

# SEEDS, SPACE AND TIME: ASSESSING PLANT COMMUNITY DISPERSAL DYNAMICS IN THE SOUTH BAY SALT POND RESTORATION PROJECT

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# Wetland Loss in SF Bay

SF Bay Circa 1800



SF Bay Circa 2000



90% of the Bay's historic wetlands lost  
~45,000 acres remain, ~32,000 un-restored in public ownership  
100,000 acre goal



# Why Restore?

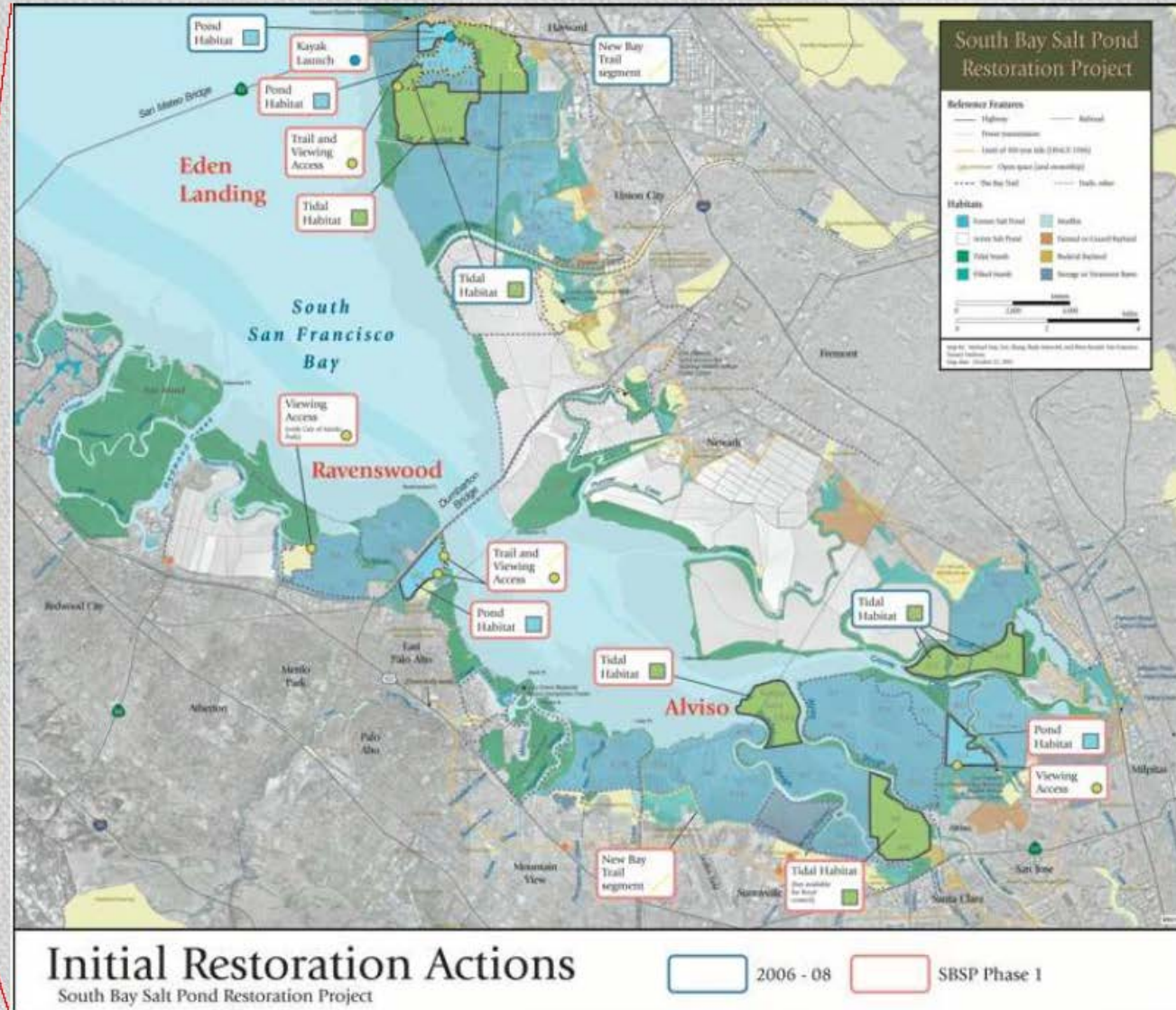
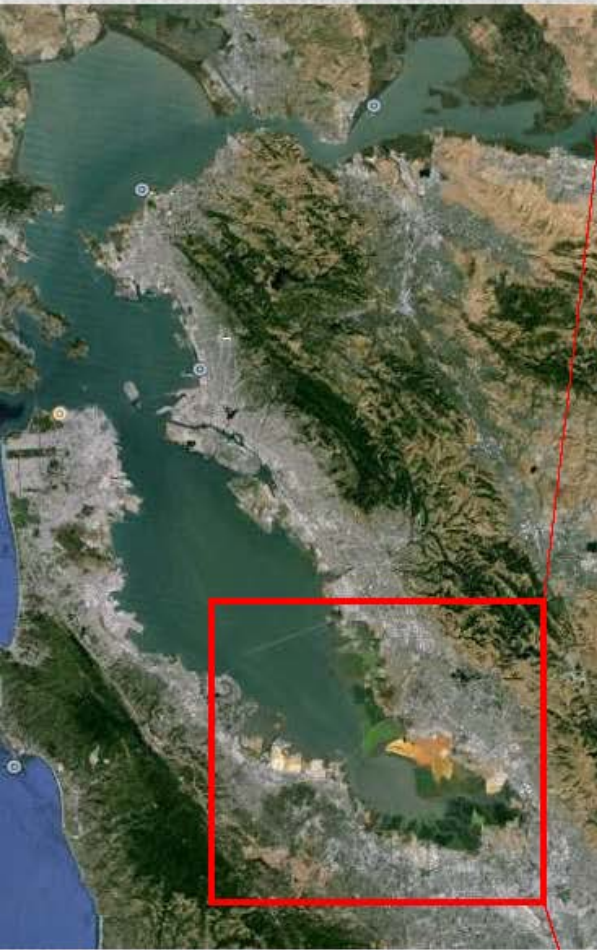


