Habitat Restoration Experiment: First Year of Seed Establishment Results

San Diego South County Grasslands Project:
Habitat Restoration BMP Development

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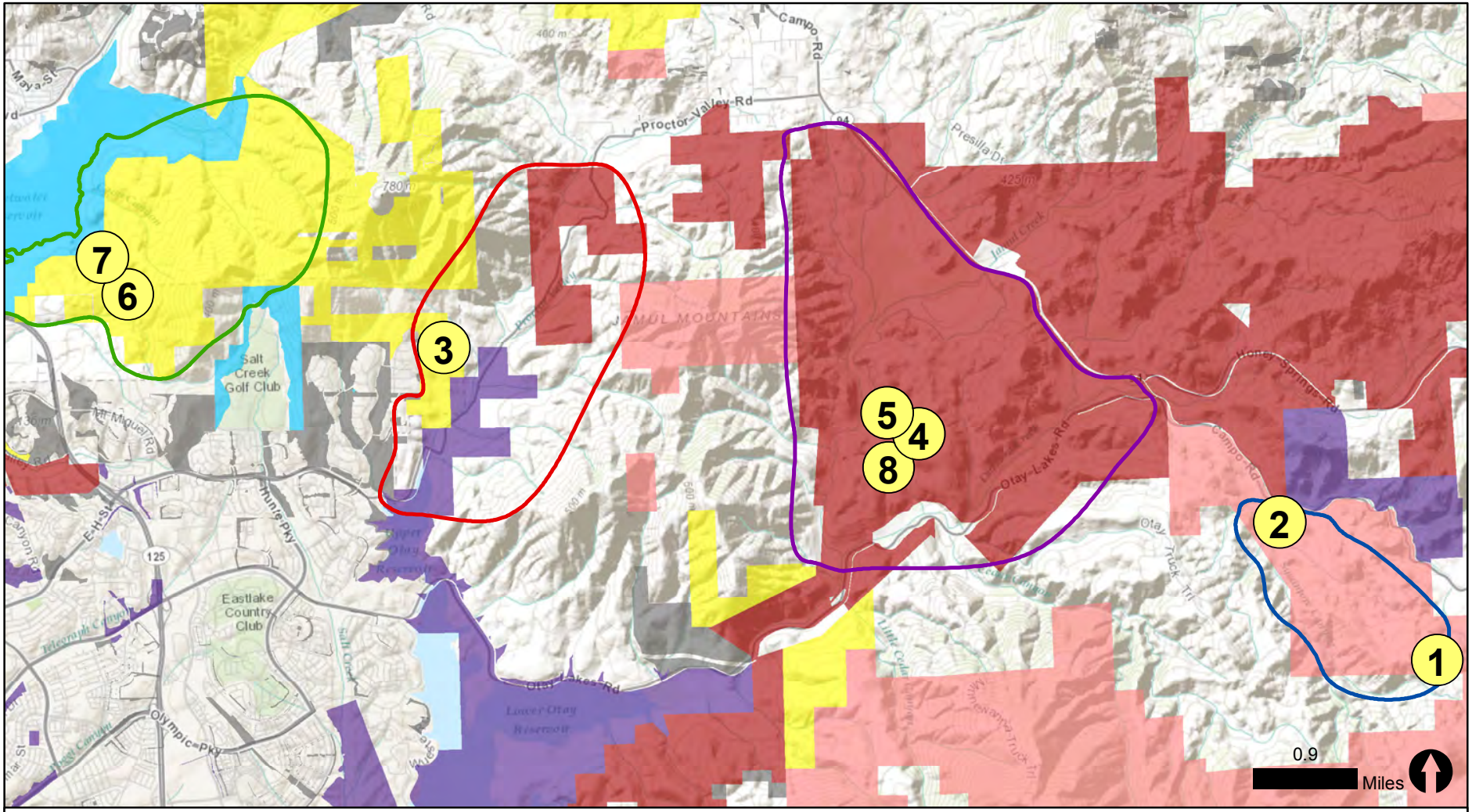
Project Summary

- Site Preparation, Seeding and Maintenance Weeding of **7.8-acres for habitat restoration** of grassland, forbland, QCB habitat and OTP habitat (2013-2017)
- **35.2 acres of weed management in buffers** around Sites 2, 4, 5, 6, 7 and 8.
- **Targeted invasive species control** in immediate area around QCB habitat restoration plots.
- Production of **1.17-lbs of cleaned F1 OTP seed** bulked from three populations for future seeding effort following genetic analysis results
- Year 1 of Seed Establishment data collection and analysis
  - Baseline data to compare to a future second effort
  - Snapshot assessment of first year native plant establishment and weed management success
- Qualitative photo monitoring by EDI volunteers/citizen scientists



1 Restoration Sites

Study Areas

- Sweetwater Reservoir
- Proctor Valley
- Rancho Jamul Ecological Reserve
- Sycamore Canyon

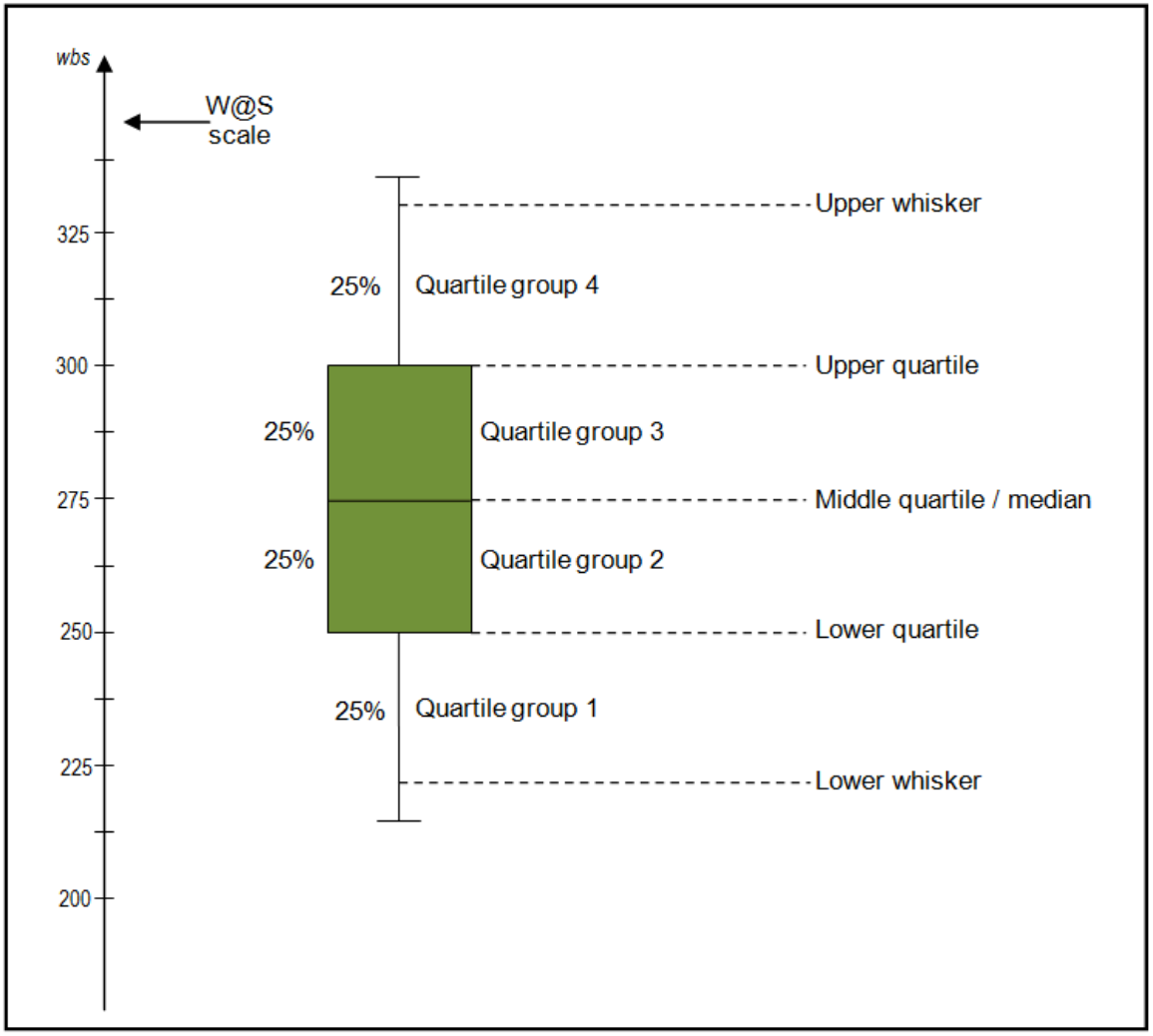
Conserved Land Ownership

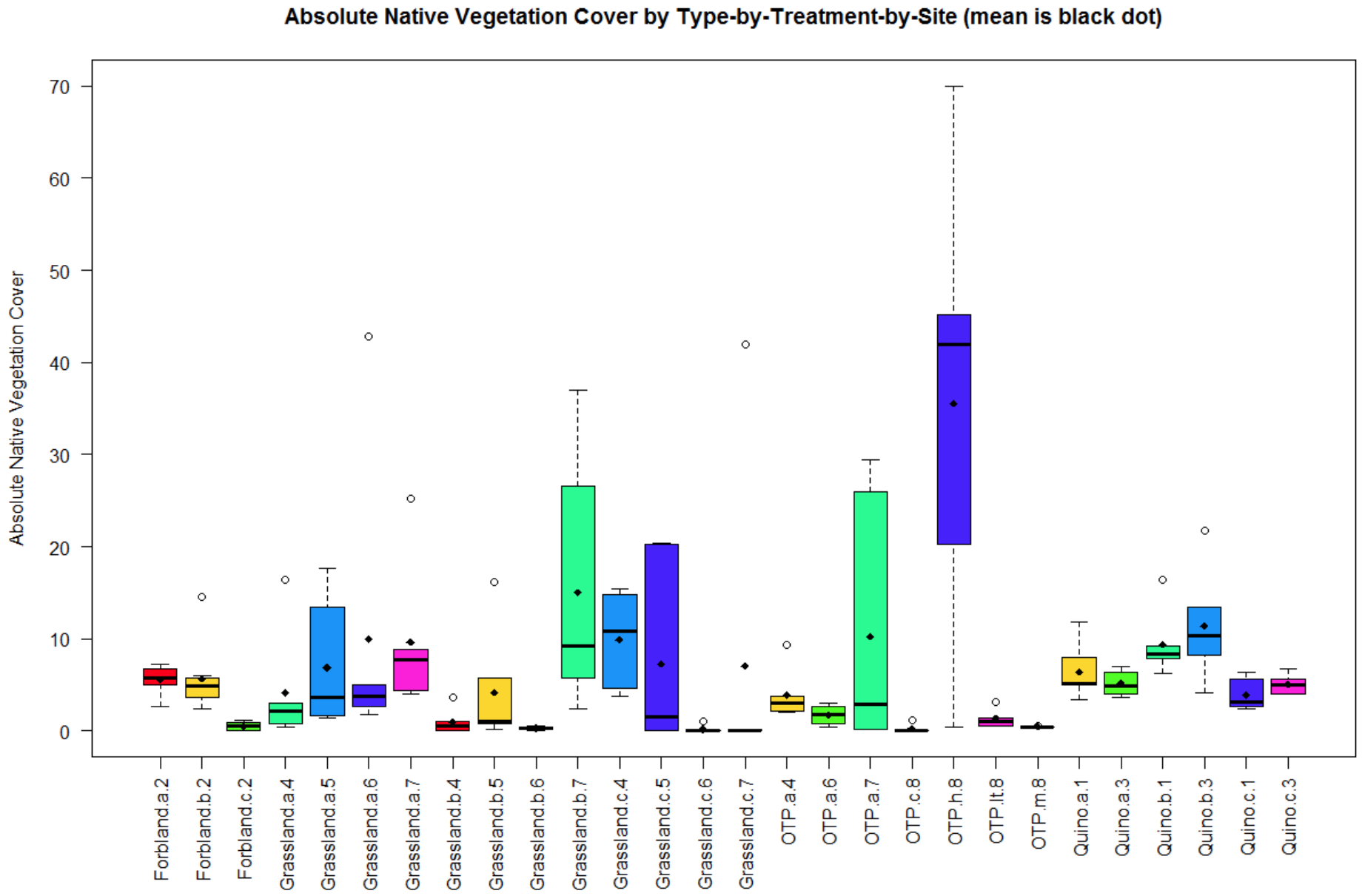
- BLM
- City/County
- Forest Service
- Private/Conservancy
- State
- USFWS NWR
- Water District

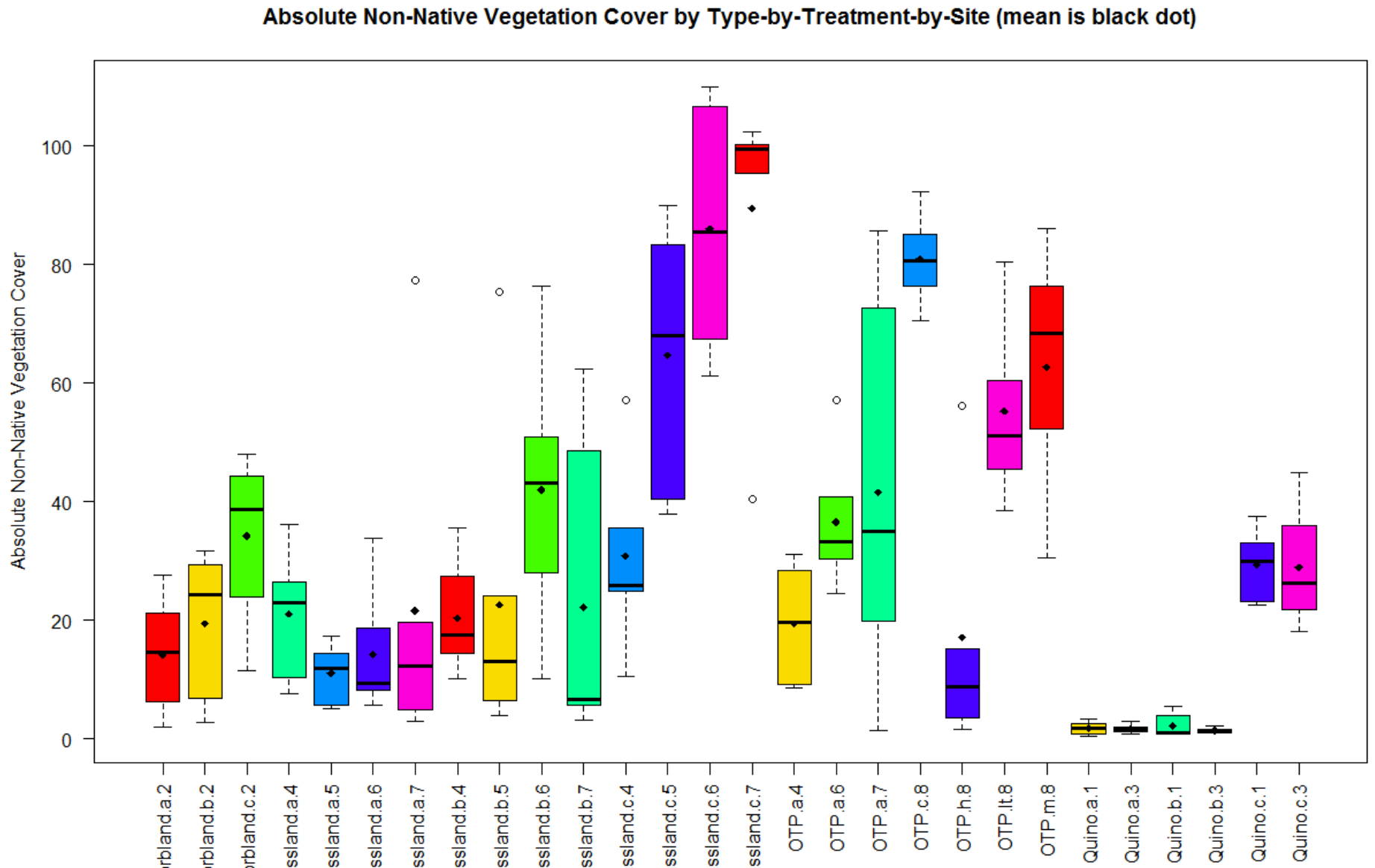
Methods

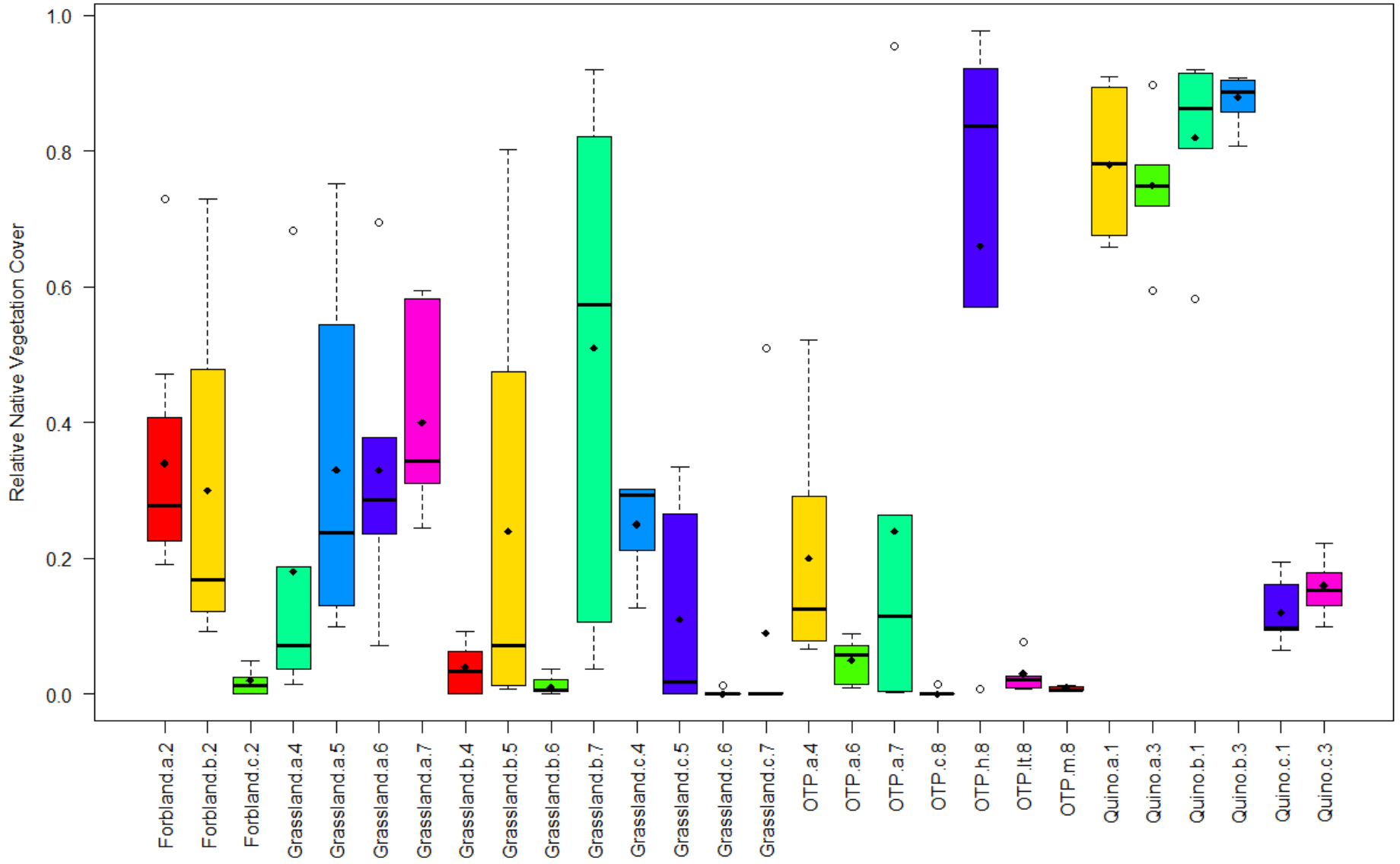
- QCB (Sites 1 and 3)
  - Randomized Block Design, 20 x 20 ft plots
  - Two-way ANOVA examining effect of Site and Treatments, and Interaction between them (if any)
- Forblands (Site 2)
  - Paired plots design, 24 x 50 ft plots
  - Assumptions:
    - expect field variation to be patchy, but can't predict it
    - Adjacent plots more likely to be homogenous
  - Control located outside buffer area for practical management reasons
- Grasslands and Otay Tarplant (Sites 4-7)
  - Same as Forblands, but 72 x 72 ft plots (width of drill seeder is 6-ft)
    - 72 x 30 ft plots at Site 7
  - Two-way ANOVA to examine effect of Site and Treatments, and Interactions between them (if any)
    - Examine any influence of pre-project fire
  - Generalized Linear Model (regressions) on proportion data with a Quasi-Poisson distribution
- Semi-quantitative monitoring plots − cover and species richness
- Photo monitoring for comparison over time

