, STUDY SITE, ACTIVITIES, AND METHODS

<u>*Cassin's Auklet*</u>**—** Cassin's Auklet ranges from Alaska to northern Baja California, Mexico. Historic population estimates throughout California are summarized in Adams (2008) and previous monitoring efforts within the Channel Islands National Park (CINP) are summarized in Adams *et al.* (2009). In 2009, 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 2009, 2010, and 2011. Specifically, we report on (1) auklet-related breeding parameters including nest site occupancy, clutch initiation, hatching success, fledging success, and overall breeding success

among artificial Cassin's Auklet burrows at both colonies, and (2) plant community composition and trends in percent cover within vegetation restoration and monitoring plots on Scorpion Rock.

Site descriptions— 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, Scripps's Murrelet, Ashy Storm-Petrel, Pigeon Guillemot (*Cepphus columba*), Pelagic Cormorant (*Phalacrocorax pelagicus*), Brandt's Cormorant (*Phalacrocorax penicillatus*), and Western Gull (*Larus occidentalis*). The largest of the islets, Scorpion Rock, 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 (*Leptosyne gigantea*)[1], Cliff Aster (*Malacothrix saxatilis*), Wild Cucumber (*Marah macrocarpus*) 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**). The earliest and only known plant species list was compiled by Philbrick and Cummings in 1977 (**Table 1**).

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.

Common name	Scientific name[1,*]	Alpha Code	Native?	Propagated?
Giant Coreopsis	*Leptosyne gigantea*[1,*,†]	LEGI	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
Northern Island Hazardia	*Hazardia dentosa*[2]	HADE	Yes	Yes
Seaside Daisy	*Erigon glaucus*[†]	ERGL	Yes	No
Coastal Goldenbush	*Isocoma menziesii*[2]	ISME	Yes	Yes
Emory's Rock Daisy	*Perityle emoryi*[†]	PEEM	Yes	No
Coastal Sunflower	*Encelia californica* [2]	ENCA	Yes	Yes
Seaside Woolly Sunflower	*Eriophyllum staechadifolium* [2]	ERST	Yes	Yes
White Everlasting	*Gnaphalium canescens ssp. Microcephalum*	GNMI	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	—

[1] 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.

Common name	Scientific name[1,*]	Alpha Code	Native?	Propagated?
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	—
Ripgut Brome Grass	*Bromus diandrus*[1]	BRDI	No	—
Foxtail/Barley	*Hordeum murinum*[1]	HOMU	No	—
Kikuyu Grass	*Pennisetum clandestinum*[1]	PECL	No	—
Broad-leafed Filaree	*Erodium botrys*[1]	ERBO	No	—
Cheeseweed	*Malva parviflora*[1]	MAPA (MALV)	No	—
Weedy Cudweed	*Pseudognaphalium luteoalbum*	PSLU	No	—
Sweet Clover	*Melilotus spp.*	MESP	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
Sea Blight	*Sueda taxifolia*[1, †]	SUTA	Yes	Yes
Coastal Prickly Pear	*Opuntia littoralis* [2]	OPLI	Yes	Yes
Tall prickly pear	*Opuntia oricola* [2]	OPOR	Yes	Yes

[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 island Nurseries.
[†] Recorded on Scorpion Rocks by Ralph Philbrick (SBBG) 21 August 1977.

Figure 1. Natural Cassin's Auklet burrow on Scorpion Rock located within native Giant Coreopsis and Alkalai Heath. Photo by: David Mazurkiewicz, NPS.

The vegetated soil on Scorpion Rock also provides burrowing habitat for nesting Cassin's Auklets (**Figure 1**). 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*) 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 *unpublished data*). Seasonal desiccation of this annual weed releases concentrated salts to

the soil; over time, soil salinity increases and potentially can inhibit recolonization by native plants (Kloot 1983, Vivrette & Muller 1977).

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 & 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.

<u>*Cassin's Auklet monitoring*</u>— In 2009, 2010, and 2011, USGS and NPS continued monitoring seabird nest occupancy, reproductive success, and chick growth. We continued banding Cassin's Auklets captured at Scorpion Rock and Prince Island colonies and assessed nesting activity for Cassin's Auklets 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 were desirable, logistic constraints limited the number of repeat visits to colonies. Colonies generally were visited approximately every two weeks. We used 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 provided the necessary background for the evaluation, implementation, and monitoring of such structures during future restoration actions. Herein, *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 nest sites where an egg was laid; *hatching success* is the total number of eggs that hatched divided by the number of eggs laid (and includes replacement or second clutches); *fledging success* is the total number of chicks assumed to have fledged divided by number that hatched; and *breeding success* is the total number of fledged chicks divided by the number of nest sites initiated (*i.e.*, nests sites where an egg was 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 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 [Harvey, 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. Upon subsequent evaluation, we have resumed using 1643- bands, recently relocated remaining 1313- bands, and new 1743- (size 3B)[2].

Native plant propagation— To assist with native plant palette selection for the re-vegetation effort, we examined reference sites on Little Scorpion and SCI and searched available historical information. We surveyed Coastal bluff plant communities on SCI and Little Scorpion Rock to develop appropriate species assemblages for restoration. 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**). We chose plant species that would provide quality habitat for nesting seabirds (*i.e.*, cover and soil stabilization) and ability to compete with the invasive species.

Figure 2. Nursery facility constructed at the Scorpion Ranch corral site approximately 2 km from the Scorpion Rock restoration site. Photo by: David Mazurkiewicz, NPS.

The farther plants are grown from Scorpion Rock (*i.e.*, in mainland nursery facilities), the greater the potential for unwanted pest introductions, therefore, we collected seeds for this project on Scorpion Rock and SCI and conducted grow-outs in on-island nursery facilities (**Table 2**). The nurseries were located on SCI, the facility used in 2009 was located in the Island's Central Valley, adjacent to the University of California (UC) Reserve. In late 2009 through early 2010, we constructed a second nursery facility at the East

[2] 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.

end of Santa Cruz Island at Scorpion Ranch (**Figure 2**). This facilitated project logistics and moved all plant production closer to Scorpion Rock. Seed collection trips for the 2009 – 2011 growing seasons took place throughout the fall and spring of each year when target species were ready for collection. Due to varying phenology among selected plant species, we collected seeds opportunistically during monitoring and site restoration trips throughout the year. All

Table 2. Species sown for the Scorpion Rock Restoration Project during 2009, 2010, and 2011. 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
ERST	*Eriophyllum staechadifolium*	Seaside Woolly Sunflower	Scorpion Bluffs
HADE	*Hazardia dentosa*	Island Hazardia	Scorpion Bluffs
ISME	*Isocoma menzsii*	Coast Goldenbush	Scorpion Bluffs/Cavern Point
OPLI	*Opuntia littoralis*	Prickly Pear	Scorpion Bluffs

seeds were collected from source materials as close to Scorpion Rock as possible, predominately from the east end of Santa Cruz Island along the north side coastal bluffs. We propagated plants from seeds sown in the SCI nursery facilities (**Table 3**). Seeds were sown in a sterile Sunshine #5 sterile planting mix contained in 14×16×3.5 in wooden flats. Seeds generally were sown in late winter to early spring of each growing year. We transplanted seedlings into either 3.5×3.5-in, 4×6-in (MTP) nursery containers, or D-27 tubes and held in these containers until out-planting. For grow-outs in the nursery, we used Sunshine #4 sterile planting mix. Growing Solutions (GS) and MSRP staff managed plant propagation and nursery maintenance in 2009. In 2010 and 2011, all nursery work was conducted by MSRP seabird staff at the Scorpion Ranch nursery facility. Many volunteers helped with plant propagation efforts, including groups from Santa Barbara City College, Santa Barbara High School, Waldorf School of Santa Barbara, Santa Barbara City College, Girl Scouts of America, and Patagonia Inc.

Table 3. Native plant species propagated on Santa Cruz Island and used for restoration out-planting on Scorpion Rock during 2009, 2010, and 2011. Included are total numbers grown for infill 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.

Native Out-planting Species		**Experimental Plots Infill Plantings 3.5 /4" pot or tree tube**			**Non-experimental Areas Infill Plantings 2, 3.5/4" pot or tree tube**			**Sub-totals**			
Scientific Name	**Common Name**	**2009**	**2010**	**2011**	**2009**	**2010**	**2011**	**2009**	**2010**	**2011**	**Total**
Achillea millefolium	Yarrow		54			28	12		82	12	**94**
Artemesia californica	California Sage	36	39	42	191	17	32	227	56	74	**357**
Atriplex californica	California Saltbush	63	162	24	19	111	8	82	273	32	**387**
Atriplex lentiformis	Quailbush	98		63	265	294	87	363	294	150	**807**
Calystegia macrostegia	Island Morning-glory			28	47	6	13	47	6	41	**94**
Leptosyne gigantea	Giant Coreopsis	128	144	159	540	63	123	668	207	282	**1157**
Encelia californica	Coastal Sunflower			2	37	5		37	5	2	**44**
Erigonum grande	Island Buckwheat	54	54	94	78	20	194	132	74	288	**494**
Erigonum arborescens	SCI Buckwheat	87	51		27	103		114	154		**268**
Eriophyllum staechadifolium	Seaside Woolly Sunflower	36		31	41	15	28	77	15	59	**151**
Frankenia salina	Alkali Heath	185	112	170	365	89	108	550	201	278	**1029**
Hazardia dentosa	Island Hazardia			46			34			80	**80**
Isocoma menzsii	Coast Goldenbush			5						5	**5**
Leymus condensatus	Giant Rye Grass		54	93	183	62	231	183	116	324	**623**
Malacothrix saxatilis	Cliff malacothrix	69		14	173	24	4	242	24	18	**284**
Rhus integrifolia	Lemonadeberry				95	54		95	54		**149**
Opuntia littoralis	Prickly Pear			15			65			80	**80**
Suaeda taxifolia	Sea Blite		54	6	101	141		101	195	6	**302**
	Totals	**756**	**724**	**792**	**1439**	**1032**	**939**	**2918**	**1756**	**1731**	**6405**

We conducted ongoing monitoring of the SCI central valley nursery site throughout the 2009 growing season for Argentine ants (*Linepithema humile*). Because this non-native ant species was noted near the nursery facility in 2008 and thought to be expanding in range near the UC Reserve, CINP and GS established a monitoring protocol to determine if ants occurred within the nursery footprint. The construction of the Scorpion Ranch nursery site in 2009 – 2010 alleviated concerns regarding Argentine ant infestation to nursery plants destined for out-planting on Scorpion Rock. Plants were regularly inspected for pests and health. We used sterile soil medium and clean nursery containers (*e.g.*, pots, soil containers) to 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 pests, specifically ants and aphids.

Scorpion Rock restoration site preparation—We continued to maintain a water storage system on Scorpion Rock of approximately 1200 gallons housed in 55 gallon drums delivered to and placed along the middle of the Rock in 2008. Supplemental water was necessary for out-plantings conducted each fall to help plants establish before winter rains. Water delivery to Scorpion Rock was accomplished via NPS vessels and pumped into the storage containers through 1.5-in fire hose and ¾-in garden hoses. In 2009, after a consultation (site visit 20 February 2009) with the National Resource Conservation Service (NRCS; **Appendix 1**), we began soil stabilization and site preparation within the eastern gulley area on Scorpion Rock. The gully was down-cutting the existing soil horizon, causing soil calving and annual wasting. We knocked the headwall back to a 2:1 slope and wrapped the gulley with erosion control fabric before planting during 2009 fall out-planting. In 2010 after experimental plot annual vegetation monitoring (6 May 2010) and soil sampling (10 August 2010) we removed all non-native vegetation from the control sup-plots before out-planting with natives during fall 2010.

Weather monitoring— We maintained a small weather station (HOBO microstation #MAN-H21-002, Onset Computer Corporation, Bourne, MA) on Scorpion Rock. The station was mounted approximately 1 m above the surface to a metal post driven into the ground. Data were recorded every 30 min from 1 January to 31 December 2009, 2010, 2011. Herein we report daily minimum and maximum temperature (°C), and total daily rainfall (mm). Although relative humidity (%RH) is not reported herein, the RH sensor failed from 12 July through 30 October 2009. No weather data were recorded between 27 and 29 October 2009 during servicing.