- 500 migratory and resident species, 100 threatened or endangered
- Flood and storm surge protection
- Pollutant filtering
- Public access
- Jobs: 30 jobs created for each 1 million spent on restoration





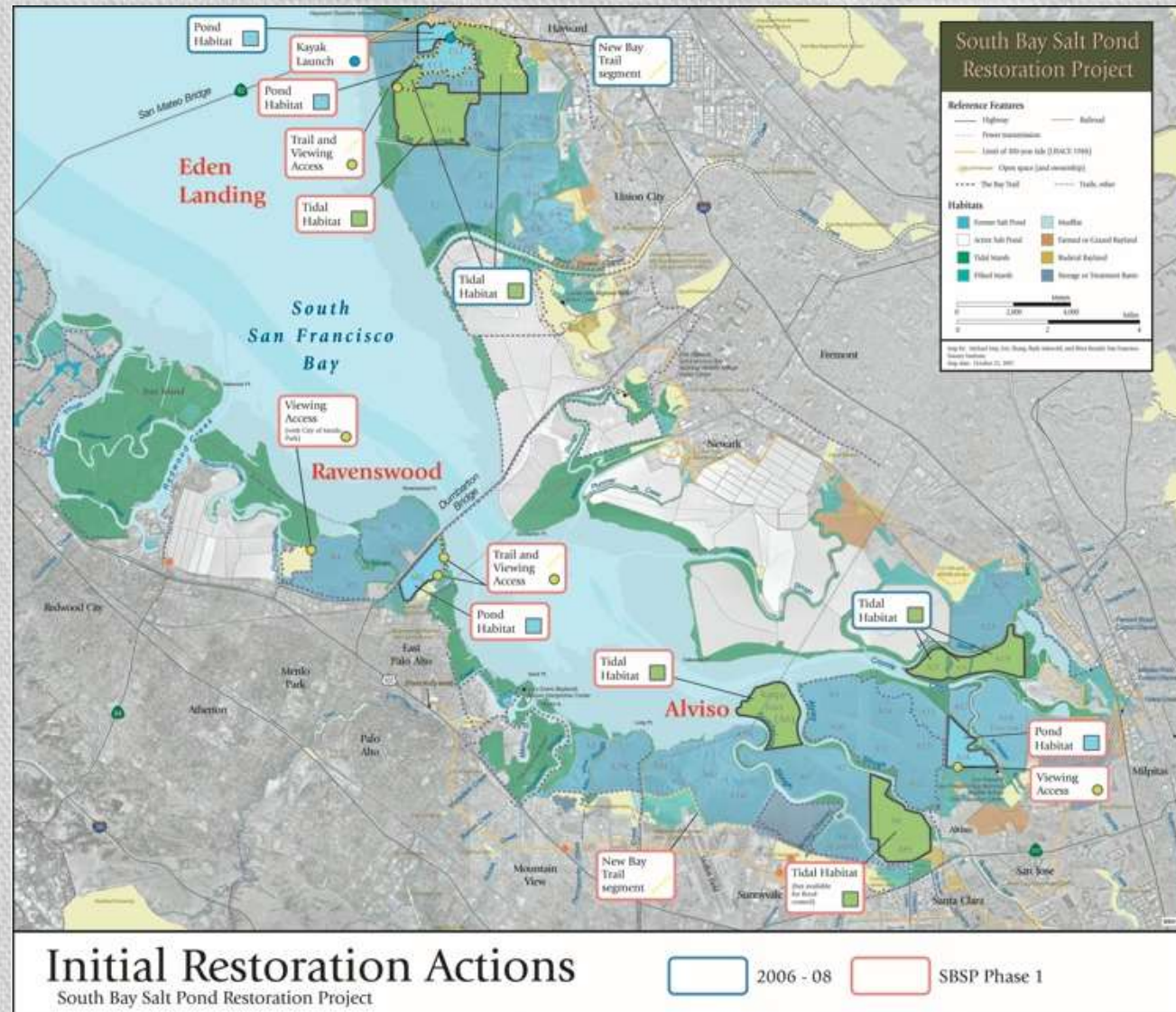
# South Bay Salt Pond Restoration Project





# South Bay Salt Pond Restoration Project

- ~15,000 acres
- Managed and tidal habitats
- Multiple agency management overseen by SBSPRP

