Seabird Habitat Restoration onSanta Barbara Island, California:
2007-2014 Data Report

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14 December 2015

Suggested Citation: Jacques, M.E., A.A. Yamagiwa, D.M. Mazurkiewicz, A.L. Harvey, and A. Little. 2015. Seabird habitat restoration on Santa Barbara Island, California: 2007-2014 data report. Unpublished report, California Institute of Environmental Studies. 242 pages.

ACRONYMS

ACMI: Common Yarrow (*Achillea millefolium*)

ARXX: Coastal Sagebrush (*Artemisia californica*) and Island Sagebrush (*Artemisia nesiotica*)

ATCA: California Saltbush (*Extriplex californica*; formerly *Atriplex californica*)

BAPI: Coyote Brush (*Baccharis pilularis*)

BHP: Beacon Hill Restoration Plot

CAAU: Cassin's Auklet (*Ptychoramphus aleuticus*)

CAMA: Island Morning-Glory (*Calystegia macrostegia s. amplissima*)

CHCA: California Goosefoot (*Chenopodium californicum*)

CIES: California Institute of Environmental Studies

CINP: Channel Islands National Park

COGI: Giant Tickseed (*Leptosyne gigantea*; formerly *Coreopsis gigantea*)

CONE: Nevin's Woolly Sunflower (*Constancea nevinii*; formerly *Eriophyllum nevinii*)

DECL: Island Tarplant (*Deinandra clementina*; formerly *Hemizonia clementina*)

ERGC: Santa Barbara Island Buckwheat (*Eriogonum giganteum var. compactum*)

ESC: Elephant Seal Cove Restoration Plot

HP: House Restoration Plot

LACO: Landing Cove Restoration Plot

LYCA: California Box-thorn (*Lycium californicum*)

MSRP: Montrose Settlements Restoration Program

NEF: North East Flats Restoration Plot

NOAA: National Oceanic and Atmospheric Administration

NPS: National Park Service

NTP: Nature Trail Restoration Plot

OPXX: Prickly-pear (*Opuntia littoralis* and *Opuntia oricola*)

SBI: Santa Barbara Island

SCMU: Scripps's Murrelet (*Synthliboramphus scrippsi*)

SPMA: Sticky Sandspurrey (*Spergularia macrotheca*)

STXX: Foothill Needle Grass (*Stipa lepida*; formerly *Nassella lepida*) or Purple Needle Grass (*Stipa pulchra*; formerly *Nassella pulchra*)

SUTA: Woolly Seablite (*Suaeda taxifolia*)

USFWS: U.S. Fish and Wildlife Service

EXECUTIVE SUMMARY

- This data report summarizes Scripps's Murrelet (*Synthliboramphus scrippsi*, SCMU) and Cassin's Auklet (*Ptychoramphus aleuticus*; CAAU) habitat restoration activities on Santa Barbara Island (SBI), from 2007 to 2014. It includes restoration objectives, funding, methods (included protocols in appendices), data summaries, and recommendations.
- Spanning 2.6 km^2, SBI is the smallest of five islands comprising Channel Islands National Park (CINP) in California. SBI hosts ecosystems that were severely degraded by human activities. Within the last two centuries, ecosystems on SBI have shifted from native perennial shrub communities to non-native annual grasslands and non-native Iceplant (*Mesembryanthemum* spp.) fields.
- SBI has the largest colony of SCMU in the United States, although the number of SCMU nesting on SBI drastically decreased due to cat predation, artificial light pollution, toxic pollution, and habitat destruction during the 20th and 21st centuries. Similar anthropogenic activities have led to the extirpation in the early 1900's of a historically important nesting colony of CAAU on SBI. CAAU now only nest in low numbers on SBI.
- In 2006, the Montrose Settlements Restoration Program (MSRP) identified the need to restore critical nesting habitat for SCMU and CAAU on SBI by removing non-native vegetation and re-vegetating areas with native plants, but no short-term objectives were given. We identified four short-term objectives to evaluate the on-going success of restoration efforts on SBI: (1) to increase the cover of native species; (2) to decrease the cover of non-native species; (3) to increase native genera richness; and (4) to achieve a 50% survival rate one year post planting in the restoration plots.
- The primary funding for the restoration program was provided by MSRP, with in-kind support from CINP via vessel transportation and logistical support. Other funders included the National Fish and Wildlife Foundation and Patagonia, Inc. The annual yearly cost of the restoration program on SBI was approximately $450K.
- The lack of permanent sources of freshwater on SBI and the remote location of the island (61 km from the mainland) contributed to the challenges of restoration. Developing efficient ways to deliver water to SBI and increasing the amount of water storage on SBI became fundamental to the success of this project. Installing a desalination unit on SBI would greatly reduce the time and effort associated with water delivery to the island.

- Adaptive management was key to improving restoration success on SBI over time. With experience, we refined our outplanting techniques, nursery facilities and growing skills, and water delivery and storage methods.
- Since 2007, six restoration plots have been established on SBI: Beacon Hill (BHP), Elephant Seal Cove (ESC), House (HP), Landing Cove (LACO), Nature Trail (NTP), and North East Flats (NEF). These restoration plots are located on the northernmost half of the island and are divided into subplots used for monitoring purposes. Between 2007-2014, restoration plots covered a total of 31,200 m^2 (7.71 acres).
- Over 29,000 plants have been outplanted in restoration plots between 2007-2014 and over 2,800 native plants have been added outside restoration plots for landscaping or erosion control purpose or for trial plantings.
- Perennial species selected for propagation included native species with known records of SCMU nesting, native species with a high potential for SCMU nesting, and other native species to increase community diversity and provide soil stabilization necessary for CAAU burrows. Plants were predominantly propagated from seeds, although species that did not germinate readily from seeds were propagated from cuttings. All seeds and cuttings used for propagation were collected on island and, from 2008 to 2014, always stored on island to reduce the risks of introducing novel non-native species on SBI.
- In 2010, a custom-made nursery with a cutting chamber was constructed on SBI to accommodate ~7,500 plants annually. The nursery had a subfloor for water catchment and three grow-out areas. Pond liner covered the tables in the grow-out areas to catch rainfall and to allow for flood irrigation of plants.
- Nursery pests have been minimized in the nursery through an integrated pest management approach, including mechanical control, insecticide application, and other methods.
- Planting plans for restoration plots were based on the quantity and size of plants available in the nursery, as well as basic species requirements. The spatial arrangement of plants seemed to affect success as plants outplanted in patches fared better over time than plants outplanted in a stratified random manner.
- At a minimum, before outplanting and every spring and fall, plots were weeded of non-native species (mechanically or chemically). Extensive weed control probably accounted for the

decrease in the cover of thatch and for the increase in bare ground in plots following the onset of restoration.

- If plots appeared susceptible to erosion, erosion control fabric and fiber rolls were installed with staples and stakes. These erosion control methods also helped to the retention of native seeds within restoration plots.
- After plants were put in the ground, restoration plots were typically watered for a year or two on a bi-weekly to monthly basis.
- Several improvements to the watering systems were made through the years. These improvements decreased the time and costs necessary to deliver water to restoration plots. Starting in 2014, drip irrigation was used to water plants, which increased plant survival and accelerated growth rates.
- Overall, survival rates for outplanted plants watered by hand tended to be higher during wet years than during dry years.
- Within eight years of restoration, we recorded restoration successes on SBI in the form of increased native plant cover, decreased non-native cover, and increased native genera richness in many restoration plots. We also achieved an average survival rate of 81% at BHP between December 2013 and September 2014. This survival rate surpassed our objective to achieve 50% survival one year post-planting.
- Our project provided invaluable outreach and education opportunities for volunteers and SBI visitors. It also provided benefits to non-target native species such as endemic arthropods, landbirds, the endemic Santa Barbara Deer Mouse (*Peromyscus maniculatus elusus*), and endemic Island Night Lizard (*Xantusia riversiana*).
- We hope our project will help guide future habitat restoration efforts elsewhere and benefit land managers who deal with similar issues: lack of permanent sources of freshwater, field site remoteness, drought conditions, heavy invasive seed bank, low native species seed bank, and soil disturbances. Recommendations and lessons learned from this project are provided within this report.

ACKNOWLEDGMENTS

We thank all personnel who have worked on SBI during the course of this project: S.A. Auer, S. Avery, K.W. Barnes, M.G. Buratti, S.M. Cady, S. Carr, C.A. Carter, C.L. Ender, L.A. Ferguson, N.A. Giese, C.E. Hand, L.A. Hennes, N.B. Hernandez, J.A. Howard, G.R. Keeler, R.W. Kessler, S.J. Kim, J.S. Koepke, C.E. Kroeger, A.M. Lessing, C.J. Mills, K.M. Robison, R.E. Robison, S.K. Thomsen, and E.W. Wynd. An additional thank you should be given to J. Boyce (MSRP), H. Holly Gellerman (MSRP), J.A. Howard (CIES), and G.R. Keller (CIES) for reviewing this manuscript. We also thank Channel Islands National Park (CINP) boat captains and volunteers for their tremendous help over the years: Jeff Beller, D. Brooks, D. Carlson, K. Duran, Evan Jones, E. Mayer, J. Spille, and D. Willey. Aspen Helicopter pilots also provided safe and trust-worthy transportation to SBI: B. Hansen, J. McCrory, C. McLaughlin, Jay Soukelsian, and R. Throckmorton. Special thanks to the NPS maintenance team for their handy work; Kate Faulkner and Russell Galipeau for their support; I. Williams for safety consultations and logistical support for helicopter operations; the CINP law enforcement division for their help; Growing Solutions Restoration Education Institute (K. Flagg and D. Hartley), S. Chaney, K. McEachern, and D. Rodriguez for botanical expertise; K. Minas for archeological consultation; R. Rudolph for GIS assistance; D. Richards for project guidance and insight; and C. Bornstein, G.F. Hrusa, and H. Scheck for their expert knowledge on plant pathology and taxonomy. Special thanks to J. Boyce of the Montrose Trustee Council for her support over the years. We also thank the volunteers who provided enthusiastic assistance on SBI and our funding sources: Montrose Settlements Trustee Council (major funder), CINP, the National Fish and Wildlife Foundation, and Patagonia, Inc. This project was conducted under BBL permit #22539.

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I. INTRODUCTION

Spanning 2.6 km^2, Santa Barbara Island (SBI) is the smallest of five islands comprising Channel Islands National Park (CINP) in California (Figure 1). Ranching, grazing, fire, and other anthropogenic activities on SBI have resulted in soil erosion, native plant removal, gully formation, and introduction of non-native species (Halvorson et al. 1988). SBI is now host to severely degraded ecosystems. Within the last two centuries, ecosystems have shifted from native perennial shrub communities to non-native annual grasslands and non-native Iceplant (*Mesembryanthemum* spp.) fields (Halvorson et al. 1988, Handley et al. 2012; Figure 2). Long-term vegetation monitoring data from CINP point to a clear lack of natural vegetation recovery (Davidson et al. *in review*, Handley et al. 2012, Rodriguez et al. *in review*).

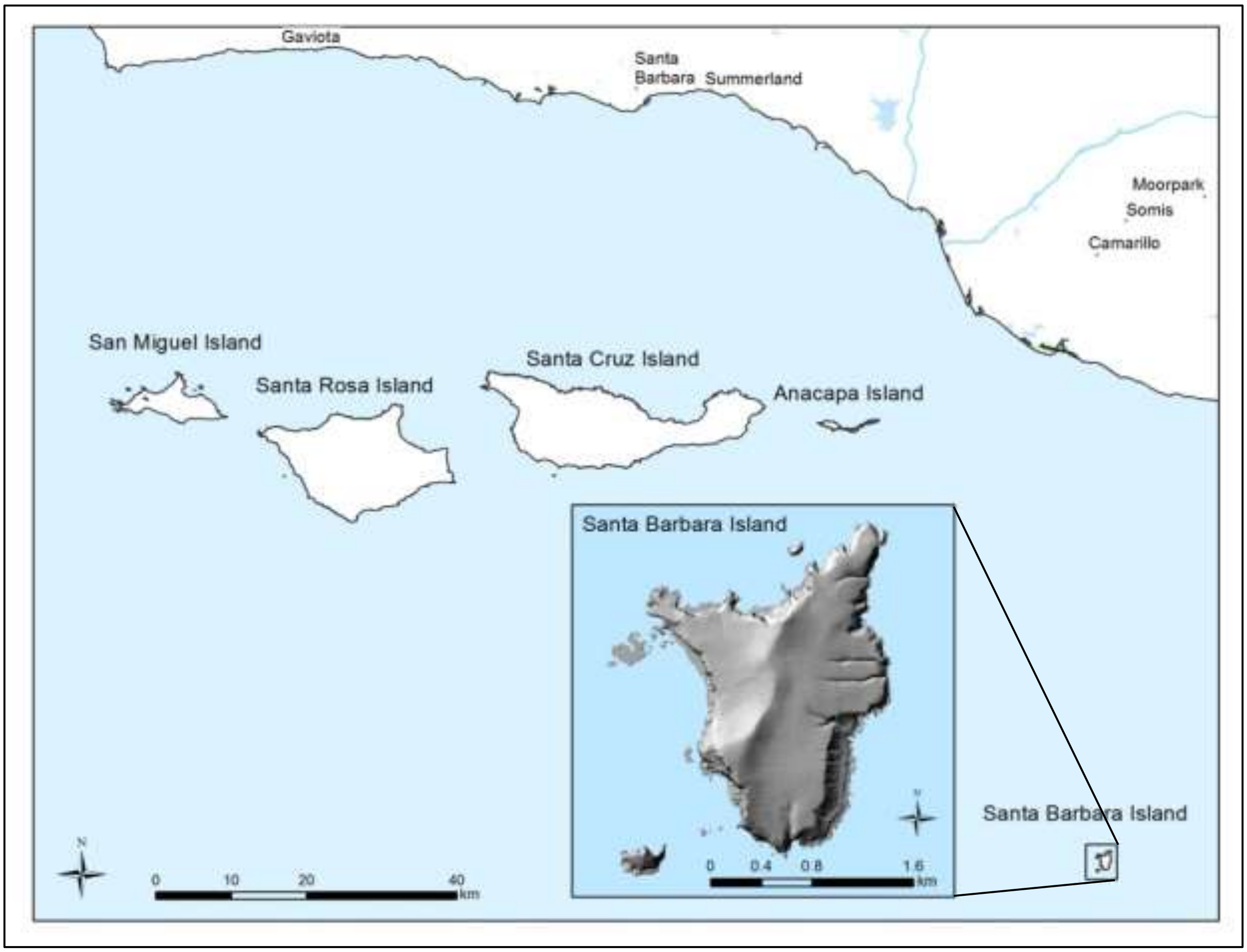

Figure 1: Map of CINP and close-up view of SBI.
CINP is located off the coast of southern California and consists of five islands: San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara. The insert shows SBI's topography.

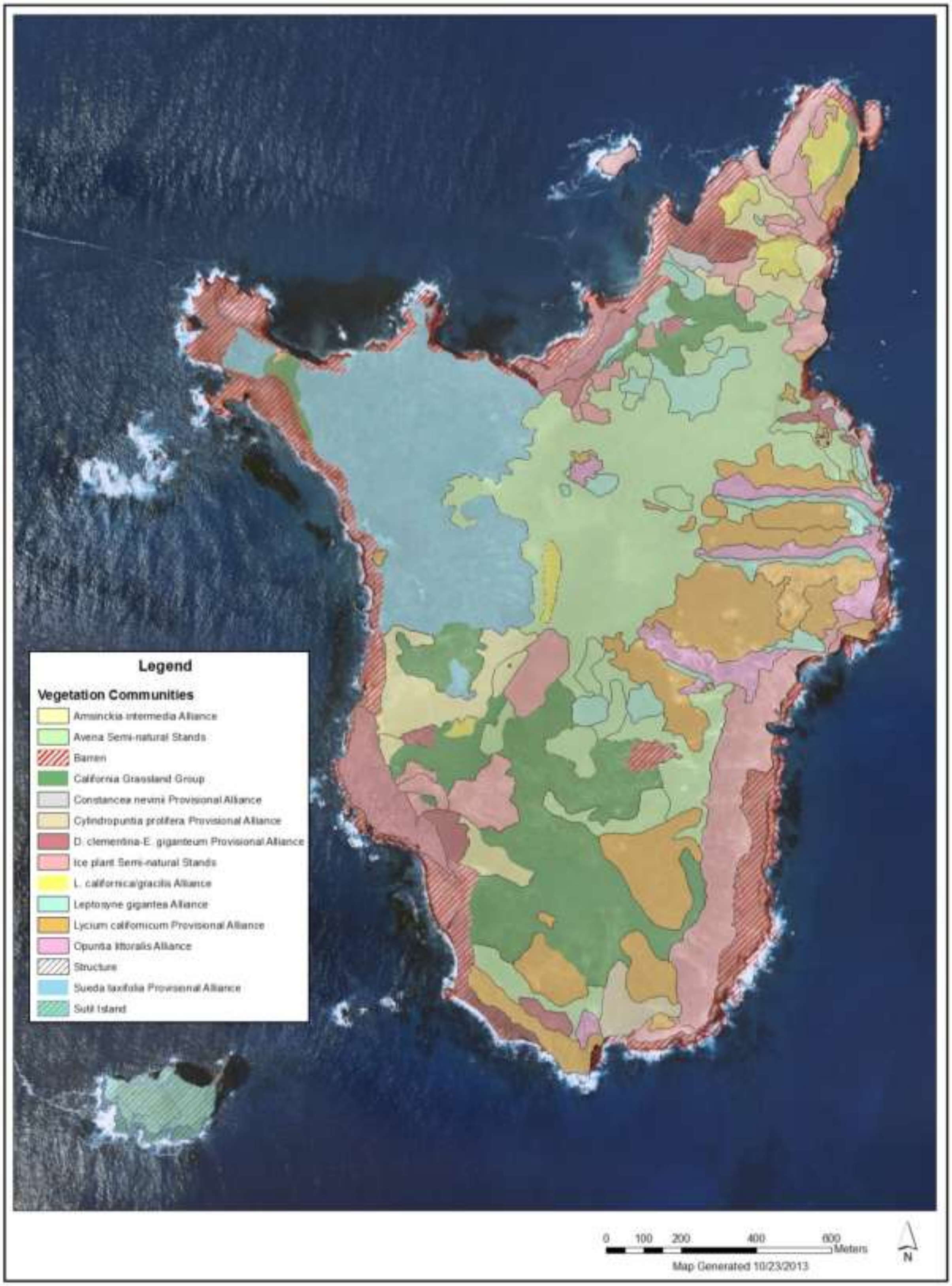

Figure 2: 2010 SBI vegetation classification map.
Credit: Rodriguez et al. *in review*.

SBI has the largest nesting colony of Scripps's Murrelet (*Synthliboramphus scrippsi*, SCMU) in the United States although the number of SCMU nesting on SBI drastically decreased during the 20^{th} and 21^{st} centuries due to cat predation, artificial light pollution, toxic pollution, and habitat destruction (Howell 1917, Burkett et al. 2003, Adams 2008). Similar anthropogenic activities have led to the extirpation in the early 1900's of a historically important nesting colony of Cassin's Auklet (*Ptychoramphus aleuticus*; CAAU) on SBI (Grinnel 1897, Howell 1917, Burkett et al. 2003, Whitworth et. al 2009, Harvey et al. 2012). In 1897, CAAU bred in large numbers on SBI (Grinnel 1897), but the CAAU colony was extirpated in the early 1900's due to feral cat predation, farming, ranching, and "possibly in conjunction with other factors such as low prey availability and high avian predation" (Whitworth et. al 2009). Surveys conducted in the early 1990s demonstrated that the CAAU colony had not recovered from the impacts of cat predation (Carter et al. 1992, Whitworth et. al 2009), and that they only persisted in small numbers on the offshore islet of Sutil Island and at Elephant Seal Point on SBI proper (Carter et al. 1992). In 2009-2010, biologists documented the first breeding by CAAU on SBI since 1994 (Whitworth et al. 2011).

On SBI, SCMU breed from late winter throughout spring (Murray et al. 1983, Harvey et al. 2013) and typically nest in rock crevices or under vegetation (Murray et al. 1983). Females lay two eggs eight days apart directly on bare rocks or in shallow depressions (Murray et al. 1983). Eggs are then incubated by both parents in three day shifts for 34 days (Murray et al. 1983). Chicks are precocial and leave the nest two nights after hatching (Murray et al. 1983). Egg depredation is proportionally lower in nests under shrubs than in nests in crevices (Murray et al 1983, Harvey et al. 2013, Howard et al. 2014), and clutch success is higher in nests under native shrubs than in crevices (Harvey et al. 2013, Howard et al 2014).

CAAU typically nest in excavated burrows 0.6 to 1.5m deep or in rock crevices (Thoresen 1964, Manuwal 1974). Thoresen (1964) noted that CAAU prefer to establish their nests in burrows under "solid material", such as the base of rocks or roots. CAAU lay a single egg, and both parents incubate it (Manuwal 1974, 1979). In the northern Channel Islands, nesting occurs throughout spring (Adams et al. 2004, Adams et al. 2014). The mean incubation period varies between 37-42 days and the mean nestling period is $\geq$41 days (Manuwal and Thoresen 1993). Nesting success is lower in larger rock crevices due to Western Gull (*Larus occidentalis*) predation or in burrows excavated in loose, shallow soil due to erosion at the nest entrance or burrow collapse (Manuwal 1974; Manuwal and Thoresen 1993).

In 2006, the Montrose Settlements Restoration Program (MSRP) identified the need to restore critical nesting habitat for SCMU and CAAU on SBI by removing non-native vegetation and re-vegetating areas with native plants (MSRP 2005). The goal of restoring native plant communities on SBI was to create additional nesting habitat and improve SCMU nesting success. Restoration of native plant communities on SBI will also improve critical nesting habitat for CAAU by stabilizing the soil and providing CAAU access to nesting substrate currently excluded by non-native vegetation. Native shrub communities will also provide greater protection to nesting seabirds from predators such as the Barn Owl (*Tyto alba*) and Peregrine Falcon (*Falco peregrinus*), as has been documented on Scorpion Rock off of Santa Cruz Island, CA (Adams et al. 2014).

This report summarizes SCMU and CAAU habitat restoration activities from 2007 to 2014 on SBI, including restoration objectives, funding, methods, data summary, and discussion. This is a data report only and statistical analysis of data will be done in separate publications. Plant restoration work is projected to continue through 2020. Discussion of seabird monitoring, vocalization playback systems, and artificial nest cavities/boxes are beyond the scope of this report, but can be found in other MSRP publications (e.g., Harvey et al. 2013, 2014, Howard et al. 2014).

Plant nomenclature is according to the Jepson Flora Project and plant acronyms are according to CINP as of 15 January 2015.

I.I RESTORATION OBJECTIVES

The long-term objectives of the seabird restoration program on SBI were to “improve recruitment and productivity of SCMU” and “re-establish an active CAAU breeding population” on the island (MSRP 2005). To be met, these objectives would require successful habitat restoration which can take decades to achieve, especially in areas like SBI where water is scarce and native plants grow slowly. To restore strong, resilient native communities that can sustain breeding bird populations, restoration efforts will need to produce native plants that can grow to maturity, reproduce, and self-propagate. Native plants also would need to outcompete non-native species for limited resources (nutrients, light, and water) in soils that have been altered by anthropogenic causes and non-native species. To track plant community changes in restored areas over time and assess the yearly success of restoration efforts on SBI, a set of short-term objectives were established to complement the MSRP's long-term objectives. These short-term objectives were to:

- Increase the cover of native species,
- Decrease the cover of non-native species,
- Increase native genera richness, and
- Achieve a 50% survival rate one year post-planting in the restoration plots.

Ways to evaluate the success of these objectives are described in the methods section.

I.II FUNDING

The primary funding for the restoration program was provided by MSRP and the project was implemented by the California Institute of Environmental Studies (CIES), with assistance from CINP staff. This program has been administered by six State and Federal agencies and focuses on the restoration of natural resources in the Southern California Bight that were harmed by DDTs and PCBs. In-kind support came from CINP via vessel transportation and logistical support since 2007. Additional funding has been received from entities such as the National Fish and Wildlife Foundation and Patagonia, Inc. The annual yearly cost of the restoration program on SBI was approximately $450K. The restoration program is expected to run at least until 2020 with current MSRP funding, but the goal is to keep the restoration program ongoing for the next decade with funding from a variety of different sources. For more information on CIES and MSRP, please visit http://ciesresearch.org/ and http://www.montroserestoration.noaa.gov/.

II. METHODS

II.I Precipitation Data

Native vegetation recovery is tightly linked with precipitation patterns on SBI (Handley et al. 2012, Rodriguez et al. *in review*). Precipitation data on SBI were therefore obtained to interpret restoration data. Precipitation data were recorded with a remote automated weather station on SBI through the Western Regional Climate Center (compiled by Handley et al. 2012 and M.E. Jacques).

II.II Adaptive Management

Adaptive management was key to improving restoration success on SBI. Protocol changes through the years increased crew safety, restoration success, work efficiency, and nursery growing capacity, while minimizing risks of non-native species introduction. These changes often required a lengthy planning and permitting process. Coordination between work crews on and off-island and collaboration between CIES, CINP, MSRP staff, and other entities were necessary for the success of the program.

II.III Field Crew Logistics

Field crews usually worked on SBI eight days at a time, typically using CINP transportation to and from the island. When boat transportation was not available, transportation took place via helicopters (Aspen Helicopters, Inc.). On some occasions, CINP concession boats (Island Packers) and research boats (NOAA) were also used. Field crews were housed in CINP residences on SBI.

II.IV Water Delivery to SBI

The lack of permanent sources of freshwater on SBI (Fellers and Drost 1991) and the remote location of the island (61 km from the mainland) contributed to the challenges of restoration. Between 2007 and 2013, water was delivered to the island via CINP boats on transportation days, most often in 400-gallon stainless steel containers (liquitote®). The CINP vessel *Ocean Ranger* would usually deliver four of these containers at a time (1,600-gallons per delivery).

These containers were craned from the boat to the dock. Water was pumped into the main water storage system on SBI, and then empty containers were craned back onto the boats. Starting in 2012, the CINP landing craft *Surf Ranger* was also used to deliver water to the island in a more efficient way. Water was pumped directly to the island from four 3,000-gallon containers on the landing craft. A maximum of 12,000 gallons of water could be delivered at a time using this method. The amount of available water storage on SBI increased from ~10,000 gallons in 2007 to ~24,000 gallons by the end of 2014.

II.V Desalination Unit

Efforts have been made to obtain a permit to install a desalination unit on SBI. In the long-term, a desalination unit on the island would be more cost-efficient than water deliveries by boat. A desalination unit would also help mitigate the project's impact in terms of fossil fuel emissions and water use from the mainland. It would be safer for island and boat staff because it would eliminate the need to crane 3500 lbs. water containers on and off of moving boats, which would eliminate the potential for mishaps.

II.VI Restoration Plot Selection

Although habitat restoration efforts are needed over most of the island, location of nesting seabirds, crew safety, native vegetation status, and overall geographic constraints dictated the location of restoration plots. Specifically, the following criteria were used to evaluate potential restoration plots:

<u>Positive selection criteria for plot location:</u>

1. Proximity to known SCMU or CAAU nesting,
2. Suitable soil horizon for CAAU burrow excavation,
3. Mostly northern to eastern aspect,
4. Gentle slopes,
5. Safely accessible by foot,
6. Ability to transfer water to a given site, and

7. Lack of native shrub cover.

Negative selection criteria for plot location:

1. Proximity to known nesting areas by seabirds such as: California Brown Pelican (*Pelecanus occidentalis*), Brandt's Cormorant (*Phalacrocorax penicillatus*), Double-crested Cormorant (*P. auritus*), Pelagic Cormorant (*P. pelagicus*), and Western Gull (*Larus occidentalis*),
2. Southwestern aspect,
3. Steep slopes,
4. Good natural shrub cover and good recruitment of native plant species,
5. CINP survey areas (including long-term vegetation monitoring, and long-term monitoring of seabird species, Santa Barbara Deer Mouse [*Peromyscus maniculatus elusus*], and Island Night Lizard [*Xantusia riversiana*]), and
6. Presence of archeological artifacts.

Sites meeting all of these criteria were considered for restoration. Since 2007, six restoration plots have been implemented on SBI (Figure 3):

1- Beacon Hill (BHP),
2- Elephant Seal Cove (ESC),
3- House (HP),
4- Landing Cove (LACO),
5- Nature Trail (NTP), and
6- North East Flats (NEF).

The location and pre-restoration conditions of these plots are described below.

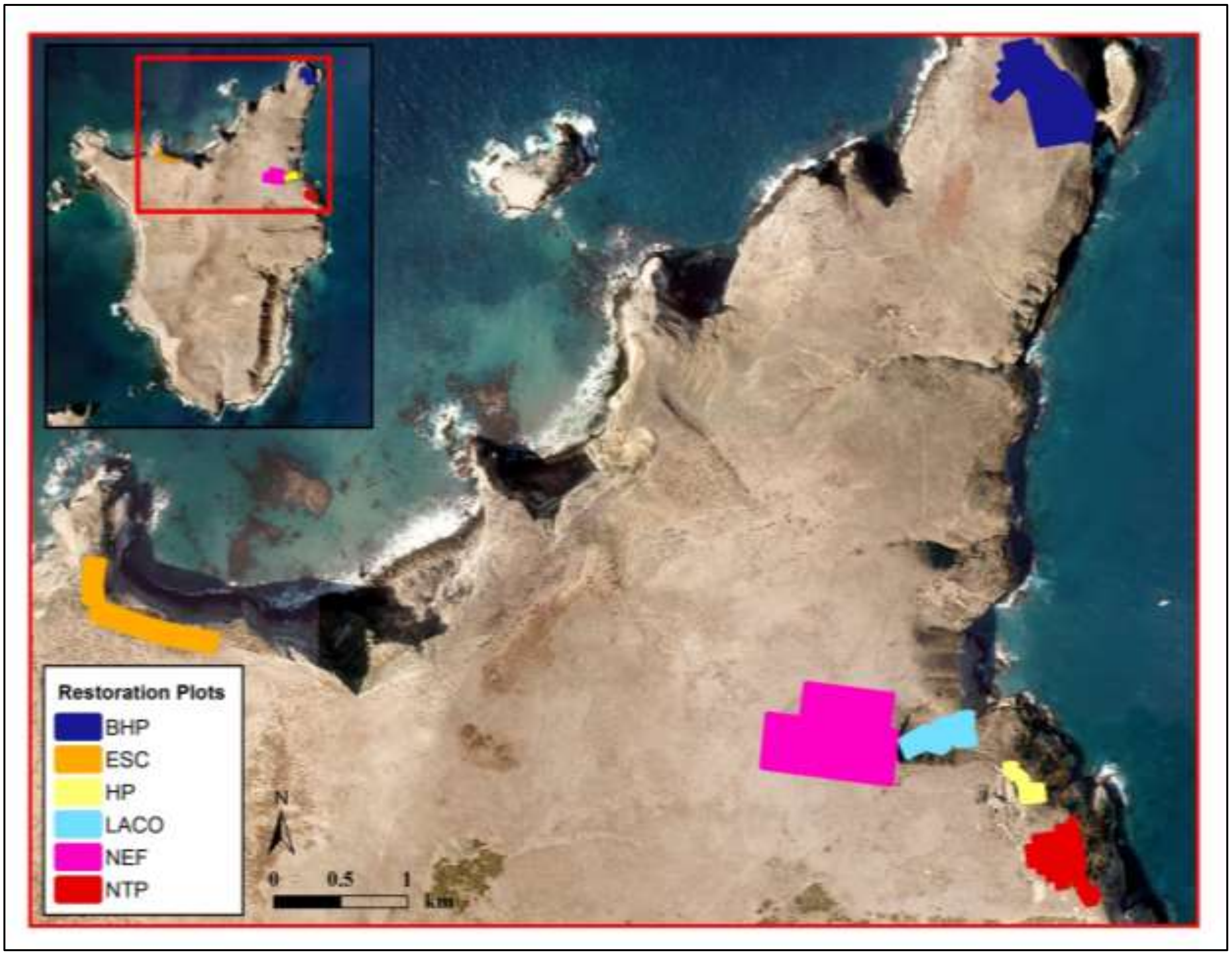

Figure 3: Location of restoration plots on SBI.
The six restoration plots are located on the northernmost half of the island.

II.VI.I Beacon Hill Restoration Plot (BHP)

Beacon Hill Restoration Plot (BHP) was selected to restore SCMU and CAAU habitat due to its proximity to nesting birds. It is located between Arch Point and the light beacon on SBI. It is characterized by a gentle slope with a northern to easterly aspect. The plot is predominantly surrounded by non-native plants, including Crystalline Iceplant (*Mesembryanthemum crystallinum*), Slender-leaved Iceplant (*M. nodiflorum*), non-native grasses, patches of bare ground, and bare rocks. A small patch of Cholla (*Cylindropuntia prolifera*) is the only native perennial plant in the vicinity. Prior to restoration, BHP was predominantly covered by bare ground and rocks, non-native grasses, and Crystalline Iceplant. Native perennial plants were not present in the plot pre-restoration, except for a small patch of California Saltbush (*Extriplex californica*).

II.VI.II Elephant Seal Cove Restoration Plot (ESC)

Elephant Seal Cove Restoration Plot (ESC) is located on cliffs overlooking Elephant Seal Cove, on the northern side of the island. It is characterized by rocky moderate slopes with a northern to easterly aspect. This site was identified as potential nesting habitat for both SCMU and CAAU due to its proximity to a remnant CAAU colony and because it had many rocky crevices with high potential for SCMU and CAAU nesting. Healthy patches of native Woolly Seablite (*Suaeda taxifolia*) and SBI Buckwheat (*Eriogonum giganteum var. compactum*) are found on the plateau above ESC and large patches of native California Saltbush and Chilicothe (*Marah macrocarpa*) were found on the steep slopes below ESC. ESC proper was initially covered in non-native Crystalline Iceplant and grasses, interspersed with bare patches and sparse non-native Australian Saltbush and Goosefoot (*Chenopodium murale*). Very little native perennials were present prior to restoration, except for small patches of perennial Woolly Seablite and Yarrow (*Achillea millefolium*).

II.VI.III House Restoration Plot (HP)

The House Restoration Plot (HP), formerly known as “Prohibition Point”, was chosen for its potential as a SCMU nesting site because of its proximity to nesting murrelets. It was also chosen for its ease of access and for its aesthetic and educational value due to its location next to the visitor center. HP is located between the Ranger Station to the west and cliffs to the east. It is characterized by gentle to moderate slopes with an easterly aspect. The area surrounding the plot consist of a matrix of non-native grasses with patches of native Giant Tickseed (*Leptosyne gigantea*) and Prickly-pear (*Opuntia spp.*) and patches of non-native Australian Saltbush and Crystalline and Slender-leaf Iceplant. Prior to restoration, most of the ground in HP proper was bare or covered with non-native grasses, with minor components of non-native Australian Saltbush, Goosefoot, and Iceplant and minor components of native Giant Tickseed, Woolly Seablite, Yarrow, and Nevin's Woolly Sunflower (*Constancea nevinii*).

II.VI.IV Landing Cove Restoration Plot (LACO)

Landing Cove Restoration Plot (LACO) was identified as potential nesting habitat for both SCMU and CAAU due to its proximity to nesting murrelets and rocky crevices and because it had deep soils. LACO is located in Landing Cove between the upper reaches of Landing Cove Canyon and the ocean. LACO is characterized by gentle to medium slopes with a northeasterly aspect. It was surrounded by a matrix of Iceplant and non-native grasses, with healthy patches of the following native species: Island Tarplant (*Deinandra clementina*), Giant Tickseed, SBI Buckwheat, Yarrow, Prickly-pear, Cholla, Island Morning-Glory (*Calystegia macrostegia* ssp. *amplissima*), and California Box-thorn (*Lycium californicum*). The area chosen for restoration was highly degraded, predominantly covered in non-native grasses with minor components of non-native Goosefoot, Australian Saltbush, and Crystalline Iceplant, and minor components of native Chilicothe, Island Tarplant, Giant Tickseed, Yarrow, Woolly Seablite, and Island Morning-Glory.

II.VI.V Nature Trail Restoration Plot (NTP)

Nature Trail Restoration Plot (NTP), formerly known as "Campground Plot", was identified as a potential site for restoring SCMU and CAAU nesting habitat due to its deep soils and proximity to nesting SCMU. NTP is located along the bluffs next to the eastern-most part of the Nature Trail and extends into the campground. NTP was also chosen for restoration because of its ease of access and for its aesthetic and educational value due to its location. It is characterized by gentle to moderate slopes with an easterly aspect. The area south, east, and north of NTP is dominated by native communities of Giant Tickseed, California Box-thorn, Woolly Seablite, Island Tarplant, Prickly-pear, SBI Buckwheat, and Cholla. These native communities are found within a matrix of bare ground, rocks, and non-native grasses, with isolated patches of Iceplant. The area chosen for restoration was highly degraded, predominantly covered in non-native grasses, with minor components of bare ground, rocks, non-native Australian Saltbush, Cheeseweed (*Malva parviflora*), and native perennials (Giant Tickseed, SBI Buckwheat, Woolly Seablite, California Box-thorn, and Cholla).

II.VI.VI Northeast Flats Restoration Plot (NEF)

Northeast Flats Restoration Plot (NEF), formerly known as "North Peak" (NPK), was identified for CAAU nesting habitat restoration due to its deep soils. It was also selected to create a continuum of native plant communities between Landing Cove and North Peak to allow nesting

SCMU and CAAU to move westward from Landing Cove towards North Peak (NEF is located 20 m west of LACO). NEF is characterized by a gentle slope with an easterly aspect. It is flanked to the west by a large patch of Giant Tickseed within a matrix of non-native grasses and Crystalline Iceplant. Non-native grasses surround the plot to the north and south, with minor components of Crystalline Iceplant. Before restoration activities began, NEF was predominantly covered with non-native annual grasses. Big patches of non-native Iceplant had invaded the northern edge of the plot (in the gully at the head of Landing Cove Canyon). Minor components of non-native Australian Saltbush, native Giant Tickseed, and Island Morning-Glory were also present in the plot prior to restoration.

II.VII NATIVE PLANT PROPAGATION

The following sections describe all stages of plant propagation for the seabird nesting habitat restoration project on SBI, from seed collection to getting plants ready for outplanting. Descriptions of nursery facilities and pest prevention methods are also included. Please note that nursery facilities were built in areas vetted through the CINP internal project review process.

II.VII.I Nursery Facilities

In Spring 2007, a temporary nursery was built on SBI, south of housing (Figure 4). The nursery consisted of a shade-house (~ 5.5 x 6 m) and an unshaded grow-out area to "harden-off" plants before planting. The ground under these structures was leveled in April 2007, and then covered with black weed block fabric to reduce tripping hazards and prevent weed growth. The shade-house frame was built with a metal carport frame, and then covered with shade cloth; guy wires anchored the structure. Automatic drip irrigation and a water catchment system with gutters were installed to reduce water needs.

In Summer 2007, plants propagated from SBI seeds were grown on the mainland at NPS facilities and then moved to the temporary nursery on SBI. The plants were brought to the island via CINP boat, craned to the dock, and carried by foot to the nursery. In March 2008, the discovery of snails and earthworms in several nursery pots during an outplanting event led to the dismantling of the nursery. Since then, all seeds have been collected, stored, and propagated on island to minimize the risks of non-native species introduction to the island.

The temporary nursery was rebuilt in 2008. The watering system was changed to an irrigation system that misted plants. Both this watering system and water catchment system required constant maintenance and were later disassembled. In Summer 2009, a second shade-house was installed southeast of housing. When additional space was needed, plastic tables were used on the house porch. Live- traps (Sherman) were set at night and checked in the morning when mice-predation was noticed in the nursery.

Figure 4: Temporary shade-house.
Photo credit: Growing Solutions Restoration Education Institute (bottom).

On November 27, 2009, the upper shade-house collapsed due to very strong wind. After the destruction of this shade-house, it was decided a more structurally sound native plant propagation facility was needed to withstand the elements encountered on an offshore remote island (i.e., strong winds, salt, sun etc.). In Summer 2010, the construction of a more sturdier nursery began. All components of the nursery were custom-designed and fabricated by island staff to withstand many years in the harsh island environment. It took nearly a year to construct the nursery due to the difficulty of moving large amounts of soil by hand (no motorized vehicles were present on SBI), shipping materials to such a remote location (involving the use of boats and helicopters), and time constraints imposed by other restoration and monitoring activities.

The new nursery was built west of housing, on a leveled area cleared by hand by staff and volunteers (Figure 5). The soil was stabilized with retaining walls, terraces, and native shrubs. The nursery (13 X 6.5 m) consisted of a frame, tables on a raised deck, a subfloor, and shade-cloth. The frame was made with galvanized steel poles (41.3mm [1 5/8”] schedule 40) set in concrete footings to increase stability in high winds (Figure 6). Fittings used to construct the shade-house frame were manufactured by Kee Klamp Inc. Shade cloth rated at 40% shade was mounted to the poles surrounding the raised deck. The deck was made of pressure-treated lumber. On top of the deck, three tables running the length of the nursery were built with durable recycled plastic decking (fenceboards) and pressure-treated lumber. Below the raised deck, a sub-floor of sloped plastic sheeting directed rainwater and irrigation overflow into a water catchment tank (Figure 6).

Figure 5: Leveling the nursery.
The nursery site was leveled by hand, using shovels, rock picks, rock bars, and wheel-barrels.

Figure 6: Nursery construction details.
Concrete footings (top) and sub-floor (bottom).

An overhead misting system with automatic timers was later set up in the nursery, in case the island was left unattended for several days (Figure 7). The misting system was not used on a regular basis because the characteristics high winds on SBI tended to blow water away from plants.

Figure 7: Nursery.
Viewed from the outside (top) and from the inside (bottom).

In late 2012, a cuttings chamber was added to the shade-house (Figure 8). Constructed of pressure-treated lumber and clear plastic sheeting, it was 1.75 x 1 m (0.5 m tall) and could accommodate ~600 cuttings. Its purpose was to keep humidity high and temperatures warm with low levels of light, ideal conditions for propagating cuttings.

Figure 8: Cutting chamber.
The chamber was used to propagate cuttings.

The nursery could accommodate ~7,500 mature plants at peak production. Some of these plants were staged in three grow-out areas (Figure 9). One grow-out areas was located directly east of the nursery (56 m^2). The location of the two other grow-out areas corresponded to the location of the two temporary shade-houses, each covering 63 square meters[1]. Until summer 2014, the grow-out areas consisted of folding plastic tables set on somewhat leveled ground covered in ground fabric. In summer 2014, the grow-out areas were leveled more evenly and re-covered with ground fabric. The temporary folding plastic tables were then replaced with permanent wood tables. Elements of construction included pond liner and drain valves that were added to the tables to catch rainfall and to allow for flood irrigation of plants (Figure 10).

Figure 9: Nursery location.

The nursery was made of an enclosed shaded area and three open air grow-out areas.

[1]The temporary shade-house that had not collapsed under high winds was taken down between Spring 2010 and Fall 2012.

Figure 10: Improved grow-out tables.
Folding white tables were replaced by larger, more durable tables. Black pond liner can be seen on the four tables to the left. Pond liner and drain valves were added to the four tables on the right in 2015.

II.VII.II Native Plant Selection

Plants were predominantly propagated from seeds in a nursery setting, although species that did not germinate readily from seeds were propagated from cuttings. Plant species with known records of SCMU nesting were selected for propagation. These included: California Box-thorn, Island Tarplant, Prickly-pear, Sagebrush (*Artemisia californica* and *Artemisia nesiotica*), Giant Tickseed, Nevin's Woolly Sunflower, SBI Buckwheat, and Woolly Seablite (Murray et al. 1983, Harvey et al. 2013). Other native species were chosen to increase community diversity and provide soil stabilization necessary for CAAU burrows. These included: California Saltbush, California Goosefoot (*Chenopodium californicum*), Yarrow, Coyote Brush (*Baccharis pilularis*, unsuccessfully propagated until 2015), Island Morning-Glory, Sticky Sandspurrey (*Spergularia macrotheca*), and Needle Grass (*Stipa* spp.). All species propagated were perennials.

II.VII.III Seed Collection

All plants used for restoration were propagated from seeds or cuttings collected on SBI. Seeds and cuttings were collected by the seabird monitoring and habitat restoration crew and their volunteers, except those used for propagation in 2007, which were provided by NPS Restoration Ecologist Sarah Chaney (Figure 11). To mitigate the negative effects of seed collection on wild plant recruitment, seed collection was always limited to ≤10% of seeds per plant. Seeds were collected in small brown paper bags and the following information was recorded for each collection:

- Species code (unique four letter code given to each plant species on SBI),
- Date,
- Collector name,
- Collection location, and
- Number of individuals collected from.

Figure 11: Volunteer collecting SBI buckwheat seeds.

A unique identifying number was assigned to each bag and bags were then stored in plastic bins. Bags from the same species were stored into different bins. This insured that not all seeds for a species would be lost, should a bin be compromised by insects or mice predation, water damage, or mold.

Seed collections were then entered in an electronic database. The database was updated as seeds were used for propagation. Whenever feasible, qualitative germination success (great, good, average, poor) was entered in the database. The database ensured ease in finding seeds from the seed stock inventory and helped summarize seed collection information. A table identifying prime seeding months for all seeds propagated was prepared to guide collection efforts (Appendix I).

II.VII.IV Seed Propagation

Seed sowing was spread throughout spring and early summer to increase the diversity in potted plant age classes. This was important in the event of mass outbreaks of diseases, pests, or uncharacteristic weather events that would affect plant age classes differently. However, each species had its own requirements and did better when sowed at a specific time of year. Time of sowing was also dictated by the amount of time each species took to become big enough to survive outplanting, while minimizing the time spent in the nursery, and thus reducing watering and fertilizing needs and effort.

Species sowed early in the year were Giant Tickseed, Nevin's Woolly Sunflower and, Sagebrush. These species were susceptible to attack by Leaf Miners (*Melanagromyza splendida*), a stem-borer that can kill host plants (Figure 12). Greatest success was achieved by sowing these species early in spring, as this allowed plants to attain a larger size before Leaf Miners would infest them, which improved survival.

SBI Buckwheat was sown often due to its susceptibility to fungus. However, it germinated better when temperature increased, so more seeds were sowed in summer than in spring. Woolly Seablite also had higher germination rates in warmer temperatures. Yarrow was sown later in spring or early summer because it is fast growing and germinates easily year-round. Significant mortality induced by disease or pests were not observed in Woolly Seablite or Yarrow.

Seeds were typically sown between March and August in the shade-house. Between 2007 and 2010, seeds were sown in plastic seed flats. Starting in 2010, seeds were sown in custom wood seed flats (50 X 50 cm, 10 cm deep). Prior to sowing, newspaper was added to the bottom of wood flats to prevent soil from seeping through cracks. To reduce predation by birds, wood flats were covered with lids made of wood and screen mesh (0.64 cm (1/4”) hardware cloth; Figure 13).

Figure 12: Dying Giant Tickseed infested with leaf miners.

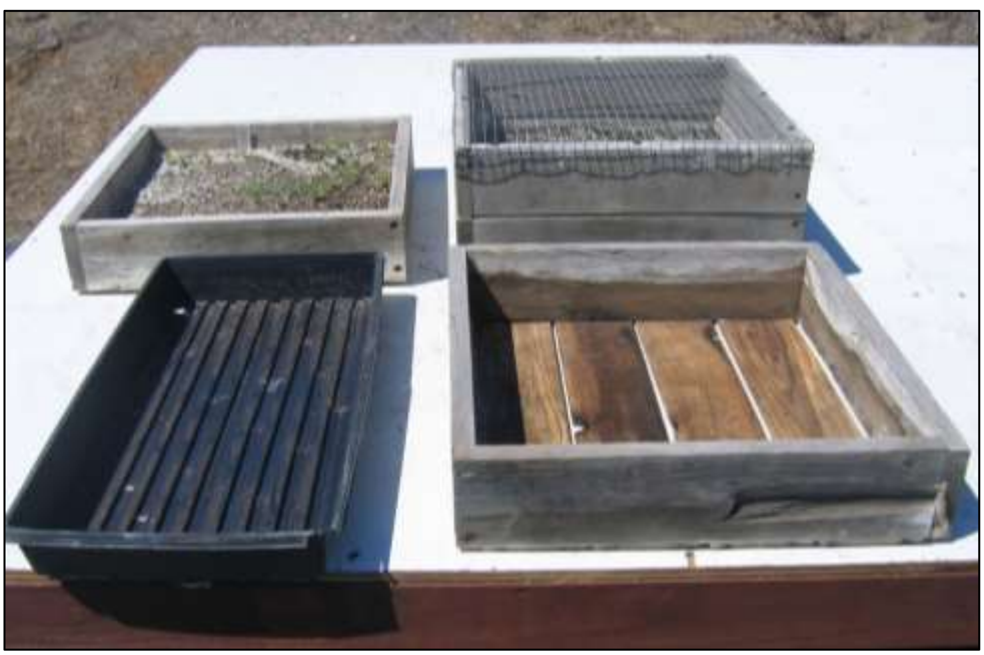
Figure 13: Seed flats.

Plastic flats (bottom left) were used between 2007 and 2010, while wood flats were used between 2010 and 2014. Bottom right: wood flat. Top left: wood flat after seed sowing. Top right: wood flat with bird-proof lid.

Except California Box-thorn, species selected for propagation did not require seed treatment to germinate, other than frequent watering. As for California Box-thorn, literature recommended no seed treatment before sowing. However, very little germination was achieved with simply sowing seeds. On SBI, three methods allowed higher germination rates than simply sowing seeds without treatment. The first method involved simulating the conditions of seeds being eaten by animals. Seeds were blended lightly in vinegar to scarify seed coats and simulate chewing/ gizzard action. The vinegar simulated stomach acid and acted to wear down the seed coat, allowing water in and causing germination. The vinegar and seed mix was left for 1-2 days in the fridge before sowing. The second method involved a 24-hour cold water soak in the fridge. Seeds were then sowed during cooler temperatures. The third successful propagation method involved propagating seeds from bird regurgitate found on the ground. These three methods produced staggered germination, with seedlings coming up months after initial germination. Therefore, transplanting seedlings when ready, but not overly disturbing seed flats allowed the remaining seeds to germinate.

Once seedlings were big enough, they were transplanted from seed flats to root trainers or bigger pots, depending on their root mass. Once plants had been transplanted in pots ≥ 8.9cm by 8.9 cm for at least two weeks, they were moved to the grow-out areas. All plants in the nursery were watered as needed, either by hand or with automatic sprinklers (refer to “Nursery Facilities” for more information). Pots were fertilized with slow-release fertilizer (Osmocote brand 15-15-15 or similar), according to manufacturer’s direction. When plants were small, emerging flowers were cut to reduce the amount of energy spent by a plant on reproductive parts.

II.VII.V Propagation by Cuttings

All plants were propagated from seeds, except Prickly-pear, California Box-thorn, and Coyote Brush, which were usually propagated from cuttings. To increase genetic diversity, cuttings were collected from as many locations as possible on SBI.

Prickly-pear pads were collected from wild individuals. Pads ≥ 15 cm long were severed from mother plants with small cuts, using a large knife and BBQ prongs. Pads were carried back to the nursery and then set to dry upside down on old wood pallets (≥ 2 weeks). Pads did not need treatment prior to outplanting.

It took several years to determine the best way to propagate California Box-thorn and Coyote Brush from cuttings on SBI, due to the lack of available information. After trial and error, the following procedure yielded the best results. Although cuttings were successfully propagated year-round, propagation success increased when cuttings were taken in spring, before mature California Box-thorn shrubs began to leaf-out from dormancy or new growth occurred on Coyote Brush. Shrubs with relatively straight branches ≥ 0.5 cm in diameter were selected. Sharp pruning shears were used to cut branches, while taking care to leave > 90 % of all branches on a shrub. Back at the nursery, branches were cut into ~10 cm-long pieces and all side branches were removed. The ends of the branches that were closer to the root of the original shrub were dipped into liquid rooting concentrate ("dip-n-grow"), according to the manufacturer's instructions for woody plants. Cuttings were then placed into plastic trays with ~ 4 cm of well-watered sterile perlite (Figure 14). The cuttings were placed upright in the trays, with the dipped ends securely surrounded by perlite but not touching the plastic tray. Cuttings were spaced about 0.5-1 cm apart. This distance was close enough to maximize the number of cuttings that could fit in a tray, but far enough to avoid future growth from different cuttings touching each other. This distance also kept humidity high among cuttings. Trays were then placed in the cutting chamber and misted 1-5 times per day (or often enough to avoid the perlite from completely drying, but infrequently enough to avoid the perlite from being completely soaked at all times). When new growth and roots appeared (3-5 weeks), cuttings were transplanted into normal potting soil.

Figure 14: Cuttings.
Cuttings were propagated in ~ 4 cm of well-watered sterile perlite.

II.VII.VI Pest Prevention

Since the beginning of the project, efforts have been made to minimize the risks of introducing non-native species to the island. In Summer 2007, prior to moving plants from the mainland nursery to the SBI nursery, all plants were inspected for non-native invertebrates and preventatively treated with pesticides according to NPS Integrated Pest Management protocols. However, later that summer, slugs were found in nursery pots on SBI. To prevent the spread of this non-native species to the rest of the island, a new slug treatment was used. No other invertebrates were found before outplanting.

While outplanting the first batch of plants in March 2008, snails and earthworms were discovered in several nursery pots. NPS ecologists and Santa Barbara Natural History Museum curator E. Hochberg confirmed that no earthworm species were native to SBI. Outplanting efforts immediately ceased and the remaining plant stock was returned to the mainland and the SBI nursery was disassembled. A thorough survey of the house, nursery area, and outplanting plots, in conjunction with an island-wide survey of invertebrate species were conducted to determine if restoration efforts had inadvertently introduced non-native invertebrates to SBI. The island-wide study of invertebrates replicated the sampling stations used in Hochberg's Natural History Survey on SBI in 1978 and 1979. The results of these surveys were all negative for the target non-native species.

Starting in 2008, all seeds were collected, stored, and propagated on island to minimize the risks of non-native species introduction. The only nursery materials that came from the mainland were brand new, never-used nursery pots, trays, fertilizer, construction material, chlorinated water, and bagged sterile potting soil, delivered to the NPS boat yard the day before transportation and sent out to the island the next day (barring weather delays). To our knowledge, native plant restoration on SBI did not cause further introduction of non-native species.

Several nursery pests were documented on SBI, although experts believe they were likely already present on the island prior to 2007. Starting in Fall 2010, three plant species in the nursery (Giant Tickseed, Nevin's Woolly Sunflower, and Sagebrush) suffered damaged from Leaf Miner, a subtropical insect found in California. Leaf Miner larvae are stem-borers (Spencer 1981) that can kill host plants. The larvae turn into pale yellowish pupae within the plant. Trials applying Spinosad pesticide (Conserve® SC for insects or Captain Jack's DEADBUG Brew® Spinosad) on a weekly basis slightly reduced leaf miner outbreaks. Giant Tickseed suffered the most damage. Caging plants with insect-proof fabric did not help control infestations. Greatest success avoiding Leaf Miner damage was achieved by sowing susceptible species early on as this allowed plants to attain a larger size before outbreaks which, in turn, increased the survival rates of infested plants. One theory was that the Leaf Miners moved into the nursery after wild plants on SBI had gone dormant.

In 2011, which was a relatively wet year, fungus killed 90% of the SBI Buckwheat in the nursery. Specimens were sent for identification to Heather Scheck PhD, plant pathologist from the Agricultural Commissioner's Office in Santa Barbara County. *Rhizoctonia* sp. was detected in culture from roots and lower stems. *Rhizoctonia* is an aggressive common soil-borne pathogen that can cause pre-and post-emergence damping off, a disease that kills or weakens seedlings before or after they emerge. The same fungus also covered wild buckwheat all over the island. Trials applying *Bacillus thuringiensis* (Bt) (BT Worm Killer by GreenLight) and Safer Brand Garden Fungicide on a weekly basis did not control the outbreaks. The most effective way to control the fungus in the nursery was to keep the foliage dry. Therefore, potted plants were watered from below by placing them on aluminum baking trays filled with water. When plants were thoroughly saturated, they were removed from the baking trays to allow excess water to drain out (Figure 15). When plants grew together too densely, excess leaves were trimmed to increase airflow and decrease local humidity.

In 2011, a chenopod-specific rust fungus was seen on Wooly Seablite (identified by S. Chaney). The fungus formed orange spots on leaves and stems. Safer Brand Garden Fungicide was applied and preventative measures were taken to reduce moisture on leaves. No plants seemed to have died from the fungus, so fungicide use was ended.

Figure 15: Watering SBI buckwheat.
To prevent fungus growth, we watered SBI Buckwheat from below by placing potted plants on aluminum baking trays filled with water.

II.VIII OUTPLANTINGS

The following sections describe activities that took place before, during, and after outplantings on SBI.

II.VIII.I Plot Preparation/ Pre-restoration Surveys

In 2010-2014, plots were divided into square subplots with unique identifying labels[2]. The corners of each subplot were marked with wooden stakes. Geographical coordinates and pre-restoration surveys were then taken for each subplot. Pre-restoration surveys estimated the cover of native and non-native plant species, as well as the cover of bare ground, man-made objects, rocks, and thatch (dead vegetation). Species presence/absence surveys were also taken some years, but were discontinued because the data they provided could be obtained from the cover survey data. Photographs taken from permanently established points called “photopoints” were

[2] Prior to 2010, restoration plots were not consistently divided into subplots and pre-restoration surveys were not always rigorously or consistently conducted. Therefore, statistical analyses of restoration results may not always be possible.

also taken to evaluate vegetation changes through the years. Photopoints were taken for every subplot ("subplot photopoints") and "overview photopoints" were established to capture overall changes within each plot. Appendices II and III describe the protocols for plot preparation and percent cover surveys, while appendix IV describes the protocol for overview photopoints.

Planting plans were designed a month before outplanting. For each subplot, the number of individuals (by species) to be outplanted was determined. This number depended on the quantity and size of plants available in the nursery[3], as well as basic species requirements. For example, plants with deeper roots were planted in deeper soil. California Saltbush and Woolly Seablite tolerated salty soils well (Halvorson et al. 1988, M.E. Jacques, personal observations), so they were often planted in soils previously occupied by thick carpets of Iceplant. In contrast, SBI Buckwheat and Nevin's Woolly Sunflower were not planted in subplots dominated by Iceplant because they exhibited a low tolerance for salty soils (M.E. Jacques, personal observations). Because of their tolerance for drier conditions, cacti were planted on slopes with a southerly aspect (M.E. Jacques, personal observations). Between 2007 and 2009, plants were put in the ground in a stratified random manner. Starting in fall 2010, plants were outplanted in patches, in an effort to recreate the patchy nature of plant communities on SBI. This patchy design reduced the risk of weed-whacking outplanted plants and decreased watering time. In 2013, we also started to plant subplots more densely. Denser outplantings reduced weeding needs quicker due to more rapid establishment of native vegetation. Once natives were established, they were better at controlling invasive species with minimal human intervention. It became much more time efficient to restore smaller areas with higher densities of natives than to spread the same amount of plants over larger areas.

Before outplanting, plots were weeded of non-native species. Weeds were either pulled by hand, detached with a hoe, or with a weed-whacker. Efforts were made to weed species before they went to seed to reduce the non-native seed bank. If new invasive species were found in fruit, plants were bagged before being disposed.

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[3] Only plants with well-developed roots were used for outplanting, from 8.9 X 8.9 cm (3.5X3.5") to 3.8 litter (1gallon) pots.

The future location of each plant was marked with flags color-coded by species (Figure 16) and holes were dug with an auger or a shovel (Figure 17). Heavy gear, plants, and water were then moved to restoration plots. This was either done by helicopter (BHP, ESC, and NEF[4]) or by foot (HP, LACO, NTP, and NEF[5]), depending on the location of each plot.

Figure 16: Flagging prior to outplanting (Fall 2012).
The placement of each plant to be outplanted was marked with a flag. Each species is represented by a different flag color.

Figure 17: Hole digging prior to outplanting (Fall 2012).
Boots, gloves, ear, and eye protection were worn while operating the auger.

[4] 2011, 2012, and 2014 ouplantings
[5] 2007 and 2010 outplantings

II.VIII.II Outplanting Events

The first day of each outplanting event, experienced personnel trained volunteers on how to properly put plants in the ground, as follows. First, a plant was carefully removed from its pot by gently squeezing and tapping the pot, but never by pulling on the plant's leaves, branches, or stems. Second, the plant's roots were slightly disturbed to minimize constriction risks. Third, the plant was put in the center of a hole and the hole was filled with native soil to cover the roots but not the stem. The plant was positioned slightly lower than ground level (~10 cm) and a berm (strip of soil surrounding the plant) was created to allow water to collect and saturate equally around roots (Figure 18). Finally, the plant was watered. All plants were outplanted in this manner, except Prickly-pear.

Figure 18: Plants with berms.
Berms collect water during raining events and while watering.

Prickly-pear pads were outplanted in shallow trenches with their cut side down. For stability, pads were then covered to about a third of their height with packed soil (

Figure 19). If plots appeared susceptible to erosion, erosion control fabric and fiber rolls were installed with staples and stakes (Figure 20). Holes were cut through the fabric for native plants.

Figure 19: Outplanted Prickly-pear pads.
Top: freshly outplanted pad, bottom: prickly pear 5.5 years after outplanting (without watering).

Figure 20: Erosion control at ESC.

Erosion control fabric was laid down to protect the plot from erosion. When necessary, fiber rolls were also added. Photo credit: Growing Solutions Restoration Education Institute (top).

II.IV Maintenance Activities

After plants were put in the ground, restoration plots were typically watered every two to three weeks and berms were maintained as needed. Plants were not watered if the soil surrounding them was moist or, for plants that were not on drip irrigation, if they were dormant (i.e., Giant Tickseed and Yarrow during the dry season). Plants were typically watered up to two years following outplanting[6]. After a couple of years, plant roots were usually well-developed and supplemental watering was no longer necessary. Cacti were never watered after planting.

Restoration plots were weeded at a minimum every spring and fall and as time permitted the rest of the year. Weeds were either pulled by hand, detached with a hoe, weed-whacked, or were sprayed with herbicide. Efforts were made to weed species before they went to seed to reduce the non-native seed bank. If new invasive species were found in fruit, plants were bagged before being disposed. Except for Iceplant and plant matter containing seeds, pulled weeds were usually left on site as mulch. Iceplant was carried outside restoration plots and left to dry in tall mounds in areas predominantly covered by more Iceplant. Because drying Iceplant can alter soil chemistry by releasing large amounts of salt accumulated in the plant's tissues (Vivrette and Muller 1977, Adams et al. 1998), removing Iceplant material from the plots prevented more salt from leaching into restoration plots.