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. This design was composed of 6, 15×15-m plots. Each plot contained 3, 5×5-m treatment sub-plots (*control*, *manual removal + native out-planting*, and *desiccant + native out-planting*). Each treatment sub-plot 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 (not reported herein), effects of plots in ANOVAs will be blocked to control for potential inter-plot variability in environmental/soil conditions.

The control (non-removal) sub-plot portion of this experiment constituted 10% (450 of 4,300 m^2) of the total estimated vegetative area of Scorpion Rock. On 17 April 2009, 6 May 2010, and 20 May and 8 June 2011, we measured the vegetation composition and percent cover within all 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/EC material, and presence of an artificial burrow. We used rope and/or transect tapes to delineate each 5×5-m sub-plots and then used a 1×1-m reference quadrat to estimate percent cover for each species within each 5×5-m sub-plot. 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.

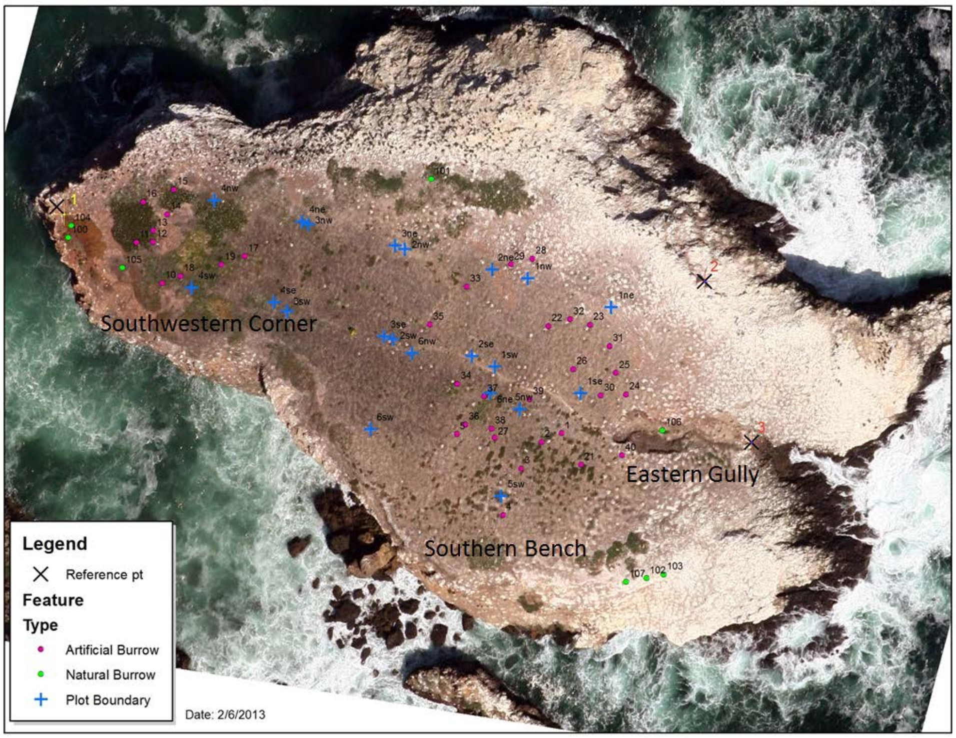

Figure 3. Georeferenced aerial photo (6 February 2013) showing locations for artificial Cassin's Auklet nest sites (pink dots, N = 35) and natural burrows (green dots, N = 8 in 2013).

During 23-26 October 2009, native out-planting selections included a combination of plant forms (*i.e.*, mat-forming ground cover and mounding perennials) distributed within each 5×5-m treatment sub-plot. We used assemblages that included nine pre-determined species (**Table 3**): Alkalai Heath (*Frankenia salina*), *L. gigantea*, Island Buckwheat (*Eriogonum grande*), Santa Cruz Island Buckwheat (*E. arborescens*), California Saltbrush (*Atriplex californica*), Brewer's Saltbrush (*A. lentiformis breweri*), Cliff Aster (*M. saxitalis* var. *implicate*), California Sage (*Artemesia californica*), and Sea-side Woolly Sunflower (*Eriophyullum staechadifolium*). For each of the 5×5-m sub-plots, one individual of each new species was added to each sub-plot. Remaining plant species were planted in each sub-plot based on the previous year's mortality and supplemented adaptively based on which species survived best in each location (*i.e.*, some micro-climate differences between north and south facing sides and soil composition favored certain species over others).

Non-experimental restoration and out-planting— The remaining vegetated portion of Scorpion Rock (i.e., outside the experimental plots) was subjected to manual removal of exotic vegetation and out-planted each year (since initial out-planting in 2008) with natives on 23-26 October 2009, 8-11 October 2010, and 27-30 October 2011(see section below). 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 included the head and adjacent upslope margin of the stabilized eastern gully, the southwestern corner area, and the southern bench area of Scorpion Rock (**Figure 3**). 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 of the island was sparsely vegetated with *M. saxatilis* var. *implicate* and *F. salina.* We supplemented these existing natives with additional plants of these two species and also added *R. integrifolia, S. taxifolia,* and *C. macrostegia.* The eastern gully and adjacent upslope 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 (**Figure 4**). Areas between plots and the main central drainage also were planted with available native species.

Soil chemistry— On 10 August 2010, we conducted follow-up soil sampling to compare changes in soil chemistry with pre-restoration samples collected two years previous on 12 August 2008 (Adams *et al.* 2009). Originally, we had intended to measure soil chemistry differences among sub-plot treatments during August 2011, but to further deplete the seed production of exotic vegetation on Scorpion Rock, restoration managers preferred to remove *M. crystallinum* from control plots following soil sampling in 2010. Using identical methods as in 2008, we collected 3 sub-samples each ~500 ml (surface to 20 cm depth) from each treatment sub-plot (n = 162 sub-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 evaluated the potential effects of vegetation control and restoration of native flora on 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.

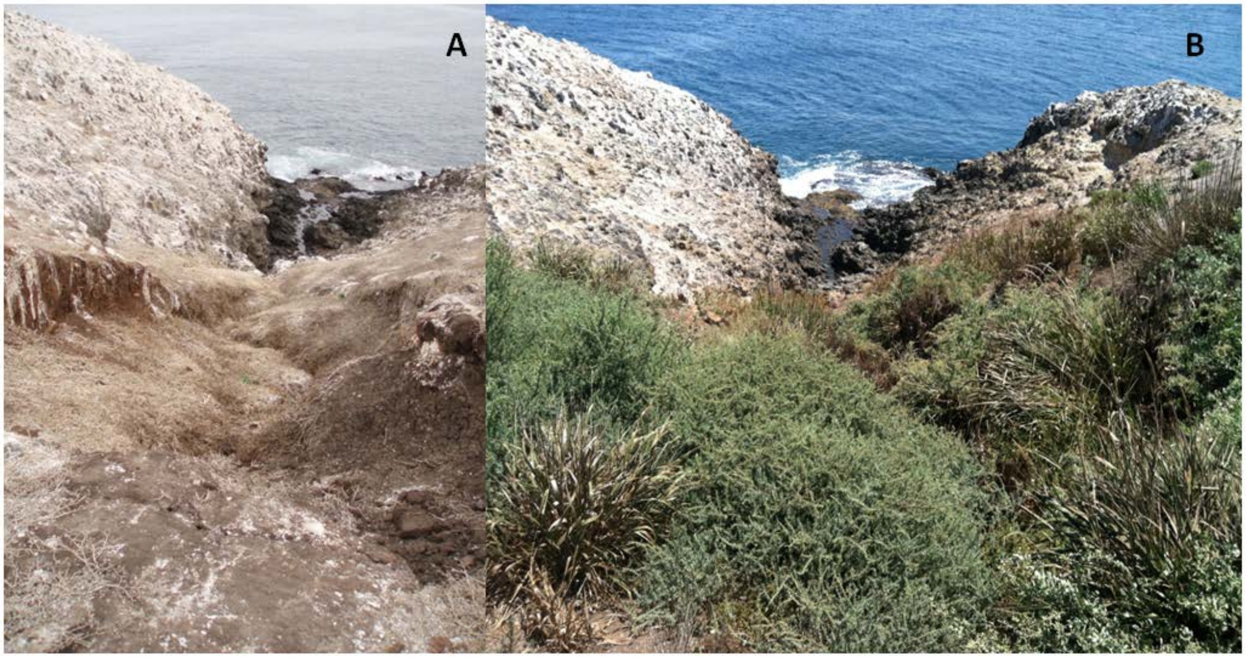

Figure 4. Pre-restoration condition of the eastern gully on Scorpion Rock showing extensive soil erosion and dessicated *M. crystallinum* in August 2008(A). Post-vegetation restoration in August 2012 revealing dramatic habitat stabilization following weed control and native out-planting (B). Photos by: David Mazurkiewicz, NPS.

RESULTS

Cassin's Auklet phenology— In 2009, hatching spanned 129 days on Scorpion Rock (2 March – 9 July; median hatch date: 28 March) and 122 days on Prince Island (25 February – 28 June; median hatch date: 28 March). In 2010, hatching spanned 95 days on Scorpion Rock (30 March – 3 July; median hatch date: 27 April) and 102 days on Prince Island (31 March – 11 July). In 2011, hatching spanned 67 days on Scorpion Rock (8 April – 15 June; median hatch date: 30 April) and 75 days on Prince Island (13 April – 27 June; median hatch date: 22 April).

Cassin's Auklet reproductive effort Scorpion Rock— Nest-site locations on Scorpion Rock were mapped and are provided in **Figure 3**. Currently, there are 35 artificial Cassin's Auklet burrows (AB sites) on Scorpion Rock, and in 2009, 2010, and 2011 combined we located a maximum of nine unique natural burrow sites (**Figure 3**). 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); we could not determine hatching or fledging among natural burrow sites. Five of nine sites persisted throughout all three years. Of seven natural burrow sites in 2009, four appeared active, one was not active, and the remaining two sites had collapsed or had disappeared. Of the six natural burrow sites in 2010, four appeared active, two were not active, and the two remaining sites that collapsed in 2009, remained unused. Of the seven natural burrow sites in 2011, five appeared active, one was not active, and the remaining site had collapsed or had disappeared.

Occupancy among AB sites decreased at Scorpion Rock from 71% in 2009, to 60% in 2010, and 54% in 2011 (**Table 4**, **Figure 5**). Nest initiation was 43% in 2009 and 2010 and increased slightly in 2011 to 49% **(Table 4**, **Figure 5**). Hatching success was moderate in 2009 (65%) and increased slightly in 2010 (74%) and 2011 (70%; **Table 4**). Of the eggs that hatched, fledging success was 100% in 2009, 86% in 2010, and 94% in 2011 (**Table 4**). Ultimately, breeding success (fledged per sites initiated) was 0.9 in 2009, 0.8 in 2010, and 0.9 in 201l (**Table 4**, **Figure 5**). In 2009, 2010, and 2011, based on nest site occupancy among AB sites and natural burrows on Scorpion Rock, we estimate a maximum breeding population of 58, 50, and 48 birds, respectively (values reflect double the number of occupied nest sites, which may include a small proportion of annual non-breeders). In 2009, we counted 9 dead (depredated or scavenged) adult auklets on Scorpion Rock mainly during the pre-breeding, prospecting months (January – March). In 2010, we counted 8 dead adult auklets during the same period. In 2011, we did not find any depredated or scavenged auklets.