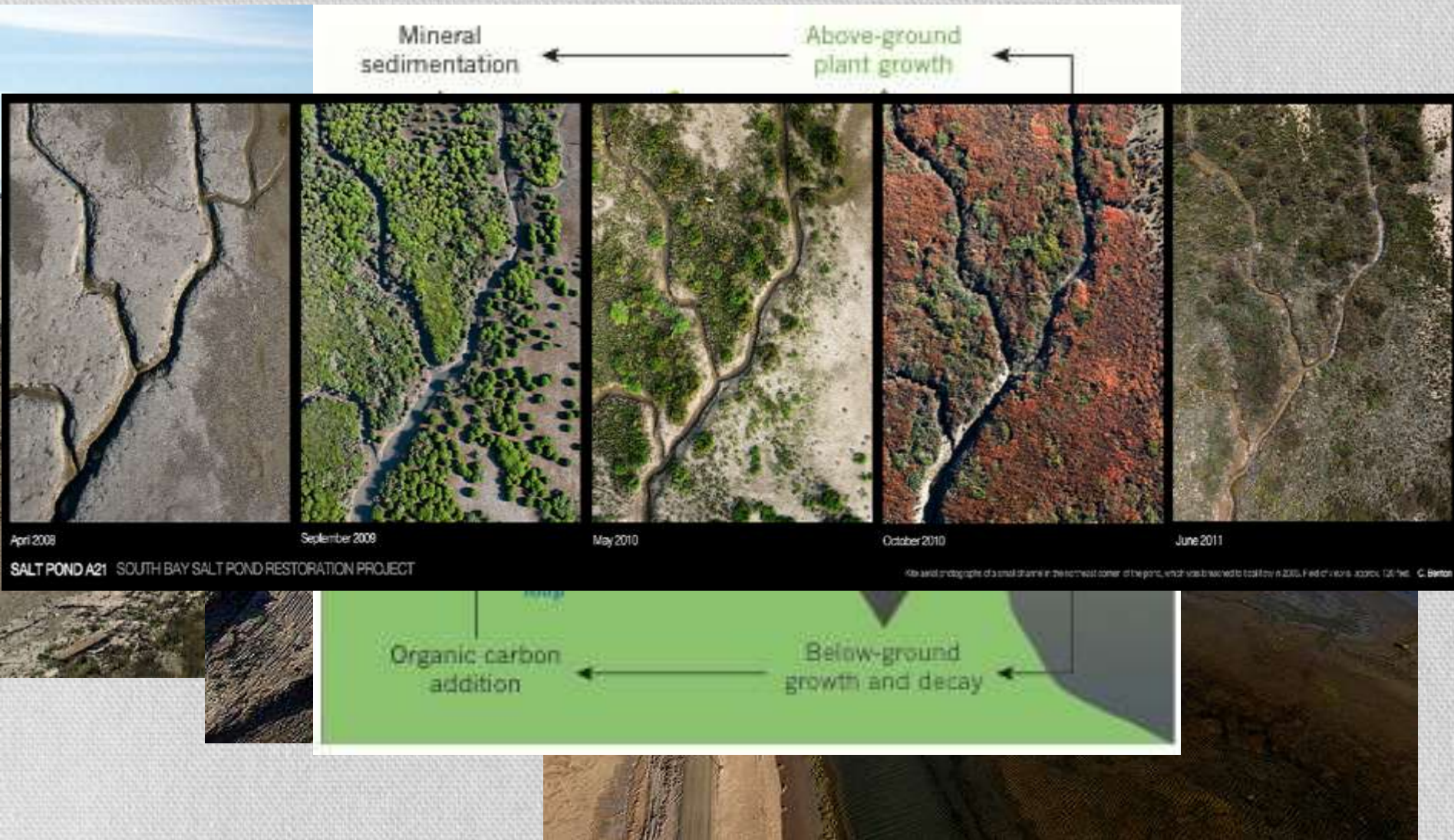








# Restoration Process: Eco-geomorphic Interactions, Passive Dispersal





# Ecological filters influencing ecological restoration



Restoration Site  
(1-2 Species)



Reference Site  
(8-9 Species)



# Ecological filters influencing ecological restoration



Restoration Site  
(1-2 Species)



Dispersal



Establishment



Persistence



Reference Site  
(8-9 Species)





# Ecological filters influencing ecological restoration



Restoration Site  
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Persistence



Reference Site  
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# Previous work

## **Allison 1996**

- Clonal re-establishment most common

## **Morzaria-Luna and Zedler 2007**

- Low seed density in restoration projects

## **Diggory and Parker 2011**

- Petaluma River
- Abundant seeds
- Low diversity

## **Callaway et al. 2009**

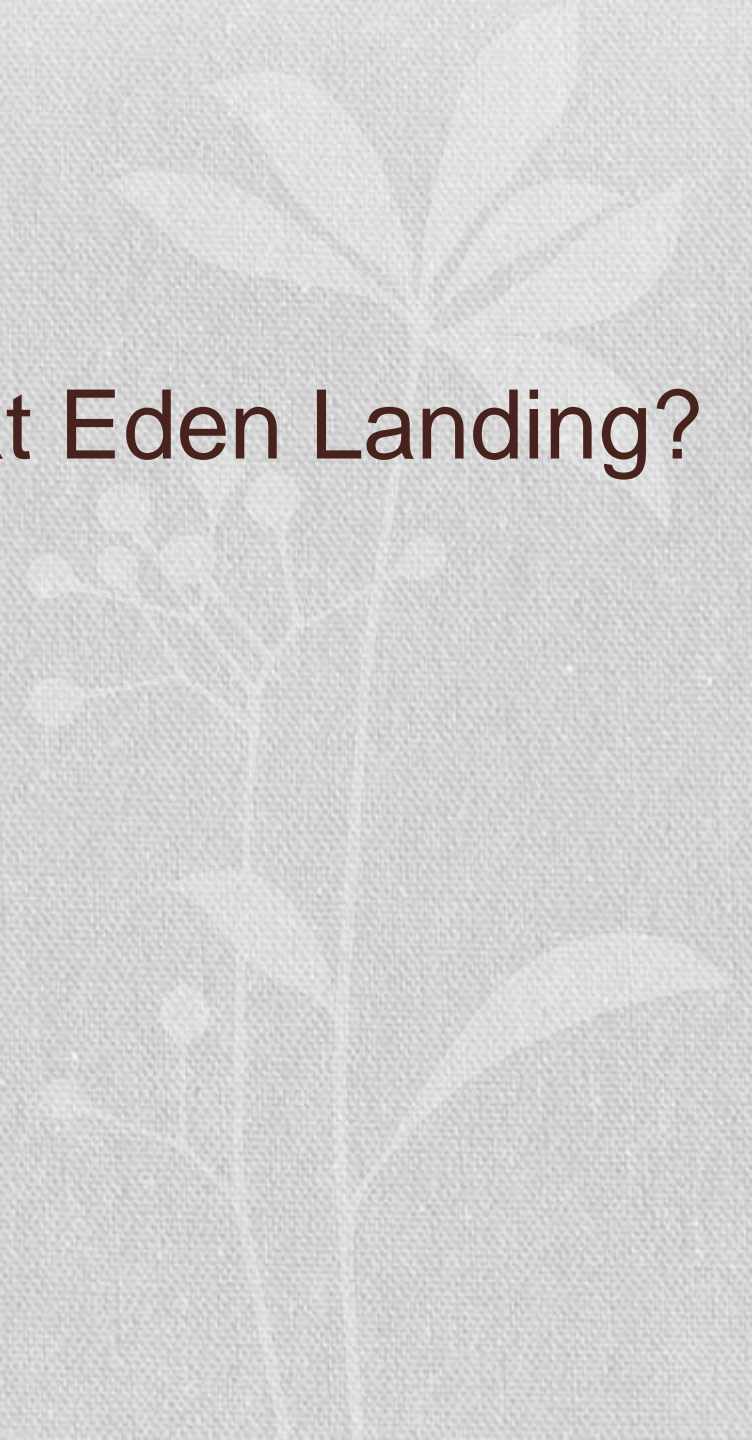
- Alviso Ponds
- Prevalence of unoccupied suitable sites