II.V Watering Systems

Several improvements to the watering systems were made through the years and will be described below, plot by plot. These improvements reduced the time and costs necessary to deliver water to restoration plots. Plants were watered by hand with backpack sprayers, watering cans, or garden hoses, or watered with drip irrigation (starting in 2014). Hoses and drip irrigation lines were attached to water spigots around housing, to 189-litter (50-gallon) water barrels, or to 500-gallon water tanks staged above the plots (Figure 21). The first water barrels were made of

[6] Exception: outplantings in the original 2007 subplots at NEF were not watered from January to July 2009 or in 2010.

metal, but rusted quickly, so they were replaced with plastic barrels in 2010. Water tanks were made of plastic.

Figure 21: Water tanks at BHP.
Water tanks held about 500 gallons of water.

Watering outplantings using water barrels was first attempted at ESC. In an effort to refill barrels with rain and fog water, two water catchment systems were created in Winter 2009-2010. The first system consisted of an individual catchment area for each barrel, comprised of round plastic discs (208 litter [55 gallon] drum covers, W. W. Grainger, Inc.) funneling water to barrels through PVC pipes (Figure 22). Mesh wire covered the catchment areas to prevent wildlife from entering barrels. A second water catchment system was constructed in January 2010. This system consisted of a drip net and a tarp. However, both systems were unsuccessful at harvesting water due to adverse weather conditions and seabird interactions, and were disassembled in 2010. In February 2010, barrels were refilled with water using nine 507-litter (134-gallon) water bladders carried by helicopter. For subsequent water deliveries to ESC, empty water barrels were either carried back to housing with a backpack frame or via helicopter, and either refilled at housing or on the mainland. They were then flown back to ESC via helicopter.

Figure 22: Failed water catchment system at ESC.

HP and LACO were hand-watered with hoses attached to water spigots close to housing. Gravity allowed water to flow to the plots without the need for a pump. At NTP, plants were first watered by hand with hoses attached to water spigots close to housing. Drip irrigation was then installed in 2014 to water the 2013 and 2014 outplantings (Figure 23).

At NEF, plants were first watered with backpack sprayers refilled with water from housing. This was very time consuming and physically demanding as approximately six gallons of water could be carried in a sprayer, totaling ~25 kg (55lbs) per water delivery; about a dozen plants could be watered before the sprayer needed to be refilled. In Winter 2010-2011, several water barrels were added west of NEF to remove the need to carry water uphill from housing. However, the amount of water required was under-estimated and the barrels were drained before the outplanting was finished. Once again, water was carried from housing to the plot with backpack sprayers. Starting in Summer 2011, old fire-fighting hoses, fittings, and a water pump were used to refill water barrels with water pumped from housing. Although this greatly reduced the time and cost needed to water NEF, the hoses often leaked. In 2013, water barrels were replaced by two 500-gallon water tanks and a sturdy water pipeline was built, from housing to NEF. The updating of the water delivery system was finished in Winter 2013-2014. The tanks could then be refilled with water from housing through the pipe system at ~ 91 litter (24 gallon)/minute, using a water pump. Drip irrigation was installed in Fall 2014 to water 2014 outplantings. This water delivery method proved effective.

Figure 23: Drip irrigation at NTP.

Water barrels flown by helicopters were used at BHP until 2013. Starting in Summer 2013, water barrels were replaced by three 2461-litter (650-gallon) tanks plus one 2082-litter (550-gallon) tank, and a sturdy water pipeline connected to the NEF tanks was built. The updating of the water delivery system and drip irrigation at BHP was finished in December 2013, totaling over 9450 litters (2,500 gallons) of storage for this plot.

II.VI Volunteer Involvement

Outplanting and weeding events involving hundreds of volunteers were organized throughout the duration of the project. Volunteers from various backgrounds planted native species and manually removed non-native species in restoration plots. Organizing and supervising volunteering events proved time consuming and involved extra hours of logistical planning, but provided the community with hands-on outreach opportunities and educational experiences of incalculable value. By assisting with outplanting, watering, and weeding, volunteers greatly reduced the staff's field workload. An average of 63 volunteers have helped yearly on the seabird restoration and monitoring program at CINP between 2011 and 2014, with a yearly average close to 3000 volunteering hours (Table 1; volunteer hours not available prior to 2011). The project collaborated with Growing Solutions Education Institute and Prescott College whom helped organize volunteer trips for college students. We recommend continuing the involvement of volunteers in future outplanting and weeding events to reduce staff's workload and to provide outreach opportunities to the general public.

Year	Number of Hours Volunteered	Number of Volunteers Involved
2011	3058	88
2012	2364	38
2013	3234	63
2014	3210	62

Table 1: Volunteering effort on the seabird restoration and monitoring program at CINP.

II.VII RESTORATION MONITORING

Restoration plots were typically surveyed during winter or spring (growing season) and fall (dry season) to monitor annual and perennial vegetation cover. Surveys were usually taken before significant weeding efforts took place. Survey methods were the same as noted for pre-restoration vegetation surveys, with cover determined for native and non-native plants, as well as for bare ground, man-made objects, rocks, and thatch (dead vegetation).

Two other types of survey (tag and survivorship surveys) were also sporadically taken. Tag surveys consisted of recording how many tagged plants survived by species and measuring their growth. Some tags were made of aluminum wrapped cardboard while others were made of 0.635mm (0.025") thick aluminum. These tags were stapled into the soil near each plant. Tag surveys were abandoned in Fall 2010, due to the difficulty in re-locating tags.

Survivorship surveys were not done consistently due to improper field crew training. Surveys taken before Fall 2010 were a count of the number of outplanted plants that were alive or dead in each subplot, while surveys taken in Fall 2010 were a count of all native perennial plants in each subplot (wild and outplanted). The survey was then abandoned for a few years. However, recording the survival rates of outplanted plants was important to assess restoration success and to compare the success of different restoration techniques. Therefore, in Fall 2014, we counted the number of outplanted plants that were alive in each subplot for the survivorship survey. Refer to Appendix V for the current protocol for survivorship surveys and refer to Appendix VI for a list of surveys taken between 2007 and 2014 in each restoration plot.

II.VIII Data Storage and Manipulation

A database manager was assigned to the project in 2014, with the primary responsibilities to create a restoration database and determine ways to ensure data quality (other responsibilities of the manager are listed in Appendix VII). The database "SBI_RestorationDatabase" was created in Microsoft Access 2010 and contains all the restoration data, with the exception of photopoints. Missing data are indicated by empty cells in the database. Table 2 summarizes the Access objects within the database and the following sections describe data manipulation for this report.

Access Objects (Tables)	Description
%Cover_RestorationPlots	Cover data for restoration plots.
NativeGeneraRichness_RestorationPlots	Native genera richness data for restoration plots.
PlantTags_RestorationPlots	Data on the survival and growth of tagged plants within restoration plots, taken between 2007 and 2010.
PostplantingCounts_RestorationPlots	Data related to the number of plants per species outplanted within each restoration plot.
PostplantingCounts_Landscaping	Data related to the number of plants per species outplanted outside restoration plots.
RestorationPlots_Area	Size of each restoration plot expansion, by year.
Seeding_RestorationPlots	Data related to seeds broadcasted within restoration plots.
Survivorship_RestorationPlots	Survivorship data for plants outplanted in restoration plots.

Table 2: Access objects within the SBI restoration database.

II. VIII.I Outplantings

All available data on the number of plants outplanted on SBI between 2007 and 2014 are included in the results section of this report. However, the location of outplantings, the species outplanted, and the number of plants outplanted was not always recorded. Therefore, data on outplantings represent a minimum amount of plants put in the ground by species at each recorded location. Unknown species or locations are indicated by “ND” (no data). Subplots are grouped by year of first outplanting.

II. VIII.II Percent Cover Surveys

Percent cover for subplots of irregular shape (i.e., not rectangular) are neither included in this report nor in the database. We calculated the cover of native annuals and perennials by adding the cover of native annual and perennial species, respectively. Data for each restoration plot are presented separately and corrected for differences in subplot sizes, where applicable[7]. To make data comparable from year to year, subplots are divided by year of first outplanting and percent covers are averaged for each growing or dry season. Standard error is provided for each average.

II. VIII.III Native Genera Richness

Native genera richness was defined as the average number of genera per subplot. Richness was obtained by recording the presence of genera within subplots based on cover data. Because a few native species were not identified to species during percent cover surveys, we computed richness at the genus level. Data are presented separately for each restoration plot. For the purpose of this data report, richness was grouped by subplots of the same size to eliminate the need to correct for differences in sampling size (Melo et al. 2003). Richness is averaged by season (dry or growing season). We chose to only present data from subplots that had available pre-restoration conditions. Standard error is provided for each average.

II. VIII.IV Survival

Survival data were obtained from the tag and survivorship surveys described in the “Restoration Monitoring” section. Data are presented separately for each restoration plot. Tag data were

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[7] This was only necessary for LACO January 2011 Expansion Subplots and LACO November 2011 Expansion Subplots.

summarized by species and plant condition (alive, dead, tag not found). Data from survivorship surveys were also summarized by species.

II. VIII.V Growth

Height and width of outplanted plants were obtained during tag surveys. Only data from tagged plants that were relocated and alive during all surveys are included in this report, but all available data are included in the database. Data for Giant Tickseed and Common Yarrow are not presented in this report due to inconsistencies in measurement methods. Data are presented separately for each restoration plot. Only species with a sample size >5 are presented. Standard error is provided for each average.

III. DATA SUMMARIES

III.I PRECIPITATION

Figure 24 shows yearly precipitation on SBI against the 20 year average. Except for 2010, all years have been below the 20-year precipitation average of 21.7 cm on SBI.

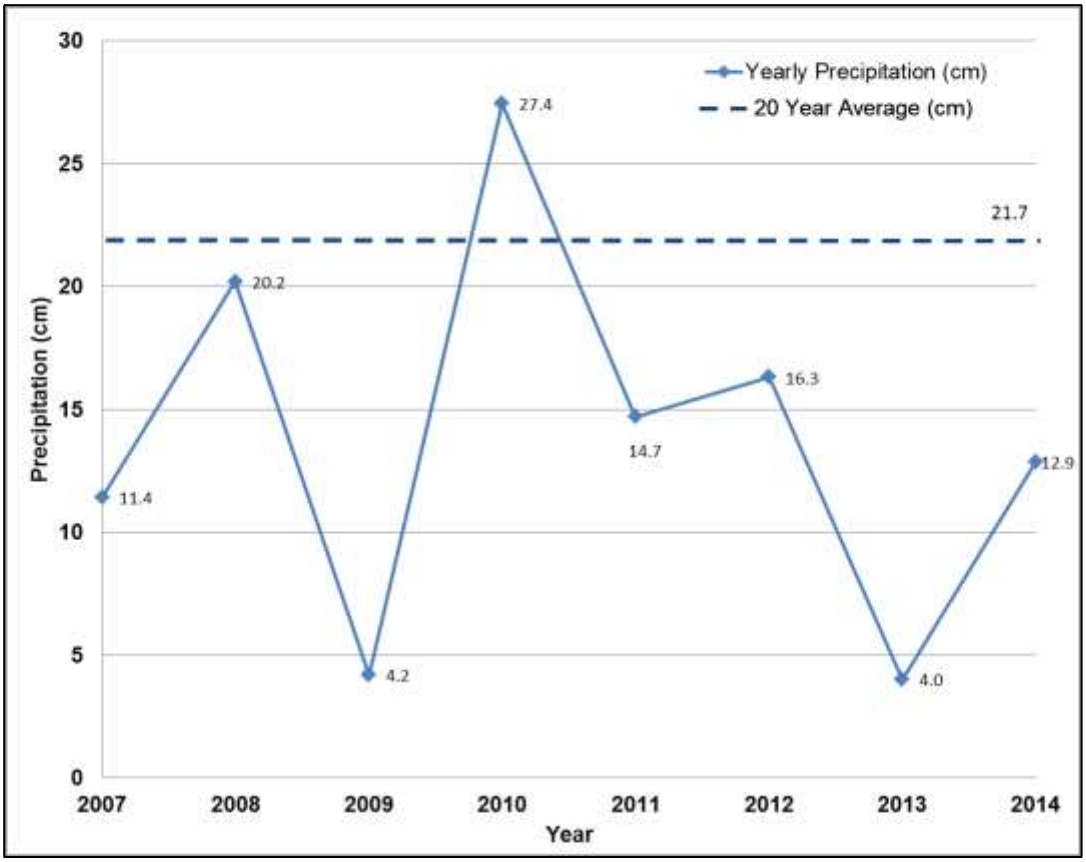

Figure 24: Yearly precipitation on SBI.
Data credits: Western Regional Climate Center and NPS; compiled by Handley et al. 2013 and M.E. Jacques.

III.II RESTORATION PLOTS

III.II.I Beacon Hill Restoration Plot (BHP)

Outplantings

BHP was first was established in November 2011 (3,000 m^2; 0.74 ac), and expanded in November 2012 (2,500 m^2; 0.62 ac) and December 2013 (2,250 m^2; 0.56 ac). As of the end of 2014, BHP covered a total of 7,750 m^2 (1.92 ac). The site was sub-divided into 70 subplots of

100 m^2 (0.02 ac), plus an irregular band of 750 m^2 (0.19 ac - Figure 25). A total of 6,029 plants were outplanted at BHP between 2011 and 2014: 1,173 plants in November 2011 (in the 2011 subplots), 1,813 plants in November 2012 (in the 2011 and 2012 subplots), and 3,043 plants in December 2013 (in the 2012 and 2013 subplots).

The original 2011 subplots at BHP were always watered by hand. The 2012 expansion subplots were watered by hand during the first year of restoration, then with drip irrigation during the second and third year of restoration. As for the 2013 expansion subplots, they were always watered with drip irrigation.

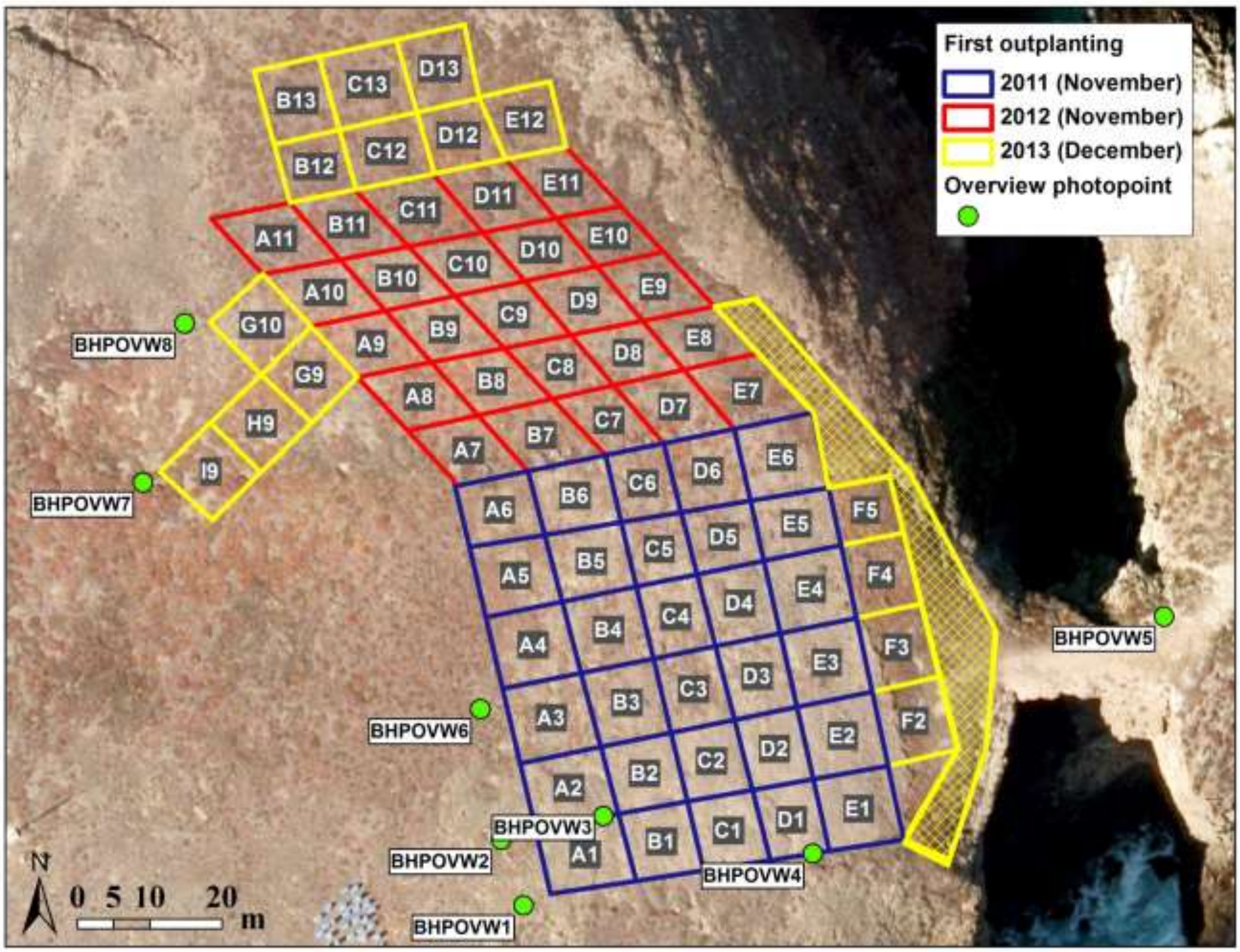

Figure 25: Map of BHP.

The initial plot location is indicated in blue (November 2011) and further expansions in red (November 2012) and yellow (December 2013). Each subplot was given a unique identifying label. Cross- hatched sections were not surveyed, but were maintained.

Cover Surveys

BHP Original 2011 Subplots: n = 30

Before restoration began at BHP, the original 2011 subplots did not have perennial native plants and were predominantly covered by thatch (Figure 26). Following restoration efforts, thatch was gradually replaced by bare ground and native perennial cover increased from 0% during the 2011 dry season to 4.2 ±0.5% during the 2012 dry season, and then decreased around 3% during the 2013 and 2014 dry seasons. The cover of native perennials increased to 7.9±0.8% during the 2012-2013 growing season, and then decreased to 4.1±0.6% during the 2013-2014 growing season. Non-native cover decreased from 39.3±4.4% during the 2012-2013 growing season to 26.6±4.1% during the 2013-2014. Figure 27 and Figure 28 show BHP before and after the onset of restoration.

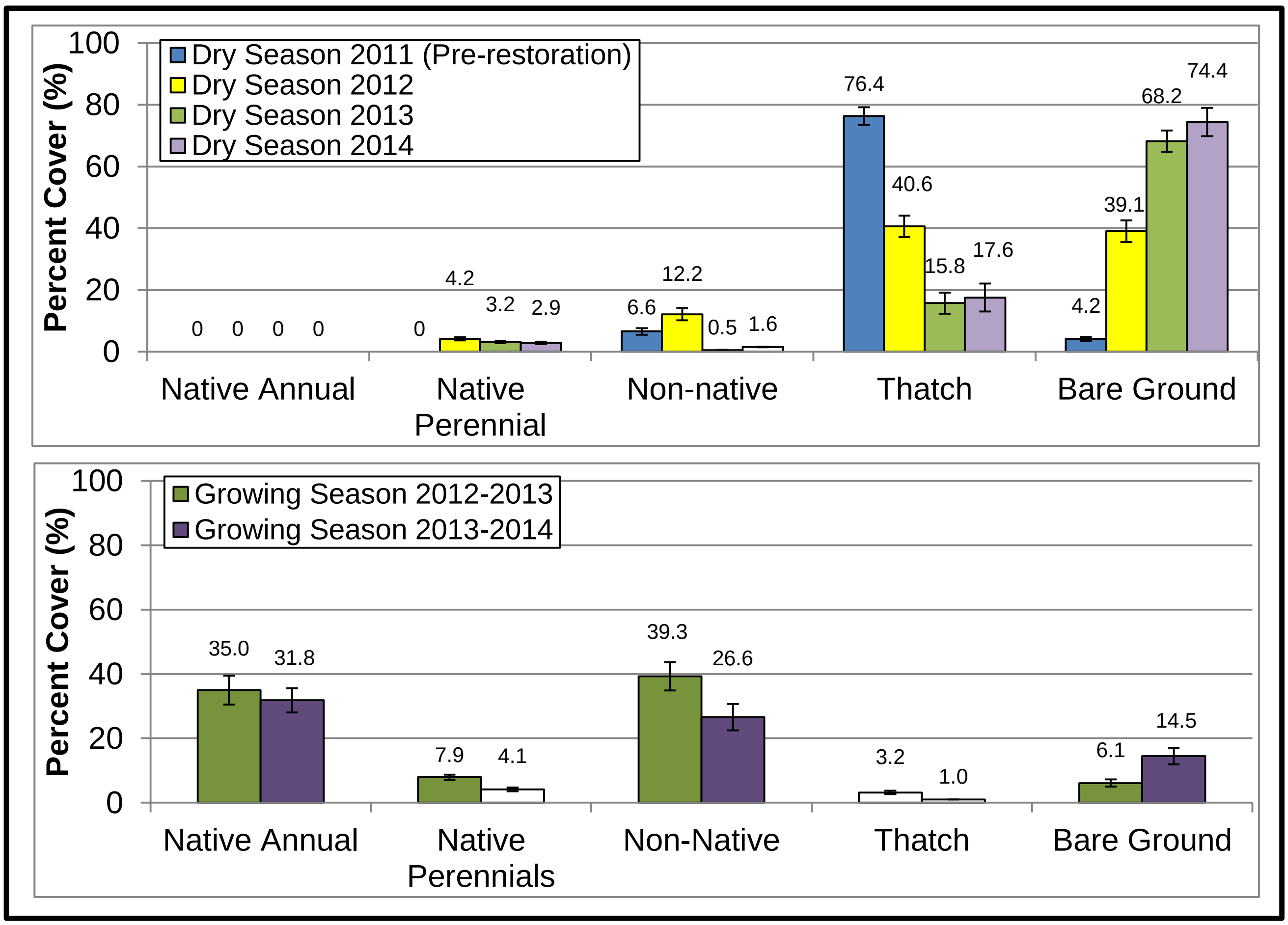

Figure 26: Changes in cover in the original 2011 subplots at BHP.
Top: dry season. Bottom: growing season. Data comes from 30 subplots, 10 X 10 m each. Thin bars represent standard error.

Figure 27: Overview photopoint of the original 2011 subplots at BHP.

Top: October 2011 (pre-restoration). Bottom left: November 2014. Bottom right: January 2015. Note the reduction in Iceplant and thatch, the increase in bare ground, and the appearance of Nevin's Wooly Sunflower and Wooly Seablite in the restoration plot. Yellow flowers are native annuals [Fiddleneck (*Amsinckia* spp.) and Goldfields (*Lasthenia* spp.)].

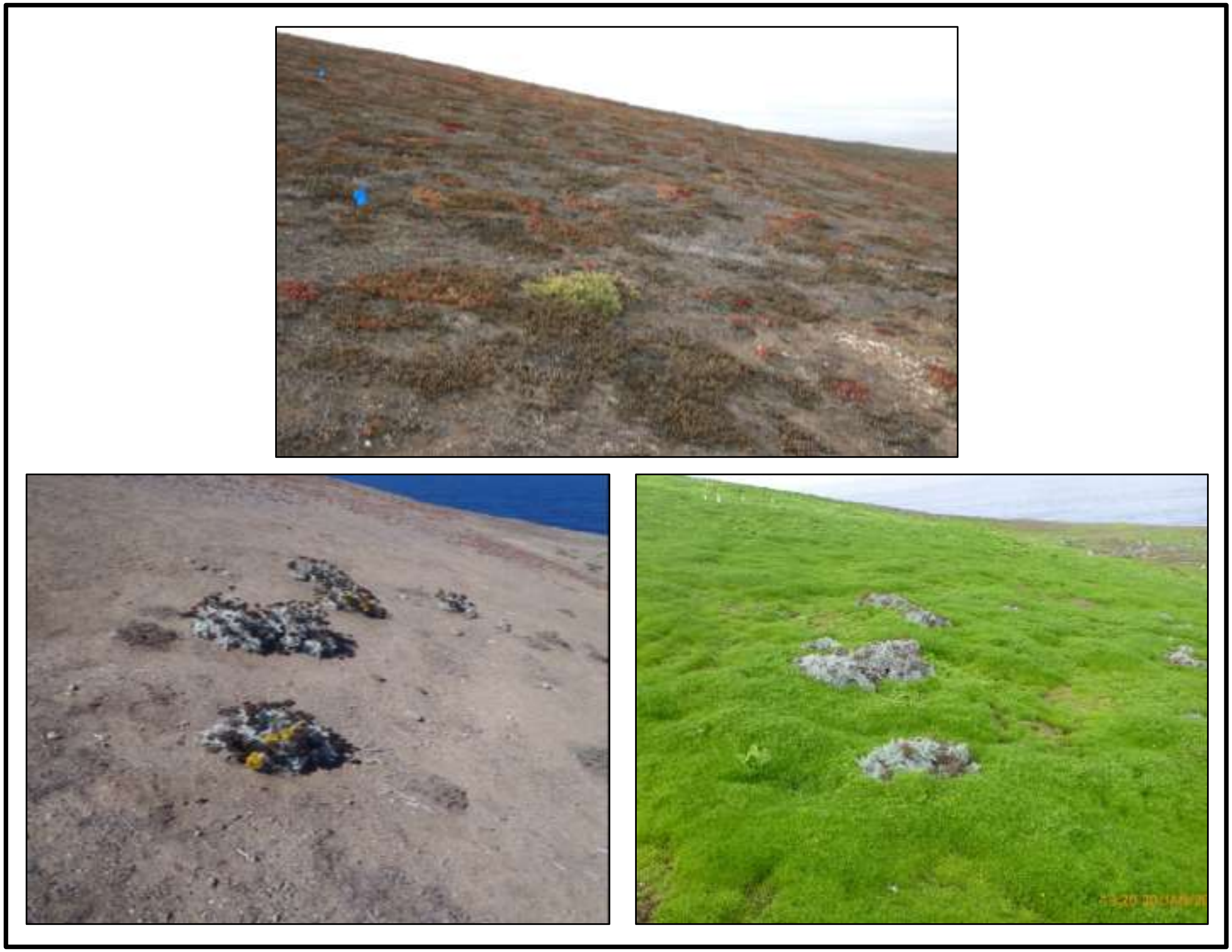

Figure 28: Photopoint for subplot A5 at BHP.

Top: October 2011 (pre-restoration). Bottom left: September 2014. Bottom right: January 2015. Note the reduction in Iceplant, thatch, and Australian Saltbush, the increase in bare ground (dry season), the appearance of Nevin’s Wooly Sunflower, and the abundance of Goldfields during the growing season 2015 (97% cover).

BHP 2012 Expansion Subplots: n = 25

Expansion in these subplots increased native perennial cover and bare ground year-round, and decreased non-native cover during the growing season (Figure 29). Figure 30 shows pictures of a typical 2012 expansion subplot pre-restoration (2012) and two to three years after the onset of restoration (2014-2015).

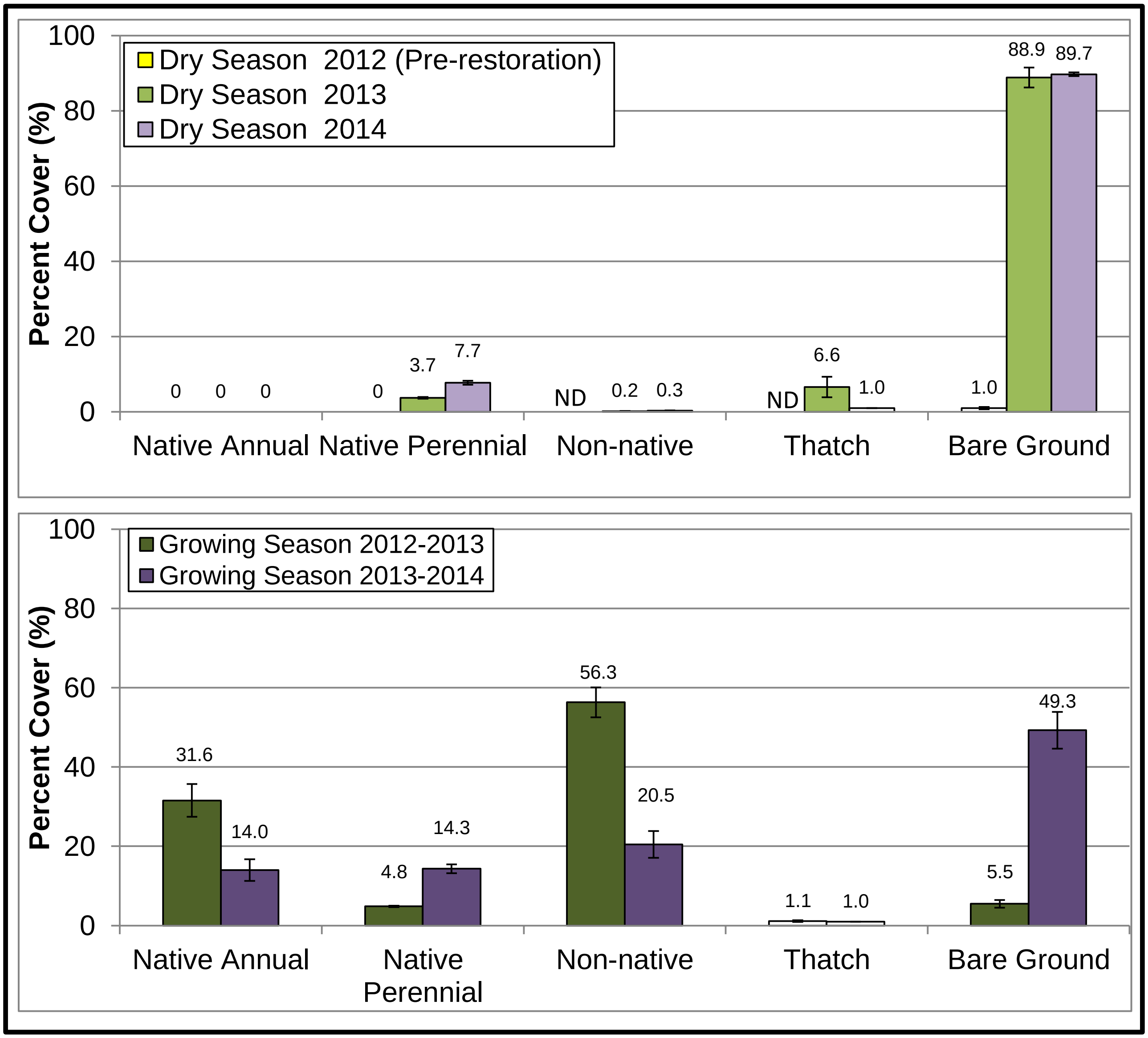

Figure 29: Changes in cover in the 2012 expansion subplots at BHP.

Top: dry season. Bottom: growing season. Data comes from 30 subplots, 10 X 10 m each. Thin bars represent standard error. Data not available for non-native species and thatch during the 2012 dry season.

Figure 30: Photopoint for subplot B10 at BHP.
Top: November 2012 (pre-restoration). Bottom left: September 2014. Bottom right: January 2015. Note the reduction in Iceplant and thatch, the increase in bare ground in September 2014, and the appearance of several native species. Live annuals in January 2015 are a mix of Iceplant and native species.

BHP 2013 Expansion Subplots: n = 15

During pre-restoration surveys (2013 dry season surveys), natives covered ~0.1% of the 2013 expansion subplots at BHP. Following restoration, the cover of native and bare ground increased while the cover of non-natives and thatch decreased substantially. During the 2013-2014 growing season, native plants covered 15.2±1.8% of the plot (12.6±1.4% were perennials), non-native plants 35.5±6.5%, thatch 1.0±0.0%, and bare ground 46.3±7.9% (Figure 31). Figure 32 and Figure 33 show pictures of the 2013 expansion subplots before and after restoration work began.

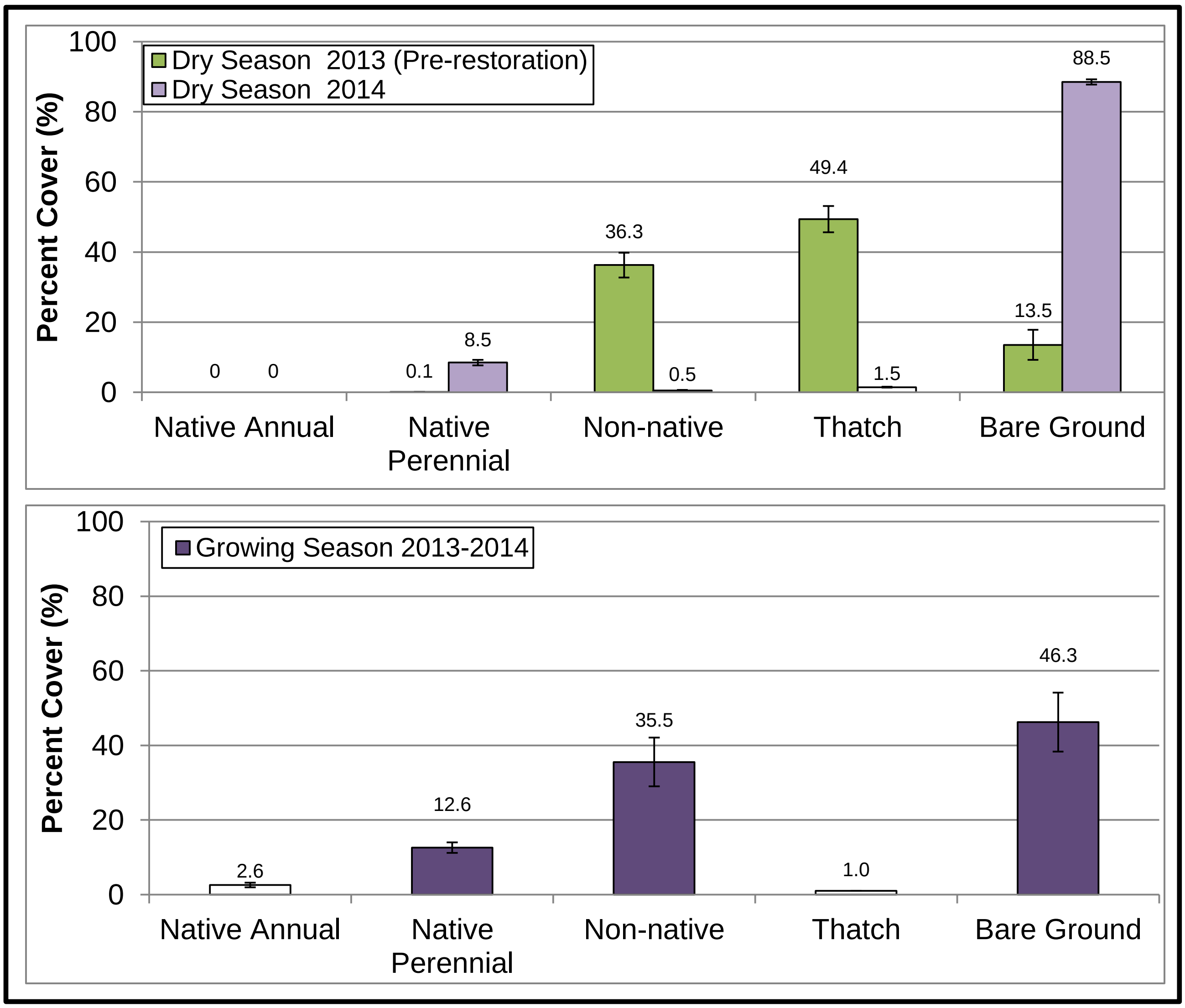

Figure 31: Changes in cover in the 2013 expansion subplots at BHP.
Top: dry season. Bottom: growing season. Data comes from 15 subplots, 10 X 10 m each. Thin bars represent standard error.

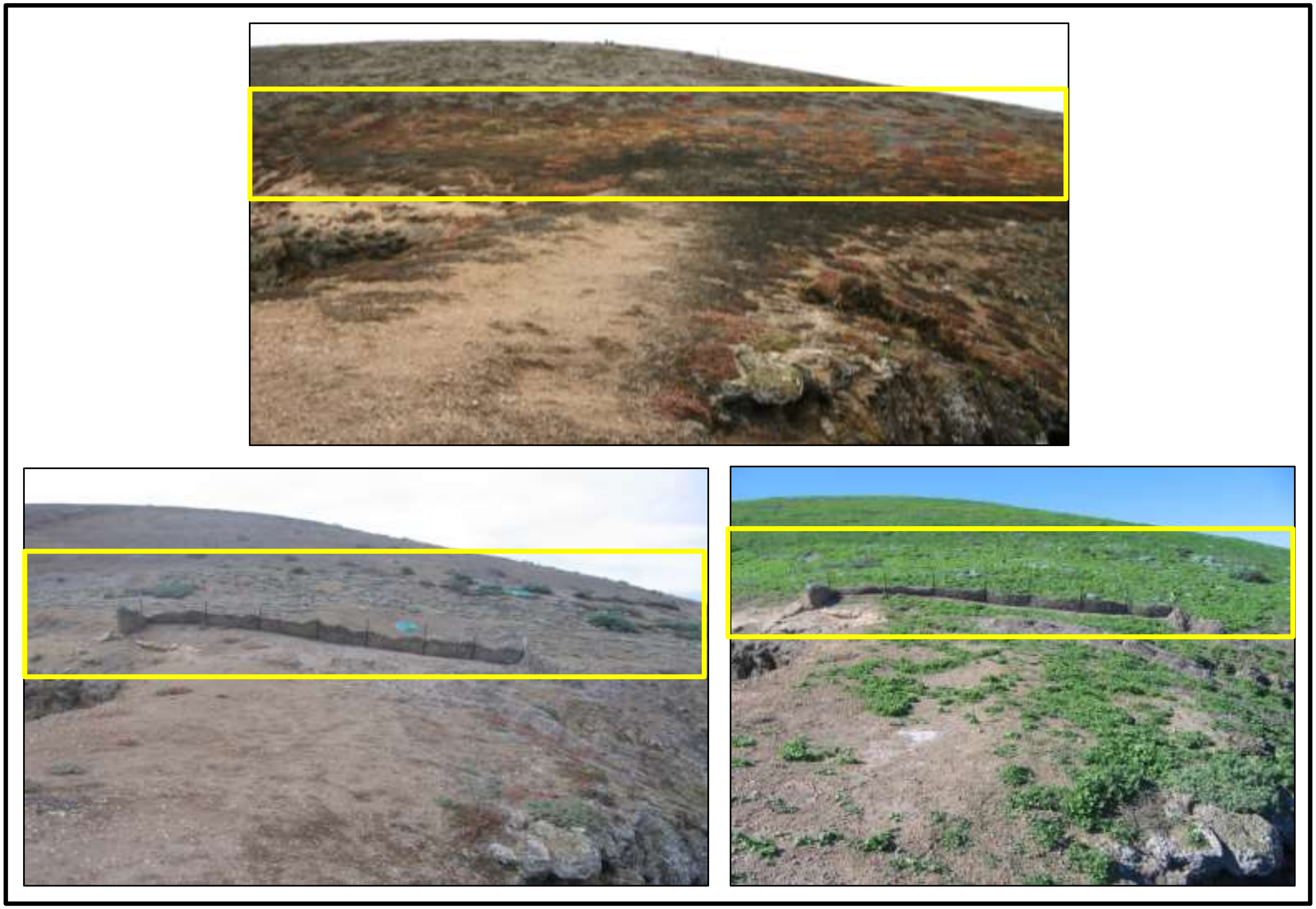

Figure 32: Overview photopoint of the 2013 expansion subplots at BHP.

Top: October 2011 (pre-restoration). Bottom left: November 2014. Bottom right: January 2015. The yellow boxes show the easternmost portion of the 2013 expansion subplots. Note the reduction in Iceplant, the increase in bare ground in November 2014, and the appearance of several native species in the restoration plot (2014 and 2015).

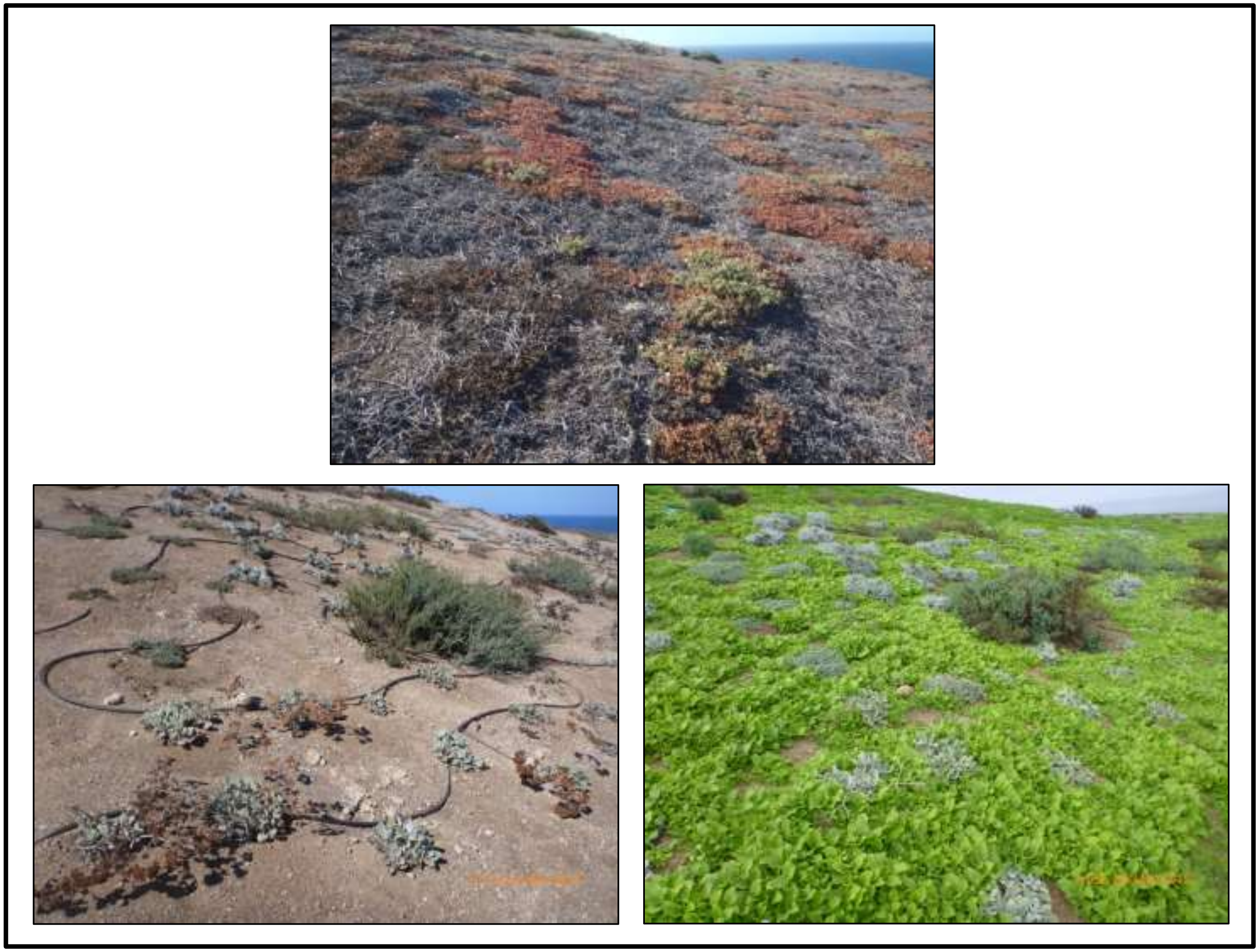

Figure 33: Photopoint for subplot F4 at BHP.

Top: September 2013 (pre-restoration). Bottom left: September 2014. Bottom right: January 2015. In September 2014, note the reduction in Iceplant and thatch and the increase in bare ground. More Iceplant seedlings emerged in January 2015.

Native Genera Richness

The dry season native genera richness averaged close to zero genera per subplot at BHP prior to the onset of restoration, but increased following restoration (Figure 34). The 2011, 2012, and 2013 dry season richness correspond to the pre-restoration richness at BHP in the original 2011 subplots, 2012 expansion subplots, and 2013 expansion subplots, respectively.

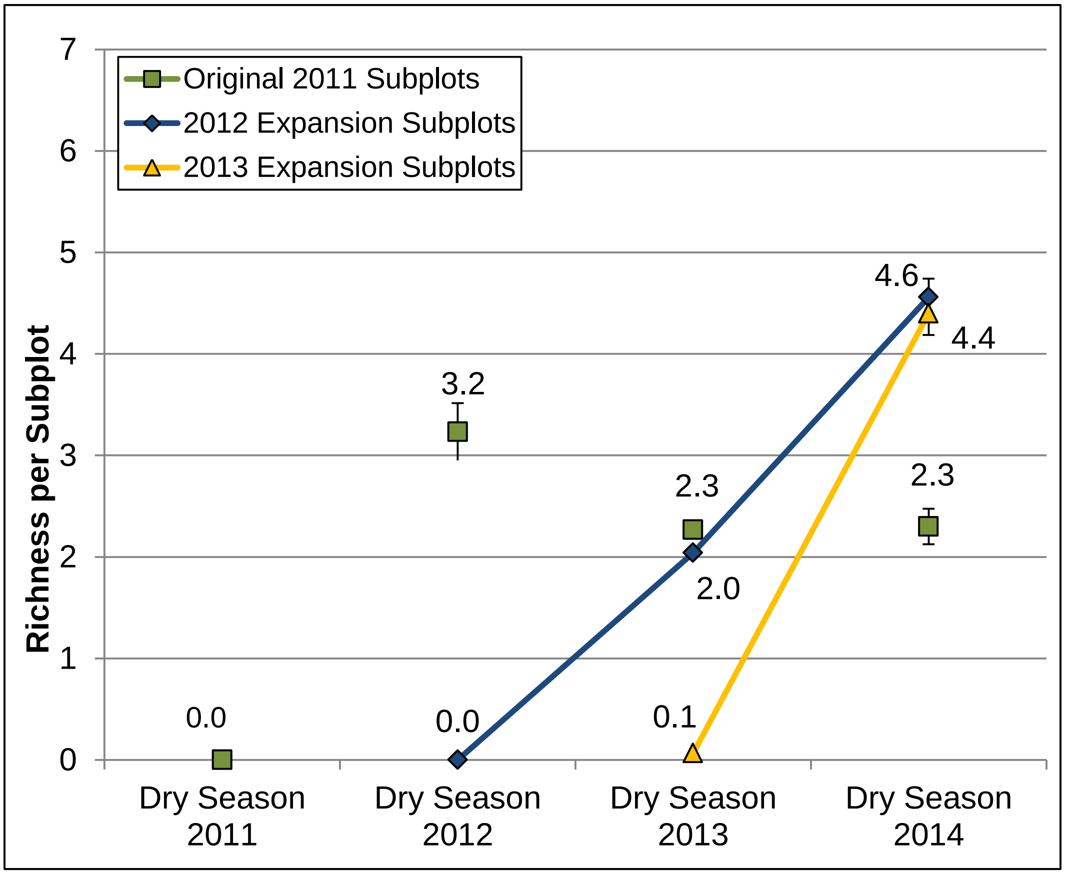

Figure 34: Native genera richness at BHP.
Thin bars represent standard error.

Survival

Survival rates were obtained for the 2013 expansion subplots at BHP. Plants were outplanted in December 2013 and survival data was taken at the end of the dry season in September 2014 (Table 3). All species exhibited a survival rate over 75%, except Giant Tickseed which had a survival rate just below 50%.

Species	# Outplanted in December 2013	# Alive in September 2014	Survival Rate (%)
ATCA	442	384	87
COGI	144	70	49
CONE	588	503	86
ERGC	629	497	79
SUTA	198	167	84
Total	2001	1621	81

Table 3: Survival rates at BHP between December 2013 and September 2014.

Growth

Species growth was not monitored at BHP.

III.II.II Elephant Seal Cove Restoration Plot (ESC)

Outplantings

The first outplanting at ESC happened between November and December 2008, when 944 plants were put in the ground within 2,000 m^2 (0.49 ac). In February 2009, 32 more plants were added. In September 2009, this area was divided into 20 subplots of 10X10 m. In November 2009, 1,195 more plants were added in these subplots and 592 in November 2010. The plot was expanded by another 2,000 m^2 (0.49 ac) divided into 20 new subplots in November 2010. In the November 2010 expansion, 978 plants were added in November 2010, and another 1,595 plants in November 2011. As of the end of 2014, 5,336 native perennial plants had been outplanted at ESC within a 4,000 m^2 (0.99 ac) area (Figure 35). Outplantings at ESC were always watered by hand.

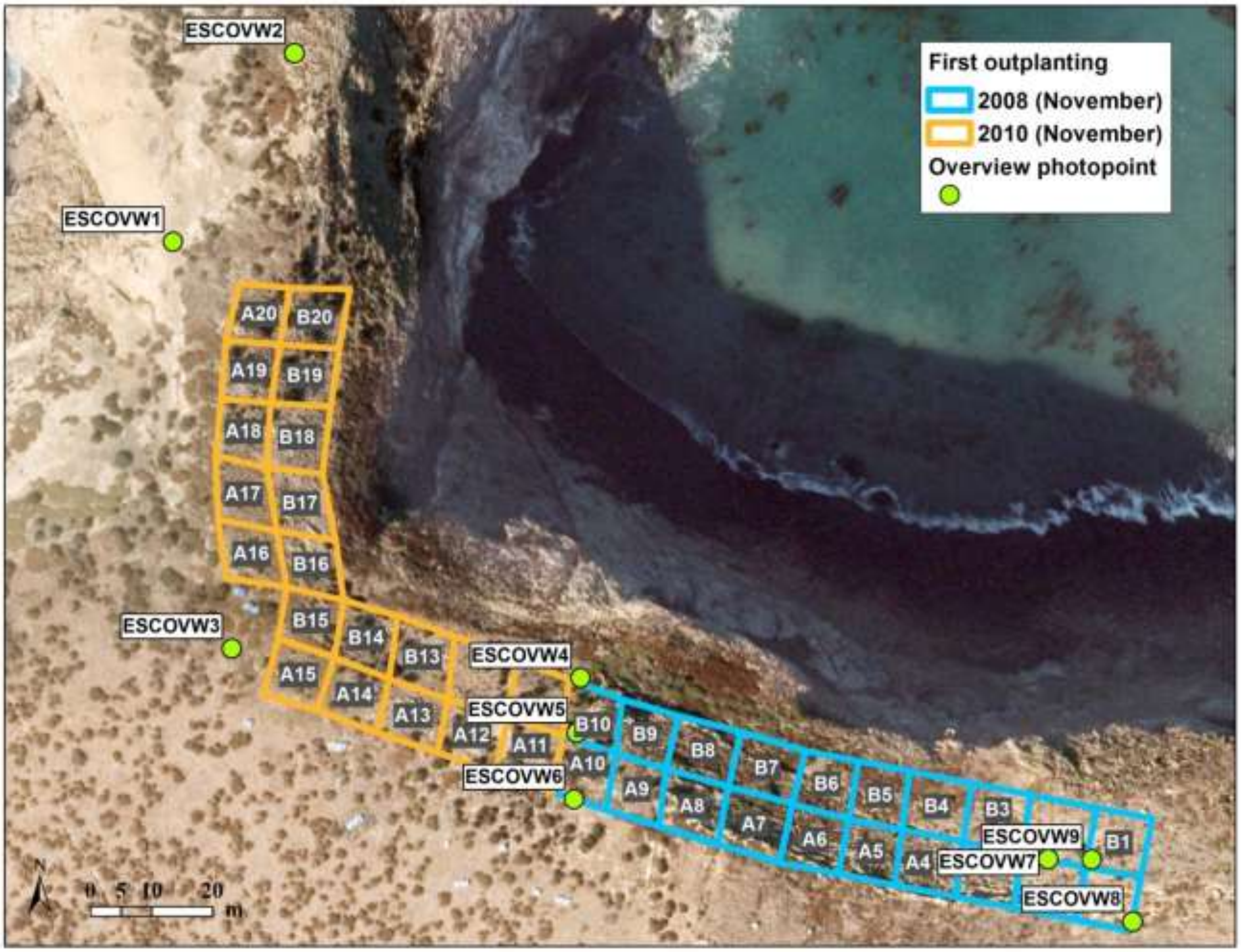

Figure 35: Map of ESC.
The initial plot location is indicated in pale blue (2008) and the 2010 expansion in orange. Each subplot was given a unique identifying label.

<u>Percentage Cover</u>

<u>ESC 2008 Original Subplots: n = 20</u>

At ESC, no thorough cover survey was done in the original 2008 subplots prior to the onset of restoration. However, during the dry season, the subplots were grossly estimated to contain between 75% and 100% of Crystalline Iceplant and the only native perennials seen were one Wooly Seablite and approximately five Yarrows.

The dry season surveys did not show obvious trends for the cover of natives and non-native since 2009, although natives have been decreasing during the growing season since 2010 (no data were taken during the 2011-2012 growing season). Thatch has been overall decreasing during the dry season since 2009 (with the exception of 2013), while bare ground has been increasing (Figure 36). Figure 37 and Figure 38 show pictures of the 2008 original subplots at ESC.

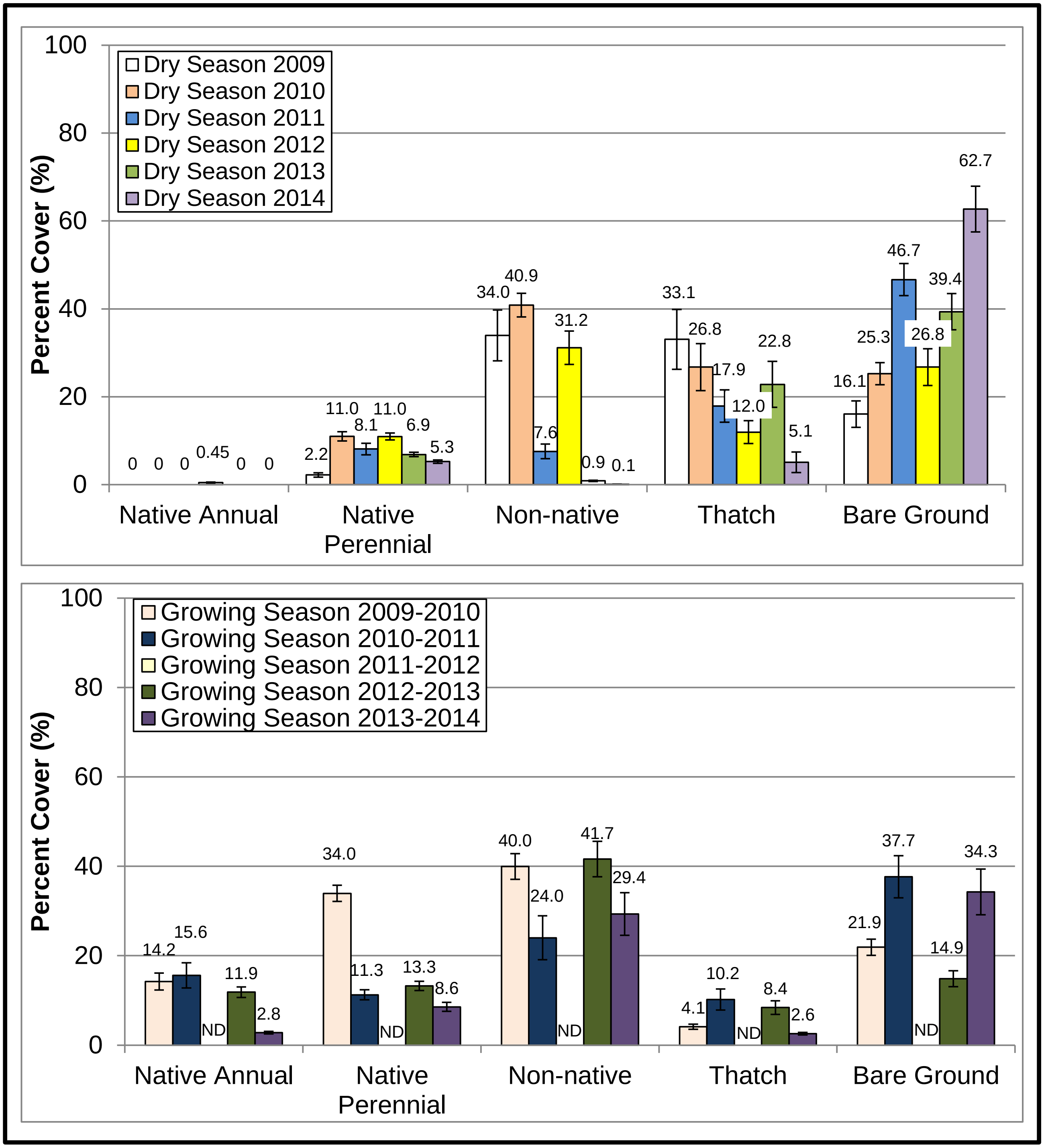

Figure 36: Changes in cover in the original 2008 subplots at ESC.
Top: dry season. Bottom: growing season. Data comes from 20 subplots, 10 X 10 m each. Thin bars represent standard error.

Figure 37: Overview photopoint of the original 2008 subplots at BHP.
Top: March 2009 (first growing season following the onset of restoration). Bottom: January 2015. Note the reduction in Iceplant and non-native grasses, the increase in bare ground, and the appearance of a few native plants.

Figure 38: Photopoint for subplot A6 at ESC.
Top: February 2010. Bottom left: September 2014. Bottom right: January 2015. Note the reduction in Iceplant, the increase in bare ground and the appearance of several native plants species.

ESC 2010 Expansion Subplots: n = 20

In the 2010 expansion subplots at ESC, the cover of native perennials increased between the 2010 and 2012 dry seasons, and then decreased between the 2012 and 2014 dry seasons. Since 2010, non-natives and thatch have been decreasing during the dry season while bare ground has been increasing, but non-natives have been increasing during the growing season (Figure 39). Figure 40 shows pictures of the 2010 expansion subplots taken pre-restoration (2010 dry season) and four years following the onset of restoration (2014 dry season).

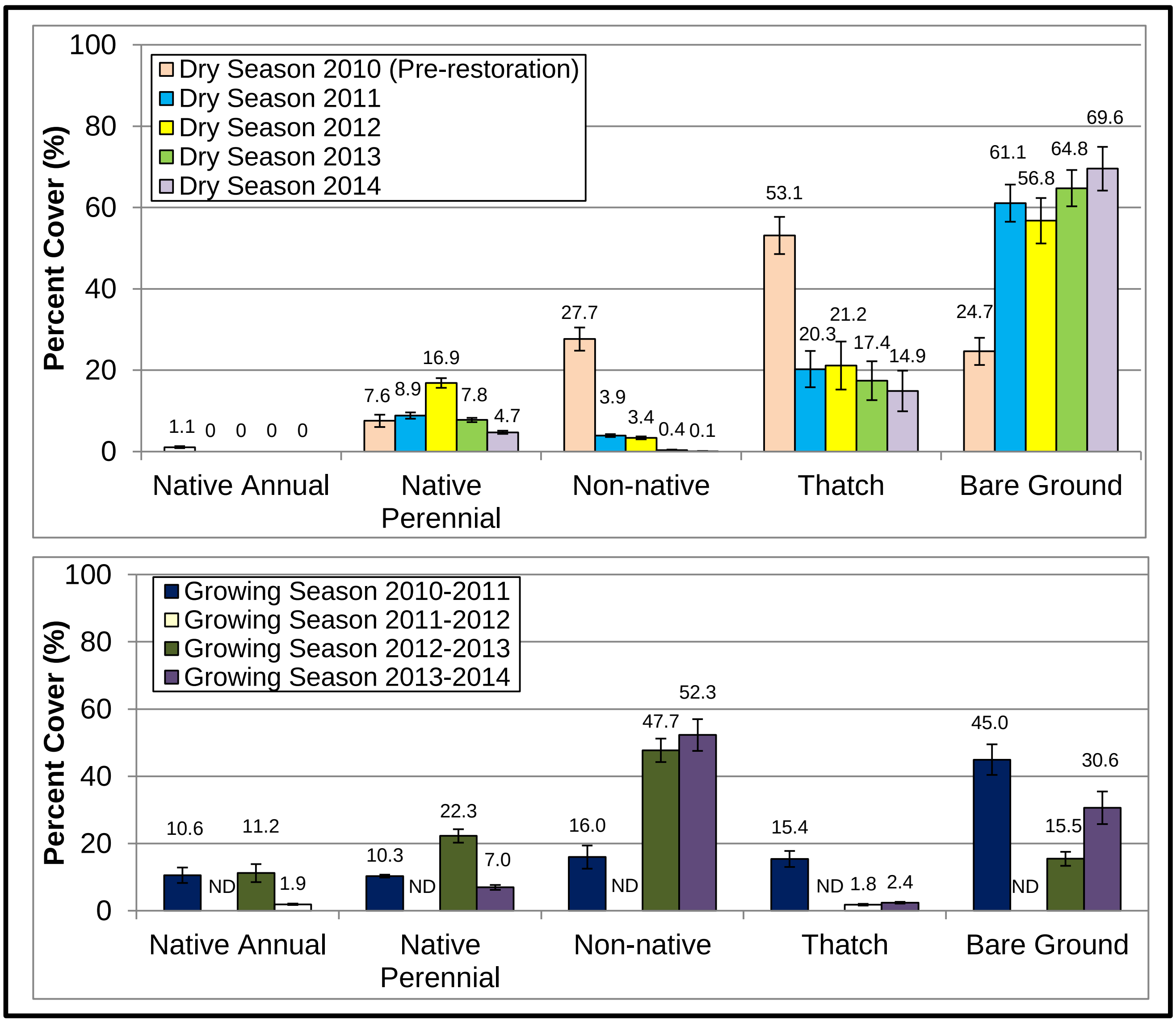

Figure 39: Changes in cover in the 2010 expansion subplots at ESC.
Top: dry season. Bottom: growing season. Data comes from 20 subplots, 10 X 10 m each. Thin bars represent standard error.

Figure 40: Photopoint for subplot A13 at ESC.

Top: November 2010 (pre-restoration). Bottom left: September 2014. Bottom right: January 2015. Note the reduction in thatch, the increase in bare ground and the appearance of plants from several native species.

Native Genera Richness

Fall native genera richness averaged ~1.5 genera per subplot at ESC prior to the onset of restoration and increased following restoration (Figure 41).