Box Plot


wbs
W@S scale
325
300
275
250
225
200
Upper whisker
25%
Quartile group 4
Upper quartile
25%
Quartile group 3
Middle quartile / median
25%
Quartile group 2
Lower quartile
25%
Quartile group 1
Lower whisker


Absolute Native Vegetation Cover by Type-by-Treatment-by-Site (mean is black dot)
Absolute Native Vegetation Cover
0
10
20
30
40
50
60
70
Forbland.a.2
Forbland.b.2
Forbland.c.2
Grassland.a.4
Grassland.a.5
Grassland.a.6
Grassland.a.7
Grassland.b.4
Grassland.b.5
Grassland.b.6
Grassland.b.7
Grassland.c.4
Grassland.c.5
Grassland.c.6
Grassland.c.7
OTP.a.4
OTP.a.6
OTP.a.7
OTP.c.8
OTP.h.8
OTP.lt.8
OTP.m.8
Quino.a.1
Quino.a.3
Quino.b.1
Quino.b.3
Quino.c.1
Quino.c.3

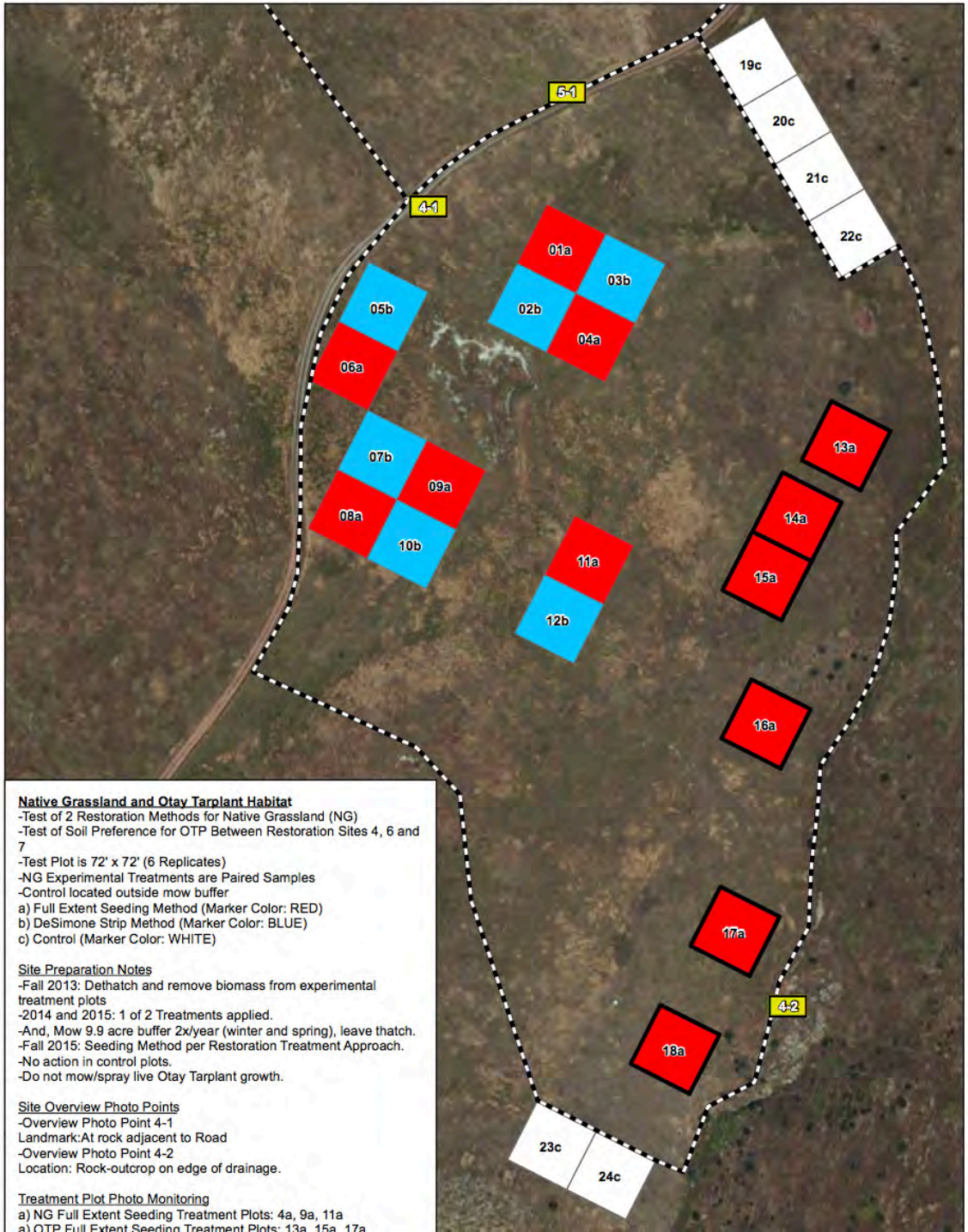

Absolute Non-Native Vegetation Cover by Type-by-Treatment-by-Site (mean is black dot)
Absolute Non-Native Vegetation Cover
0
20
40
60
80
100
Forbland.a.2
Forbland.b.2
Forbland.c.2
Grassland.a.4
Grassland.a.5
Grassland.a.6
Grassland.a.7
Grassland.b.4
Grassland.b.5
Grassland.b.6
Grassland.b.7
Grassland.c.4
Grassland.c.5
Grassland.c.6
Grassland.c.7
OTP.a.4
OTP.a.6
OTP.a.7
OTP.c.8
OTP.h.8
OTP.lt.8
OTP.m.8
Quino.a.1
Quino.a.3
Quino.b.1
Quino.b.3
Quino.c.1
Quino.c.3


Relative Native Vegetation Cover by Type-by-Treatment-by-Site (mean is black dot)
Relative Native Vegetation Cover
1.0
0.8
0.6
0.4
0.2
0.0
Forbland.a.2
Forbland.b.2
Forbland.c.2
Grassland.a.4
Grassland.a.5
Grassland.a.6
Grassland.a.7
Grassland.b.4
Grassland.b.5
Grassland.b.6
Grassland.b.7
Grassland.c.4
Grassland.c.5
Grassland.c.6
Grassland.c.7
OTP.a.4
OTP.a.6
OTP.a.7
OTP.c.8
OTP.h.8
OTP.lt.8
OTP.m.8
Quino.a.1
Quino.a.3
Quino.b.1
Quino.b.3
Quino.c.1
Quino.c.3

Grassland Habitat

Study Goals and Questions at Sites 4, 5, 6 & 7

- Compare effectiveness of two mechanized habitat restoration approaches (n=6):
  - (**a**) Herbicide 2x per year and Full Extent 2-way drill seeding
  - (**b**) Mowing 2x per year and Modified DeSimone strips drill seeded 1-way
- Determine whether a fall burn has an impact on the success of the two habitat restoration approaches
  - All sites burned in 2007 Harris fire
  - Sites 4 and 5 burned in 2003 Otay fire
  - Site 4 burned in fall 2012
- Evaluate scaled down methods at Site 7 for less accessible site conditions to Site 6, using line trimmers instead of mowers for (b) and backpack sprayers for (a).



Native Grassland and Otay Tarplant Habitat
-Test of 2 Restoration Methods for Native Grassland (NG)
-Test of Soil Preference for OTP Between Restoration Sites 4, 6 and 7
-Test Plot is 72' x 72' (6 Replicates)
-NG Experimental Treatments are Paired Samples
-Control located outside mow buffer
a) Full Extent Seeding Method (Marker Color: RED)
b) DeSimone Strip Method (Marker Color: BLUE)
c) Control (Marker Color: WHITE)

Site Preparation Notes
-Fall 2013: Dethatch and remove biomass from experimental treatment plots
-2014 and 2015: 1 of 2 Treatments applied.
-And, Mow 9.9 acre buffer 2x/year (winter and spring), leave thatch.
-Fall 2015: Seeding Method per Restoration Treatment Approach.
-No action in control plots.
-Do not mow/spray live Otay Tarplant growth.

Site Overview Photo Points
-Overview Photo Point 4-1
Landmark:At rock adjacent to Road
-Overview Photo Point 4-2
Location: Rock-outcrop on edge of drainage.

Treatment Plot Photo Monitoring
a) NG Full Extent Seeding Treatment Plots: 4a, 9a, 11a
a) OTP Full Extent Seeding Treatment Plots: 13a, 15a, 17a

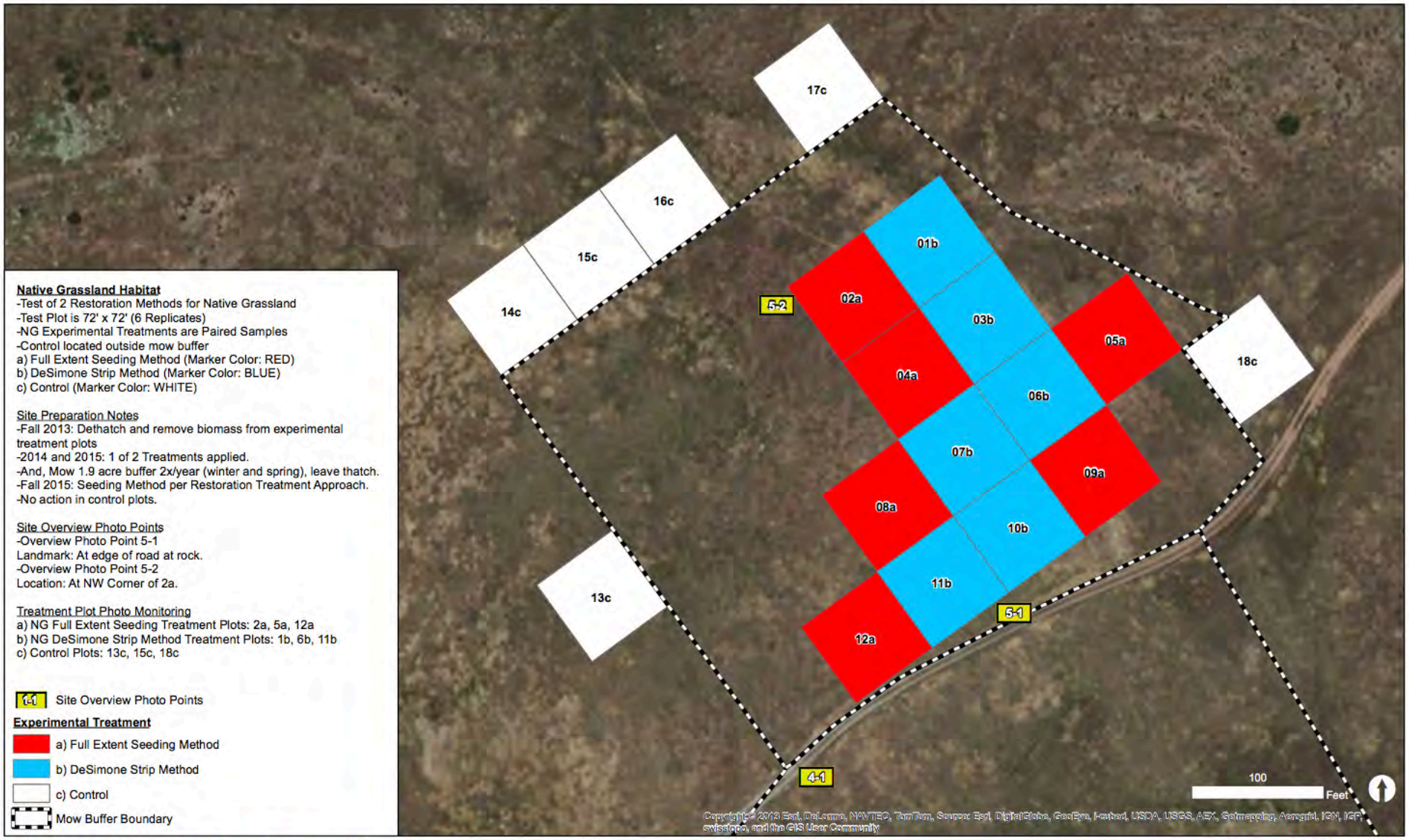


Figure 10. Rancho Jamul Ecological Reserve Native Grassland Restoration Site 5.

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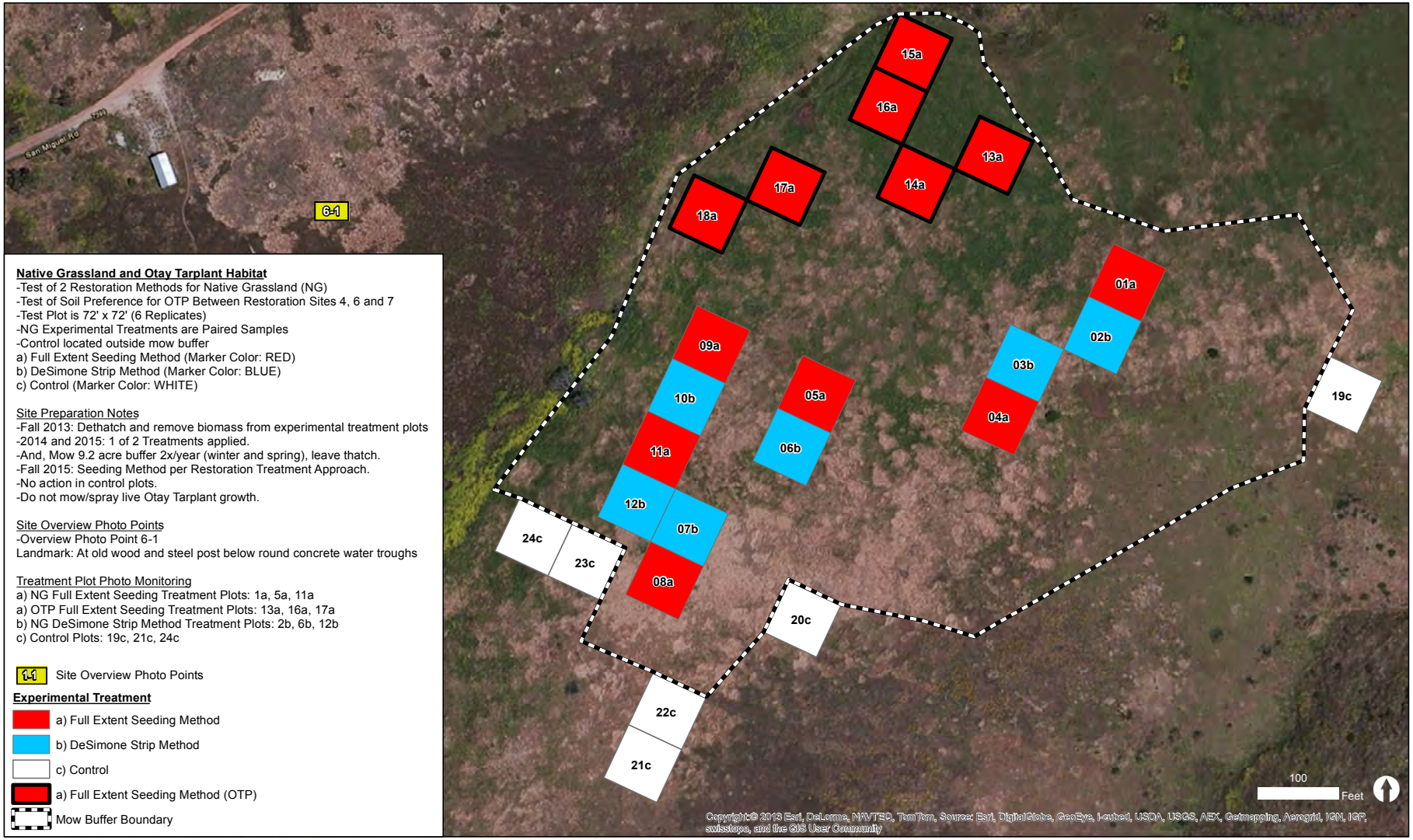


Native Grassland and Otay Tarplant Habitat
-Test of 2 Restoration Methods for Native Grassland (NG)
-Test of Soil Preference for OTP Between Restoration Sites 4, 6 and 7
-Test Plot is 72' x 72' (6 Replicates)
-NG Experimental Treatments are Paired Samples
-Control located outside mow buffer
a) Full Extent Seeding Method (Marker Color: RED)
b) DeSimone Strip Method (Marker Color: BLUE)
c) Control (Marker Color: WHITE)

Site Preparation Notes
-Fall 2013: Dethatch and remove biomass from experimental treatment plots
-2014 and 2015: 1 of 2 Treatments applied.
-And, Mow 9.2 acre buffer 2x/year (winter and spring), leave thatch.
-Fall 2015: Seeding Method per Restoration Treatment Approach.
-No action in control plots.
-Do not mow/spray live Otay Tarplant growth.

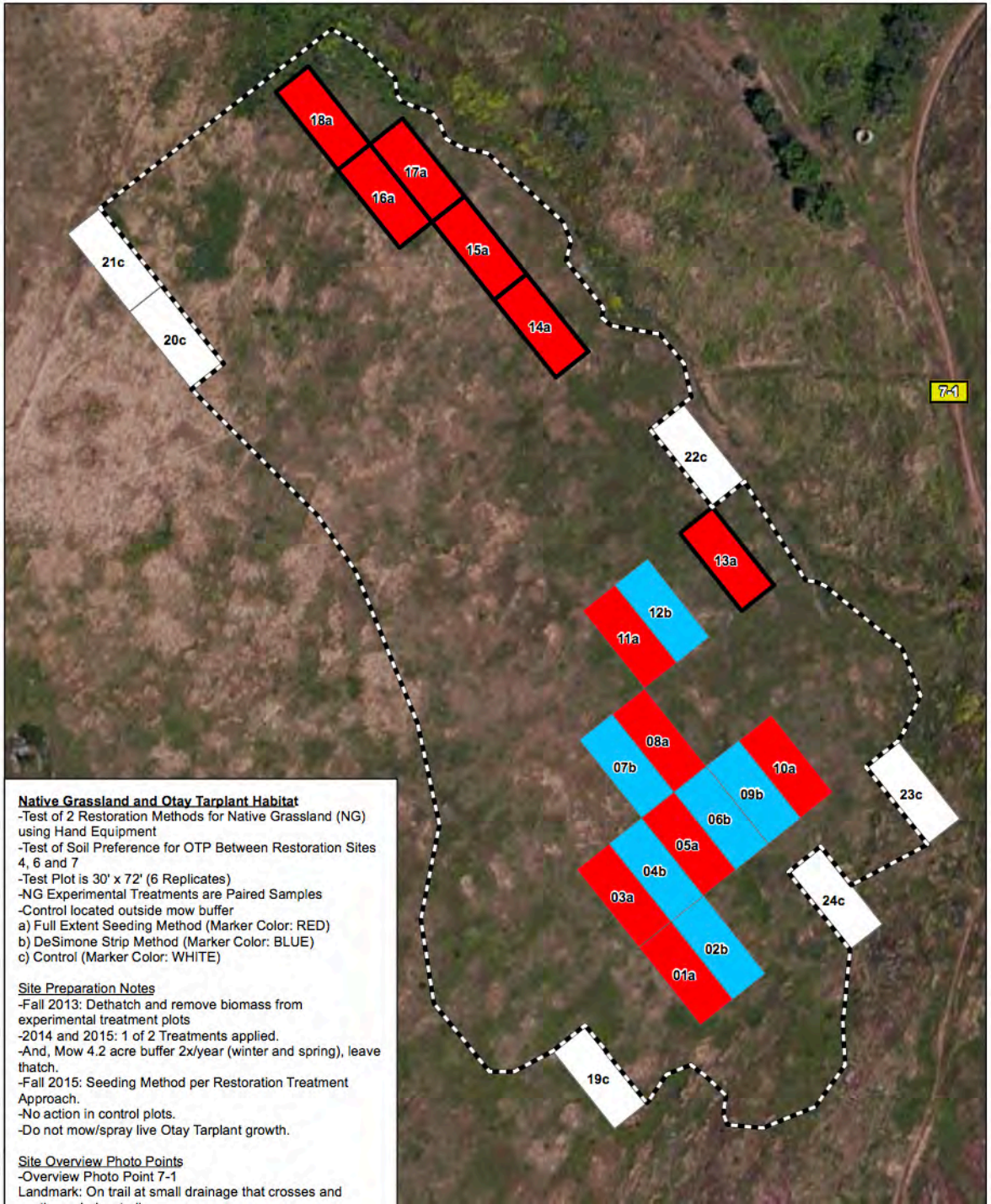
Site Overview Photo Points
-Overview Photo Point 6-1
Landmark: At old wood and steel post below round concrete water troughs

Treatment Plot Photo Monitoring
a) NG Full Extent Seeding Treatment Plots: 1a, 5a, 11a
a) OTP Full Extent Seeding Treatment Plots: 13a, 16a, 17a
b) NG DeSimone Strip Method Treatment Plots: 2b, 6b, 12b
c) Control Plots: 19c, 21c, 24c

1-1 Site Overview Photo Points

Experimental Treatment
a) Full Extent Seeding Method
b) DeSimone Strip Method
c) Control
a) Full Extent Seeding Method (OTP)
Mow Buffer Boundary

Figure 11. Sweetwater Reservoir Native Grassland and Otay Tarplant Habitat Restoration Site 6.