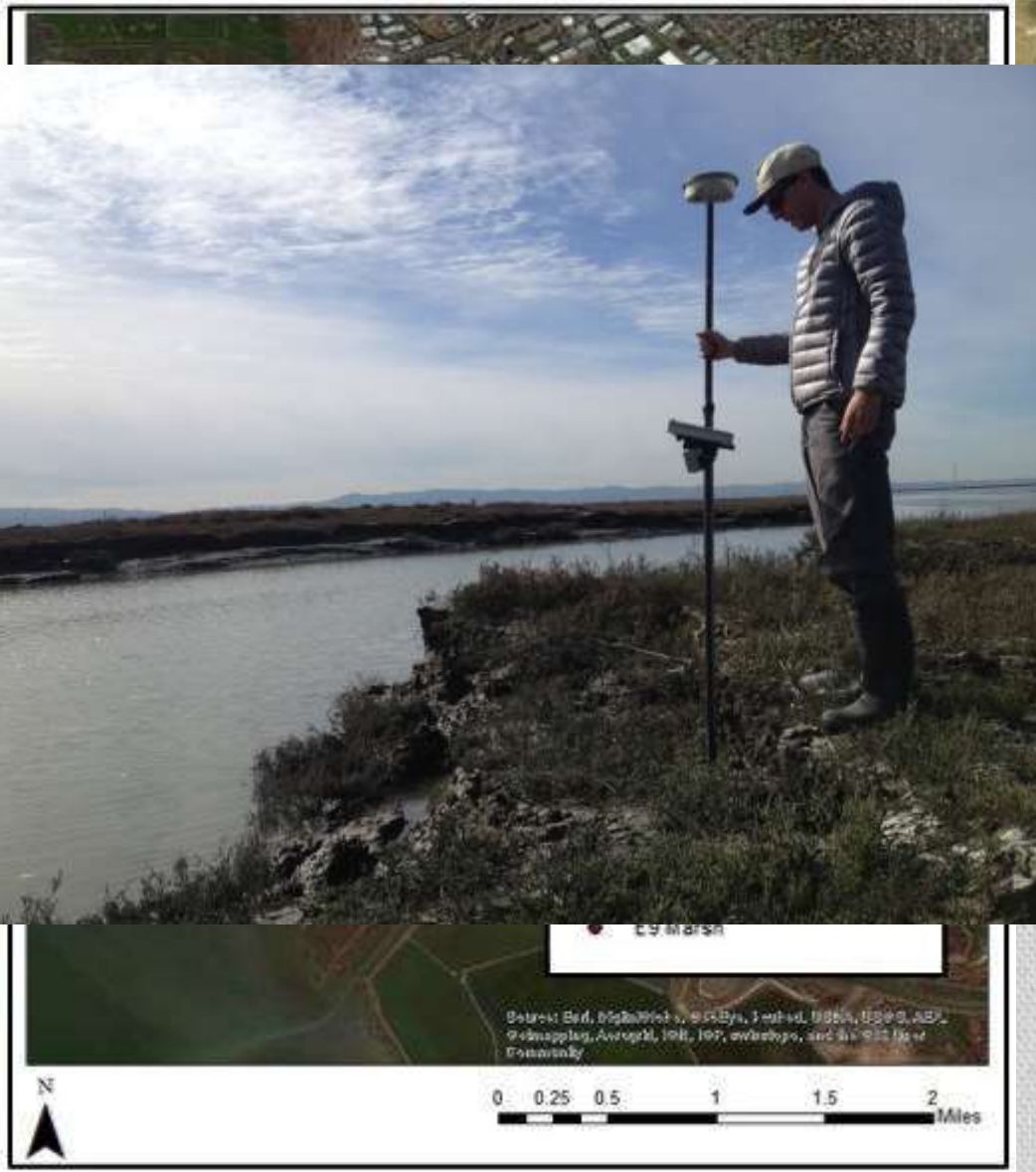
# How are seeds moving at Eden Landing?

- Landscape scale
- Local scale





# Methods



- 6 sites
  - 3 reference
  - 3 restored
- 5x3 sampling grid
- 30m spacing between each point
- ~2cm accuracy elevation and location with RTK



# Methods

- Collect seed bank (3 6cmx8cm cores)
- Collect dispersing seeds in mats
  - Deployed from September 2013-February 2014
  - After Diggory and Parker 2011
- Sample percent vegetation cover at 2x3 m





# Methods



- Samples cold-stratified at 4° C for 6 weeks
- Watered with fresh water
- Removed 3 weeks after final emergence