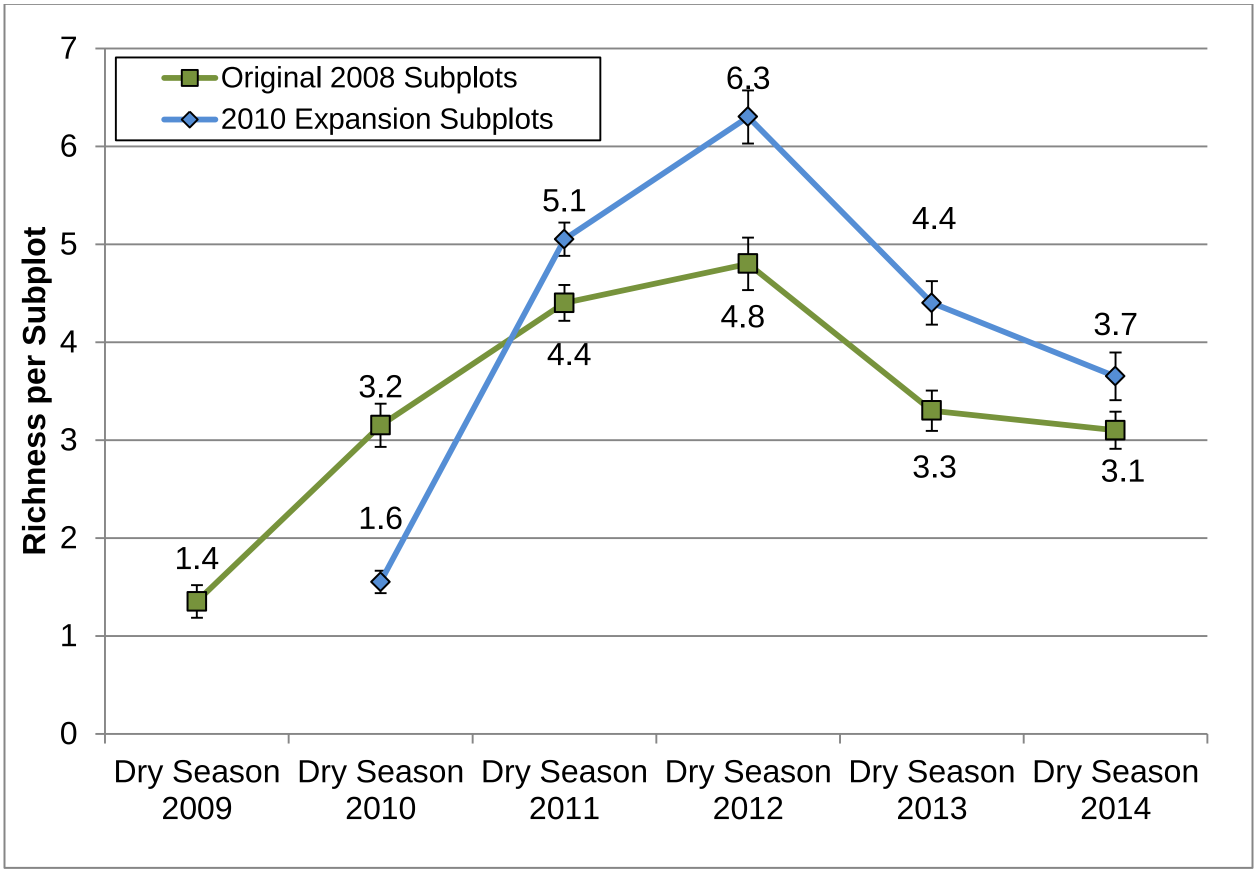

Figure 41: Native species richness at ESC.
Thin bars represent standard error.

Survival

Survival data was obtained for the 2008 expansion subplots at ESC. Plants were outplanted in November 2009 and survival data was taken in May 2010 (Table 4). California Saltbush exhibited the lowest survival rate at 27%. The survival rates of other species varied between 49 and 69%. These plants were hand-watered.

Species	# Outplanted in November 2009	# Alive in May 2010	Survival rate (%)
ATCA	71	19	27
COGI	74	51	69
CONE	116	59	51
ERGC	591	288	49
SUTA	24	14	58
TOTAL	876	431	49

Table 4: Survival rates of outplanted plants between November 2009 and May 2010.

We also recorded the survival rates of tagged plants. However, the large number of tags not found hindered the interpretation of the results (Table 5). Plants were outplanted in November 2009 and tagged between May and June 2010. Their survival was assessed in October 2010. Out of 193 tags installed in Spring 2010, 60 could not be relocated in Fall 2010.

Species	May June 2010	October 2010					
	Tagged	Alive		Dead		Tag not found	
	#	#	%	#	%	#	%
ATCA	19	6	*32*	6	*32*	7	*37*
COGI	51	40	*78*	0	*0*	11	*22*
CONE	55	33	*60*	9	*16*	12	*22*
ERGC	58	33	*57*	2	*3*	24	*41*
SUTA	10	4	*40*	0	*0*	6	*60*
Total	193	116	*60*	17	*9*	60	*31*

Table 5: Summer 2010 survival at ESC based on tagged plants.

Growth

We measured the height and width of tagged plants in May/ June 2010 and in October 2010. Only data from plants that were relocated and alive during these two surveys were included in Figure 42. Giant Tickseed was not included due to inconsistencies in measurement methods and Wooly Seablite was not included due to its low sample size (<5).

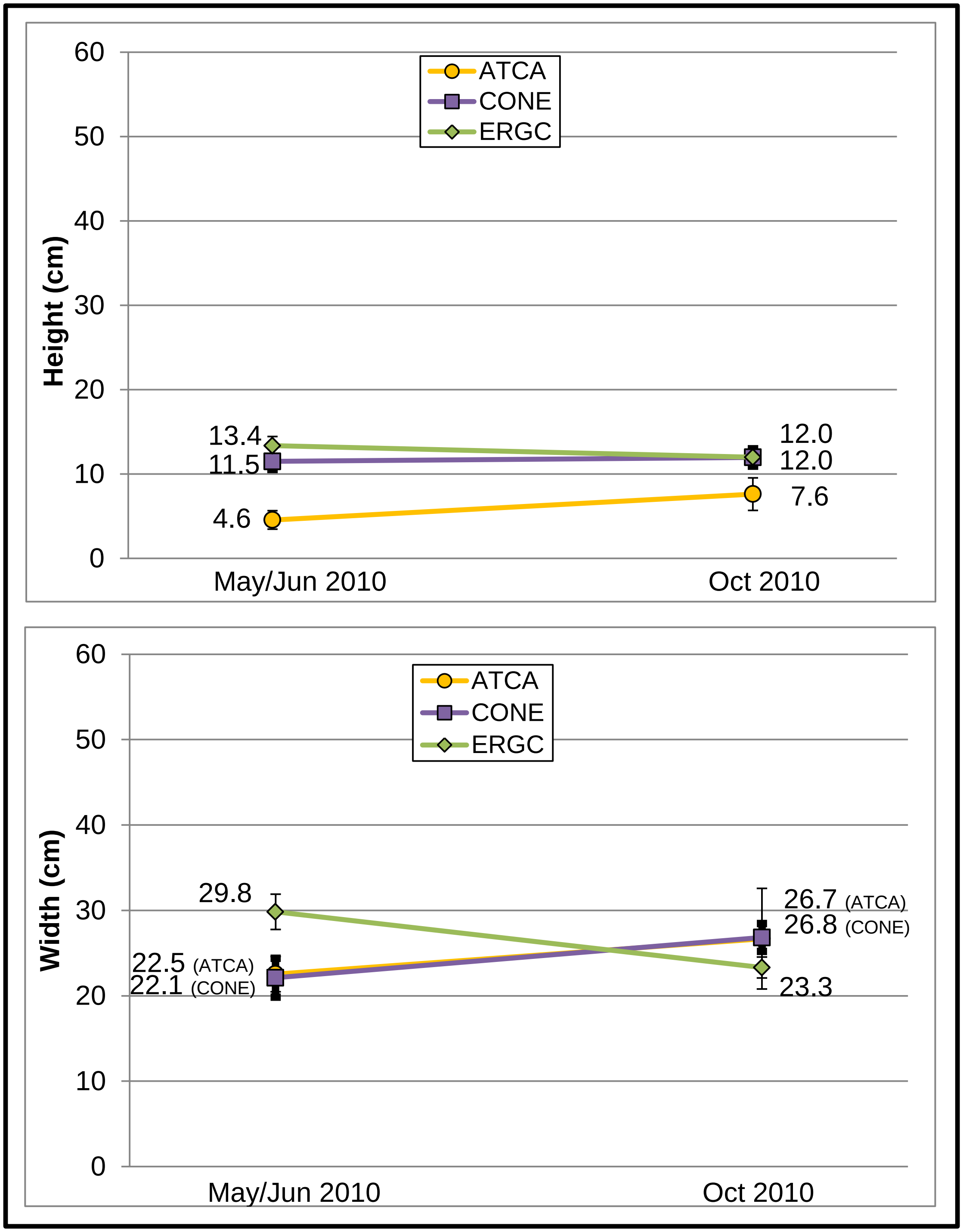

Figure 42: Size of tagged plant at ESC in late May/early June 2010 and October 2010. Only plants that were found alive and measured in all surveys were included. Sample size: 6 ATCA, 33 CONE, and 33 ERGC. Thin bars represent standard error (for clarity, bars are thicker for CONE).

III.II.III House Restoration Plot (HP)

Outplantings

HP was established in September 2007. Although it initially covered 375 m^2 (0.09 ac) divided into 15 subplots of 5X5 m each, the three easternmost subplots were not monitored or maintained past summer 2008 as they were judged too steep for the working crew's safety. In 2007, 158 plants were outplanted in these 15 subplots. In November 2008, an additional 122 plants were outplanted in the twelve westernmost subplots. Between December 2009 and January 2010, 87 more plants were added to these subplots and 26 Prickly-pear in February 2012. In December 2012, the plot was expanded northward by 300 m^2 (0.07 ac) divided into 12 subplots of 5X5 m and 283 plants were outplanted there. As of the end of 2014, HP covered a total of 675 m^2 (0.17 ac) divided into 27 subplots of 5X5 m, including the unmaintained portion (Figure 43). Altogether, 676 plants were outplanted at HP; these plants were hand-watered.

Figure 43: Map of HP.
The initial plot location is indicated in pink (September 2007) and the December 2012 expansion in red. Each subplot was given a unique identifying label. Cross-hatched sections were not surveyed or maintained past summer 2008.

Percentage Cover

HP Original 2007 Subplots: n = 12 for the dry season data, n = 9 for the growing season data

No dry season cover data is available for the original 2007 subplots at HP in 2008, 2009, and 2014. The cover of all natives (annual and perennials combined) during the 2007 dry season was estimated as 8.6±2.1 (not displayed in Figure 44). Following the onset of restoration, the dry season cover of natives increased, while the cover of non-natives decreased. Thatch has been overall increasing year-round since 2007, while bare ground has been decreasing year-round except during the 2013-2014 growing season (Figure 44). Figure 45 and Figure 46 show pictures of the original 2007 subplots at HP through the years.

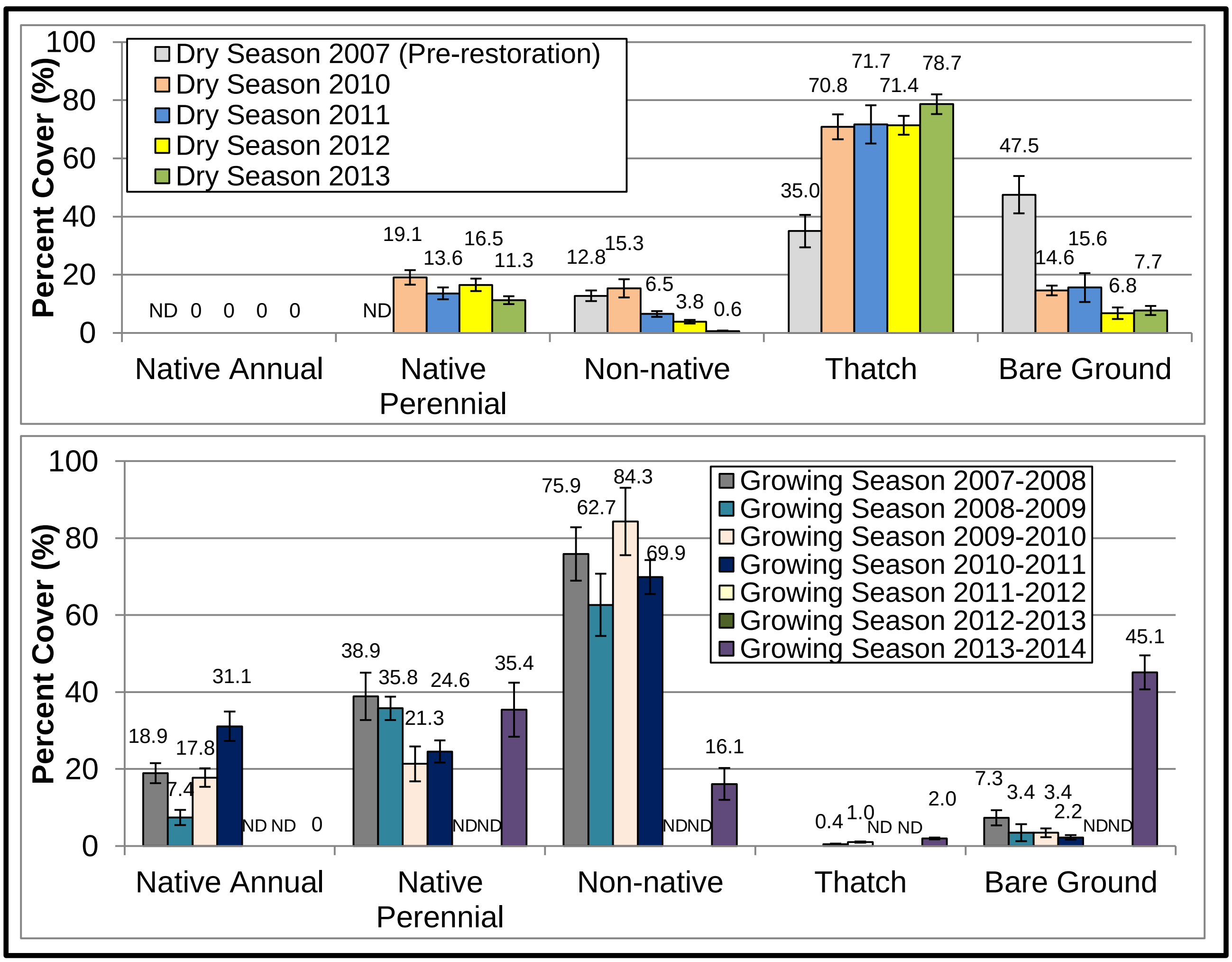

Figure 44: Changes in cover in the original 2007 subplots at HP.
Top: dry season. Bottom: growing season. 12 subplots were surveyed during the dry season and 9 subplots were surveyed during the growing season (5 X 5 m each). Thin bars represent standard error. No data is available for the 2008, 2009, and 2014 dry seasons.

Figure 45: Overview photopoint of the original 2007 subplots at HP.
Top: Fall 2007 (pre-restoration). Bottom left: November 2014. Bottom right: January 2015. Note the increase in Giant Tickseed and Prickly-pear and the decrease in Wooly Seablite and Australian Saltbush.

Figure 46: Overview photopoint of the original 2007 subplots at HP.

Top: Fall 2007 (after outplanting). Bottom left: November 2014. Bottom right: January 2015. Note how most outplanted SBI Buckwheat and Nevin's Wooly Sunflower did not survive. However, Prickly-pear grew from a single outplanted pad in February 2012 to plants with several pads in 2014. Giant Tickseed also grew increased in size and number.

HP 2012 Expansion Subplots: n = 12

The pre-restoration cover survey for the 2012 expansion subplots at HP were taken during the 2012-2013 growing season and no surveys were taken during the 2014 dry season. Between the 2012-2013 and 2013-2014 growing seasons, the cover of native perennials nearly doubled and the cover of non-natives nearly decreased by half. Moreover, the cover of thatch slightly decreased and the cover of bare ground greatly increased. During the 2013 dry season, native perennials covered on average 9.1±0.9% of the subplots, non-native covered less than 1%, thatch 33.2±8.9%, and bare ground 55.3±8.7% (Figure 47). Figure 48 shows pictures of the 2012 expansion subplots at HP through the years.

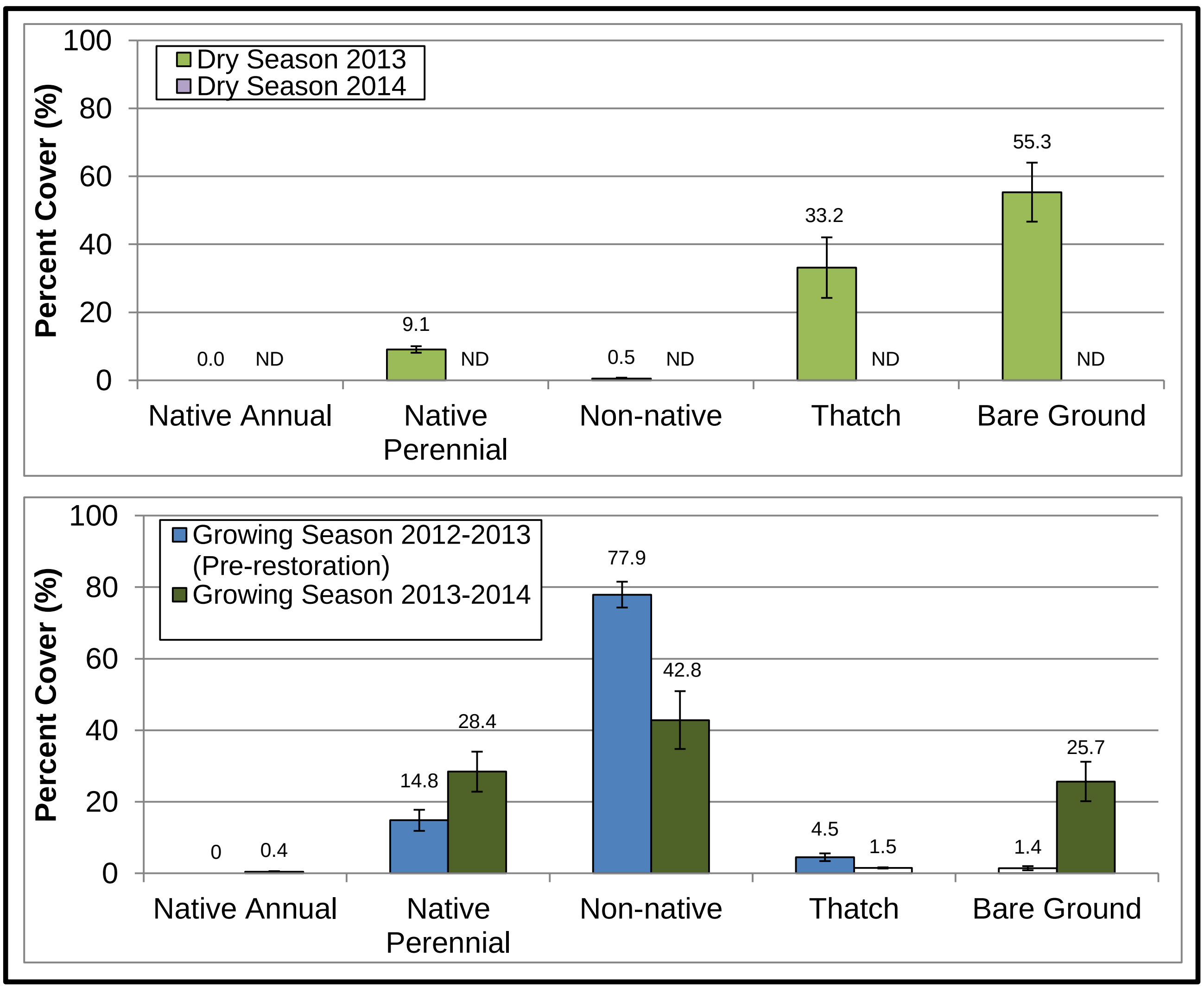

Figure 47: Changes in cover in the 2012 expansion subplots at HP.
Top: dry season. Bottom: growing season. Data comes from 12 subplots, 5 X 5 m each. Thin bars represent standard error.

Figure 48: Photopoint for subplot H at HP.

Top: December 2012 (taken after outplanting). Bottom left: September 2014. Bottom right: January 2015. Note the difference in size between the newly outplanted Nevin’s Wooly Sunflowers in the top picture and the bottom pictures. Some non-native grasses were replaced by non-native Cheeseweed between 2012 and 2015.

Native Genera Richness

Between the 2012-2013 growing season (pre-restoration) and the 2013-2014 growing season, native genera richness increased from 2.3 ±0.3 per subplot to 3.8 ±0.4 in the 2012 expansion subplots (Figure 49). Note that each subplot was 5 X 5m.

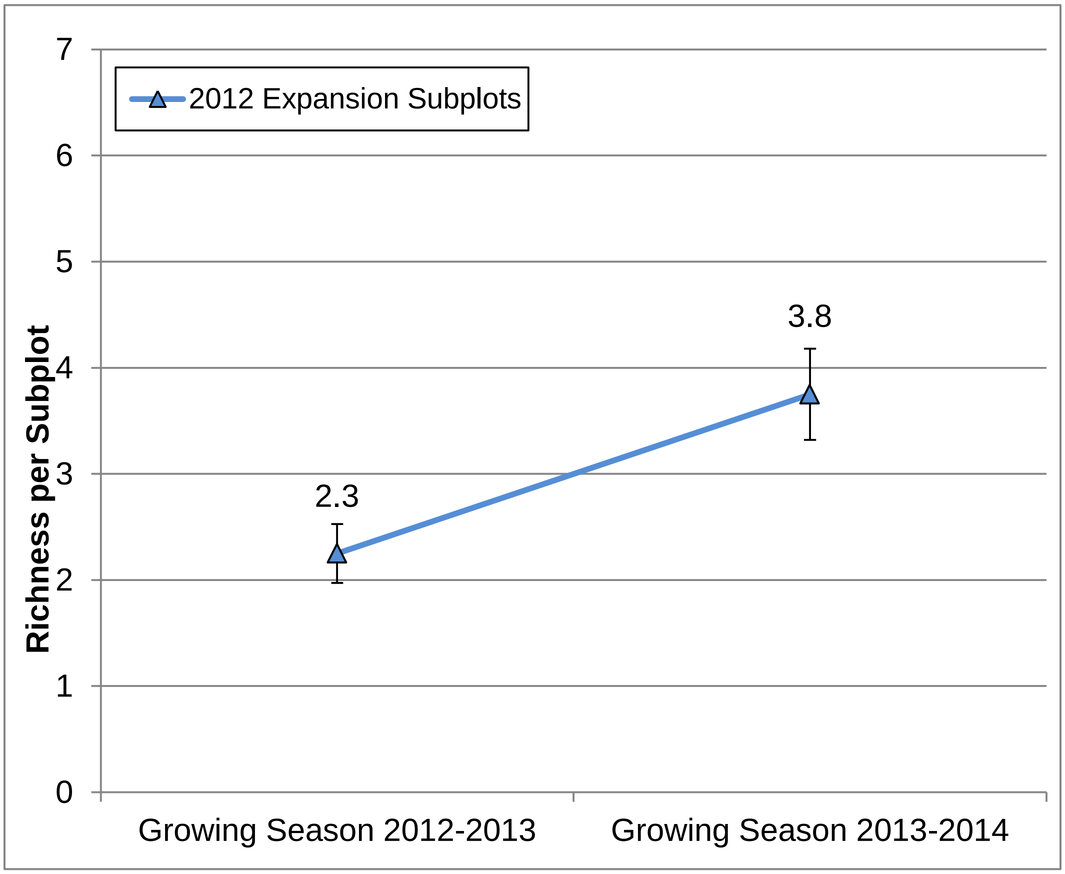

Figure 49: Average native genera richness in the 2012 expansion subplots at HP.
Thin bars represent standard error.

Survival

Plants used to determine survival rates at HP were outplanted in September 2007 and tagged the same month. Their survival was assessed in January and April 2008 and February 2009. Out of 97 tags installed, one could not be relocated during the first survey, four during the second survey, and eight during the last survey (Table 6).

Species	Sep 07	Jan 08						Apr 08						Feb 09					
	Tagged	Alive		Dead		Tag not found		Alive		Dead		Tag not found		Alive		Dead		Tag not found	
	#	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
ACMI	7	6	*86*	0	*0*	1	*14*	2	*29*	1	*14*	4	*57*	1	*14*	5	*71*	1	*14*
COGI	3	3	*100*	0	*0*	0	*0*	2	*67*	1	*33*	0	*0*	2	*67*	1	*33*	0	*0*
CONE	36	34	*94*	2	*6*	0	*0*	34	*94*	2	*6*	0	*0*	15	*42*	19	*53*	2	*6*
ERGC	30	30	*100*	0	*0*	0	*0*	14	*47*	16	*53*	0	*0*	7	*23*	21	*70*	2	*7*
SUTA	21	16	*76*	5	*24*	0	*0*	12	*57*	9	*43*	0	*0*	6	*29*	12	*57*	3	*14*
Total	97	89	*92*	7	*7*	1	*1*	64	*66*	29	*30*	4	*4*	31	*32*	58	*60*	8	*8*

Table 6: Survival rates at HP based on tagged plants.

<u>Growth</u>

We measured the height and width of tagged plants in September 2007, January 2008, and February 2009. Only data from plants that were relocated and alive during these three surveys were included in Figure 50. ACMI and COGI were not included due to their low sample size (<5) and inconsistencies in measurements.

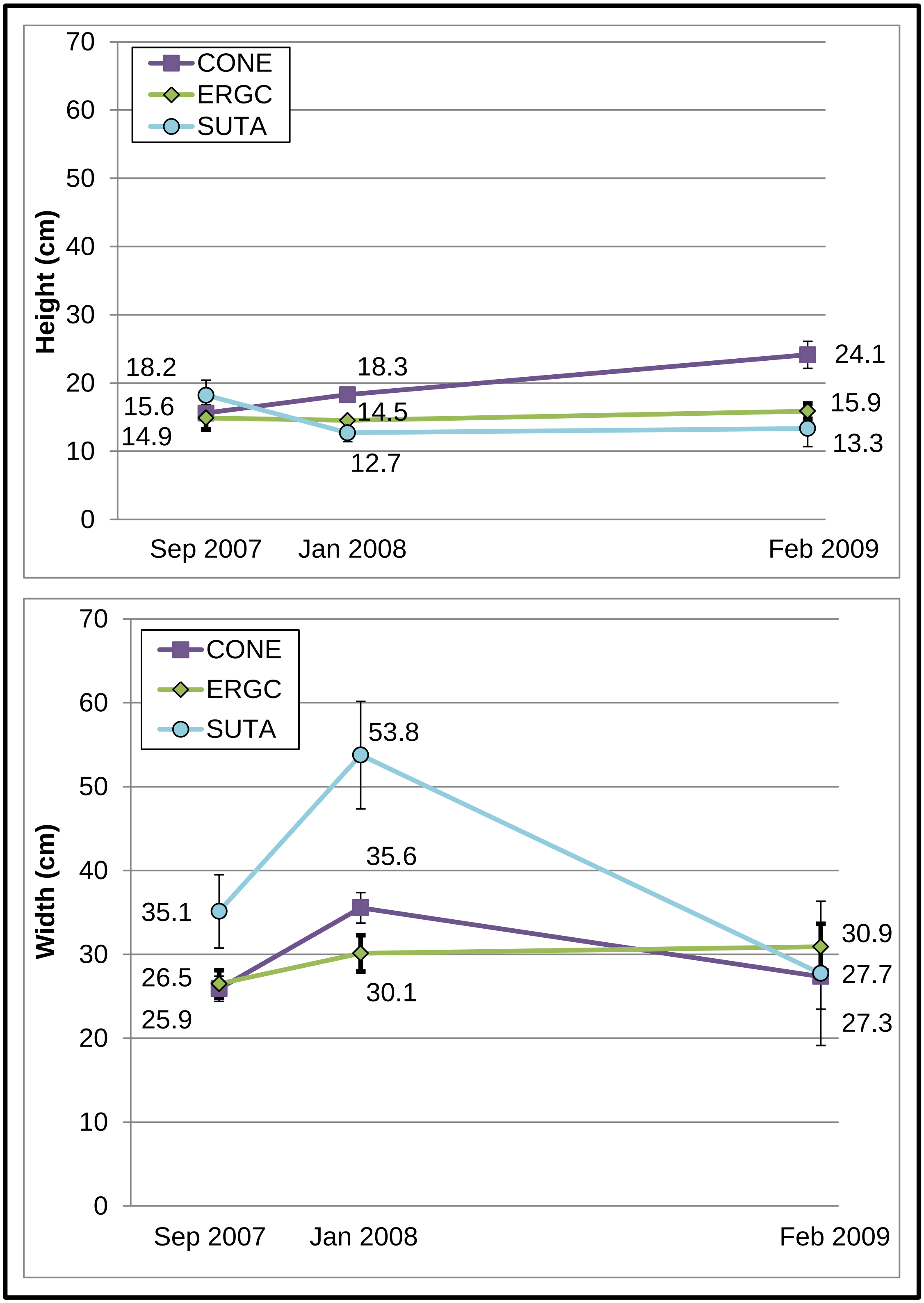

Figure 50: Tagged plant size at HP in September 2007, January 2008, and February 2009. Sample size: 15 CONE, 7 ERGC, and 6 SUTA. Thin bars represent standard error (for clarity, bars are thicker for the standard error of ERGC's height and width).

III.II.VI Landing Cove Restoration Plot (LACO)

Outplantings

LACO was originally planted in December 2007 (165 m^2; 0.04 ac) and expanded in March 2008 (240 m^2; 0.06 ac), January 2009 (220 m^2; 0.05 ac), December 2009 (320 m^2; 0.08 ac), January 2011 (410 m^2; 0.10 ac), and November 2011 (920 m^2; 0.23 ac). As of the end of 2014, LACO covered a total of 2,275 m^2 (0.56 ac). The site was sub-divided into subplots of irregular shape (Figure 51).

Between 2007 and 2013, over 3,200 plants were put in the ground at LACO. 30 plants were outplanted in December 2007, 18 plants in March 2008, over 138 plants in January 2009, 1,012 plants in December 2009, 505 plants in January and February 2011, 1,497 plants in November and December 2011, and 21 plants in October 2013[8]. These numbers do not include OPLI planted in patches north of LACO or around the lower CAAU artificial burrows (these were outside the plot boundaries and are thus included with the "landscaping" data). LACO was always hand-watered.

Percentage Cover

LACO 2007 Original Subplots: n = 9

No cover surveys were taken during the 2008 and 2009 dry seasons or the 2007-2008, 2008-2009, and 2011-2012 growing seasons. The cover of all natives (annual and perennials combined) during the 2007 dry season was estimated at 20.0±7.9% per subplots (not displayed in Figure 52). Following the onset of restoration, the dry season cover of natives slightly increased, while the cover of non-natives decreased. During the growing season, the cover of non-natives was at its lowest in 2013-2014. During the growing season, the cover of native perennials has been increasing since 2009-2010, the earliest growing season when data was collected. Thatch has been overall decreasing year-round, while bare ground increased. No subplot photopoints were available pre-restoration (overview photopoints are provided on pages 92-97).

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[8] The 21 plants added in 2013 were to replace CAAU artificial burrows that were removed from subplots J5, K5, and the adjacent "extra" subplot.

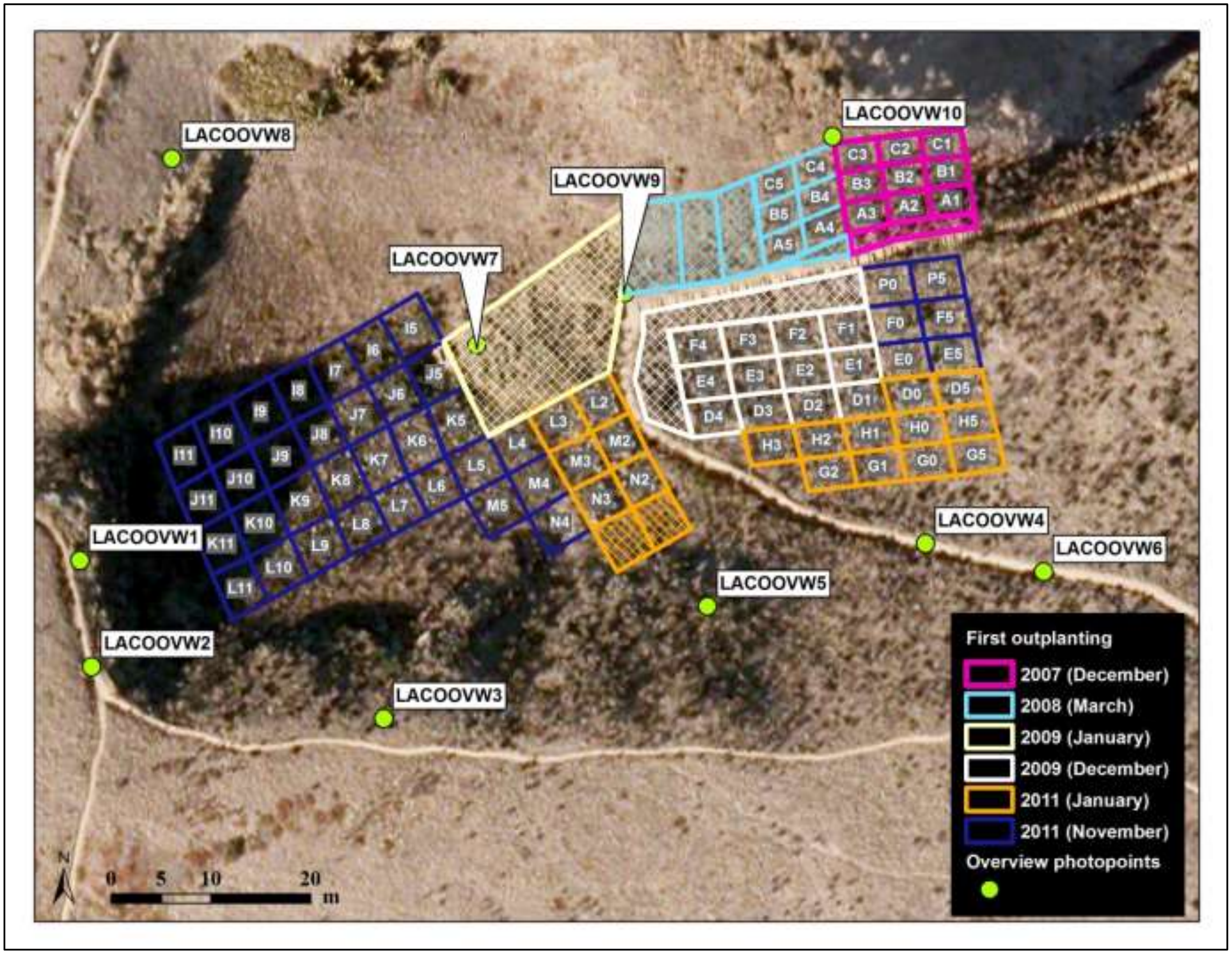

Figure 51: Map of LACO.

The initial plot location is indicated in pink (2007) and further expansions in pale blue (2008), cream (January 2009), white (December 2009), orange (January 2011), and dark blue (November 2011). Cross- hatched sections were not surveyed, but were maintained.

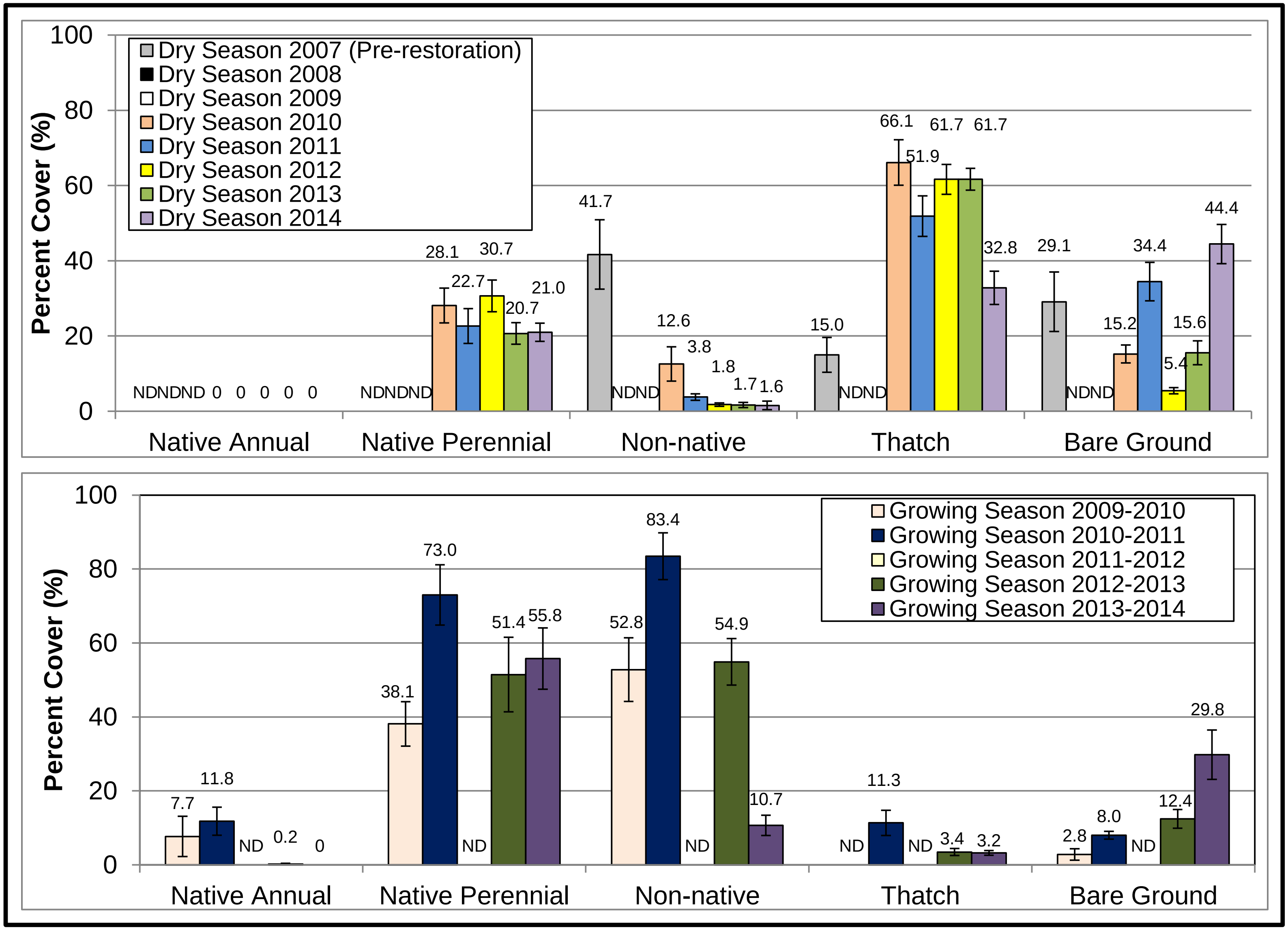

Figure 52: Changes in cover in the 2007 original subplots at LACO.

Top: dry season. Bottom: growing season. Data comes from 9 subplots, 3 X 5 m each. Thin bars represent standard error.

LACO 2008 Expansion Subplots: n = 6

No cover surveys were taken during the 2008 (pre-restoration) and 2009 dry seasons. The cover of natives and non-natives decreased between 2010 and 2014. Over the dry seasons, thatch decreased and bare ground increased between 2010 and 2014 (Figure 53). No subplot photopoints were available pre-restoration (overview photopoints are provided on pages 94-97).

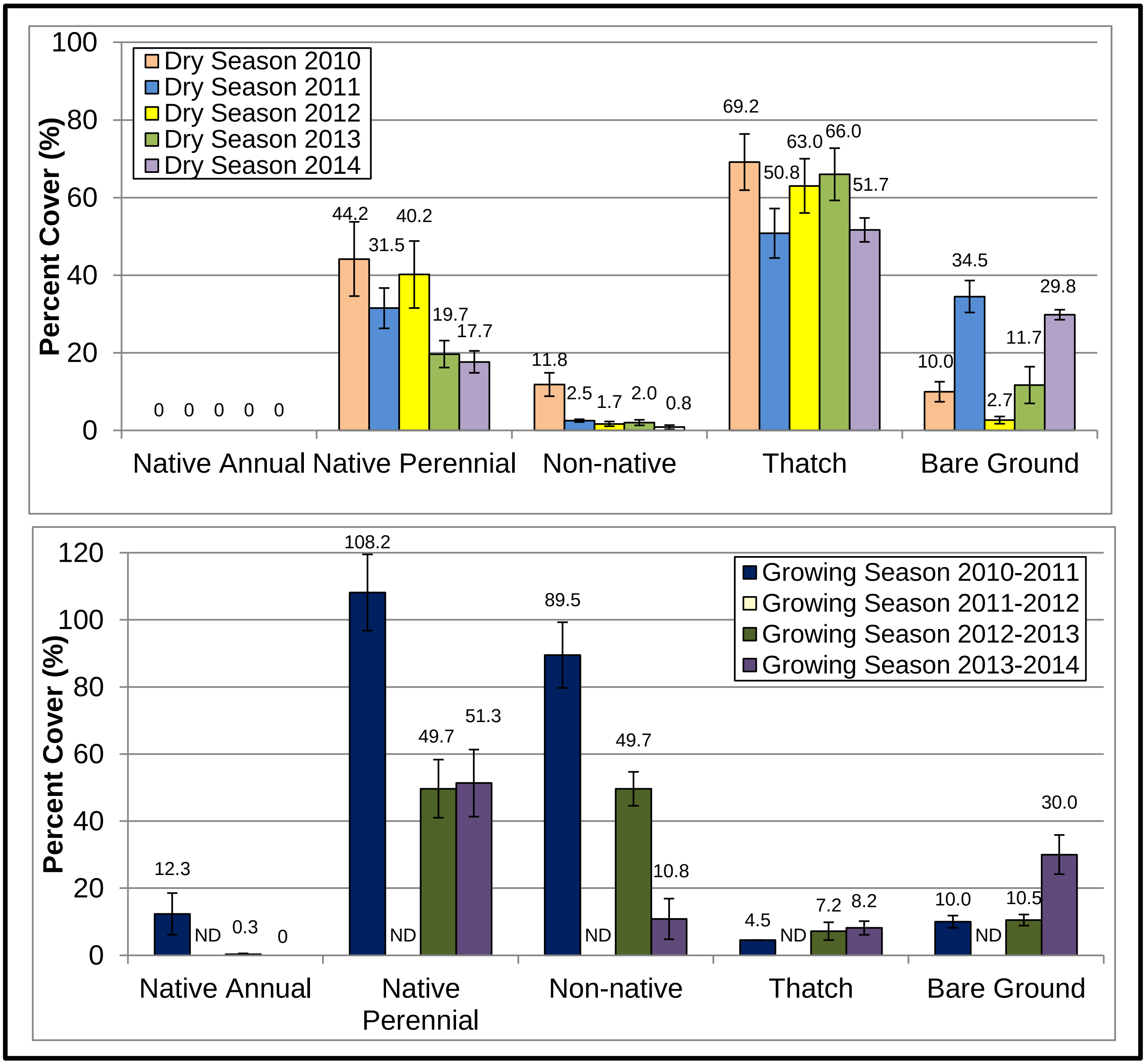

Figure 53: Changes in cover in the 2008 expansion subplots at LACO.
Top: dry season. Bottom: growing season. Data comes from 6 subplots, 3 X 5 m each. Thin bars represent standard error. No data were taken prior to 2010 and no data were taken during the 2011-2012 growing season.

LACO December 2009 Expansion Subplots: n = 12

No cover data is available pre-restoration for the December 2009 expansion subplots at LACO. However, native perennial cover has been high since restoration, with a slight downward trend. The cover of non-native species overall decreased yearly since 2010 (Figure 54). During the 2014 dry season, percent cover surveys were taken improperly for the December 2009 subplots and were therefore discarded. No subplot photopoints were available pre-restoration (overview photopoints are provided on pages 92-97).

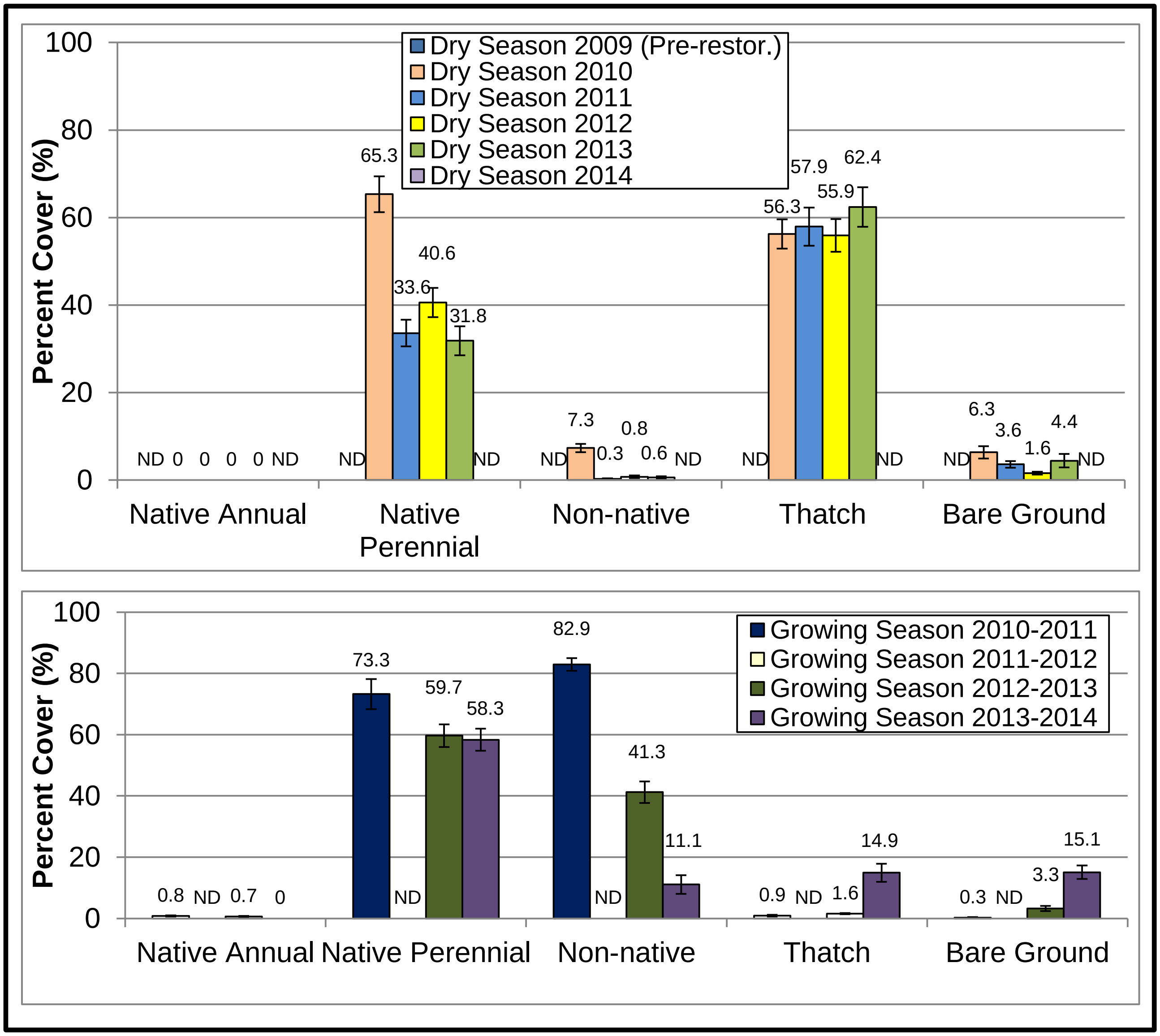

Figure 54: Changes in cover in the December 2009 expansion subplots at LACO.
Top: dry season. Bottom: growing season. Data comes from 12 subplots, 4 X 5 m each. Thin bars represent standard error. No data were taken in 2009 or during the 2011-2012 growing season.

LACO January 2011 Expansion Subplots: n = 17

The cover of native plants in the January 2011 expansion subplots declined compared to pre-restoration conditions from January 2011. However, non-native cover has been decreasing during the growing season and thatch has been increasing during the dry season. Averages presented in Figure 55 were weighted by subplot size. During the 2014 dry season, percent cover data were taken improperly for these subplots; data were therefore discarded. Overview photopoints are provided on pages 92-97.

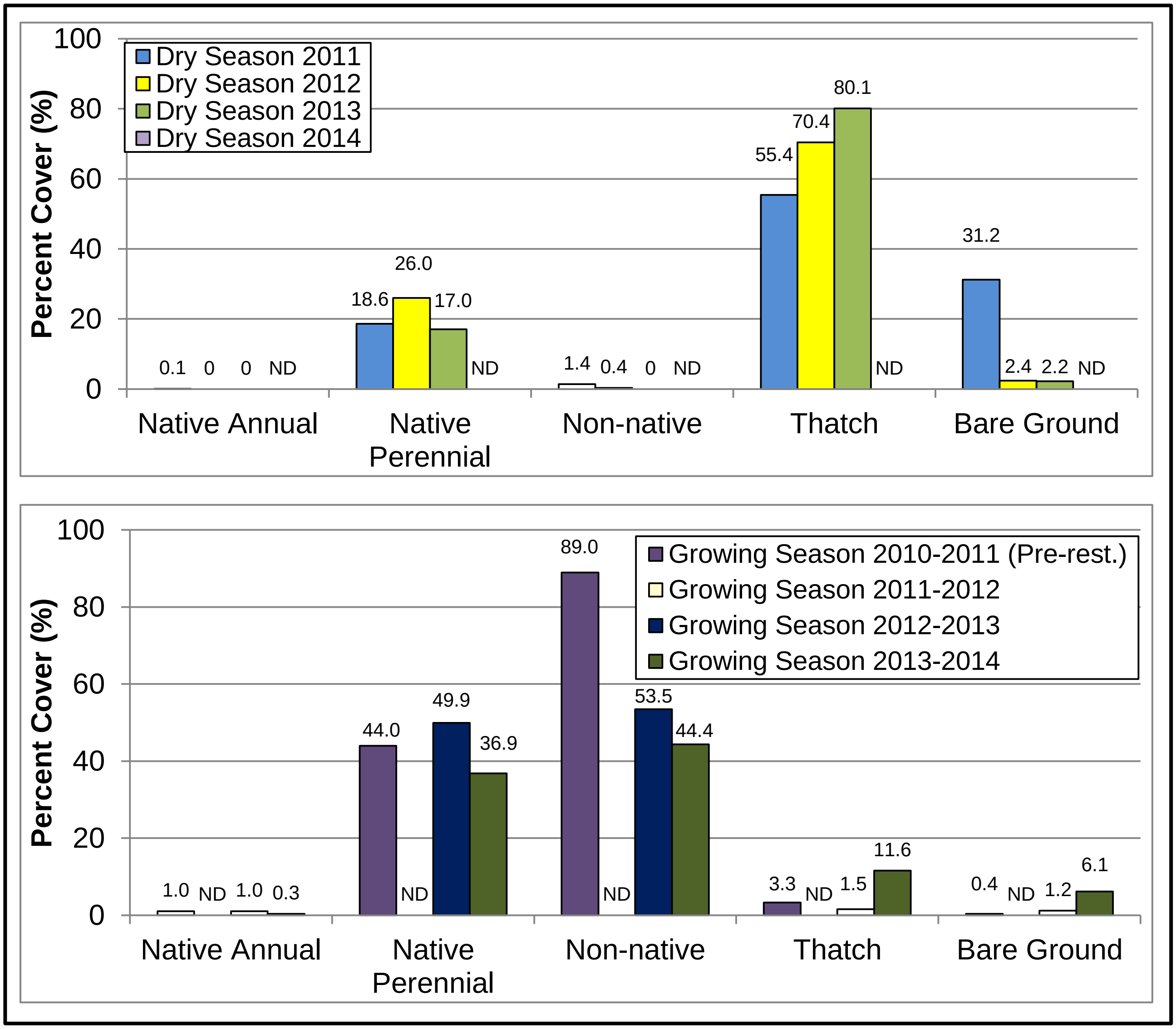

Figure 55: Changes in cover in the January 2011 expansion subplots at LACO.
Top: dry season. Bottom: growing season. Data comes from 17 subplots: 11 subplots were 4 X 5 m and 6 subplots were 5 X 5 m. Data were not available for the 2014 dry season or the 2011-2012 growing season.

LACO November 2011 Expansion Subplots: n = 38

The cover of native perennials in the November 2011 expansion subplots increased between the 2011 (pre-restoration) and 2013 dry seasons. Non-native cover has been decreasing and bare ground remained relatively low year-round since 2011. Thatch has been increasing during the growing season and decreasing during the dry season. Averages in Figure 56 were weighted by subplot size. Overview photopoints are provided on pages 92-97 and photopoints of subplot J6 are provided on page 98.

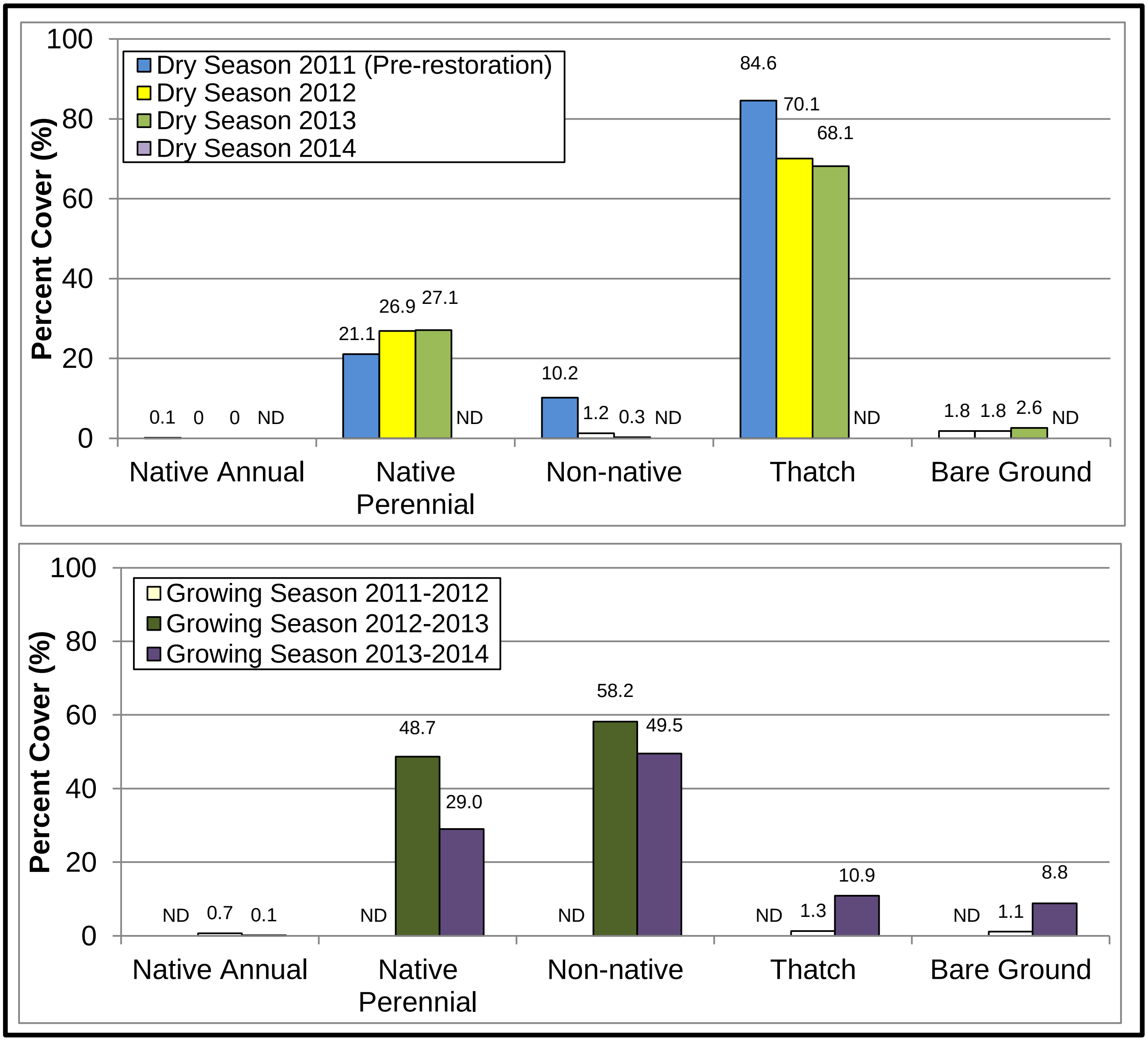

Figure 56: Changes in cover in the November 2011 expansion subplots at LACO.
Top: dry season. Bottom: growing season. Data comes from 38 subplots: 6 subplots were 4 X 5 m and 32 subplots were 5 X 5 m.

All LACO Subplots

Figure 57 through Figure 63 show changes in LACO between 2007 and 2015.

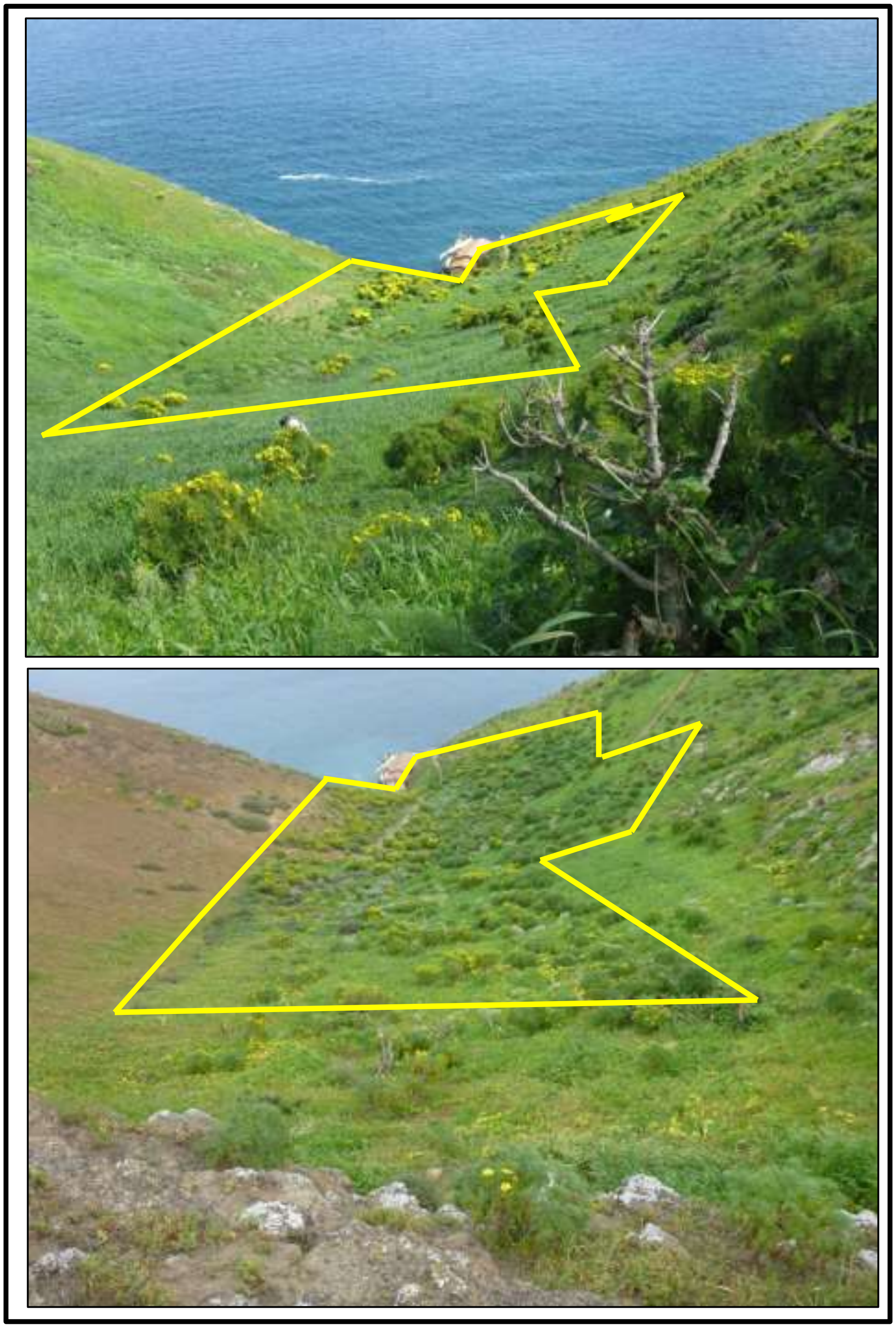

Figure 57: Overview photopoint of LACO (Figure 1 of 6).
Top: March 2010. Bottom: February 2015. Note the increase in native perennials and decrease in non-native annuals within the restoration plot (yellow).

Figure 58: Overview photopoint of LACO (Figure 2 of 6).
Top: February 2009. Bottom: January 2015. The March 2008 expansion subplots are outlined in blue and the January 2009 expansion subplots are outlined in beige. Note the growth of outplanted natives between 2009 and 2015.

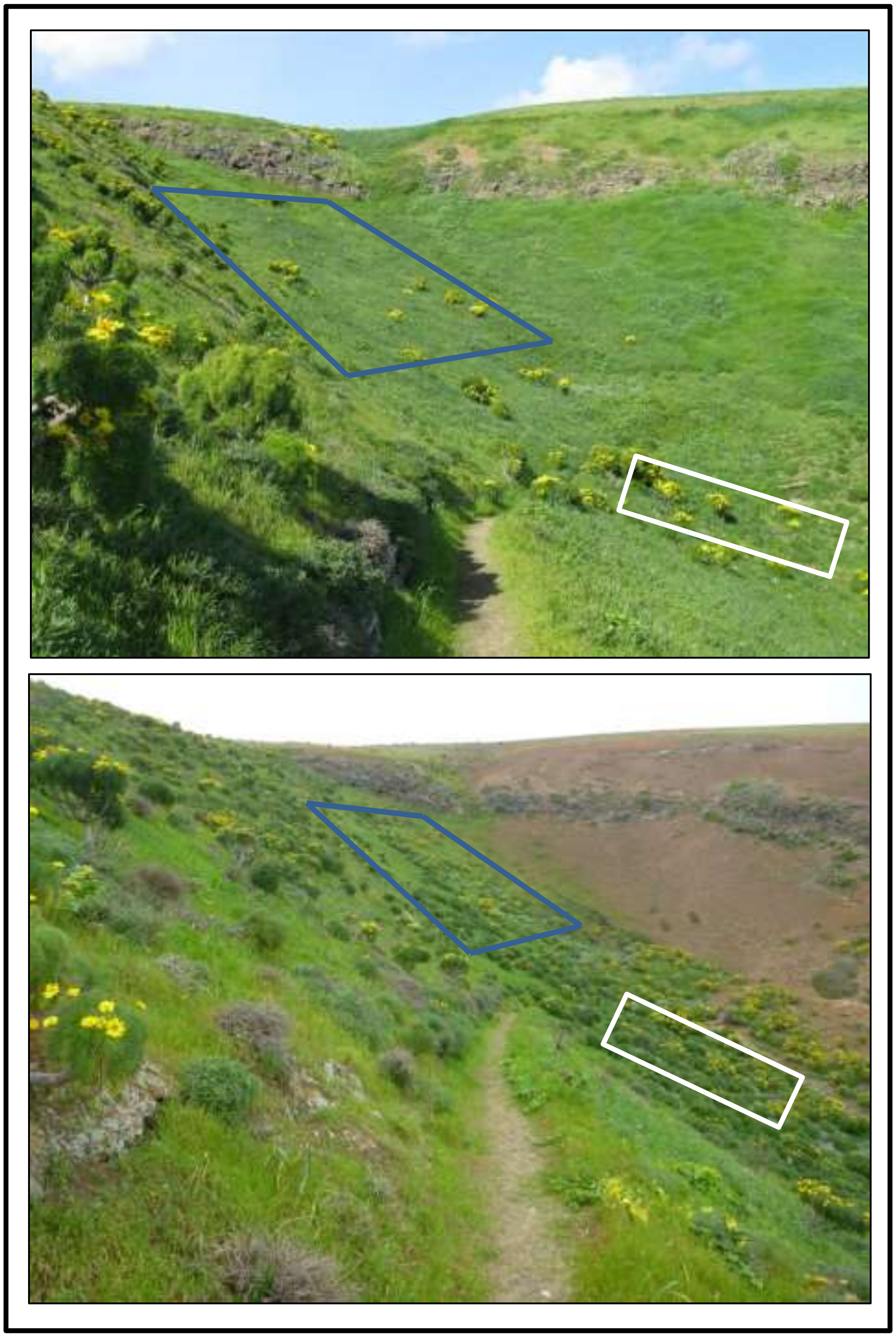

Figure 59: Overview photopoint of LACO (Figure 3 of 6).
Top: March 2010. Bottom: February 2015. Note the increase in native perennials and decrease in non-native annuals. For reference, the December 2009 expansion is outlined in white and the November 2011 expansion is outlined in blue.