<u>*Cassin's Auklet reproductive effort Prince Island*</u>— Nest-site locations on Prince Island were mapped and are provided in *Adams et al*. (2009). On Prince Island, there currently are 47 haphazardly-distributed AB sites (AB01–AB48; AB44 does not exist). Additionally there are a single row of 25 uniformly-spaced artificial burrows that replaced the existing CINP southeast boxes (SBO01–SBO25). Therefore, a total of 71 – 72 sites were monitored in 2009 (72), 2010 (71), and 2011 (72). 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). We observed 100% occupancy among AB sites at Prince during 2009, 2010, and 2011 (**Table 4**, **Figure 5**). Within available AB sites, auklets at Prince Island initiated clutches in 96% (2009), 100% (2010), and 98% (2011) of nest sites (**Table 4**, **Figure 5**). Hatching success was 72% in 2009, 79% in 2010, and 62% in 2011 (**Table 4**). Fledging success (based on number of hatched eggs) was 91% in 2009, 97% in 2010, and 93% in 2011 (**Table 4**). Ultimately, breeding success among AB sites at Prince Island was 1.1, 1.3, and 0.8 in 2009, 2010, and 2011, respectively (**Table 4**, **Figure 5**). Occupancy among CINP boxes (SBO sites) at Prince Island displayed similar high proportions as found among the AB sites, ranging from 92% in 2011 to 100% in 2009, and 2010 (**Table 5**, **Figure 5**. Auklets initiated clutches in 54% (2009), 64% (2010), and 68% (2011) of available Prince Island SBO sites (**Table 5**, **Figure 5**). Hatching success ranged from 54% in 2009, to 76% in 2010 and fledging success was high ranging from 91% in 2009 to 100% in 2010 and 2011 (**Table 5**). Ultimately, breeding success among SBO sites at Prince Island was 0.8 in 2009, 1.0 in 2010, and 0.8 in 2011 (**Table 5**, **Figure 5**).

<u>*Cassin's Auklet chick growth*</u>—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 [MFC] to fully feathered [FFC] chicks). Average CCI ranged from 1.24 ± 0.05 at Scorpion in 2010 to 1.40 ± 0.02 at Prince during 2010. The greatest inter-colony differences in 2010 are consistent with the greatest differences in annual breeding success measured within AB sites on Scorpion (0.8) and Prince (1.3; **Table 6**Error! No bookmark name given.). CCI measured at Prince in 2008, during a year with reduced breeding success was 1.16 ± 0.03). Although not yet evaluated, preliminary trends in this index appear correlated with reproductive parameters and breeding success, thus CCI may reflect changes in the availability or quality of food among provisioning adults.

Table 4. Summary of breeding effort parameters for Cassin's Auklets nesting within artificial burrows (AB) on Prince Island and Scorpion Rock in 2009, 2010, and 2011. 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**		
	2009	**2010**	**2011**	**2009**	**2010**	**2011**
# Sites	47	46	47	35	35	35
% Occupied	100% (47/47)	100% (46/46)	100% (47/47)	71% (25/35)	60% (21/35)	54% (19/35)
% Initiated (sites with egg[s] laid)	96% (45/47)	100% (46/46)	98% (46/47)	43% (15/35)[b]	43% (15/35)	49% (17/35)
Hatching success (eggs hatched/eggs laid)	72% (55/76)	79% (63/80)	62% (42/68)	65% (13/20)[c]	74% (14/19)	70% (16/23)
Fledging success (chicks fledged/eggs hatched)	91% (50/55)	97% (61/63)	93% (39/42)	100% (11/11)[d]	86% (12/14)	94% (15/16)
Breeding success (chicks fledged/sites initiated)	1.1 (50/45)[e]	1.3 (61/46)	0.8 (39/46)	0.9 (11/13)[e]	0.8 (12/15)	0.9 (15/17)

[b] Minimum value as 2/35 sites were not accessible because adults tunneled beyond nest chamber (both sites showed evidence of chicks, but number of eggs laid, hatched, and fledged could not be determined). Value includes 3 sites where adults were observed in incubating posture (but where egg was not observed) and 2 non-accessible sites with evidence of chicks. 20 eggs laid by 15 pairs

[c] value includes and 2 non-accessible sites with evidence of chicks.

[d] Value does not include 2 non-accessible sites with evidence of chicks (i.e. fledging could not be determined).

[e] Breeding success in 2009 reflects chicks fledged/nest sites initiated (SR: 4/13 [31%] and PI: 18/45 [40%] of pairs double brooded, respectively). Value for SR in 2009 does not include 2 non-accessible sites with evidence of chicks (i.e. fledging could not be determined)

Table 5. Summary of breeding effort parameters for Cassin's Auklets nesting within CINP Southeast Boxes (SBO) on Prince Island (2009, 2010, and 2011). Values in parentheses are actual numbers observed.

	Prince Island		
	2009	2010	2011
# Sites	25	25	25
% Occupied	100% (25/25)	100% (25/25)	92% (23/25)
% Initiated (sites with eggs[s] laid)	54% (13/24)[b]	64% (16/25)	68% (17/25)
Hatching success (eggs hatched/eggs laid)	65% (11/17)	76% (16/21)	57% (13/23)
Fledging success (chicks fledged/eggs hatched)	91% (10/11)	100% (16/16)	100% (13/13)
Breeding success (chicks fledged/sites initiated)	0.8 (10/13)	1.0 (16/16)	0.8 (13/17)

[b] Values excludes site SBO23 where bird excavated beyond the nest chamber and became unavailable (sign indicate that this site contained a hatched egg, but chick was never observed).

Table 6. Annual Cassin's Auklet Chick-condition Index (CCI) measured at Scorpion Rock and Prince Island colonies (mean ± SE) with sample size in parentheses.

Year	Scorpion Rock	Prince Island
2009	1.34 ± 0.02 (6)	1.35 ± 0.03 (34)
2010	1.24 ± 0.05 (8)	1.40 ± 0.02 (47)
2011	1.39 ± 0.06 (12)	1.39 ± 0.03 (39)

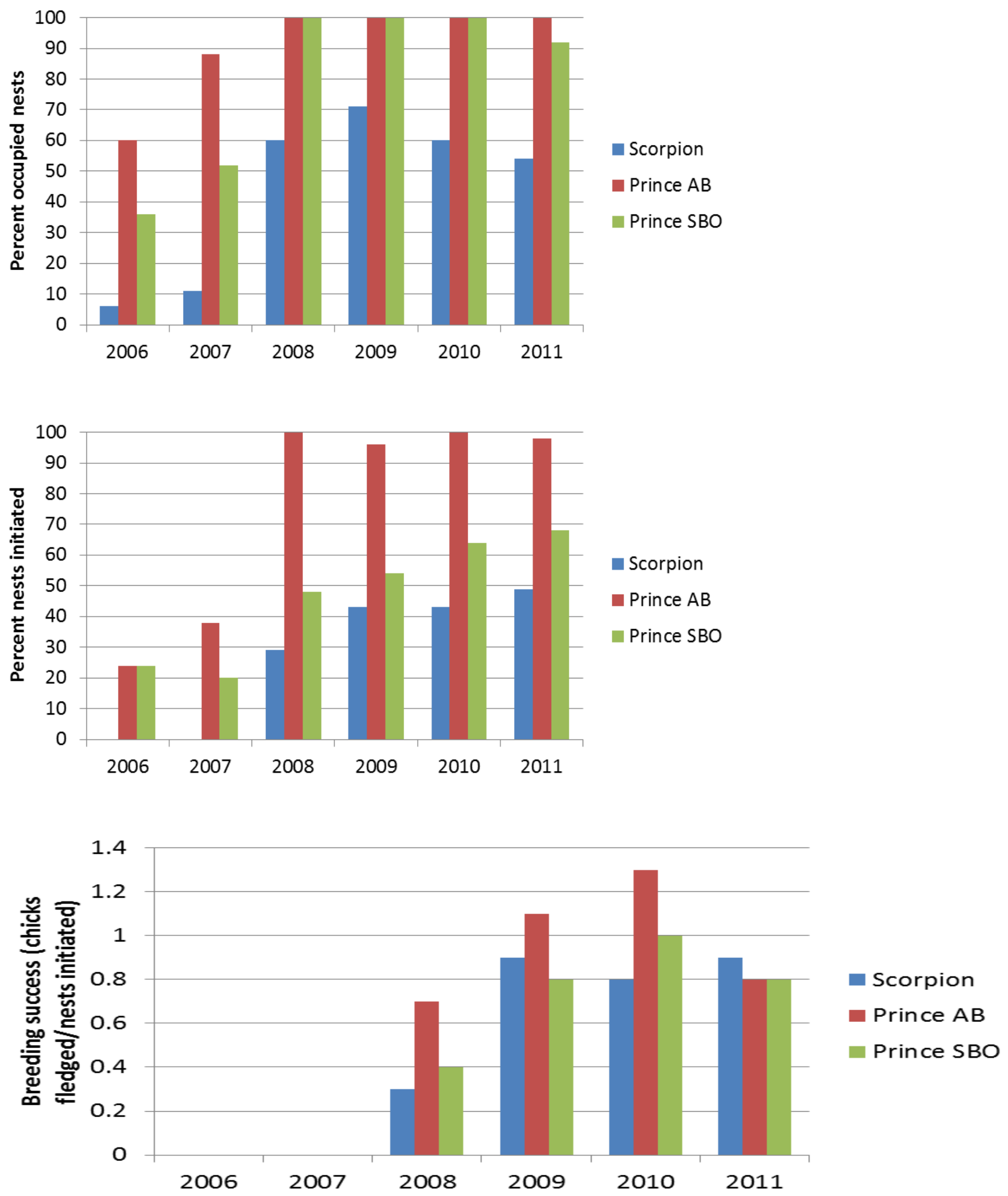

Figure 5. Annual occupancy, clutch initiation, and breeding success among Cassin's Auklets nesting on Scorpion Rock and Prince Island during the period 2006 – 2011.

Nest site temperature—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) and Scorpion Rock (2007 only; see Adams *et al.* 2009, for details). 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; Figure 6). 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 (**Figure 6**). 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; **Figure 6**). In 2010, we conducted follow-up temperature measurements among AB sites (n = 15) with retrofitted cement-board lids and SBO sites (n = 6) from 18 April – 5 May and 17 May – 27 June (**Table 7**). Overall, average minimum and maximum temperatures in AB sites in 2010 were similar to values for natural burrows on Prince Island in 2008, and average maximum temperatures in AB sites were slightly less than those recorded in AB sites on Prince Island in 2007 and 2008, before retrofitting the lids to increase solar insulation (**Figure 6**). The average daily SD among AB sites on Prince Island in 2010 was similar to 2007 and 2008 (2.6 °C). The high reproductive output among Cassin's Auklets nesting within AB and SBO sites on Prince during 2009 – 2011 indicates that these artificial nest structures provide suitable habitat for the species and extensive temperature records could serve as a reference for evaluating similar artificial nest sites for this species at other locations (*e.g.*, Southeast Farallon Island, Santa Barbara Island, Baja California, Mexico).

Table 7. Nest site temperature recorded during 2010 among natural, artificial, and SBO sites on Prince Island in 2010. Shown are island, site, archival temperature logger (ATL) number, analysis period, minimum temperature (°C), maximum temperature (°C), and the average daily SD of temperature (°C).