Native Grassland and Otay Tarplant Habitat
-Test of 2 Restoration Methods for Native Grassland (NG) using Hand Equipment
-Test of Soil Preference for OTP Between Restoration Sites 4, 6 and 7
-Test Plot is 30' x 72' (6 Replicates)
-NG Experimental Treatments are Paired Samples
-Control located outside mow buffer
a) Full Extent Seeding Method (Marker Color: RED)
b) DeSimone Strip Method (Marker Color: BLUE)
c) Control (Marker Color: WHITE)

Site Preparation Notes
-Fall 2013: Dethatch and remove biomass from experimental treatment plots
-2014 and 2015: 1 of 2 Treatments applied.
-And, Mow 4.2 acre buffer 2x/year (winter and spring), leave thatch.
-Fall 2015: Seeding Method per Restoration Treatment Approach.
-No action in control plots.
-Do not mow/spray live Otay Tarplant growth.

Site Overview Photo Points
-Overview Photo Point 7-1
Landmark: On trail at small drainage that crosses and

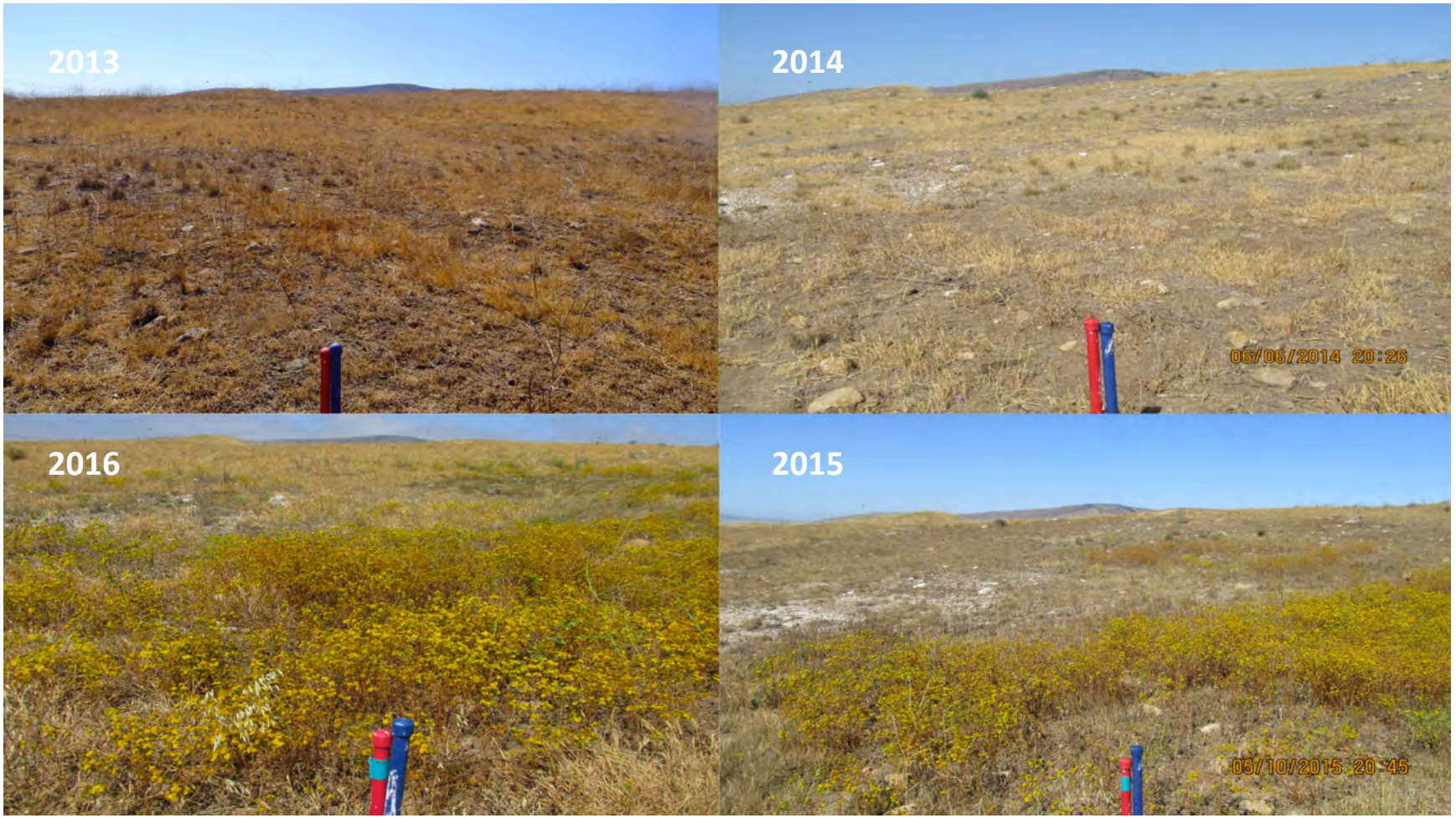
Grassland Habitat
Results

- Sites were seed limited, except for Site 8 and OTP populations
- In first year of seed establishment, native cover is similar to existing (lower diversity) native cover in controls − which, is significant.
  - Native diversity in controls is low and cover is primarily from mature *Stipa pulchra*.
- Good establishment of native seed mix, as measured by higher diversity and cover for the Herbicide 2x treatment, reflects lower non-native cover and litter
- Methods used at Site 7 (back pack sprayers and line trimmers) are as good, if not perhaps better due to greater attention to detail by crew, than mechanized methods at the other grassland sites.

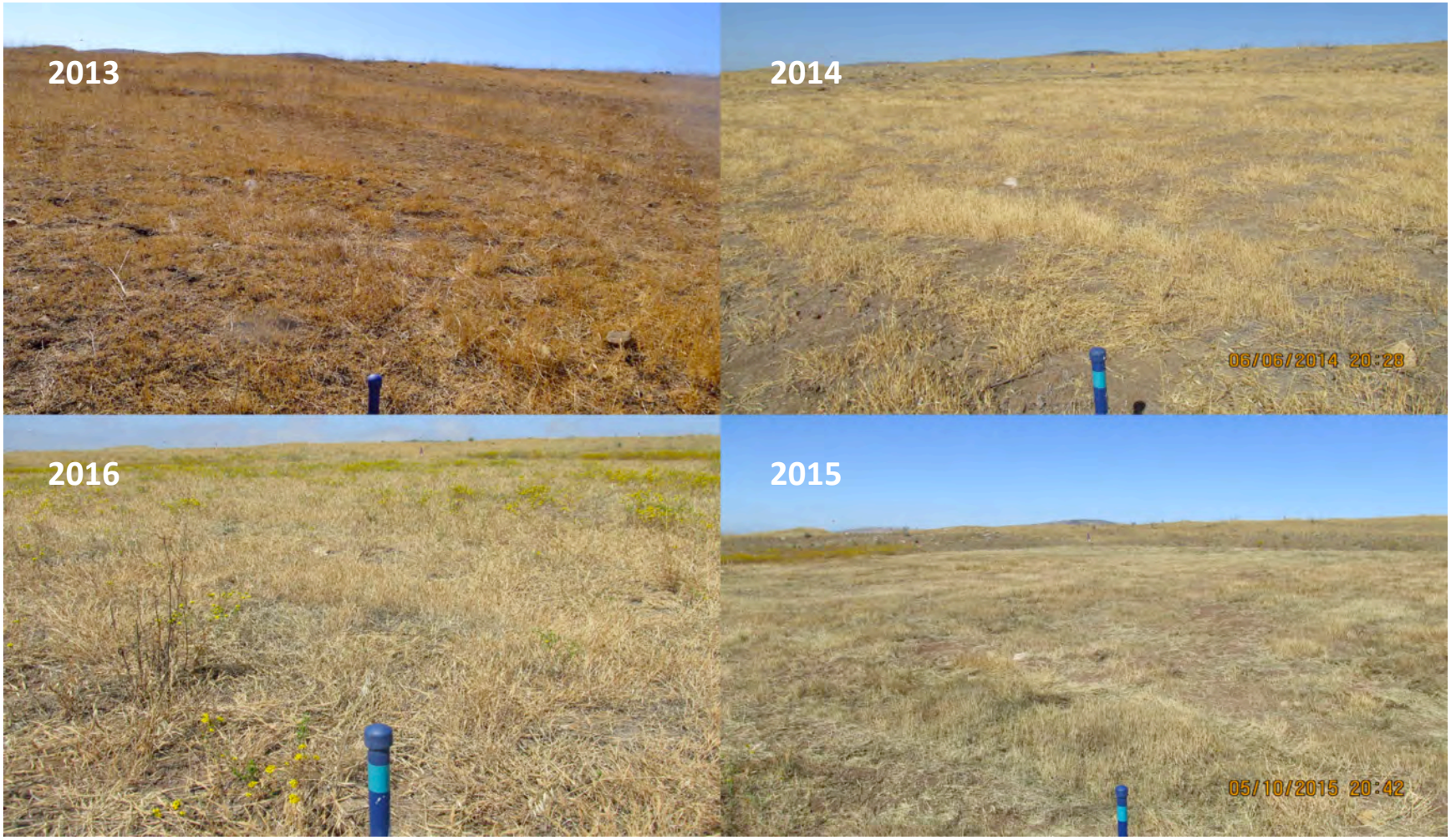
Grassland Habitat

Results

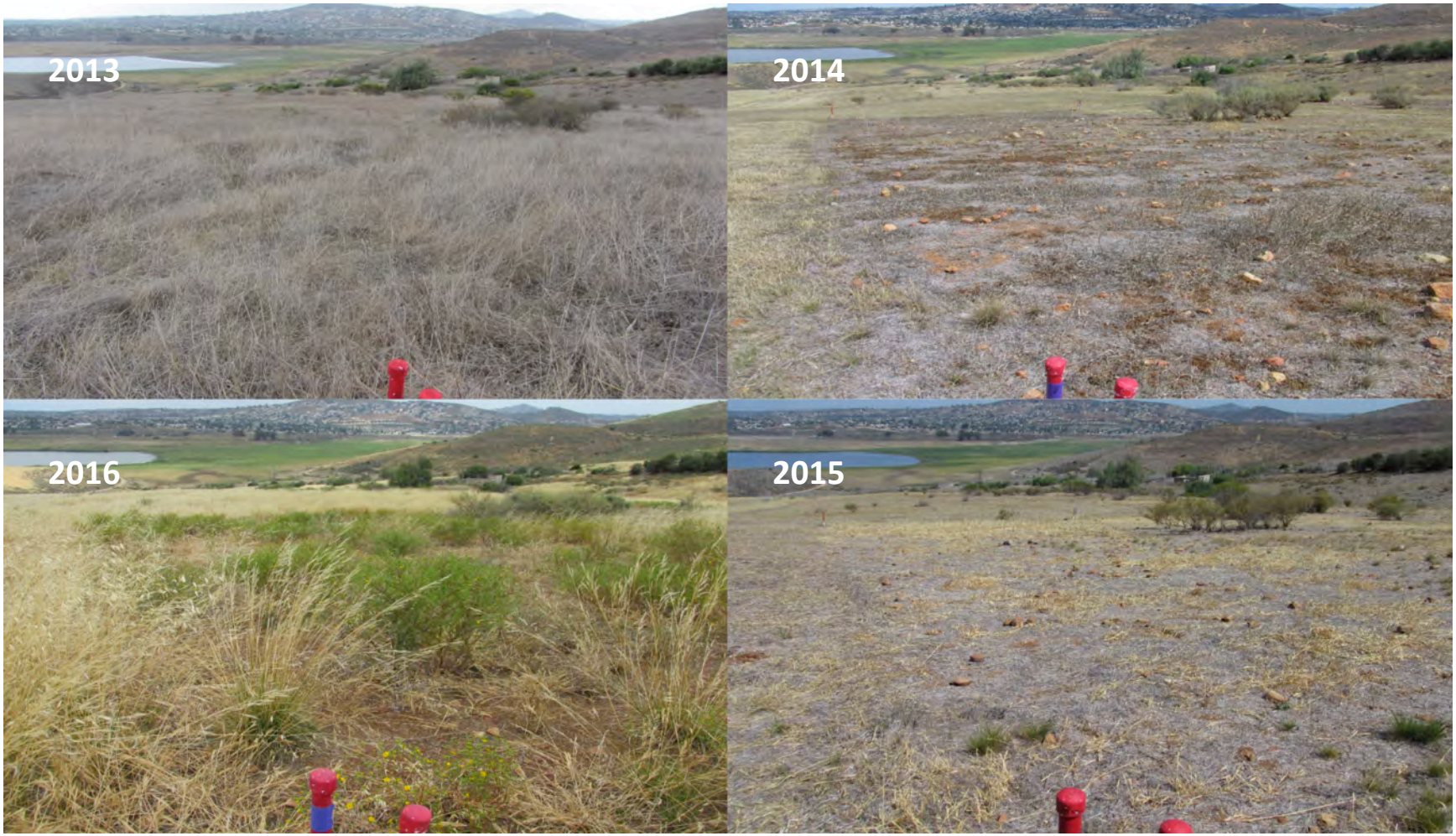
- **Site Preparation:**
  - Both effective methods for controlling weeds, but Herbicide 2x (a) had better cover in some sites and higher species diversity (Sites 4-6) than (b) Mow 2x
  - Mechanical: Line trimming 2x == mow 2x
  - Chemical: Back pack == wand on truck mounted tank
- **Seeding Method**
  - Full extent method established higher cover of forbs and *Stipa pulchra*, but only long term site trajectory will tell if more effective than Modified DeSimone Strip method.
  - More native forbs in seeded plots than control, but lots of variability so, not statistically significant. Also, because cover is relatively low in most plots.
- **Influence of Pre-Restoration Fall Fire at Site 4?**
  - No significant trends, but native cover is lower at Site 4. Should be reevaluated in the future.



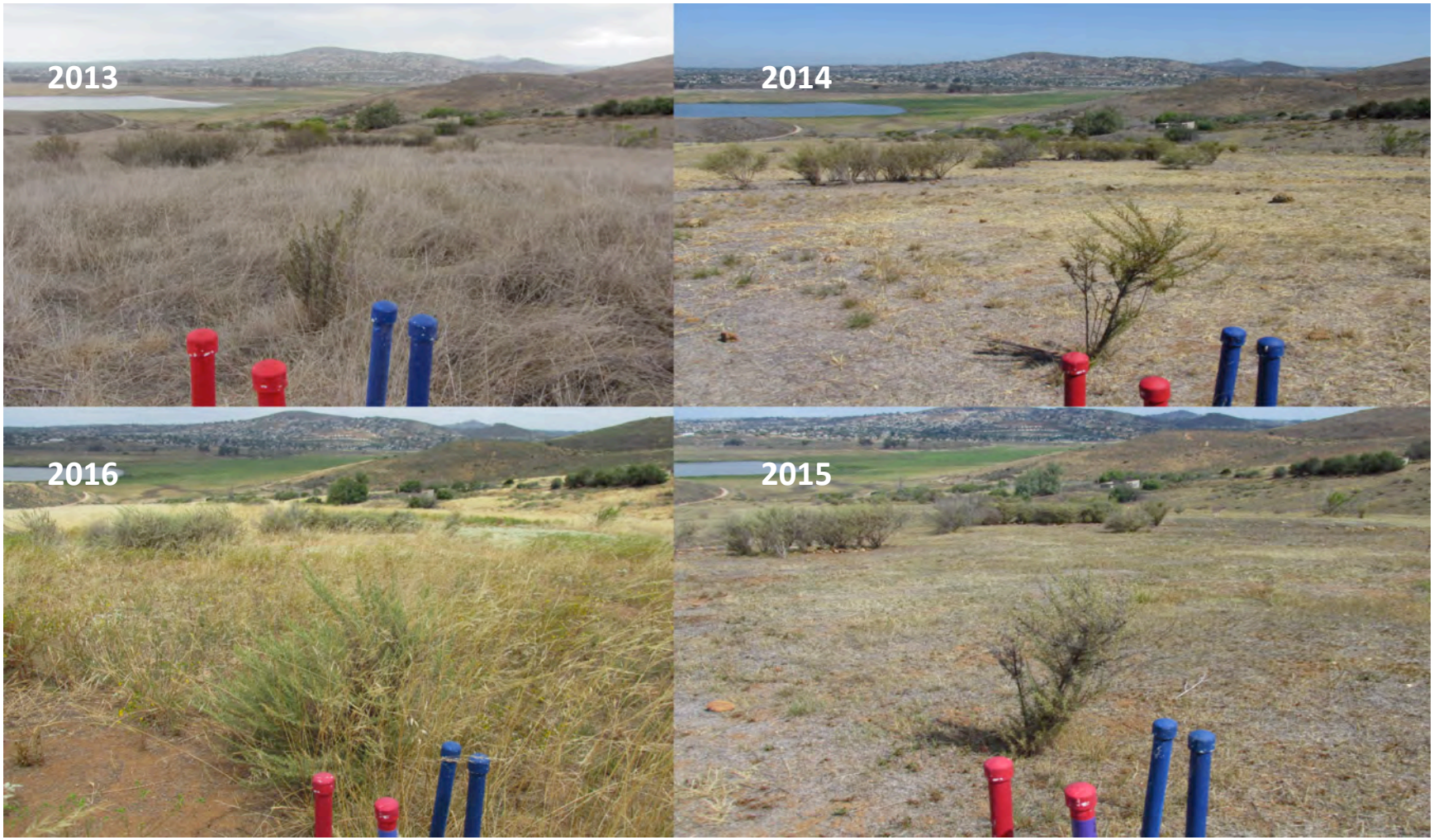
Site 4: (**a**) Herbicide 2x + Full Extent 2-way Drill Seeding