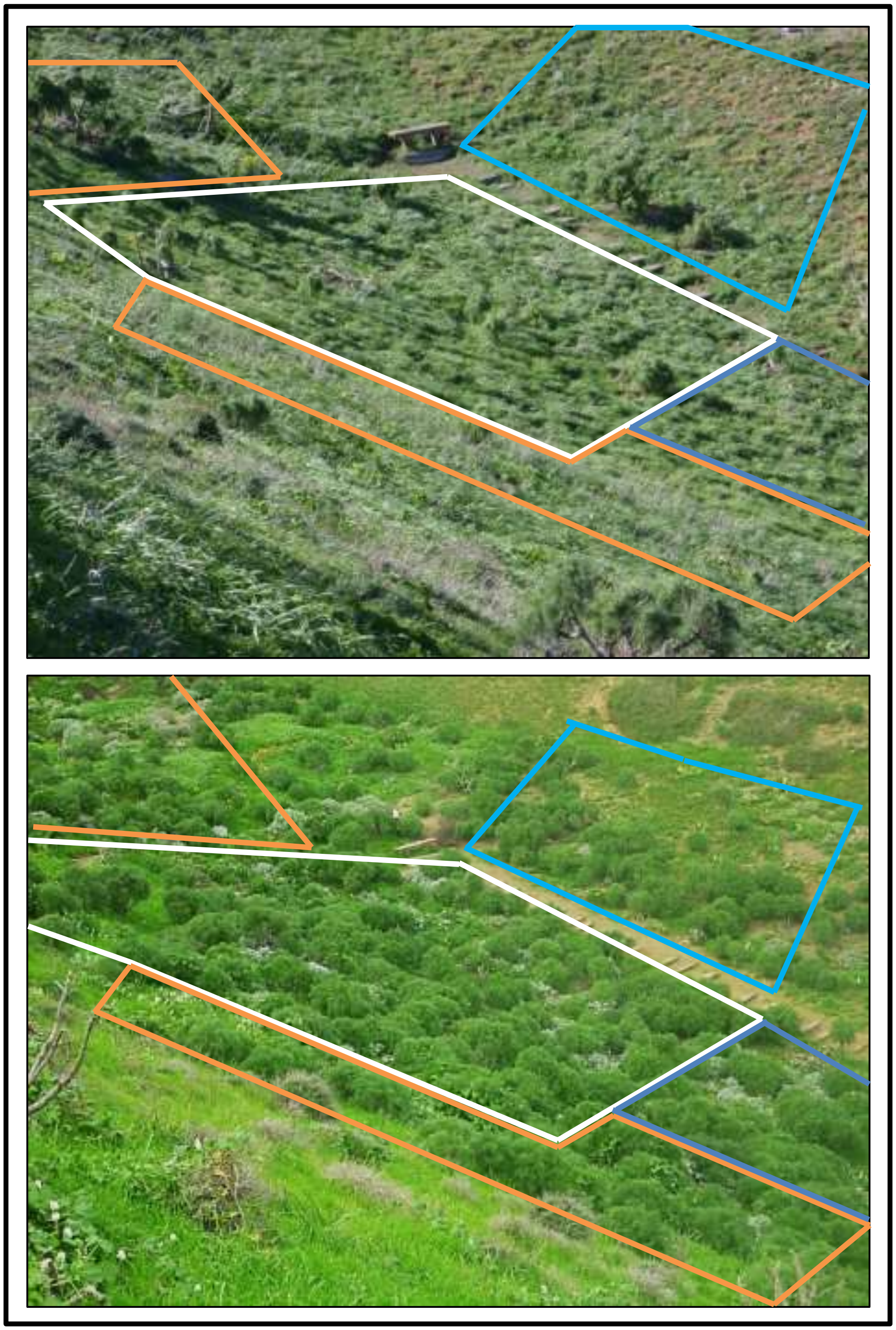

Figure 60: Overview photopoint of LACO (Figure 4 of 6).
Top: February 2009, bottom: January 2015. Note the increase in native perennials and decrease in non-native annuals. For reference, the March 2008 expansion is outlined in pale blue, the December 2009 expansion subplots in white, the January 2011 expansion in orange, and the southernmost subplots of the November 2011 expansion in dark blue.

Figure 61: Overview photopoint of LACO (Figure 5 of 6).
Top: January 2011. Bottom: January 2015. The January 2011 photopoint was taken during the pre-restoration cover survey for the January 2011 expansion subplots; the measuring tapes in the top picture outline the subplot boundaries. Note the increase in native perennials and the decrease in non-native annuals.

Figure 62: Overview photopoint of LACO (Figure 6 of 6).
Top: February 2009. Bottom: February 2015. Note the increase in native perennials and decrease in non-native annuals.

Figure 63: Time series of subplot J6 in LACO.
Top left: October 2011 (pre-planting). Top right: September 2013. Bottom left: September 2014. Bottom right: January 2015. This subplot is representative of some of the changes in LACO. Note the overall increase in native perennials since planting, despite the decrease in Wooly Seablite between 2013 and 2015.

Native Genera Richness

Following the onset of restoration, native genera richness increased in the monitored subplots. The 2011dry season data correspond to the pre-restoration richness in the November 2011 expansion subplots. Similarly, the growing season 2010-2011 data correspond to the pre-restoration richness in the January 2011 expansion subplots (Figure 64).

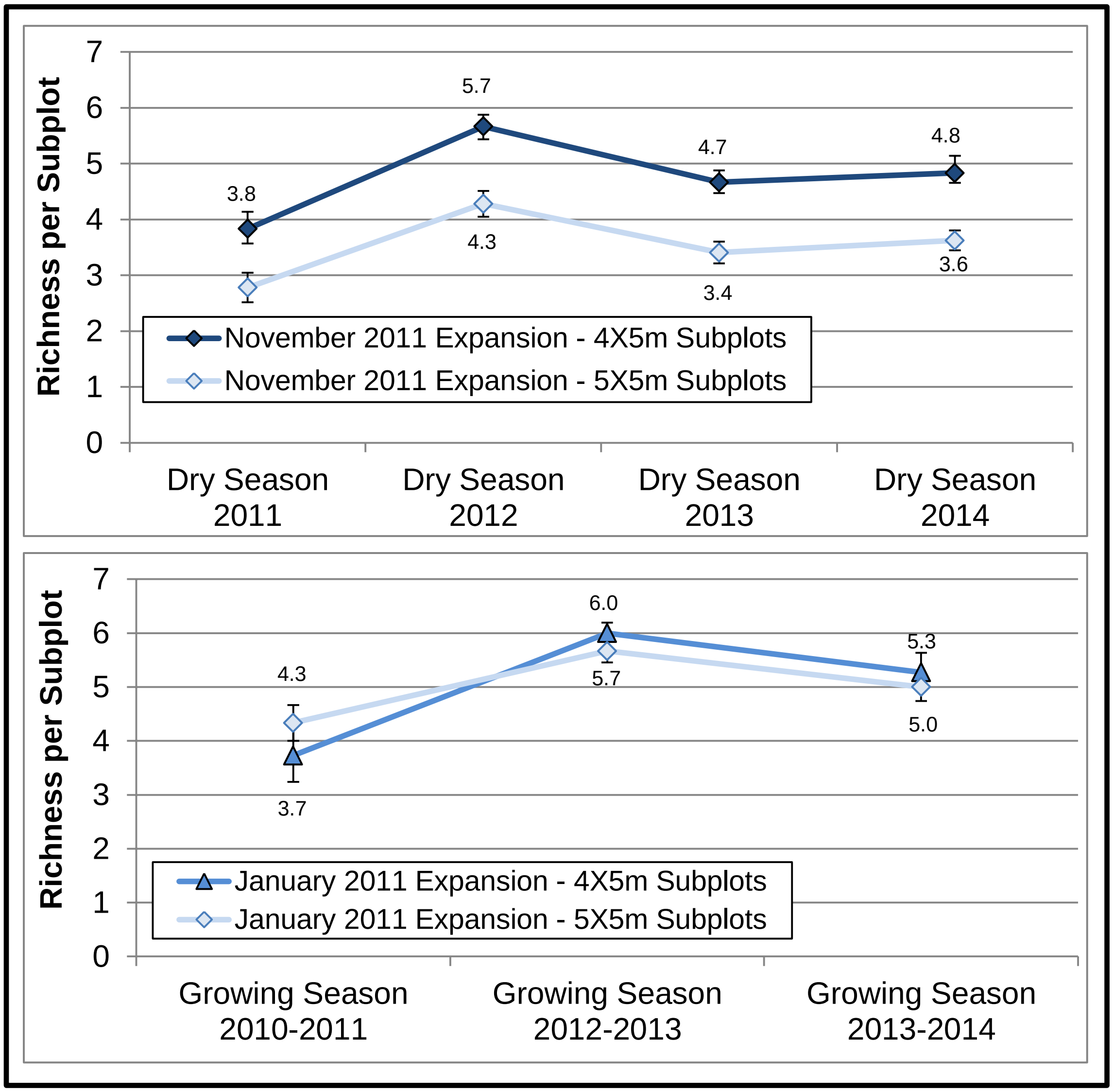

Figure 64: Native genera richness in LACO.
Top: dry season. Bottom: growing season. November 2011 expansion - 4X5m subplots: n=6; November 2011 expansion - 5X5m subplots: n=32; January 2011 expansion - 4X5m subplots: n=11; January 2011 expansion - 5X5m subplots: n=6. Thin bars represent standard error.

Survival

Survival rates of planted plants in LACO were obtained from survivorship surveys. Plants were outplanted in December 2009 and survival data was taken in August 2010 (Table 7). Nevin's Woolly Sunflower exhibited the highest survival rate at 81%. Other species monitored survived the eight month periods with survival rates between 53 and 67%.

Species	# Outplanted in Dec 2009	# Alive in Aug 2010	Survival rate (%)
CAMA	51	27	53
COGI	335	223	67
CONE	162	132	81
ERGC	394	219	56
TOTAL	942	601	64

Table 7: Survival rates in LACO between December 2009 and August 2010.

We also recorded the survival rates of tagged plants. Plants were outplanted and tagged in January 2009, and their survival was assessed in December 2009. Out of 120 tags installed, only four could not be relocated in December 2009. As opposed to the survival rate obtained from the survivorship surveys, Nevin's Woolly Sunflower exhibited the lowest survival rate compared to other species (Table 8).

Species	Jan 09	Dec 09					
	Tagged	Alive		Dead		Tag not found	
	#	#	%	#	%	#	%
ACMI	40	18	*45*	21	*53*	1	*3*
CONE	40	9	*23*	29	*73*	2	*5*
ERGC	40	19	*48*	20	*50*	1	*3*
Total	120	46	*38*	70	*58*	4	*3*

Table 8: Survival rate of tagged plants in LACO between January 2009 and December 2009.

Growth

We measured the height and width of tagged plants in January 2009 and December 2009. Only data from plants that were relocated and alive during these two surveys are included in Figure 65. ACMI was not included due to inconsistencies in measurement methods.

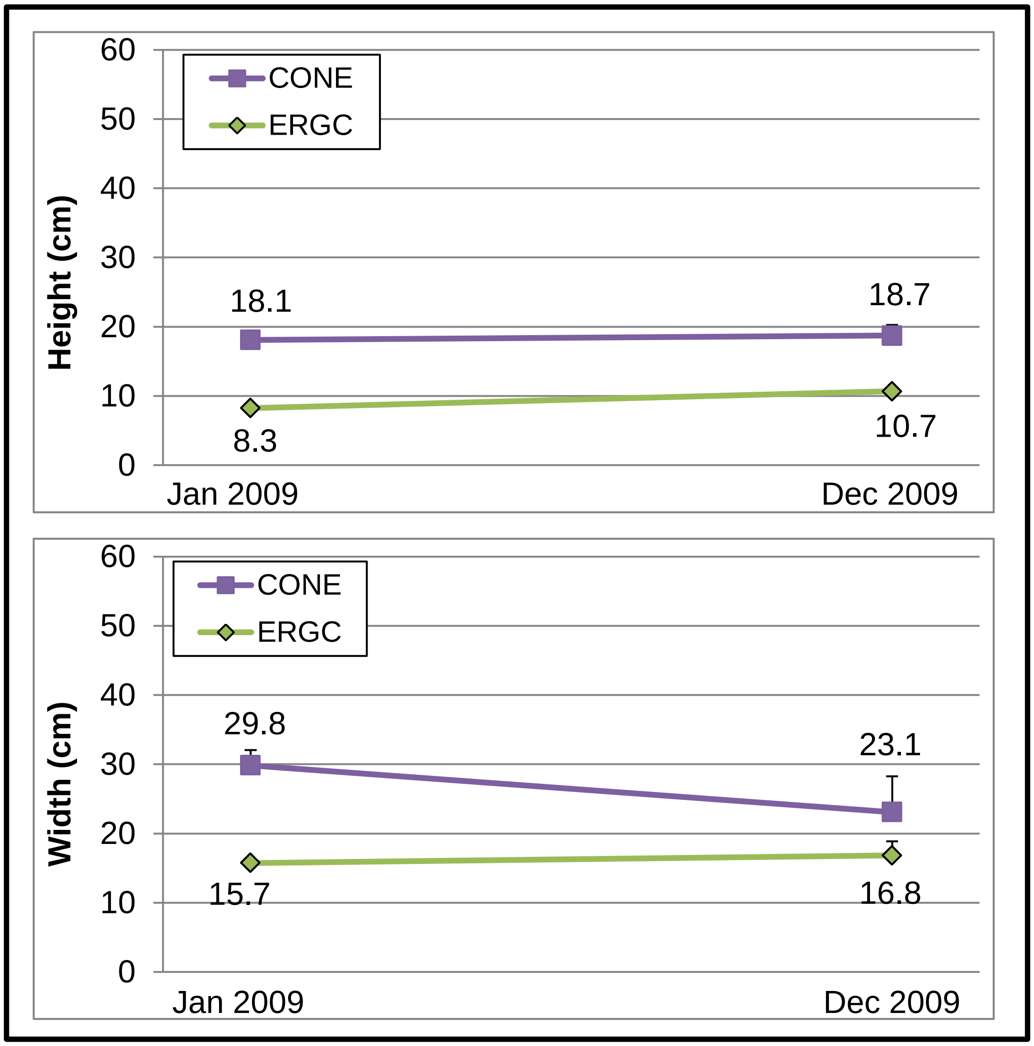

Figure 65: Tagged plant growth at LACO in January 2009 and December 2009. Sample size: 8 CONE and 18 ERGC. Thin bars represent standard error.

III.II.V Nature Trail Restoration Plot (NTP)

Outplantings

NTP was established in October 2013, when 2,373 plants were put in the ground within a 2,500 m^2 (0.62 ac) area. The area was divided into 18 subplots of 10X10 m, plus 4 irregular subplots. NTP was expanded by 1,000 m^2 (0.25ac) in November and December 2014. Between November and December 2014, 727 plants were outplanted in the expansion and in the westernmost original subplots. As of the end of 2014, NTP covered a total of 3,500 m^2 (0.86ac) with 3,100 outplanted plants (Figure 66). Being a more recent plot, NTP was always watered with drip irrigation.

Figure 66: Map of NTP.

The initial plot location is indicated in yellow (October 2013) and the November 2014 expansion in green. Cross- hatched sections were not surveyed, but were maintained.

Percentage Cover

NTP Original 2013 Subplots: n = 13

The cover of native perennials in the original 2013 subplots increased during the dry season following restoration (Figure 67). Non-native cover remained low during the dry season, thatch radically decreased, and bare ground drastically increased. Figure 68 shows NTP before and after the onset of restoration.

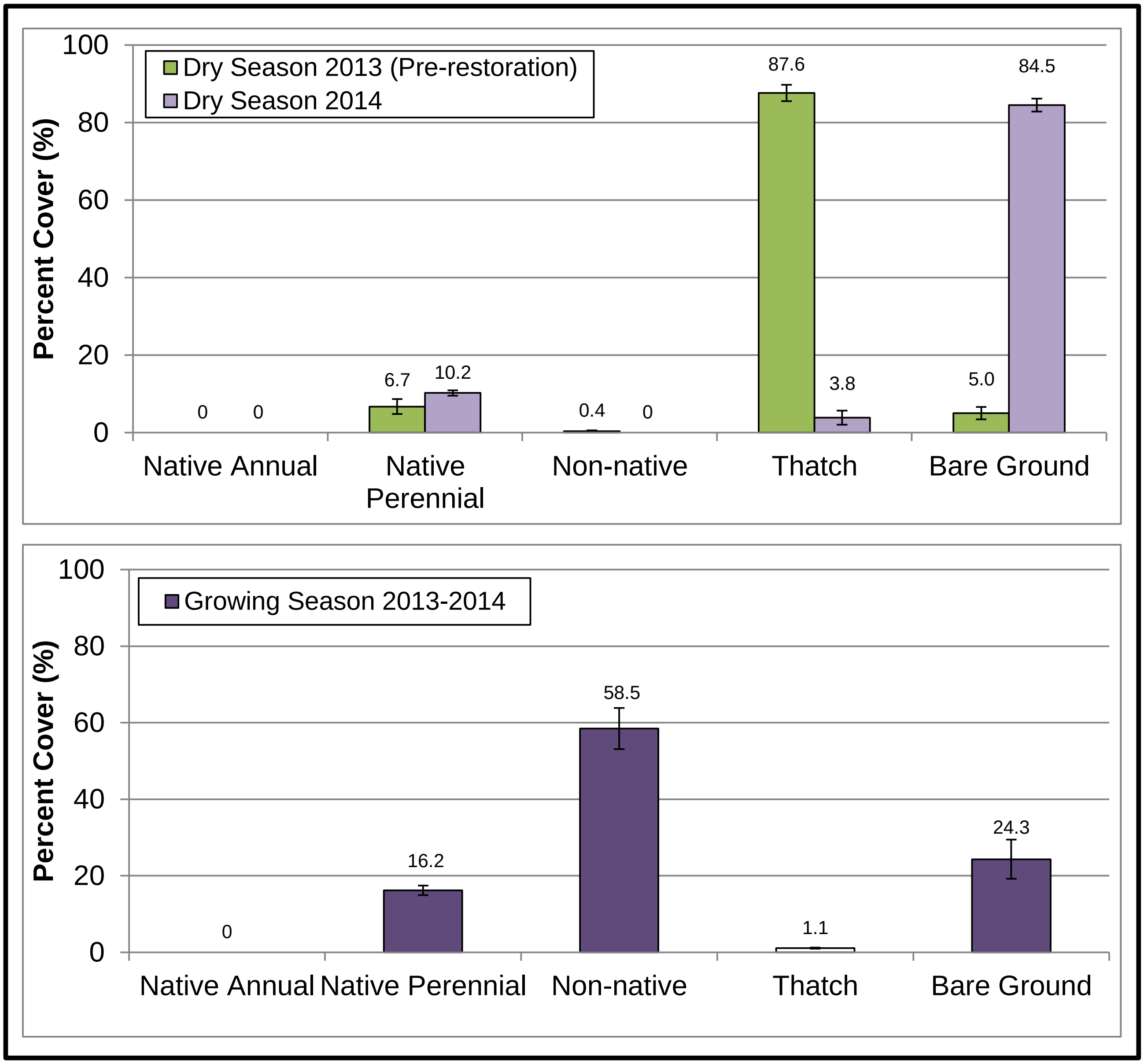

Figure 67: Changes in cover in the original 2013 subplots at NTP.
Top: dry season. Bottom: growing seasons. Data comes from 13 subplots, 10 X 10 m each. Thin bars represent standard error.

Figure 68: Overview photopoint of the original 2013 subplots at NTP.
Top: October 2013 (pre-restoration). Bottom left: September 2014. Bottom right: January 2015. Note the increase in bare ground and the decrease in thatch between October 2013 and September 2014, the increase in native plant cover and diversity year-round, and the extensive cover of non-native Cheeseweed in January 2015.

NTP 2014 Expansion Subplots: n = 7

The pre-restoration cover survey for the 2014 Expansion at NTP was done during the 2014 dry season. Subplots were dominated by thatch (90.0±1.3%), with a small cover of native perennials (5.9±1.2%; Figure 69). Figure 70 shows a picture taken during the outplanting.

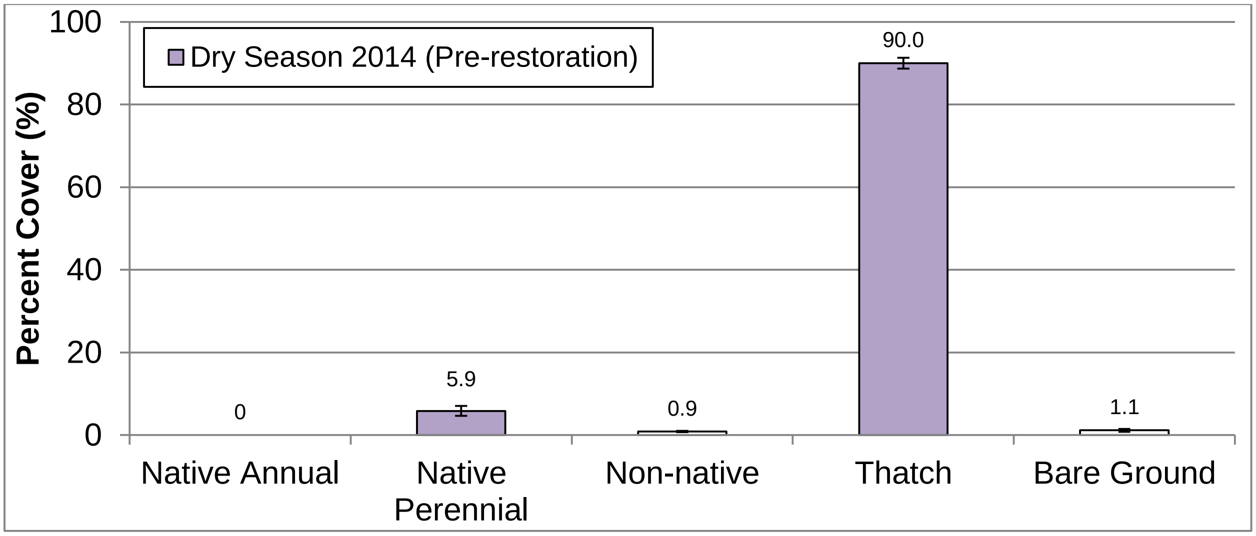

Figure 69: Pre-restoration cover in the 2014 expansion subplots at NTP.
Data comes from 7 monitored subplots, 10 X 10 m each. Thin bars represent standard error.

Figure 70: Photopoint of the 2014 expansion subplots at NTP (November 2014 planting).
Flags indicate the location of plants that were outplanted shorty after this picture was taken.

Native Genera Richness

At NTP, the average native genera richness per subplot increased following restoration in the original 2013 subplots (n=13). The 2013 and 2014 dry season data correspond to the pre-restoration richness in the original 2013 subplots and 2014 expansion subplots, respectively (Figure 71).

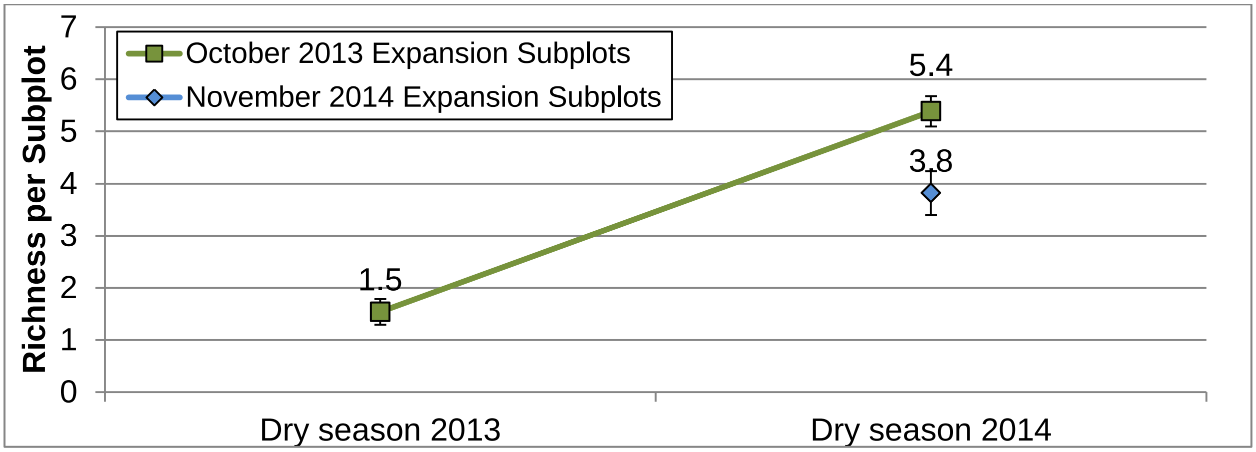

Figure 71: Native species richness during the dry season at NTP.
Thin bars represent standard error.

Survival

No survival data is available for NTP.

Growth

No data on species growth is available for NTP.

III.II.VI North East Flats Restoration Plot (NEF)

Outplantings

NEF was first established in December 2007 (6,000 m^2; 1.48 ac), expanded downhill (east) in December 2010 (2,800 m^2; 0.69 ac), November 2011 (100 m^2; 0.02 ac), and December 2012 (100 m^2; 0.02 ac), and expanded north in November 2014 (4,000 m^2; 0.99 ac). The plot was divided into 130 subplots of 10X10 m.

The first planting took place in December 2007 when 690 plants were put in the ground in the initial 60 subplots. In November 2008, 735 more plants were added to this area and 953 in November 2009. In December 2010, 1,618 plants were added to the 2010 expansion. In November 2011, 1,516 plants were added to the gully within NEF; an additional 1,625 plants were added to the same area in December 2012. In Fall 2012, 474 plants (mainly Sagebrush) were added to original 2007 subplots. When the area was expanded north in November 2014, 3,121 plants were added to the 2014 expansion. As of the end of 2014, NEF covered a total of 13,000 m^2 (3.21 ac), with over 10,700 outplanted plants (Figure 72). The November 2014 expansion subplots at NEF were watered with drip irrigation. All other subplots were hand-watered.

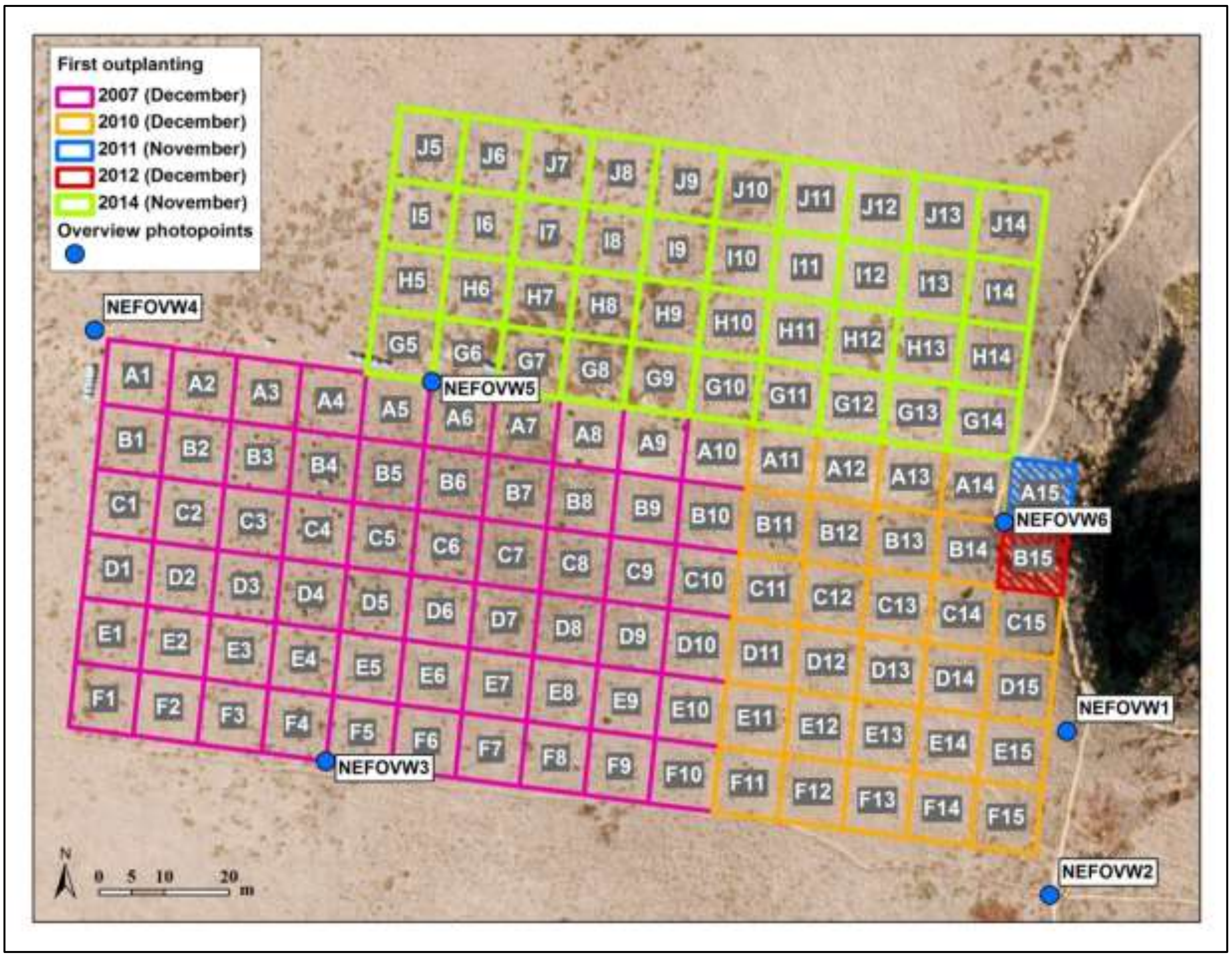

Figure 72: Map of NEF.

The initial plot location is indicated in pink (December 2007) and further expansions in orange (December 2010), dark blue (November 2011), red (December 2012), and green (November 2014). Cross- hatched sections were not surveyed, but were maintained.

Percentage Cover

NEF Original 2007 Subplots: n = 60

The cover of native perennials in the original 2007 subplots at NEF appeared to have slightly declined between the 2007 dry season and the 2014 dry season (Figure 73). Non-native cover and thatch also declined, while bare ground increased. No cover survey was taken during the growing season 2011-2012 because subplots were weeded all winter. No survey was taken during the growing season 2012-2013 (logistical issues). The cover of natives and non-natives declined between the 2009-2010 and 2013-2014 growing seasons. However, photopoints show an increase in native cover (Figure 73).

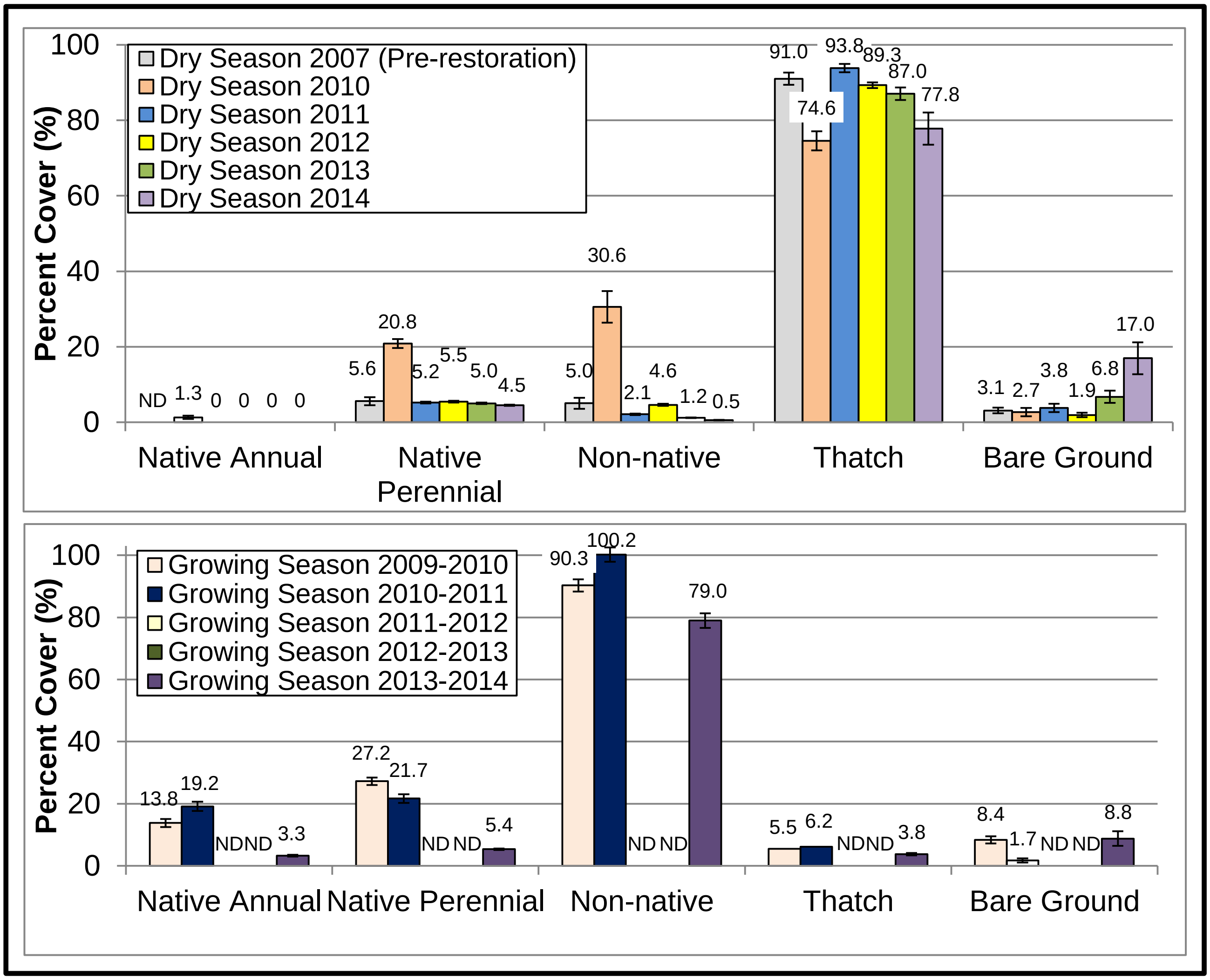

Figure 73: Changes in cover in the original 2007 subplots at NEF.
Top: dry season. Bottom: growing seasons. Data comes from 60 subplots, 10 X 10 m each. Thin bars represent standard error.

Figure 74: Overview photopoint of the original 2007 subplots at NEF.

Top: September 2007 (pre-restoration). Bottom left: November 2014. Bottom right: January 2015. Note the increase in native plant cover and native plant diversity year-round and the vast Iceplant cover in 2015.

NEF 2010 Expansion Subplots: n = 28

According to the data, the cover of native perennials in the 2010 expansion subplots at NEF remained similar to pre-restoration conditions. However, photopoints contradict the data. Photopoints show an increase in Nevin's Wooly Sunflower and an increase in the number of Giant Tickseed (Figure 75-77). The data also show a drastic decline in the cover of non-native species, a moderate decline in the cover of thatch and an increase in bare ground. The cover of non-natives was still high during the growing season 2013-2014, despite three years of restoration. No cover survey was taken during the 2010-2011, 2011-2012, and 2012-2013 growing seasons.

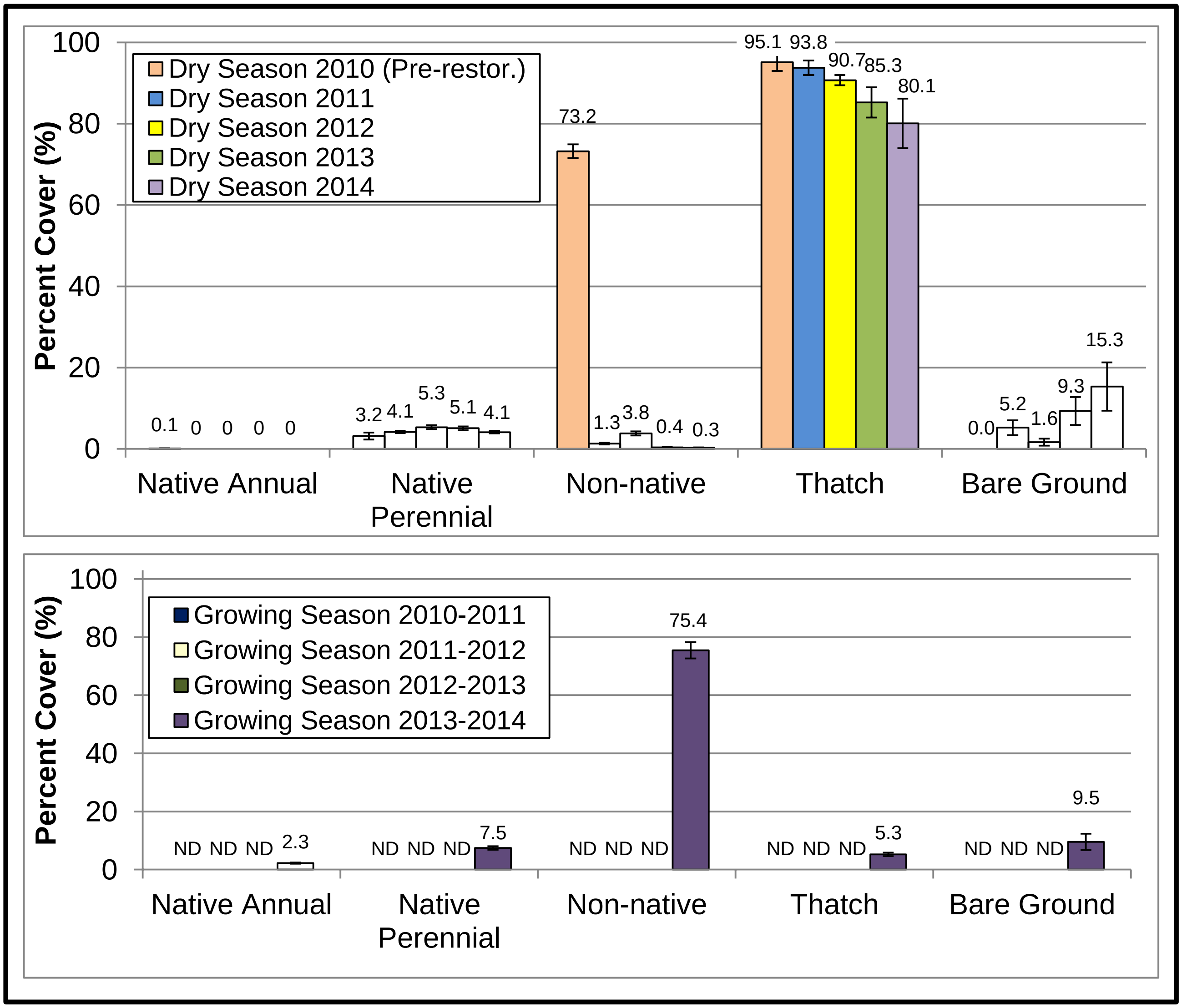

Figure 75: Changes in cover in the 2010 expansion subplots at NEF.
Top: dry season. Bottom: growing season. Data comes from 28 subplots, 10 X 10 m each. Thin bars represent standard error.

Figure 76: Photopoint of subplot D12 at NEF.
Top: November 2010 (pre-restoration). Bottom left: March 21014. Bottom right: September 2014. Note the increase in native plant cover and native plant diversity.

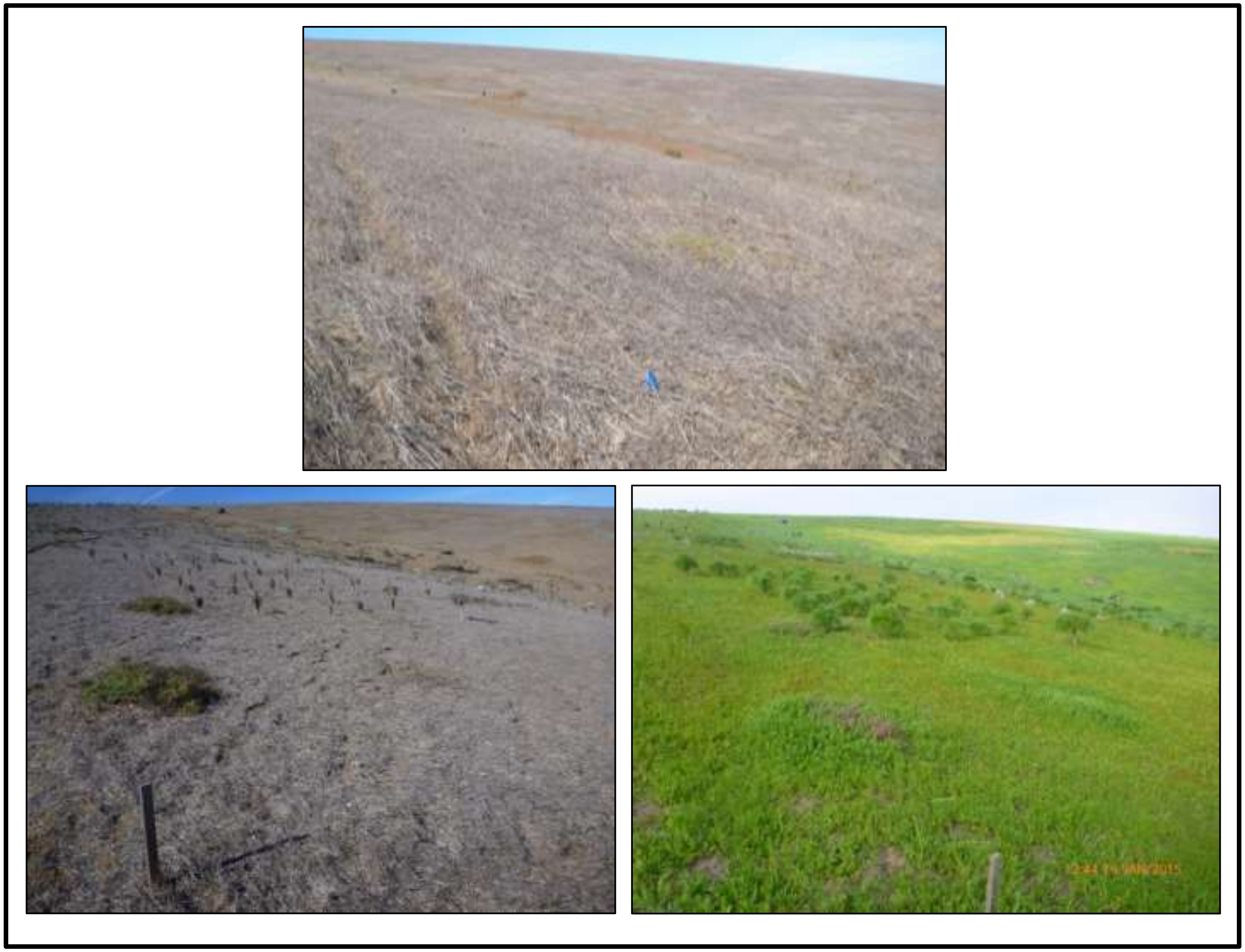

Figure 77: Overview photopoint of the 2010 expansion at NEF.
Top: September 2007 (pre-restoration), bottom left: November 2014, bottom right: January 2015. Note the increase in the number of Giant Tickseed, but the still prominent non-native cover.

NEF 2014 Expansion Subplots: n = 40

In fall 2014, prior to the onset of restoration, the 2014 expansion subplots at NTP were dominated by thatch, with some bare ground and very little native cover (Figure 78). Figure 79 is a picture of a typical subplot pre-restoration.

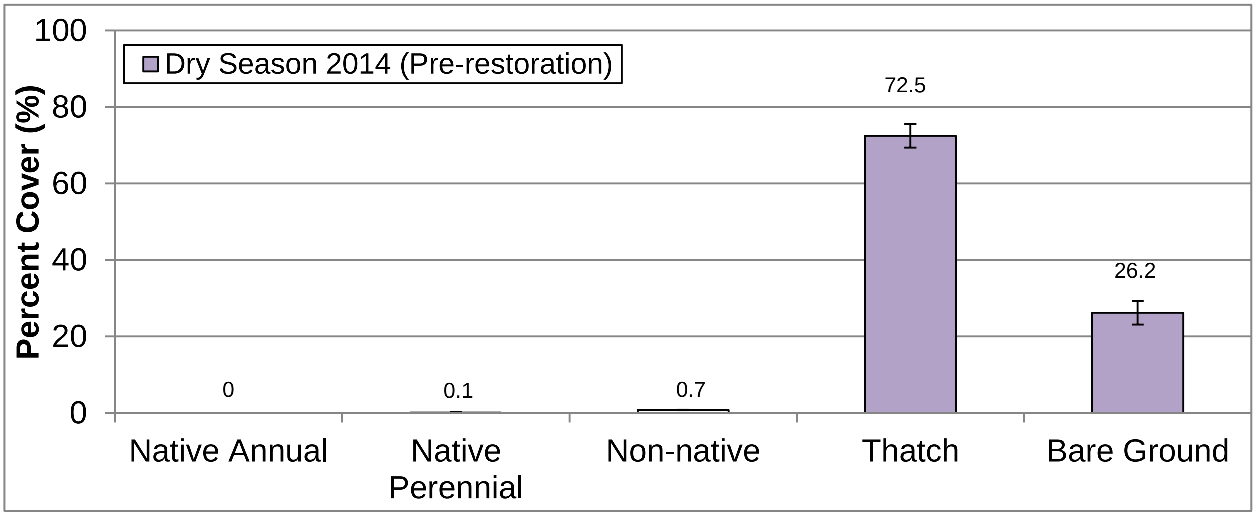

Figure 78: Cover during the 2014 dry season in the 2014 expansion subplots at NEF. Data comes from 40 subplots, 10 X 10 m each. Thin bars represent standard error.

Figure 79: Photopoint of subplot H10 at NEF in November 2014 (pre-restoration). This subplot is representative of the 2014 expansion subplots, with a high cover of thatch, some bare ground, and no native species.

Genera Richness

The average native genera richness per subplot in the 2010 expansion at NEF increased from less than 1 native genera per subplot (pre-restoration) to ~3.5 genera per subplot following the onset of restoration (n=28; Figure 80). The 2014 expansion subplots had an average richness close to zero per subplot pre-restoration (n=40).

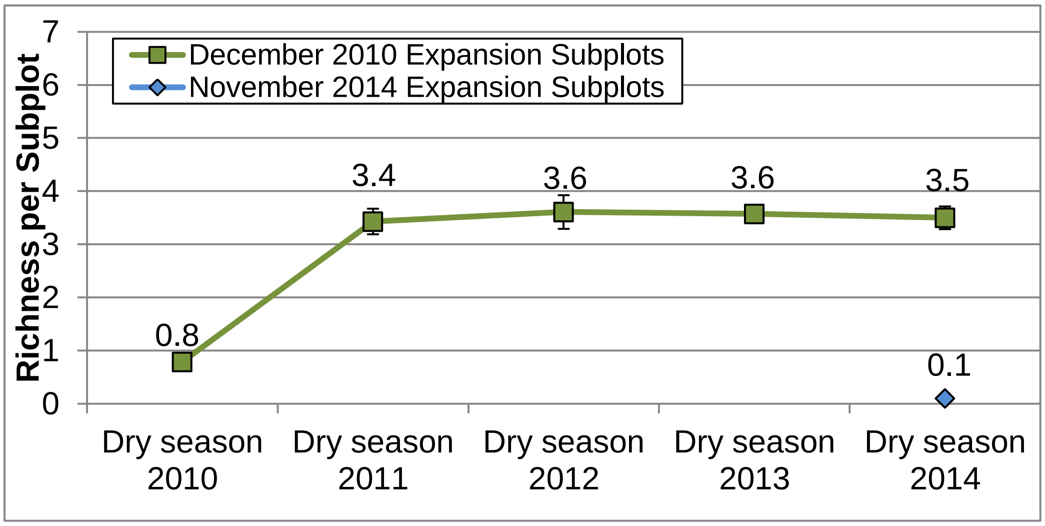

Figure 80: Native genera richness at NEF.
Thin bars represent standard error.

Survival

Survival rates of planted plants were obtained for NEF. Plants were outplanted in November 2009 and survival data was taken in June 2010 (Table 9). Island Morning-Glory exhibited the highest survival rate at 93%. Other species monitored survived the seven month periods with survival rates between 68 and 79%.

Species	# Outplanted in Nov 2009	# Alive in Jun 2010	Survival rate (%)
CAMA	116	108	93
COGI	147	116	79
CONE	200	155	78
ERGC	294	200	68
TOTAL	757	579	76

Table 9: Outplanted plants survival rates at NEF between November 2009 and June 2010.

We also recorded the survival rates of tagged plants. Two set of tags were installed at NEF. The first set of tags consisted of ten tags per subplot (tags 1-10; 600 tags total), affixed in Fall 2007 to plants outplanted the same season. Survival for these tagged plants was assessed in January 2009 and October 2010. Out of 600 tags installed, 23 were not relocated in January 2009 and 147 in October 2010 (Table 10).

Species	Fall 07	Jan 09						Oct 10					
	Tagged	Alive		Dead		Tag not found		Alive		Dead		Tag not found	
	#	#	%	#	%	#	%	#	%	#	%	#	%
COGI	160	129	81	30	19	1	1	112	70	31	19	17	11
CONE	140	84	60	55	39	1	1	46	33	55	39	39	28
ERGC	170	76	45	91	54	3	2	36	21	96	56	38	22
SUTA	130	70	54	42	32	18	14	17	13	60	46	53	41
Total	600	359	60	218	36	23	4	211	35	242	40	147	25

Table 10: Survival rate of tagged plants at NEF – Tags 1-10 series.

The second set of tags consisted of 78 tags (100 series), affixed in January 2009 to plants outplanted November 2008. Survival for these tagged plants was assessed in January and December 2010. Out of 78 tags installed, ten were not relocated 12 months later and 20 were not relocated 21 months later (Table 11).

Species	Jan 09	Jan 10						Oct 10					
	Tagged	Alive		Dead		Tag not found		Alive		Dead		Tag not found	
	#	#	%	#	%	#	%	#	%	#	%	#	%
ACMI	20	8	40	9	45	3	15	6	30	10	50	4	20
COGI	20	8	40	9	45	3	15	6	30	11	55	3	15
CONE	7	5	71	1	14	1	14	4	57	1	14	2	29
ERGC	19	15	79	1	5	3	16	9	47	3	16	7	37
SUTA	12	10	83	2	17	0	0	4	33	4	33	4	33
Total	78	46	59	22	28	10	13	29	37	29	37	20	26

Table 11: Survival rate of tagged plants at NEF – Tags 100 series.

Growth

In January 2009 and October 2010, we measured the height and width of plants tagged between October and December 2007. Only data from species that had at least 5 plants that were relocated and alive during these three surveys were included in Figure 81. ACMI and COGI were not included due to inconsistencies in measurement methods.

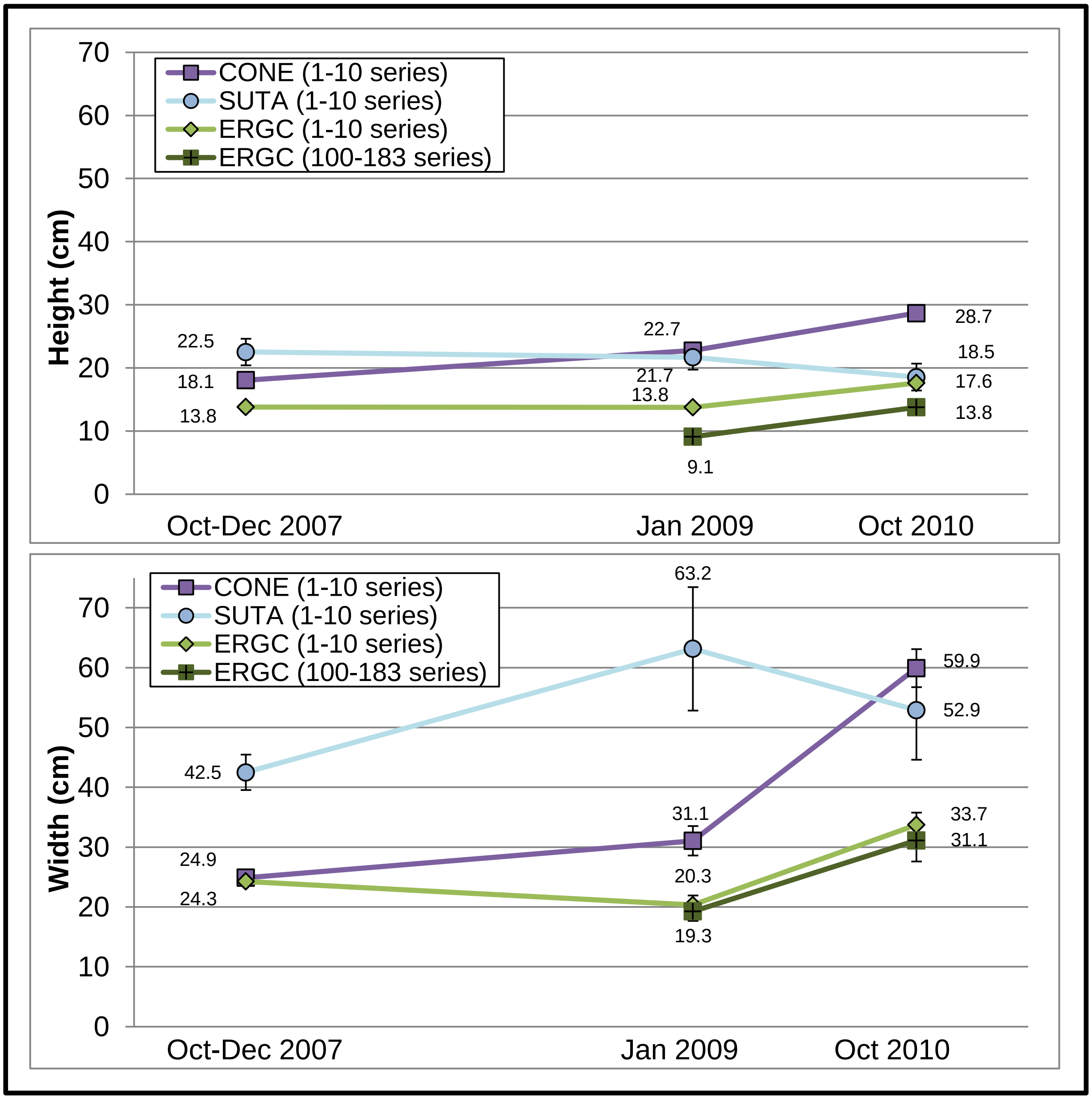

Figure 81: Tagged plant growth at NEF.
Note that only plants that were found alive and measured in all surveys were included. Sample size: 44 CONE from 1-10 series, 36 ERGC from 1-10 series, 9 ERGC from 100-183 series, and 15 SUTA from 1-10 series.

III.II.VII Summary for All Restoration Plots

Outplantings - Summary

Over 29,000 plants have been outplanted in restoration plots between 2007 and 2014 (Table 12). By the end of 2014, restoration plots covered 31,200 m^2 (7.71 acres; Table 13).

Plot	Year	ARXX	ACMI	ATCA	CAMA	COGI	CONE	DECL	ERGC	LYCA	OPXX	SPMA	STXX	SUTA	ND	TOTAL
BHP																
	2011	41	138	496	35	40	242	0	0	19	0	0	0	162	0	
	2012	141	386	377	35	0	455	0	0	0	166	0	0	253	0	
	2013	0	0	469	0	401	888	0	1087	0	0	0	0	198	0	
		182	**524**	**1342**	**70**	**441**	**1585**	**0**	**1087**	**19**	**166**	**0**	**0**	**613**	**0**	6029
ESC																
	2008	0	82	0	17	24	145	0	514	0	0	0	0	60	102	
	2009	0	319	71	0	77	120	0	616	0	0	0	0	24	0	
	2010	0	401	226	113	0	149	0	441	0	40	0	0	200	0	
	2011	44	376	228	106	225	309	0	11	0	49	0	0	247	0	
		44	**1178**	**525**	**236**	**326**	**723**	**0**	**1582**	**0**	**89**	**0**	**0**	**531**	**102**	5336
HP																
	2007	0	8	0	0	3	53	3	55	0	0	0	0	36	0	
	2008	0	28	0	10	0	25	0	28	0	0	0	0	31	0	
	2009	0	0	0	0	0	0	0	0	0	15	0	0	0	0	
	2010	0	0	0	0	48	17	0	7	0	0	0	0	0	0	
	2012	0	4	0	4	0	275	0	0	0	26	0	0	0	0	
		0	**40**	**0**	**14**	**51**	**370**	**3**	**90**	**0**	**41**	**0**	**0**	**67**	**0**	676
LACO																
	2007	0	0	0	0	0	10	0	15	0	0	0	0	5	0	
	2008	0	0	0	0	0	3	6	9	0	0	0	0	0	0	
	2009	0	75	0	64	335	202	0	434	5	35	0	0	0	0	
	2011	121	501	22	21	455	672	2	26	8	6	0	0	168	0	
	2013	2	4	1	4	2	4	0	2	0	0	0	0	2	0	
		123	**580**	**23**	**89**	**792**	**891**	**8**	**486**	**13**	**41**	**0**	**0**	**175**	**0**	3221
NEF																
	2007	0	0	0	0	160	140	0	170	0	0	0	90	130	0	
	2008	0	195	0	149	106	30	0	147	0	0	0	0	106	2	
	2009	0	196	0	116	147	200	0	294	0	0	0	0	0	0	
	2010	3	150	0	6	772	513	0	0	0	77	0	96	1	0	
	2011	400	134	0	298	263	0	0	0	0	25	0	0	396	0	
	2012	661	324	134	85	261	325	0	1	2	0	0	0	306	0	
	2014	108	0	0	0	494	192	0	540	140	1549	0	0	98	0	
		1172	**999**	**134**	**654**	**2203**	**1400**	**0**	**1152**	**142**	**1651**	**0**	**186**	**1037**	**2**	10732
NTP																
	2013	730	664	56	30	187	338	0	261	20	0	7	1	79	0	
	2014	16	65	0	37	6	3	0	131	162	0	13	0	294	0	
		746	**729**	**56**	**67**	**193**	**341**	**0**	**392**	**182**	**0**	**20**	**1**	**373**	**0**	3100
Total		**2267**	**4050**	**2080**	**1130**	**4006**	**5310**	**11**	**4789**	**356**	**1988**	**20**	**187**	**2796**	**104**	29094

Table 12: Summary of outplantings by plot, year, and species.

Plot	Subplots Outplanted	Yearly Expansion (Square Meter)								Total Area (Square Meter)	(Acre)
		2007	2008	2009	2010	2011	2012	2013	2014		
BHP											
	November 2011 Original Subplots					3,000	X				
	November 2012 Expansion Subplots						2,500	X			
	December 2013 Expansion Subplots							2,250			
										7,750	1.92
ESC											
	November 2008 Original Subplots		2,000	X	X						
	November 2010 Expansion Subplots				2,000	X					
										4,000	0.99
HP											
	September 2007 Original Subplots	375	X	X	X		X				
	December 2012 Expansion Subplots						300				
										675	0.17
LACO											
	December 2007 Original Subplots	165	X	X							
	March 2008 Expansion Subplots		240	X		X					
	January 2009 Expansion Subplots			220		X		X*			
	December 2009 Expansion Subplots			320		X		X*			
	January 2011 Expansion Subplots					410					
	November 2011 Expansion Subplots					920					
										2,275	0.56
NEF											
	December 2007 Original Subplots	6,000	X	X		X**	X**				
	December 2010 Expansion Subplots				2,800	X**	X**				
	November 2011 Expansion Subplots					100	X**				
	December 2012 Expansion Subplots						100				
	November 2014 Expansion Subplots								4,000		
										13,000	3.21
NTP											
	October 2013 Original Subplots							2,500	X		
	November 2014 Expansion Subplots								1,000		
										3,500	0.86
		6,540	**2,240**	**540**	**4,800**	**4,430**	**2,900**	**4,750**	**5,000**	31,200	7.71

Table 13: Restoration plots dimensions as of December 2014.

Numbers represent restored area size in square meters. X represent areas where plants were in-filled (restoration started in those subplots during the previous years).

* Small outplanting to fill in where the middle CAAU artificial burrows were located.

** Outplanting in the gully area only.

Percentage Cover - Summary

We could not determine the average cover across plots because of different subplot sizes, different years of first outplanting, and different survey years. Because of that, we can only make general statements about cover changes through the years. First, the cover of native plants was higher in 2010 compared to other years. Second, data show that switching from systematic to grouped plantings at HP and NEF coincided with a greater increase in native cover following restoration. Third, more recently outplanted subplots exhibited a greater increase in native cover and a greater decrease in non-native cover than the first outplanted subplots. Fourth, the cover of thatch typically decreased following the onset of restoration, while the cover of bare ground increased. Finally, a greater increase in native cover at BHP was recorded in subplots where drip irrigation was installed compared to subplots that were hand-watered.