## **Question 1:**

**Are restoration sites seed limited?**

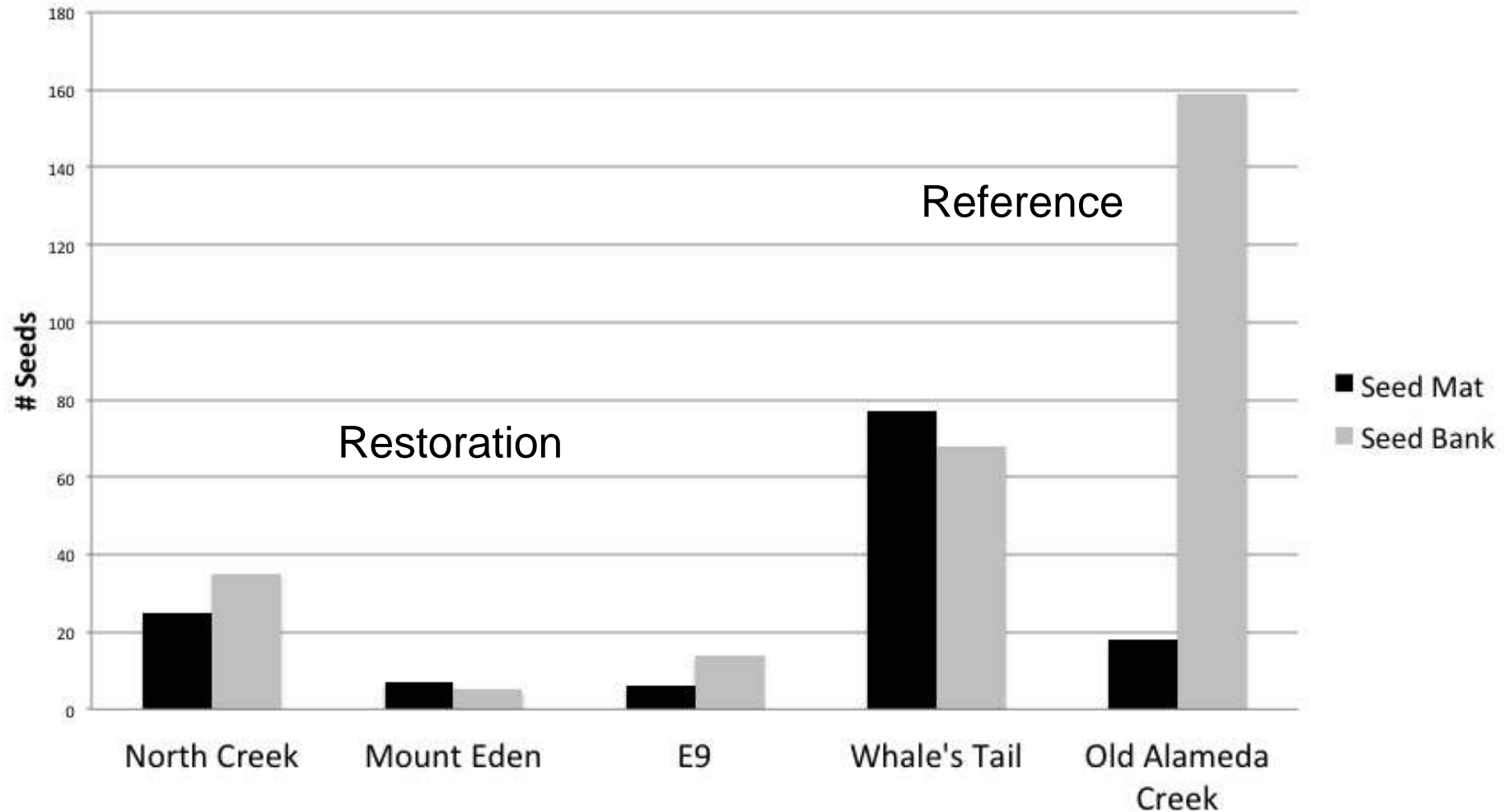
H1: Restoration sites contain fewer seeds  
than reference sites







# Seed Density Over Sites



**H1: Restoration sites contain significantly fewer seeds compared to reference**  
Seed counts are higher in both seed mats and seed banks ( $p=0.02$ ) from reference sites



## **Question 2:**

**Does distance between points influence seed composition?**

H2: Seed composition will change with distance





## Bray-Curtis dissimilarity

$$BC_{ij} = \frac{2C_{ij}}{S_i + S_j}$$

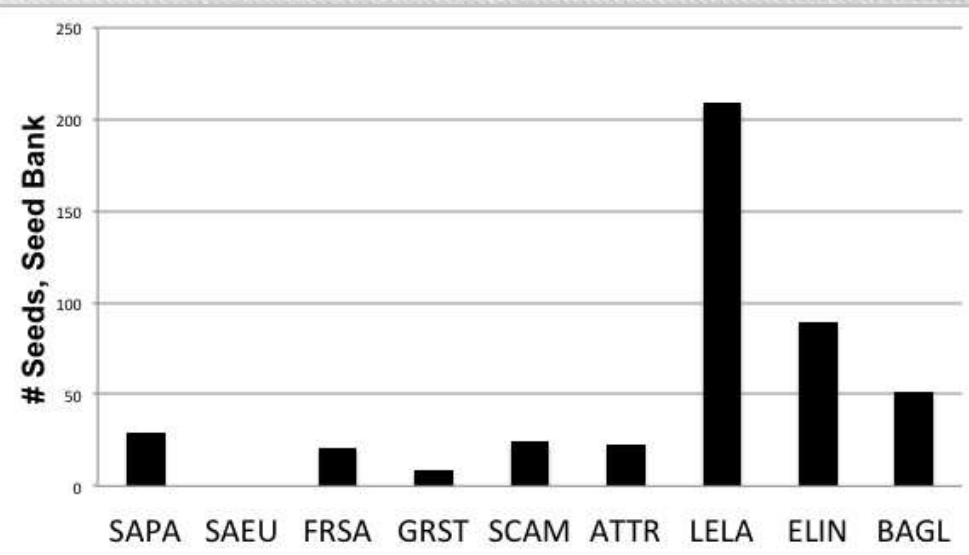
$C(ij)$  = sum of the lesser value for species present at both sites