Site	ATL	Deploy	Recover	Min	Max	Ave Daily SD	Comments
AB03	TL3741	4/18/2010	5/3/2010	—	—	—	Bad data
AB07	TL4841	4/18/2010	5/3/2010	12.1	25.6	2.1	
AB12	TL3141	4/18/2010	5/3/2010	13.7	24.2	1.3	
AB15	TL2D41	4/18/2010	5/3/2010	13.1	26.1	2.1	
AB20	TL4041	4/18/2010	—	—	—	—	Lost
AB37	TLDF41	4/18/2010	5/3/2010	15.7	23.7	1.2	
AB39	TLA941	4/18/2010	5/3/2010	15.6	25.2	1.6	
AB41	TL3A41	4/18/2010	5/3/2010	—	—	—	Bad data
SBO01	TL7641	4/18/2010	5/3/2010	16.2	24.2	1.2	
SBO03	TL1541	4/18/2010	5/3/2010	14.2	23.2	1.3	
SBO05	TLFE41	4/18/2010	5/3/2010	13.2	21.7	1.1	
SBO13	TL1241	4/18/2010	5/3/2010	15.2	21.7	1.0	
SBO19	TLB441	4/18/2010	5/3/2010	14.2	20.2	0.9	
SBO23	TL9341	4/18/2010	5/3/2010	15.7	20.7	0.5	
AB01	TL1241	5/17/2010	6/27/2010	11.6	34.2	4.3	
AB05	TL3141	5/17/2010	6/27/2010	13.2	29.7	3.3	
AB07	TL4841	5/17/2010	6/27/2010	14.1	27.6	1.9	
AB08	TLA941	5/17/2010	6/27/2010	12.1	32.2	3.6	
AB10	TL3741	5/17/2010	6/27/2010	13.1	29.2	3.1	
AB15	TL7641	5/17/2010	6/27/2010	13.2	27.7	2.4	
AB17	TL3A41	5/17/2010	6/27/2010	11.7	33.7	4.0	

Site	ATL	Deploy	Recover	Min	Max	Ave Daily SD	Comments
AB22	TL2D41	5/17/2010	6/27/2010	—	—	—	Lost
AB25	TLDF41	5/17/2010	6/27/2010	13.7	28.2	2.7	
AB27	TL9341	5/17/2010	6/27/2010	11.6	30.2	2.5	
AB35	TL1541	5/17/2010	6/27/2010	13.1	31.2	3.4	
AB43	TLF241	5/17/2010	6/27/2010	14.1	27.6	2.4	
AB48	TLB441	5/17/2010	6/27/2010	11.6	32.7	3.9	
AB12	TLFE41	5/17/2010	6/27/2010	13.2	25.2	1.5	

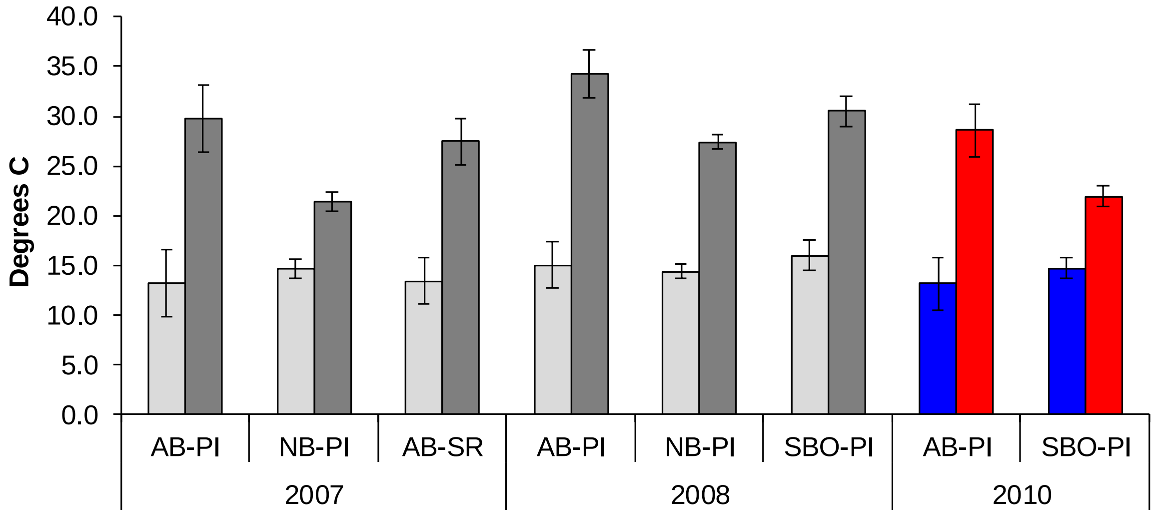

Figure 6. Average minimum (light gray bars) and maximum (dark gray bars) burrow temperatures (C°) recorded within Cassin's Auklet nest sites on Scorpion Rock and Prince Island during 2007 and 2008. Categories include artificial burrows on Prince Island (AB-PI: 2007, n = 4; 2008, n = 4), Natural burrows on Prince Island (NB-PI: 2007, n = 4; 2008, n = 4), artificial burrows on Scorpion Rock (AB-SR: 2007, n = 5), and reconstructed (2007) southeast boxes on Prince Island (SBO-PI: 2008, n = 6). 2010: average minimum (blue) and maximum (red) temperature values for AB-PI (n = 15) and SBO-PI (n = 6) are shown following modification to AB-PI lids in 2009. 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.

Western Gulls on Scorpion Rock— Western Gulls continued to nest on Scorpion Rock in 2009, 2010, and 2011. On 10 June 2009, 10 of 25 Western Gull nests had initiated hatching: one nest contained one egg, 12 nests contained two eggs/chicks, and 12 nests contained three eggs/chicks. We were not able to estimate hatching success or fledging success in 2009. During August 2009, we counted remains of 13 hatch-year gulls. In addition to HY mortalities, we counted the remains of seven immature and five adult gulls. On 14 May 2010, we counted 31 Western Gull nests: 15 with three eggs, 10 with two eggs, two with one egg, and four empty nest-scrapes. 25 of 31 nests (80%) in 2010 were associated with restored, native vegetation. During 2010, we recorded and removed six dead hatch-year gulls and an additional four immature and eight adult gulls. On 23 July 2010, we recorded 29 hatch-year gulls of fledging size. On 20 May 2011, we counted 22 Western Gull nests: 13 with three eggs, seven with two eggs, and two with single eggs. 17 of 22 nests (77%) in 2011 were associated with restored, native vegetation. On 14 July

2011, we recorded 31 near fledging hatch-year gulls. Throughout 2011, we counted a total of five immature and five adult Western Gull carcasses.

<u>*Vegetation restoration study plots*</u>— During 2009, 2010, and 2011 we planted 2,272 native plants within the restoration plots (17 Species, **Table 3**). Compared with conditions before restoration and out-planting, vegetative cover within restoration study plots on Scorpion Rock changed dramatically: from 94% cover (6 exotic species) in 2008 to 12% cover (5 exotic species) in 2011 (**Figure 7**). Vegetation change was dominated by dramatically reduced cover of vegetative and desiccated *M. crystallinum*, (62% cover in 2008 to 7% cover in 2011), Cheeseweed (*Malva parviflora*; 13% cover in 2008 to <1% cover in 2011), and Nettle-leaf Goosefoot (*Chenopodium murale*; 17% cover in 2008 to <1% cover in 2011; **Figure 8**). With restoration between 2008 and 2011, native plant richness changed from 6 to 17 species (**Figure 9**), with percent cover of native plant species increasing 12-fold (**Figure 10**): from <4% in 2008 to 48% in 2011, dominated by Giant Coreopsis (*Leptosyne gigantea*; 32% cover in 2011), Alklai Heath (*Frankenia salina*; 3% cover in 2011, California Sage (*Artemesia californica*; 2% cover in 2011) and Brewer's Saltbush (*Atriplex lentiformis spp.*; 2% cover in 2011). We continued to expand out-planting and exotic vegetation control outside experimental plots during 2009, 2010, and 2011 (17 species, 3,410 plants; **Table 3**).

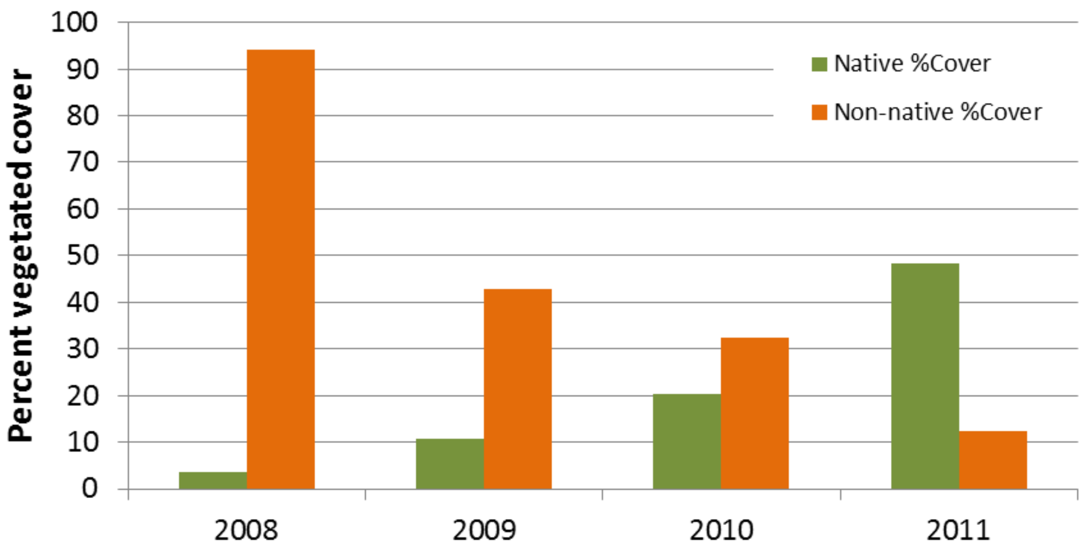

Figure 7. Total percent cover within all study plots combined for native species (green) and introduced, non-native species (orange) from 2008 (pre-restoration) through 2011.

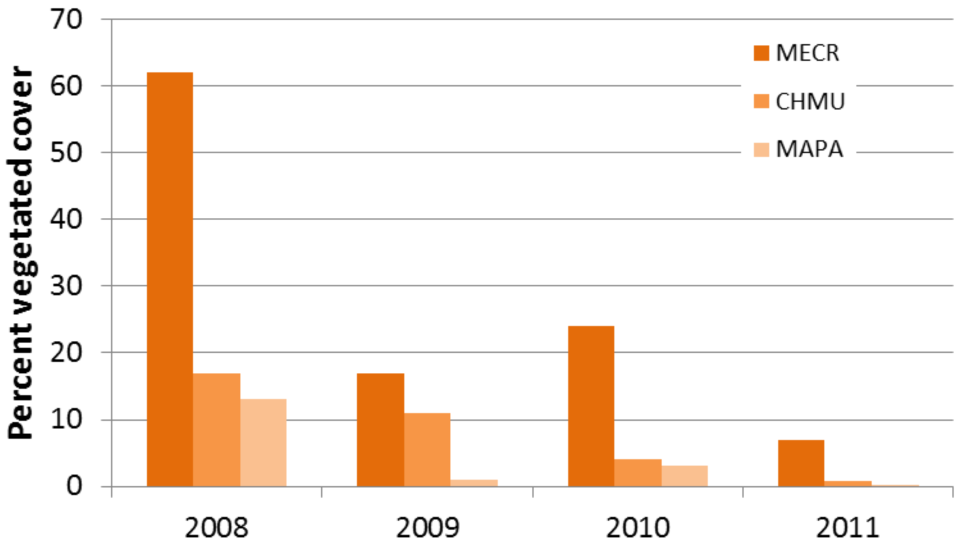

Figure 8. Annual changes in total percent vegetated cover from 2008 through 2011 within all study plots combined for three introduced, non-native plants: MECR, Crystalline Ice Plant (*Mesembryanthemum crystallinum*); CHMU, Nettle-leafed Goosefoot (*Chenopodium murale*); and MAPA, Cheeseweed (*Malva parviflora*).