Native Genera Richness - Summary

Figure 82 summarizes changes in the average native plant genera richness per subplots. The figure shows data for all subplots with pre-restoration data and data for at least one dry season following the onset of restoration. To better illustrate changes in richness following restoration, the x-axis represents subplot age, where age “0” represents pre-restoration richness during the dry season immediately preceding outplanting, age “1” represents richness during the first dry season following the onset of restoration, and so on. All original subplots and expansion show an increase in their average genera richness per subplot following the onset of restoration.

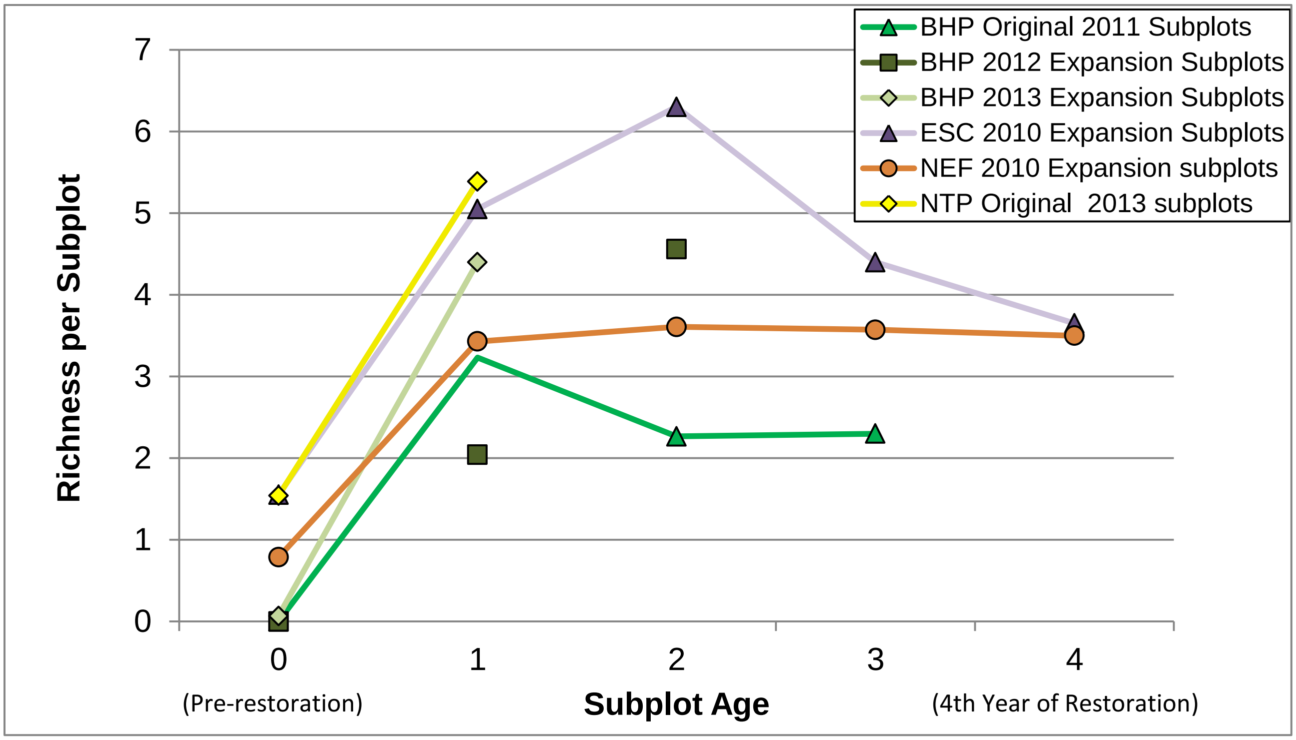

Figure 82: Changes in native plant genera.

Age "0" represents pre-restoration richness during the dry season, age "1" represents richness the first dry season following the onset of restoration, and so on.

Survival - Summary

Because of the difficulty in relocating tagged plants, the tag surveys gave poor estimates of species survival rates. Survivorship surveys gave better survival estimates. However, we did not observe general trends for species survival rates that applied for all plots and years. For example, California Saltbush had the highest survival rate at BHP (87% between December 2013 and September 2014), while it had the lowest survival rate at ESC (27% between November 2009 and May 2010).

Growth - Summary

Three trends in growth were observed across plots. First, Nevin's Wooly Sunflower tended to grow taller and wider than SBI Buckwheat. Second, measured plants did not always grow through time. Finally, Wooly Seablite displayed greater variation in growth from year to year, compared to other species measured.

III.III Other Restoration Work on SBI

III.III.I Coyote Brush: Population Monitoring

Anthropogenic activities on SBI have reduced Coyote Brush (*Baccharis pilularis*) to only a few remnant populations. Coyote Brush is a dioecious native plant, having male and female flowers on separate individuals. In 2011 and 2014, we mapped the location of Coyote Brush on SBI and sexed flowering plants (Figure 83, Table 14). No viable seeds were found, but attempts to propagate plants from cuttings were successful in 2014. Plants should be outplanted in Fall 2015.

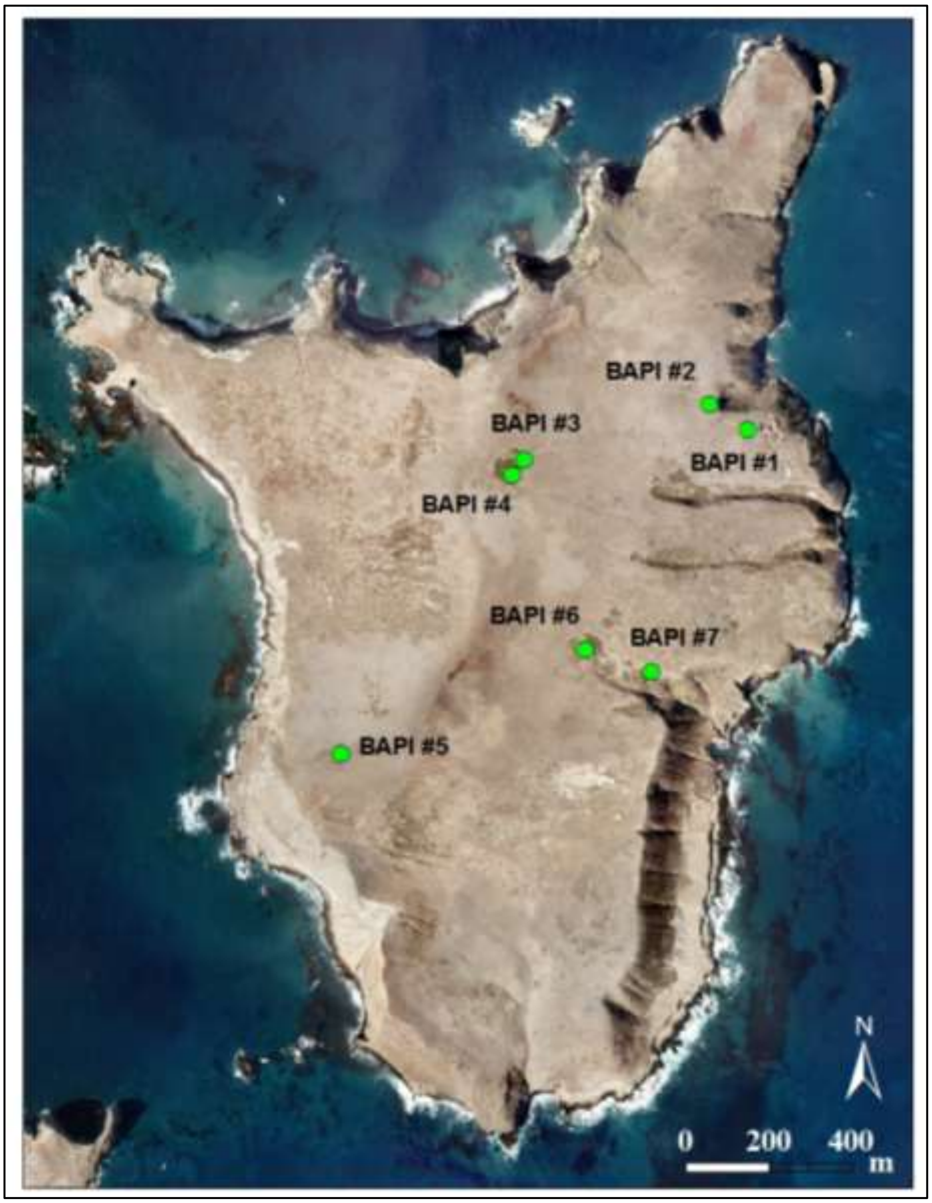

Figure 83: Coyote Brush populations on SBI.
Populations are indicated with green dots and labels correspond to those in Table 14.

Population	X-Coordinate	Y-Coordinate	Count		Sex	Note
			Jan-11	Sep-14		
1	311363	3706398	2	0	NA	Died between 2011 and 2014.
2	311270	3706461	1	0	NA	Died between 2011 and 2014.
3	310824	3706327	3	2 or 3	Male	Only 1 individual was flowering (sex of other individuals unknown).
4	310794	3706289	7	10	Male	Only 2 individuals were flowering (sex of other individuals unknown).
5	310382	3705616	1	1	Male	Only 1 individual was flowering (sex of other individuals unknown).
6	310970	3705868	10	4	Female	Only 1 individual was flowering (sex of other individuals unknown).
7	311131	3705814	NA	1	Female	2011: Individual not seen (either we missed it or it germinated afterwards). 2014: Individual looks very brown and unhealthy.

Table 14: Coyote Brush populations on SBI.
Population numbers correspond to labels on Figure 83.

III.III.II SBI Dudleya Monitoring

On December 10, 2013, our crew monitored the status of SBI Dudleya (*Dudleya traskiae*) populations on SBI. SBI Dudleya is an endangered species endemic only to SBI (Figure 84). Table 15 summarizes findings and Figure 85 through Figure 90 show DUTR populations on SBI.

Figure 84: Photos of SBI Dudleya from June 2015.

Coordinates		Population	Number of Individuals	Comments
Easting	Northing			
311525	3706215	Cave Canyon 1	15	South wall of canyon, near OPPR patch.
311520	3706213	Cave Canyon 1		
311515	3706213	Cave Canyon 1		
311562	3706098	Middle Canyon 1	1	South wall of canyon, about 20 meters from ocean. Multiple old pelican nests nearby.
311557	3705101	Middle Canyon 2	1	South wall of canyon, about 20 meters from ocean. Multiple old pelican nests nearby.
311556	3706086	Middle Canyon 3	1	South wall of canyon, about 20 meters from ocean. Multiple old pelican nests nearby.
311527	3706098	Middle Canyon 4	7	South wall of canyon, further upslope from population 1,2, and 3.
311520	3706081	Middle Canyon 4		
311525	3706081	Middle Canyon 4		
311524	3706080	Middle Canyon 4		
311535	3706080	Middle Canyon 4		
311523	3706075	Middle Canyon 5	1	
311490	3706116	Middle Canyon 6	>100	North wall of canyon above barn owl cave.
311496	3706122	Middle Canyon 6		
311491	3706126	Middle Canyon 6		
311488	3706126	Middle Canyon 6		
311479	3706114	Middle Canyon 7	~60	Close to population 6; separated by a patch of bare earth.
311480	3706115	Middle Canyon 7		
311485	3706118	Middle Canyon 7		
311486	3706111	Middle Canyon 7		
311489	3706118	Middle Canyon 7		
311475	3706092	Middle Canyon 8	~80	South wall of canyon. Up-canyon from 6 and 7. Some individuals were very small.
311467	3706086	Middle Canyon 8		
311461	3706086	Middle Canyon 8		
311464	3706091	Middle Canyon 8		
311462	3706089	Middle Canyon 8		
311461	3706084	Middle Canyon 8		
311177	3706079	Middle Canyon 9	1	
311166	3706070	Middle Canyon 10	7	
311162	3706071	Middle Canyon 11	1	Tagged "DUTR 138-7-06".
311142	3706070	Middle Canyon 12	2	No tag, but flagged.
311136	3706071	Middle Canyon 13	1	Tagged "DUTR 133".
311116	3706074	Middle Canyon 14	1	No tag.
311116	3706076	Middle Canyon 15	2	Tagged "DUTR 128".
311104	3706078	Middle Canyon 16	5	Tagged "DUTR 119 '98".
311526	3705879	Graveyard Canyon 1	1	Between Graveyard and Middle canyons. On the bottom of slope by cliff edge.
310802	3704778	Cat Canyon 1	8-10	In a band along cliff edge, extending 10 meters West from this UTM coordinate.
310793	3704745	Cat Canyon 2	1	
310748	3704782	Cat Canyon 3	2	
310645	3704838	Cat Canyon 4	>100	Patch extending South from this UTM coordinate to cliff edge. Some individuals were very small.
310669	3704823	Cat Canyon 4		
310384	3705393	Signal Peak	7	About 10m downslope from Signal Peak trail.
311446	3707010	Between Sin Nombre and ArchPoint	2	There were also about six dead plants. This population was marked with large nails/flagging.

Table 15: Wild populations of SBI Dudleya on SBI.

GPS coordinates are in NAD83. If more than one set of coordinates are given for a population, the coordinates outline the polygon within which the population was located. The table does not include known outplanted populations around housing and along Landing Cove trail.

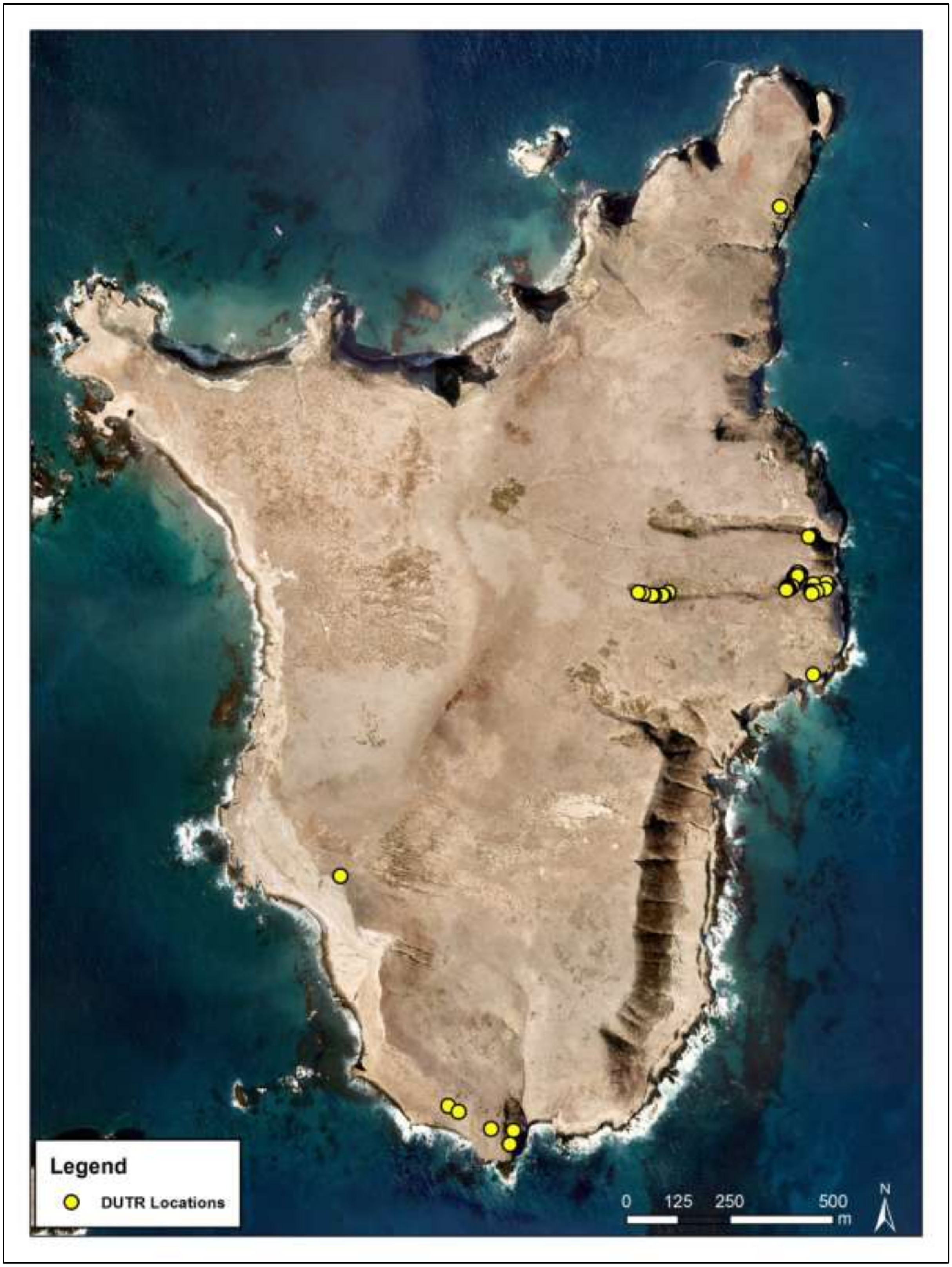

Figure 85: Overview of DUTR locations surveyed on SBI in December 2013. Outplanted populations around housing and along Landing Cove trail were not surveyed.

Figure 86: SBI Dudleya population at Cave Canyon.
A total of 15 individuals were located.

Figure 87: SBI Dudleya population between Middle and Graveyard Canyons.
Only 1 individual was located.

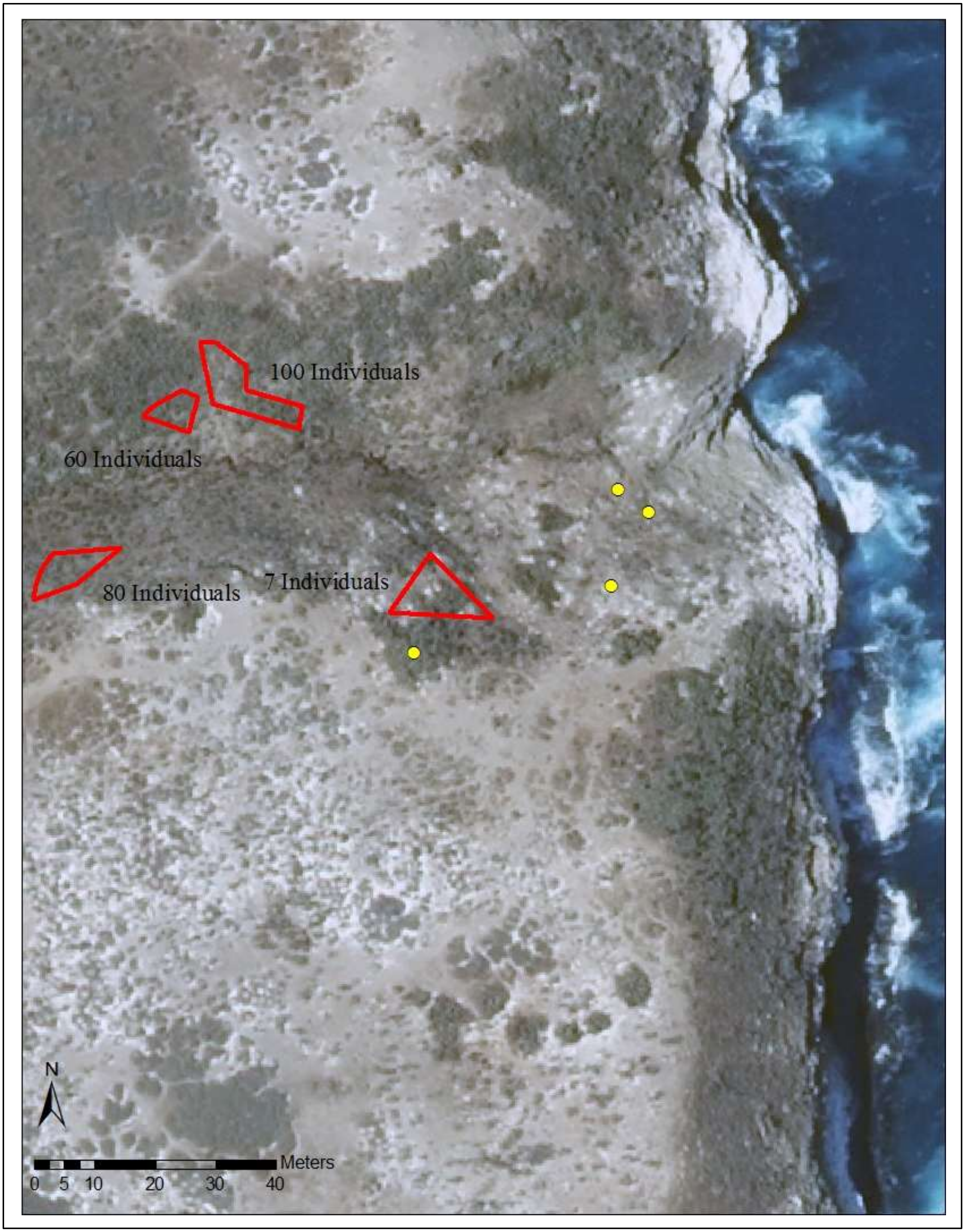

Figure 88: SBI Dudleya population at Middle Canyon (map 1 of 2).
Over 250 individuals were located.

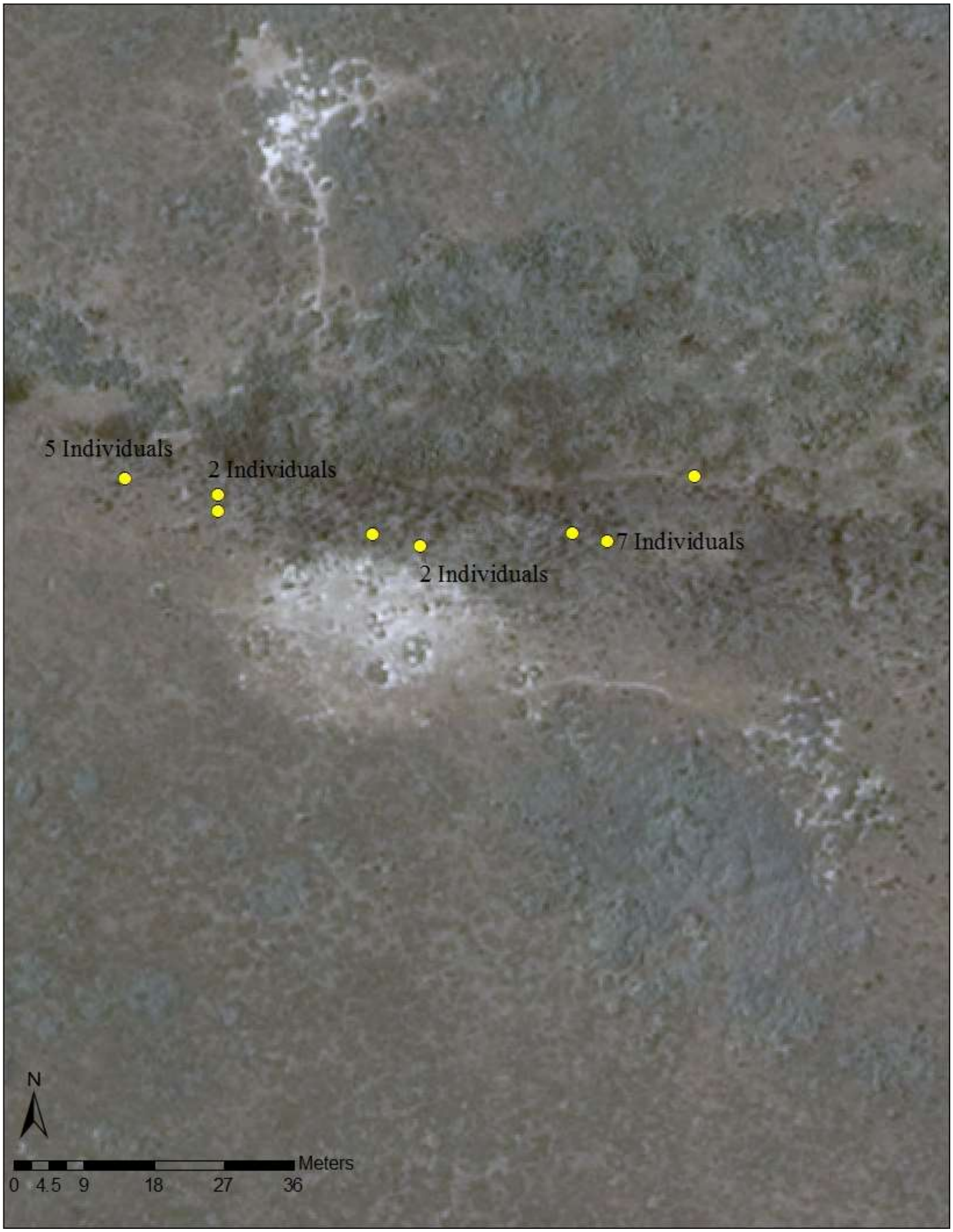

Figure 89: SBI Dudleya population at Middle Canyon (map 2 of 2).
A total of 20 individuals were located. Some of these populations were tagged/ flagged.

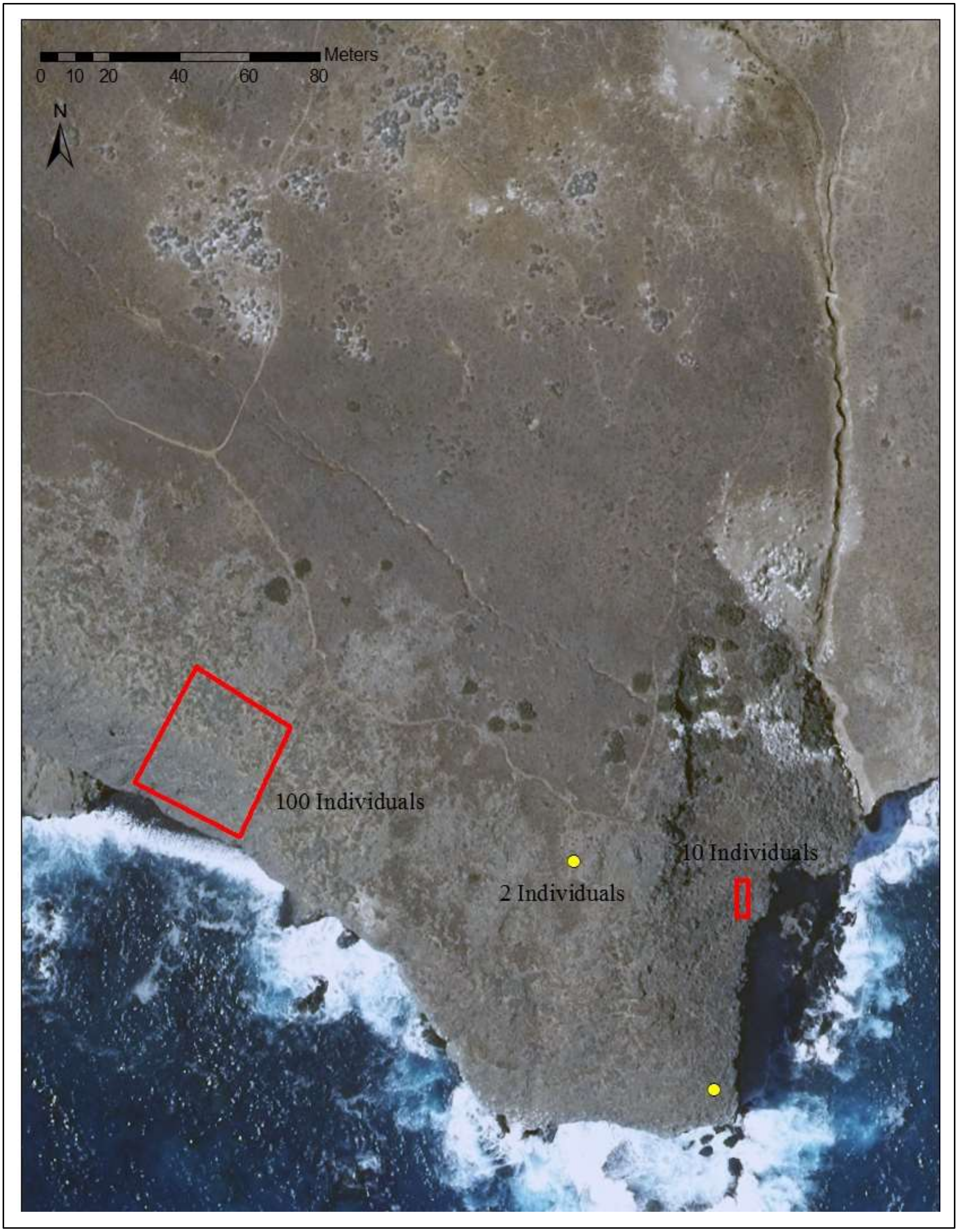

Figure 90: SBI Dudleya population at Cat Canyon.
Over 120 individuals were located.

III.III.III Tocalote Removal

Tocalote (*Centaurea melitensis*) is a non-native annual species from southern Europe (Figure 91). It invaded disturbed areas in California, including grasslands. Tocalote was first reported on SBI in 1963 (Philbrick 1972, Halvorson 1992); it was found in Landing Cove, on the terrace at the head of Cat Canyon, and on the northwest slope of Signal Peak (Junak et al. 1993). It was reported again in 1968, between Landing Cove and the bunkhouse (Philbrick 1972). According to Junak et al. (1993) "This taxon was spreading before eradication efforts began in 1984". Eradication efforts were thought to have extirpated Tocalote from SBI by 1997 (Junak et al. 1997). However, the species was rediscovered on SBI in the NEF restoration plot in March 2008. It was very dense in a 10 X 30 m area corresponding to subplots D10, E10, and F10. In an attempt to control the invasion, MSRP staff hand-pulled individuals, but did not have time to remove all. In April 2008, Tocalote was also found in Landing Cove along the NNE-facing slope above the dock trail. All plants were removed; none were flowering.

Figure 91: Tocalote.
Seedling (left) and mature plant (right). Photo credit: M.L. Charters, University of Wisconsin- Stevens Point (right).

The next Tocalote sighting dated from June 2010, in subplots D10 to F10 at NEF. All individuals were removed by hand; over 100 plants were pulled, ranging from small seedlings to seeding plants. Another individual was found within 50m north of the gully and was removed. In February 2011, 400 small seedlings were found in subplots D9, F9, and D10 through F10. For the rest of 2011, MSRP staff regularly surveyed NEF for Tocalote and hand-pulled all individuals found (on average once every other week) until less than five seedlings were found. Plants with flower buds were bagged and discarded. A total of 44.5 hours were spent removing thousands of individuals from NEF between February and June 2011 (Figure 92). Most individuals were found in subplot E10.

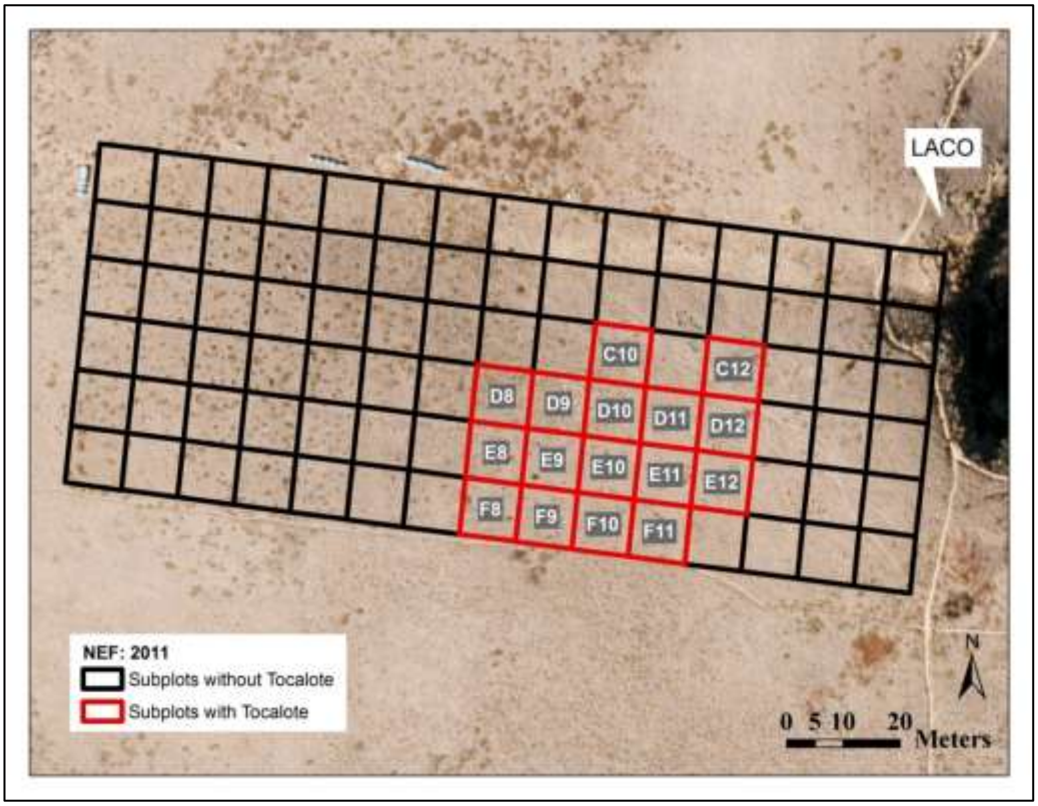

Figure 92: Tocalote sightings in NEF, winter/spring 2011.

In Winter 2011-2012, the first seedlings were observed on January 10 (location and removal efforts unknown). Two more seedlings were observed in subplot E10 at NEF on January 18. A two-hour removal survey was conducted at the beginning of February; subplots in rows 7-12 were searched at NEF and most Tocalote were found in subplot E10. Another survey was conducted mid-March. One hour was spent surveying rows 9 and 10; 17 individuals were found in E10, 25 individuals in E9, 9 individuals in D9, and 3 in D10. No survey has been conducted since 2012, but individuals were removed when spotted afterwards. In 2012 and 2013, staff weed-whacked the entire plot early so most individuals would have been removed then. Staff never found more than 1-2 individuals at a time after weed-whacking and were careful to weed-whack all the way to the ground until bare dirt was seen.

Hand-pulling from roots is the preferred control method for Tocalote on SBI, especially when plants have flower heads. Herbicide spraying could be effective at reducing infestations, as long as plants are sprayed at the seedling stage of development. Weed-whacking can reduce infestations if done at the seedling stage, but plants need to be weed-whacked to bare ground. Otherwise, weed-whacking can promote flower head development.

III.III.IV Shepherd's Purse Removal

A non-native species of the mustard family, Shepherd's Purse (*Capsella bursa-pastoris*), was first discovered on SBI by MSRP staff in February 2010 (Figure 93). Between February and March 2010, patches were found along the Landing Cove trail, close to the shop, mid-way up the trail to Signal Peak from North Peak, and in the campground. Most of the plants found were between the flowering and dehisced stages of development. The invasion likely spread from the campsite closest to housing. All Shepherd's Purse plants found were pulled by the roots, collected, and removed from the island. Several specimens were delivered to Sarah Chaney for archival.

Figure 93: Shepherd's Purse.
Illustration credit: USDA-NRCS PLANTS Database / USDA NRCS. Wetland flora: Field office illustrated guide to plant species. USDA Natural Resources Conservation Service.

Approximately 60 hours were spent surveying and removing hundreds of individuals during the 2010-2011 growing season and approximately 20 hours during the 2011-2012 growing season. No removal efforts took place during the 2012-2013 growing season. Weeds in part of the campground area were sprayed with a mixture of dish soap, vinegar, salt and water in March 2014.

In 2010 and 2011, plants first emerged in December and were last seen emerging in May. At the beginning of February 2012, Shepherd's Purse was found in a new location in Landing Cove: along the water pipeline connecting the dock water intake to the main water pipe system.

Hand-pulling from the roots is the preferred control method on SBI. An attempt to control Shepherd's Purse using herbicide (vinegar mixed with salt and soap) was not successful. Figure 94 shows Shepherd's Purse known locations on SBI.

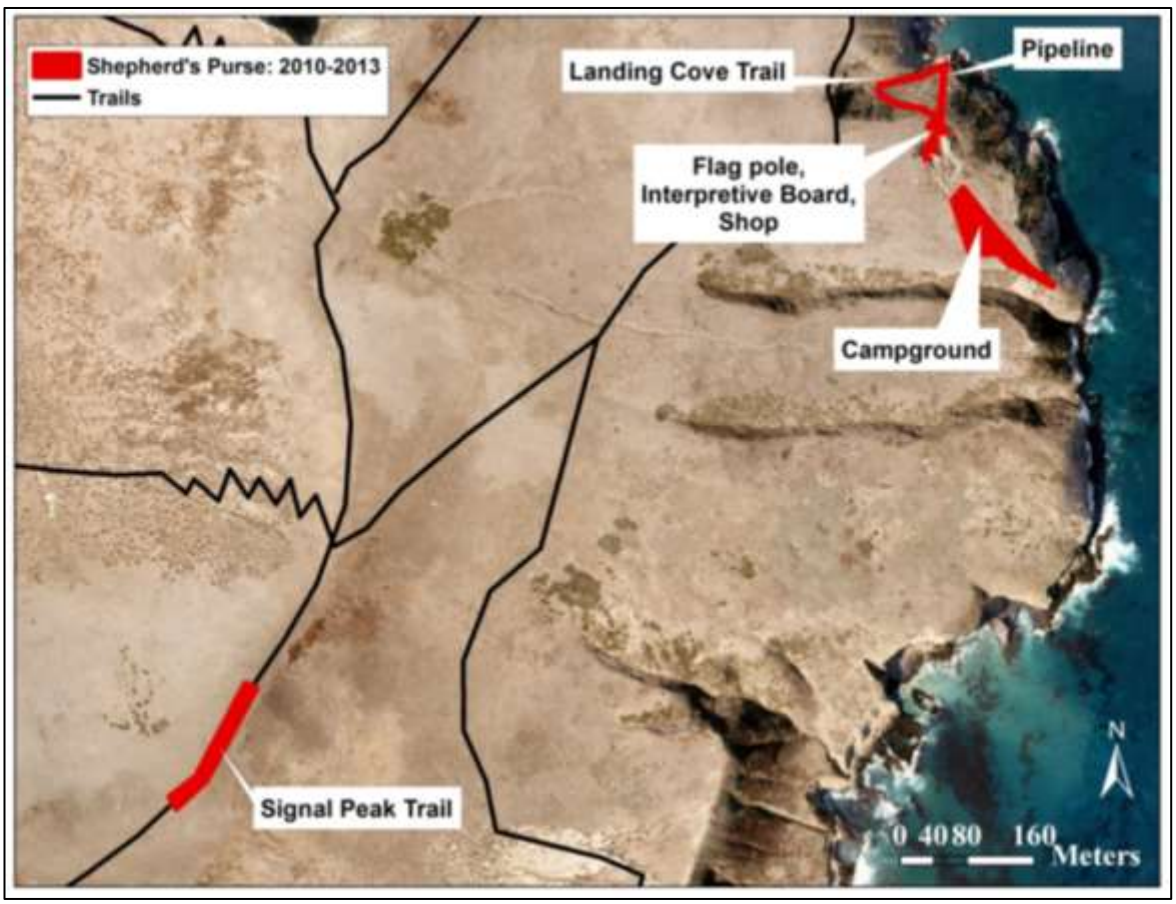

Figure 94: Shepherd's Purse populations on SBI, 2007-2013.
The population along the trail to Signal Peak is located around the following GPS coordinate: 310,562E; 3,705,713N (NAD83).

III.III.V Canary Grass Removal

CIES personnel remove Canary Grass (*Phalaris minor*) on SBI in 2010 and 2012 (Figure 95). Canary grass, which is native to the Mediterranean, is invasive in many U.S. states. On SBI, Canary Grass has been found in several locations: around housing, around the lower grow-out area, along the Landing Cove trail, in several spots along the trail to Cat Canyon, and around Middle Canyon. Control methods included hand pulling and bagging flowering and seeding plants from the roots or weed-whacking non-reproductive plants. Twenty-four hours were spent hand pulling Canary Grass during the 2010-2011 growing season and 14.5 hours were spent hand pulling and weed-whacking plants during the 2011-2012 growing season. Targeted Canary Grass removal efforts stopped in 2012 because eradication seemed unlikely.

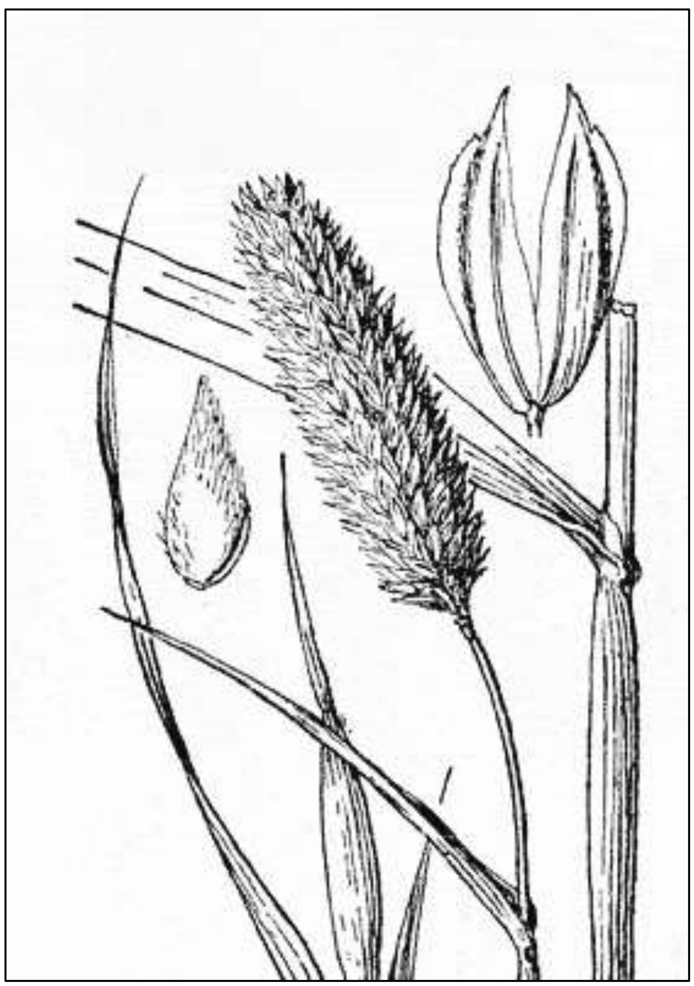

Figure 95: Canary Grass.

Illustration credit: Hitchcock, A.S. (rev. A. Chase). 1950. Manual of the grasses of the United States. USDA Miscellaneous Publication No. 200. Washington, DC.

III.III.VI Landscaping

To safeguard against unexpected mortalities in the nursery, we typically grew more plants than needed for outplantings in restoration plots. When we had extra plants, we planted them around infrastructures or around trails for landscaping, erosion control purposes, or for trial plantings (

Figure 96 and Figure 97). For example, a trial planting was done at Arch Point in March 2008 to determine whether smaller plants could survive without being watered (most plants died shortly after planting). All plants outplanted outside restoration plots have been called "landscaping plants", regardless of their outplanting purpose. Over 2,800 landscaping plants have been outplanted between 2007 and 2014 (Table 16). In Fall 2011, landscaping overview photopoints were established to document changes in the landscaping around housing (refer to the protocol in Appendix VIII). Figure 98 through Figure 101 show the most noticeable changes in landscaping between 2011 and 2014.

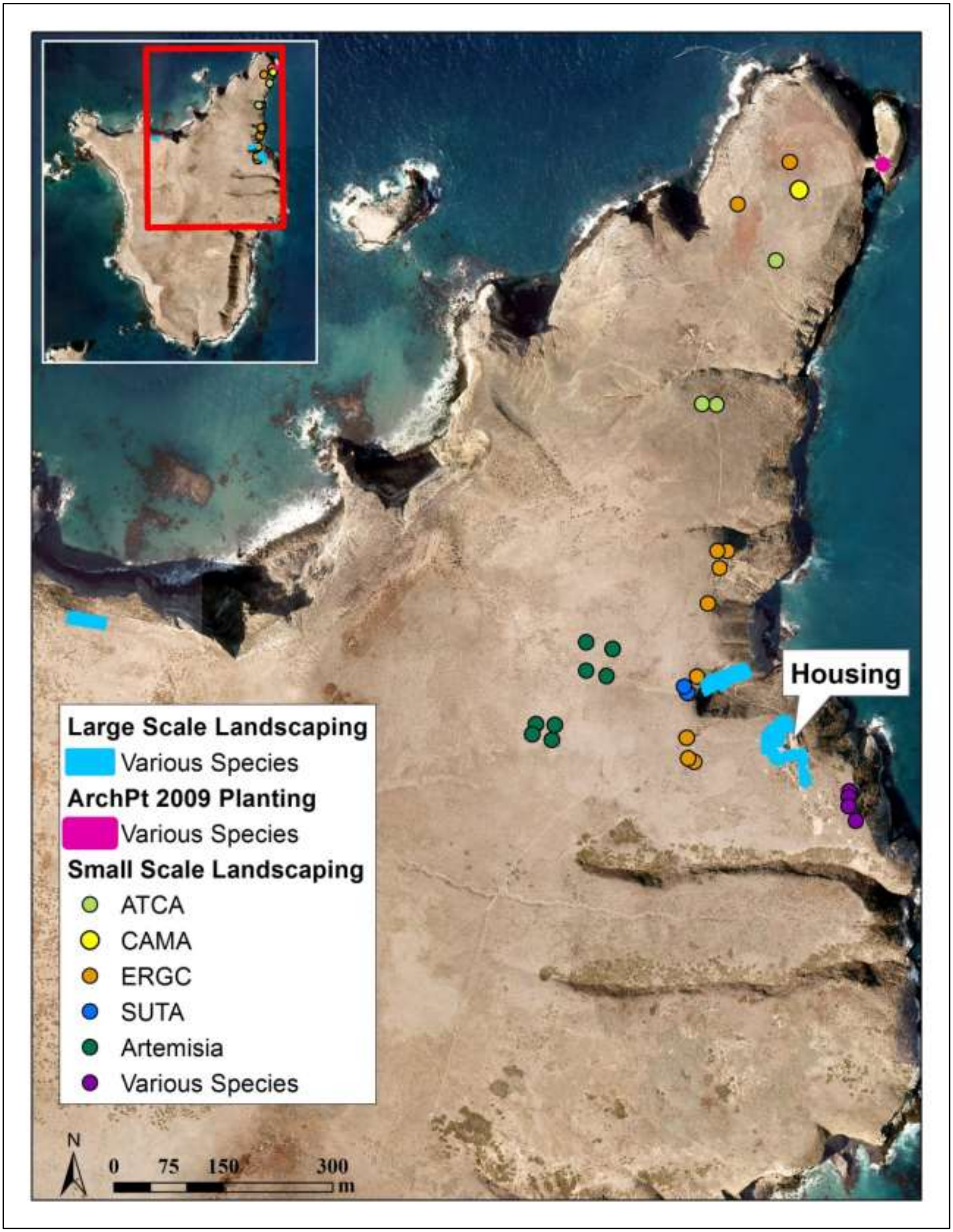

Figure 96: Location of landscaping plants, 2007-2014.

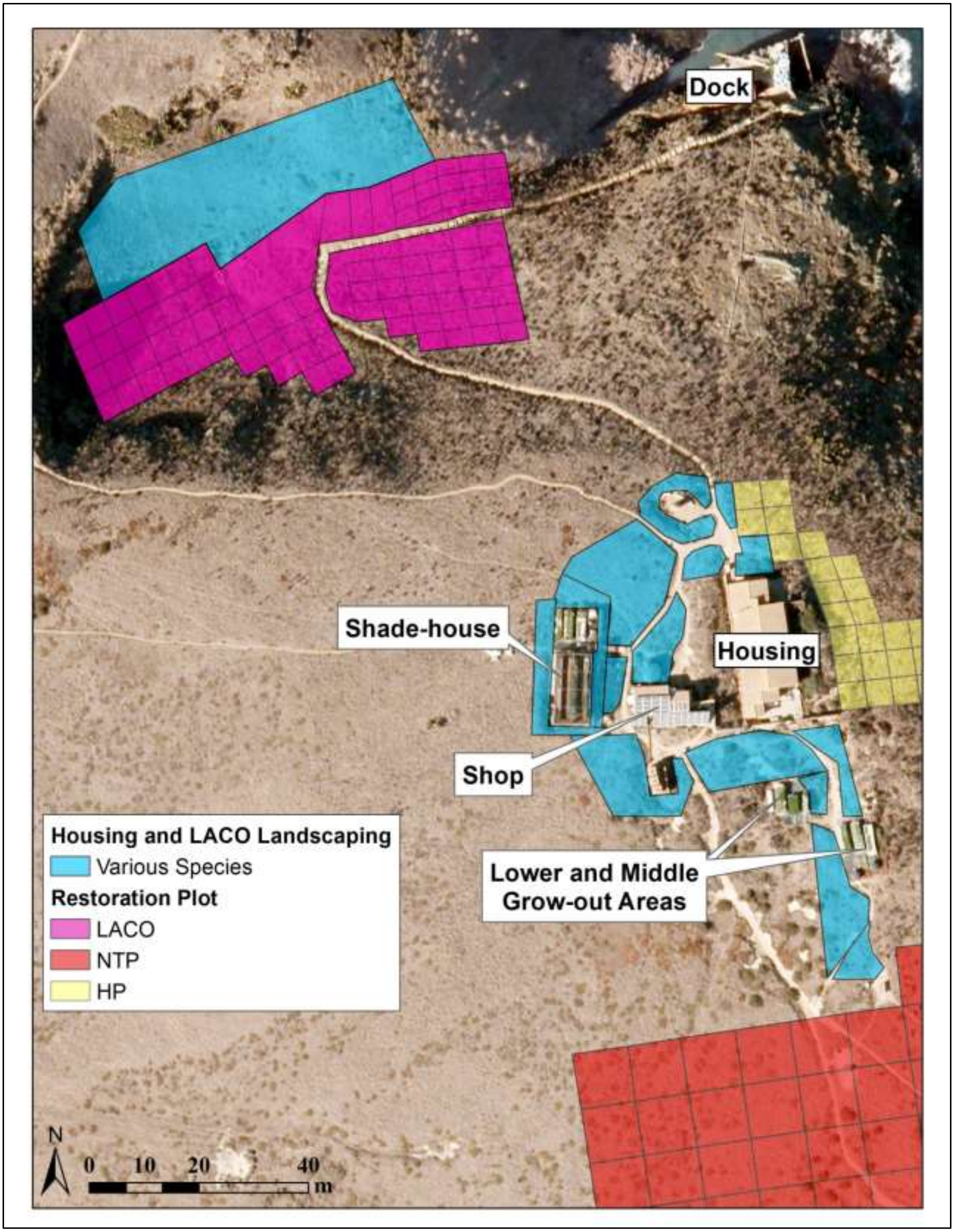

Figure 97: Landscaping plants around housing and Landing Cove.

Location	Year	ACMI	ARXX	ATCA	CAMA	COGI	CONE	ERGC	MEIM	STXX	PEEM	Prickly Pear	SUTA	ND	TOTAL
Arch Pt															**220**
	2008	0	0	0	0	0	36	7	0	0	0	0	0	0	
	2009	0	0	0	0	0	0	177	0	0	0	0	0	0	
Arch Pt trail															**301**
	2009	0	0	63	0	0	0	237	0	0	0	0	1	0	
Campground															**127**
	2007	0	0	0	0	34	0	0	0	0	0	0	0	0	
	2009	2	0	0	0	10	0	43	0	0	0	0	38	0	
BHP tanks															**10**
	2013	0	0	0	10	0	0	0	0	0	0	0	0	0	
Flag pole															**31**
	2010	0	0	0	0	10	10	11	0	0	0	0	0	0	
Housing															**191**
	2009	0	0	0	0	0	0	11	0	13	0	0	0	0	
	2010	0	0	0	0	0	0	0	0	0	0	0	0	18	
	2012-2014	0	34	0	26	44	27	18	0	0	0	0	0	0	
Interpretive sign															**174**
	2010	0	0	0	0	16	22	21	0	0	0	0	0	0	
	2012-2014	8	45	0	2	5	24	31	0	0	0	0	0	0	
Landing cove															**70**
	2013	0	0	0	0	0	0	0	0	0	0	70	0	0	
Lower CAAU condos															**53**
	2011	25	16	0	0	2	0	0	0	0	0	0	0	0	
	2013	2	0	0	1	1	1	0	0	0	0	5	0	0	
lower grow-out area															**305**
	2009	0	0	0	3	58	2	39	0	0	0	0	1	0	
	2011	0	0	27	0	0	15	0	0	0	0	0	0	160	
Middle grow-out area															**76**
	2011	0	0	0	0	76	0	0	0	0	0	0	0	0	
Nature trail															**43**
	2009	0	0	0	0	0	0	43	0	0	0	0	0	0	
NEF trail															**136**
	2009	0	0	0	1	0	0	112	0	0	0	0	23	0	
North of LACO															**80**
	2011	0	0	0	0	0	0	0	0	0	0	80	0	0	
Permanent nursery															**776**
	2010	45	0	0	17	8	173	0	0	200	22	0	0	0	
	2011	0	0	0	0	0	0	0	0	0	0	0	0	0	
	2012-2014	76	65	0	5	27	108	30	0	0	0	0	0	0	
Shop															**0**
	2009	0	0	0	0	0	0	0	0	0	0	0	0	0	
Various															**120**
	2009	0	0	0	0	22	1	8	29	29	0	0	31	0	
East of HP															**15**
	2008	0	0	0	0	0	15	0	0	0	0	0	0	0	
West of NEF (Sage plots)															**88**
	2009	0	88	0	0	0	0	0	0	0	0	0	0	0	
Total		**158**	**248**	**90**	**55**	**313**	**434**	**788**	**29**	**242**	**22**	**155**	**94**	**178**	**2816**

Table 16: Plants added outside restoration plots between 2007 and 2014. Some outplantings were not recorded.

Figure 98: Landscaping west of the nursery.
Top left: September 2011. Top right: November 2014. Bottom: February 2015.

Figure 99: Landscaping north of the nursery.
Top left: September 2011. Top right: November 2014. Bottom: February 2015.

Figure 100: Landscaping north of the shop.
Top left: September 2011. Top right: November 2014. Bottom: February 2015.

Figure 101: Landscaping around the bulletin board.
Top left: September 2011. Top right: November 2014. Bottom: February 2015.

IV. DISCUSSION

In this section we will examine data quality, interpret data, discuss some of the benefits of the project, and summarize recommendations and lessons learned from eight years of restoration work on SBI. During these eight years of restoration, we refined our outplanting techniques, nursery facilities and growing skills, and water delivery and storage methods. Modifications to planting designs and watering techniques in restoration plots increased plant survival and the use of erosion control fabric reduced erosion risks. Storing and propagating seeds on SBI minimized the risks of non-native species introduction to the island. The construction of a structurally sound nursery on SBI increased growing capacity and the installation of a cuttings chamber allowed the propagation of species not efficiently propagated from seeds. We learned how to reduce fungal growth in the nursery by modifying watering techniques. Moreover, the installation of water catchment areas around housing and within the nursery provided a passive way to collect water; these improvements reduced the costs and time associated with plant watering needs. Changes in water delivery and water storage on SBI increased the amount of water that could be transported and stored on the island. These changes made restoration on SBI more cost-efficient and successful within each restoration plot. However, data quality was not consistent over the project duration and the success of our restoration program was not always reflected by the data.

IV.I DATA QUALITY

Several issues reduced data quality and will complicate future analysis. First, because the data was not consistently organized in a database prior to Fall 2014, data from some surveys were lost and only some surveys were conducted, which resulted in patchy time-series. Second, the lack of clearly defined data collection protocols led to data inconsistencies through the years and between users. Third, multiple observers collected data through the years, which increased data variability caused by observer bias. Fourth, data quality assurance/quality control was not consistently implemented until Fall 2014; data inconsistencies that could have been avoided led to unusable data. Fifth, we will not be able to perform a statistically rigorous analysis of restoration success in subplots without pre-restoration data. Sixth, cover surveys during the dry season were not good indicators of cover changes in annual and dormant species. Because most non-native species are annuals that have finished their growth cycles by summer, cover surveys during the dry season also misrepresented the cover of non-natives species in restoration plots. The issues mentioned above demand caution in the interpretation of some of the data obtained on SBI. However, photopoints can be used to confirm or refute trends seen in the data.

IV.II RESTORATION PLOTS

In the following subsections, we will first discuss trends observed across several plots, and then discuss trends observed in each plot separately.

IV.II.I Discussion of Trends Observed Across Several Plots

Some of the trends observed across plots were correlated with precipitation patterns. Overall, survival rates for outplanted plants tended to be lower in 2009 compared to 2010, which can partially be explained with precipitation data. Years of precipitation under average, such as 2009, likely induced a water stress on plants, favoring species adapted to low moisture conditions and plants with well-established roots. Because of their smaller root mass, seedlings and recently outplanted plants would have been particularly susceptible to water stress in 2009.

Across plots, native plant cover was higher in 2010 compared to other years. Two factors were likely implicated in this trend. First, higher than average precipitation occurred in 2010, which likely induced above average growth and survival rates of native plants. Second, protocols to calibrate cover estimates were not in place until Fall 2011. After the protocols were in place, observers that conducted the 2010 surveys realized they had previously overestimated the cover of less abundant species, particularly native species. Therefore, the actual cover of native plants was likely greater in 2010 than in other years due to rain, but not as high as estimated because of data inflation due to human error. Based on photopoints, the cover of native plants was also likely over-estimated in 2007-2009 and in Spring 2011.

At HP, NEF, and BHP, more recently outplanted subplots exhibited a greater increase in native cover and a greater decrease in non-native cover than the first subplots outplanted. Three changes in restoration technique coincided with these observations. First, we switched from a stratified random outplanting design (2007-2009) to a patch design (2010-2014). The patch design likely reduced the risk of weed-whacking outplanted plants and decreased watering time.

It is also possible that native plants planted in patches provided shade and wind protection for each other. Second, we increased the density of our outplanted plants in later years. Denser outplantings reduced weeding needs by decreasing the amount of available space for non-native species and by increasing the amount of native seeds released from outplanted plants (in turn increasing native plant recruitment). Third, we switched from hand-watering to drip irrigation. Drip irrigation allowed water to slowly saturate the roots of outplanted species which resulted in more water use by the plant and less water loss through evaporation and runoff. These factors likely explain better restoration success in the later years of the project.

The cover of thatch typically decreased following the onset of restoration, while the cover of bare ground increased. Extensive weeding during the growing and dry seasons (after surveying) and weeding as time permitted the rest of the year accounted for the decrease in thatch and increase in bare ground. Using herbicide in some of the plots instead of hand-weeding and weed-whacking may reverse this trend in the future.

Non-native cover has been reduced in some of the restoration plots. Although we likely reduced the non-native seed input by weeding before non-native plants go to seed, the non-native seed bank is still likely abundant due to the long-term viability of some of the invasive species on SBI. Gutterman and Gendler (2005) germinated 32 years old seeds from Iceplant and Miller, and. Nalewaja (1990) germinated 14 years old Wild Oats seeds; these two species are abundant non-native plants on SBI. We thus recommend continuing long-term non-native plant removal in restoration plots.

Pre-restoration surveys during the dry season did not give a good estimate of non-native cover because most non-native species on SBI were annuals that completed their life cycles before the dry surveys were taken. Moreover, Giant Tickseed and Common Yarrow were typically dormant during the dry season, so the cover of perennials was usually much lower during the dry survey than during the growing season surveys.

Several factors contributed to the difficulty in relocating plant tags used to track survivorship, especially at ESC. For example, soil often completely covered tags on steep slopes at ESC due to erosion. Moreover, ESC and HP did not have maps showing the location of tagged plants within subplots and LACO had a poor quality map of tag locations. Not having detailed maps for each subplot increased the difficulty in relocating tags, especially in bigger subplots (i.e., at ESC). Tags for dead plants were especially hard to relocate when plants were dead and unrooted, because it removed further clues as to where tags could be located. Finally, the quality of some of the tags was not good enough to withstand the harsh environment on SBI and some of the tags ripped off from their staples. For all these reasons, tag surveys became very time consuming and yielded poor data quality for survivorship. They were thus abandoned in 2010. However, the growth data was representative of how slowly native species grew on SBI and strengthened the argument that restoration is a long-term process.

The next subsections will discuss results obtained in each plot.

IV.II.II Discussion of Results Observed at Beacon Hill Restoration Plot (BHP)

BHP is located at a lower elevation than other plots (except LACO). Its lower elevation combined with its geographic location on SBI occasionally resulted in saltwater spray covering plants when strong northerly winds and large waves occurred. Soil chemistry at BHP was thus likely different from other plots. Therefore, we would have expected species better adapted to salty soils (e.g., Iceplant, California Saltbush, Woolly Seablite, etc.) to exhibit higher survival rates compared to species with lower tolerance for salty soils (e.g., Sagebrush, SBI Buckwheat, Nevin's Woolly Sunflower, etc.). We noticed that all Sagebrush outplanted in 2011 and 2012 died in 2013 following an important saltwater spray event. However, all species outplanted in Fall 2013 fared well at BHP with a survival rate between 79 and 87%, except Giant Tickseed at 49%. Saltwater spray and strong winds at BHP may have contributed to the low survival rate of Giant Tickseed, the tallest outplanted species. Moreover, Giant Tickseed was not put on drip irrigation because of its ability to go dormant. Irrigating this species could have improved its survival success by allowing it to increase the depth of its roots to withstand the harsh weather conditions. As for Wooly Seablite, its survival rate was probably slightly inflated because a handful of drip irrigation emitters on empty berms were moved towards recruits from wild Wooly Seablite.

At BHP, we observed a greater increase in native cover in subplots where drip irrigation was installed compared to subplots that were hand-watered. Precipitation was unlikely to have contributed to this observation because hand-watered plots were outplanted in 2011 and 2012 and drip-irrigated plots were outplanted in 2012 and 2013; 2011 was a drier year than 2013, although both years were below average. Plants on drip irrigation were watered for two years (on average every two or three weeks the first year and every three to four weeks the second year), compared to one year for hand-watered plants (on average every two or three weeks the first year of planting). The deeper watering provided by drip irrigation and longer watering duration likely led to higher survival and growth rates of planted plants in subplots watered with drip irrigation, thus leading to faster native cover increase. Although drip irrigation likely played a crucial role in the high native plant survival and growth rate at BHP, a deeper soil horizon and less rocky soil must have also contributed to the greater increase in native cover in subplots with drip irrigation.

In summary, restoration at BHP was successful in that it increased native cover, decreased non-native cover, and increased native genera richness. The high survival rate of native plants in the 2013 expansion subplots was probably linked to a deep soil horizon and drip irrigation.