$S(i)$  &  $S(j)$  = species found at each site

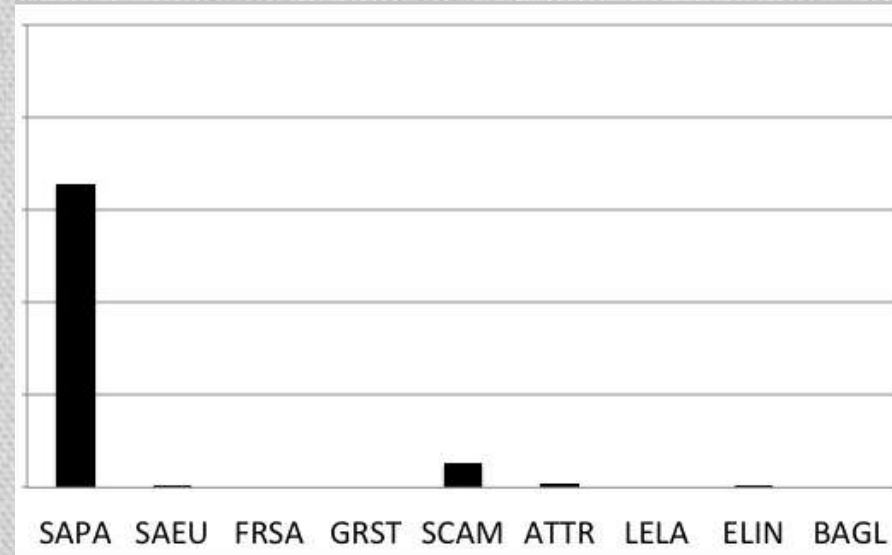


# Seed Density Over Sites: Old Alameda Creek

## Seed Density, Brackish



## Seed Density, Saline



~1 km



**H2: Seed composition will change with distance**

Mantel permutation test confirms H2 ( $p=0.0002$ , Mantel Statistic=0.4)



## Question 3:

Is seed density correlated with vegetation density?

H3: Seeds are more abundant in vegetated plots

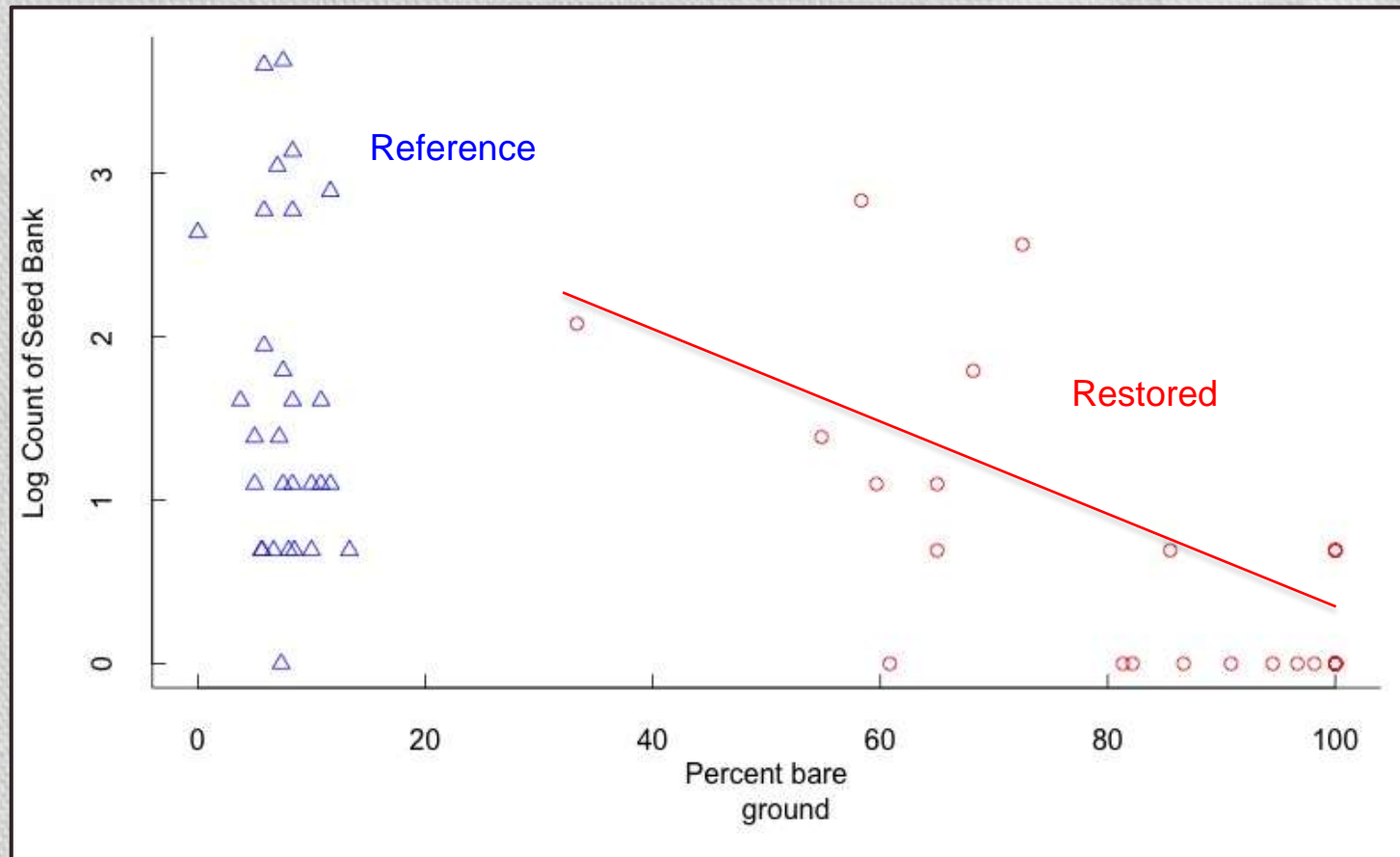
H3a: Vegetation density is correlated with increased elevation