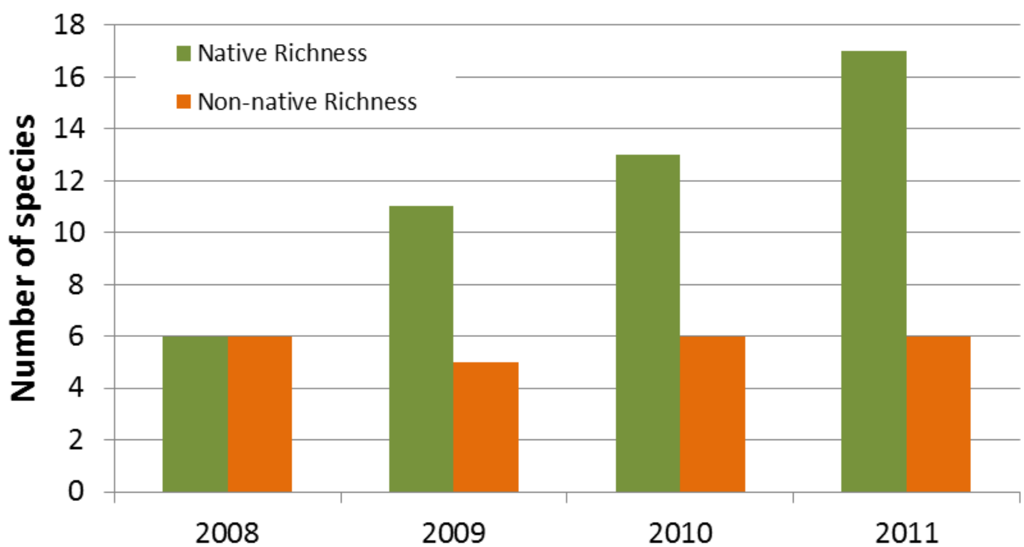

Figure 9. Plant species richness (number of species) within all study plots combined for native species (green) and introduced, non-native species (orange) from 2008 (pre-restoration) through 2011.

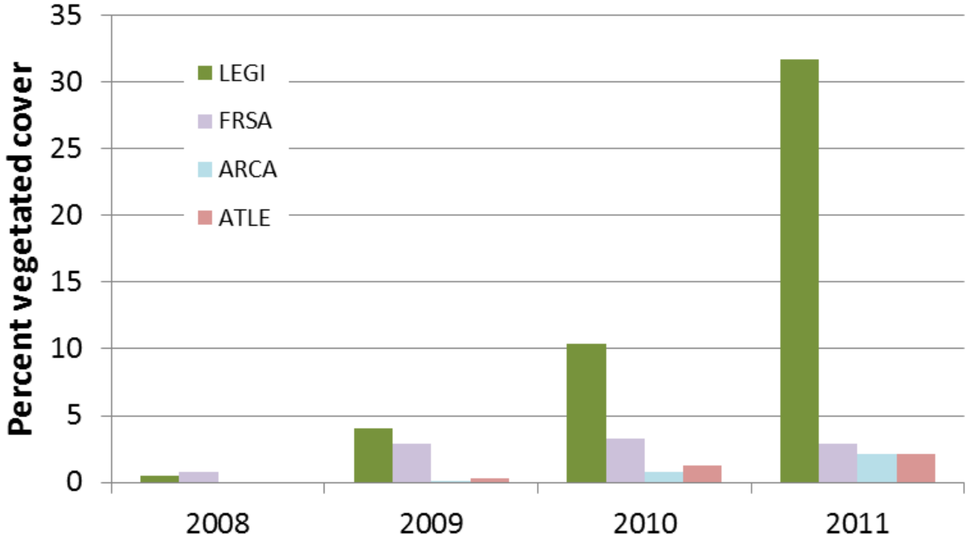

Figure 10. Annual changes in total percent vegetated cover from 2008 through 2011 within all study plots combined for four restored native plants: LEGI, Giant Coreopsis (*Leptosyne gigantea*); FRSA, Alkali Heath (*Frankenia salina*); ARCA, California Sage (*Artemesia* californica); and ATLE, Brewer's Saltbush (*Atriplex lentiformis spp.*).

Soil chemistry— Complete soil chemistry analyses reports are provided in **Appendix 2**. Major nutrients, soil composition, and soil chemistry varied throughout the experimental plots on Scorpion Rock (**Table 8**, **Table 9**). We found small but significant decrease in phosphorus concentration between years (2008: 238.2 ± 7.6 µg g^{-1}; 2010: 217.5 ± 4.7 µg g^{-1}; ANOVA: $F_{1,72}$ = 6.087, P = 0.016), and among plots (ANOVA: $F_{5,72}$ = 3.218, P = 0.011; significant Year × Plot interaction, P = 0.015). There was no difference detected among the three treatments (P = 0.106). We found a significant difference in nitrogen (nitrate) concentrations between years (2008: 183.7 ± 13.0 µg g^{-1}; 2010: 54.0 ± 5.7 µg g^{-1}; ANOVA: $F_{1,72}$ = 98.880, P < 0.001). Nitrate concentration also differed among plots (ANOVA: $F_{5,72}$ = 2.330, P = 0.051; significant Year × Plot interaction, P = 0.045). There were no significant differences among sub-plot treatments ($F_{2,72}$ = 1.787, P = 0.175) and the Plot × Treatment interaction was significant (P = 0.036). We found no significant differences in percent organic matter (arcsine transformed) between years (ANOVA: $F_{1,72}$ = 0.016, P = 0.901), but plot 4 had the greatest percent organic matter in both years (ANOVA: $F_{5,72}$ = 2.585, P = 0.030). None of the interactions were significant (all P > 0.57). We found a slight but significant decrease in soil pH between years (2008: 4.7 ± 0.04; 2010: 4.4 ± 0.04; ANOVA: $F_{1,72}$ = 24.387, P < 0.001), slight but significant differences among plots ($F_{5,72}$ = 2.594, P = 0.033, significant Year × Plot interaction, P = 0.004), with the two treatment plots having slightly more acidic soils (lower pH) than the controls ($F_{2,72}$ = 4.965, P = 0.010); the interactions were not significant (P > 0.167). We found significant decrease in soluble salts (conductivity: mmhos cm^{-1}) between years (2008: 3.1 ± 0.2; 2010: 1.4 ± 0.1); ANOVA: $F_{1,72}$ = 94.850, P < 0.001), among plots ($F_{5,72}$ = 2.983, P = 0.017) and among sub-plot treatments (with control sub-plots showing slightly lesser soluble salt concentrations than the two treatment groups; $F_{2,72}$ = 3.304, P = 0.042). All interactions were not significant (P > 0.074).

Table 8. Soil chemistry (major nutrients, composition, & chemistry) among experimental plots on Scorpion Rock 10 August 2010 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 (SE).

	Major Nutrients, Composition, & Chemistry					
Plot	**P (μg g^{-1})**	**NO_3 (μg g^{-1})**	**%OM**	**ENR**	**pH**	**EC (mmhos cm^{-1})**
1	208.8 (9.5)	76.3 (18.0)	6.9 (0.9)	167.8 (18.7)	4.3 (0.1)	2.0 (0.3)
2	220.4 (10.2)	74.7 (17.4)	7.7 (0.7)	184.2 (13.6)	4.2 (0.1)	1.8 (0.3)
3	224.1 (16.7)	38.1 (7.9)	6.4 (0.2)	158.3 (4.7)	4.3 (0.1)	1.3 (0.2)
4	219.5 (12.6)	62.4 (14.0)	8.0 (1.0)	190.0 (21.0)	4.3 (0.1)	1.6 (0.2)
5	213.8 (14.8)	38.1 (11.7)	6.4 (0.4)	157.2 (7.5)	4.7 (0.1)	1.1 (0.2)
6	218.3 (5.3)	34.2 (6.5)	6.1 (0.4)	152.0 (7.4)	4.6 (0.1)	0.9 (0.1)
Total	**217.5 (4.7)**	**54.0 (5.7)**	**6.9 (0.3)**	**168.2 (5.6)**	**4.4 (0.3)**	**1.4 (0.1)**

Table 9. Soil chemistry (Cations and micronutrients, μg g^{-1}) among experimental plots on Scorpion Rock 10 August 2010 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 (SE).

	Soil Cations					**Soil Micronutrients**				
Plot	**K**	**Mg**	**Ca**	**Na**	**S**	**Zn**	**Mn**	**Fe**	**Cu**	**B**
1	1075.9 (92.8)	191.9 (26.6)	929.3 (95.3)	104.1 (13.9)	74.3 (14.9)	5.2 (1.0)	6.0 (1.3)	106.4 (13.3)	1.4 (0.32)	0.3 (0.02)
2	1126.2 (81.5)	161.4 (9.2)	1231.1 (73.9)	125.6 (21.8)	57.0 (7.4)	4.9 (1.0)	10.7 (1.9)	115.8 (10.1)	0.3 (0.04)	0.5 (0.06)
3	1160.2 (39.6)	156.2 (8.3)	1099.9 (45.7)	84.0 (9.6)	62.0 (14.4)	3.2 (0.4)	10.5 (1.7)	140.7 (29.7)	0.4 (0.03)	0.3 (0.02)
4	1070.0 (50.2)	145.3 (9.2)	1256.5 (76.2)	140.9 (69.9)	71.0 (10.4)	5.0 (0.8)	8.4 (0.9)	124.5 (33.5)	0.4 (0.03)	0.3 (0.03)
5	1743.6 (98.9)	315.7 (27.5)	1347.9 (41.8)	199.1 (29.0)	33.1 (3.8)	3.2 (0.6)	17.2 (2.0)	132.3 (17.2)	1.5 (0.3)	0.4 (0.04)
6	1584.8 (136.9)	254.3 (28.8)	1281.0 (53.4)	187.9 (35.6)	38.4 (8.8)	2.3 (0.4)	15.9 (2.1)	146.9 (27.2)	2.3 (1.14)	0.4 (0.05)
Total	**1293.4 (50.6)**	**204.1 (11.6)**	**1190.9 (32.3)**	**140.3 (15.1)**	**55.9 (4.7)**	**4.0 (0.3)**	**11.4 (0.9)**	**127.8 (9.3)**	**1.1 (0.2)**	**0.4 (0.02)**

Figure 11. Daily temperature extremes and rainfall totals on Scorpion Rock during 2009, 2010, and 2011.

Weather conditions monitored on Scorpion Rock— In each year 2009, 2010, and 2011, minimum and maximum daily temperatures were more variable during January – May and September – December and most stable during late spring – summer (June – August; **Figure 11**). In 2009, warm events (maximum temperatures exceeding 25° C) occurred 18 times (40 days), and events lasted from 1 to 9 days. In 2009, maximum recorded temperatures exceeded 30° C on four days: 20 April, 13 July, 27 August, and 16 October (**Figure 11**). The maximum temperature (37.2° C) occurred 20 April 2009 (Figure 11). Measurable precipitation totaled 154.4 mm and occurred in all months except July and November (**Figure 11**). In 2010, warm events (maximum temperatures exceeding 25° C) occurred 11 times (24 days), and events lasted from 1 to 6 days. In 2010, maximum recorded temperatures exceeded 30° C on six days: 25 – 28 September and 3 – 4 November (**Figure 11**). The maximum temperature (35.4° C) occurred 27 September 2010 (**Figure 11**). Measurable precipitation totaled 525.1 mm and occurred in all months (**Figure 11**).

In 2011, warm events (max temperatures exceeding 25° C) occurred 10 times (20 days), and events lasted from 1 to 4 days. In 2009, maximum recorded temperatures exceeded 30° C on one day: 12 October (**Figure 11**). The maximum temperature (32.0° C) occurred 12 October 2011 (**Figure 11**). Measurable precipitation totaled 348 mm and occurred in all months except July, August, and September (**Figure 11**).

DISCUSSION

Cassin's Auklet reproduction and nesting habitat— Occupancy among monitored auklet nest sites on Prince remained relatively high (>90%) during 2009, 2010, and 201l, likely due to availability of sufficient prey within about 40 km of the colonies (Adams *et al.* 2004). Although occupancy at Scorpion Rock (51 – 74%) dropped slightly among artificial burrows from 2009 – 2011, the proportion of occupied sites was substantially greater than the exceptionally poor reproductive years of 2006 and 2007 (Adams *et al.* 2009). In contrast to the decline in overall occupancy at Scorpion Rock, the proportion of nests initiated there increased slightly and breeding success and chick condition (except in 2010) at Scorpion Rock was similar to reference sites on Prince Island. Overall, based on occupancy rates (see methods) we estimated that there were 48 breeding auklets on Scorpion Rock in 2011 – down from 62 estimated during 2008 (Adams *et al.* 2009). Compared with previous years (2006 – 2008), breeding success at Scorpion and Prince were greater (and similar among islands and nest types; **Figure 5**), indicating that beneficial ocean conditions and prey availability prevailed during these seasons. In 2009 and 2010 combined, we counted 17 dead adult auklets which may have been killed at sea and brought to the island by Peregrine Falcon (*Falco peregrinus*) or depredated by Barn Owls (*Tyto alba*) during night/crepuscular prospecting early in the breeding season. Although it is hard to know for certain, the lack of any depredated or scavenged remains of auklets in 2011 may indicate that recovery of native vegetation and perennial cover could have afforded protection to auklets while prospecting. Paine *et al.* (1990) reported that recovery of falcons at Tatoosh Island, WA during the 1980s may have been responsible for concurrent decreases in the abundance of Cassin's Auklet and Rhinoceros Auklet (*Cerorhinca monocerata*), both of which were recognized as primary falcon prey.