IV.II.III Discussion of Results Observed at Elephant Seal Cove Restoration Plot (ESC)

ESC is the steepest and rockiest restoration plot on SBI, with an important colony of nesting Western Gulls in spring. Plants at ESC were always watered by hand using hoses attached to water barrels. Dragging hoses to water plants caused erosion in some portions of the plot. Eroded soil covered some plants which resulted in significant plant mortality, while loose rocks rolled down the hill and sometimes disturbed nesting gulls (these issues led to the installation of erosion control fabric and fiber rolls on the steeper part of the plot). Erosion likely contributed to the lower survival rate of California Saltbush and the higher survival rate of Giant Tickseed compared to other monitored species. California Saltbush has a prostrate form (i.e., shoots and branches lay low to the ground) and can easily become covered by eroded soil and missed during hand-watering. On the other end of the spectrum, Giant Tickseed grows erect and was the tallest monitored species at ESC. Outplanted Giant Tickseed was unlikely to die from being covered by soil or missed during hand-watering. Erosion thus likely interfered with outplanted plants survival and growth rates, which was reflected in the cover surveys; only a small increase in native cover was recorded in the original 2008 subplots, while a decrease was observed in the 2010 expansion subplots. However, native cover estimated in the pre-restoration survey for the

2010 expansion subplots was probably over-estimated. Although data showed a decrease in cover between the 2010 dry season (pre-restoration), photopoints showed a similar cover of natives between 2010 and 2014. As for non-natives, they decreased in the entire plot during the dry season. During the growing season, non-natives decreased between the 2009-2010 and 2013-2014 growing seasons in the original 2008 subplots, but increased between the 2010-2011 and 2013-2014 growing seasons in the 2010 expansion subplots. Therefore, non-native removal should continue at ESC in the 2010 subplots.

California Saltbush and Nevin's Wooly Sunflower grew in height and width between May/June 2010 and October 2010, while SBI Buckwheat became smaller and shorter. Western Gulls have been observed to tear plants leaves during the breeding season, potentially as a display of territoriality. They seem to especially target SBI Buckwheat and Nevin's Woolly Sunflower (Marie-Eve Jacques, personal observation), which could account for the smaller size of SBI Buckwheat between May/June and October 2010.

The onset of restoration at ESC coincided with an increase in the average genera richness per subplot. Richness had more than doubled one year after the onset of restoration and remained higher than pre-restoration conditions during all subsequent surveys. Augmenting native richness at ESC should increase the diversity of seeds in the seed bank. A diverse native seed bank coupled with continued weeding and perhaps passive restoration (i.e., seeding) could help increase native cover at this location.

In summary, restoration at ESC was only partially successful; native genera richness increased, but non-native cover was only reduced in the original 2008 subplots and native cover only increased in these subplots. Although restoration was not as successful as anticipated, we learned valuable restoration lessons at ESC: we need to improve restoration methodology on steep and rocky habitat.

IV.II.IV Discussion of Results Observed at House Restoration Plot (HP)

At HP, non-native cover declined and native cover increased slightly following the onset of restoration. Although these changes are restoration successes, perhaps watering plants with drip irrigation could have resulted in a greater native cover increase. As opposed to the general trend in most plots, thatch actually increased through the years during the dry season. Too many surveys were not taken during the growing season to determine whether thatch consisted of dried up non-native or native annuals plants.

One of the restoration successes at HP was the increase in average genera richness per subplot. In the 2012 expansion subplots, average richness increased by 65% between the 2012-2013 growing season (pre-restoration) and the 2013-2014 growing season. Restoration at HP was therefore successful in that it increased native genera richness and native cover, and decreased non-native cover.

IV.II.V Discussion of Results Observed at Landing Cove Restoration Plot (LACO)

Summarizing data for LACO required extra steps to account for different subplot sizes and to account for the multitude of expansions. The data and photopoints showed that thatch and non-native species decreased over most of LACO. The only available pre-restoration data at LACO were for the January 2011 and November 2011 expansion subplots. Following the onset of restoration, native perennial cover decreased in the January 2011 expansion subplots and increased in the November 2011 expansion subplot. Incomplete data for other sections of LACO showed an overall decrease in native cover; however, photopoints showed a clear increase in native cover in all sections of the plot since the onset of restoration. Photopoints also showed that the only species that declined in cover since 2012 was Wooly Seablite, a trend observed over most of the island. Discrepancies in estimated cover between surveys and photopoints were likely due to an overestimation of native species cover in surveys taken before Fall 2011. It is also possible that surveyors did not calibrate their cover estimate for smaller subplot sizes at LACO.

Despite subplots being smaller in LACO than in other plots, the average native genera richness per subplot was higher in LACO than in other plots. LACO was more shaded than other plots and is the only plot located within a deep drainage. Perhaps these conditions favored native plant richness.

Between January 2009 and December 2009, the average height of eight Nevin's Wooly Sunflower increased less than 1 cm while the average width of these plants decreased by 6.7 cm.

The other species measured, SBI Buckwheat, increased in height by less than 1 cm and in width by 1.1 cm. 2009 was a dry year; low precipitations could have contributed to the poor growing rate of both species.

In summary, LACO was more shaded, moist, and wind-protected than other restoration plots. This likely contributed to the great restoration success at LACO, such as an increase in native species richness and cover.

IV.II.VI Discussion of Results Observed at Nature Trail Restoration Plot (NTP)

Drip irrigation and the deep soil horizon at NTP likely contributed to the 3.5% increase in native perennial cover within the first year of restoration, despite NTP being in a fairly dry section of the island. Thatch decreased from 87.6% to 3.8% within the first year of restoration and was replaced by bare ground. Removing thatch and non-native plants and increasing bare ground should allow seeds from nearby native plant patches to germinate at NTP. Restoring NTP should also reduce the non-native seed bank in the campground, thus reducing the risks of spreading non-native seeds from the campground to other parts of the island. Campground restoration will continue to promote outreach and education opportunities with island campers.

IV.II.VII Discussion of Results Observed at North East Flats Restoration Plot (NEF)

The cover of non-native species and thatch decreased following the onset of restoration at NEF, while the cover of bare ground increased. Both photopoints and data from surveys in the 2010 expansion subplots showed a slight increase in native cover. Although photopoints showed the appearance of a few native plants in the original 2007 subplots, cover data from surveys showed a small decrease in native perennial cover between the 2007 and 2014 dry season. More plants had been outplanted in the original 2007 subplots than in the 2010 expansion subplots (4,744 plants vs 2,750 plants, respectively), so we would have expected a greater increase in cover in the original 2007 subplots compared to the 2010 expansion subplots. The fact that native cover fared better in subplots with less outplanted native plants was probably due to:

1- A difference in planting design. The original 2007 subplots were planted in a stratified random manner while the 2010 expansion subplots were planted in patches.

2- Different supplemental frequencies. Plants outplanted in November 2008 in the original 2007 subplots were not watered from January to July 2009 and plants outplanted in November 2009 were never watered in 2010, while all outplanted plants in the 2010 expansion subplots were watered every 2-3 weeks for a year.
3- Differences in precipitation. Greater precipitation was observed in 2010 and 2011 compared to previous years.

Because the cover of native plants was slightly overestimated until the 2011 dry season surveys, it is possible that there actually was an increase in native perennial cover in the entire plot following the onset of restoration. However, the original 2007 subplots were watered with backpack sprayers refilled with water from housing. This was very time consuming and physically demanding and led to plants being under-watered, which probably caused the stunted growth observed between Fall 2007 and January 2009.

Nevin's Wooly Sunflower and SBI Buckwheat grew taller and wider between January 2009 and October 2010 than they did between Fall 2007 and January 2009. Above average precipitation during the 2009-2010 growing season could have caused a spike in growth during winter 2009-2010. However, this hypothesis does not explain the opposite growing trend for Wooly Seablite, which may have been an artifact of the low sample size (n = 15).

In summary, restoration efforts at NEF produced mixed results. Non-native cover decreased and native species richness increased, but native cover did not always increase. Ensuring proper watering at NEF and planting all plants in patches could have resulted in greater restoration success.

IV.III Restoration Impacts on Target and Non-target Native Species

Nesting attempts by CAAU have been documented in artificial burrows at LACO since 2011 (Harvey et al. 2014). Not having detected CAAU or SCMU nesting under native vegetation in restoration plots between 2007 and 2014 should not be perceived as a project failure. Habitat restoration can take decades to achieve and checking for nests under natural vegetation within restoration plot is difficult and time consuming; nesting attempts could have occurred without being detected. Moreover, seabirds need to be attracted to the newly restored areas, but previous attempts to use playback of CAAU vocalization in LACO increased predation pressure by Barn Owls (Thomsen and Harvey 2012). Successful nesting occurred in 2015 at BHP and LACO and will be discussed in future reports. Habitat has been continually improving within the restoration plots and we hope more seabirds will nest in restoration plots within the next decade.

Restoration has benefitted non-target native animals such as endemic arthropods, landbirds, native Deer Mice, and the island Night Lizard. For example, in 2011, one Orange-crowned Warbler (*Vermivora celata sordida*) nested in an Island Sage planted within LACO (Harvey et al. 2013). Habitat restoration on SBI was one factor considered in the delisting of the island night lizard from the Endangered Species List (USFWS 2014). Habitat restoration also benefitted a rare endemic gelechiid moth, *Chionodes bardus*, a species known only from SBI whose larvae feed on SBI Buckwheat (pers. comm., entomologist J. A. Powell). Continued restoration will increase nesting success from non-target avian species and provide additional habitat for native endemics.

Relieving some of the non-native plant pressure from the restoration plots has allowed native species to appear in areas where they were absent for several years. For example, in Winter 2011-2012, Philbrick's Malacothrix (*Malacothrix foliosa* subsp. *philbrickii*), a rare endemic annual plant, was noticed for the first time since 2007 at ESC. Continued restoration will provide additional benefits to other natives as well.

IV.IV Non-Restoration Related Benefits of Having a Full-Time Crew on SBI

The project required a continued presence on SBI between 2007 and 2014. Several non-restoration related benefits came from this presence. First, a presence on SBI reduced the risks of vandalism, disturbance, poaching, and stealing on and around the island. Second, personnel were able to respond in a timely manner to emergencies and were able to perform first aid when necessary. Third, personnel routinely monitored NPS equipment on SBI, performed maintenance as needed and reported issues to NPS employees. Fourth, as time permitted, personnel helped on other projects to reduce costs associated with transporting collaborators to SBI. Finally, personnel performed visitor orientation when visitors came ashore, explaining trail closures, island safety, rules and regulations, etc. Visitor outreach and education was often performed at the same time. These benefits strengthened working relationships with NPS staff and increased visitor experience.

IV.V Recommendations and Lessons Learned

This section summarizes eight years of lessons learned from restoration on SBI and the recommendations that developed from the lessons learned.

Vegetation Surveys

1- Written protocols are necessary to ensure data accuracy and consistency between users, and through time. Protocols should be written before a new survey is undertaken, appended as needed, and read by all surveyors before each survey season.
2- The number of surveyors should be kept at a strict minimum to reduce observer bias.
3- Calibration of surveyors, especially personnel new to vegetation surveys, should be done before each survey. Training in plant identification and in estimating cover should be completed just before surveys are taken.
4- Surveys should be done in pairs to reach a consensus on cover and other parameters. Total cover should be tallied at the end of each subplot to ensure it is ≥100%.
5- Stakes with subplot labels should be re-labeled on a yearly basis to prevent surveying the wrong area because of faded subplot labels. Moreover, the most up-to-date restoration plot maps should be taken in the field during each survey.
6- All subplots should be staked, mapped, and surveyed prior to the onset of restoration and photopoints should be established (with GPS locations) before restoration work begins.
7- Data should be entered directly into a personal digital assistant (PDA) and simultaneously recorded on hardcopies. This should reduce data proofing and entering time and increase data accuracy.
8- For new subplots, pre-restoration and annual cover surveys should be taken during the growing season. Surveys taken during the growing season provide data on both perennial and annual vegetation, while surveys taken during the dry season only provide data on perennial vegetation.

9- If the number of subplots to be surveyed becomes unmanageable from a surveying standpoint, only a subset of subplots should be surveyed. Subplots should be selected in a stratified manner from each plot section with pre-restoration data.

10- Having subplots of different sizes unnecessarily complicated cover surveys and data analysis. We strongly recommend dividing all future plots into 10 X 10 m subplots.

11- Tag surveys to determine species survival and growth rates were time consuming and yielded poor data quality because of issues relocating tags. Should someone desire to monitor plant growth and survival through tag surveys, they should double tag plants and use high quality tags. One tag at soil level and one tag around the highest part of the plant should increase tag relocating and retention. Moreover, detailed maps showing tag location should be drawn to a small scale to further increase relocation success.

<u>Database Management</u>

12- One of the greatest challenges to the creation of this report arose from not having a database manager for the duration of the project. This resulted in either data not being entered, entered and not proofed, entered in a multitude of Excel formats, or lost. In 2014, a database that could only be accessed by the database manager was created. Should the current database manager leave the project, a new manager should be properly trained before the departure of the current manager. A properly trained database manager should be assigned throughout the project.

13- The database manager should ensure that all surveys are completed and that all data are entered and proofed in a timely manner. Photocopies of all datasheets should be kept on island and originals should be kept on the mainland. If the data is entered in a PDA, backup of the electronic files should be kept on and off-island.

14- The database manager should implement data quality assurance (QA) procedures, including:

   a. Writing and updating survey protocols as needed.
   b. Preparing and updating survey datasheets as needed.
   c. Creating and maintaining a relational database and documenting modifications to the database.

d. Ensuring personnel are properly trained and "calibrated" before performing surveys on their own.

15- The database manager should implement data quality control (QC) procedures, including:

a. Verifying that the data is entered and proofed.

b. Randomly reproofing a portion of the data to ensure quality.

c. Making sure data columns and rows line up properly.

d. Looking for missing data entry.

e. Looking for obvious irregularities in data entries, including outliers.

16- The database manager should address data issues with personnel performing surveys and personnel entering and proofing data.

17- The database manager should also back-up the database when new data is entered, when data is proofed, or when the database is modified.

Seed Collection and Storage

18- On-island seed collection should be a directed effort, as not all plants seed at the same time and seeding time varies from year to year. Dedicated seed collection missions should be worked into the weekly work plans during each species' seeding timeline.

19- Staff and volunteers should be properly trained on seed collection protocols and seed identification to reduce non-seed material within the seed inventory. Excessive amounts of non-seed material increases risks of introducing insect species to the seed inventory, increases moisture retention, and requires additional space for storage.

20- Insect predation was noticed in some seeds stored in our seed bank. To mitigate the risks of seed predation, most seeds should be frozen for 48 hours to kill insects before being stored[9].

21- A database should keep track of all stored seeds and be updated as new seeds are added or removed for the seed stock.

22- Native seed scarcity is an inhibiting factor to restoration on SBI. Therefore, we recommend restoring an area on SBI that would be used for intense seed collection to increase seed

[9] A decrease in seed viability following freezing was not observed for species propagated on SBI, but has been observed elsewhere (Santa Barbara Botanic Garden, 2015).

availability for restoration efforts (plans are underway to create a seed farm in Winter 2015-2016).

23- Seed viability decreases over time. Therefore, oldest seeds should be used first for propagation in the nursery to ensure a frequent turn-over in the seed inventory.

24- To increase seed longevity and decrease the risks of seed predation, a temperate dark room or closet with a dehumidifier should be used to store seeds on SBI.

Propagation

25- Density of seedlings within seed flats was a factor in developing healthy growth within appropriate timeframes. Sowing seeds at high density often resulted in tightly packed struggling plants, while lower densities provided adequate space between plants when it was time to transplant them to larger pots.

26- Prolific seeders like *Spergularia* spp. should be kept isolated from the rest of the propagation area because of seed infiltration into neighboring flats.

27- It was helpful to use a micronutrient and mineral blend for small seedlings (maxicrop seaweed extract or similar) to give small plants a healthy start.

28- For plants in 2" and larger pots, mixing time release fertilizer (15-15-15, 6-month release osmocote or similar) with soil when transplanting from smaller to bigger pots provided adequate nutrients for several months. Osmocote was inexpensive, portable, and had a long shelf life. Adding extra fertilizer as needed also increased plant health and survival.

29- The use of a cutting chamber with an overhead misting system within the chamber greatly improved the propagation success for California Box-thorn. Propagation trials through cuttings should be made for other species not easily seed propagated, such as Coyote Brush[10].

30- We observed that watering SBI Buckwheat from below reduced fungus-related death in the nursery. However, the baking trays used to water buckwheat from below only accommodated one tray of plants each. When numerous buckwheat trays within the shade-house needed to be watered at the same time, this process became time-intensive and required space not

[10] In 2015, successful propagation through cuttings were made for Coyote Brush and will be discussed in future report.

always available in the shade-house during peak propagation months. We recommend purchasing larger watering dishes or plumbing in floodable tables in the shade-house.

31- Overhead sprayers were not efficient means of watering the nursery on SBI due to the exposed location of the nursery and variable winds on SBI (water droplets would get wind-blown away from the plants). If the nursery was more protected from the wind, overhead watering could be used.

32- Hand-watering in the nursery required someone to be on island at all times, but saved water. The increased presence in the nursery required for hand-watering improved the ability for staff to identify pests and diseases in a timely manner.

33- Young plants in the SBI nursery were vulnerable to many insects, including Leaf Miner, aphids, caterpillars, and flies. Use of appropriate control methods early and consistently helped to maintain healthier nursery crops. Usually most small insect problems were taken care of by natural processes when the plants were moved from the shade-house to grow-out areas. Having well-trained staff diligently checking for pests also minimized the risks of large outbreaks. Early identification and quick control were keys in preventing large outbreaks of insect pests.

34- Approximately a week after transplanting plants from 2” to mini treepots, plants should be moved to grow-out areas outside the shade-house. Moving plants outside the shade-house made plants more robust at outplanting, because it reduced the transplanting shock (plants had already adapted to sunnier and windier environments before planting). If left in the shade-house too long, plants became softer and spindlier and were more susceptible to pests and diseases and more likely to die from outplanting stress.

35- As a general rule, nursery cleanliness is important to reduce pests and diseases. However, only the filter in the shade-house rain collection system on SBI can be cleaned; the rest of the subfloor is not accessible and cannot be cleaned thoroughly, which creates an ideal environment for many insects including fungus gnats. Nursery infrastructure should always be designed with cleanliness in mind.

36- Starting in 2010, Giant Tickseeds with well-developed roots were not watered in the nursery until a couple of weeks before outplantings. This technique reduced water usage in the nursery and should be applied to all dormant species in the future (e.g., Giant Tickseed, Common Yarrow, etc.).

Restoration

37- Restoring areas of the island with a deeper soil horizon and gentler slopes yielded better results per effort than restoring steeper cliffs with shallow soil horizon. However, targeted seabird species tend to nest on steeper cliffs at the periphery of the island. Therefore, we recommend ameliorating methodologies to restore habitat on steeper cliffs. Using drip irrigation and installing erosion control fabric before outplanting should mitigate erosion. Trials using broadcasted seeds should also be implemented; if successful, seeds would eliminate the need to dig holes, which should reduce soil instability.

38- Denser outplantings reduced weeding needs quicker due to more rapid establishment of native vegetation. Once native plants were established, they were better at controlling invasive species with minimal human intervention. It became much more time efficient to restore a smaller area with a higher density of natives than to spread the same amount of plants over a larger area.

39- Hand-watering was not an efficient use of time or water resources. Maintaining large berms was required before watering, which was time consuming. Hand-watering also required dragging hoses across subplots. This was time consuming as great care was needed to avoid dragging hoses over plants and nesting gulls. It also increased seabird disturbance and soil erosion. Water was slow to soak into the soils and resulted in pools within the berms. During warm months, more water would evaporate from those pools than would evaporate from drip irrigation. When compared to hand-watering, drip irrigation increased watering efficiency, plant survival, and plant growth (drip allowed for rapid plant growth through efficient and deep watering). In turn, larger plants increased fog collection, which reduced watering needs. Drip irrigation should be used in all future plantings. Initial costs of drip irrigation are more expensive than hand-watering, but long-term costs are less expensive due to reduced labor. Drip systems could potentially be re-used in later years.

40- Planting natives within berms slightly below the soil surface was an effective way to increase water collection through rain. It also prevented water from running off when the soil surface was dry and hydrophobic.

41- Increasing the diversity of outplanted perennial plants could improve habitat quality. In addition to the species outplanted between 2007 and 2014, we suggest propagating the other native perennial species found on SBI: Silver Lotus (*Acmispon argophyllus var. niveus*), Trask's Locoweed (*Astragalus traskiae*), Coyote Brush, Cholla, Soaproot (*Chenopodium californicum*), SBI Island Liveforever (*Dudleya traskiae*), California Brittlebush (*Encelia californica*), Cucamonga Manroot (*Marah macrocarpus*), California Four-O'Clock (*Mirabilis laevis var. crassifolia*), Emory's Rockdaisy (*Perityle emoryi*), and Douglas' Nightshade (*Solanum douglasii*).[11,12]

42- Propagating Coyote Brush from cuttings could potentially save this species from extirpation on SBI (propagation was started in 2015).

43- Unless ground moisture is adequate, outplantings should be watered on average once every two or three weeks the first year following planting. The second year, outplantings should be watered less frequently (on average, every three to four weeks). Outplantings should not be watered more than two years.

44- A pilot study should be implemented to determine the most efficient way to restore landscapes on SBI. The study should determine whether seeding could increase restoration success.

45- Hand-pulling non-native species over large areas destabilized the surface integrity of soils and potentially increased the effects of wind and water erosion. Spraying herbicide (glyphosate) on large infestations of Chrystalline Iceplant was very effective at reducing non-native cover. Herbicide application was also a good alternative to manual weeding on unstable substrate such as found at ESC. Less traffic across the terrain meant less soil disturbance and erosion, with faster invasive plant control. Herbicide application decreased competition with non-natives, stopped non-native seeds from reentering the seed stock, and left root structures in the ground, which reduced the effects of erosion over time. Moreover, spraying was less labor-intensive than hand-pulling by the acre. Timing of herbicide application after the native annuals finished seeding effectively eliminated the loss of potential future native ground cover, and lessened the competition for native annuals the following season. Herbicide use also decreased disturbance to nesting seabirds due to reduced staff presence.

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[11] The proper permits should be obtained before seed collection / propagation for the federally and state listed SBI Island Liveforever.
[12] Propagation of most of these species was initiated in 2015.

46- Non-native cover has been reduced in some of the restoration plots. Although we likely reduced the non-native seed input by weeding before non-native plants go to seed, the non-native seed bank is still likely abundant due to the long-term viability of some of the invasive species on SBI. We thus recommend continuing long-term non-native plant removal in restoration plots.

47- The use of alternative herbicides (soap, salt, vinegar, and/or clove oil based) was marginally effective. Perfect wind and sun conditions were required for application during spring, when wind and sun condition are highly variable. Glyphosate was much more effective.

48- The use of volunteer labor allowed much work to be accomplished in short periods. Volunteers collected seeds from large areas, weeded patches of non-native plants quickly, and transported, planted, and irrigated thousands of plants a day. Volunteering events provided invaluable opportunities for outreach and education.

Infrastructure

49- On an island without an aquifer or perennial water sources, water acquisition required weekly transport of hundreds of gallons of water from the mainland to SBI. This posed considerable logistical issues, increased transportation costs, environmental impacts, and safety concerns. Installing a small scale desalination unit on SBI would greatly alleviate these issues.

50- Installing rain collection systems in the nursery and around buildings on SBI reduced the dependence on water deliveries to the island, although rain events were unpredictable.

51- One of the biggest challenges to restoration on SBI was water delivery to the plants. Initial plans of hiking jugs of water to individual plants were labor-intensive and not practical for larger scale work. Installing water lines to storage tanks above restoration plots and establishing drip irrigation systems within the plots greatly increased the efficiency and feasibility of larger scale restoration on SBI.

52- Using multiple smaller tanks rather than one large main water storage tank on SBI increased the complexity of the water system (more pumps and hoses were needed, more plumbing was involved, etc.). However, it decreased the risk of losing the entire water storage on SBI to a single incident. On an island with such limited water access, this has been invaluable.

53- Floodable tables to replace plastic tables in the grow-out areas of the nursery conserved water and allowed for easier watering from the bottom for species susceptible to mold and mildew such as SBI Buckwheat.

54- Purchasing the highest quality supplies was initially expensive, but cheaper alternatives quickly degraded in the harsh environment on SBI. Great sums of money were saved by initially investing in sturdier supplies. Maintaining equipment was also very important.

<u>Other</u>

55- Unidentified plant species found on SBI should be reported immediately to a CINP botanist for identification. If a species without known records on SBI is discovered, this knowledge should be passed along to all personnel involved with plant work on the island. New invasive species discovered on SBI should be eradicated and rare native species should be protected.

56- Sharing work-plans, mid-week updates, and trip notes among personnel working on SBI greatly increased communication between working crews on- and off-island. We recommend continuing these communication aids. We also recommend all-staff meetings at least twice per year to discuss goals, protocols, issues, new restoration plans, etc.

V. CONCLUSION

Habitat restoration can take decades to achieve. However, within eight years of restoration, we already started recording restoration successes on SBI in the form of increased native plant cover, decreased non-native cover, and increased native genera richness in many restoration plots. We have also achieved an average survival rate of 81% at BHP between December 2013 and September 2014, which points towards a survival rate higher than our objective of achieving a 50% survival rate one year post-planting.

Our restoration efforts provided many benefit to the island, including improved habitat for non-targeted native animals such as rare endemic arthropods, landbirds, the endemic Deer Mouse, and the Island Night Lizard (de-listing partly due to our restoration activities). Additionally, rare native annuals have benefitted from restoration. The removal of non-native species around the campground and other frequently visited areas also minimized the risks of spreading invasive species, while the planting of native species increased the visual appeal of landscapes on SBI. Our project also provided invaluable outreach and education opportunities for volunteers and SBI visitors.

Habitat has been continually improving within the restoration plots; we anticipate further successful CAAU and SCMU nesting within the restoration plots within the next decade. We hope our project will help guide future habitat restoration efforts elsewhere and benefit land managers who deal with similar issues: lack of permanent sources of freshwater, field site remoteness, drought conditions, heavy invasive seed bank, low native species seed bank, and soil disturbances.

VI. LITERATURE CITED

Adams, P., D.E. Nelson, S. Yamada, W. Chmara, R.G. Jensen, H.J. Bohnert, and H. Griffiths. 1998. Growth and development of *Mesembryanthemum crystallinum* (Aizoaceae). New Phytologist 138:171-190.

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

Adams, J. 2008. Cassin's Auklet (*Tychoramphus aleuticus*) *in* Shuford, W.D., and T. Gardali (eds.). 2008. California bird species of special concern: a ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento.

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.

Burkett, E.E., N.A. Rojek, A.E. Henry, M.J. Fluharty, L. Comrack, P.R. Kelly, A.C. Mahaney, and K.M. Fien. 2003. Report to the California Fish and Game Commission: status review of Xantus's Murrelet (*Synthliboramphus hypoleucus*) in California. California Department of Fish and Game, Habitat Conservation Planning Branch Status Report 2003-03.

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.

Unpublished draft final report, U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Dixon, California.

Fellers, G.M., and C.A. Drost. 1991. Ecology of the Island Night Lizard, *Xantusia riversiana*, on Santa Barbara Island, California. Herpetelogical Monographs 5:28-78.

Grinnell, J. 1897. Report on the birds recorded during a visit to the islands of Santa Barbara, San Nicholas and San Clemente in the spring of 1987. Pasadena Academy of Sciences 1:4-26.

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

Halvorson, W.L., D.B. Fenn, and W.R. Allardice. 1988. Soils and vegetation of Santa Barbara Island, Channel Islands National Park, CA. Environmental Management 12:109-118.

Halvorson W.L. 1992. Alien plants at Channel Islands. Pp 64-96 *in* Stone, C.P., C.W. Smith, and J.T. Tunison (eds.). 1992. Alien plant invasions in native ecosystems of Hawaii: management and research. University of Hawaii, Cooperative National Park Resources Unit, Honolulu.

Handley, T., A.K. McEachern, D. Rodriguez, J. Yee. 2012. Twenty-seven years of vegetation change on Santa Barbara Island: Modeling methods and ecological results. 8th California Islands Symposium.

Handley, T., D. Rodriguez, J. Yee, and A.K. McEachern. 2013. Exploring long-term trends in vegetation of Santa Barbara and Santa Rosa Islands, Channel Islands National Park. Draft technical report, USGS, Channel Islands Field Station, Ventura, CA.

Harvey, A.L., C.E. Hand, and S.A. Auer. 2012. Scripps's Murrelet reproductive performance on Santa Barbara Island, California in 2008-2009. Unpublished report to the Montrose Settlements Trustee Council.

Harvey, A.L., S.A. Auer, K.W. Barnes, D.M. Mazurkiewicz, C.A. Carter, M.E. Jacques, and A.A. Yamagiwa. 2013. Scripps's Murrelet, Cassin's Auklet, and Ashy Storm- Petrel colony monitoring and restoration activities on Santa Barbara Island, California in 2010- 2011. Unpublished report. California Institute of Environmental Studies.

Harvey, A.L., J.A. Howard, D.M. Mazurkiewicz, M.E. Jacques, S.A. Auer, C.A. Carter, K.W. Barnes, A.A. Yamagiwa and S.J. Kim. 2014. Scripps's Murrelet, Cassin's Auklet, and Ashy Storm-Petrel reproductive monitoring and restoration activities on Santa Barbara Island, California in 2012. Unpublished report, California Institute of Environmental Studies.

Howard, J.A., A.L. Harvey, S.J. Kim, R.E. Robison, D.M. Mazurkiewicz, A.A. Yamagiwa, C.A. Carter, E.F.W. Wynd. 2014. Scripps's Murrelet and Cassin's Auklet reproductive monitoring and restoration activities on Santa Barbara Island, California in 2013. Unpublished report. California Institute of Environmental Studies.

Howell, A.B. 1917. Birds of the islands off the coast of southern California. Pacific Coast Avifauna 12:1-127.

Miller, S.D., and J.D. Nalewaja. 1990. Influence of burial depth on wild oats (*Avena fatua*) seed longevity. Weed Technology 4:514-517.

Jepson Flora Project (eds.) 2015. Jepson eFlora. http://ucjeps.berkeley.edu/IJM.html [accessed on 01/15/2015].

Junak S., R. Philbrick, and C. Drost. 1993. A revised flora of Santa Barbara Island: An annotated catalog of the ferns and flowerings plants and a brief history of botanical exploration. Pp 54-112 *in* M Daily (Ed.). 1993. Santa Barbara Island. Occasional paper #6. Santa Cruz Island Foundation, Santa Barbara, CA.

Junak, S., R. Philbrick, S. Chaney, and R. Clark. 1997. A checklist of vascular plants of Channel Islands National Park: includes San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara Islands. Second Edition. Southwest Parks and Monuments Association, Tucson, AZ.

Manuwal. 1974. The natural history of Cassin's Auklet (*Ptychoramphus aleuticus*). The Condor 76(4):421-431.

Manuwal. 1979. Reproductive commitment and success of Cassin's Auklet. The Condor 81(2):111-121.

Manuwal, D.A., and A.C. Thoresen.1993. Cassin's Auklet. The birds of North America 50:1-18.

Melo, A.S., R.A.S. Pereira, A.J. Santos, G.J. Shepherd, G. Machado, H.F. Medeiros, and R.J. Sawaya, 2003. Comparing species richness among assemblages using sample units: why not use extrapolation methods to standardize different sample sizes? Oikos 101(2): 398-410.

Montrose Settlements Restoration Program. 2005. Appendix D2. Restore Alcids to Santa Barbara Island *in* Final restoration plan and programmatic environmental impact statement, and environmental impact report. Report of the 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.

Murray, K.G., K. Winnett-Murray, Z.A. Eppley, G.L. Hunt, Jr., and D.B. Schwartz. 1983. Breeding biology of the Xantus' Murrelet. The Condor 85(1):12-21.

Philbrick, R.N. 1972. The plants of Santa Barbara Island, California. Madroño 21:329-393.

Santa Barbara Botanic Garden. 2015. Conservation Seed Collection. https://www.sbbg.org/conservation-research/rare-plants/seed-bank [accessed on 11/25/2015].

Spencer K.A. 1981. A revisionary study of the leaf-mining flies (Agromyzidae) of California. California Division of Agriculture Sciences, University of California.

Thomsen, S.K. and A.L. Harvey. 2012. Factors influencing depredation of Xantus's Murrelets by Barn Owls on Santa Barbara Island: Summary results from the 2010 field season. Unpublished report prepared for: Montrose Settlements Restoration Program.

Thoresen, A.C. 1964. The breeding behavior of the Cassin Auklet. The Condor 66(6):456-476.

U.S. Fish and Wildlife Service. 2014. Endangered and threatened wildlife and plants; removing the Island Night Lizard from the Federal list of endangered and threatened wildlife. Federal Register 79(62): 18190-18210.

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., H.R. Carter, and A.L. Harvey. 2009. Cassin's Auklets, Xantus's Murrelets and other crevice-nesting seabirds at Santa Barbara Island, California: 2008 surveys and historical status. Unpublished report, California Institute of Environmental Studies, Davis, California; Carter Biological Consulting,Victoria, British Columbia, and Channel Islands National Park, Ventura, California.

Whitworth, D.L., A.L. Harvey and H.R. Carter. 2011. Cassin's Auklets, Xantus's Murrelets and Other Crevice-Nesting Seabirds at Santa Barbara Island, California: 2009-10 Surveys. Unpublished report, California Institute of Environmental Studies, Davis, California; Channel Islands National Park, Ventura, California; and Carter Biological Consulting, Victoria, British Columbia.

VII. APPENDICES

Appendix I: Names, Abbreviations, and Seeding Months of Species Propagated on SBI

Table 1 summarizes species propagated on SBI and seed collection period. The seed collection period can vary yearly depending on weather patterns.

CODE	Botanical Name	Common Name	Seed Collection Period	Note
ACMI	*Achillea millefolium*	Yarrow	June-October	
ARXX	*Artemisia californica* *Artemisia nesiotica*	Coastal Sagebrush Island Sagebrush	September-December	
ATCA	*Extriplex californica* (*Atriplex californica*)	California Saltbush	June-August	
BAPI	*Baccharis pilularis*	Coyote Brush	NA	All collected seeds were infertile.
CAMA	*Calystegia macrostegia s. amplissima*	Island Morning-Glory	May-December	Seeding almost year-round.
CHCA	*Chenopodium californicum*	California Goosefoot	April	
COGI	*Leptosyne gigantea* (*Coreopsis gigantea*)	Giant Tickseed	February-June	
CONE	*Constancea nevinii* (*Eriophyllum nevinii*)	Nevin's Woolly Sunflower	June-September	
DECL	*Deinandra clementina* (*Hemizonia clementina*)	Island Tarplant	June- November	
ERGC	*Eriogonum giganteum var. compactum*	SBI Buckwheat	September-December	
LYCA	*Lycium californicum*	California Box-thorn	February-March	Easier to propagate from cuttings.
STXX	*Stipa lepida* (*Nassella lepida*) *Stipa pulchra* (*Nassella pulchra*)	Foothill Needle Grass Purple Needle Grass	April-July	
OPXX	*Opuntia littoralis* *Opuntia oricola*	Prickly-Pear	NA	Propagated from cuttings.
SPMA	*Spergularia macrotheca*	Sticky Sandspurrey	NA	
SUTA	*Suaeda taxifolia*	Woolly Seablite	July-September	

Table 1: Name, abbreviation, and seed collection period for species propagated on SBI. Plant nomenclature is according to the Jepson Flora Project. Botanical names in parenthesis are no longer accepted.

APPENDIX II: PLOT PREPARATION PROTOCOL

This protocol should be followed every time a new plot is established on SBI or every time an existing plot is expanded. Properly following this protocol will ensure that no step is forgotten when new restoration plots are created or when existing plots are expanded.

Materials needed

- Stakes
- Measuring tapes (5)
- Sharpie
- GPS
- Clipboard
- Blank sheets
- Pencils
- Materials needed for percent cover surveys (refer to percent cover survey protocol)
- Materials needed for photopoints (refer to photopoints protocol)

Procedure:

Several months to several years before outplantings

- Scope out potential plot locations.
- Obtain the appropriate permits.
- Coordinate volunteering trips if volunteers will be involved in the outplanting.
- Make boat and helicopter reservations, as needed.
- Once the area has been approved, divide the plot into square subplots of 10 X 10 m using measuring tapes. Use stakes to mark subplot boundaries.
- Label each subplot on the upper left corner stake with a unique identifying code.
- Select and turn on the track option on the GPS (NAD 83) and trace the outer boundary of the new plot or plot expansion. Save the track.
- Make a hand-drawn map of the new plot location. Include any prominent features (man-made infrastructure, big patches of native plants, etc.) in your drawing.

- Upon return to the office, send the GPS track file and hand-drawn map to the vegetation database manager.

The spring preceding the first outplanting

- Take the pre-restoration percent cover survey and photopoints. Refer to the appropriate protocols.

At least a day before outplanting (up to several years before outplanting)

- Weed subplots of non-native species.
- Remove thatch as requested by your restoration manager.
- Deliver water to the plot.

Within a couple of days before outplanting

- Mark the future location of each plant with flags color-coded by species (follow the planting plan). Group flags of the same species in patches.
- Dig holes with an auger (preferred), a posthole digger, or a shovel.
- Carry plants to the plot by helicopter or by foot.

APPENDIX III: PERCENT COVER SURVEY PROTOCOL

Percent cover surveys are used to determine the effects of restoration on the cover of native plants, non-native plants, thatch, and bare ground. Data from these surveys can also be used to calculate native genera richness in each subplot.

This survey should be taken in each restoration plot every year in late January or early February (growing season) and in late September or early October (Fall dry season). The growing season surveys should be taken before annual plants die off and the dry season surveys should be taken before outplanting events.

Materials needed

- 1m^2 PVC frame
- Stakes
- Measuring tapes
- Sharpie
- Camera
- GPS
- Clipboard
- PDA
- Datasheets
- Pencils
- Map of restoration plot
- Copy of protocol for overview photopoints
- GPS coordinates for overview photopoint

Procedure:

- Surveys should be completed in teams of two (always including an experienced observer), until similar results are obtained by both observers. When both observers consistently obtain similar results, observers can survey independently of one another.
- Observers should perform the following tasks:

    1- Locate subplot corners marked with wooden stakes. Looking uphill, the stake at the top left corner of the subplot should be labeled with the subplot unique code. If labels are faded, re-label them with a sharpie. If stakes are missing, replace them, using a measuring tape to determine their exact location.

2- For each subplot, estimate the percent cover of each species within the subplot and the percent cover of bare ground, man-made objects, rocks, and thatch (dead vegetation):

a. To increase data accuracy, use the 1 m^2 PVC frame to calibrate your estimates. As a reference, the frame covers 1% of a 10 X10 m subplot or 4% of a 5 X 5 m subplot.

b. Estimate percent cover independently for each species within a subplot and for bare ground, man-made objects, rocks, and thatch. Because of vertical stratification, total percent cover within a subplot can be ≥100%. For an example, refer to Figure 1.

c. When estimating the percent cover of a species, only the live portion of each plant should be included in the estimate. Dead grass and other dead vegetation should be recorded as “thatch”.

d. If a species cover less than 1% of the subplot, record it as 1%.

e. Record data on the PDA and on datasheets.

f. If you encounter a species that is not on the PDA or datasheets, add it to both and estimate its cover. If you do not know its species abbreviation, do not make one up; rather write its complete scientific name.

g. If you do not recognize a plant, take multiple pictures and send them to your database manager immediately upon return from the field. Record the plant as “unknown species #X” on your datasheet. Once you have a positive species ID, do not erase the label “unknown species #X” on your datasheet. Instead, make a note on the datasheet including its species name, whom identified it, and how it was identified (e.g., John Doe identified unknown species #1 as *Centaurea melitensis*, based on pictures).

h. Record estimates on the PDA and on the datasheets.

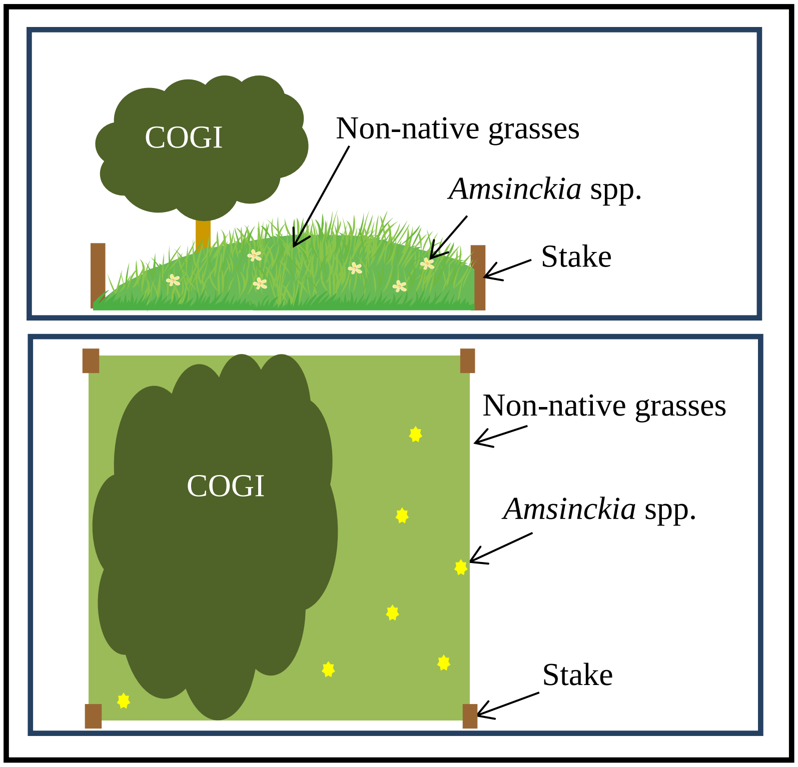


Figure 1: Frontal (top) and aerial (bottom) view of the same subplot.
The dark green shape represents COGI, the pale green shape represents non-native grasses, and the yellow flowers are *Amsinckia* spp. Estimates should be: COGI= 50%, non-native grasses = 98% (grasses cover the entire subplot, except where the COGI trunk is located), and Amsinckia spp = 1%. The total percent cover for this subplot should be 149%.

3- While in the field, verify that the total percent cover you estimated is ≥100% for each subplot. If your data do not add to ≥100%, re-estimate percent cover until it does.

4- As part of the survey, you should also take photographs from permanently established locations called "photopoints" around noon (timing is important for picture comparison). Photopoints should be taken for every subplot. Overview photopoints should also be taken (refer to the appropriate protocols). Record your picture numbers (Figure 2) on the datasheet and on the PDA.

5- Upon return to the office, give a copy of the PDA files, photopoints, and datasheets to the vegetation database manager. Always leave a backup on SBI.

Figure 2: The correct picture number is indicated in yellow (record the last 4 numbers). Do not confuse it with the number in red, which is the picture order on the memory card.

Filling out forms on the PDA:

1. Turn on the PDA using the power button located at the top right corner.
2. Click the start icon at the top left corner of the screen and select "Forms 5.1".
3. Select "Vegetation Survey Parent Form".
4. Select "New".
5. Select the correct plot ID – BHP (Beacon Hill), ESC (Elephant Seal Cove), HP (House), LACO (Landing Cove), NEF (Northeast Flats), or NTP (Nature Trail).
6. Select the date: DD-MM-YY.
7. Record observers' initials.
8. Select "percent cover".
9. Click "add" to add a subplot.
10. Write subplot ID.
11. Click "Next".
12. Record percent cover for man-made objects, bare ground, bare rock, and thatch.
13. Click "Total" to calculate NVT (non-vegetation and thatch) to verify that your estimate reflects what you see in the subplot. If necessary, use the previous button to correct your estimates; otherwise continue to step 14.

14. Click “Next”.
15. Estimate the cover of the native species displayed on the PDA. Record “0” when a species is not present. Do not leave any fields blank.
16. Click “Next”.
17. If native species are present in the subplot but not available on the PDA, add their total percent cover in the “Other Native” tab (however, record the percent cover of each of species separately on the hardcopy).
18. Click “Total” to sum up the percent cover of native species. If necessary, use the previous button to correct your estimates; otherwise continue to step 19.
19. Click “Next”.
20. Estimate the cover of each non-native species. Record “0” when a species is not present. Do not leave any fields blank.
21. If non-native species are present in the subplot but not available on the PDA, add their total percent cover in the “Other Non-native” tab (however, record the percent cover of each species separately on the hardcopy).
22. Click “Total” to sum up the percent cover of non-native species. If necessary, use the previous button to correct your estimates; otherwise continue to step 23.
23. Click “Next”.
24. The field “Total Cover” sums up the percent cover of each subplot. Re-estimate cover if this field does not add to ≥100%.
25. Add subplot photo Number.
26. In “Comments”, include any relevant notes, such as unidentified plant species, etc.
27. Click “Next”.
28. Repeat steps 9 through 27 for each subplot.
29. Click “Done” when all subplots have been surveyed.

Datasheet:

Date: ____________________

Observers: _______________

Plot: _____________________

Percent Cover

Subplot	Man-made Structures	Bare Ground	Bare Rock	Thatch	Native Cover	ACMI	Artemisia Spp	ATCA	CAMA	CHMU	COGI	CONE	ERGC	LYCA	Prickly pear	SUTA	Other native:	Other native:	Other native:	Non-Native Cover	Non-Native Grass	ATSE	Erodium	MAPA	MECR	MENO	SOOL	Other Non-Nat.:	Other Non-Nat.:	Other Non-Nat.:	Absolute Cover	Picture #	

Comments ____

____

____

Data entered (initials date): ______________

Data proofed (initials date): ______________

APPENDIX IV: PROTOCOL FOR OVERVIEW PHOTOPOINTS

Overview photopoints are taken in each restoration plot every year in late January or early February and in late September or early October. They are used to show overall changes in plots following the onset of restoration. A copy of each photopoint is provided below. Each photopoint should be recreated as closely as possible every time it is taken, but the amount of sky shown in the pictures should be minimized.

Beacon Hill Restoration Plot (BHP)

Figure 1 and Table 1 provide the location of each photopoint at BHP. Figure 2 shows photopoints 1 through 8c at BHP.

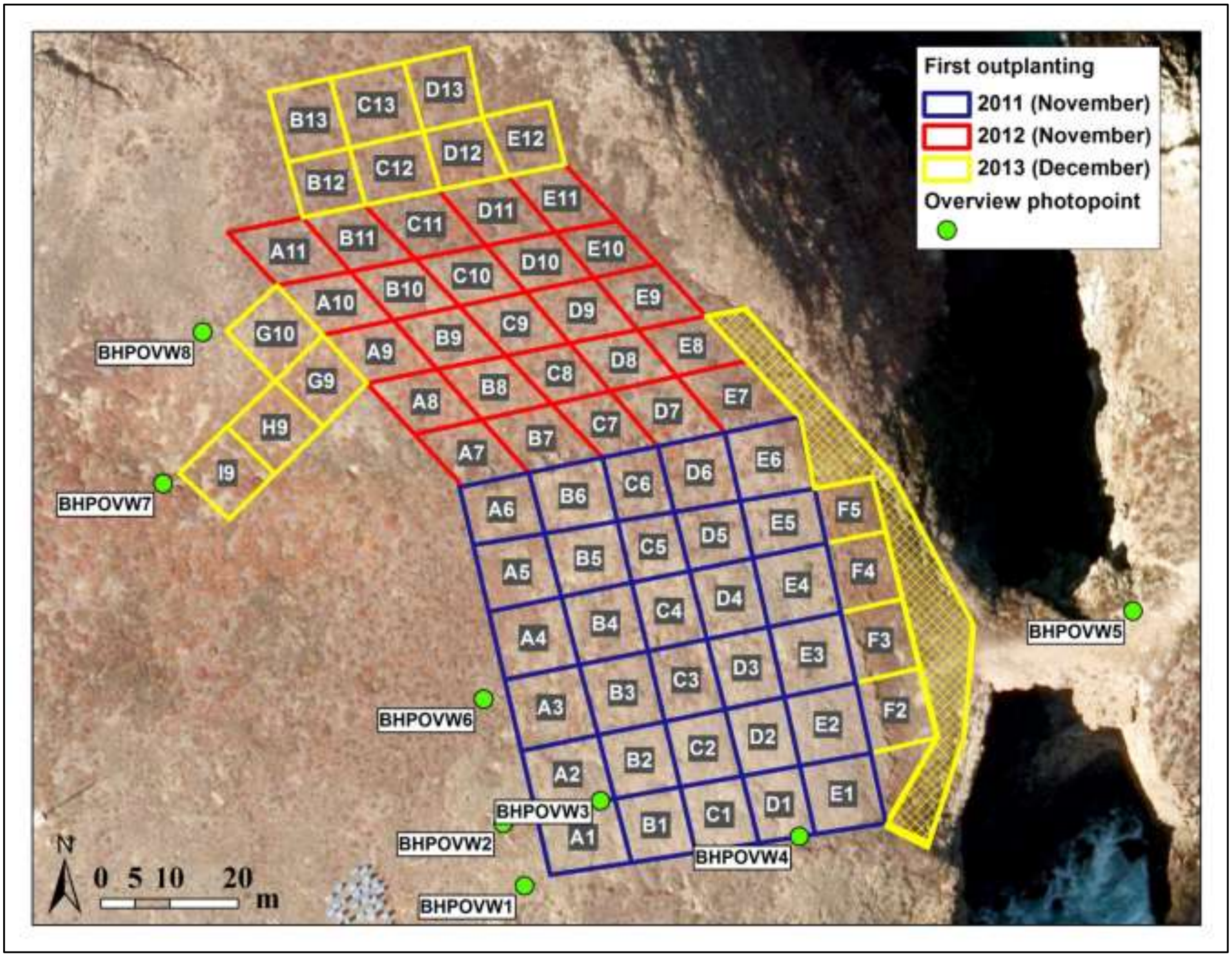
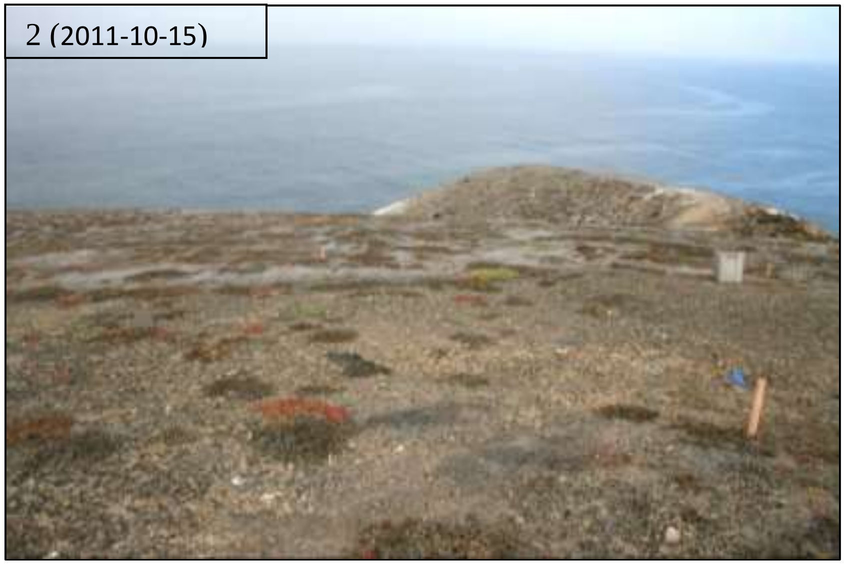


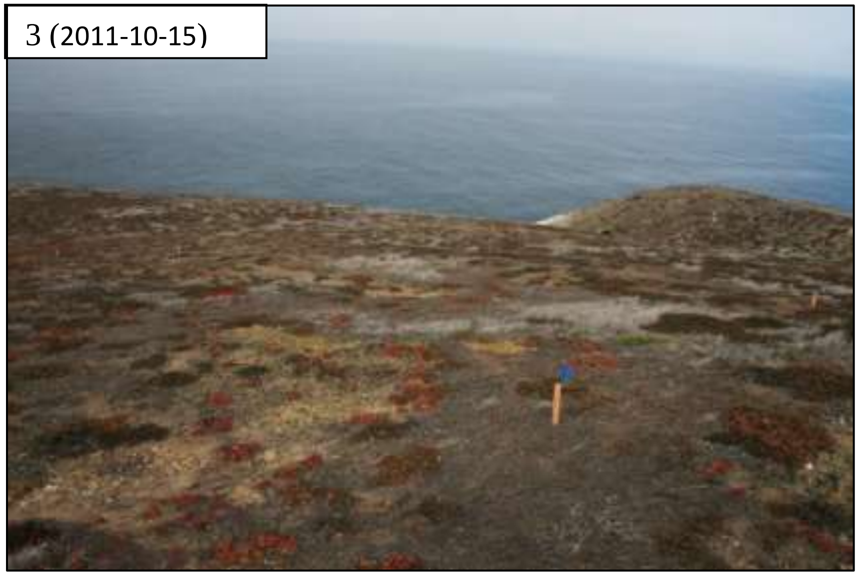
Figure 1: Location of BHP overview photopoints.

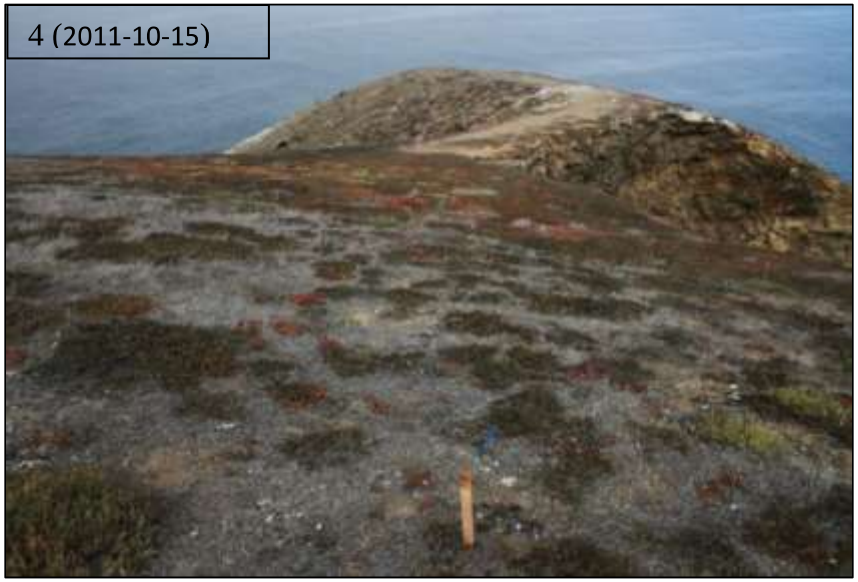
Photopoint	Waypoint ID	Easting	Northing	Location description	What to aim camera at
1	BHPOVW1	311454	3707166	Standing 3m southwest of southwest corner of subplot A1.	Right side of picture aimed at southernmost part of plot.
2	BHPOVW2	311450	3707176	Standing 3m southwest of southwest corner of subplot A2.	Right side of picture aimed at subplots A2-F2.
3	BHPOVW3	311464	3707178	Standing 2m southwest of southwest corner of subplot B2.	Looking towards subplot C3.
4	BHPOVW4	311491	3707173	Standing 2m southwest of southwest corner of subplot E1.	Right side of picture aimed at the southernmost part of plot.
5a	BHPOVW5	311541	3707205	Standing on the Arch.	Top left corner of picture aimed at southernmost part of plot.
5b					Left side of picture aimed at subplots A3-F3.
6a	BHPOVW6	311448	3707190	Standing 2m southwest of southwest corner of subplot A4.	Top of picture is centered on the arch.
6b					Looking northeast.
6c					Looking north.
7a	BHPOVW7	311399	3707225	Standing 3.5m west of northwest corner of subplot I9.	Looking northeast.
7b					Left side of picture aimed at northwestern side of subplots I9-G9 and subplots below.
8a	BHPOVW8	311406	3707248	Standing 3m southwest of northwest corner of subplot G10.	Looking towards subplots I9-G9.
8b					Looking towards subplot G10.
8c					Left side of picture aimed at northernmost part of plot.

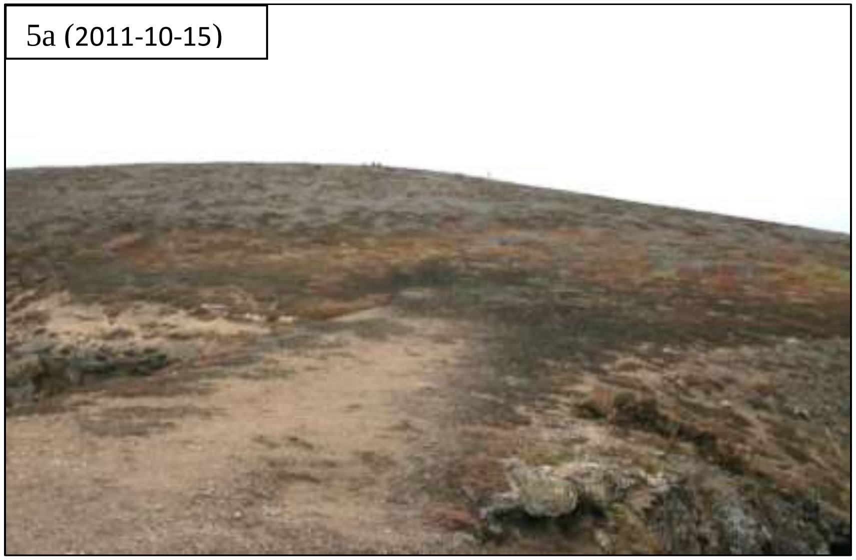
Table 1. BHP overview photopoints. GPS coordinates are in NAD83 UTM.