# Is seed density correlated with vegetation density?







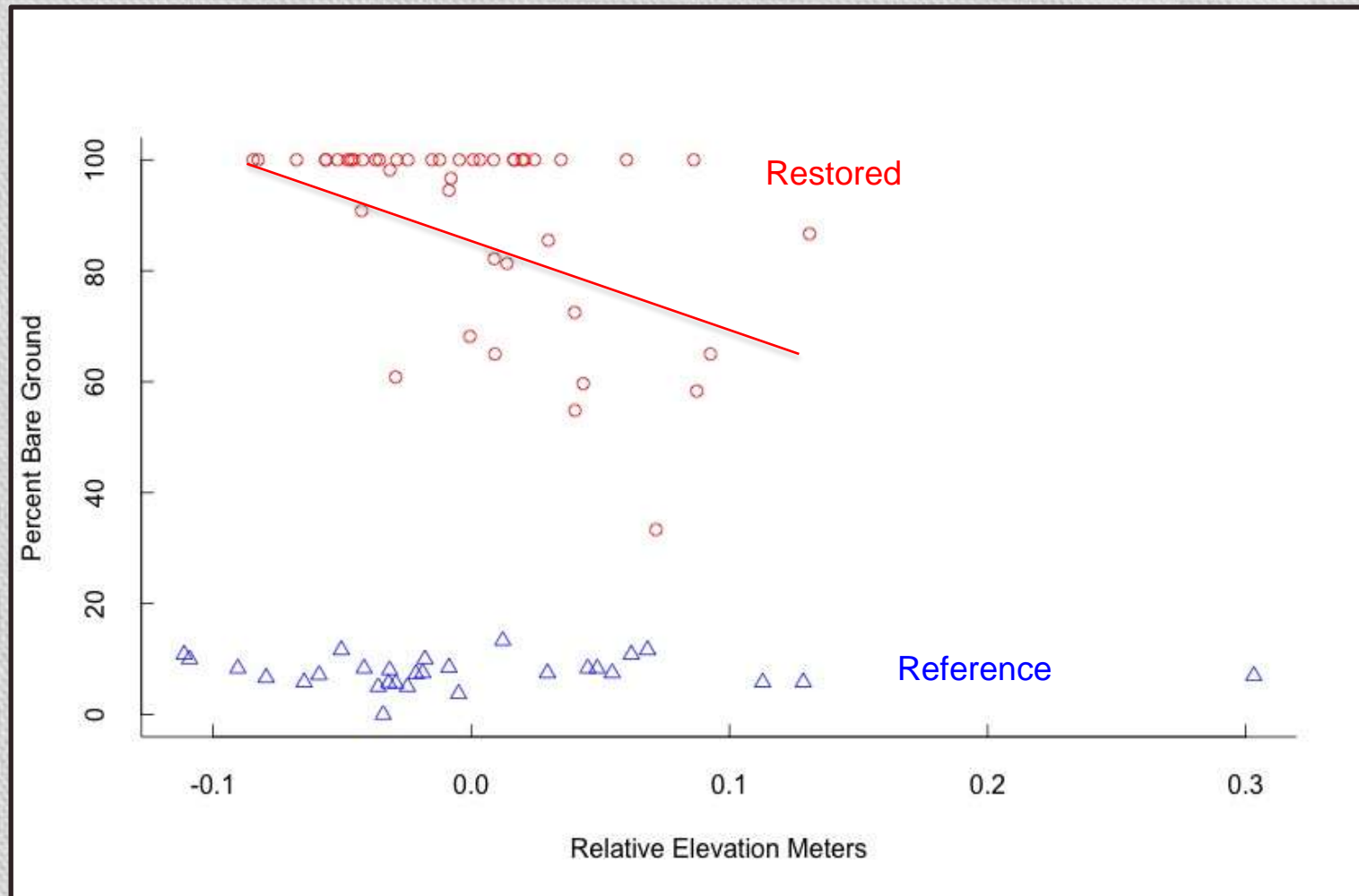
### H3: Seeds will be more abundant in vegetated plots

Seed bank and seed mat density correlated with vegetation density at restoration sites ( $p < 0.0001$ )

**Not at reference sites ( $p>0.05$ )**



# Bare Ground Over Elevation



## H3a: Vegetation density is correlated with increased elevation

Vegetation density correlated with increased elevation at restoration sites  
( $p=0.01$ )

Not at reference sites ( $p>0.5$ )



# Is seed density correlated with vegetation density?





# Implications for management

## **H1: Restoration sites contain significantly fewer seeds than reference sites**

-Augmentation of seeds or direct planting may assist development

## **H2: Seed composition changes with distance**

-More isolated restoration sites should be prioritized for active management of plant communities

## **H3: Seeds are more abundant in vegetated plots, vegetation density is correlated with increased elevation**

-Marsh mounds in developing projects may increase rate of early vegetation development

-Priority effects of pickleweed may delay the expansion of sub-dominants

-Direct planting of sub-dominants



# Ecological filters influencing ecological restoration



Restoration  
Site (1-2  
Species)



Dispersal:  
Landscape  
and local  
effects



Establishment:  
Freshwater  
flushing,  
topographic  
heterogeneity



Persistence:  
Priority  
effects of  
*Salicornia*



Reference Site  
(8-9 Species)