Site 4: (**b**) Mow 2x + Modified DeSimone Strips with 1-way Drill Seeding



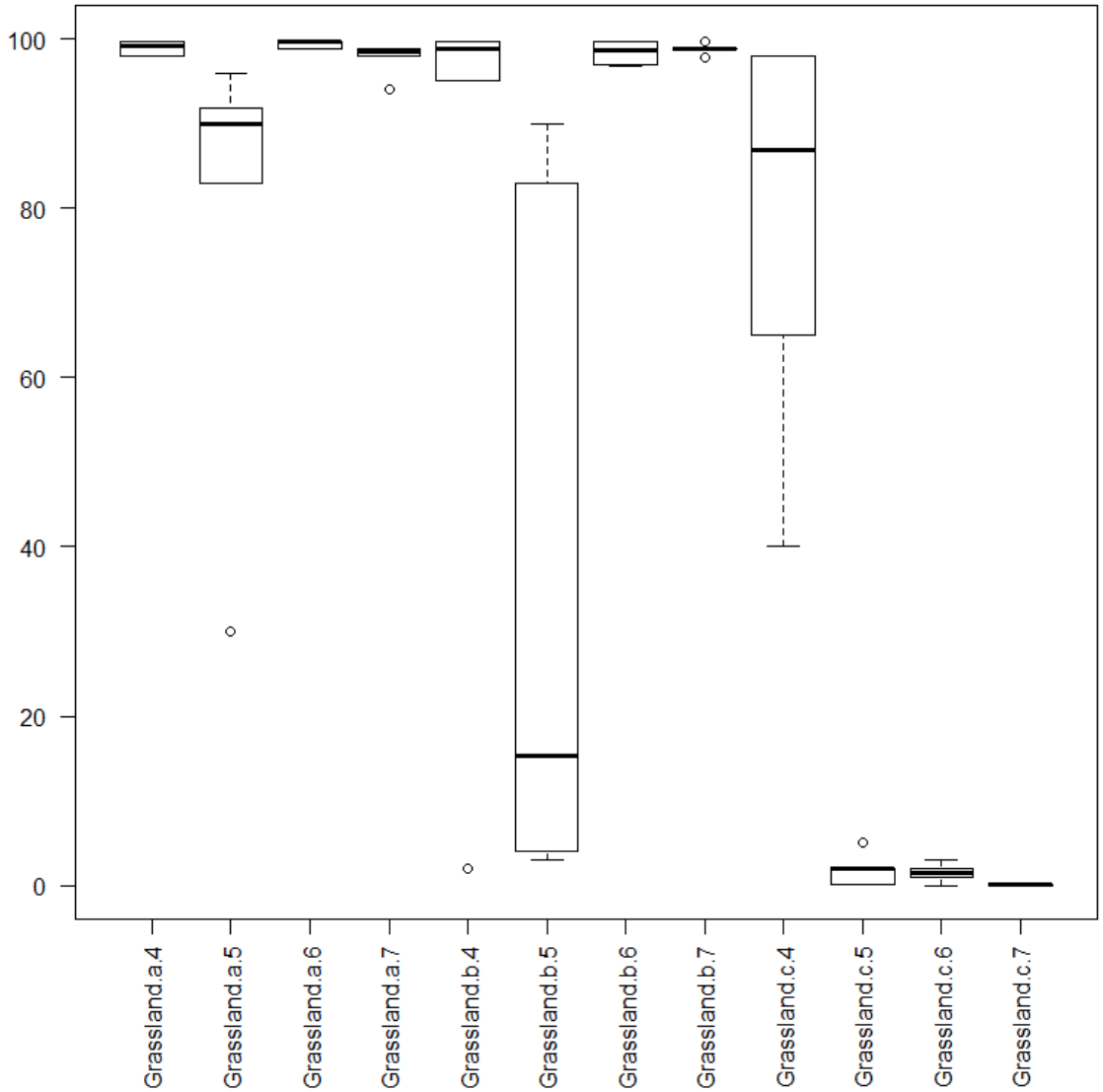
Site 7: (**a**) Herbicide 2x + Full Extent Hand Seeding + Cultipacker



Site 7: (**b**) Line Trim 2x + Modified DeSimone Strips with Hand Seeding + Cultipacker