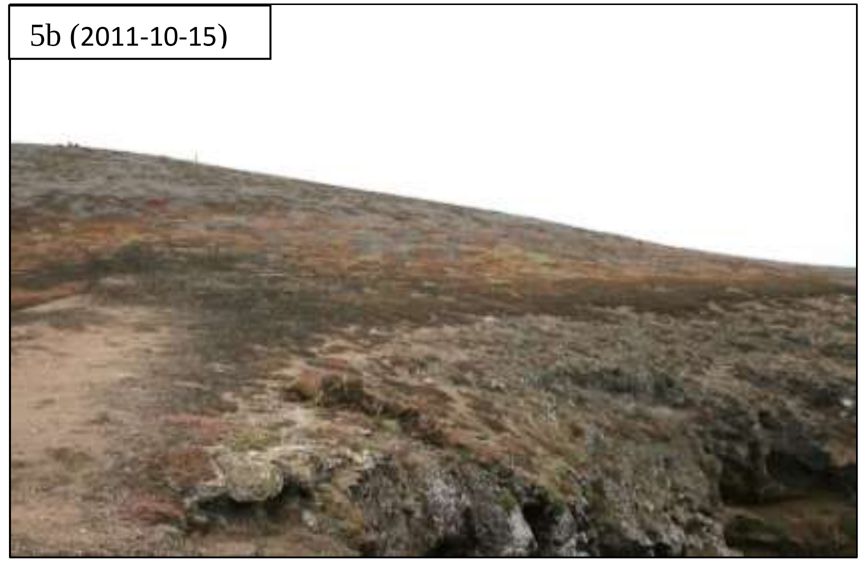

1 (2011-10-15)

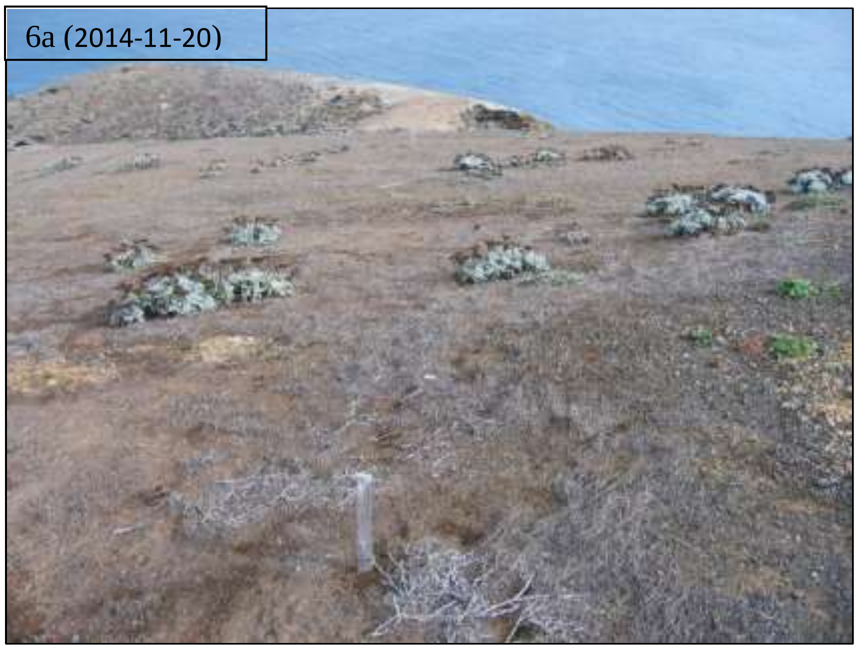

2 (2011-10-15)

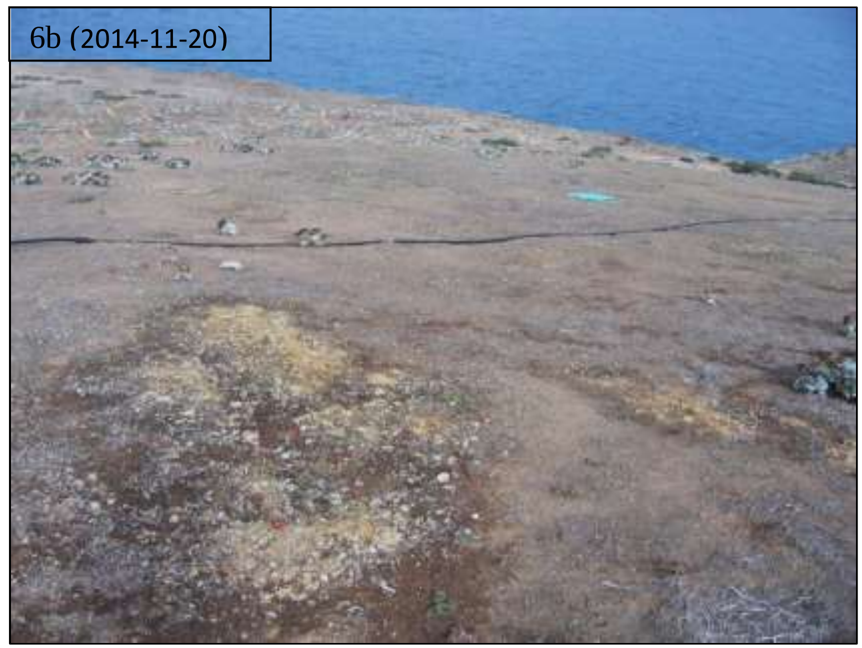

3 (2011-10-15)

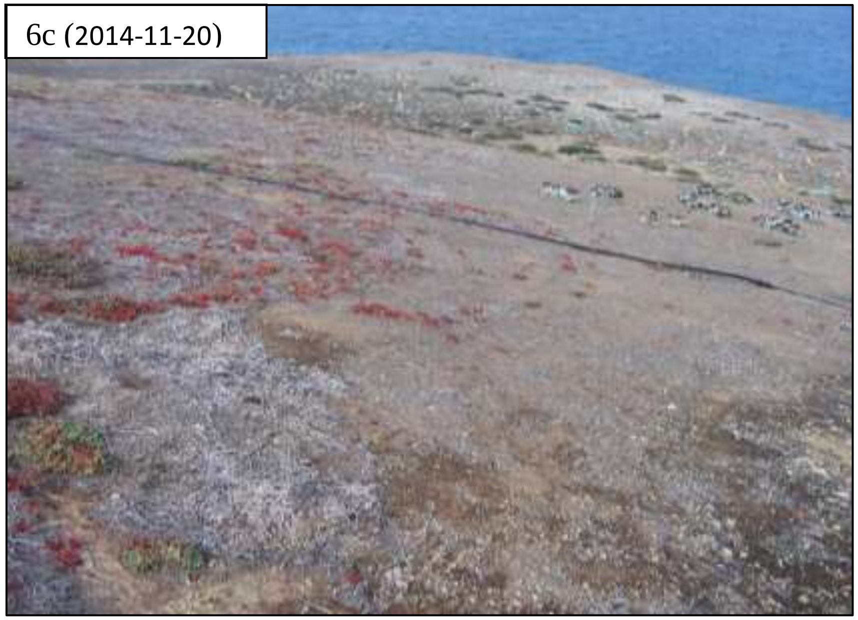

4 (2011-10-15)


5a (2011-10-15)


5b (2011-10-15)

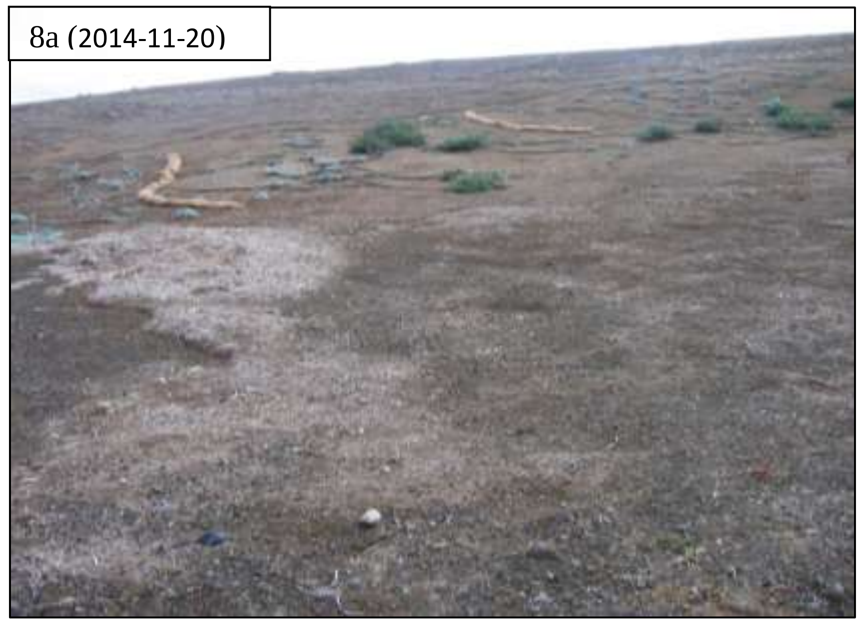

6a (2014-11-20)

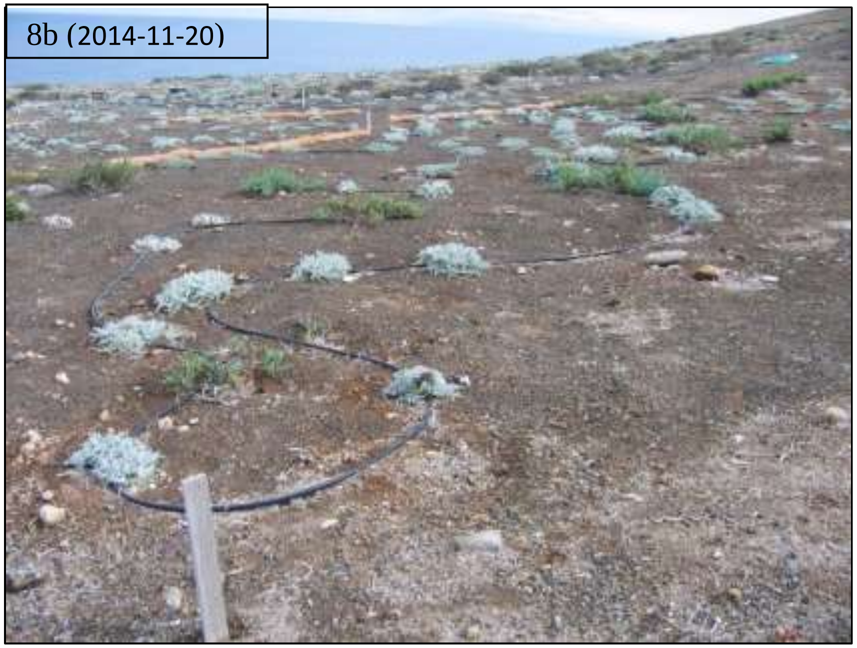

6b (2014-11-20)


6c (2014-11-20)


7a (2014-11-20)


7b (2014-11-20)


8a (2014-11-20)



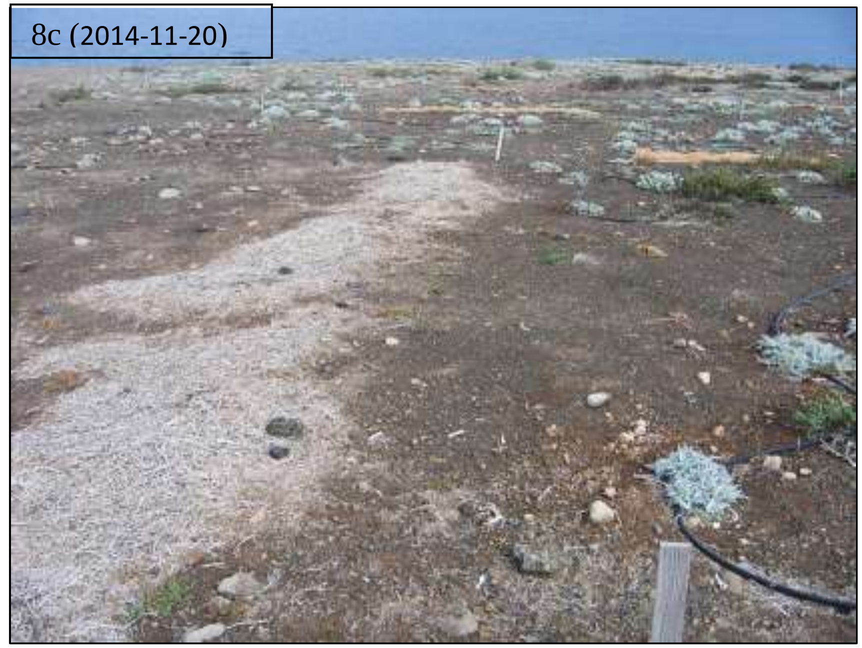


Figure 2: Photopoints 1-8c at BHP.

Elephant Seal Cove Restoration Plot (ESC)

Figure 3 and Table 2 provide the location of each photopoint at ESC. Figure 4 shows photopoints 1 through 9 at ESC.

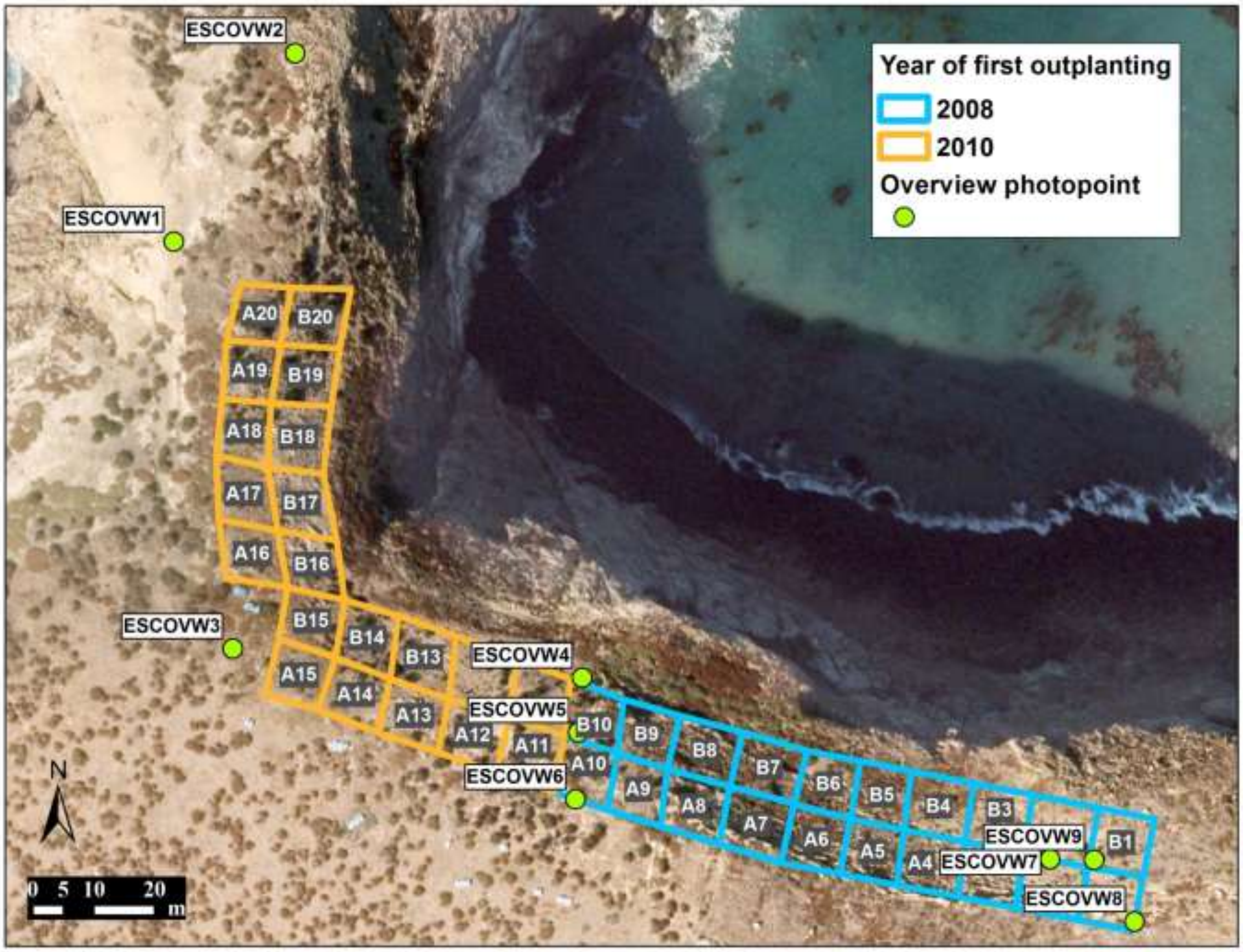
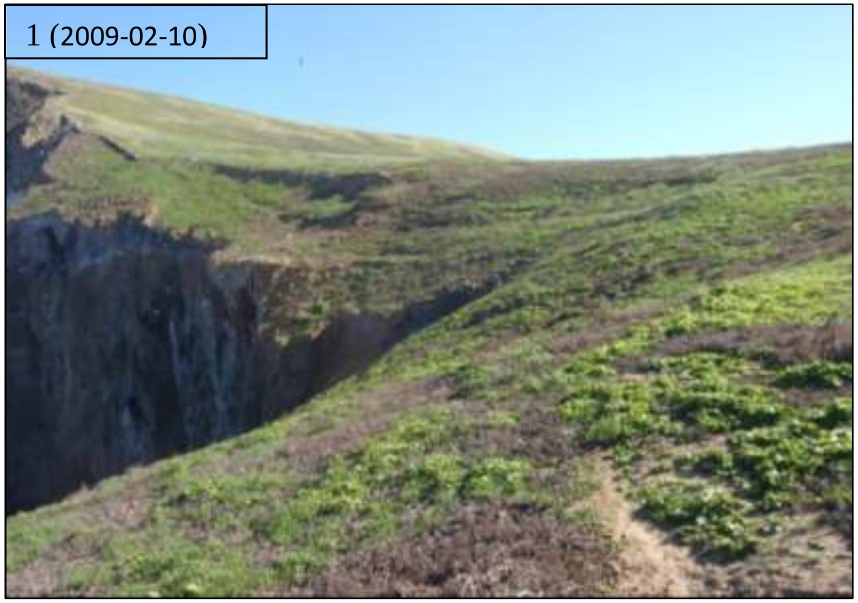


Figure 3: Location of ESC overview photopoints.

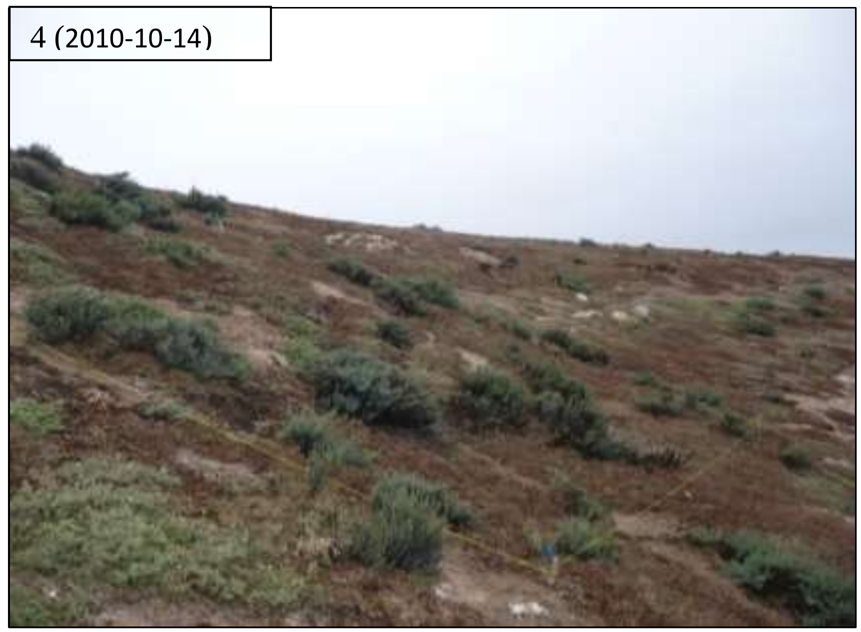
Photopoint	Waypoint ID	Easting	Northing	Location description	What to aim camera at
1	ESCOVW1	310333	3706688	By northern trail post.	North face of ESC; auklet bluff just above center of picture.
2	ESCOVW2	310353	3706719	Stand at the edge of the cliff.	North face of ESC; center picture on rockband.
3	ESCOVW3	310342	3706624	Near northwest corner of A15.	Center picture on top rockband.
4	ESCOVW4	310397	3706616	Stand 3m northeast of B11 northeast stake.	The edge of the two boulders is just outside the picture.
5	ESCOVW5	310395	3706609	Stand 3m east of B11 stake.	PLEASE PHOTOGRAPH LESS SKY. The top of Webster Point should be at the top of the picture.
6	ESCOVW6	310396	3706603	Stand 1.5m east of A11.	PLEASE PHOTOGRAPH LESS SKY. Looking west.
7	ESCOVW7	310475	3706583	Stand between A2 and B2.	Looking west at the rock bands.
8	ESCOVW8	310487	3706577	Stand close to A1 stake.	Photograph all of ESC.
9	ESCOVW9	310477	3706588	Stand close to B2 stake.	Look west towards Webster Point.

Table 2. ESC overview photopoints. GPS coordinates are in NAD83 UTM.


1 (2009-02-10)

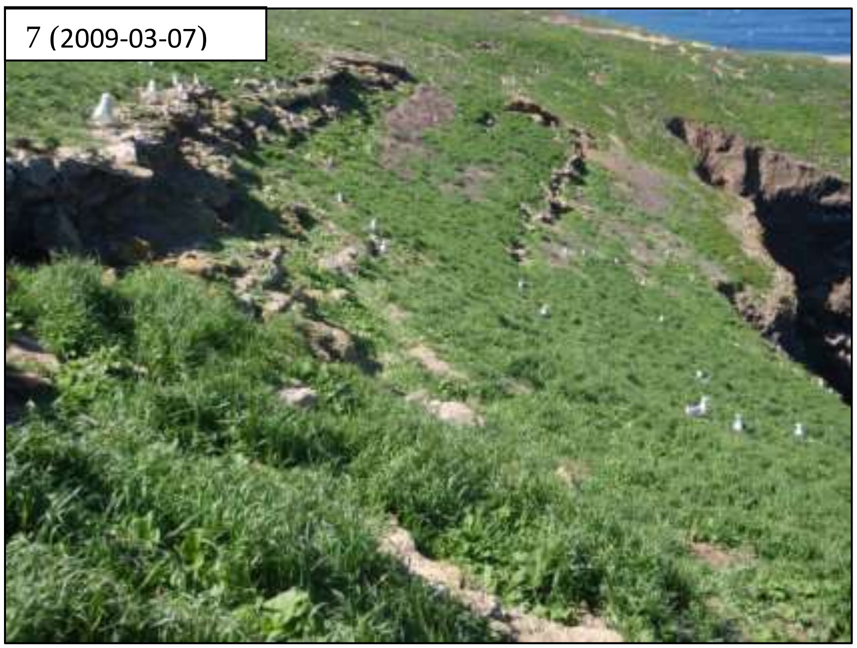

2 (2009-06-27)


3 (2010-10-14)


4 (2010-10-14)

5 (2010-10-14)

6 (2010-10-14)



7 (2009-03-07)

8 (2009-11-05)

Figure 4: Photopoints 1-9 at ESC.

House Restoration Plot (HP)

Figure 5 and Table 3 provide the location of each photopoint at HP. Figure 6 shows photopoints 1 through 7c at HP.

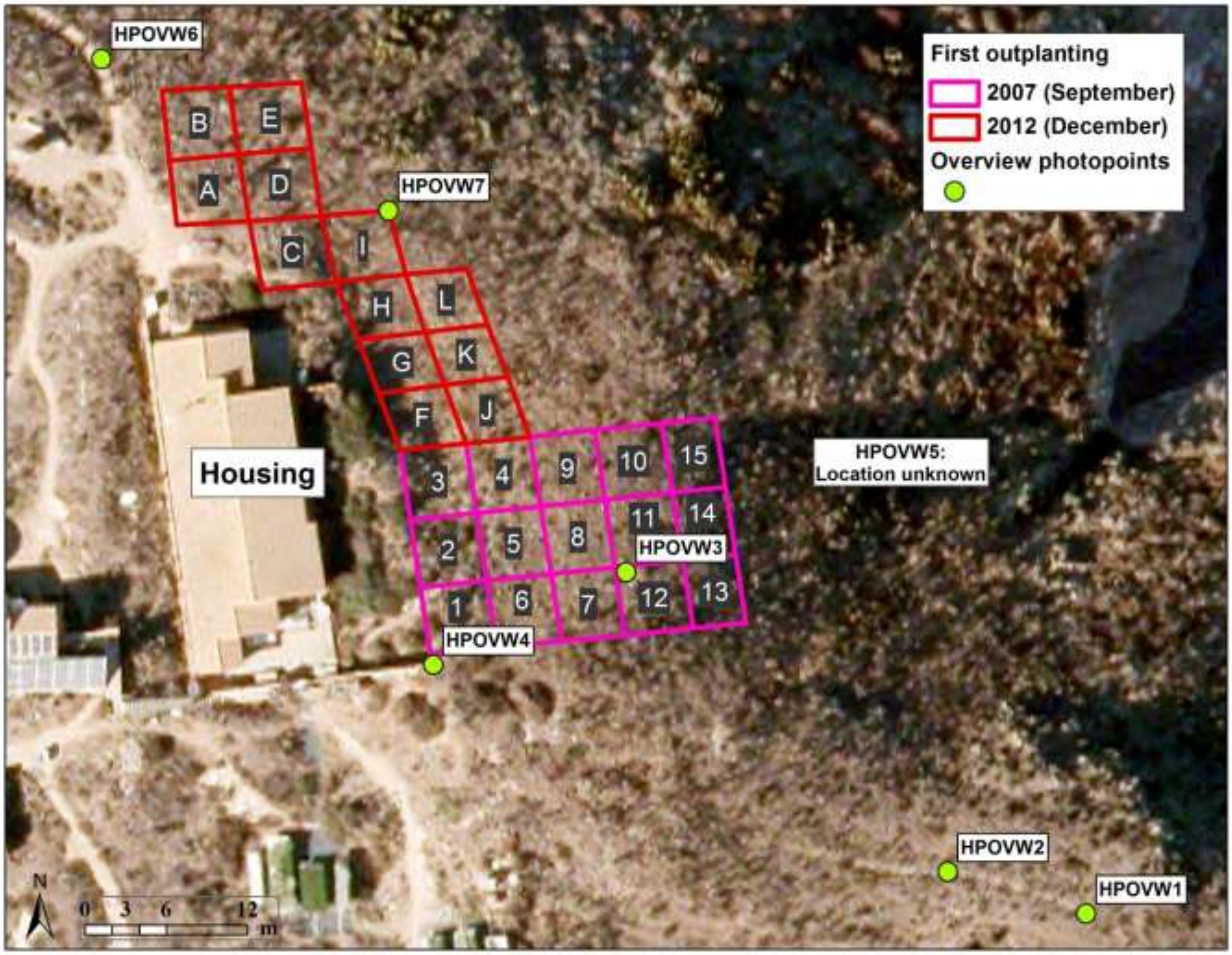


Figure 5: Location of HP overview photopoints.

Photopoint	Waypoint ID	Easting*	Northing*	Location description	What to aim camera at
1a	HPOVW1	311478	3706380	Standing on Nature Trail.	Upper left corner of picture should be aimed at the Ranger Residence.
1b					Upper left corner of picture should be aimed at the outhouses.
2	HPOVW2	311469	3706383	Standing on Nature Trail.	Upper left corner of picture should be aimed at Ranger Residence (use zoom).
3	HPOVW3	311438	3706405	Standing one meter southeast from southeast corner of HP subplot 8.	Upper left corner of picture should be aimed at Ranger Residence patio doors (master bedroom).
4	HPOVW4	311439	3706403	Standing next to brick wall edge (southeast of Ranger Residence deck).	Bottom left corner of picture should be aimed at southwestern stake of HP subplot 1.
5*	NA	NA	NA	NA	*Location of photopoint 5 unknown; photopoint discontinued.
6	HPOVW6	311404	3706443	Standing on the 11th stair from Landing Cover trail.	Upper right corner of picture should be aimed at the bunkhouse.
7a	HPOVW7	311423	3706434	Standing at northeast corner of HP subplot I.	Looking South.
7b					Upper left corner of picture should be aimed at the brick wall next to the VC.
7c					Upper left corner of picture should be aimed at the edge of the bunkhouse.

Table 3: HP overview photopoints. GPS coordinates are in NAD83 UTM.


1a (2007)


1b (2007)


2 (2007)


3 (2007)


4 (2007)


5 (2007)
DISCONTINUED


6 (2014-11-12)

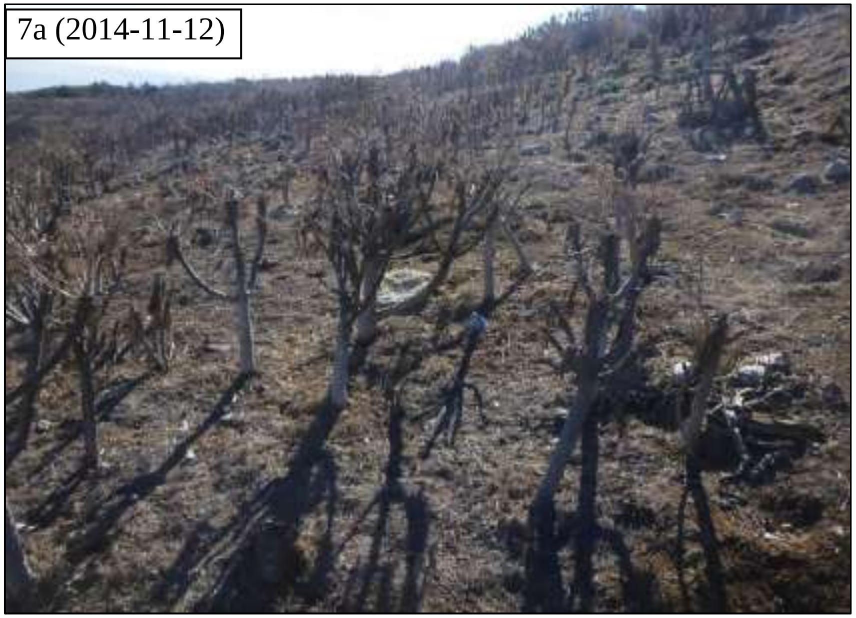

7a (2014-11-12)

Figure 6: Photopoints 1-7c at HP.

Landing Cove Restoration Plot (LACO)

Figure 7 and Table 4 provide the location of each photopoint at LACO. Figure 8 shows photopoints 1 through 10 at LACO.

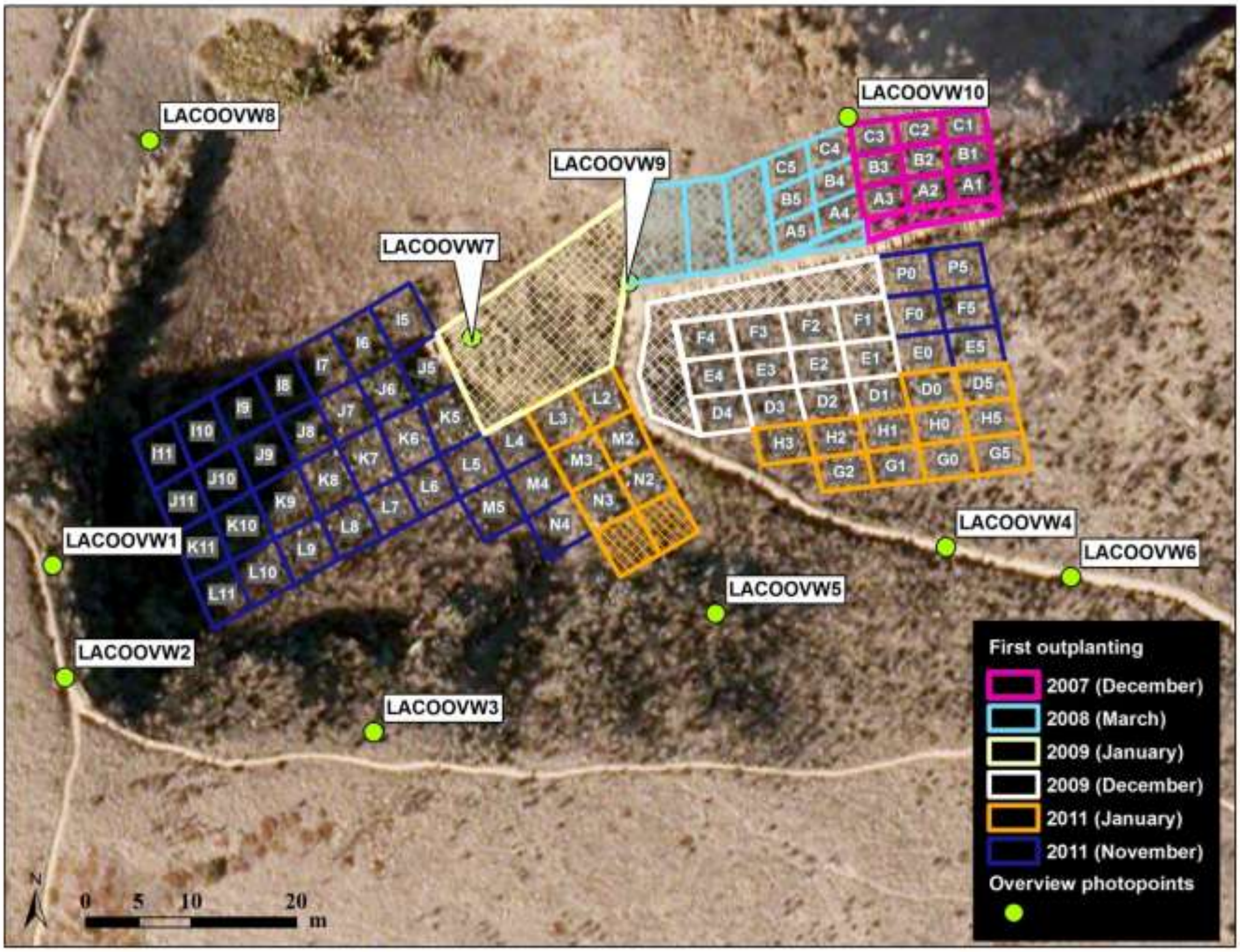


Figure 7: Location of LACO overview photopoints.

Photopoint	Waypoint ID	Easting	Northing	Location description	What to aim camera at
1	LACOOVW1	311286	3706455	Stand on rocks 1m below Arch point trail above LACO (about 10m north of retaining wall).	The dock house should be at the middle of the upper part of the picture. All of LACO plot should be in the picture.
2	LACOOVW2	311289	3706447	Arch point trail above LACO, next to retaining wall.	The right side of the picture should be aimed at the dock house. The bottom left corner of the picture should show the retaining wall next to Arch point trail.
3	LACOOVW3	311320	3706445	2m east of Arch point trail.	Zoom in to get all of the north east part of LACO plot.
4	LACOOVW4	311375	3706463	Stand on LACO trail.	The top of LACO canyon should be centered in the middle of the upper part of the picture.
5	LACOOVW5	311351	3706462	Stand on the rock band above Landing Cove trail.	The bottom right corner of the picture should be aimed at the bench.
6a	LACOOVW6	311387	3706461	Stand on LACO trail.	Picture should show all the subplots between the upper and lower part of Landing Cove trail.
6b					Zoom in: picture should be centered just below the bench.
7	LACOOVW7	311327	3706480	Stand next to artificial burrow in flatter area west of the bench in LACO.	The middle of Landing cove canyon should be at the left of the picture.
8a	LACOOVW8	311293	3706498	Stand on rock band, west of cactus patch situated north of LACO.	The top left corner of the picture should show the bunkhouse.
8b					Zoom in: the dock house should be just outside the middle left of the picture.
9	LACOOVW9	311343	3706487	Stand next to bench in Landing Cove.	The landing cove steps that are close to the bench should be just outside the bottom right corner of the picture.
10	LACOOVW10	311363	3706504	Stand 5m north of the northwest corner of subplot B3 in LACO.	The southeast part of LACO plot should be centered at the left of the picture.

Table 4. LACO overview photopoints. GPS coordinates are in NAD83 UTM.

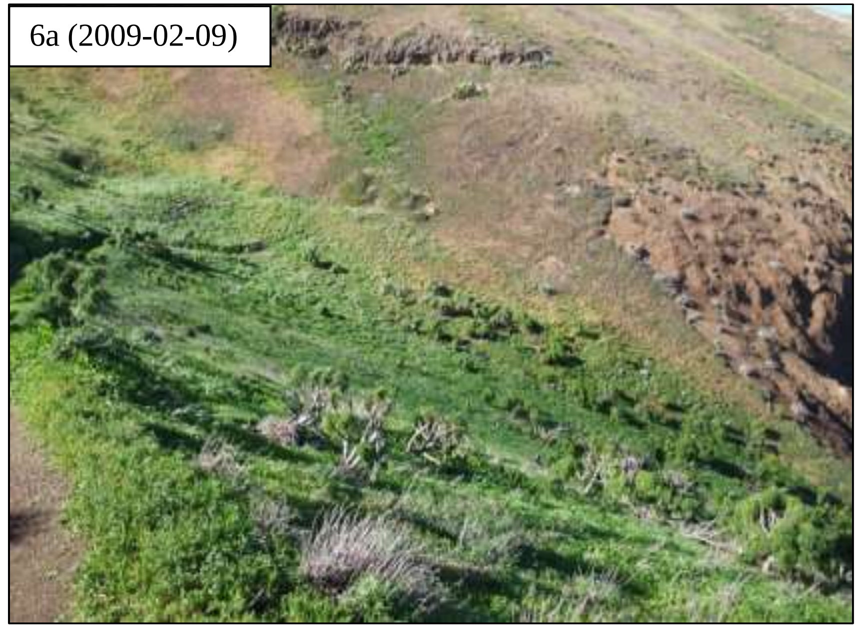

1 (2015-01-26)


2 (2015-01-26)


3 (2009-02-04)


4 (2010-03-05)

5 (2009-02-04)



6a (2009-02-09)

6b (2009-02-09)

7 (2009-02-08)

Figure 8: Photopoints 1-10 at LACO.

Nature Trail Restoration Plot (NTP)

Figure 9 and Table 5 provide the location of each photopoint at NTP. Figure 10 shows photopoints 1 through 6c at NTP.

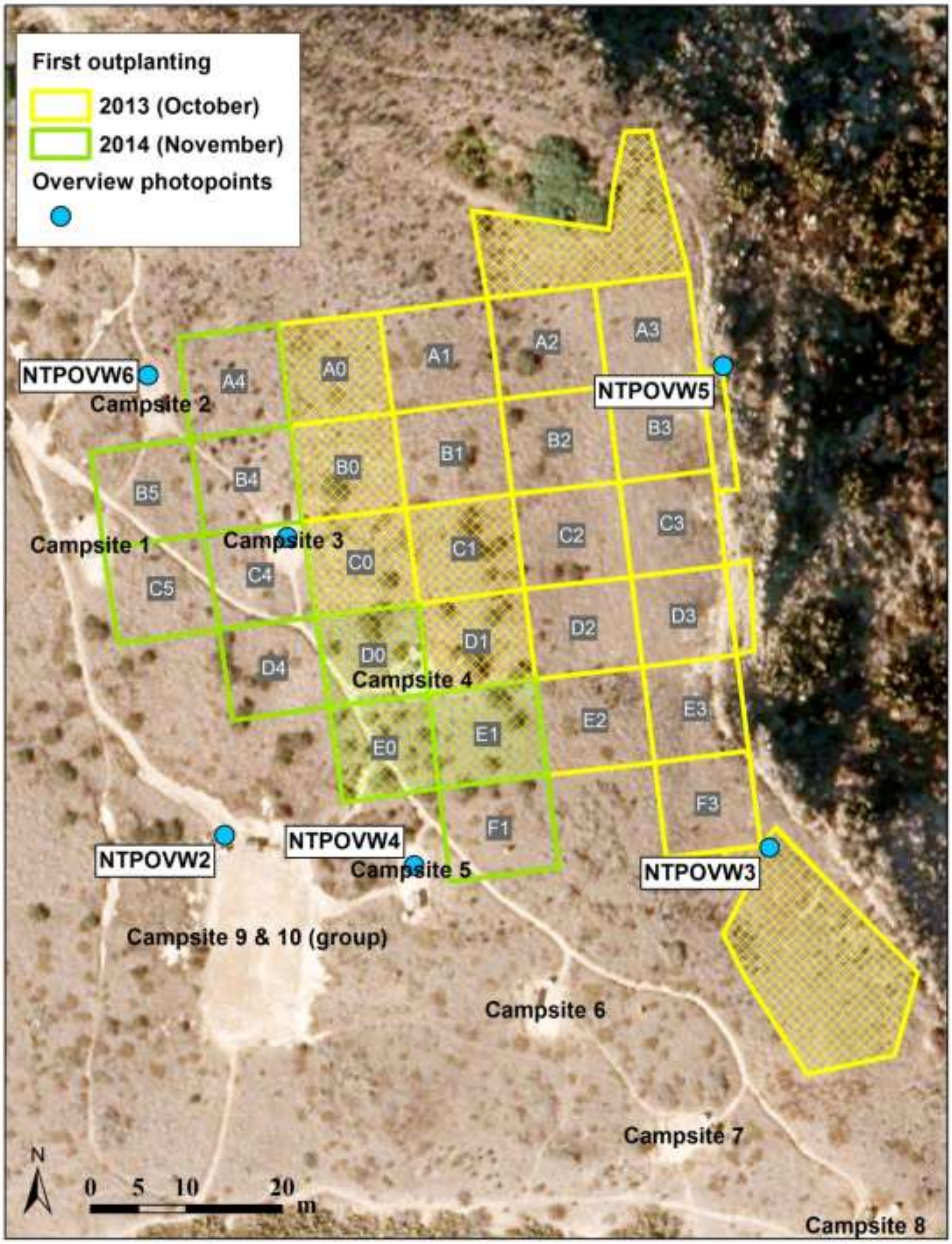
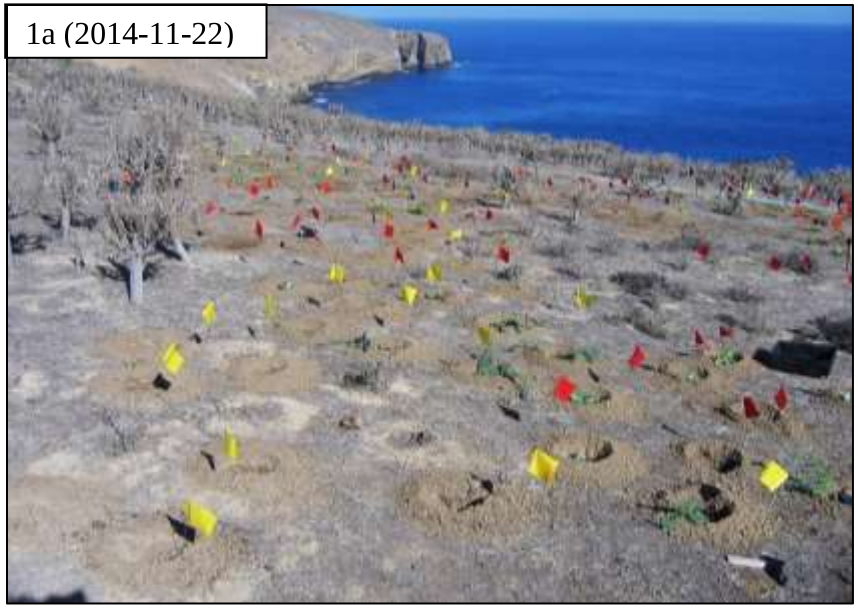


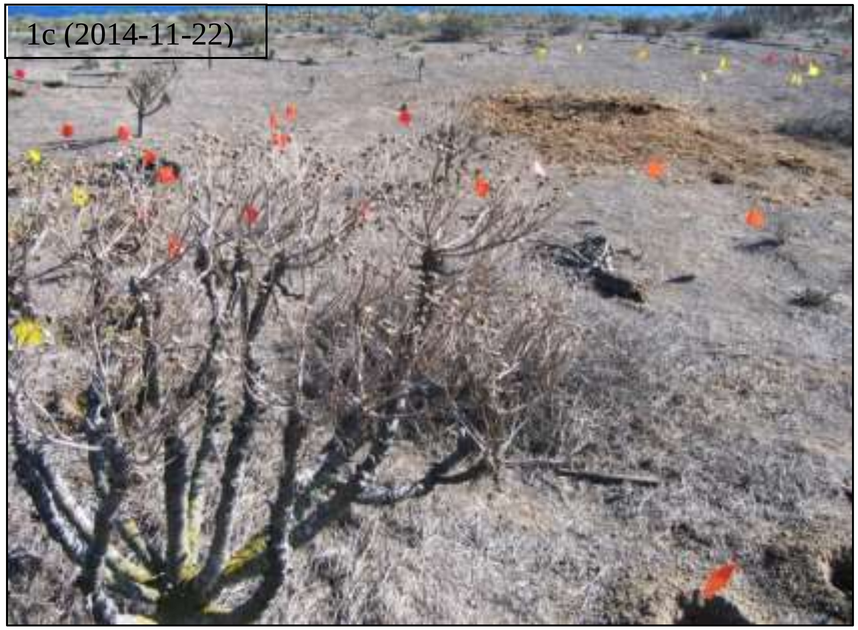
Figure 9: Location of NTP overview photopoints.

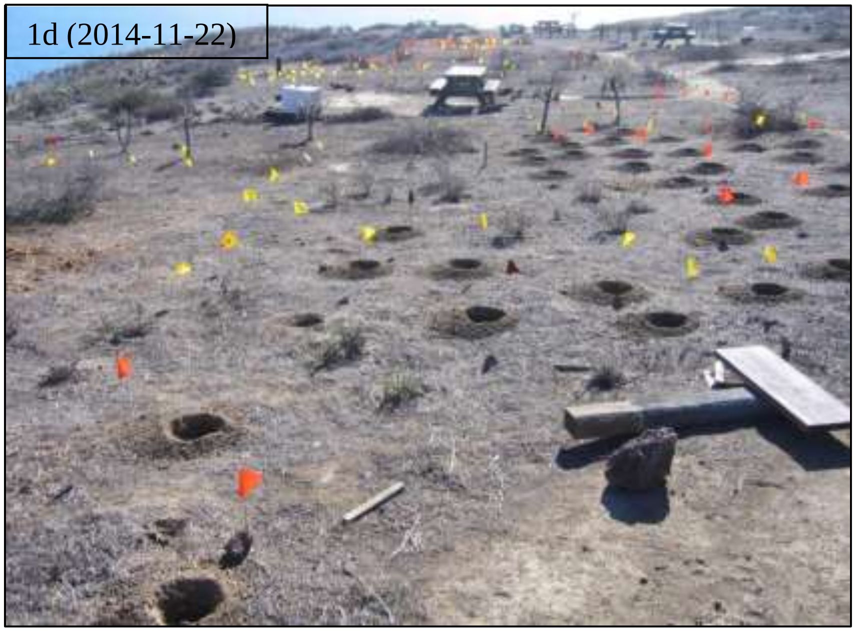
Photo point	Waypoint ID	Easting	Northing	Location description	What to aim camera at
1a	NTPOVW1	311461	3706334	Standing in campsite #3.	Top left side of picture aimed at edge of lower grow-out area.
1b					Looking towards the leach field.
1c					Looking southeast.
1d					Looking southeast, with campsite #7 in the middle of the picture.
1e					Looking towards group campground.
1f					Top right of picture aimed at edge of campsite #1.
2a	NTPOVW2	311454	3706304	Standing on top of mouse-proof containers in group campground.	Top left corner of picture aimed at housing.
2b					Top left corner of picture aimed at campsite #3.
2c					Top left corner of picture aimed at campsite #5.
3a	NTPOVW3	311511	3706303	Standing at the bottom left corner of F3.	Top left corner of picture aimed at housing.
3b					The overview bench should be at the edge of the middle top of the picture.
3c					The left edge of the picture should be aimed at the left edge of NTP subplot F3.
4a	NTPOVW4	311473	3706300	Standing in campsite #5.	Looking towards F1.
4b					The top center of the picture should be aimed at Nature Trail post 9.
4c					Top left corner of picture aimed at housing.
4d					Top left corner of picture aimed at campsite #1.
5a	NTPOVW5	311505	3706352	Standing next to nature trail post #9.	Top left corner of picture should be aimed at overlook bench.
5b					Looking south-southwest.
5c					Looking southwest.
5d					Top right corner of picture aimed at housing.
5e					Top left corner of picture aimed at housing.
6a	NTPOVW6	311446	3706352	Standing in campsite #2.	Campsite #3 just outside right side of picture.
6b					Middle left side of picture aimed at campsite #3
6C					Middle left side of picture aimed at Campsite #1

Table 5. NTP overview photopoints. GPS coordinates are in NAD83 UTM.

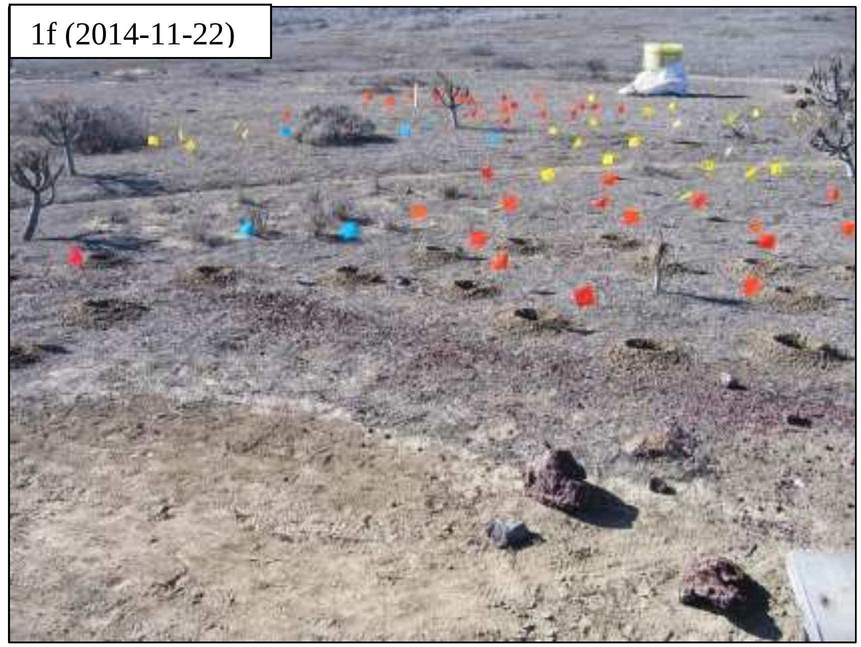

1a (2014-11-22)


1b (2014-11-22)


1c (2014-11-22)


1d (2014-11-22)


1e (2014-11-22)

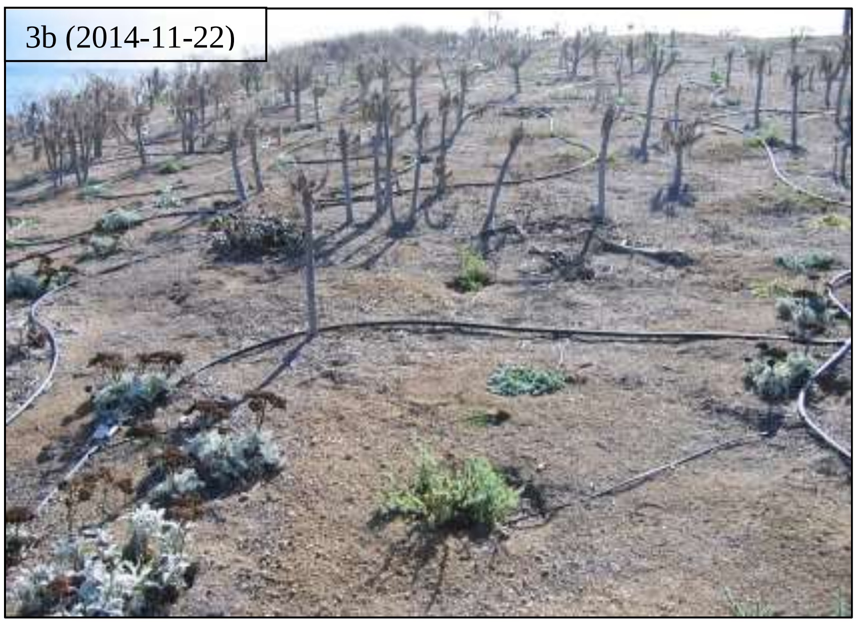

1f (2014-11-22)

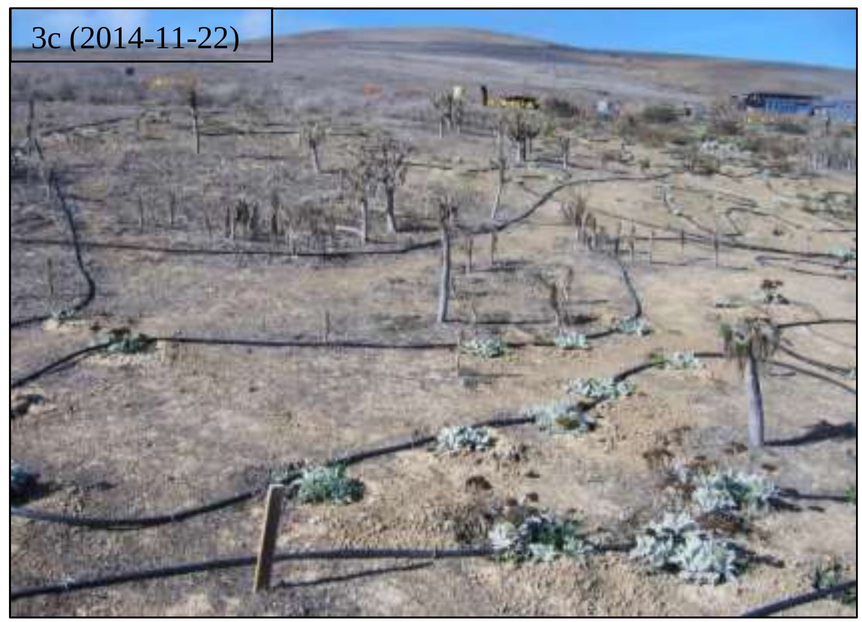

2a (2014-11-22)

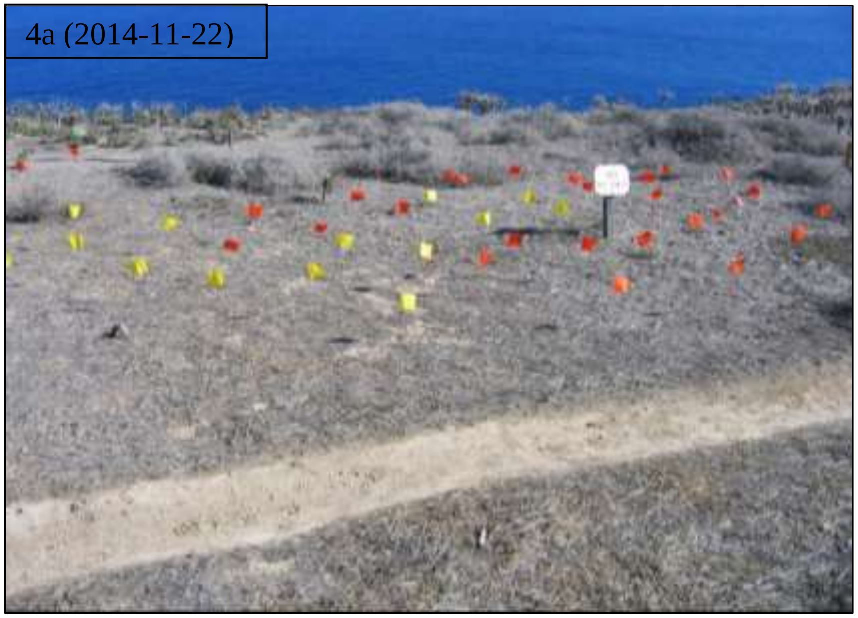

2b (2014-11-22)

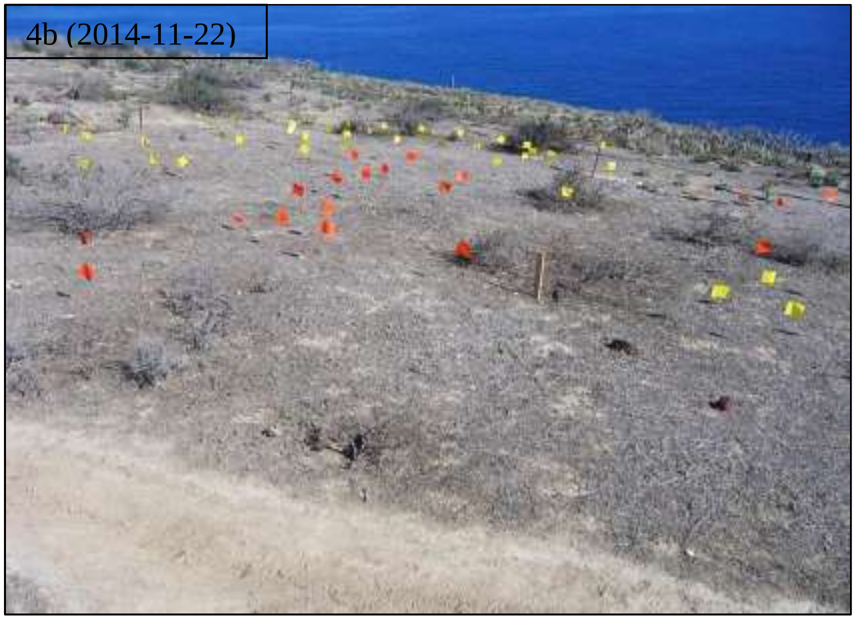

2c (2014-11-22)


3a (2014-11-22)


3b (2014-11-22)

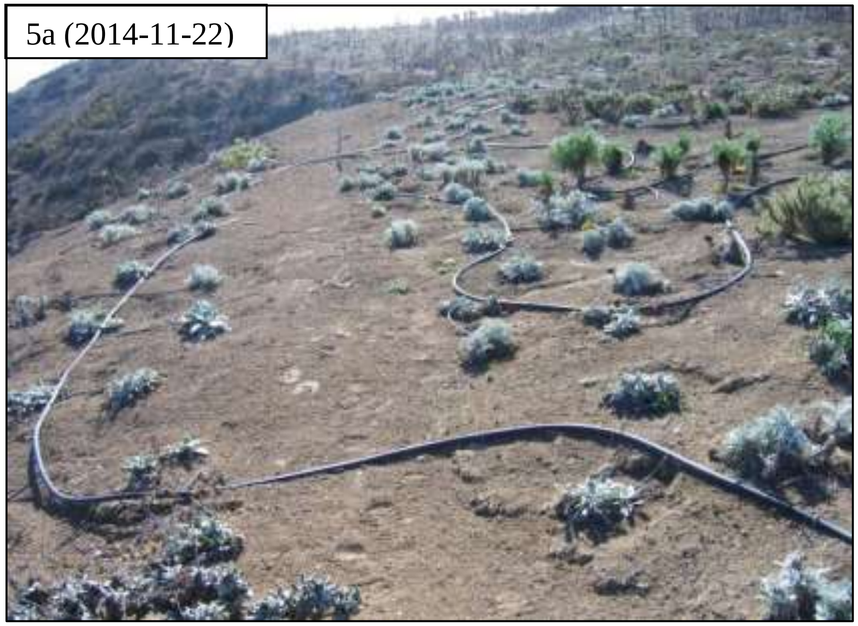

3c (2014-11-22)

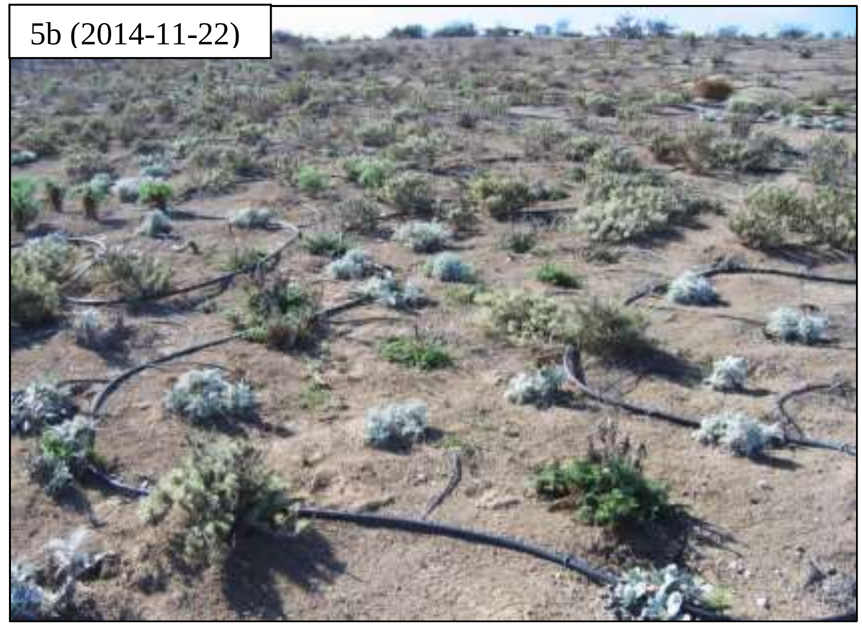

4a (2014-11-22)

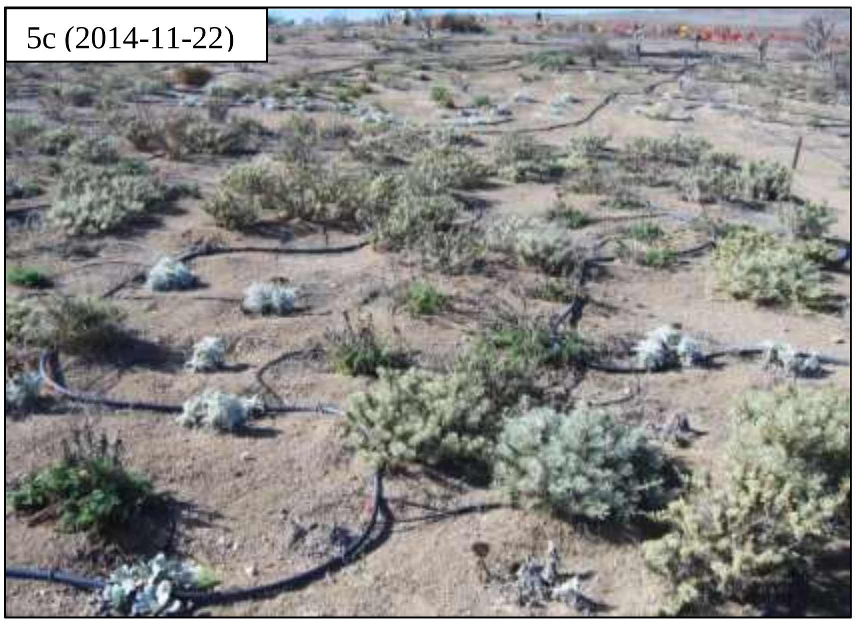

4b (2014-11-22)

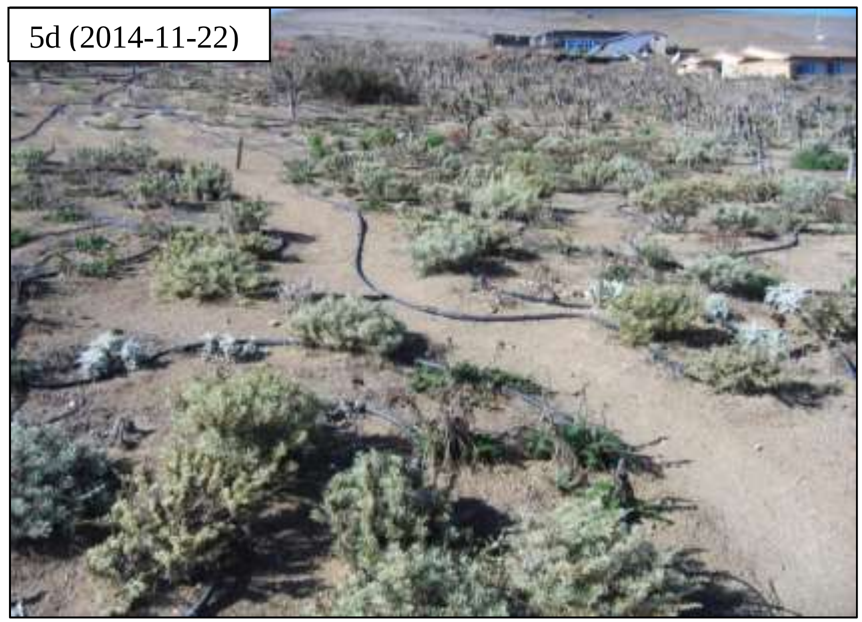

4c (2014-11-22)


4d (2014-11-22)


5a (2014-11-22)


5b (2014-11-22)


5c (2014-11-22)


5d (2014-11-22)

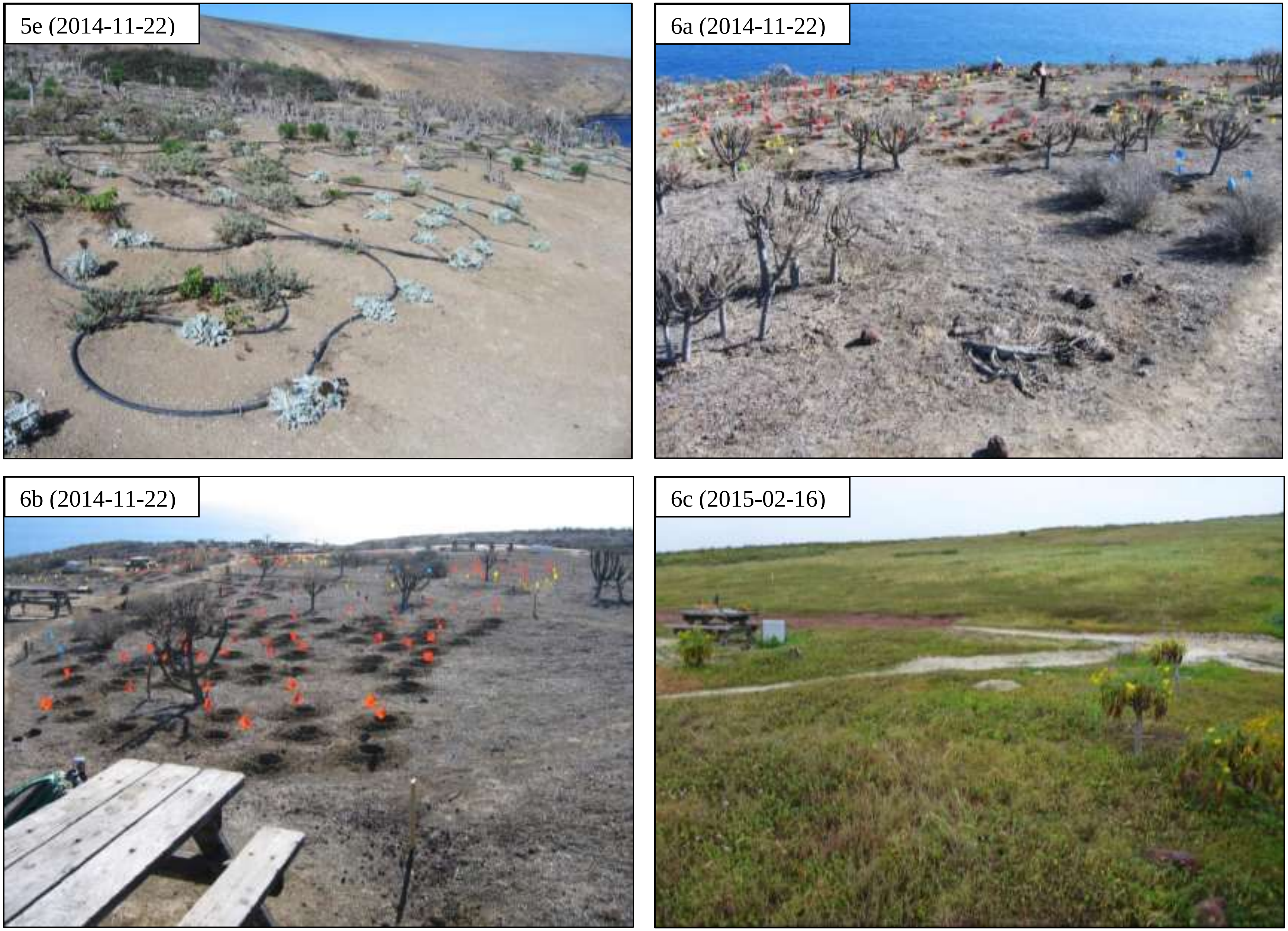


Figure 10: Photopoints 1a-6c at NTP.