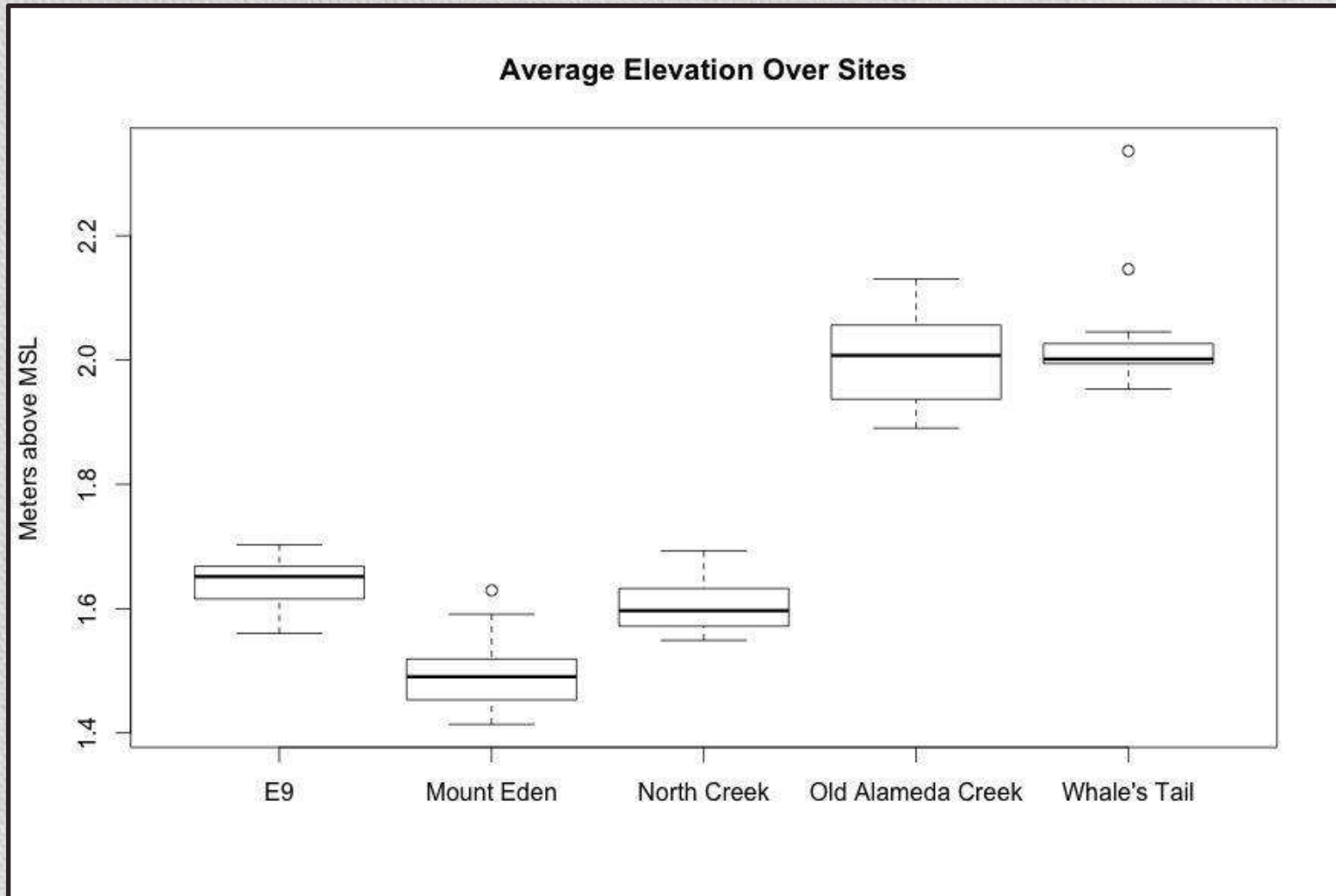


# Acknowledgements

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- Field assistance: Liana Nichols, Martin Alexander, Gordon Gross, Jack States, Nissa Sprinkle, Isobel Marcus, Carrie Levine
- Support: NSF Graduate Research Fellowship



# Question 3: Results



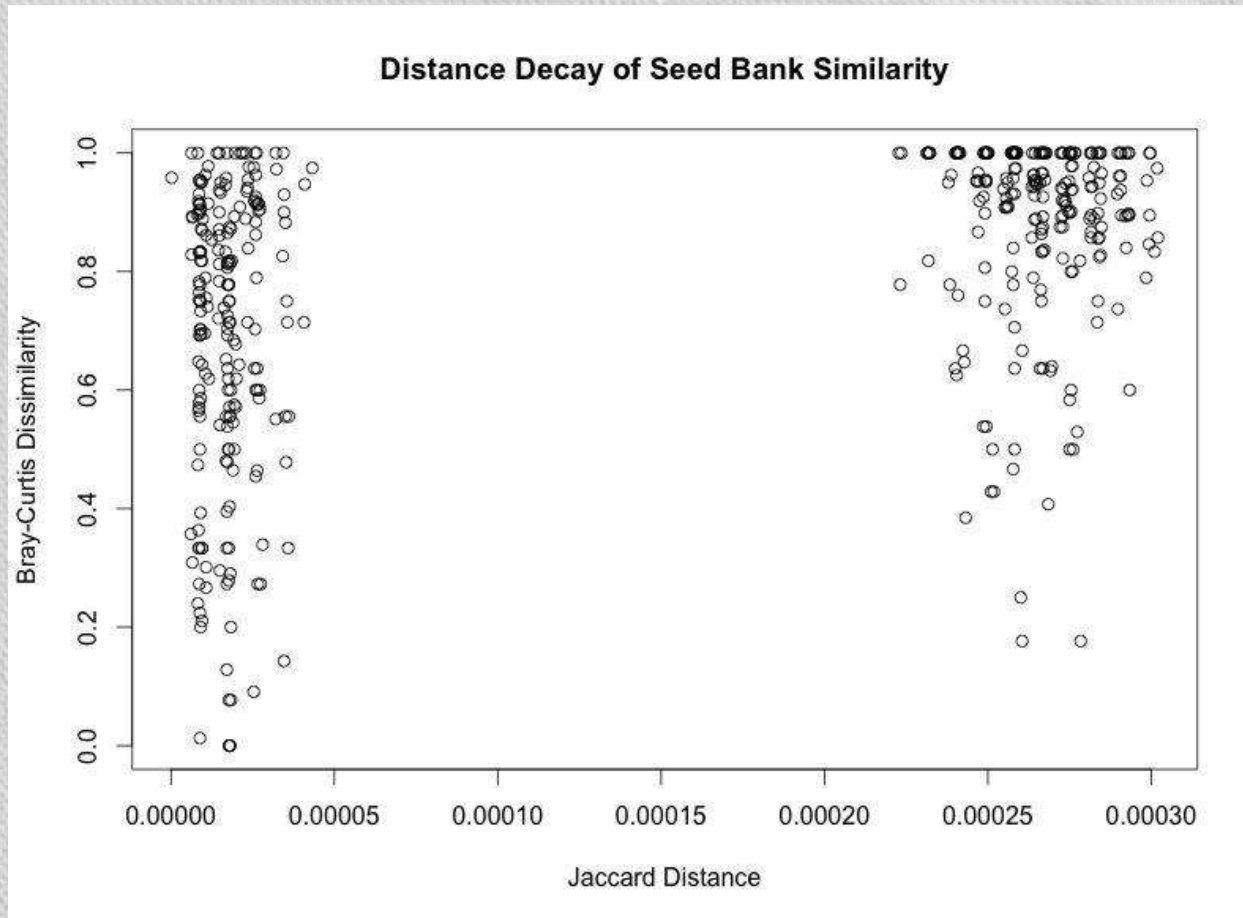
## Prediction 3a Supported

Vegetation density correlated with elevation at restoration sites ( $p < 0.001$ )

Not at reference sites ( $p = 0.5$ )



# Question 1: Results



Mantel tests confirm that both vegetation and seeds decay with distance ( $p < 0.0002$ )