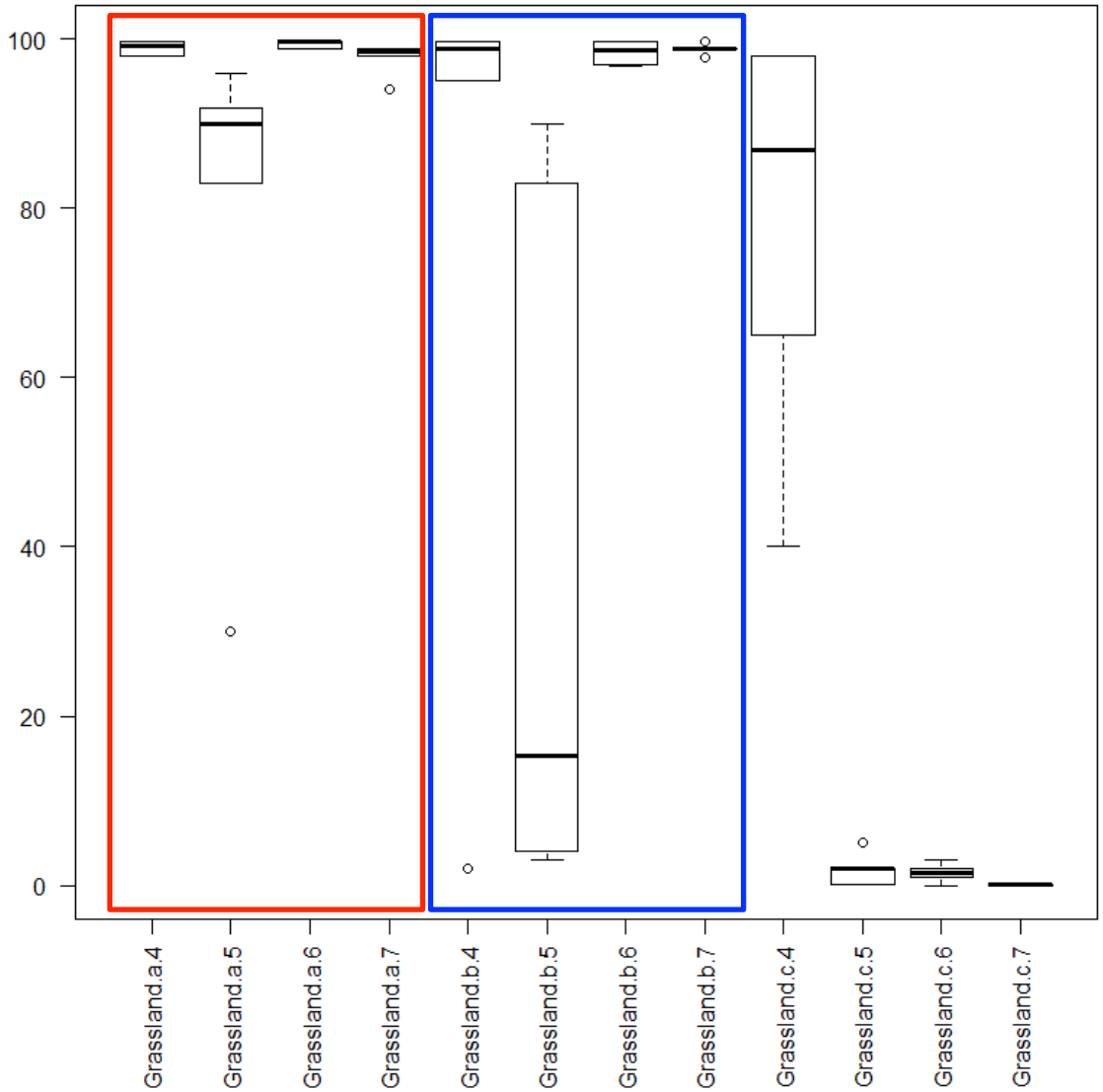
Grassland Habitat

Bare Ground Cover



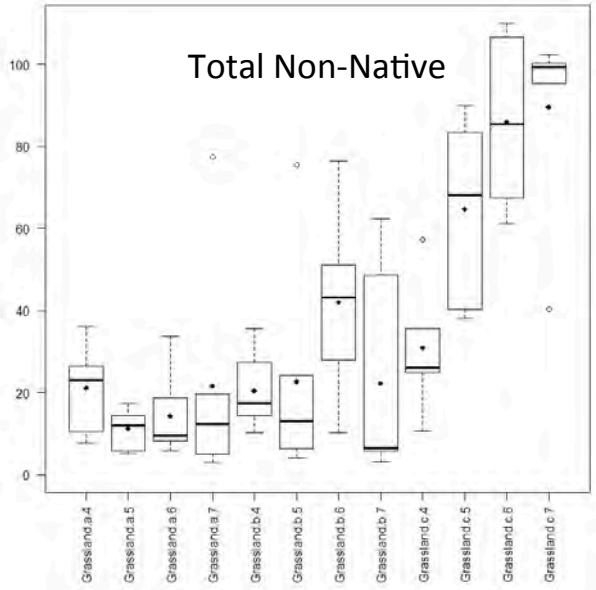
Grassland Habitat

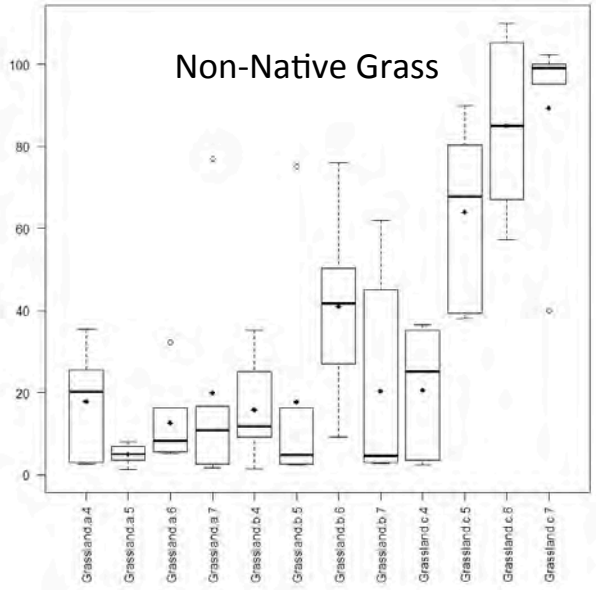
Bare Ground Cover

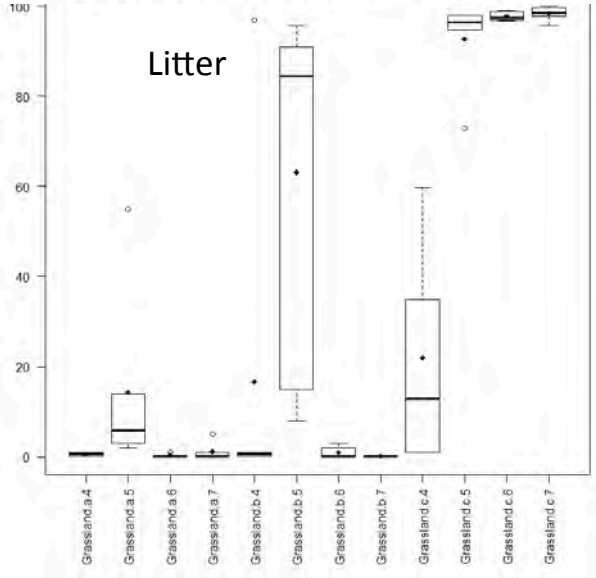


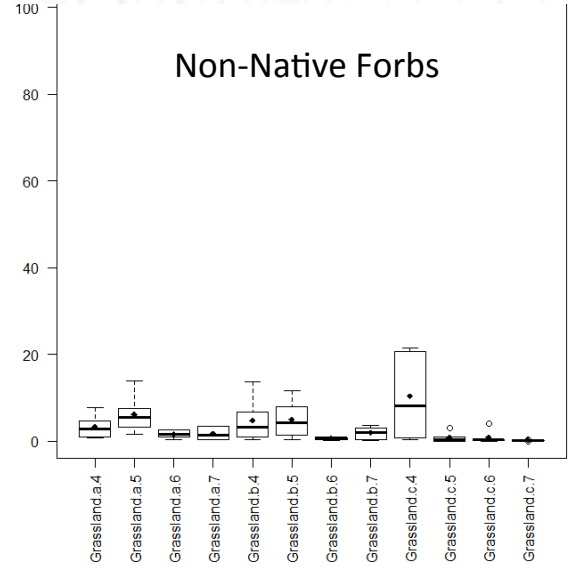
Grassland Habitat

Non-Native Cover and Litter



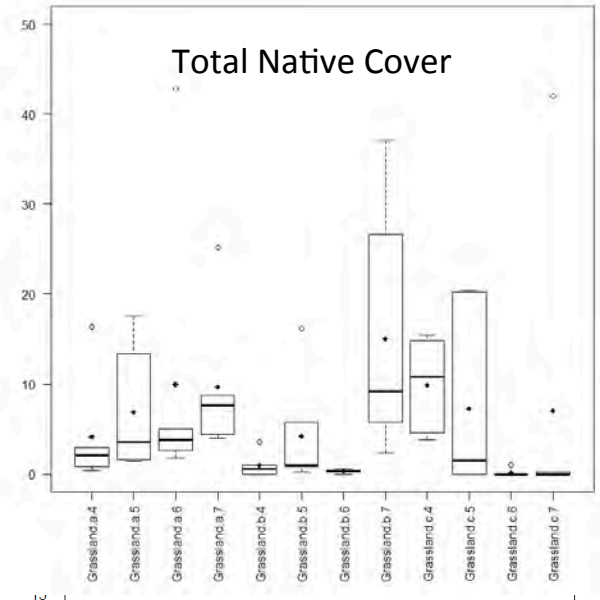


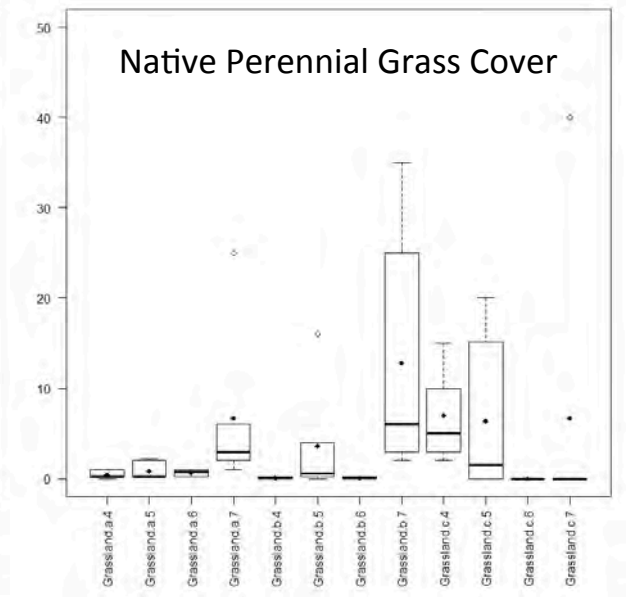


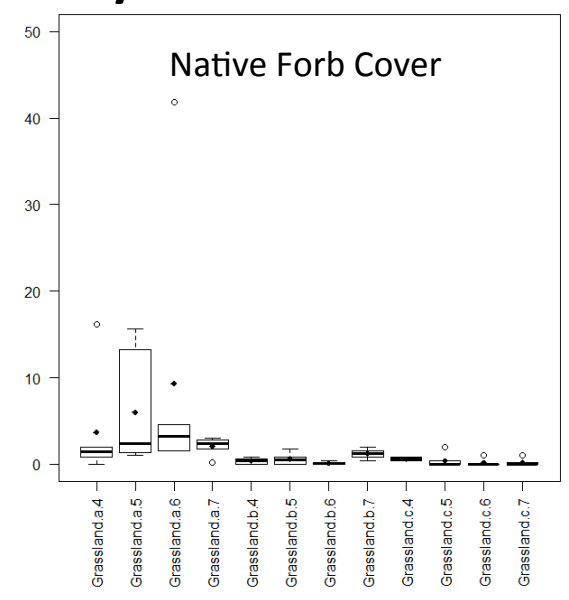


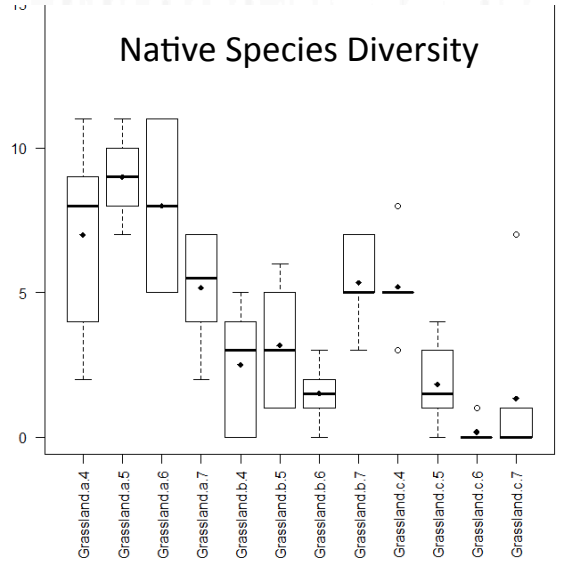
Grassland Habitat

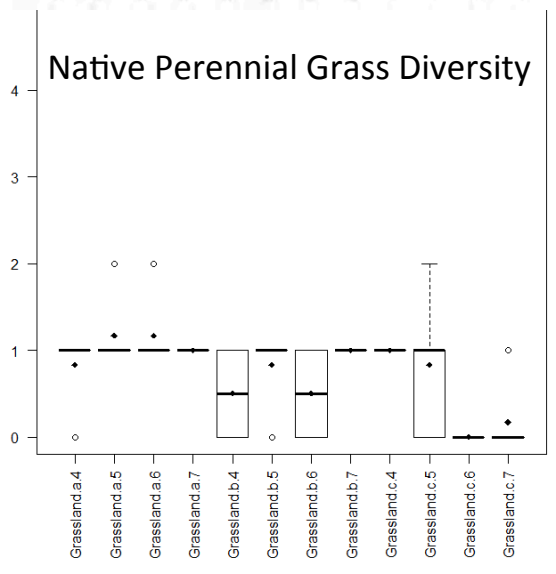
Native Cover and Diversity

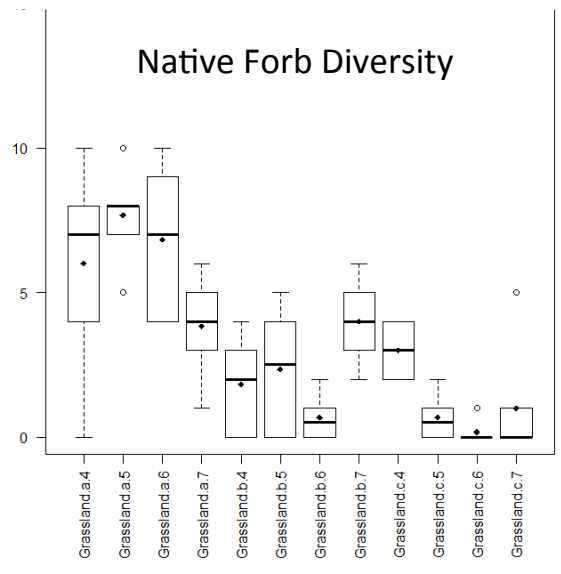






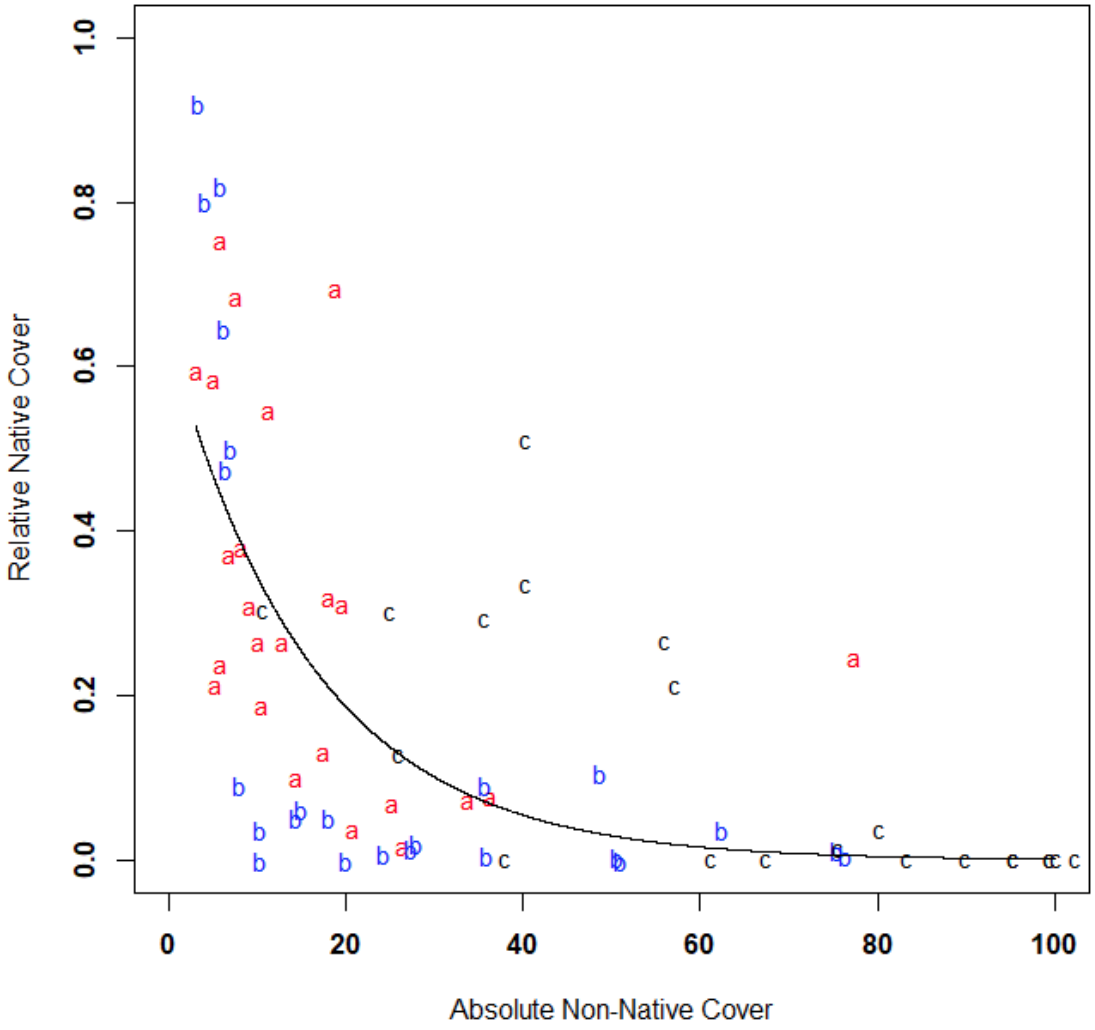






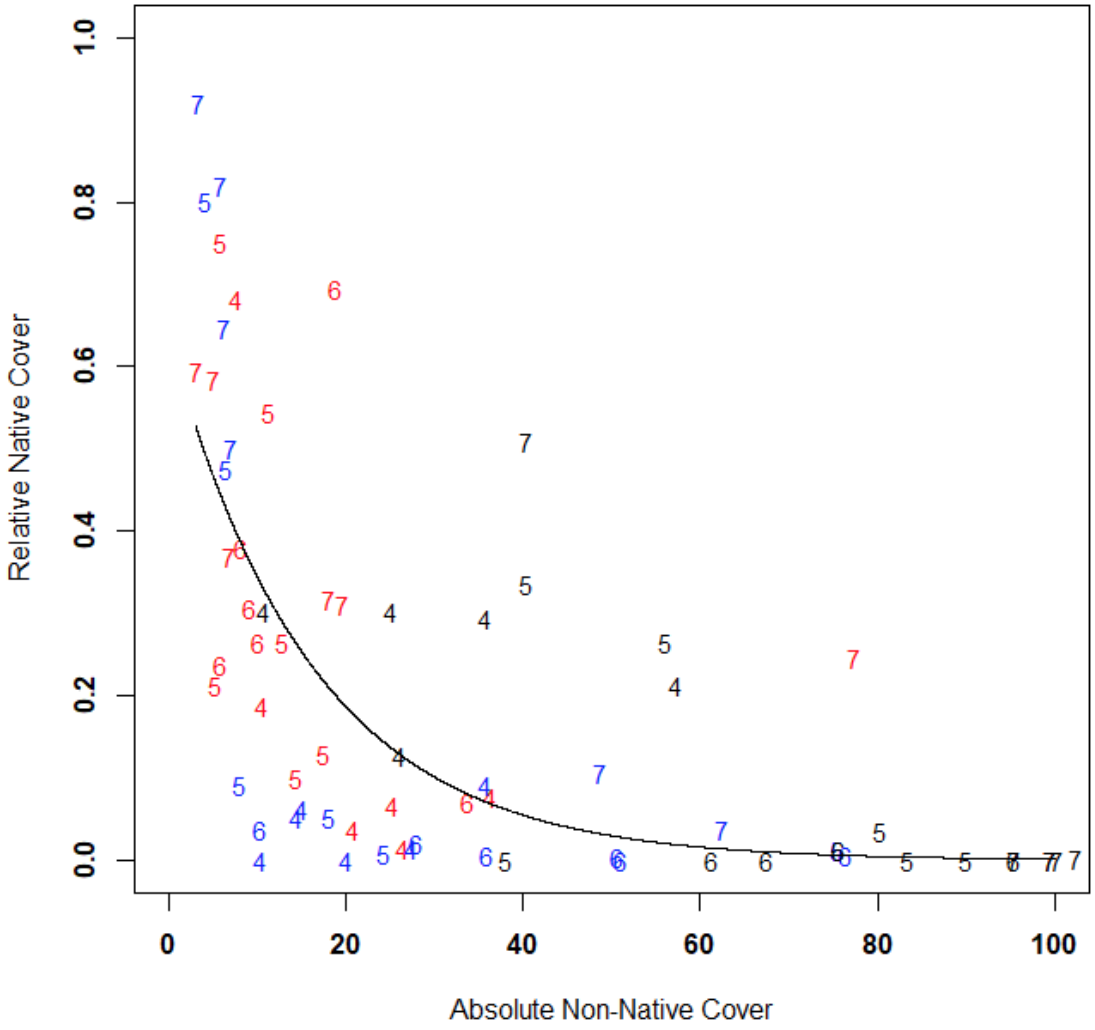
Grassland

GLM Regression



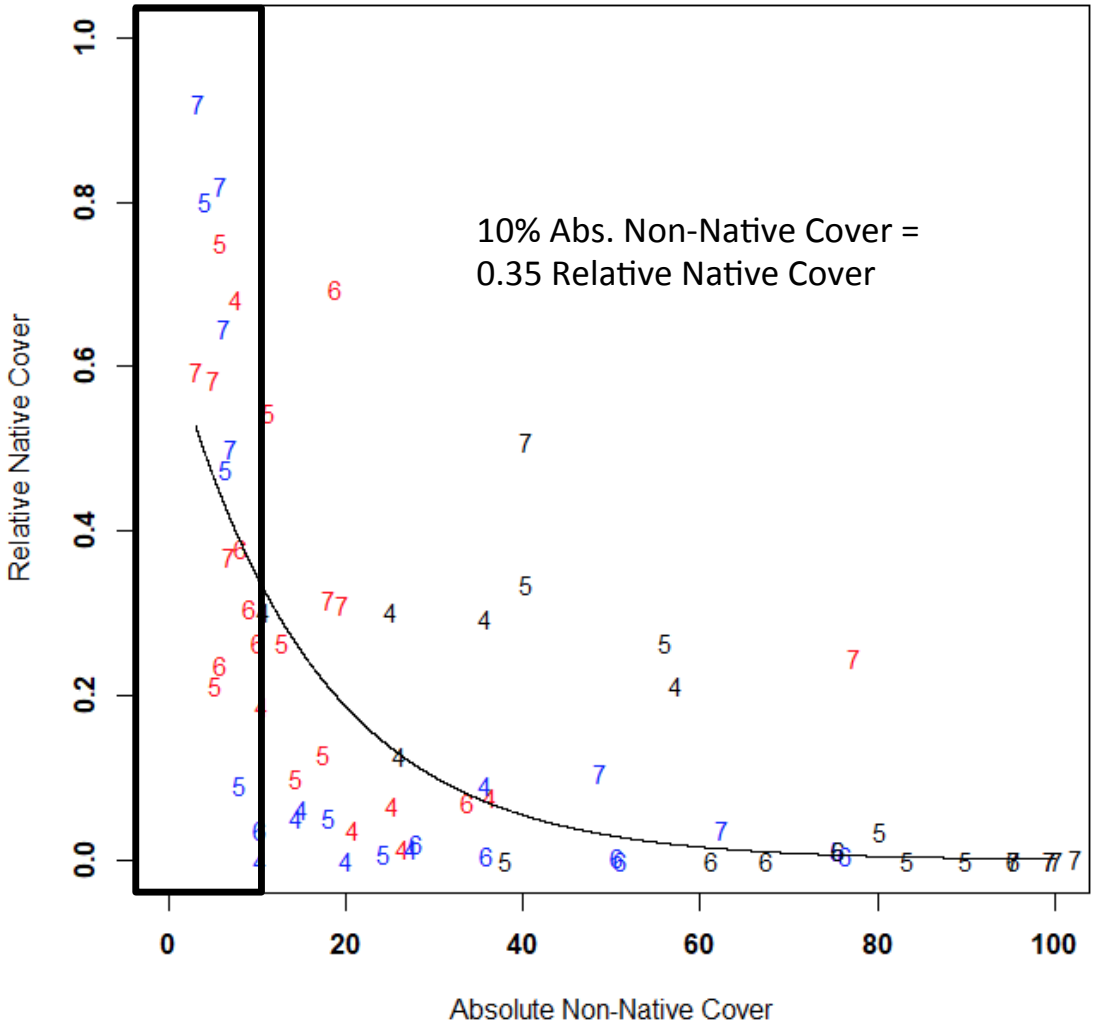
Grassland

GLM Regression

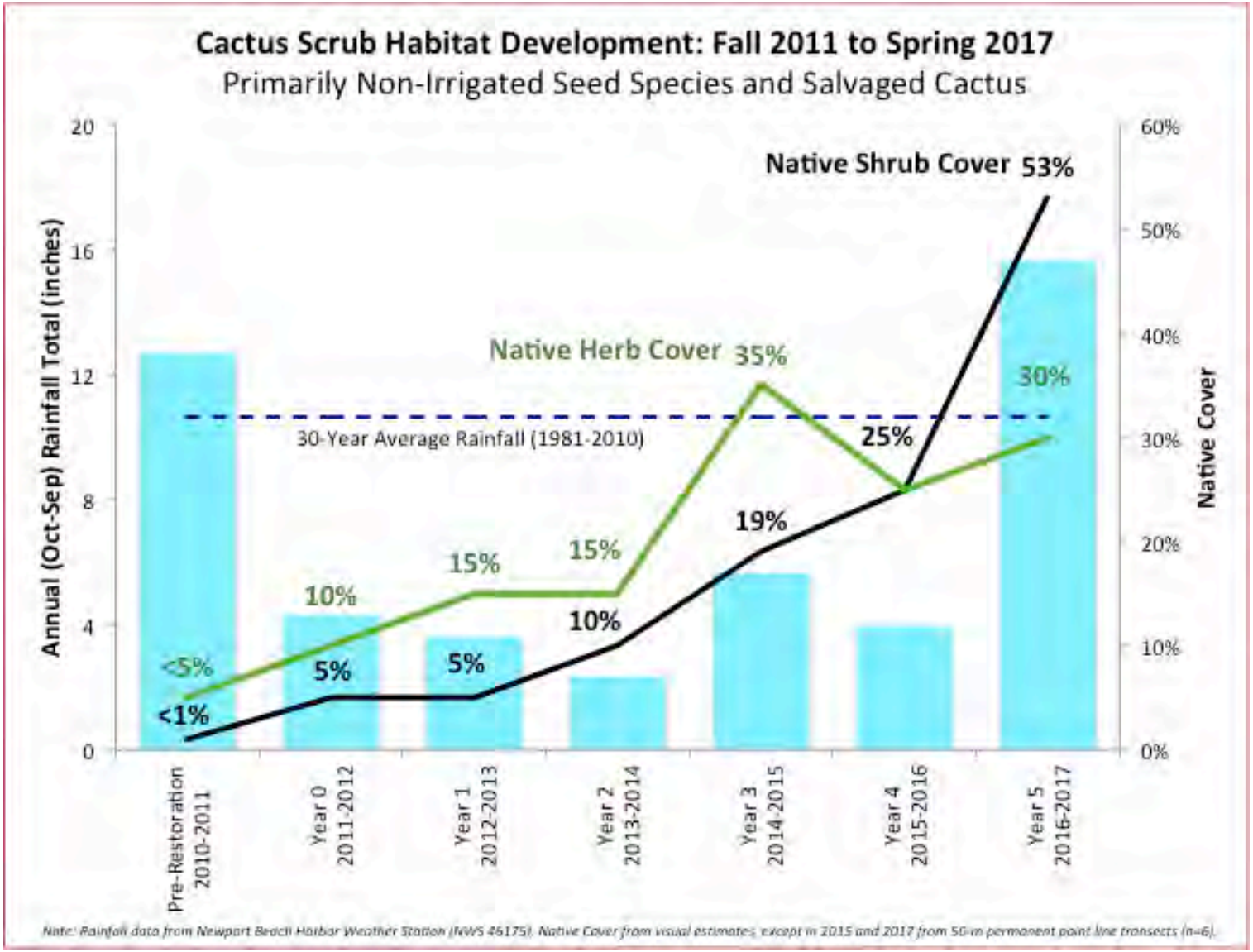


Grassland

GLM Regression



Typical seeded native cover trajectory



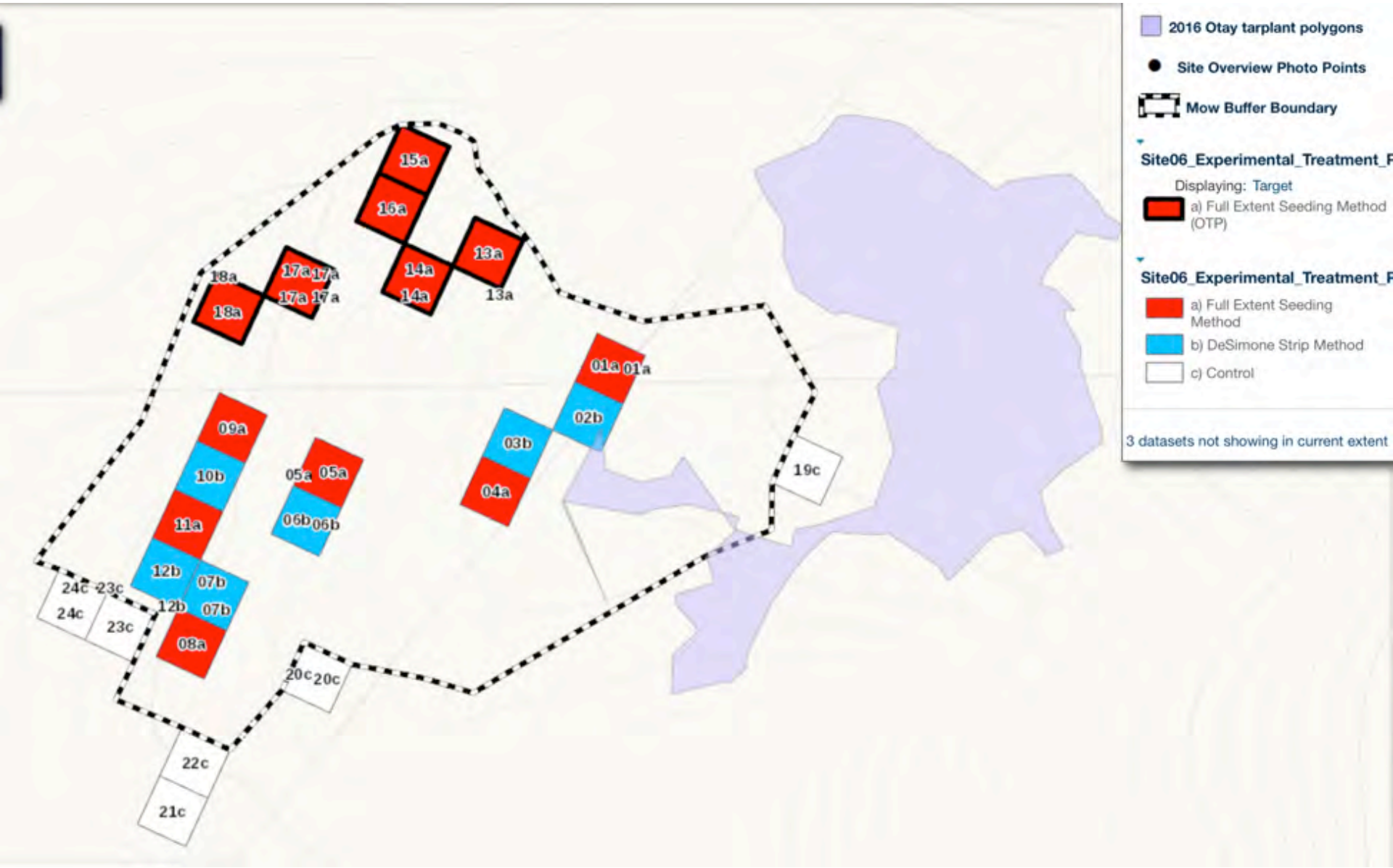
Otay Tarplant Habitat
Study Goals and Questions

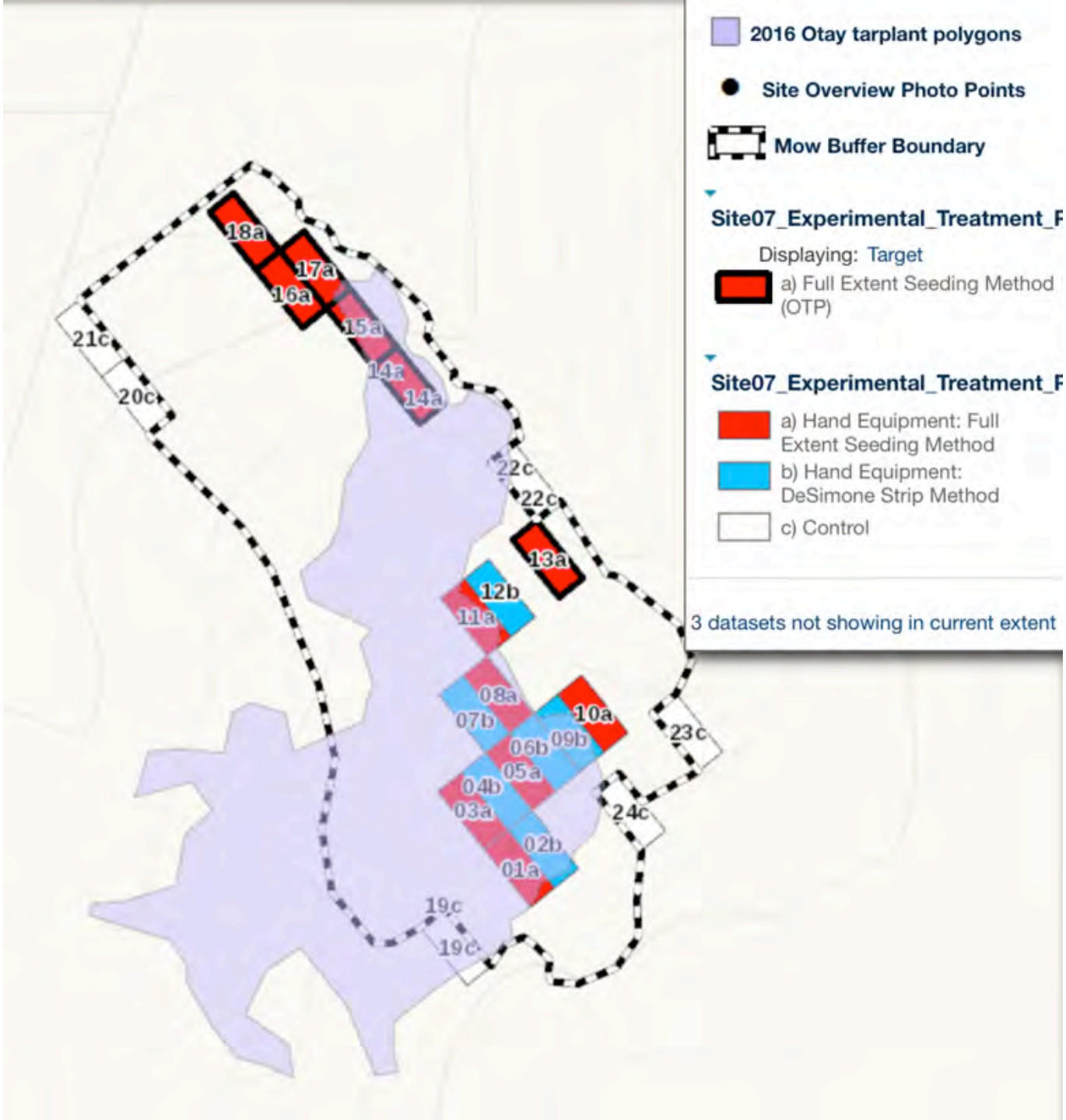
- Evaluate success of establishing OTP populations using hand-broadcast seeding or two-way drill seeding
  - Successful:
    - Seeded density of ~8 PLS/sqft (24 PLS/sqft including dormant seed)
    - Observed ~0.25 plants/sqft in Spring 2016
- Test whether calcareous soil at Site 6 is limiting to the establishment of OTP populations.
- NOTE: Only able to seed at Site 4 with seed collected from Rancho Jamul. Other seed was collected at other localities and bulked. Waiting for future results of genetic studies to release bulked seed for seeding in the OTP plots at Sites 6 and 7.