Native plant restoration and soil chemistry— Removal of non-native, invasive vegetation and the restoration of a native perennial Santa Cruz Island Coastal Bluff and Coastal Sage Scrub communities on Scorpion Rock has increased island biodiversity and is helping to provide better soil structure, nesting conditions, and cover for seabirds utilizing this location. Increased perennial native plant cover has provided soil stabilization, especially in the steep areas of the eastern gully where headward erosion was resulting in significant annual loss of soil and threatening critical, adjacent auklet nesting habitat (**Figure 4**). Examination and testing of control methods for the invasive plant species present on Scorpion Rock together with the development of unique, logistically complex remote site restoration techniques has benefitted other habitat restoration projects on Santa Barbara Island and Anacapa Island within the Channel Islands National Park (CINP *unpublished data*).

Two key factors have contributed to the success of the Scorpion Rock restoration project: well-coordinated extensive volunteer efforts during outplanting, and a well-designed and maintained

local nursery located about 2 km from the islet. To inform restoration actions early on in this effort, we established two vegetation control treatments: manual removal and desiccant spray (Burnout™), both supplemented with native plant infill. These treatments were originally designed to be compared with control plots and allow for the evaluation of success across a strong gradient of exposure and soil quality on Scorpion Rock. After 2008, however, it became apparent that manual removal of exotic vegetation was preferred, and spraying was abandoned. Although haphazard, opportunistic desiccant and flame treatments were conducted in 2009 – 2010, we discontinued these methods due to difficulty with weather windows for flaming and the ineffectiveness of the clove oil-based desiccant, Burnout™ which would desiccate foliage, but plants would readily regenerate new growth with sufficient rainfall. Furthermore, the increase in native recruitment in each subsequent year made it difficult to target weeds without harming native plants, and the overgrowth of *M. chrystallinum* around the out-plantings and recruits made fine-scale treatments using desiccant or flame difficult.

We recognize that through restoration actions (invasive weed control and native outplanting) we have substantially improved the vegetation community on Scorpion Rock from what was relatively recently, a low diversity suite of introduced annual weeds, to an established, diverse assemblage of native perennial vegetation. Future efforts should be applied to maintaining weed control efforts and tracking change at Scorpion Rock. We expect that the relative proportions of native plants reflected in spring percent cover surveys will change through time as this restoration experiment achieves equilibrium – some of the restored natives will persist, and others may not be able to recruit effectively unless conditions (*e.g*., altered soil composition and shelter) also change. These changes are expected to take multiple years and these initial measurements (*c.f.*, Adams *et al.* 2009) provide a reference to allow for quantification of the effects of habitat restoration on Scorpion Rock. Although new natural burrows numbers for Cassin's Auklet have remained low at Scorpion Rock, more information and continued monitoring is needed to evaluate nest site selection, predation rates, and prey availability near reference colonies, in order to better understand complexities associated with population recovery and natural variation throughout the auklet's breeding range in southern California. In addition to better understanding the effects of natural variation in climate forcing (*e.g.*, ENSO), weather conditions (*e.g.*, ensuing drought conditions), and trophic dynamics (*e.g.*, availability of zooplankton prey in the eastern Santa Barbara Channel), resource managers might evaluate potential impacts by humans to Scorpion Rock including visitor disturbance, Common Raven (*Corvus corax*) subsidies at Scorpion Ranch, and effects of nocturnal lighting by vessels visiting Scorpion Anchorage.

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., D. Mazurkiewicz, and A.L. Harvey. 2009. Population monitoring and habitat restoration for Cassin's Auklets at Scorpion Rock and Prince Island, Channel Islands National Park, California: 2007–2008. Interim Data Summary Report. U.S. Geological

Survey, Western Ecological Research Center, Moss Landing Marine Laboratories, Moss Landing, California and Channel Islands National Park, Ventura, California. Unpublished interim data summary report to the Montrose Trustee Council. 51 pages, 9 tables, 27 figures and 4 Appendices.

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. 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. 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., 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.

Bjorkstedt, E.P., R. Goericke, S. McClatchie, E. Weber, W. Watson, N. Lo, B. Peterson, B. Emmett, J. Peterson, R. Durazo, G. Gaxiola-Castro, F. Chavez, J. T. Pennington, C.A. Collins, J. Field, S. Ralston, K. Sakuma, S. Bograd, F. Schwing, Y. Xue, W. Sydeman, S. A. Thompson, J. A. Santora, J. Largier, C. Halle, S. Morgan, S. Y. Kim, K. Merkens, J. Hildebrand. 2011. State of the California Current 2010–2011: Regionally variable responses to a strong (but fleeting?) La Niña. CalCOFI Rep., 51, 39–69.

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

Kloot, P.M. 1983. The role of common iceplant *(Mesembryanthemum crystallinum)* in the deterioration of medic pastures. Australian Journal of Ecology 8: 301–306. doi: 10.1111/j.1442-9993.1983.tb01327.x

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.

McClatchie, S., R. Goericke, J. A. Koslow, F. B. Schwing, S. J. Bograd, R. Charter, W. Watson, N. Lo, K. Hill, J. Gottschalk, M. L'Heureux, Y. Xue, W. T. Peterson, R. Emmett, C. Collins, G. Gaxiola-Castro, R. Durazo, M. Kahru, B. G. Mitchell, K. D. Hyrenbach, W. J. Sydeman, R. W. Bradley, P. Warzybok, and E. Bjorkstedt. 2008. The State of the California Current, 2007–2008: La Niña conditions and their effects on the ecosystem. CalCOFI Rep., 49, 39–76.

McClatchie, S. R. Goericke, F. B. Schwing, S. J. Bograd, W. T. Peterson, R. Emmett, R. Charter,W. Watson, N. Lo, K. Hill, C. Collins, M. Kahru, B. G. Mitchell, J. A. Koslow, J. Gómez-Valdes , B. E. Lavaniegos, G. Gaxiola-Castro, J. Gottschalk, M. L'Heureux, Y. Xue, M. Manzano-Sarabia, E. Bjorkstedt, S. Ralston, J. Field, L. Rogers-Bennett, L. Munger, G. Campbell, K. Merkens, D. Camacho, A. Havron, A. Douglas and J. Hildebrand. 2009. The state of the California Current, 2008–2009: Cold conditions drive regional difference. CalCOFI Rep., 50, 43–68.

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.

Paine, R.T., J.T. Wootton, and P.D. Boersma. 1990. Direct and indirect effects of Perigrin Falcon predation on seabird abundance. The Auk 107(1): 1-9.

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

Sydeman, W.J., S.A. Thompson, J.A. Santora, J.A.Koslow, 4 R. Goericke, and M.D. Ohman. *In press*. Climate – ecosystem change off southern California: seabird numerical responses and regime-specific predator-prey interactions. DSRII

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.

Vivrette N.J. and C.H. Muller. 1977. Mechanism of Invasion and Dominance of Coastal Grassland by *Mesembryanthemum crystallinum*. Ecological Monographs 47(3):301-318.

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.

Appendix 1: NRCS Eastern Gulley Consultation

RE: Scorpion Rock Site Visit - NRCS Eastern Gulley Consultation

20 February 2009 - NOAA R/V R4107

Personnel: David Mazurkiewicz (CIES), Nikki Smith and Daniel Little (NRCS)

This site visit was conducted with an agricultural engineer and a soils conservationist from the National Resource Conservation Service (NRCS) out of Santa Maria, CA. The purpose of the visit was to examine the project site and explore possible options to deal with soil erosion issues in and around a drainage gulley on the eastern side of Scorpion Rock. Boat support for this visit was provided by the Channel Islands National Marine Sanctuary-NOAA.
Discussion of erosion control (EC) methods for Scorpion Rock included the understanding of the logistics involved with working on the site (access, sea conditions, skiff delivery of materials etc.) and the need to take into consideration the aesthetics of the location and the frequent visitation by recreational boaters and kayakers to the area.

Main points and methods discussed during the visit to help combat the erosion issues on site include:

- Slowing the flow of water coming down the main drainage of the rock into the gulley. This would involve the placement of more substantial one-rock dams roughly every 10 meters through the steeper eastern side of the main drainage. The current rock/wattles that were placed in the main channel are not engineered appropriately to effectively slow the water down.

- Placement of longer fabric wattles between the one rock dams across the drainage area; the current small wattles in the drainage are not long enough and not as effective as ones that are installed level and extend at least 5-8 meters to either side of the drainage. This would help to keep the existing soil on the rock and help combat erosive processes.

- The “knocking back” of the main head-cut at the top of the gulley to at least a 2:1 slope and covering it with EC material. Contouring the existing gulley below the head-cut to avoid further channelizing of the water flow.

- Re-vegetation of the surrounding drainage slopes and around the created EC structures to help increase the effectiveness of the efforts and offer continued long term protection.

- Continued re-vegetation/ restoration efforts Rock wide to help with soil stabilization and erosion prevention.

Most of these efforts can be undertaken with minimal logistical input and with materials currently on site. Resources for erosion control mentioned by NRCS, include the following helpful guide to EC methods: http://quiviracoalition.org/images/pdfs/73-Erosion_Control_Field_Guide.pdf

Appendix 2: Soil Chemistry Analyses Reports

This page intentionally left blank.

A & L WESTERN AGRICULTURAL LABORATORIES

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

REPORT NUMBER: 10-245-062

CLIENT NO: 5130-D

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

SUBMITTED BY: JOSH ADAMS

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

SOIL ANALYSIS REPORT

PAGE: 1

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 %
1N	57282	5.4VH	138	200VH	243**	832H	216L	952VL	64L	4.4	5.8	14.6	23.5	9.1	7.6	20.2	62.0	1.2
1S	57283	7.5VH	181	178VH	269**	1230VH	223L	1419VL	78L	4.6	5.8	14.6	26.9	11.7	6.8	26.3	54.0	1.3
1E	57284	7.4VH	179	219VH	266**	1219H	176VL	944VL	134L	4.2	5.2	23.5	33.3	9.4	4.3	14.1	70.4	1.7
1W	57285	5.0H	130	160VH	284**	1297H	324L	915VL	166L	4.0	4.8	33.8	45.1	7.4	5.9	10.1	75.0	1.6
1NE	57286	4.8H	125	220VH	176**	1183VH	248L	1127VL	147L	4.5	5.7	15.6	27.0	11.2	7.6	20.9	58.0	2.4

** 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
1N	82VH	53VH	1.9M	4M	77VH	2.6VH	0.3VL	L	2.3H						
1S	22M	24M	6.2VH	8M	96VH	0.6L	0.4L	L	0.9M						
1E	73VH	105VH	8.2VH	5M	111VH	0.5L	0.3VL	L	1.7M						
1W	168VH	166VH	1.5M	15H	80VH	2.6VH	0.3VL	L	4.4VH						
1NE	103VH	104VH	3.8H	3M	69VH	2.4H	0.4L	L	2.7H						

* 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.

