

# Using population genomics to uncover the rapid colonization of Sahara mustard (*Brassica tournefortii*) in the United States

Daniel E. Winkler<sup>1</sup>, Kenneth J. Chapin<sup>2</sup>, David Garmon<sup>3</sup>, Travis E. Huxman<sup>1</sup>

<sup>1</sup>Department of Ecology & Evolutionary Biology, University of California, Irvine

<sup>2</sup> Department of Ecology & Evolutionary Biology, University of California, Los Angeles

<sup>3</sup>Tubb Canyon Desert Conservancy



# Overview

## Introduction

Why study invasion routes?

Theoretical and applied needs

Sahara mustard and its impacts

## Objectives

1. Population structure in U.S.

2. Invasion patterns and pathways

## Current & Next steps



# Why study invasion routes?

- *Invasion routes: the geographical pathways followed by propagules from their source to the invading populations (Estoup and Gillimaud 2010)*
- Approximately 50,000 invasive species in United States. Environmental damage \$120 billion per year (Pimentel et al. 2005)
- Globally, as many as 80% of the endangered species are threatened due to pressures of invasives (Armstrong 1995)



# Theoretical needs

- Fundamental questions in biology related to evolutionary selection
- Basic research in population biology
- Natural dispersal events and range expansions of noninvasive species



# Applied needs

- Reconstructed invasion routes valuable for land managers
  - designing control programs that effectively reduce spread of invasives (Mack et al. 2000)
  - land managers can monitor geographic areas at high invasion risk to curtail invasive spread (Estoup and Guillemaud 2010)





# Sahara mustard (*Brassica tournefortii*) and its impacts

- Capable of self-fertilization
- >10,000 seeds per plant possible
- Broad germination requirements (Bangle et al. 2008)
- Drought tolerant (Pratap and Gupta 2009)
- Promotes fires in deserts (Steers 2008)
- Negatively impacts native plants (Barrows et al. 2009)

















# Sahara mustard (*Brassica tournefortii*) and its impacts

- First collected in North America  
February 1927
- Presumed to disperse via roadways  
(Sanders and Minnich 2000)
- Present distribution: CA, AZ, NV, UT,  
NM, TX





**Year: 1927**









# Research objectives

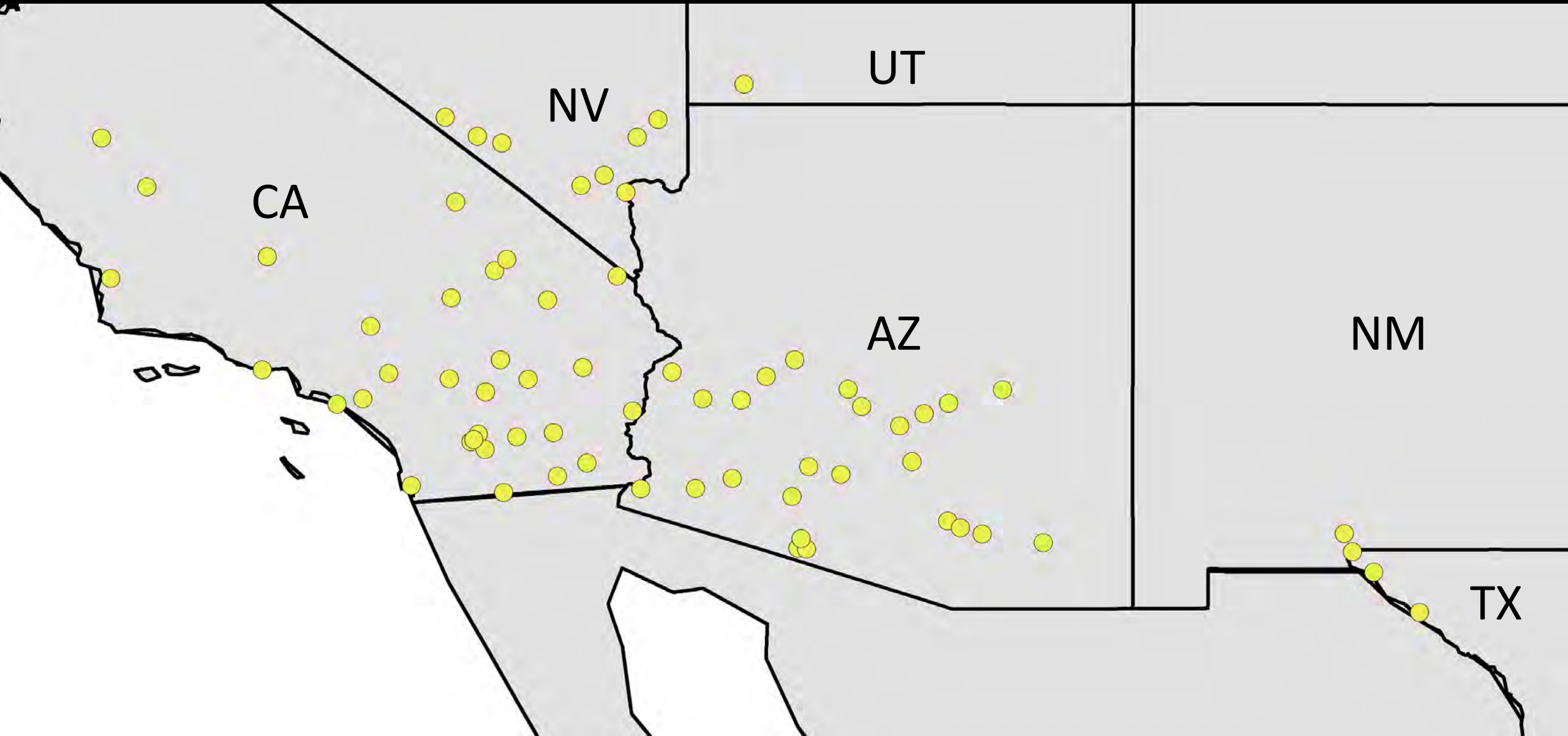
1. Identify level of genetic diversity in U.S.
2. Determine genetic structure of North American population(s)
3. Test models of isolation and association to understand diversity
  - Geographic distance
  - Distance along roadways
  - relatedness