Otay Tarplant Habitat
Monitoring Results

Site	Population Size Estimate	Extent	Notes
4 (RJER)	~10,000	1.55 acre	Greatest density of individuals are in seeded OTP restoration plots 13-18, which is 0.71 acres **~1,267 ave. plants per plot (5,184 sqft) x 6 plots is ~7,600 individuals total in restoration plots**
6 (Sweetwater, USFWS)	~2,000-10,000	4.66 acre	Primarily to the west of Site 6; ~200 total from Plots 1, 4 and 5 combined
7 (Sweetwater, USFWS)	~15,000	3.55 acre	Includes grassland plots 1-10, OTP plots 14-16 and control plot 22 (~219 ave. plants per plot, 0.05 ac per plot)
8 (RJER)	~85,500	5.21 acre	Data from 2016 IMG Rare Plant Monitoring, CBI


2016 Otay tarplant polygons
Site Overview Photo Points
Mow Buffer Boundary
Site04_Experimental_Treatment_F
a) Full Extent Seeding Method
b) DeSimone Strip Method
c) Control
4 datasets not showing in current extent
5-2
928 ft
5-1
4-1
4-2
19c
19c
20c
21c
22c
01a
02b
04a
05b
06a
07b
09a
08a
10b
11a
12b
13a
14a
15a
16a
17a
18a
18a
23c
24c

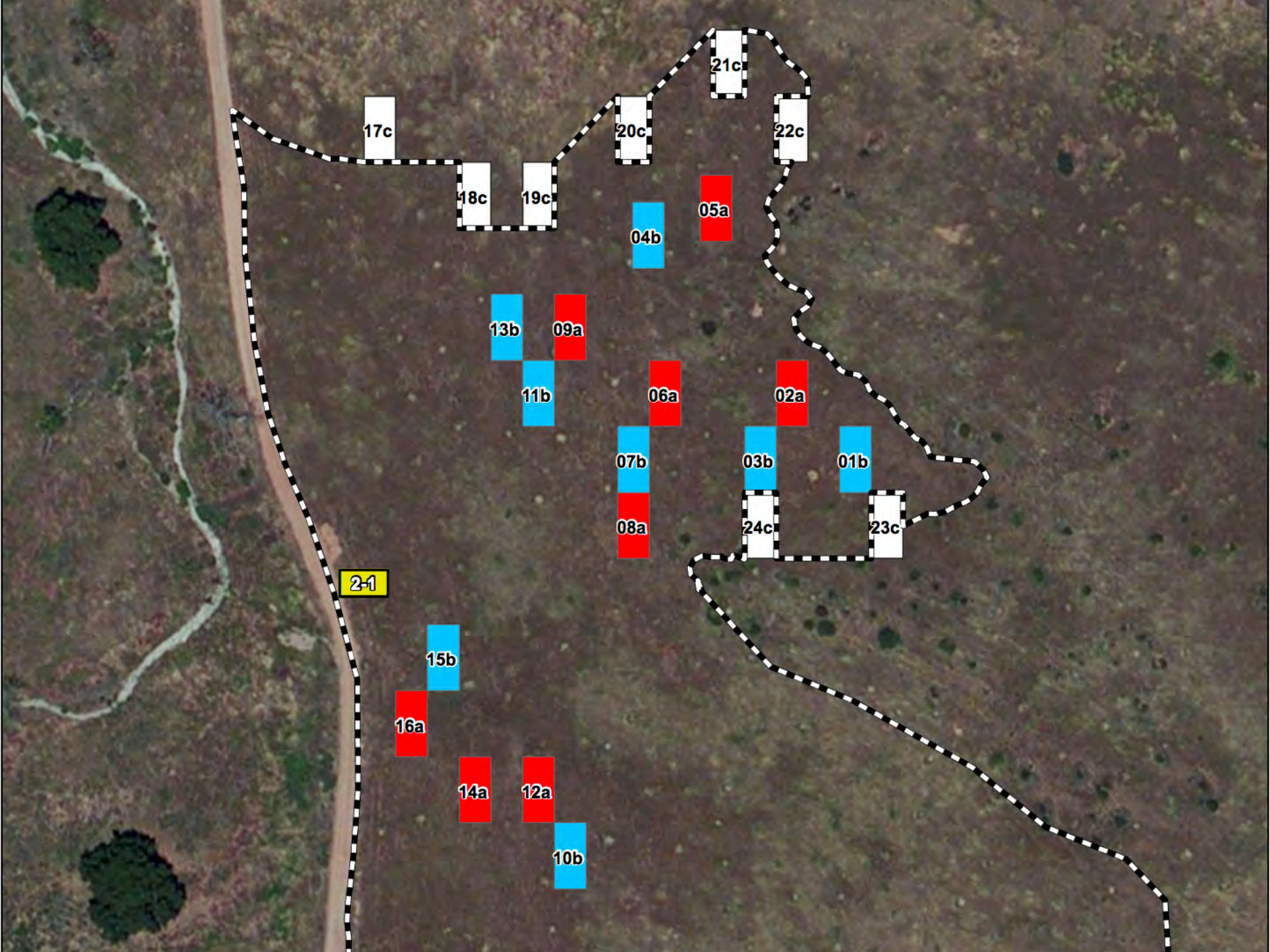

2016 Otay tarplant polygons
Site Overview Photo Points
Mow Buffer Boundary
Site06_Experimental_Treatment_F
Displaying: Target
a) Full Extent Seeding Method (OTP)
Site06_Experimental_Treatment_F
a) Full Extent Seeding Method
b) DeSimone Strip Method
c) Control
3 datasets not showing in current extent
15a
16a
13a
14a
18a
17a
01a
02b
03b
04a
09a
10b
11a
05a
06b
12b
07b
08a
24c
23c
20c
22c
21c
19c


2016 Otay tarplant polygons
Site Overview Photo Points
Mow Buffer Boundary
Site07_Experimental_Treatment_F
Displaying: Target
a) Full Extent Seeding Method (OTP)
Site07_Experimental_Treatment_F
a) Hand Equipment: Full Extent Seeding Method
b) Hand Equipment: DeSimone Strip Method
c) Control
3 datasets not showing in current extent
18a
17a
16a
15a
14a
14a
21c
20c
22c
22c
13a
12b
11a
08a
07b
10a
09b
06b
05a
04b
03a
02b
01a
23c
24c
19c
19c

Forbland Habitat

Study Goals and Questions at Site 2

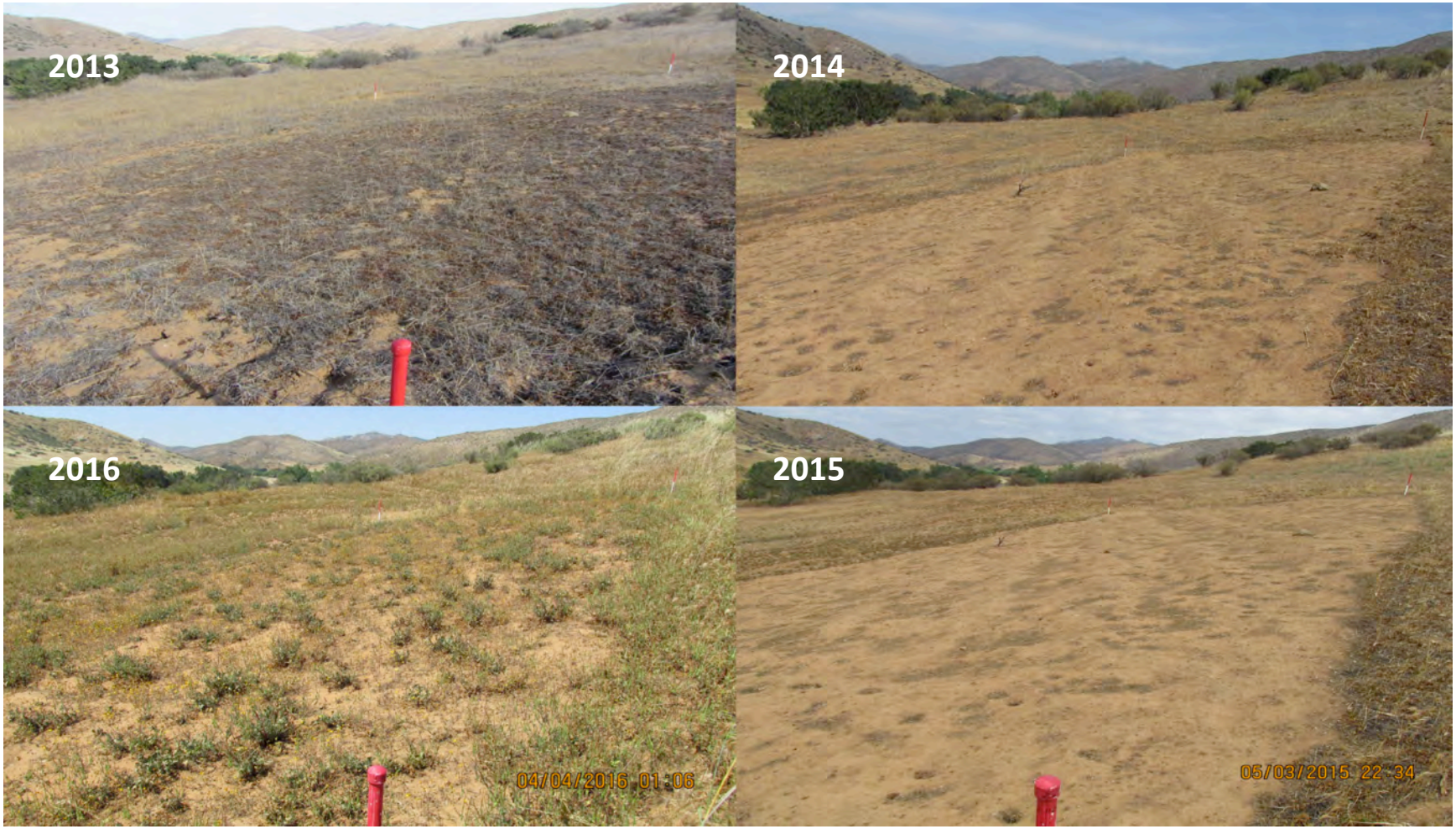
- Assess two site preparation techniques, prior to application of a forbland seed mix.
- Compare two years of winter and spring treatment methods (n=8):
  - (**a**) line trimming 2x, or
  - (**b**) two broad spectrum herbicide applications (glyphosate)


21c
17c
20c
22c
18c
19c
05a
04b
13b
09a
11b
06a
02a
07b
03b
01b
08a
24c
23c
2-1
15b
16a
14a
12a
10b

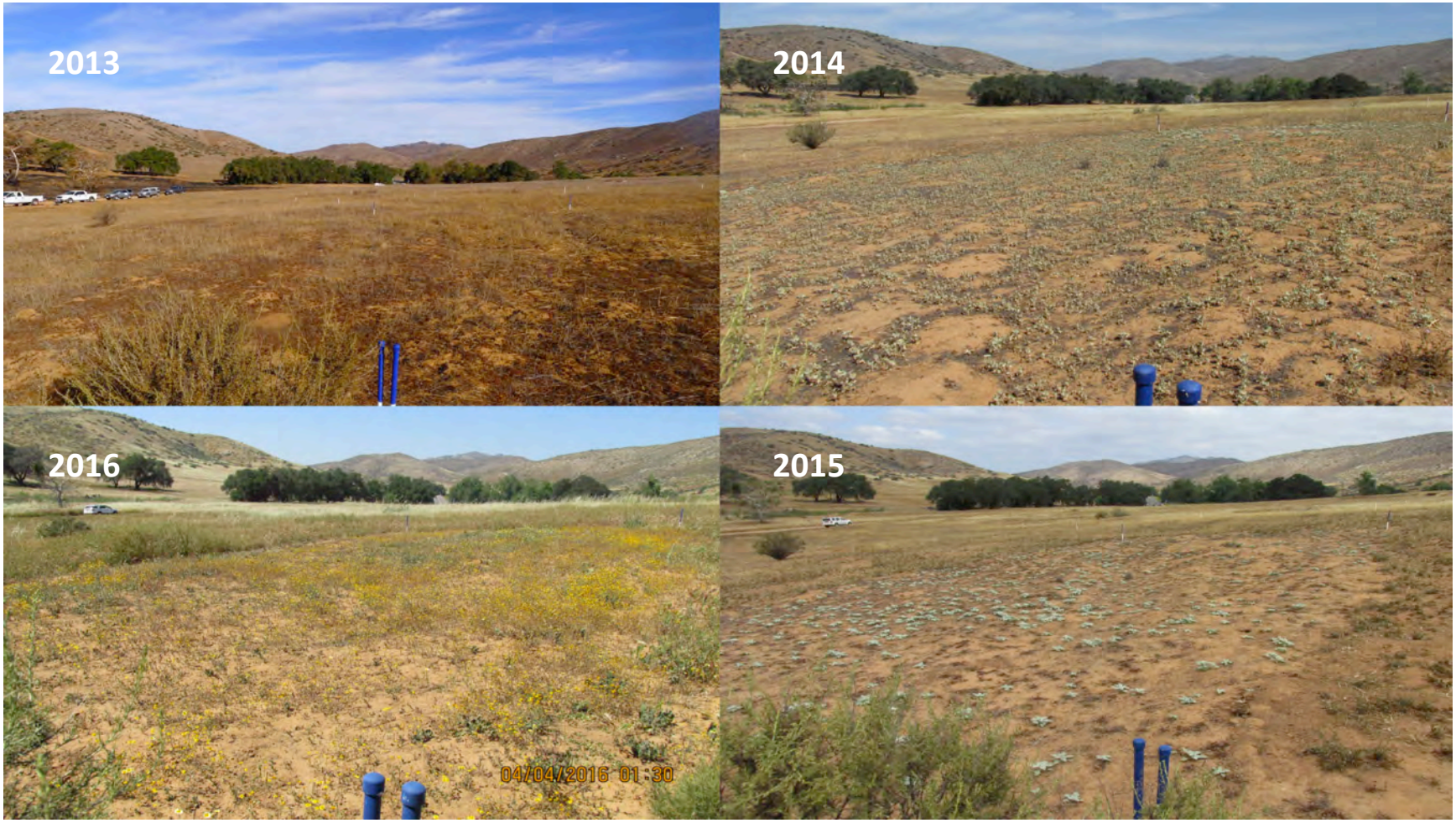
Forbland Habitat

Results

- Increase in Native cover compared to control
  - 30% relative native cover in treatment plots, and rest is primarily Erodium spp.
  - Seed limitation likely
- Significant reduction in grass, but no significant difference in forbs (which is primarily *Erodium botrys*)
  - Non-native grasses include (n=8, average cover %):
    - *Bromus madritensis* (8% in control)
    - *Bromus diandrus* (6% in control)
    - *Avena barbata* (5% in control)
    - *Bromus hordeaceus* (rare, 0.3% in control)
    - *Festuca myuros* (rare, 0.1% in control)
- Less litter, more bare ground than controls
  - But will this hold over time?
- Reduced cover of soil crusts from seeding technique
  - Can soil crusts colonize and increase when weed management stops, and increase over control?



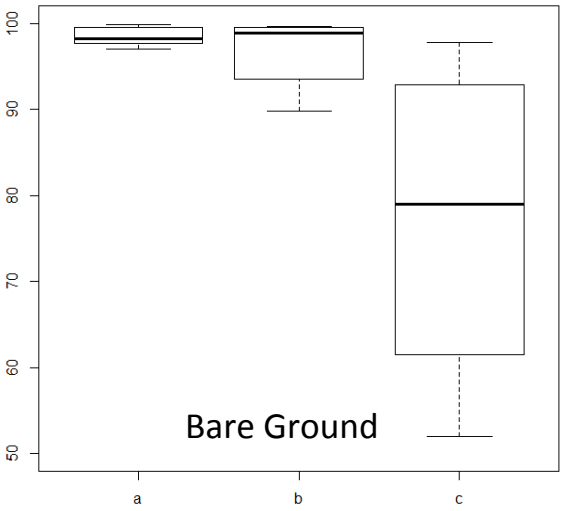
(**a**) line trimming 2x

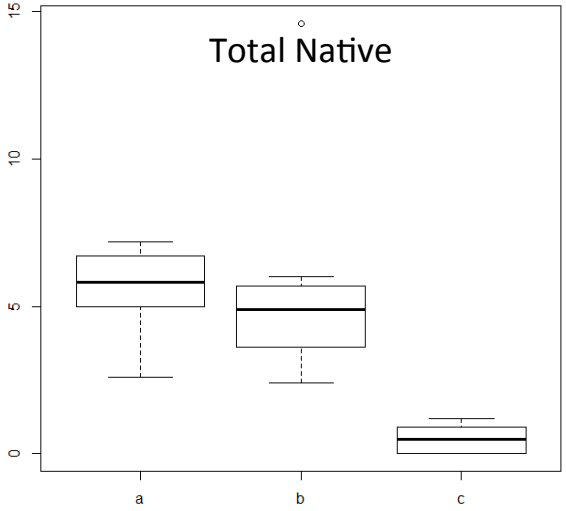


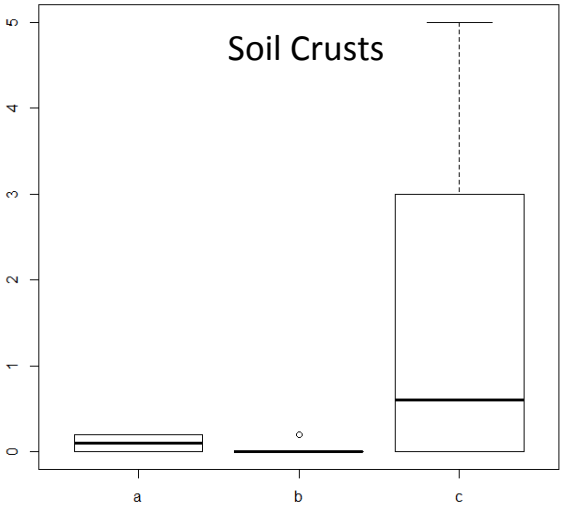
(b) broad spectrum herbicide (glyphosate) 2x