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: 10-245-062

CLIENT NO: 5130-D

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

SUBMITTED BY: JOSH ADAMS

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
1NW	57287	5.0H	130	224VH	278**	1206VH	224L	1166VL	98L	4.6	5.9	13.1	24.3	12.7	7.6	24.0	54.0	1.8
1SE	57288	13.8VH	306	240VH	136**	423H	51VL	556VL	34VL	4.0	5.9	13.3	17.7	6.1	2.4	15.7	75.0	0.8
1SW	57289	6.7VH	164	247VH	128**	1186VH	111VL	557VL	104L	4.3	5.9	13.9	21.1	14.4	4.3	13.2	66.0	2.2
1M	57290	6.4VH	157	191VH	131**	1107VH	155L	729VL	112L	4.3	5.7	16.0	24.2	11.7	5.3	15.0	66.0	2.0

** 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
1NW	17M	48VH	4.6H	4M	78VH	1.8H	0.3VL	L	1.3M						
1SE	147VH	39VH	10.7VH	2L	126VH	0.5L	0.4L	L	1.8M						
1SW	39H	81VH	3.8H	7M	124VH	0.5L	0.3VL	L	1.7M						
1M	37H	49VH	5.8H	5M	196VH	0.7L	0.4L	L	1.5M						

* 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: 10-245-063

CLIENT NO: 5130-D

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

SUBMITTED BY: JOSH ADAMS

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
2N	57291	7.7VH	184	207VH	134**	1186H	181VL	1365VL	155L	4.0	4.8	36.0	48.0	6.3	3.1	14.2	75.0	1.4
2S	57292	6.3VH	156	223VH	141**	1111H	154VL	977VL	159L	4.2	5.2	23.1	32.7	8.7	3.9	14.9	70.4	2.1
2E	57293	7.6VH	182	228VH	139**	877H	140VL	1037VL	50VL	4.2	5.4	20.9	29.7	7.5	3.9	17.4	70.4	0.7
2W	57294	7.3VH	177	207VH	139**	1347H	143VL	1008VL	194L	4.0	4.8	31.5	42.0	8.2	2.8	12.0	75.0	2.0
2NE	57295	6.7VH	164	247VH	138**	702H	136L	1053VL	51L	4.5	6.0	11.6	20.0	9.0	5.6	26.3	58.0	1.1

** 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
2N	168VH	80VH	6.3VH	10M	116VH	0.3VL	0.5L	L	3.8H						
2S	110VH	43VH	3.0M	24H	79VH	0.4L	0.3VL	L	2.2H						
2E	22M	41VH	4.0H	8M	130VH	0.3VL	0.3VL	L	1.5M						
2W	67VH	79VH	3.8H	8M	93VH	0.3VL	0.3VL	L	1.9M						
2NE	25M	28H	4.1H	5M	93VH	0.4L	0.4L	L	1.1M						

* 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: 10-245-063

CLIENT NO: 5130-D

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

SUBMITTED BY: JOSH ADAMS

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
2NW	57296	6.9VH	169	240VH	133**	1119H	216L	1495VL	70VL	4.4	5.4	20.2	32.6	8.8	5.5	22.9	62.0	0.9
2SE	57297	7.3VH	176	256VH	128**	1390H	189VL	1357VL	79VL	3.9	4.8	36.7	48.9	7.3	3.2	13.8	75.0	0.7
2SW	57298	6.5VH	160	152VH	140**	1429VH	147VL	1231VL	230M	4.5	5.7	16.6	28.6	12.8	4.2	21.5	58.0	3.5
2M	57299	13.0VH	290	225VH	135**	975H	146VL	1557VL	143L	4.4	5.5	19.7	31.8	7.8	3.8	24.4	62.0	2.0

** 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
2NW	50VH	69VH	3.4H	8M	99VH	0.2VL	0.6M	L	1.8M						
2SE	124VH	81VH	3.5H	13H	114VH	0.2VL	0.6M	L	1.6M						
2SW	17M	28H	3.7H	12M	144VH	0.3VL	0.5L	L	0.5L						
2M	90VH	63VH	12.5VH	10M	176VH	0.6L	0.8M	L	1.7M						

* 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

A&L LABORATORIES AGRICULTURAL • ENVIRONMENTAL • INDUSTRIAL

REPORT NUMBER: 10-245-064

CLIENT NO: 5130-D

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

SUBMITTED BY: JOSH ADAMS

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
3N	57300	6.3VH	156	230VH	238**	1192VH	147L	1301VL	97L	4.7	6.0	11.4	22.6	13.5	5.3	28.8	50.5	1.9
3S	57301	6.2VH	155	280VH	132**	1183VH	177L	1209VL	66L	4.5	5.8	14.9	25.7	11.8	5.7	23.5	58.0	1.1
3E	57302	7.9VH	187	304VH	142**	1273H	160VL	1085VL	116L	4.1	4.8	29.9	40.4	8.1	3.3	13.4	74.0	1.3
3W	57303	6.2VH	153	197VH	268**	1388VH	160VL	941VL	139L	4.4	5.7	16.6	26.8	13.3	4.9	17.5	62.0	2.3
3NE	57304	7.2VH	174	230VH	268**	1066H	128VL	1226VL	76L	4.3	5.4	19.8	30.1	9.1	3.5	20.3	66.0	1.1

** 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
3N	10L	25M	5.2H	10M	214VH	0.3VL	0.4L	L	0.6L						
3S	18M	28H	2.3M	11M	91VH	0.3VL	0.2VL	L	0.9M						
3E	69VH	70VH	1.2M	3M	99VH	0.2VL	0.3VL	L	1.9M						
3W	30H	43VH	2.0M	12M	355VH	0.3VL	0.2VL	L	1.0M						
3NE	48VH	61VH	4.6H	7M	108VH	0.5L	0.3VL	L	1.5M						

* 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: 10-245-064

CLIENT NO: 5130-D

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

SUBMITTED BY: JOSH ADAMS

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
3NW	57305	6.3VH	156	226VH	264**	1179H	162VL	1125VL	69VL	4.3	5.4	19.9	30.2	10.0	4.4	18.6	66.0	1.0
3SE	57306	6.1VH	151	217VH	127**	1100VH	130VL	979VL	67L	4.4	5.8	14.8	23.9	11.8	4.5	20.5	62.0	1.2
3SW	57307	5.4VH	139	128VH	287**	1035H	206L	1134VL	80L	4.4	5.7	16.9	27.2	9.7	6.2	20.8	62.0	1.3
3M	57308	6.2VH	154	205VH	256**	1026H	135VL	899VL	45VL	4.0	5.1	25.3	33.7	7.8	3.3	13.3	75.0	0.6

** 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
3NW	30H	53VH	3.6H	7M	99VH	0.3VL	0.2VL	L	1.2M						
3SE	14M	23M	3.4H	15H	88VH	0.5L	0.2VL	L	0.8M						
3SW	77VH	157VH	2.9M	21H	117VH	0.4L	0.3VL	L	2.2H						
3M	49VH	98VH	3.4H	8M	96VH	0.4L	0.2VL	L	1.6M						

* 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: 10-245-065

CLIENT NO: 5130-D

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

SUBMITTED BY: JOSH ADAMS

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

SOIL ANALYSIS REPORT

PAGE: 1

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 %
4N	57309	13.7VH	305	197VH	279**	989H	137VL	1276VL	65VL	3.8	4.8	30.9	41.2	6.1	2.7	15.4	75.0	0.7
4S	57310	4.5H	119	210VH	277**	1229VH	162L	881VL	695VH	5.1	6.3	7.3	19.2	16.4	6.9	22.9	38.0	15.8
4E	57311	5.8VH	145	171VH	241**	878VH	141L	1095VL	55L	4.6	6.1	10.7	19.8	11.3	5.8	27.6	54.0	1.2
4W	57312	12.3VH	277	219VH	248**	893H	113VL	1547VL	43VL	4.5	5.8	15.4	26.5	8.6	3.5	29.2	58.0	0.7
4NE	57313	7.7VH	183	195VH	258**	1104VH	197L	1410VL	52VL	4.5	5.7	16.2	27.9	10.1	5.8	25.2	58.0	0.8

** 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
4N	163VH	97VH	4.9H	8M	391VH	0.5L	0.3VL	L	3.1H						
4S	54VH	55VH	3.2H	14H	113VH	0.4L	0.3VL	L	1.6M						
4E	23M	39VH	8.3VH	7M	89VH	0.6L	0.2VL	L	0.5L						
4W	21M	35H	7.5VH	6M	78VH	0.5L	0.5L	L	1.0M						
4NE	54VH	60VH	5.4H	8M	78VH	0.4L	0.4L	L	1.5M						

* 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: 10-245-065

CLIENT NO: 5130-D

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

SUBMITTED BY: JOSH ADAMS

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

SOIL ANALYSIS REPORT

PAGE: 2

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 %
4NW	57314	7.8VH	185	209VH	190**	994H	111VL	1458VL	107L	4.2	5.0	26.7	37.9	6.7	2.4	19.2	70.4	1.2
4SE	57315	5.2H	135	213VH	152**	1115H	150VL	969VL	67VL	4.0	4.9	27.6	36.8	7.7	3.3	13.1	75.0	0.8
4SW	57316	6.5VH	160	278VH	258**	1338H	168VL	1281VL	54VL	4.1	4.8	32.5	44.0	7.8	3.1	14.5	74.0	0.5
4M	57317	8.6VH	201	285VH	151**	1090H	128VL	1392VL	130L	3.9	4.8	34.1	45.4	6.1	2.3	15.3	75.0	1.2

** 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
4NW	60VH	43VH	4.4H	5M	81VH	0.4L	0.3VL	L	1.3M						
4SE	46VH	109VH	1.4M	9M	95VH	0.3VL	0.2VL	L	1.7M						
4SW	61VH	115VH	2.8M	11M	85VH	0.4L	0.3VL	L	1.8M						
4M	80VH	85VH	6.9VH	8M	110VH	0.4L	0.3VL	L	2.0M						

* 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: 10-245-066

CLIENT NO: 5130-D

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

SUBMITTED BY: JOSH ADAMS

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
5N	57318	7.9VH	188	218VH	137**	1825VH	228L	1345VL	200L	4.4	5.2	23.0	37.2	12.6	5.1	18.1	62.0	2.3
5S	57319	5.8VH	146	188VH	134**	1506VH	277L	1411VL	110L	4.6	5.7	16.0	29.7	13.0	7.7	23.7	54.0	1.6
5E	57320	5.9VH	148	251VH	265**	1365VH	364M	1480VL	184L	4.7	5.8	15.0	29.6	11.8	10.1	24.9	50.5	2.7
5W	57321	5.3VH	136	239VH	139**	1657VH	302M	1159VL	146L	4.9	6.1	10.3	23.5	18.1	10.6	24.6	44.0	2.7
5NE	57322	8.2VH	193	235VH	248**	1566VH	314L	1345VL	399H	4.7	5.8	15.3	30.4	13.2	8.5	22.1	50.5	5.7

** 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
5N	29H	35H	4.5H	6M	123VH	1.6H	0.5L	L	1.1M						
5S	24M	31H	2.6M	20H	98VH	0.8L	0.3VL	L	1.2M						
5E	40H	29H	2.4M	18H	93VH	0.8L	0.3VL	L	1.2M						
5W	23M	23M	1.8M	17H	95VH	1.9H	0.3VL	L	0.9M						
5NE	125VH	47VH	6.6VH	19H	192VH	0.8L	0.6M	L	1.4M						

* 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: 10-245-066

CLIENT NO: 5130-D

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

SUBMITTED BY: JOSH ADAMS

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
5NW	57323	7.3VH	175	240VH	281**	1741VH	208VL	1256VL	155L	4.2	4.8	31.2	44.3	10.0	3.9	14.1	70.4	1.5
5SE	57324	6.1VH	152	248VH	251**	2016VH	470M	1533VL	198L	4.9	5.9	13.8	31.3	16.5	12.3	24.4	44.0	2.8
5SW	57325	5.7VH	145	192VH	250**	1658VH	396M	1197VL	139L	4.9	6.1	11.1	25.1	16.9	13.0	23.8	44.0	2.4
5M	57326	5.1H	132	112VH	157**	2358VH	284L	1405VL	262M	5.0	6.0	11.5	28.0	21.6	8.3	25.1	41.0	4.1

** 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
5NW	34H	53VH	4.8H	10M	217VH	0.6L	0.4L	L	1.3M						
5SE	50VH	36VH	2.0M	26H	189VH	1.2M	0.4L	L	1.3M						
5SW	10L	17M	2.0M	21H	93VH	2.6VH	0.4L	L	0.5L						
5M	9L	25M	1.8M	18H	93VH	3.1VH	0.3VL	L	0.6L						