# Methods

2,061 individuals from 70 unique localities









# Methods

- Genotyping-by-Sequencing (nextRAD)
- Sequenced 950 individuals
- 15,000 loci per individual
- 1084 SNPs identified

Population structure: Structure, Structure Harvester, and Distruct  
10,000 burnin, 100,000 MCMC runs,  
10 iterations, K=1–20

Genetic diversity: adegenet, poppr, fields R packages  
 $H_{obs} - H_{exp}$  IBD,  
Normalized Index of Association,  
Minimum spanning networks

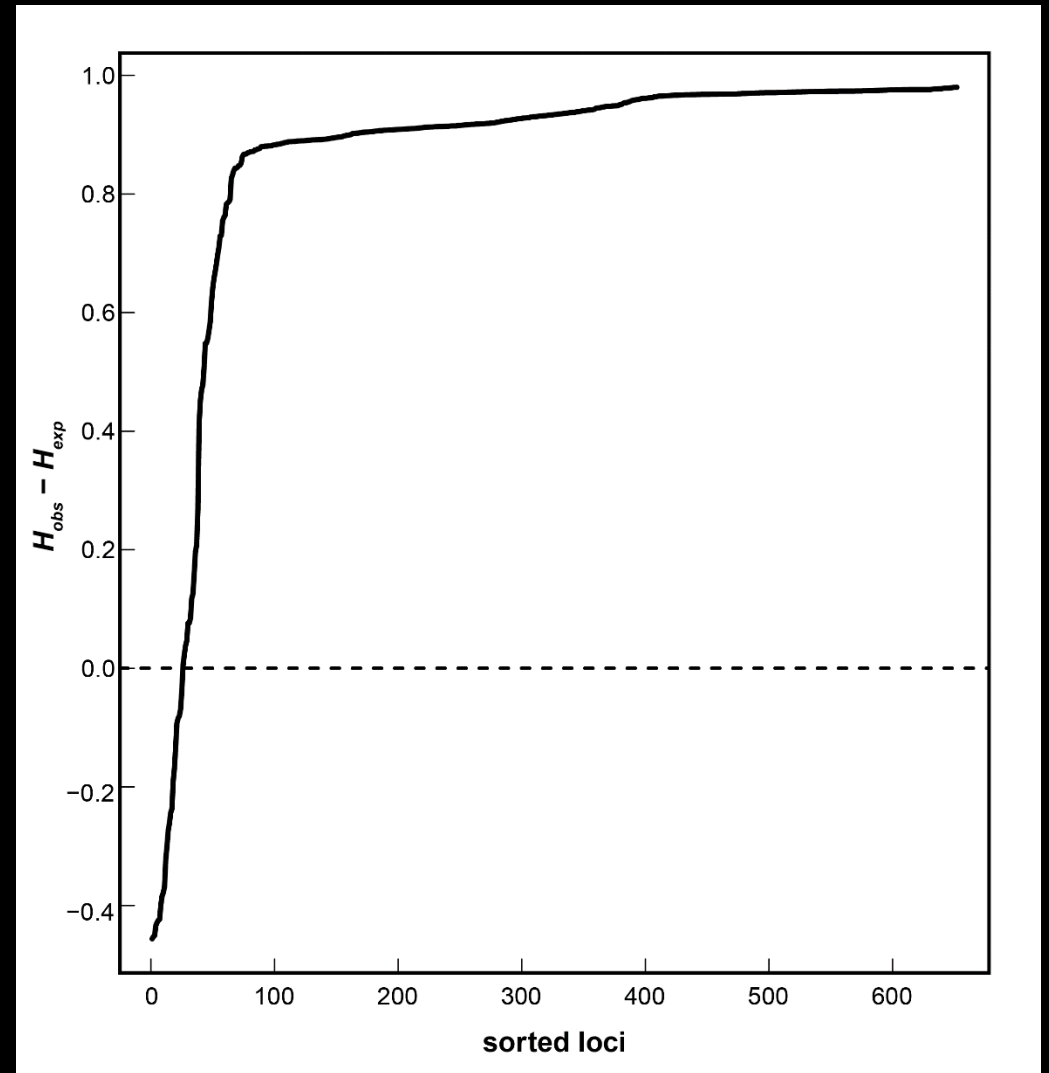


# Results

Heterozygosity is higher than expected  
~ 95% of loci

Potential implications:

- low levels of inbreeding
- Isolate-breaking effects
- Differences are rare



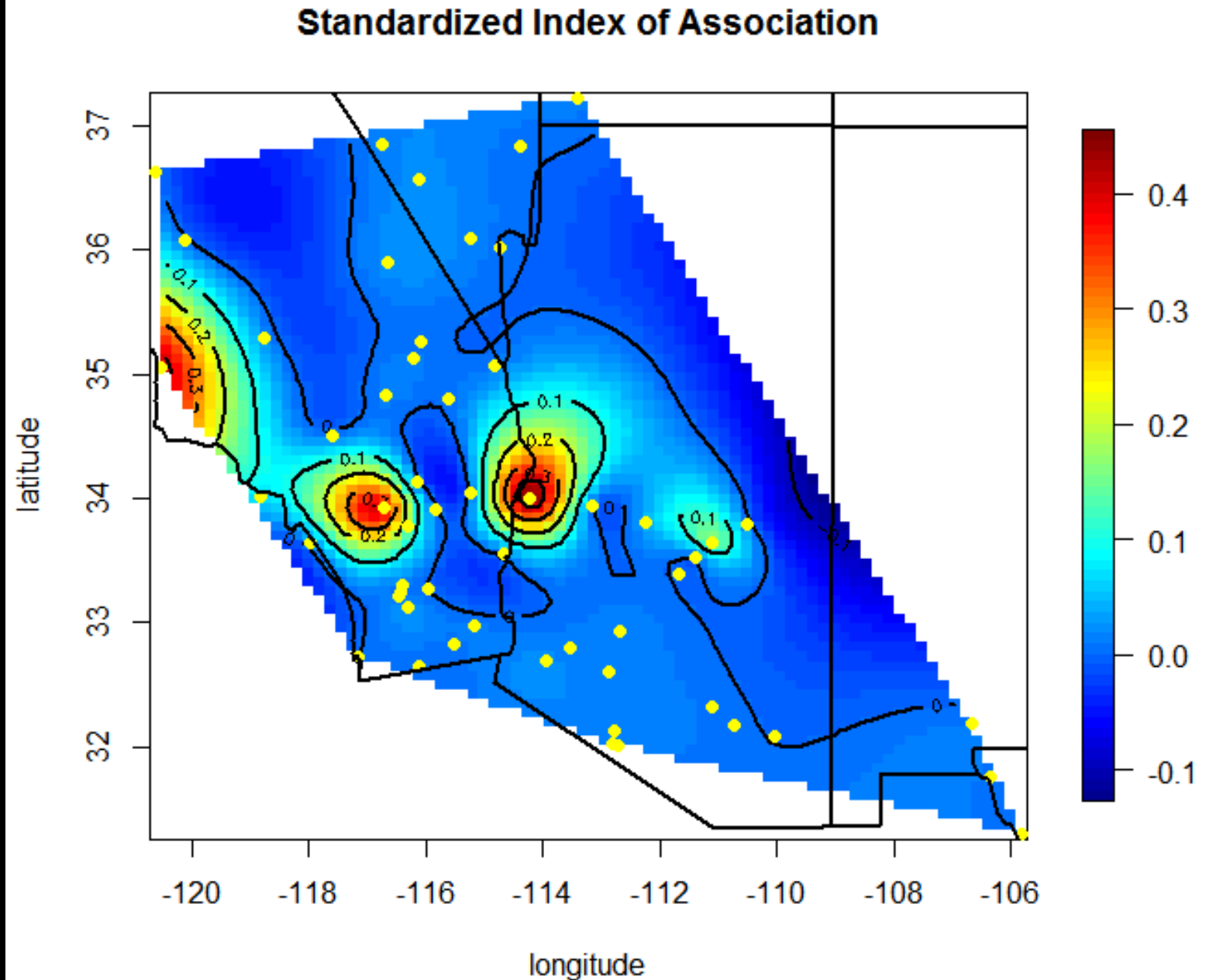


# Results

Thin plate spline of  
Standardized  $I_a$

Implies:

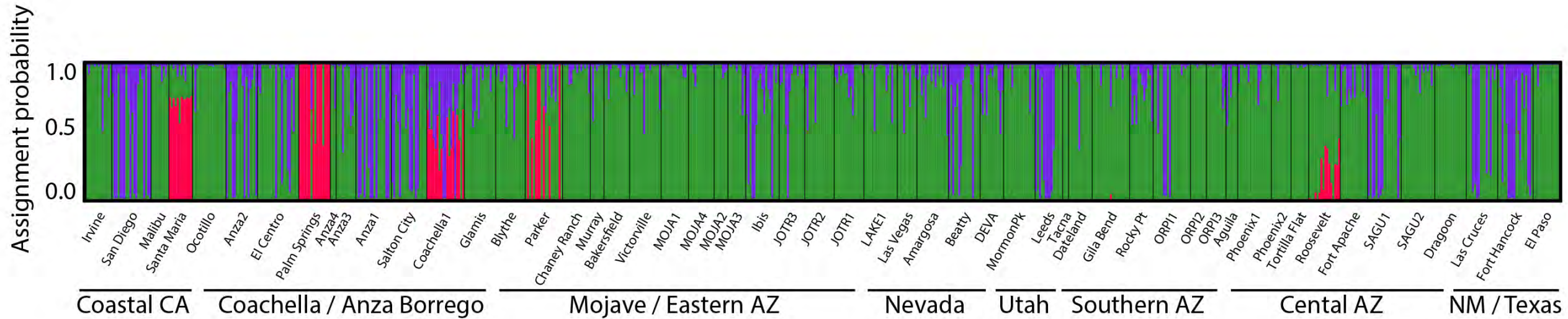
-selfing is occurring





# Results

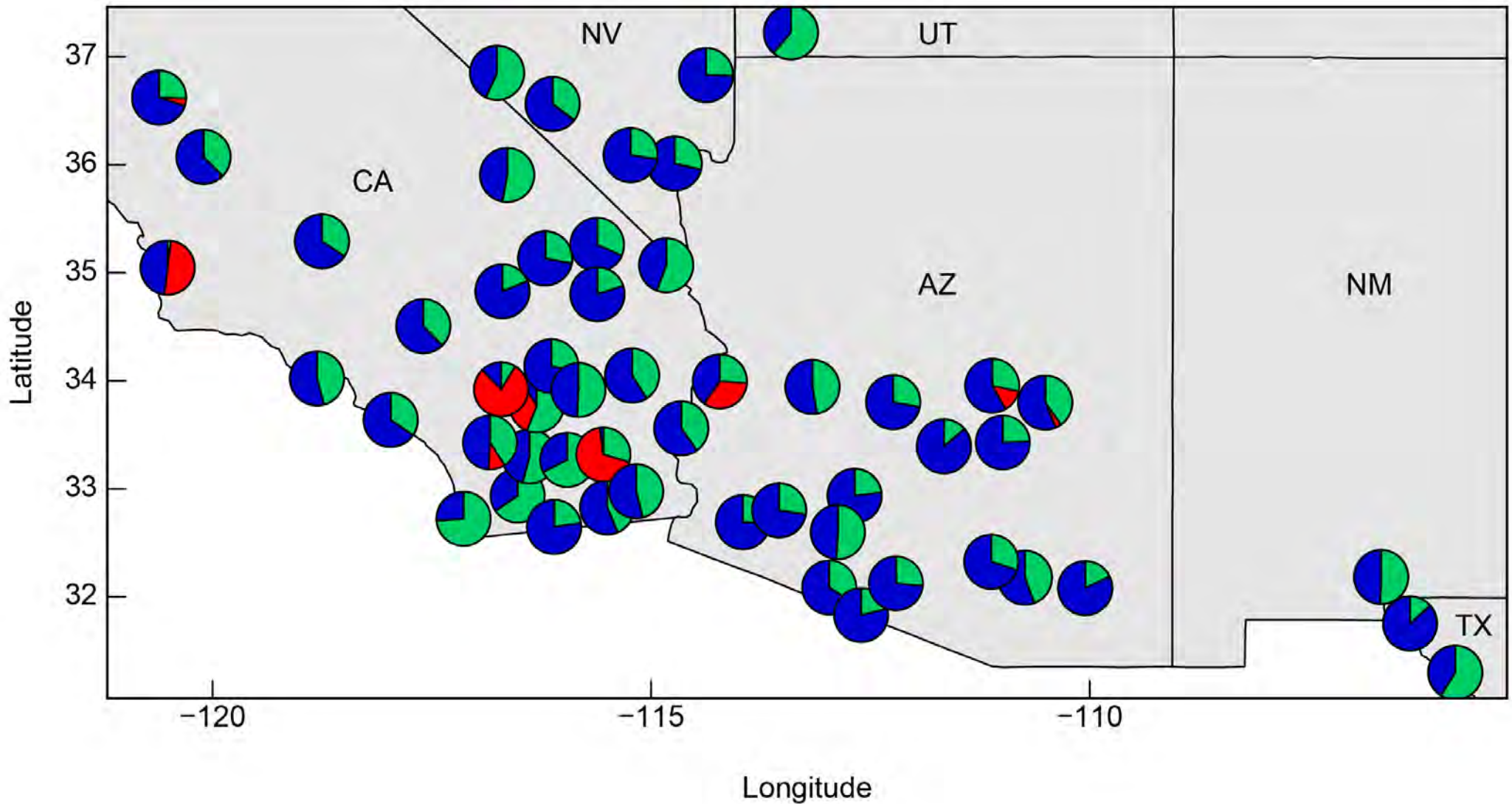