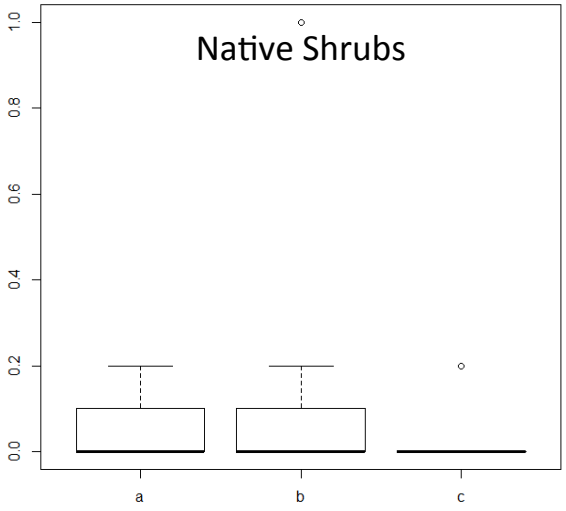
Forbland Habitat

Bare Ground, Soil Crusts & Native Cover



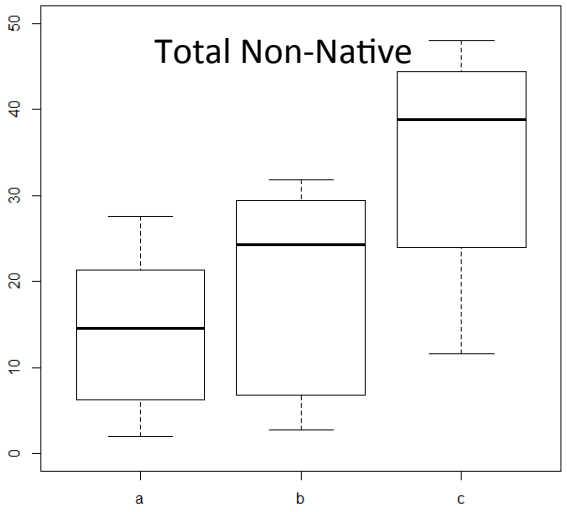


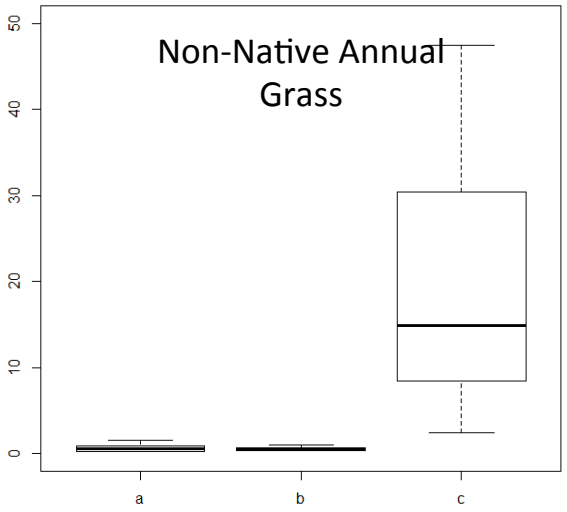


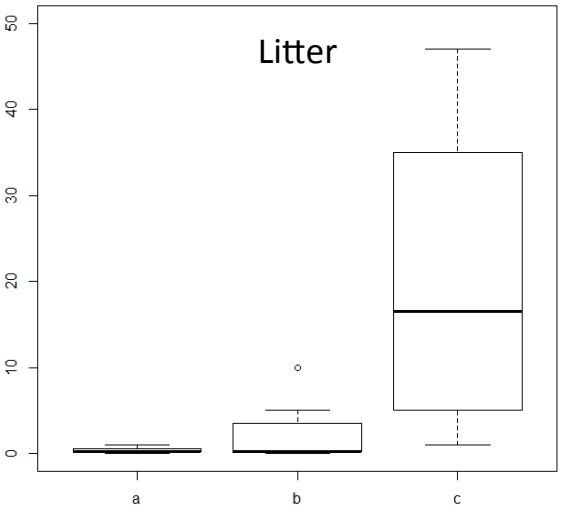


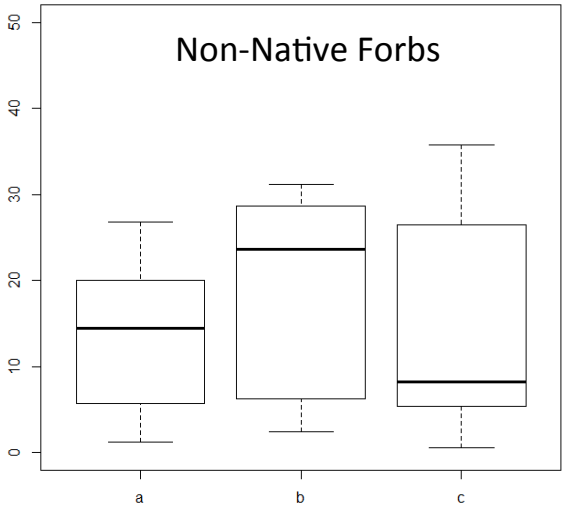
Forbland Habitat

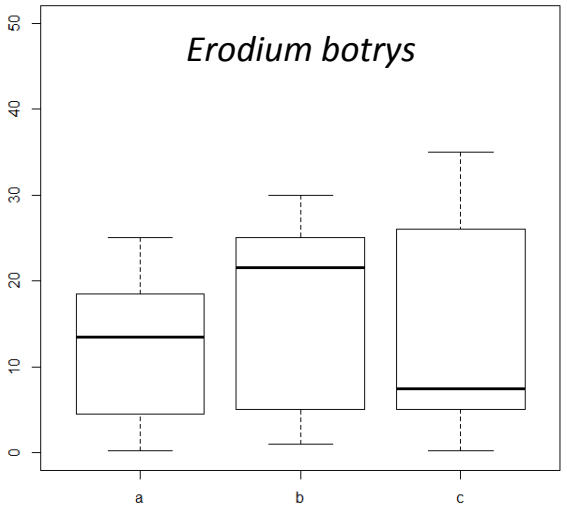
Non-Native and Litter Cover





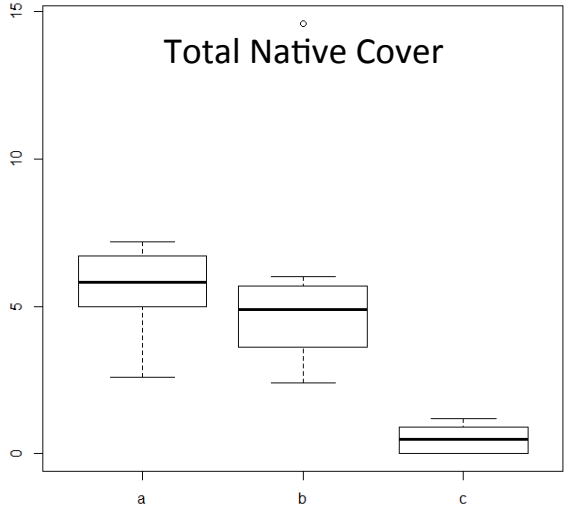


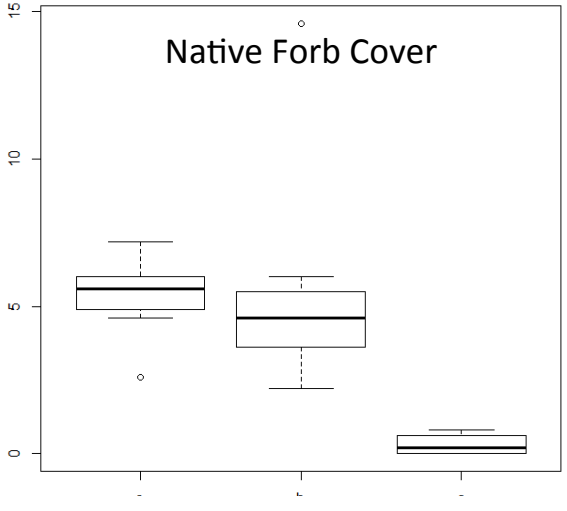


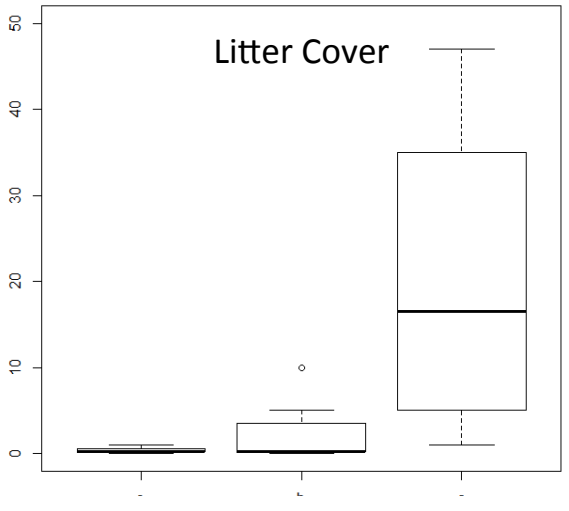


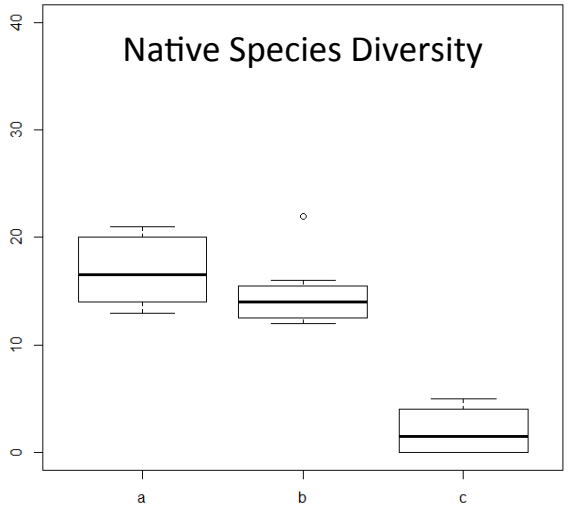
Forbland Habitat

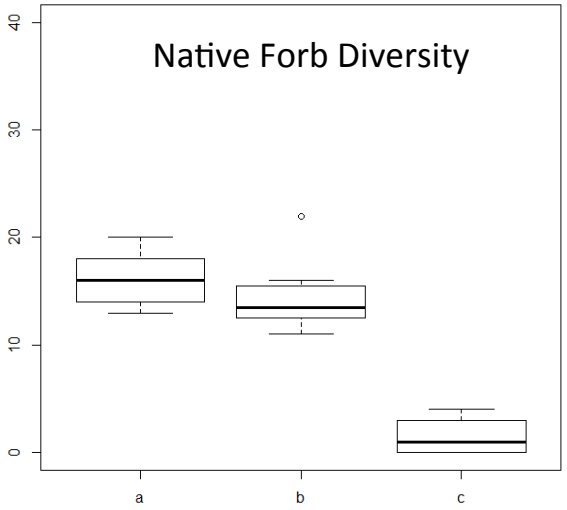
Native Cover and Diversity

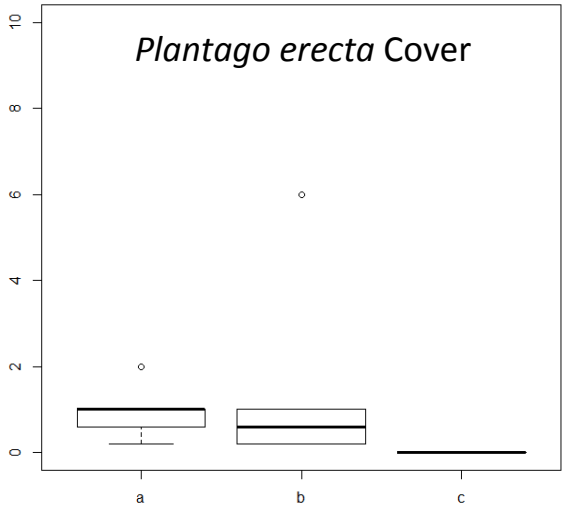








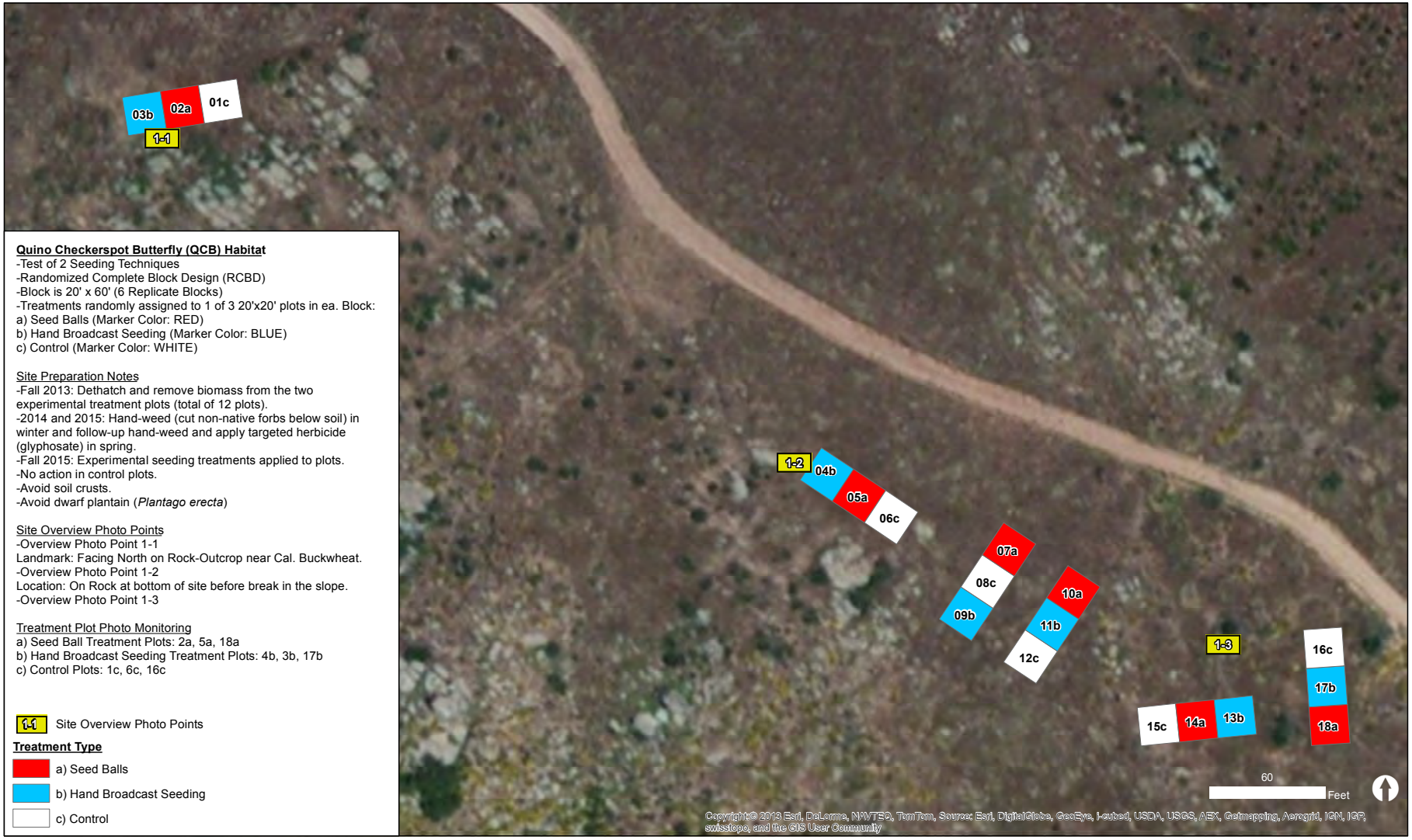




Quino Checkerspot Butterfly Habitat

Study Goals and Questions at Sites 1 and 3

- Assess two seeding techniques in establishing *Plantago erecta* and other QCB associated plant species on difficult to reach sites (e.g. ridgelines) and sites with sensitive soil crusts.
- Same site preparation with hand weeding 2x per year for 2 years
- Compare two seed techniques across two sites (n=6):
  - (**a**) seed ball
  - (**b**) hand broadcast seeding, rake in



Quino Checkerspot Butterfly (QCB) Habitat
-Test of 2 Seeding Techniques
-Randomized Complete Block Design (RCBD)
-Block is 20' x 60' (6 Replicate Blocks)
-Treatments randomly assigned to 1 of 3 20'x20' plots in ea. Block:
a) Seed Balls (Marker Color: RED)
b) Hand Broadcast Seeding (Marker Color: BLUE)
c) Control (Marker Color: WHITE)

Site Preparation Notes
-Fall 2013: Dethatch and remove biomass from the two experimental treatment plots (total of 12 plots).
-2014 and 2015: Hand-weed (cut non-native forbs below soil) in winter and follow-up hand-weed and apply targeted herbicide (glyphosate) in spring.
-Fall 2015: Experimental seeding treatments applied to plots.
-No action in control plots.
-Avoid soil crusts.
-Avoid dwarf plantain (*Plantago erecta*)

Site Overview Photo Points
-Overview Photo Point 1-1
Landmark: Facing North on Rock-Outcrop near Cal. Buckwheat.
-Overview Photo Point 1-2
Location: On Rock at bottom of site before break in the slope.
-Overview Photo Point 1-3

Treatment Plot Photo Monitoring
a) Seed Ball Treatment Plots: 2a, 5a, 18a
b) Hand Broadcast Seeding Treatment Plots: 4b, 3b, 17b
c) Control Plots: 1c, 6c, 16c

1-1 Site Overview Photo Points

Treatment Type
a) Seed Balls
b) Hand Broadcast Seeding
c) Control

Figure 6. Sycamore Canyon Quino Checkerspot Butterfly Habitat Restoration Site 1.

LAND IQ

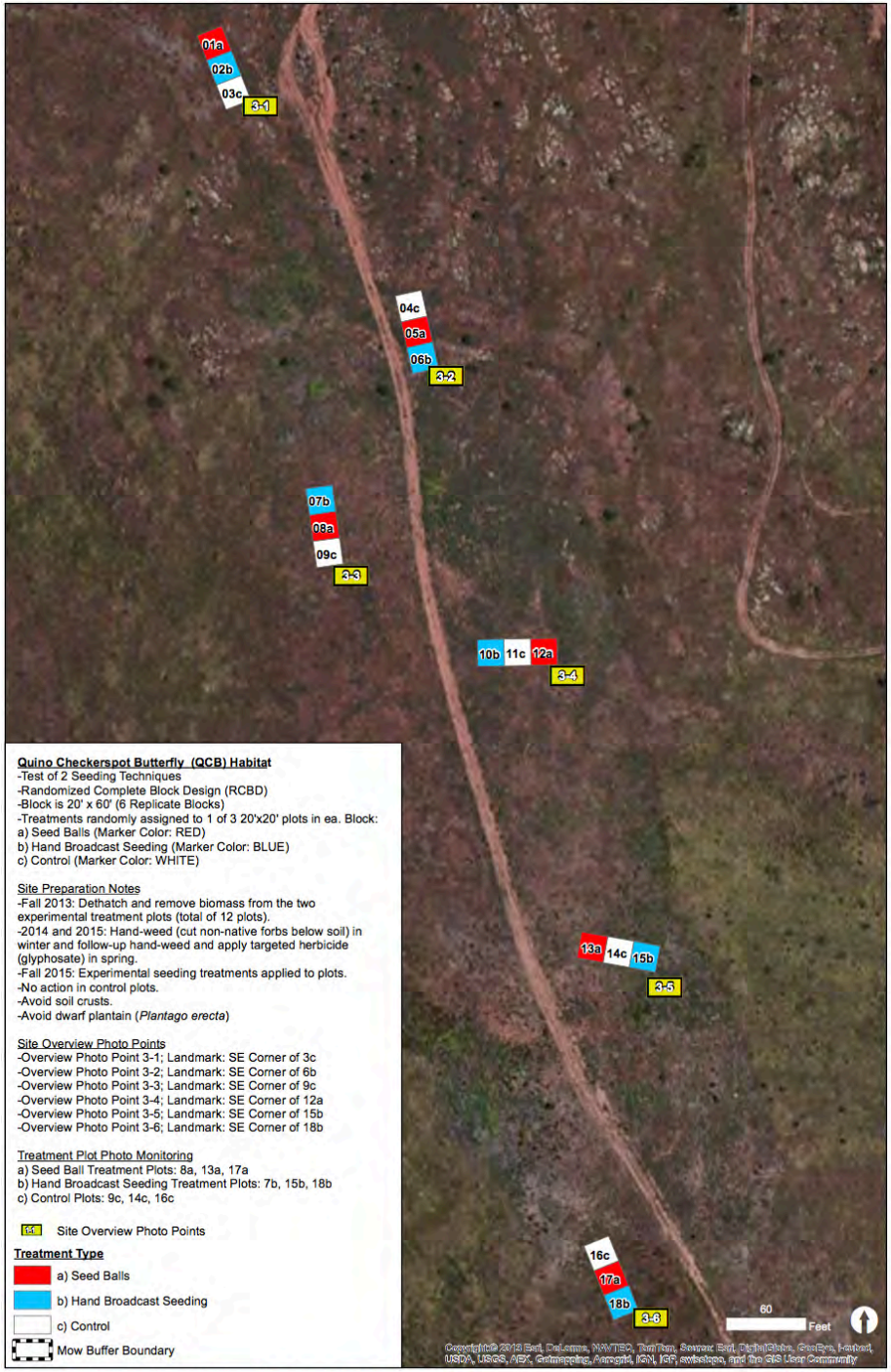


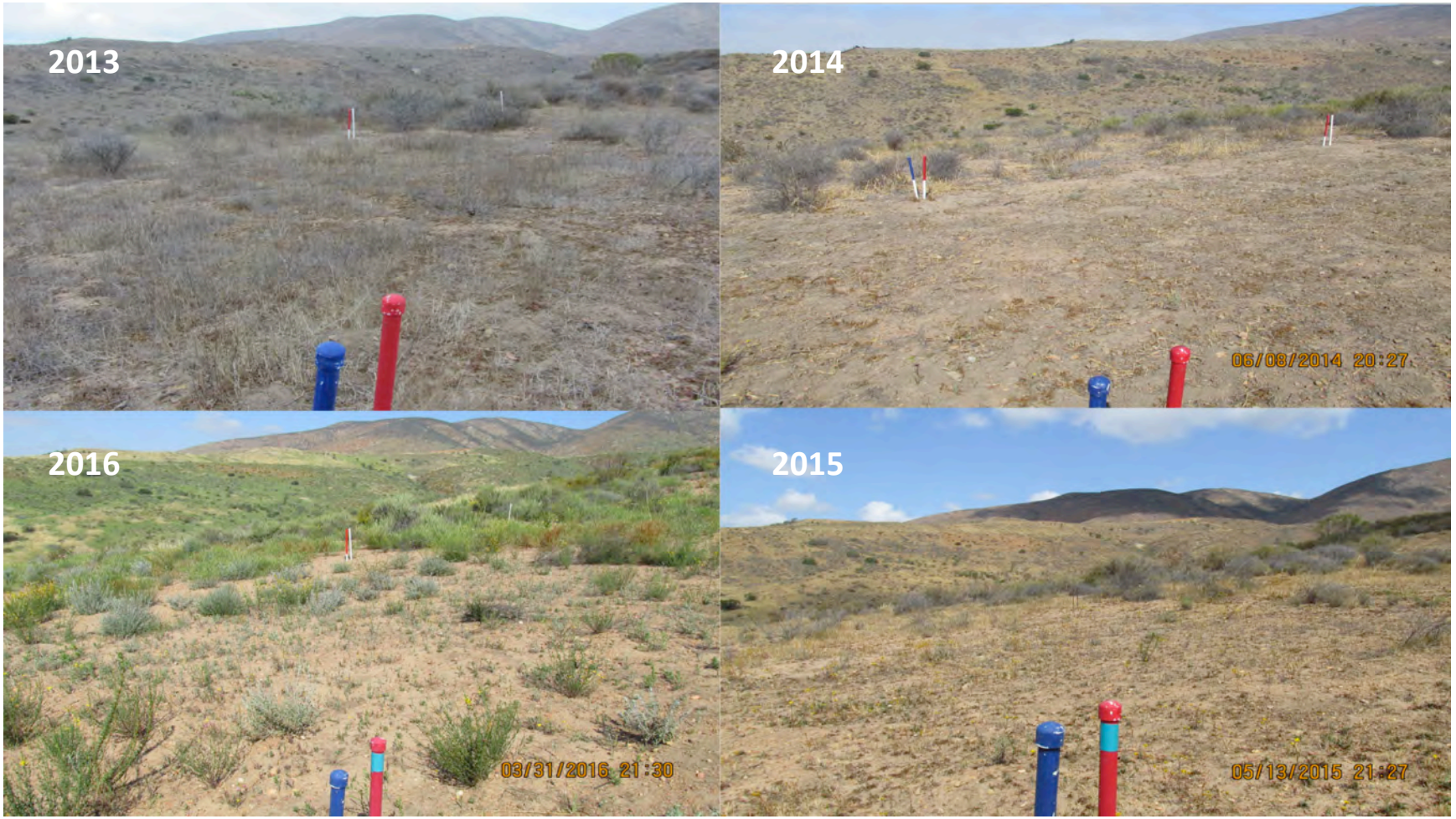
Figure 8. Proctor Valley Quino Checkerspot Butterfly Habitat Restoration Site 3.