Northeast Flats Restoration Plot (NEF)

Figure 11 and Table 6 provide the location of each photopoint at NEF. Figure 12 shows photopoints 1 through 6d at NEF.

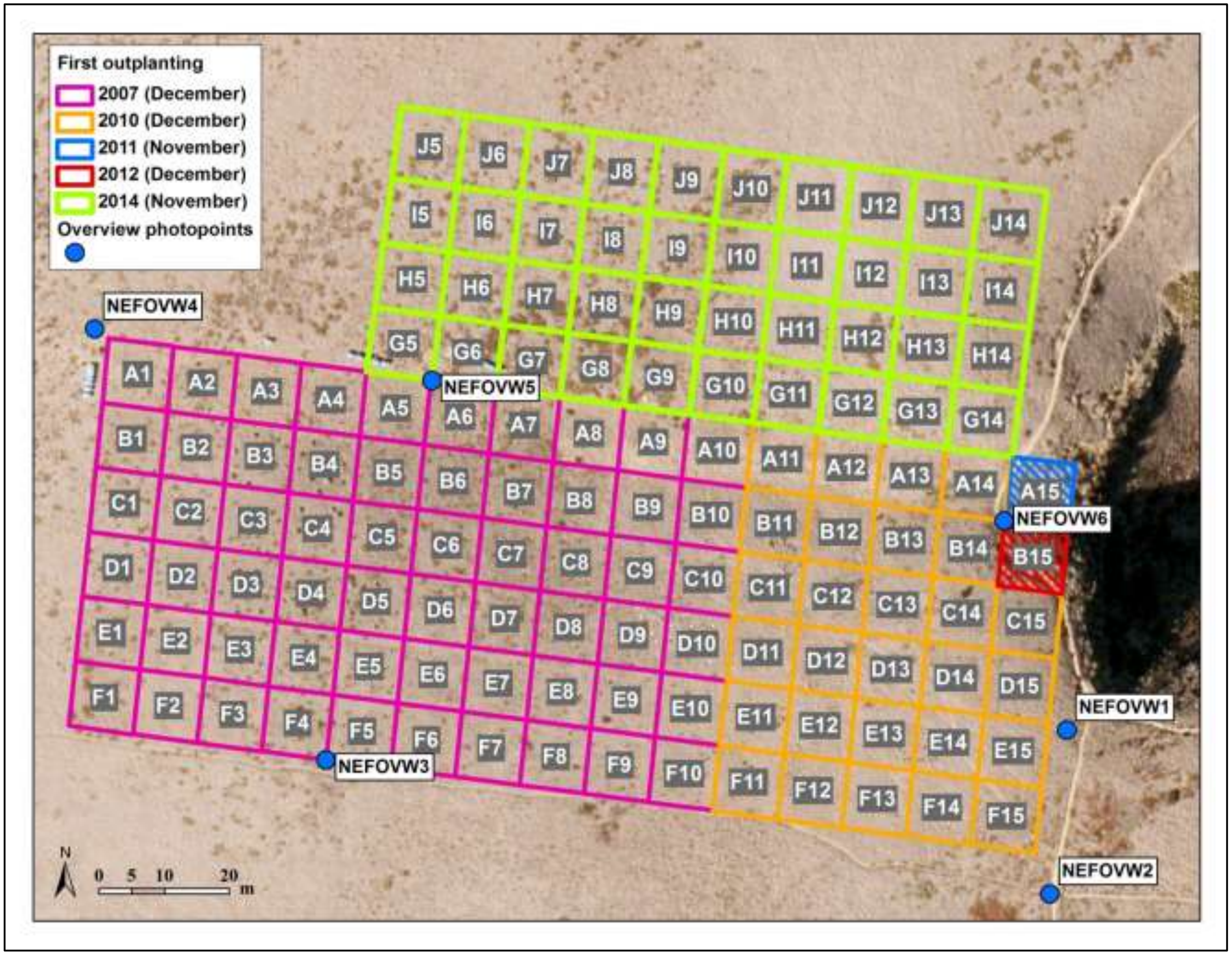
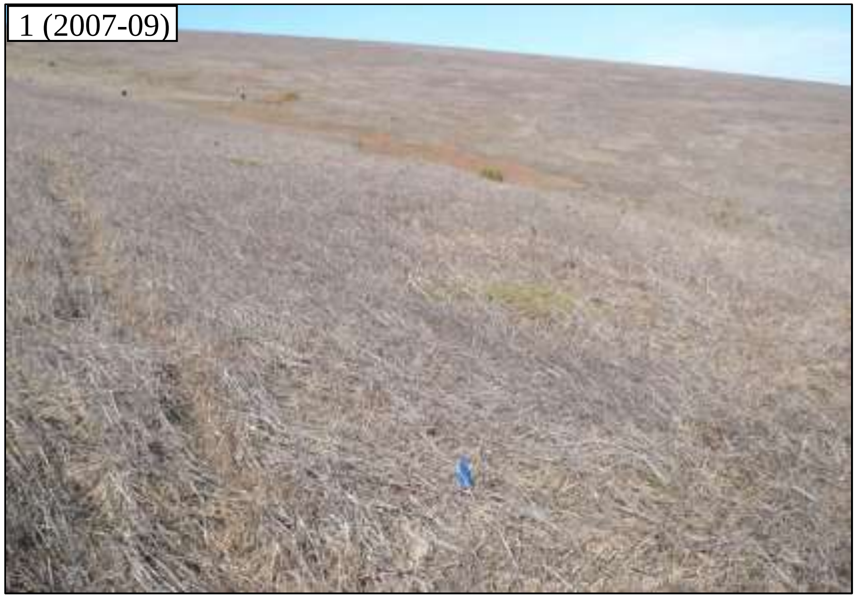


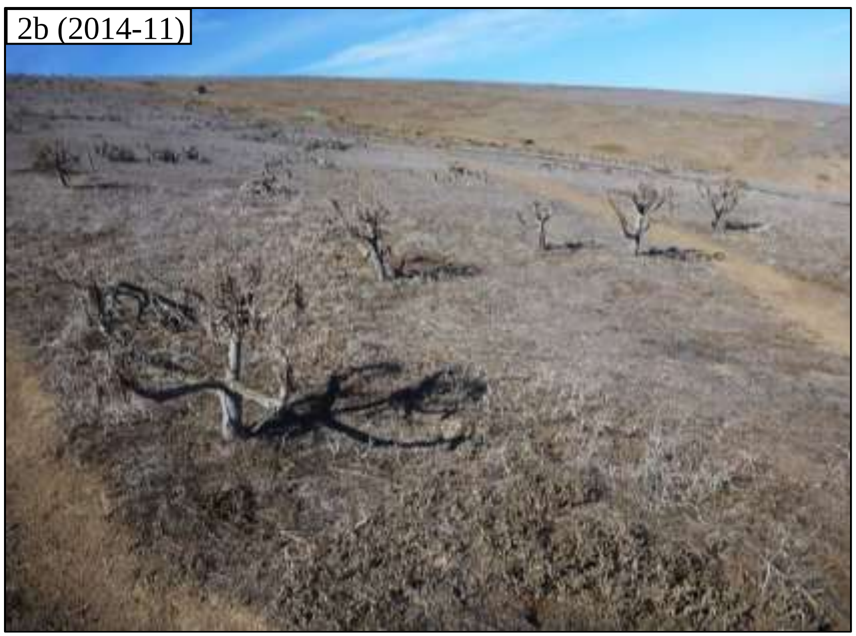
Figure 11: Location of NEF overview photopoints.

Photo point	Waypoint ID	Easting	Northing	Location description	What to aim camera at
1	NEFOVW1	311281	3706440	Standing 2m southeast of southeast corner of NEF subplot D15.	Looking northwest towards gully.
2a	NEFOVW2	311271	3706417	Standing at the intersection of the trail to NEF and Arch Pt trail (close to southeast corner of NEF).	Looking west.
2b					Looking northwest.
3a	NEFOVW3	311174	3706436	Standing at southwest corner of NEF subplot F5.	Lower left corner of picture should be aimed at trail, looking West-North-West at NEF.
3b					Looking northwest at NEF.
4	NEFOVW4	311124	3706495	Standing 2m northwest of northwest corner of NEF subplot A1.	Bunkhouse centered at the top of the picture.
5a	NEFOVW5	311182	3706495	Standing next to middle water tank.	Southwest corner of NEF subplot H6 should be centered at the left of the picture.
5b					Picture should be aimed at subplots H7 and I7.
5c					LACO centered at the top of the picture.
5d					Upper left corner of picture should be aimed at LACO.
5e					Looking southeast.
5f					Looking southwest.
6a	NEFOVW6	311262	3706472	Standing at the southeast corner of NEF subplot A14.	Looking northwest.
6b					Looking west.
6c					Looking southwest.
6d					Looking south.

Table 6. NEF overview photopoints. GPS coordinates are in NAD83 UTM.

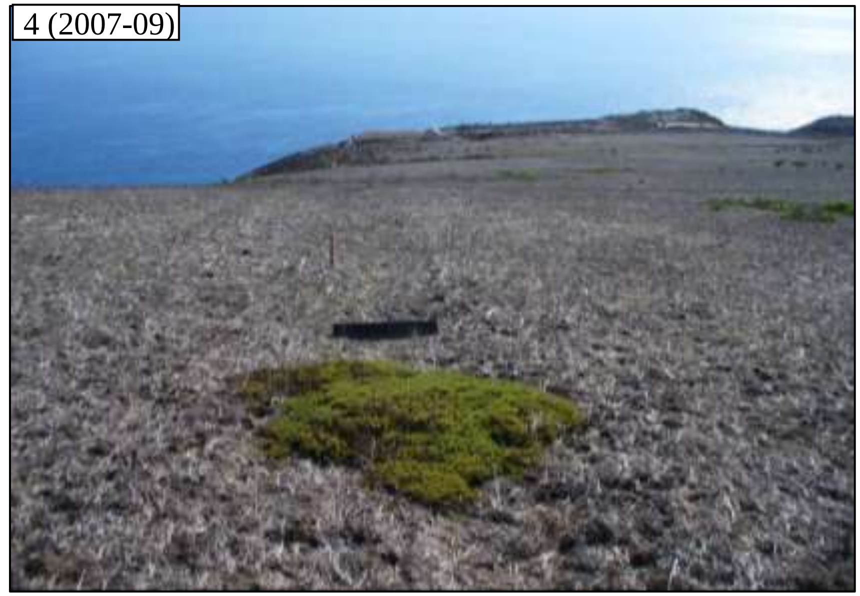

1 (2007-09)


2a (2014-11)


2b (2014-11)

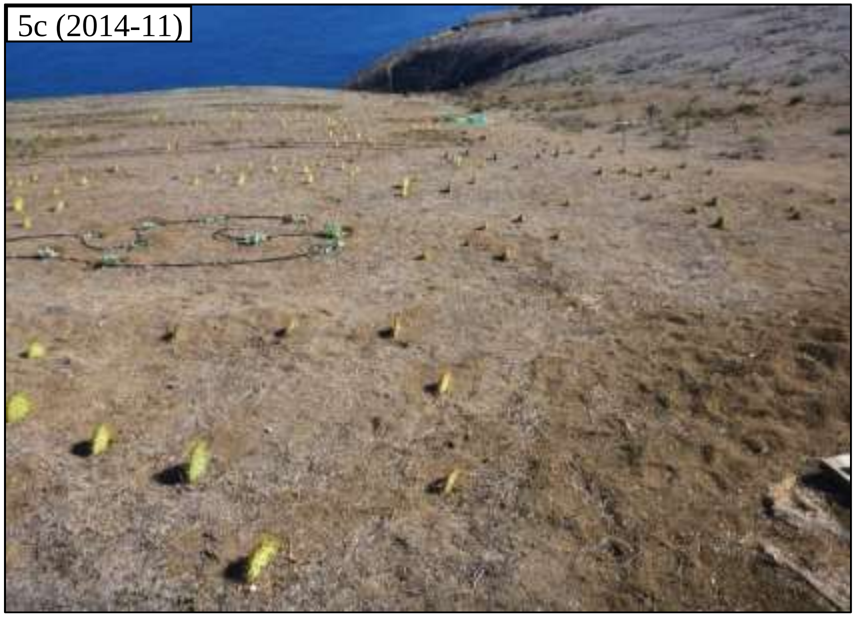

3a (2014-11)


3b (2014-11)


4 (2007-09)


5a (2014-11)


5b (2014-11)


5c (2014-11)


5d (2014-11)


5e (2014-11)


5f (2014-11)

Figure 12: Photopoints 1-6d at NEF.

Appendix V: Protocol for the First Year Survivorship Survey

The first year survivorship survey is used to determine the survival rate of recently outplanted plants. This survey should be taken one year after an outplanting. Do not repeat this survey (i.e., this survey should only be taken once per subplot, one year after the first planting).

Materials needed

- Stakes
- Sharpie
- Clipboard
- PDA
- Datasheets
- Pencils
- Map of restoration plot
- Flags (optional)

Procedure:

- In each subplot, record the number of outplanted plants that are still alive and outplanted within the last year (no recruits or older plants). Each species must be surveyed separately. You can use flags to mark individuals as you count them.
- Do not record the survival rate of species that have no above ground vegetation when dormant, such as Common Yarrow (*Achillea millefolium*).
- For dormant species with above ground vegetation, check each plant to ensure you record all outplanted live individuals.
- Record data in the PDA and on the datasheets.
- Upon return to the office, send a copy of the PDA file and datasheets to the vegetation database manager. Always leave a backup of the PDA file and a photocopy of the datasheet on SBI.

Filling out forms on the PDA:

1. Turn on the PDA using the power button located at the top right corner.

2. Click the start icon at the top left corner of the screen and select “Forms 5.1”.
3. Select “Vegetation Survey Parent Form”.
4. Select “New”.
5. Select the correct plot ID – BHP (Beacon Hill), ESC (Elephant Seal Cove), HP (House), LACO (Landing Cove), NEF (Northeast Flats), or NTP (Nature Trail).
6. Date: YEAR-MM-DD.
7. Record observers’ initials.
8. Select “survivorship survey”.
9. Click “add” to add a subplot.
10. Write subplot ID.
11. Click “Next”.
12. Record the number of plant alive by species in the selected subplot. The total number of plants per plot should be automatically generated.
13. Click “Next”.
14. In “Comments”, include any relevant notes.
15. Click “Next”.
16. Repeat steps 9 through 15for each subplot.
17. Click “Done” when finished.

Datasheet:

Survivorship																		
Plot	**Subplot**	**Date**	**Observers**	**ACMI**	**Artemisia Spp**	**ATCA**	**BAPI**	**CAMA**	**CHCA**	**COGI**	**CONE**	**DECL**	**ERGC**	**LYCA**	**Nassella Spp**	**Spergularia Spp**	**SUTA**	**Other Species**

Comments ____

____

Instructions: Only count the number of plants that are alive.

Data Entered (Initials Date): ______________ Data Proofed (Initials Date): __________________

APPENDIX VI: LIST OF VEGETATION SURVEYS AND PHOTOPOINTS TAKEN BETWEEN 2007 AND 2014

Tables 1 through 6 summarize surveys and photopoints taken in each restoration plot between 2007 and 2014. Table 7 lists landscaping photopoints taken between 2011 and 2014. These summaries will be added to the restoration database.

BHP												
Subplot surveyed			Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Nov-11	Nov-12	Dec-13										
X			2011	Dry	% Cover ¥	KWB, KMR, MEJ, CAC	15-Oct-11	Yes	Yes	Yes	NA	
X			2011	Dry	Subplot photopoints ¥	KWB, KMR	15-Oct-11	NA	Yes	NA	Yes	Photopoints from row 6 are missing.
X			2011	Dry	Overview photopoints ¥	KWB, KMR	15-Oct-11	NA	Yes	NA	No	
X			2011	Dry	Postplanting count	KWB, SAA	27-Nov-11	Yes	Yes	Yes	NA	
X			2011-2012	Growing	% Cover	NA	NA	NA	NA	NA	NA	2011-2012 growing season survey not taken. Survey would not have been a good representation of non-native because of winter weeding.
X			2011-2012	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	2011-2012 photopoints not taken. Pictures would not have been a good representation of non-native because of winter weeding.
X			2011-2012	Growing	Overview Photopoints	NA	NA	NA	NA	NA	NA	2011-2012 photopoints not taken. Survey would not have been a good representation of non-native because of winter weeding.
X			2012	Dry	% Cover	AAY, JAH	28-Oct-12	Yes	Yes	Yes	NA	
X			2012	Dry	Subplot photopoints	AAY, JAH	29-Oct-12	NA	Yes	NA	No	
X			2012	Dry	Overview Photopoints	AAY, JAH	29-Oct-12	NA	NA	NA	NA	Overview photopoints not taken.
	X		2012	Dry	% Cover ¥	SKC	1-Nov-12	*	*	Yes	NA	*Unreliable data, except native cover. Native cover proofed and added to database. Other data not added to database.

BHP (Cont'd)													
Subplot surveyed			Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Nov-11	Nov-12	Dec-13										
	X		2012	Dry	Subplot photopoints ¥	SKC	2-Nov-12	NA	Incomplete	NA	Yes	Half the pictures are missing.
	X		2012	Dry	Overview photopoints ¥	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
X	X		2012	Dry	Postplanting count	NA	2012-11	Yes	Yes	Yes	NA	
X	X		2012-2013	Growing	% Cover	AAY, JAH, EWW	12-Jan-13	Yes	Yes	Yes	NA	
X	X		2012-2013	Growing	Subplot photopoints	AAY, JAH, EWW	12-Jan-13	NA	No	NA	NA	Subplot photopoints taken but missing.
X	X		2012-2013	Growing	Overview Photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
X	X		2013	Dry	% Cover	AAY	16-Sep-13	Yes	Yes	Yes	NA	
X	X		2013	Dry	Subplot photopoints	AAY	16-Sep-13	NA	Yes	NA	No	
X	X		2013	Dry	Overview Photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
		X	2013	Dry	% Cover ¥	AAY	16-Sep-13	Yes	Yes	Yes	NA	
		X	2013	Dry	Subplot photopoints ¥	AAY	13-Sep-13	NA	Yes	NA	Yes	Photo numbers were erased.
		X	2013	Dry	Overview photopoints ¥	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
	X	X	2013	Dry	Postplanting count	NA	17-Dec-13	Yes	Yes	Yes	NA	
X	X	X	2013-2014	Growing	% Cover	AAY	30-Mar-14	Yes	Yes	Yes	NA	
X	X	X	2013-2014	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	Subplot photopoints not taken.
X	X	X	2013-2014	Growing	Overview Photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
X	X	X	2014	Dry	% Cover	AAY, GRK	28-Sep-14	Yes	Yes	Yes	NA	
		X	2014	Dry	Survivorship	GRK	28-Sep-14	Yes	Yes	Yes	NA	
X	X	X	2014	Dry	Subplot Photopoints	AAY, GRK	29-Sep-14	NA	Yes	NA	Yes	
X	X	X	2014	Dry	Overview Photopoints	MEJ	20-Nov-14	NA	Yes	NA	Yes	

Table 1: Summary of surveys and photopoints taken between 2011 and 2014 at BHP.
¥ indicates pre-restoration surveys or photopoints.

ESC											
Subplots		Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Nov-08	Dec-10										
X		2008	Dry	% Cover ¥	ALH	NA	NA	No	Yes	NA	Unuseable survey. Data not transferred to database.
X		2008	Dry	Subplot photopoints ¥	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X		2008	Dry	Overview photopoints ¥	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X		2008	Dry	Postplanting count	ALH, LMK,MH	2008-11-25	Incomplete	Yes	Incomplete	NA	Available data proofed. Data is for the entire plot.
X		2008-2009	Growing	% Cover	NA	NA	NA	NA	NA	NA	No %Cover survey taken during this growing season: too early to detect a significant change.
X		2008-2009	Growing	Postplanting count	CEH	2009-02-01	NA	Yes	No	NA	Data is for the entire plot.
X		2008-2009	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	Not taken. Too early to detect a significant change.
X		2008-2009	Growing	Overview Photopoints	NA	NA	NA	NA	NA	NA	Not taken. Too early to detect a significant change.
X		2009	Dry	% Cover	ALH, NAG	2009-09-26	Yes	Yes	Yes	NA	
X		2009	Dry	Survivorship	NA	NA	NA	NA	NA	NA	No survivorship survey taken this dry season.
X		2009	Dry	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X		2009	Dry	Overview Photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X		2009	Dry	Postplanting count	NAG	2009-12-20	NA	Yes	No	NA	Data could have been proofed; no hardcopy found.
X		2009-2010	Growing	% Cover	NAG	2010-01-31	Yes	Yes	Yes	NA	
X		2009-2010	Growing	Subplot photopoints	NA	2010-02-02	NA	Yes	NA	Yes	
X		2009-2010	Growing	Overview Photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X		2010	Summer	Tags (initial tagging)	NAG, SAA, KWB, SLA	2010-05-25	Yes	Incomplete	Yes	NA	ACMI data was unreliable and therefore not added to database.
X		2010	Dry	Survivorship	NAG	2010-05-24	Yes	Incomplete	Yes	NA	ACMI data was unreliable and therefore not added to database. Initial tagging, but outplanted 5 months earlier. This is the only reliable survivorship taken at ESC.
X		2010	Dry	Subplot photopoints	NAG	2010-05-24	NA	Yes	NA	No	
X		2010	Dry	Overview Photopoints	NA	NA	NA	NA	NA	NA	Overview photpoints not taken.
X		2010	Dry	% Cover	KWB, MEJ	2010-10-14	Yes	Yes	Yes	NA	
X		2010	Dry	Tags	KWB, MEJ	2010-10-14	Yes	Incomplete	Yes	NA	Last tag survey taken. ACMI data was unreliable, an therefore not added to database.
X		2010	Dry	Survivorship	KWB, MEJ	2010-10-14	Yes	No	Yes	NA	Data unreliable and therefore not added to database (all live plants were recorded instead of outplanted plants only).
X		2010	Dry	Subplot photopoints	KWB, MEJ	2010-10-14	NA	Yes	NA	Yes	
X		2010	Dry	Overview Photopoints	NA	NA	NA	NA	NA	NA	Overview photpoints not taken.
	X	2010	Dry	% Cover ¥	SAA, KWB	2010-11-05	Yes	Yes	Yes	NA	
	X	2010	Dry	Subplot photopoints ¥	SAA, KWB	2010-11-05	NA	Yes	NA	Yes	

ESC (Cont'd)											
Subplots		Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints	Note
Nov-08	Dec-10										
	X	2010	Dry	Overview photopoints ¥	KWB, MEJ	2010-10-14	NA	Yes	NA	Yes	
X	X	2010	Dry	Postplanting count	MEJ	2010-11-17	Yes	Yes	Yes	NA	
X	X	2010-2011	Growing	% Cover	MEJ, SAA	2011-01-22	Yes	Yes	Yes	NA	
X	X	2010-2011	Growing	Subplot photopoints	MEJ, SAA	2011-01-22	NA	Yes	NA	No	
X	X	2010-2011	Growing	Overview Photopoints	NA	NA	NA	NA	NA	NA	Overview photpoints not taken.
X	X	2011	Dry	% Cover	MEJ, AAY	2011-09-26	Yes	Yes	Yes	NA	
X	X	2011	Dry	Subplot photopoints	MEJ, AAY	2011-09-26	NA	Yes	NA	No	
X	X	2012	Dry	Overview Photopoints	NA	NA	NA	NA	NA	NA	Overview photpoints not taken.
	X	2011	Dry	Postplanting count	REW, KMR	2011-11-17	Yes	Yes	Yes	NA	
X	X	2011-2012	Growing	% Cover	NA	NA	NA	NA	NA	NA	2011-2012 growing season %cover survey not taken. Survey would not have been a good representation of non-native because of winter weeding.
X	X	2011-2012	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	2011-2012 photopoints not taken. Pictures would not have been a good representation of non-native because of winter weeding.
X	X	2011-2012	Growing	Overview Photopoints	NA	NA	NA	NA	NA	NA	2011-2012 photopoints not taken. Survey would not have been a good representation of non-native because of winter weeding.
X	X	2012	Dry	% Cover	KMR, REW	2012-09-14	Yes	Yes	Yes	NA	
X	X	2012	Dry	Subplot photopoints	KMR, REW	2012-09-14	NA	Yes	NA	No	
X	X	2012	Dry	Overview Photopoints	NA	NA	NA	NA	NA	NA	Overview photpoints not taken.
X	X	2012-2013	Growing	% Cover	AAY, JAH, EWW	2013-01-10	Yes	Yes	Yes	NA	
X	X	2012-2013	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X	X	2012-2013	Growing	Overview Photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X	X	2013	Dry	% Cover	AAY	2013-09-17	Yes	Yes	Yes	NA	
X	X	2013	Dry	Subplot photopoints	AAY	2013-09-17	NA	Yes	NA	No	
X	X	2013	Dry	Overview Photopoints	NA	NA	NA	NA	NA	NA	Overview photpoints not taken.
X	X	2013-2014	Growing	% Cover	AAY	2014-04-07	Yes	Yes	Yes	NA	
X	X	2013-2014	Growing	Subplot photopoints	AAY	2014-04-07	NA	Yes	NA	No	
X	X	2013-2014	Growing	Overview Photopoints	NA	NA	NA	NA	NA	NA	Overview photpoints not taken.
X	X	2014	Dry	% Cover	AAY, GRK	2014-09-30	Yes	Yes	Yes	NA	
X	X	2014	Dry	Subplot photopoints	GRK	2014-09-30	NA	Yes	NA	No	
X	X	2014	Dry	Overview Photopoints	NA	NA	NA	NA	NA	NA	Overview photpoints not taken.

Table 2: Summary of surveys and photopoints taken between 2008 and 2014 at ESC.

¥ indicates pre-restoration surveys or photopoints.

HP											
Subplots		Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Sep-07	Dec-12										
X		2007	Dry	% Cover ¥	ALH	2007-09-13	Yes	Yes	Yes	NA	Data taken by categories.
		2007	Dry	Subplot photopoints ¥	NA	NA	NA	NA	NA	NA	Photopoints not taken.
		2007	Dry	Overview photopoints ¥	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X		2007	Dry	Postplanting count	ALH, KWB	2007-09-15	Yes	Yes	Yes	NA	Every outplanted plant was tagged.
X		2007	Dry	Tags (initial tagging)	ALH, KWB	2007-09-15	Yes	Yes	Yes	NA	Every outplanted plant was tagged.
X		2007-2008	Growing	% Cover	ALH	2008-01-28	Incomplete	Yes	Incomplete	NA	Only part of the hardcopy was found and proofed.
X		2007-2008	Growing	Tags	ALH	2008-01-28	Yes	Yes	Yes	NA	
		2007-2008	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
		2007-2008	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X		2007-2008	Growing	Tags	EM	2008-04-18	Yes	Yes	Yes	NA	Only surveyed subplots 1-9, because the lower plots were too close to BRPE nests.
		2008	Dry	% Cover						NA	Survey either not taken or lost.
X		2008	Dry	Tags	JSK	2008-10-26	NA	No	Yes	NA	Unreliable data not added to database (many CONE and ERGC were labelled as dormant).
		2008	Dry	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
		2008	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X		2008	Dry	Postplanting count	Unknown	2008-11-30	Yes	Yes	Yes	NA	
X		2008-2009	Growing	% Cover	ALH	2009-02-06	Yes	Yes	Yes	NA	
X		2008-2009	Growing	Survivorship	LMK, ALH, P__	2009-02-07	NA	No	Yes	NA	Unreliable data. Do not use.
X		2008-2009	Growing	Tags	ALH, LMK	2009-02-07	Yes	Yes	Yes	NA	Last tag survey taken.
X		2008-2009	Growing	Subplot photopoints	ALH	2009-02-06	NA	Yes	NA	No	Photos of each subplot taken from below and from above.
X		2008-2009	Growing	Overview photopoints	ALH	2009-02-06	NA	*	NA	No	Only some of the overview photopoints were taken.
X		2009	Dry	% Cover						NA	Survey either not taken or lost.
X		2009	Dry	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X		2009	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X		2009	Dry	Postplanting count	Unknown	2009-12-14	Partially	Yes	Partial	NA	Some hardcopies of what was planted was found in various notebooks and proofed.
X		2009-2010	Growing	% Cover	NAG	2010-01-28	Yes	Yes	Yes	NA	
X		2009-2010	Growing	Subplot photopoints	NAG	2010-01-28	NA	Yes	NA	No	
X		2009-2010	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
X		2010	Summer	Overview photopoints	NA	2010-06-09	NA	Yes	NA	No	
X		2010	Summer	Survivorship	NAG, SLA	2010-06-05	NA	No	Yes	NA	Unreliable data (more ERGC were found alive than planted). Do not use.
X		2010	Dry	% Cover	KWB, MEJ	2010-10-13	Yes	Yes	Yes	NA	

HP (Cont'd)											
Subplots		Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Sep-07	Dec-12										
X		2010	Dry	Survivorship	KWB, MEJ	2010-10-15	Yes	No	Yes	NA	Data unreliable and therefore not added to database (all live plants were recorded instead of outplanted plants only).
X		2010	Dry	Subplot photopoints	KWB, MEJ	2010-10-13	NA	Yes	NA	No	
X		2010	Dry	Overview photopoints	KWB, MEJ	2010-10-13	NA	Yes	NA	No	
X		2010-2011	Growing	% Cover	SAA	2011-02-08	Yes	Yes	Yes	NA	
X		2010-2011	Growing	Subplot photopoints	SAA	2011-02-09	NA	Yes	NA	No	
X		2010-2011	Growing	Overview photopoints	SAA	2011-02-09	NA	Yes	NA	No	
X		2011	Dry	% Cover	MEJ, AAY	2011-09-24	Yes	Yes	Yes	NA	
X		2011	Dry	Subplot photopoints	MEJ, AAY	2011-09-24	NA	Yes	NA	No	
		2011	Dry	Overview photopoints	MEJ, AAY	2011-09-24	NA	Yes	NA	No	
X		2011-2012	Growing	Postplanting count	Unknown	2012-02-23	Yes	Yes	Yes	NA	
X		2011-2012	Growing	% Cover	NA	NA	NA	NA	NA	NA	2011-2012 growing season survey not taken. Survey would not have been a good representation of non-native because of winter weeding.
X		2011-2012	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	2011-2012 photopoints not taken. Pictures would not have been a good representation of non-native because of winter weeding.
X		2011-2012	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	2011-2012 photopoints not taken. Survey would not have been a good representation of non-native because of winter weeding.
X		2012	Dry	% Cover	SKC, REW	2012-10-21	Yes	Yes	Yes	NA	
X		2012	Dry	Subplot photopoints	SKC, REW	2012-10-21	NA	Yes	NA	No	
X		2012	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
	X	2012-2013	Growing	% Cover ¥	AAY, JAH	2012-12-14	Yes	Yes	Yes	NA	
	X	2012-2013	Growing	Subplot photopoints ¥	AAY, JAH	2012-12-14	NA	Yes	NA	Yes	
	X	2012-2013	Growing	Overview photopoints ¥		NA	NA	NA	NA	NA	Overview photopoints not taken.
	X	2012-2013	Growing	Postplanting count	Unknown	2012-12-20	NA	Yes	No	NA	Hardcopy not found and therefore, data was not proofed.
X	X	2012-2013	Growing	% Cover	NA	NA	NA	NA	No	NA	Survey not taken or data lost.
X	X	2012-2013	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken or lost.
X	X	2012-2013	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken or lost.
X	X	2013	Dry	% Cover	AAY	2013-09-13	Yes	Yes	Yes	NA	
X	X	2013	Dry	Survivorship	NA	NA	NA	NA	NA	NA	Survey not taken.
X	X	2013	Dry	Subplot photopoints	AAY	2013-09-13	NA	Yes	NA	No	
X	X	2013	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.

HP (Cont'd)											
Subplots		Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Sep-07	Dec-12										
X	X	2013-2014	Growing	% Cover	AAY	2014-04-04	Yes	Yes	Yes	NA	
X	X	2013-2014	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X	X	2013-2014	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
X	X	2014	Dry	% Cover	GRK	2014-09-27	Yes	No	Yes	NA	Unreliable data; do not use. Data not taken properly: everything was rounded to 4m2.
X	X	2014	Dry	Photopoints	GRK	2014-09-27	NA	Yes	NA	No	
X	X	2014	Dry	Ovw Photopoints	MEJ	2014-11-22	Yes	Yes	NA	Yes	

Table 3: Summary of surveys and photopoints taken between 2007 and 2014 at HP.
Ɏ indicates pre-restoration surveys or photopoints.

LACO															
Subplots						Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Dec-07	Mar-08	Jan-09	Dec-09	Jan-11	Nov-11										
X						2007	Growing	Overview photopoints ¥	ALH	2007-01	NA	Yes	NA	NA	
X						2007	Dry	% Cover ¥	ALH	2007-12-11	Yes	Yes	Yes	NA	Some data was unclear and not added to the database.
X						2007	Dry	Subplot photopoints ¥	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X						2007	Dry	Overview photopoints ¥	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X						2007-2008	Growing	Plant count	Unknown	2007-12-16	Yes	Yes	Yes	NA	
X						2007	Dry	Tags (initial tagging)	Unknown	2007-12-01	NA	No	Yes	NA	All plants were tagged; some in Dec 07 and others in Mar 08. Subplot boundaries changed too. Tag survey unusable.
X						2007-2008	Growing	% Cover	NA	NA	NA	No	No	NA	Survey not taken or data lost.
X						2007-2008	Growing	Tags	NA	2008-05-02	Yes	No	Yes	NA	Unreliable survey. All plants should have been tagged, but this survey does not match outplanting counts.
X						2007-2008	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X						2007-2008	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X						2008	Dry	% Cover	NA	NA	NA	No	No	NA	Survey not taken or data lost.
X						2008	Dry	Subplot photopoints	JSK	2008-11-17	NA	No	NA	NA	Photopoints taken on 2008-11-17 but missing (photo # and UTMs available).
X						2008	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
	X					2008	Dry	% Cover ¥	NA	NA	NA	No	No	NA	Survey not taken or data lost.
	X					2008	Dry	Subplot photopoints ¥	NA	NA	NA	NA	NA	NA	Photopoints not taken.
	X					2008	Dry	Overview photopoints ¥	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X	X					2009	Growing	Plant count	Unknown	2009-01-24	Yes	Yes	Incomplete	NA	Data came from trip notes and 2009-01-24 plant tag survey. Most likely, more plants were outplanted, but the data was not recorded.
X	X					2008-2009	Growing	Tags (initial tagging)	LMK	2009-01-24	Yes	Yes	Yes	NA	Plants were re-tagged with different IDs. Some of them are outside the official plot boundaries.
X	X					2008-2009	Growing	% Cover	NA	NA	NA	No	No	NA	Survey not taken or data lost.
X	X					2008-2009	Growing	Subplot photopoints	NA	2009-02	NA	Yes	NA	No	
X	X					2008-2009	Growing	Overview photopoints	NA	2009-02	NA	Yes	NA	No	

LACO (Cont'd)															
Subplots						Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Dec-07	Mar-08	Jan-09	Dec-09	Jan-11	Nov-11										
X	X	X				2009	Dry	% Cover	NA	NA	NA	No	No	NA	Survey not taken or data lost.
X	X	X				2009	Dry	Tags	NAG	2009-12-17	Yes	Yes	Yes	NA	Last tag survey taken.
X	X	X				2009	Dry	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken or lost.
X	X	X				2009	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken or lost.
			X			2009	Dry	% Cover ¥	NA	NA	NA	No	No	NA	Survey not taken or data lost.
			X			2009	Dry	Subplot photopoints ¥	NA	NA	NA	NA	NA	NA	Photopoints not taken or lost.
			X			2009	Dry	Overview photopoints ¥	NA	NA	NA	NA	NA	NA	Photopoints not taken or lost.
			X			2009	Dry	Plant count	NA	2009-12-14	NA	Yes	Incomplete	No	No complete harcopy found. The data was probably given to KWB in pieces and he tallied it up.
X	X	X	X			2009-2010	Growing	% Cover	ALH	2010-02-08	Yes	Incomplete	Incomplete	NA	No data for subplots within the Dec 2009 expansion.
X	X	X	X			2009-2010	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken or lost.
X	X	X	X			2009-2010	Growing	Overview photopoints	NA	2010-03-05	NA	Yes	NA	No	
X	X		X			2010	Summer	Survivorship	NAG, SLA	2010-06-08	Yes	Yes	Yes	No	ACMI data unreliable; not added to database.
X	X	X	X			2010	Dry	% Cover	KWB, MEJ	2010-10-16	Yes	Yes	Yes	No	
X	X	X	X			2010	Dry	Survivorship	KWB, MEJ	2010-10-16	No	No	Yes	NA	Data unreliable; not added to database (all live plants were recorded instead of outplanted plants only).
X	X	X	X			2010	Dry	Subplot photopoints	KWB, MEJ	2010-10-16	NA	Yes	NA	No	
X	X	X	X			2010	Dry	Overview photopoints	KWB, MEJ	2010-10-16	NA	Incomplete	NA	No	Only a few photopoints pictures were taken.
				X		2010-2011	Growing	% Cover ¥	KWB, MEJ, SAA	2011-01-09	Yes	Yes	Yes	NA	
X	X	X	X	X		2010-2011	Growing	Survivorship	KWB	2011-01-09	Yes	No	Yes	No	Only collected for a few subplots. Survey discontinued.
				X		2010-2011	Growing	Subplot photopoints ¥	KWB	2011-01-21	NA	Yes	NA	No	
				X		2010-2011	Growing	Overview photopoints ¥	KWB	2011-01-21	NA	Incomplete	NA	No	Only a few photopoints pictures were taken.
	X	X		X		2010-2011	Growing	Plant count	MEJ, KWB, SAA	2011-01-20	Partially	Yes	Incomplete	NA	
X	X		X			2010-2011	Growing	% Cover	KWB, MEJ	2011-01-20	Yes	Yes	Yes	NA	
X	X	X	X	X		2010-2011	Growing	Survivorship	KWB, MEJ	2011-01-20	No	No	Yes	NA	Data unreliable and therefore not added to database (all live plants were recorded instead of outplanted plants only).
X	X	X	X			2010-2011	Growing	Subplot photopoints	KWB, MEJ	2011-01-20	NA	Yes	NA	No	

LACO (Cont'd)															
Subplots						Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Dec-07	Mar-08	Jan-09	Dec-09	Jan-11	Nov-11										
X	X	X	X			2010-2011	Growing	Overview photopoints	KWB, MEJ	2011-01-20	NA	Incomplete	NA	No	Only a few photopoints pictures were taken.
X	X		X	X		2011	Dry	% Cover	MEJ, AAY	2011-09-24	Yes	Yes	Yes	NA	
				X		2011	Dry	Subplot photopoints ¥	MEJ, AAY	2011-09-25	NA	Yes	NA	No	
				X		2011	Dry	Overview photopoints ¥	MEJ, AAY	2011-09-25	NA	Yes	NA	No	
					X	2011	Dry	% Cover ¥	KWB, KMR	2011-10-16	yes	Yes	Yes	NA	
					X	2011	Dry	Subplot photopoints ¥	KWB, KMR	2011-10-16	NA	Yes	NA	No	
					X	2011	Dry	Overview photopoints ¥	KWB, KMR	2011-10-16	NA	Yes	NA	No	
X	X			X	X	2011	Dry	Plant count	MEJ, REW	2011-11-22	Yes	Yes	Yes	NA	
X	X	X	X	X	X	2011-2012	Growing	% Cover	NA	NA	NA	NA	NA	NA	2011-2012 growing season survey not taken. Survey would not have been a good representation of non-native because of winter weeding.
X	X	X	X	X	X	2011-2012	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	2011-2012 photopoints not taken. Pictures would not have been a good representation of non-native because of winter weeding.
X	X	X	X	X	X	2011-2012	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	2011-2012 photopoints not taken. Survey would not have been a good representation of non-native because of winter weeding.
X	X		X	X	X	2012	Dry	% Cover	KMR, SKC, REW	2012-09-07	Yes	Yes	Yes	No	
X	X	X	X	X	X	2012	Dry	Subplot photopoints	KMR, SKC	2012-09-07	NA	Yes	NA	No	
X	X	X	X	X	X	2012	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
X	X		X	X	X	2012-2013	Growing	% Cover	AAY, JAH	2013-01-14	Yes	Yes	Yes	NA	
X	X		X	X	X	2012-2013	Growing	Subplot photopoints	AAY, JAH	2013-01-14	NA	No	NA	NA	Photopoints taken but missing.
X	X	X	X	X	X	2012-2013	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken or lost.
X	X		X	X	X	2013	Dry	% Cover	JAH	2013-09-19	Yes	Yes	Yes	No	
X	X		X	X	X	2013	Dry	Subplot photopoints	JAH	2013-09-19	NA	Yes	NA	No	
X	X	X	X	X	X	2013	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
		X				2013-2014	Dry	Plant count	Unknown	2013-10-15	NA	Yes	No	NA	Plants were only added around artificial CAAU burrows.
X	X		X	X	X	2013-2014	Growing	% Cover	AAY	2014-04-05	Yes	Yes	Yes	NA	
X	X		X	X	X	2013-2014	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X	X	X	X	X	X	2013-2014	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.

LACO (Cont'd)															
Subplots						Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Dec-07	Mar-08	Jan-09	Dec-09	Jan-11	Nov-11										
X	X		X	X	X	2014	Dry	% Cover	GRK	2014-09-27	Yes	Incomplete	Yes	NA	Do not use, except dat for Dec 2007 and Mar 2008 subplots. Data for other surveys were rounded to 4 or 5m.
X	X		X	X	X	2014	Dry	Subplot photopoints	GRK	2014-09-27	NA	Yes	MA	No	
X	X	X	X	X	X	2014	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.

Table 4: Summary of surveys and photopoints taken between 2007 and 2014 at LACO.
Ɏ indicates pre-restoration surveys or photopoints.

NTP											
Subplots		Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Oct-13	Nov-14										
X		2013	Dry	% Cover ¥	JAH, SJK	2013-10-14	Yes	Yes	Yes	NA	
		2013	Dry	Subplot photopoints ¥	JAH, SJK, LAF, EWW	2013-10-14	NA	Yes	NA	Yes	
		2013	Dry	Overview photopoints ¥	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
X		2014*	Dry	Plant count	AAY, GRK, MEJ	2014-09-26	Yes		Yes	NA	taken in fall 2014, based on plants in berms next to emitters.
X		2013-2014	Growing	% Cover	AAY	2014-04-04	Yes	Yes	Yes	NA	
		2013-2015	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
		2013-2015	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken.
X		2014	Dry	% Cover	AAY, GRK	2014-09-26	Yes	Yes	Yes	NA	
		2014	Dry	Subplot photopoints	AAY, GRK	2014-09-26	NA	Yes	NA	Yes	
		2014	Dry	Overview photopoints	MEJ	2014-11-22	NA	Yes	NA	Yes	Overview photopoints established.
	X	2014	Dry	% Cover ¥	SMC, GRK, MEJ	2014-11-21	Yes	Yes	Yes	NA	
		2014	Dry	Subplot photopoints ¥	SMC, MEJ	2014-11-21	NA	Yes	NA	NA	
		2014	Dry	Overview photopoints ¥	MEJ	2014-11-22	NA	Yes	NA	Yes	Overview photopoints established.
X	X	2014	Dry	Plant Count	MEJ	2014-11-24	Yes		Yes	NA	Includes plant count from the Oct 2013 and Nov 2014 outplantings.
X	X	2014	Dry	Plant Count	GRK, MJB	2014-12-08	Yes	Yes	Yes	NA	Count for dead plant replacement.

Table 5: Summary of surveys and photopoints taken between 2013 and 2014 at NTP.
¥ indicates pre-restoration surveys or photopoints.

NEF														
Subplots					Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Dec-07	Dec-10	Nov-11	Dec-12	Nov-14										
X					2007	Dry	% Cover ¥	KWB, SF	2007-10-15	Incomplete	Yes	Incomplete	NA	Available data proofed.
X					2007	Dry	Subplot photopoints ¥	NA	NA	NA	NA	NA	NA	
X					2007	Dry	Overview photopoints ¥	NA	NA	NA	NA	NA	NA	No photopoints found, but photos from the 2007 planting are available.
X					2007	Dry	Plant count	ALH	2007-12-14	Yes	Yes	Yes	NA	All plants were tagged, so data comes from tag survey.
X					2007	Dry	Tags (initial tagging)	NA	2007-10-25	NA	Yes	Yes	NA	
X					2007-2008	Growing	% Cover	NA	NA	NA	NA	NA	NA	Survey not taken or data lost.
X					2007-2008	Growing	Tags	Multiple	2008-03-22	No	No	Yes	NA	Unreliable data:not added to database.
X					2007-2008	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	
X					2007-2008	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	
X					2008	Dry	% Cover	NA	NA	NA	NA	NA	NA	Survey not taken or data lost.
X					2008	Dry	Tags	JSK	2008-10-21	Yes	No	Yes	NA	Did not use in database because many plants were recorded as dormant instead of dead or alive (i.e. observer did not make sure dormant plant were alive).
X					2008	Dry	Subplot photopoints	NA	NA	NA	NA	NA	NA	
X					2008	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	
X					2008	Dry	Plant count	JSK	2008-11-17	No	Yes	No	NA	Not proofed: hardcopy not found.
X					2008-2009	Growing	% Cover	NA	NA	NA	NA	NA	NA	Survey not taken or data lost.
X					2008-2009	Growing	Tags	LMK, PJM, NAG, CEH	2009-01-22	Yes	Yes	Yes	NA	
X					2008-2009	Growing	Tags (initial tagging)	NAG,CEH	2009-01-30	Yes	Yes	Yes	NA	
X					2008-2009	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	
X					2008-2009	Growing	Overview photopoints	Unknown	2009-03	NA	Yes	NA	NA	
X					2009	Dry	% Cover	NA	NA	NA	NA	NA	NA	Survey not taken or data lost.
X					2009	Dry	Survivorship	NA	2009-11-21	NA	No	Yes	NA	Unreliable data (not added to database): we cannot assume that dormant plants were alive.
X					2009	Dry	Subplot photopoints	NA	2009-11-26	NA	*	NA	No	These are not typical subplot pictures: picture were taken at the north and south
X					2009	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken or data lost.
X					2009	Dry	Plant count	SAA	2009-11-27	Yes	Yes	Yes	NA	
X					2009-2010	Growing	% Cover	NAG	2010-01-28	Yes	Yes	Yes	NA	
X					2009-2010	Growing	Tags	NAG, SAA	2010-01-05	No	Yes	No	NA	
X					2009-2010	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken or data lost.
X					2009-2010	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken or data lost.

NEF (Cont'd)														
Subplots					Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Dec-07	Dec-10	Nov-11	Dec-12	Nov-14										
X					2010	Summer	Survivorship	NAG, SAA	2010-06-03	Yes	Yes	Yes	NA	
X					2010	Dry	% Cover	KWB, MEJ	2010-10-18	Yes	Yes	Yes	NA	
X					2010	Dry	Tags	KWB, MEJ	2010-10-18	Yes	Yes	Yes	NA	
X					2010	Dry	Survivorship	KWB, MEJ	2010-10-18	Yes	No	Yes	NA	Data unreliable and therefore not added to database (all live plants were recorded instead of outplanted plants only).
X					2010	Dry	Subplot photopoints	KWB, MEJ	2010-10-30	NA	Yes	NA	No	
X					2010	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
	X				2010	Dry	% Cover ¥	SAA, KWB	2010-12-02	Yes	Yes	Yes	NA	
X					2010	Dry	Survivorship	Unknown	2010-12-02	Yes	No	Yes	NA	Data unreliable and therefore not added to database (all live plants were recorded instead of outplanted plants only).
	X				2010	Dry	Subplot photopoints ¥	NA	2010-11-30	NA	Yes	NA	NA	
	X				2010	Dry	Overview photopoints ¥	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
	X				2010-2011	Postplanting	Plant count	SAA, KWB	2011-02-08	Yes	Yes	Yes	NA	
X	X				2010-2011	Growing	% Cover	MEJ	2011-02-10	Yes	Incomplete	Incomplete	NA	Dec 2010 subplots not surveyed during the 2010-2011 growing season. Therefore, only data from the Dec 07 subplots were added to the database.
X	X				2010-2011	Growing	Subplot photopoints	NA	2011-02-10	NA	Incomplete	NA	No	Most pictures are missing.
X	X				2010-2011	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
X	X				2011	Dry	% Cover	MEJ, AAY	2011-09-22	Yes	Yes	Yes	NA	
X	X				2011	Dry	Subplot photopoints	MEJ, AAY	2011-09-22	NA	Yes	NA	No	
X	X				2011	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
		X			2011	Dry	% Cover ¥	NA	NA	NA	No	NA	NA	Only 1 new subplot: not surveyed.
		X			2011	Dry	Subplot photopoints ¥	NA	NA	NA	NA	NA	NA	Only 1 new subplot: no photopoint.
		X			2011	Dry	Overview photopoints ¥	NA	NA	NA	NA	NA	NA	Only 1 new subplot: no photopoint.
X	X	X			2011	Dry	Plant count	SAA, KWB	2011-11-29	Yes	Yes	Yes	NA	
X	X				2011-2012	Growing	% Cover	NA	NA	NA	NA	NA	NA	2011-2012 growing season survey not taken. Survey would not have been a good representation of non-native because of winter weeding.
X	X				2011-2012	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	2011-2012 photopoints not taken. Pictures would not have been a good representation of non-native because of winter weeding.

NEF (Cont'd)														
Subplots					Year	Season	Type	By	First Date of Svy	Proofed	Added to database	Hardcopy available	Relabeled (photopoints only)	Note
Dec-07	Dec-10	Nov-11	Dec-12	Nov-14										
X	X	X			2011-2012	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	2011-2012 photopoints not taken. Survey would not have been a good representation of non-native because of winter weeding.
X	X				2012	Dry	% Cover	AAY	2012-08-31	Yes	Yes	Yes	NA	
X	X	X			2012	Dry	Subplot photopoints	AAY	2012-08-31	NA	Yes	NA	No	
X	X	X			2012	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
			X		2012	Dry	% Cover ¥	NA	NA	NA	No	NA	NA	Only 1 new subplot: not surveyed.
			X		2012	Dry	Subplot photopoints ¥	NA	NA	NA	NA	NA	NA	Only 1 new subplot: no photopoint.
			X		2012	Dry	Overview photopoints ¥	NA	NA	NA	NA	NA	NA	Only 1 new subplot: no photopoint.
X	X	X	X		2012-2013	Growing	Plant count	AAY, JAH	2013-01-13	Yes	Yes	Yes	NA	Includes AAY and JAH's survey on 1/13/2013, plus plants from the planting plan for subplots in columns A-C and subplot B6.
X	X	X	X		2012-2013	Growing	Survivorship?	AAY, JAH	2013-01-13	No	No	Yes	NA	Number of native plants present in subplot A1-A15 and B7-15 (data separated between plants outplanted before fall 2012 and plants outplanted in fall 2012. Not sure if it includes wild plants.
X	X				2012-2013	Growing	% Cover	NA	NA	No	No	No	NA	Survey not taken or lost.
X	X	X			2012-2013	Growing	Subplot photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken or lost lost.
X	X	X	X		2012-2013	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	Photopoints not taken or lost lost.
X	X				2013	Dry	% Cover	AAY	2013-09-14	Yes	Yes	Yes	NA	
X	X	X	X		2013	Dry	Subplot photopoints	AAY	2013-09-14	NA	Yes	NA	NA	
X	X	X	X		2013	Dry	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
X	X				2013-2014	Growing	% Cover	AAY, NBH	2014-03-27	Yes	Yes	Yes	NA	
X	X				2013-2014	Growing	Subplot photopoints	AAY, NBH	2014-03-27	NA	Yes	NA	NA	
X	X	X	X		2013-2014	Growing	Overview photopoints	NA	NA	NA	NA	NA	NA	Overview photopoints not taken.
X	X				2014	Dry	% Cover	AAY, GRK	2014-09-26	Yes	Yes	Yes	NA	
X	X				2014	Dry	Subplot photopoints	AAY, GRK	2014-09-26	NA	Yes	NA	NA	
X	X	X	X	X	2014	Dry	Overview photopoints	MEJ	2014-11-22	NA	Yes	NA	NA	
X	X			X	2014	Dry	% Cover ¥	SMC	2014-11-01	Yes	Yes	Yes	NA	
X	X			X	2014	Dry	Subplot photopoints ¥	SMC	2014-11-01	NA	Yes	NA	NA	
X	X	X	X	X	2014	Dry	Overview photopoints ¥	SMC	2014-11-01	NA	NA	NA	NA	Pre-restoration verview photopoints not taken.
				X	2014-2015	Postplanting	Plant Count	CAC	2014-11-07	Yes	Yes	Yes	NA	

Table 6: Summary of surveys and photopoints taken between 2007 and 2014 at NEF.
¥ indicates pre-restoration surveys or photopoints.

Landscaping						
Year	Season	By	Date	Added to database	Relabeled	Note
2011	Dry	SAA	2011-09-16	Yes	Yes	Landscaping phototopoints established.
2011-2012	Growing	NA	NA	NA	NA	Photopoints not taken.
2012	Dry	NA	NA	NA	NA	Photopoints not taken.
2012-2013	Growing	NA	NA	NA	NA	Photopoints not taken.
2013	Dry	NA	NA	NA	NA	Photopoints not taken.
2013-2014	Growing	NA	NA	NA	NA	Photopoints not taken.
2014	Dry	MEJ	2014-11-11	Yes	Yes	

Table 7: List of landscaping photopoints taken between 2011 and 2014. Landscaping photopoints were established in 2011.

APPENDIX VII: RESPONSIBILITIES OF THE VEGETATION DATABASE MANAGER

Database Management

The vegetation database manager for the habitat restoration project on SBI should:

1- Ensure all surveys and photopoints are taken, including pre-restoration percent cover surveys, growing and dry season percent cover surveys, survivorship surveys, and postplanting plant counts. If a survey is not taken, the database manager should record why the survey was not taken on a datasheet to be filed with other datasheets. This information should also be added to the vegetation database.
2- Organize all hardcopies of surveys in chronological order by plot. Photocopies of all datasheets should be kept on island and originals should be kept on the mainland.
3- Back up electronic files (surveys and photopoints) when new data is entered, when data is proofed or any time the database is modified. Backups should be on external hard drives on SBI and in the mainland office.
4- Keep a list of all surveys taken.
5- Implement quality assurance (QA) procedures:
    - Write and update survey protocols as needed.
    - Prepare and update survey datasheets as needed.
    - Create and maintain a relational database and document modifications to the database.
    - Ensure personnel are properly trained and “calibrated” before performing surveys.
6- Implement quality control (QC) procedures:
    - Ensure all surveys are entered and proofed in a timely manner.
    - Randomly reproof a portion of the data to ensure quality.
    - Ensure columns and rows line up properly.
    - Review all vegetation-related surveys, for completeness (all subplots surveyed, headings properly filled, subplots and overview photopoints taken, etc.).
    - Deal with obvious irregularities in data, including outliers and percent cover data not adding up to $\geq$100%.
7- Ensure the original photo numbers of photopoints are never deleted.

8- File all electronic versions of surveys and photopoints in a database in the office desktop computer.
9- Ensure new personnel are properly trained before collecting data and taking photopoints.
10- Address data issues with personnel performing surveys and personnel entering and proofing data.
11- Report any consistent issues to the Montrose Field Supervisor.

APPENDIX VII: PROTOCOLS FOR LANDSCAPING OVERVIEW PHOTOPOINTS

Overview photopoints of the landscaping around housing are taken twice a year in late January or early February and in late September or early October. These photopoints are used to document changes in vegetation around housing. They were first taken in September 2011, although native perennials have been planted around buildings since their completion. This document contains a map (Figure 1), GPS locations of the photopoints (Table 1), and copies of the photopoints to recreate (Figure 2).

Figure 1: Location and direction of landscaping photopoints.

Photo point	Easting	Northing	Location	What to aim camera at
1a	311431	3706399	Stand on porch next to brick wall.	Camera aimed N; top left side of picture aimed at ranger station.
1b				Camera aimed E; right side of picture aimed at brick wall near ranger station.
2a	311427	3706397	Stand at bottom of stairs next to ranger station.	Camera aimed SE towards lower grow-out area.
2b				Camera aimed S at middle grow-out area.
2c				Camera aimed W; right side of picture aimed at stairs.
3a	311438	3706381	Stand E of middle grow-out area.	Camera aimed NE; top left side of picture aimed just east of brick wall.
3b				Camera aimed W; top of picture aimed at pit toilets.
3c				Camera aimed S.
4a	311441	3706369	Stand SW of lower grow-out area.	Camera aimed E; left side of picture aimed at south edge of lower grow-out area.
4b				Camera aimed S towards campsite 1.
4c				Camera aimed NW; top right side of picture aimed at solar panels.
4d				Camera aimed N; top center of picture aimed at ranger station.
5a	311416	3706396	Stand at top of stairs close to solar panels.	Camera aimed N; left side of picture aimed at deck.
5b				Camera aimed E; picture centered on stairs.
5c				Camera aimed SE; top left side of picture aimed at middle grow-out area.
5d				Camera aimed SW; right side of picture aimed at the edge of the solar panels.
6a	311379	3706424	Stand 10m NW of upper grow-out area.	Camera aimed S; top left side of picture aimed at shade-house.
6b				Camera aimed E; right side of picture aimed at the edge of the upper grow-out area.
7a	311400	3706407	Stand at the bottom of the nursery stairs close to the shop tank.	Camera aimed SW; left side of picture aimed at the edge of the shop.
7b				Camera aimed W; nursery landscaping south of the nursery tank at the top of the picture.
7c				Camera aimed NW; top left corner of the picture aimed at the nursery landscaping north of the nursery tank.
7d				Camera aimed NE; shop tan just outside the right side of the picture.
7e				Camera aimed E; shop tank at left of picture and shop at right of picture.
8a	311418	3706437	Stand at the top of LACO stairs.	Camera aimed SE; top right corner of picture aimed at bunkhouse.
8b				Camera aimed SW; top left corner of picture aimed at bunkhouse.
8c				Camera aimed W; picture shows landscaping west of stairs and around bulletin board.

Table 1. Landscaping overview photopoints. GPS coordinates are in NAD83 UTM.


1a (2011-09)


1b (2011-09)

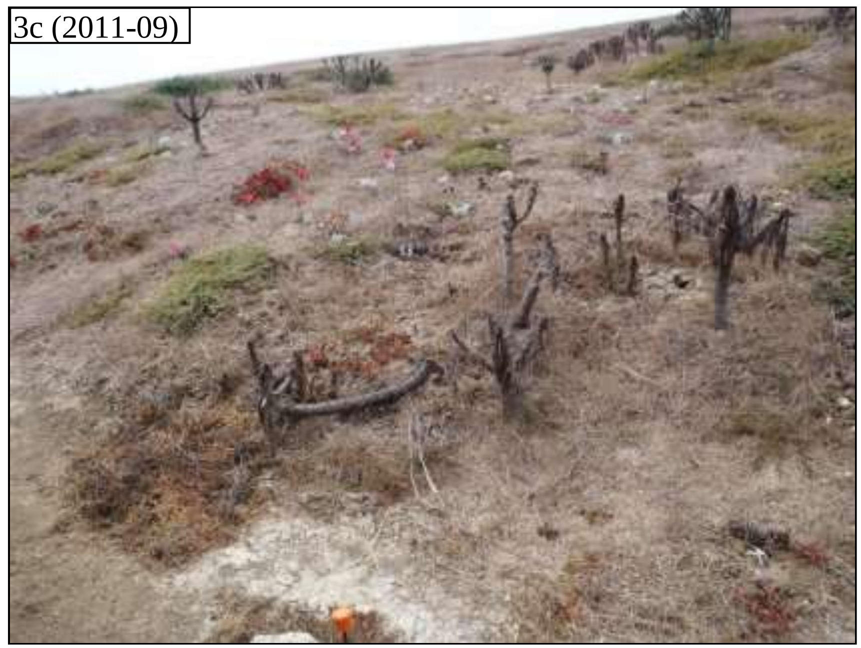

2a (2011-09)


2b (2011-09)


2c (2011-09)


3a (2011-09)


3b (2011-09)


3c (2011-09)


4a (2011-09)


4b (2011-09)


4c (2011-09)

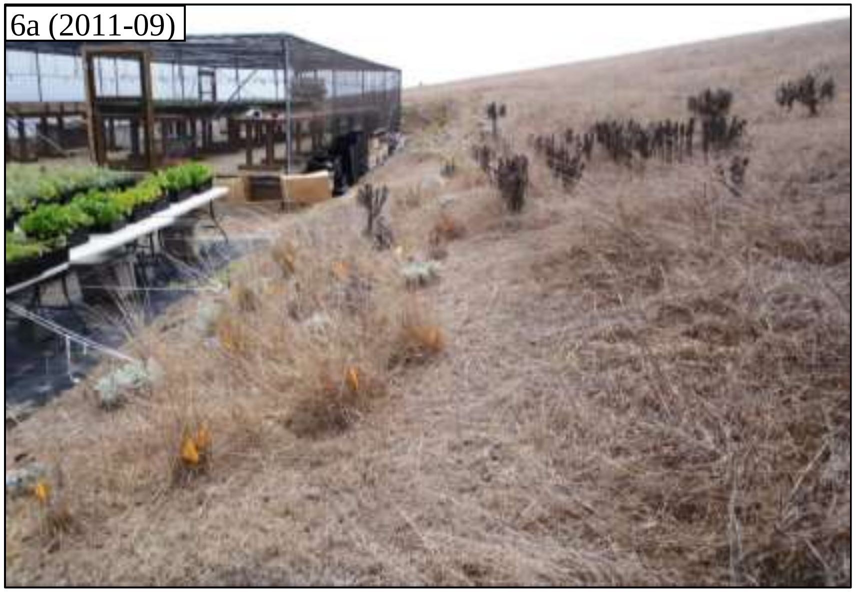

4d (2011-09)


5a (2011-09)


5b (2011-09)


5c (2011-09)


5d (2011-09)


6a (2011-09)


6b (2011-09)


7a (2011-09)


7b (2011-09)

7c (2011-09)

7d (2011-09)

7e (2011-09)

8a (2011-09)

Figure 2: Landscaping overview photopoints 1a through 8c.