Population structure in US





# Results

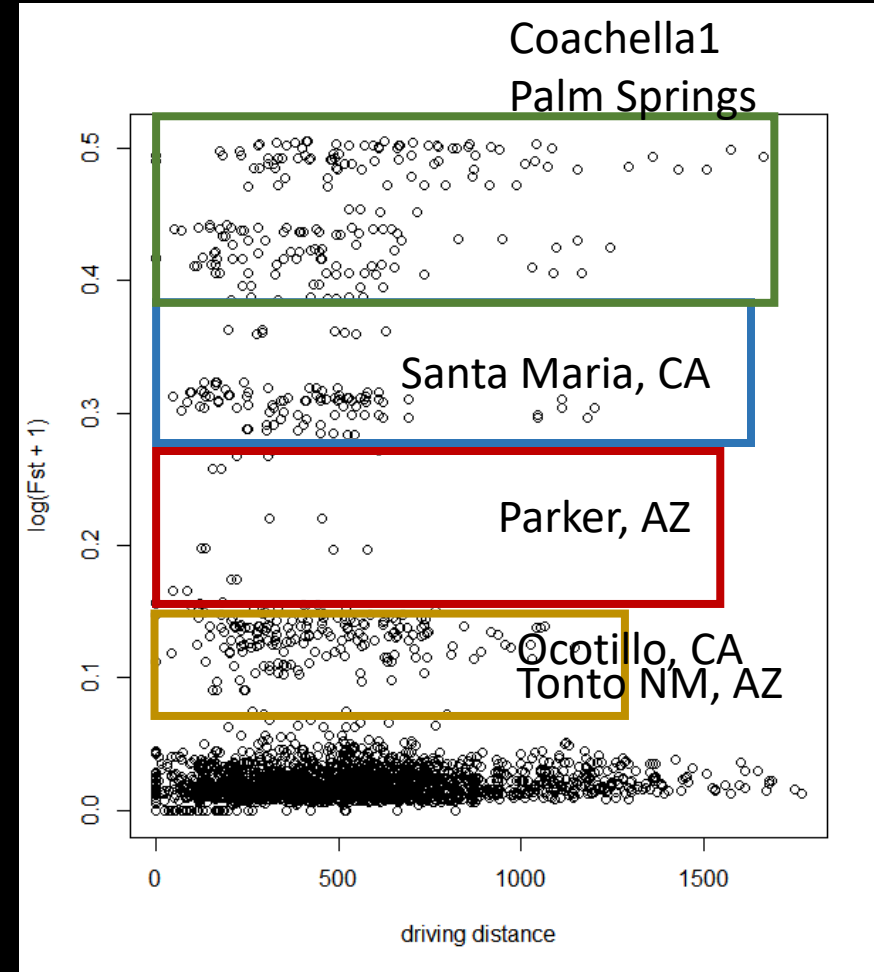
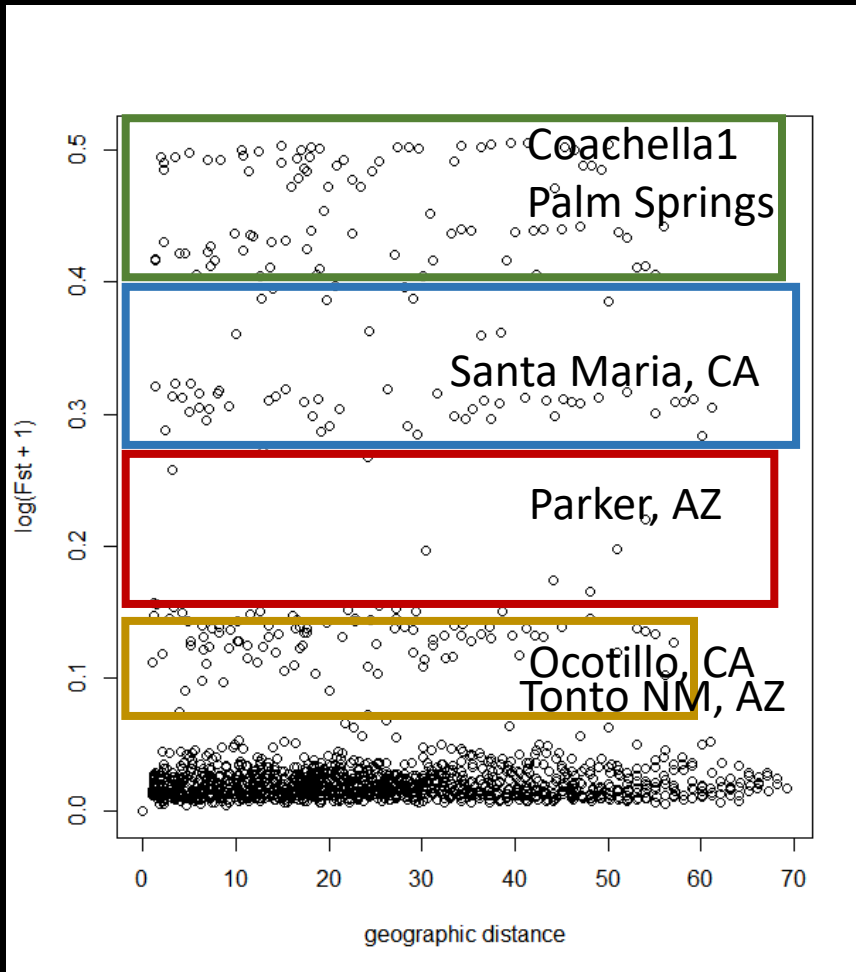
## Haplotype map