* 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: 10-245-067

CLIENT NO: 5130-D

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

SUBMITTED BY: JOSH ADAMS

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
6N	57327	6.9VH	168	220VH	140**	1515VH	195L	1194VL	141L	4.5	5.7	16.6	28.7	13.5	5.6	20.8	58.0	2.1
6S	57328	5.1H	131	217VH	134**	1604VH	237L	1116VL	317M	4.4	5.3	21.2	34.2	12.0	5.7	16.3	62.0	4.0
6E	57329	5.9VH	148	213VH	137**	1790VH	363L	1479VL	181L	4.6	5.5	18.5	34.2	13.4	8.7	21.6	54.0	2.3
6W	57330	5.7VH	145	254VH	135**	1711VH	248L	1379VL	153L	4.6	5.7	16.4	30.3	14.4	6.7	22.7	54.0	2.2
6NE	57331	8.7VH	203	218VH	142**	1236VH	183VL	1556VL	81L	4.5	5.6	17.7	30.4	10.4	4.9	25.5	58.0	1.2

** 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
6N	14M	20M	3.0M	11M	248VH	1.2M	0.3VL	L	0.3L						
6S	64VH	106VH	1.1M	16H	92VH	11.4VH	0.3VL	L	0.8M						
6E	68VH	35H	1.7M	17H	85VH	2.0H	0.7M	L	1.0M						
6W	27H	41VH	2.8M	12M	108VH	1.0M	0.5L	L	1.2M						
6NE	18M	27H	4.5H	20H	279VH	1.3H	0.6M	L	1.0M						

* 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: 10-245-067

CLIENT NO: 5130-D

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

SUBMITTED BY: JOSH ADAMS

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
6NW	57332	6.0VH	149	206VH	130**	1206VH	170L	1140VL	82L	4.5	5.8	14.5	25.1	12.3	5.6	22.7	58.0	1.4
6SE	57333	5.0H	130	197VH	146**	1203VH	240L	1173VL	194M	4.6	5.9	13.8	25.5	12.0	7.7	22.9	54.0	3.3
6SW	57334	5.7VH	145	215VH	126**	2515VH	429M	1324VL	403H	5.1	6.1	11.2	29.5	21.8	11.9	22.4	38.0	5.9
6M	57335	6.0VH	149	225VH	122**	1483VH	224L	1168VL	139L	4.4	5.5	19.7	31.8	11.9	5.8	18.4	62.0	1.9

** 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
6NW	22M	20M	2.5M	12M	97VH	0.6L	0.4L	L	1.0M						
6SE	38H	36VH	1.6M	16H	92VH	0.9M	0.3VL	L	1.1M						
6SW	30H	32H	1.1M	30H	84VH	1.3H	0.5L	L	0.7M						
6M	27H	28H	2.4M	10M	237VH	1.4H	0.3VL	L	1.0M						

* 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: 10-245-062 **CLIENT:** 5130

SUBMITTED BY: JOSH ADAMS

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
1N	57282	0.8	< 0.1	2.7	14.5	7.6	4.4	0.0	1.2	2.3	3.0	0.3	47.2
1S	57283	1.6	1.0	4.5	11.0	5.7	4.6	0.0	1.2	0.9	2.3	0.4	76.5
1E	57284	0.7	< 0.1	1.7	8.1	3.5	4.2	0.0	1.3	1.7	0.8	0.4	73.6
1W	57285	1.7	1.2	6.9	18.0	15.0	4.0	0.0	1.2	4.4	8.3	0.4	58.5
1NE	57286	1.7	1.3	5.3	12.1	6.2	4.5	0.0	1.8	2.7	3.9	0.3	54.2
1NW	57287	1.2	0.5	3.4	11.0	5.3	4.6	0.0	1.6	1.3	1.4	0.4	53.3
1SE	57288	0.7	< 0.1	2.0	14.1	3.7	4.0	0.0	1.2	1.8	2.0	0.3	81.0

NOTES:

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: 10-245-062 **CLIENT:** 5130

SUBMITTED BY: JOSH ADAMS

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
1SW	57289	2.3	2.1	4.3	4.4	2.7	4.3	0.0	1.3	1.7	2.1	0.4	64.6
1M	57290	1.8	1.4	4.2	6.8	3.9	4.3	0.0	1.7	1.5	1.7	0.4	65.8

NOTES:

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: 10-245-063 **CLIENT:** 5130

SUBMITTED BY: JOSH ADAMS

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
2N	57291	1.6	1.0	7.1	31.8	10.2	4.0	0.0	1.3	3.8	4.0	0.4	73.4
2S	57292	2.1	1.8	7.0	15.6	6.7	4.2	0.0	1.4	2.2	5.8	0.4	52.6
2E	57293	0.7	< 0.1	2.0	12.1	4.8	4.2	0.0	1.2	1.5	2.3	0.3	56.3
2W	57294	2.1	1.8	4.5	6.3	3.0	4.0	0.0	1.5	1.9	1.8	0.2	60.8
2NE	57295	0.8	< 0.1	2.1	9.6	3.6	4.5	0.0	2.1	1.1	1.4	0.3	65.1
2NW	57296	0.7	< 0.1	2.5	16.3	6.5	4.4	0.0	1.7	1.8	2.7	0.3	61.3
2SE	57297	0.8	< 0.1	2.5	14.7	5.4	3.9	0.0	1.2	1.6	2.3	0.3	56.6

NOTES:

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: 10-245-063 **CLIENT:** 5130

SUBMITTED BY: JOSH ADAMS

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
2SW	57298	2.5	2.4	4.2	4.0	1.6	4.5	0.0	1.4	0.5	0.8	0.2	60.0
2M	57299	1.2	0.5	4.1	18.0	4.9	4.4	0.0	1.6	1.7	1.9	0.3	71.2

NOTES:

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: 10-245-064 **CLIENT:** 5130

SUBMITTED BY: JOSH ADAMS

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
3N	57300	1.4	0.7	2.3	4.0	1.6	4.7	0.0	1.4	0.6	1.0	0.2	52.1
3S	57301	0.8	< 0.1	1.7	6.5	2.7	4.5	0.0	1.2	0.9	1.2	0.3	51.4
3E	57302	1.5	0.9	4.4	13.3	4.9	4.1	0.0	1.1	1.9	1.7	0.3	61.4
3W	57303	2.3	2.1	4.1	4.1	2.0	4.4	0.0	1.3	1.0	1.6	0.2	46.0
3NE	57304	0.9	0.1	2.4	10.1	3.0	4.3	0.0	1.2	1.5	1.4	0.3	59.1
3NW	57305	1.2	0.4	2.6	6.9	3.0	4.3	0.0	1.2	1.2	1.7	0.3	53.1
3SE	57306	1.3	0.6	2.2	4.4	1.9	4.4	0.0	1.2	0.8	1.1	0.2	53.0

NOTES:

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: 10-245-064 **CLIENT:** 5130

SUBMITTED BY: JOSH ADAMS

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
3SW	57307	1.0	0.2	3.7	18.8	8.3	4.4	0.0	1.2	2.2	2.1	0.2	55.4
3M	57308	0.7	< 0.1	2.0	12.0	5.0	4.0	0.0	1.1	1.6	1.8	0.2	57.4

NOTES:

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: 10-245-065 **CLIENT:** 5130

SUBMITTED BY: JOSH ADAMS

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
4N	57309	0.8	< 0.1	3.5	27.9	6.9	3.8	0.0	1.3	3.1	2.5	0.3	54.9
4S	57310	12.0	14.1	17.3	3.7	0.4	0.0	3.1	1.5	1.6	4.5	0.4	48.3
4E	57311	0.6	< 0.1	1.3	7.5	2.9	4.6	0.0	1.4	0.5	1.0	0.2	47.4
4W	57312	0.7	< 0.1	1.5	7.8	1.8	4.5	0.0	1.2	1.0	0.5	0.2	64.5
4NE	57313	0.7	< 0.1	2.1	12.3	4.9	4.5	0.0	1.7	1.5	1.2	0.3	59.6
4NW	57314	1.5	0.9	4.0	12.0	2.6	4.2	0.0	1.2	1.3	2.0	0.2	61.8
4SE	57315	1.0	0.2	2.5	8.5	3.7	4.0	0.0	1.2	1.7	2.8	0.2	44.1

NOTES:

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: 10-245-065

CLIENT: 5130

SUBMITTED BY: JOSH ADAMS

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

SOIL SALINITY ANALYSIS REPORT

PAGE: 2

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 %
4SW	57316	0.8	< 0.1	1.7	6.7	2.6	4.1	0.0	1.2	1.8	1.1	0.2	54.5
4M	57317	1.2	0.5	3.6	14.9	3.9	3.9	0.0	1.5	2.0	1.4	0.3	64.2

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: 10-245-066 **CLIENT:** 5130

SUBMITTED BY: JOSH ADAMS

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
5N	57318	2.3	2.2	3.8	3.6	1.7	4.4	0.0	1.7	1.1	1.1	0.3	59.8
5S	57319	1.3	0.7	2.7	5.6	2.9	4.6	0.0	1.1	1.2	1.0	0.3	58.0
5E	57320	1.8	1.4	4.3	6.8	4.3	4.7	0.0	1.3	1.2	2.5	0.3	58.3
5W	57321	2.1	1.8	3.6	3.6	2.3	4.9	0.0	1.1	0.9	0.8	0.3	52.8
5NE	57322	4.9	5.6	14.2	10.5	6.7	4.7	0.0	1.7	1.4	4.3	0.4	66.0
5NW	57323	1.5	1.0	3.2	6.2	2.5	4.2	0.0	1.2	1.3	0.8	0.0	68.3
5SE	57324	2.1	1.8	4.2	4.8	3.4	4.9	0.0	1.7	1.3	1.2	0.3	58.1

NOTES:

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: 10-245-066 **CLIENT:** 5130

SUBMITTED BY: JOSH ADAMS

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
5SW	57325	1.9	1.5	2.2	1.7	1.1	4.9	0.0	1.7	0.5	0.8	0.2	60.9
5M	57326	2.5	2.4	2.9	1.8	0.9	5.0	0.0	1.3	0.6	0.8	0.3	54.4

NOTES:

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: 10-245-067 **CLIENT:** 5130

SUBMITTED BY: JOSH ADAMS

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
6N	57327	1.8	1.4	2.6	2.5	1.4	4.5	0.0	1.1	0.3	0.8	0.3	62.2
6S	57328	3.6	3.9	7.4	5.5	3.0	4.4	0.0	1.1	0.8	1.8	0.2	55.3
6E	57329	1.7	1.2	3.3	4.7	3.0	4.6	0.0	1.1	1.0	1.2	0.3	58.2
6W	57330	1.6	1.1	3.3	5.3	2.6	4.6	0.0	1.1	1.2	1.1	0.3	64.8
6NE	57331	1.0	0.2	2.0	6.2	2.1	4.5	0.0	1.2	1.0	0.6	0.4	67.3
6NW	57332	1.2	0.6	2.4	5.1	2.2	4.5	0.0	1.2	1.0	1.0	0.3	58.1
6SE	57333	2.4	2.2	4.8	5.3	3.0	4.6	0.0	1.4	1.1	1.2	0.3	63.8

NOTES:

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: 10-245-067 **CLIENT:** 5130

SUBMITTED BY: JOSH ADAMS

SEND TO: USGS-SF BAY ESTUARY FLD STN
505 AZUAR DRIVE
VALLEJO, CA 94595

GROWER: PO#08WRSA0448

DATE OF REPORT: 09/10/10

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 %
6SW	57334	4.6	5.3	5.8	1.7	1.4	5.1	0.0	1.6	0.7	1.3	0.4	69.3
6M	57335	1.7	1.2	3.4	5.4	2.7	4.4	0.0	1.4	1.0	1.2	0.3	61.9

NOTES:

M Buttress

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