LAND IQ

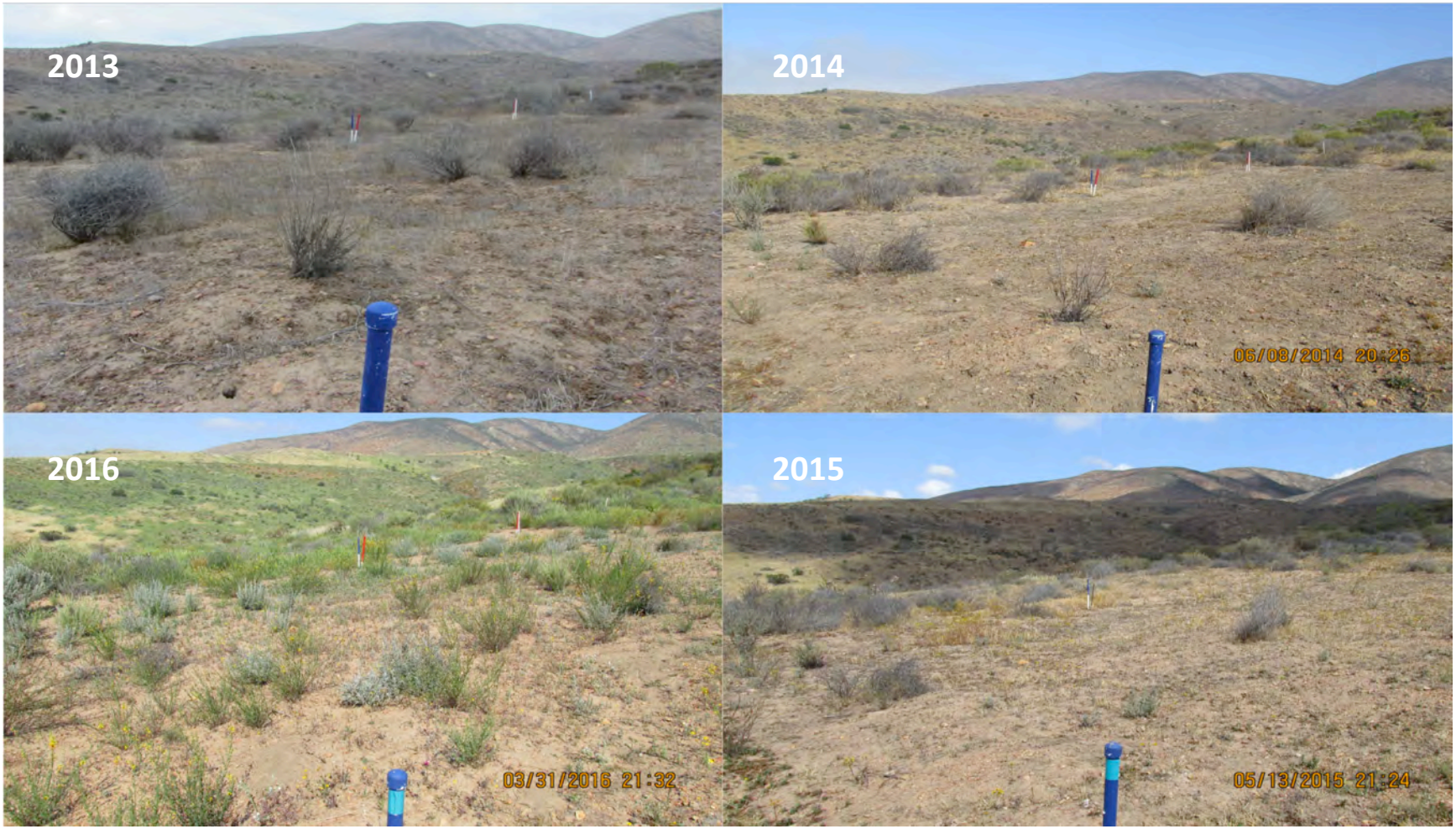
Quino Checkerspot Butterfly Habitat

Results

- Successfully established target native forb cover and maintained bare ground, which are essential habitat elements (food plants and basking) for QCB.
- Higher native cover in hand seeded (b) compared to seed balls (a)
- Rocks and bare ground are significant features of the QCB sites selected for restoration
  - More rock an average at Site 3
- More soil crusts on average in control, but not significant difference; and more soil crusts at Site 1
- Litter is not high in this habitat type, but significantly lower in the treatments compared with controls
- Non-natives: site prep and weed management was effective; significantly less than control
  - About 29% cover in controls, but non-native grass dominant at Site 3 and forbs dominant at Site 1
  - *Erodium botrys* – significant component
  - *Brachypodium distachyon* – significant at Site 3 in some plots



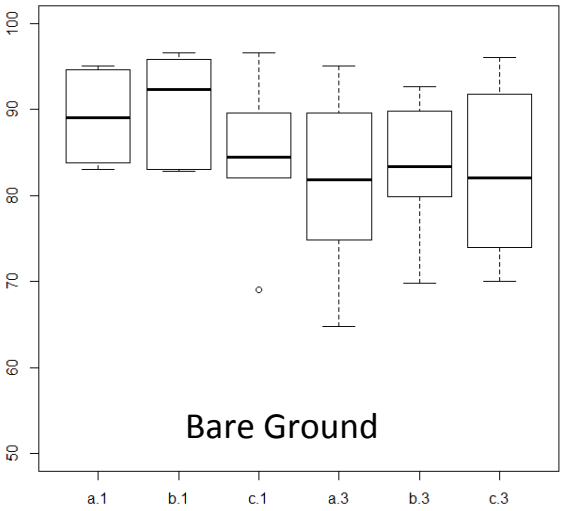
Site 3: (**a**) Seed balls

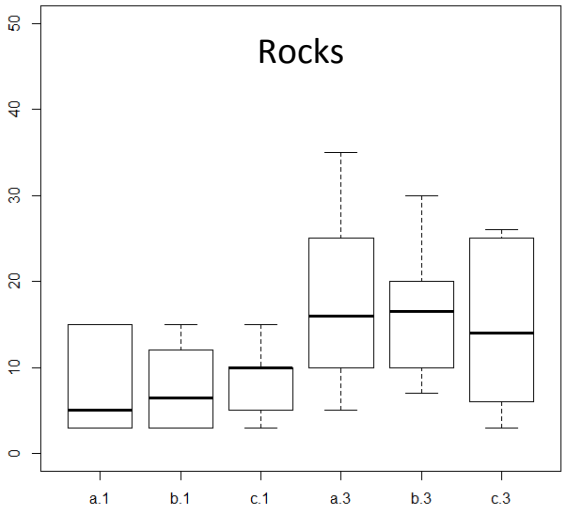


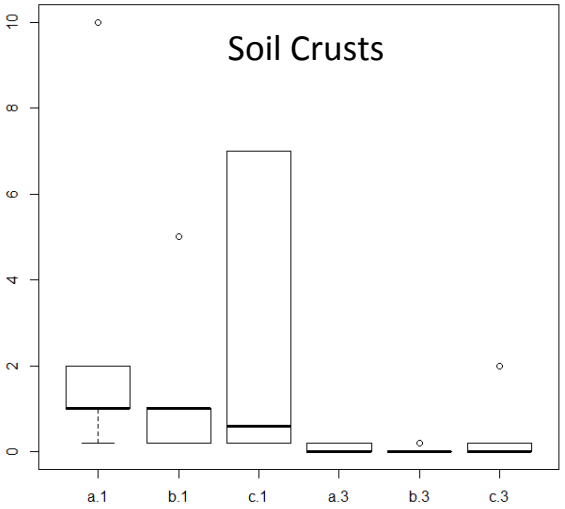
Site 3: (**b**) Hand seeding

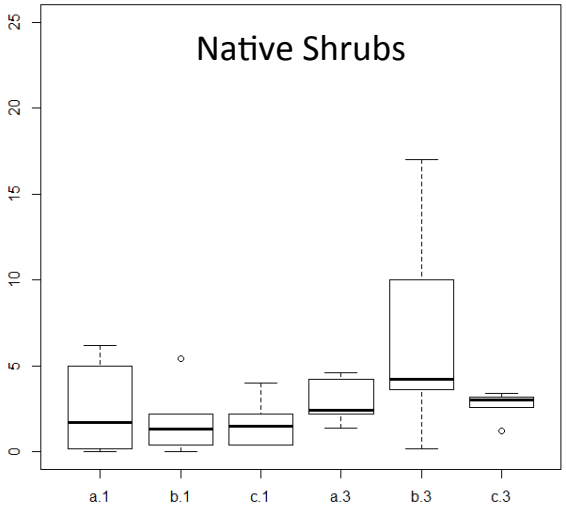
Quino Checkerspot Butterfly Habitat

Bare Ground, Rocks, Soil Crusts & Native Shrubs



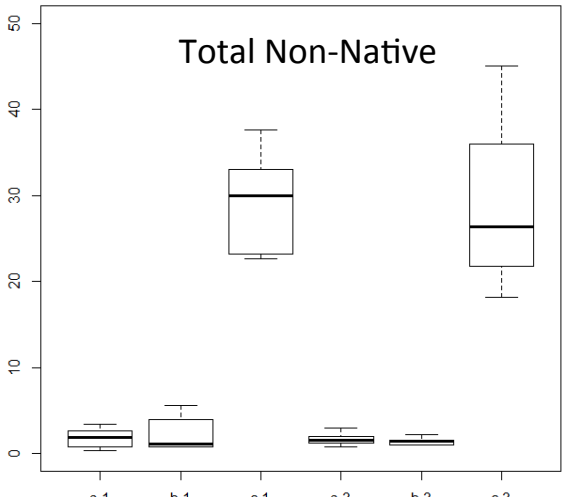


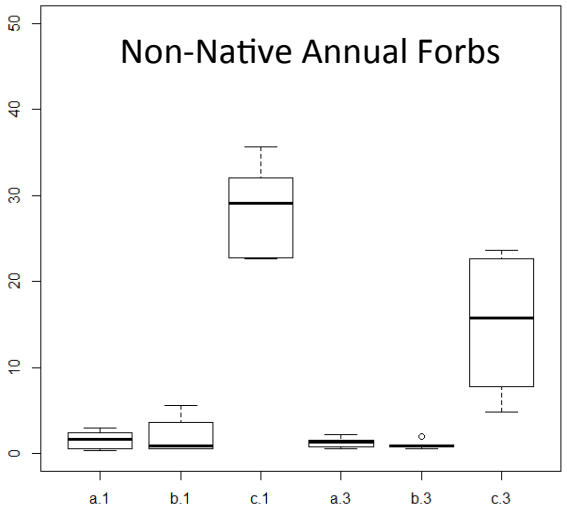


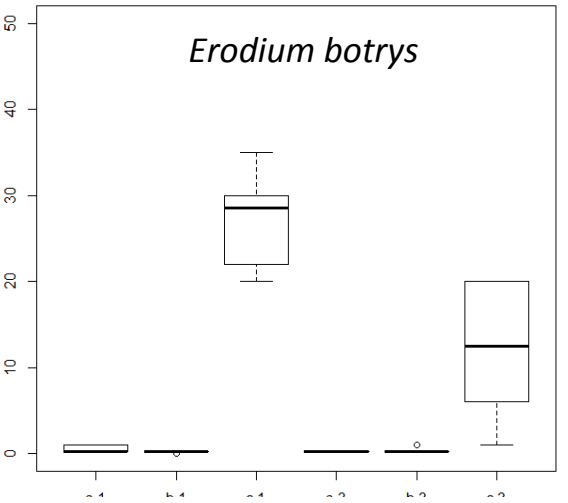


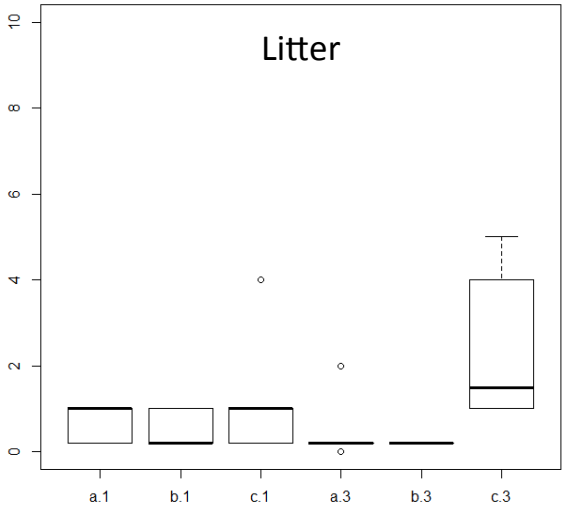
Quino Checkerspot Butterfly Habitat

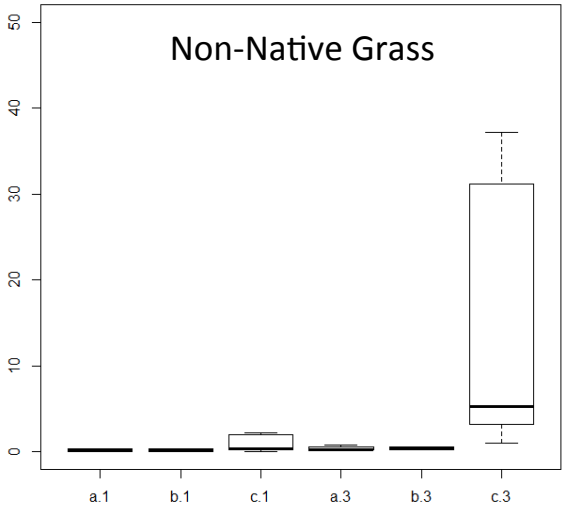
Non-Native Cover and Litter

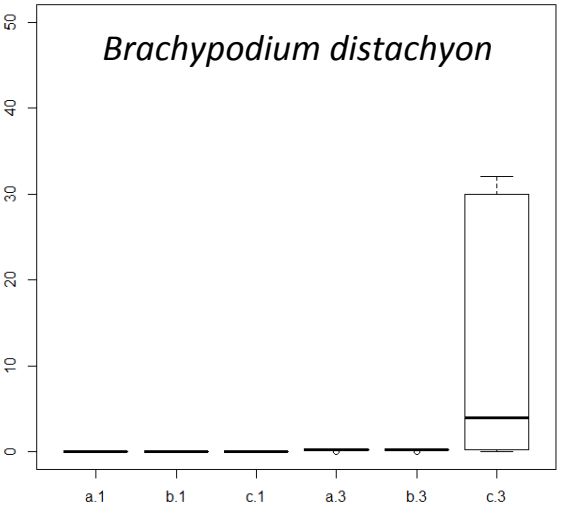






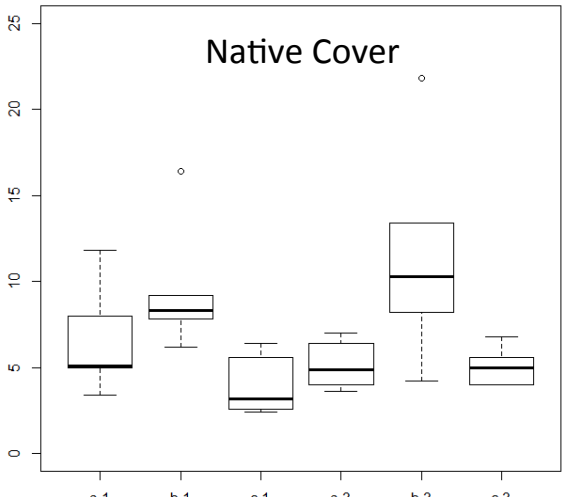


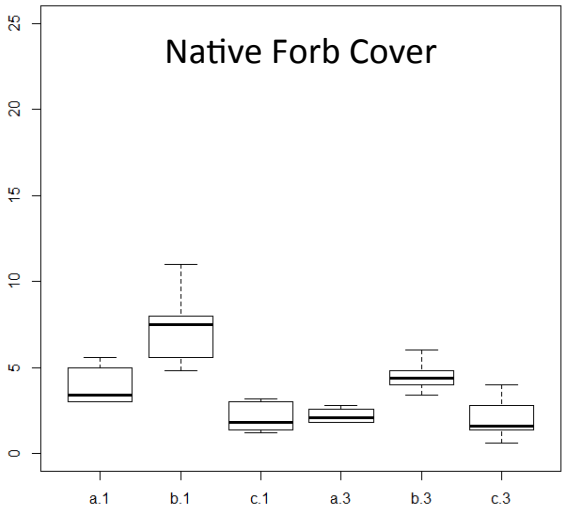


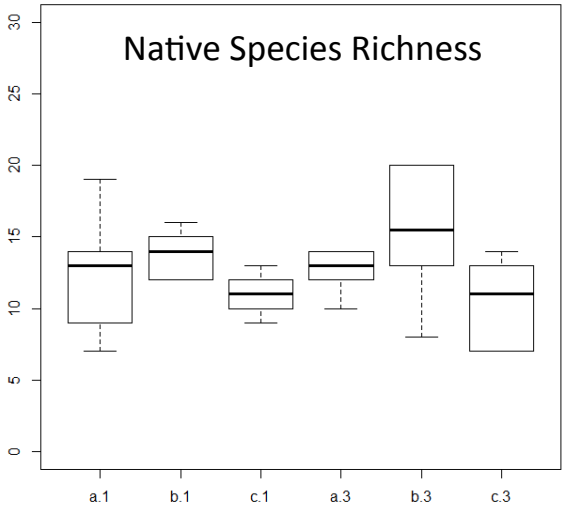


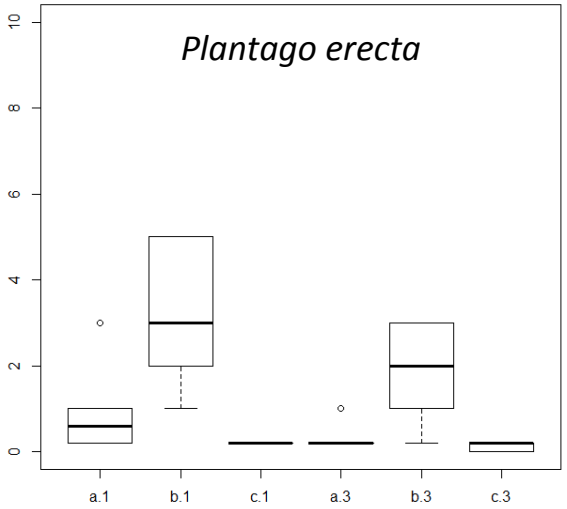
Quino Checkerspot Butterfly Habitat

Native Cover and Diversity









Quino Checkerspot Butterfly Habitat

Seed Ball vs. Hand Seed Cover

Quino Checkerspot Butterfly Habitat

Seed Ball vs. Hand Seed Cover

Example of *Plantago erecta* germination of QCB seed mix from seed ball
(Patricia Gordon-Reedy – CBI, Mar 2016).

Example of *Plantago erecta* and *Lasthenia californica* germination from QCB seed mix by hand seeding
(Patricia Gordon-Reedy – CBI, Mar 2016).