# Results

## Diversity by distance



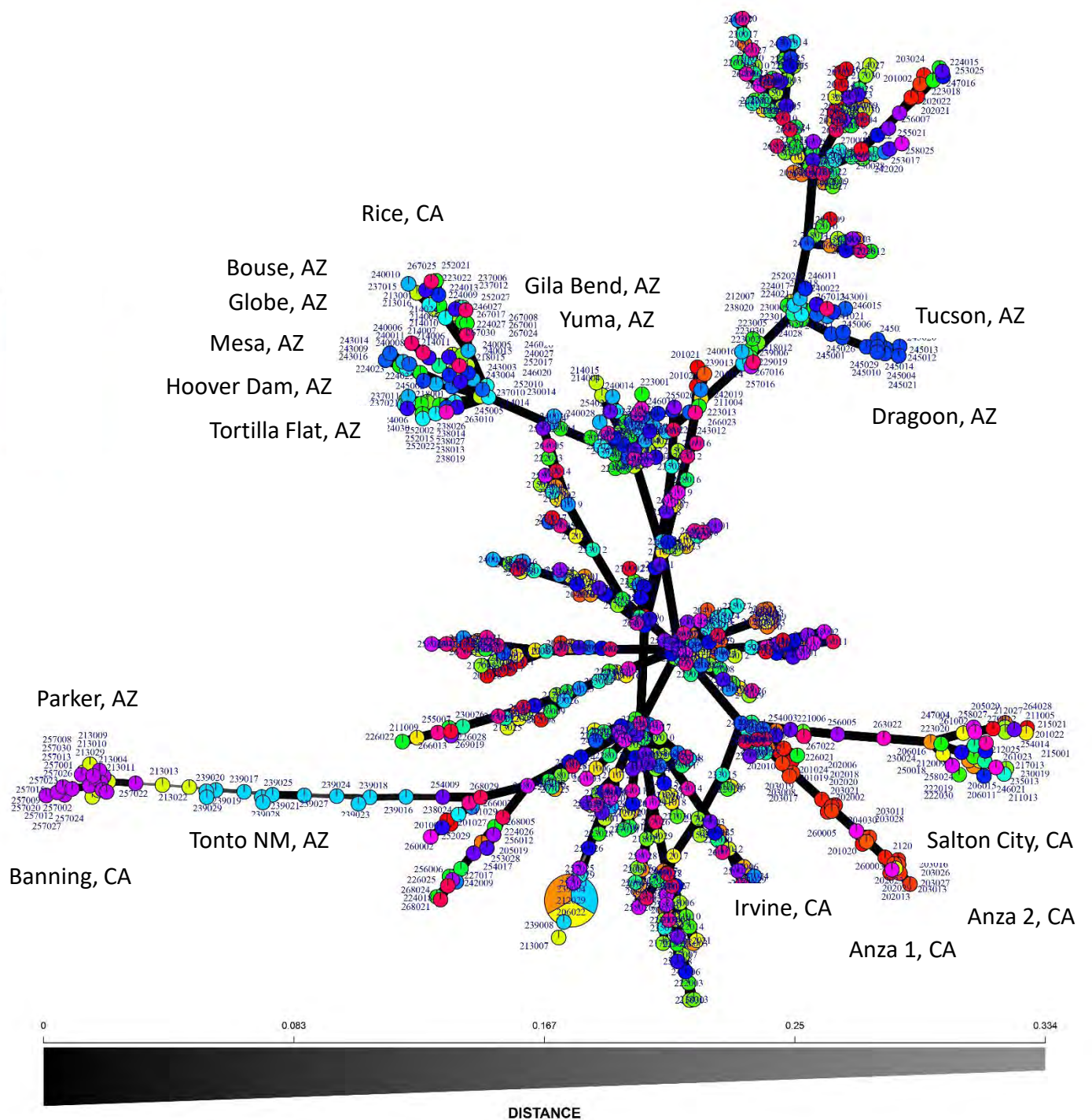
IBD Mantel tests not significant



# Results

Minimum spanning network

Regional grouping provides evidence for invasion pattern





# Conclusions & next steps

3 genetically distinct populations in US

Multiple introductions seem likely

Selfing is prevalent in invaded range







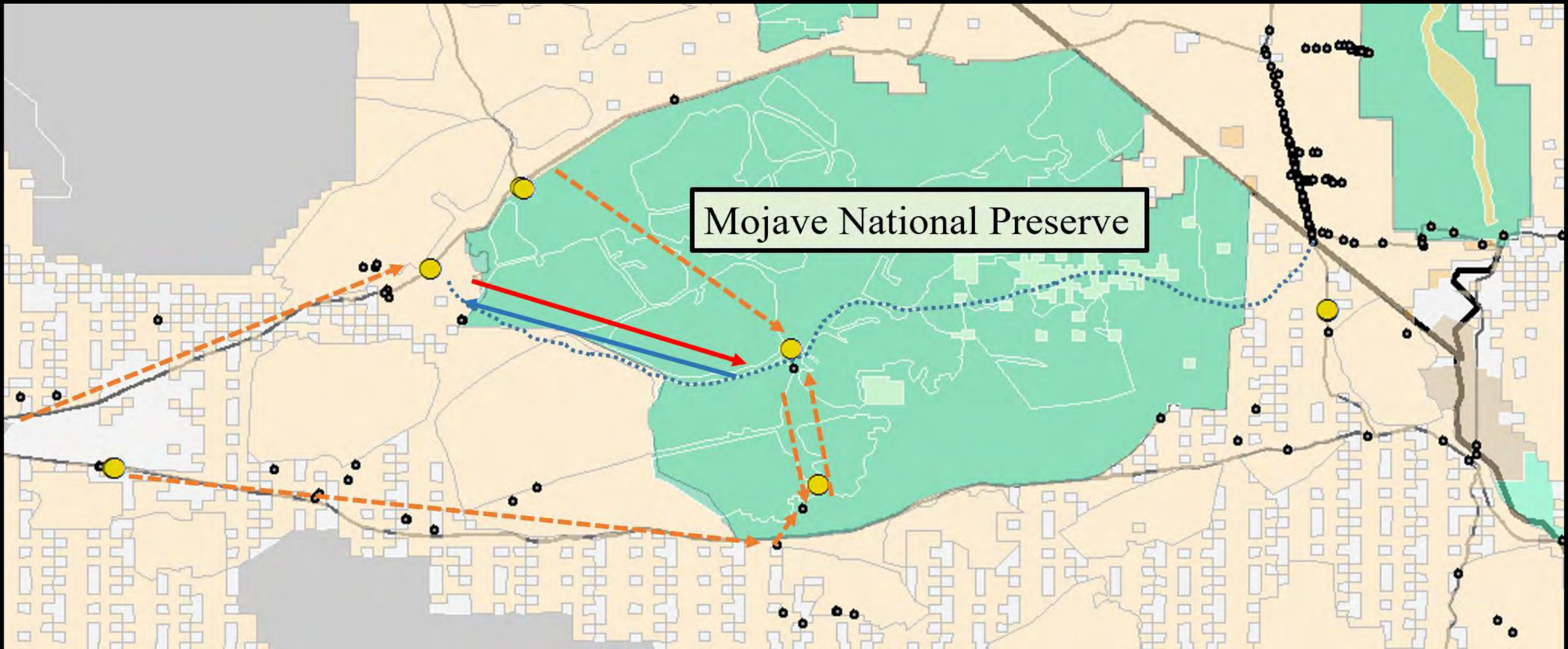
# Conclusions & next steps

- Sequence native samples to identify origin(s)
  - Collected thus far: France, Italy, Israel, Turkey, Jordan, Qatar





# Applied needs







Germination strategies, maternal investment, phenology, allocation strategies



# Thank you

## Huxman Lab

- Kim Huxman
- Melanie Kao
- June Dong
- Michelle Lin

## Gaut Lab

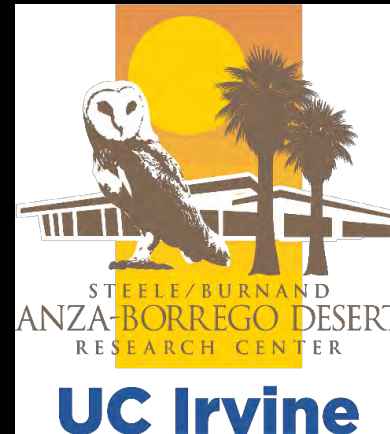
- Pam McDonald
- Kyria Roessler
- Shaun Hug

## Dissertation Committee

- Mike Goulden
- Kailen Mooney
- Valerie Olson
- Ann Sakai

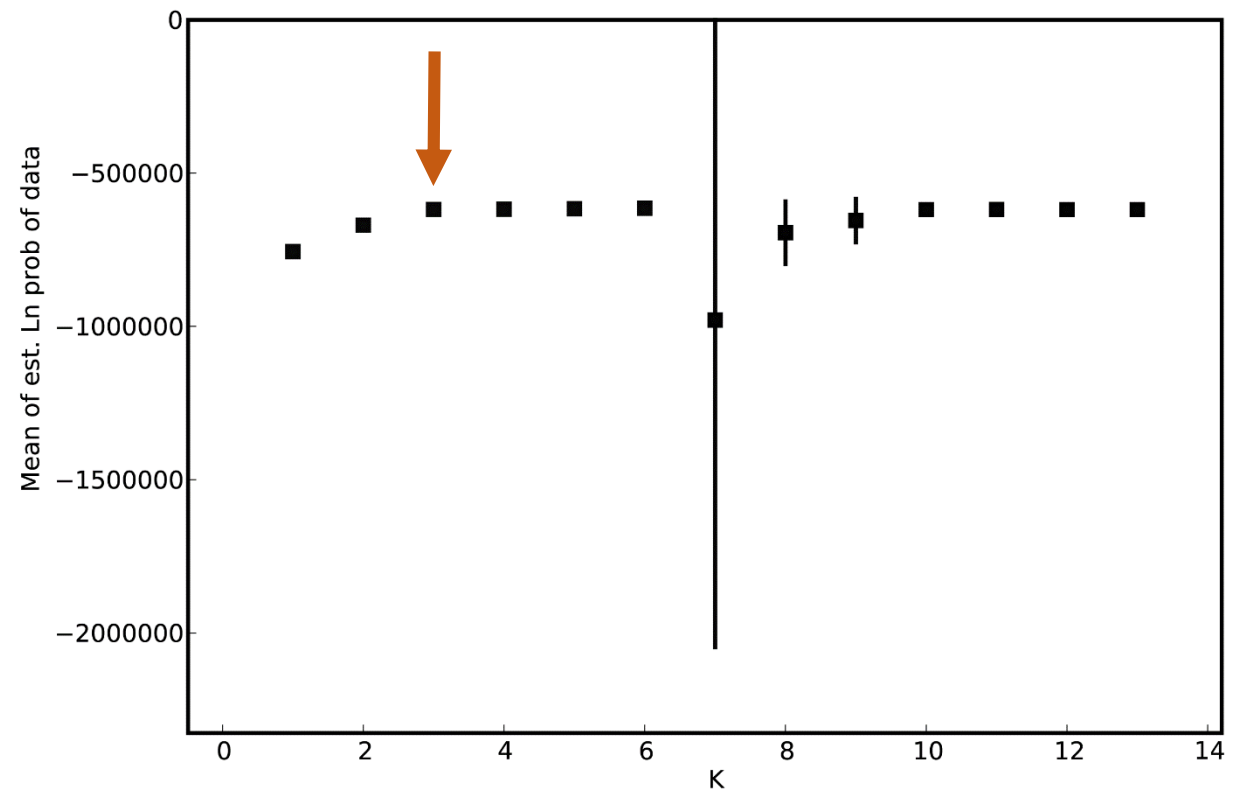
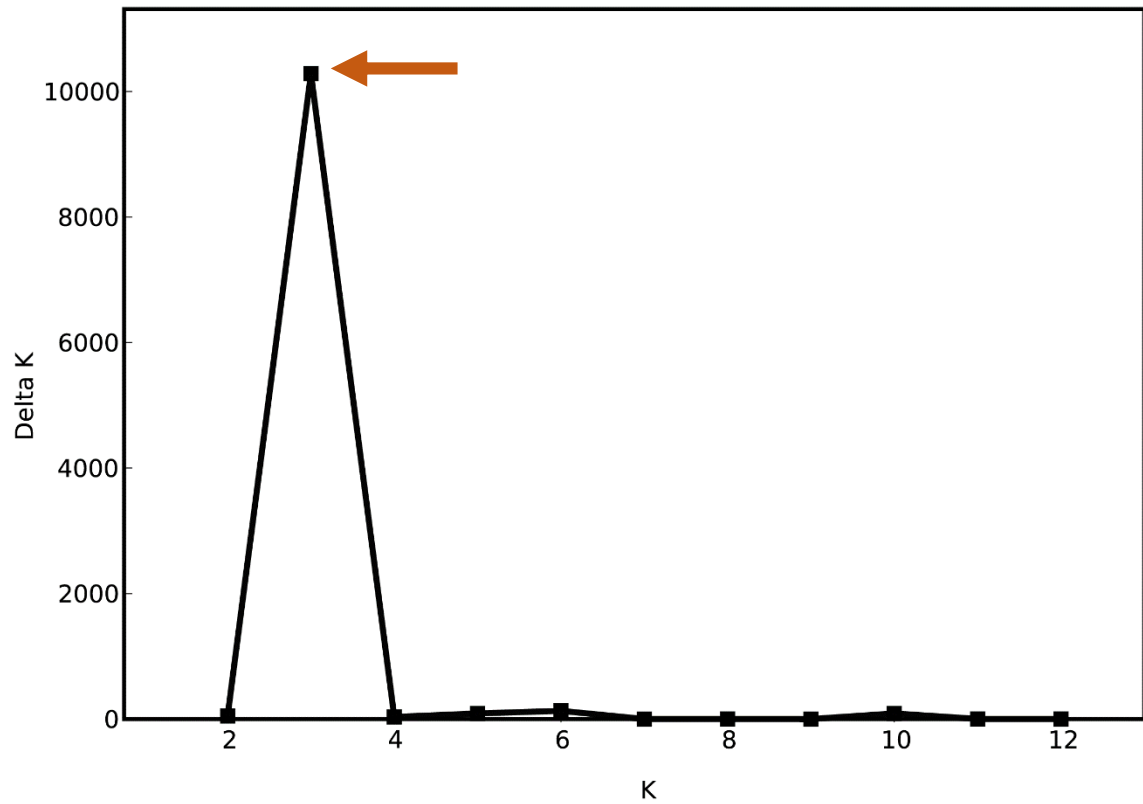
## Citizen Scientist Groups/Parks

- Tubb Canyon Desert Conservancy,
- AmeriCorps
- Death Valley NP weed eradication volunteers
- Park managers and staff





# Results





# Results

