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science for a changing world

GENETIC CONNECTIVITY OF THE COASTAL CACTUS WREN

Kelly Barr
Barbara Kus
Kris Preston
Amy Vandergast

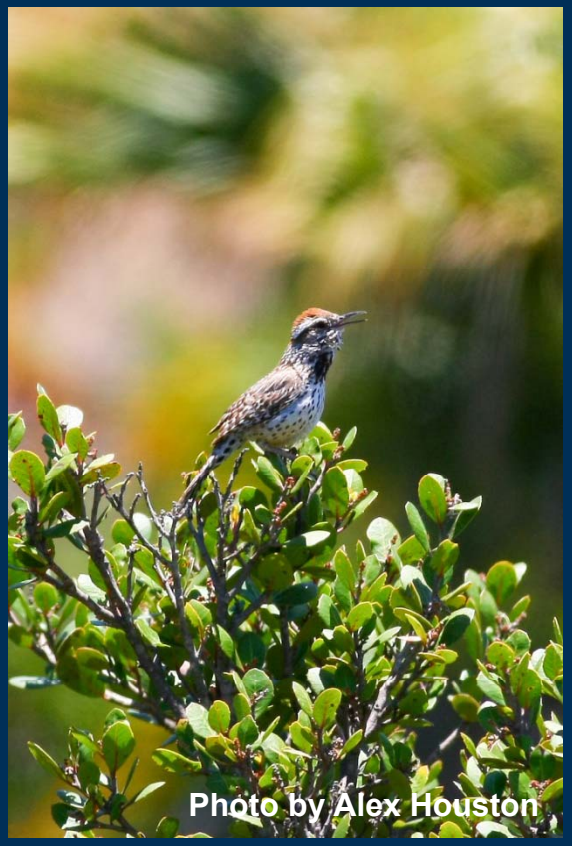
Photo by Alex Houston

U.S. Department of the Interior
U.S. Geological Survey

ACKNOWLEDGMENTS

NROC:

K. Moore & D. Kamada

USGS:

S. Howell, A. Houston, M. Madden-Smith, L. Allen, A. Gallagher, P.J. Falatek, K. Allen

Overview

- Background
- Study Design
- Results & Analyses
- What's Next?

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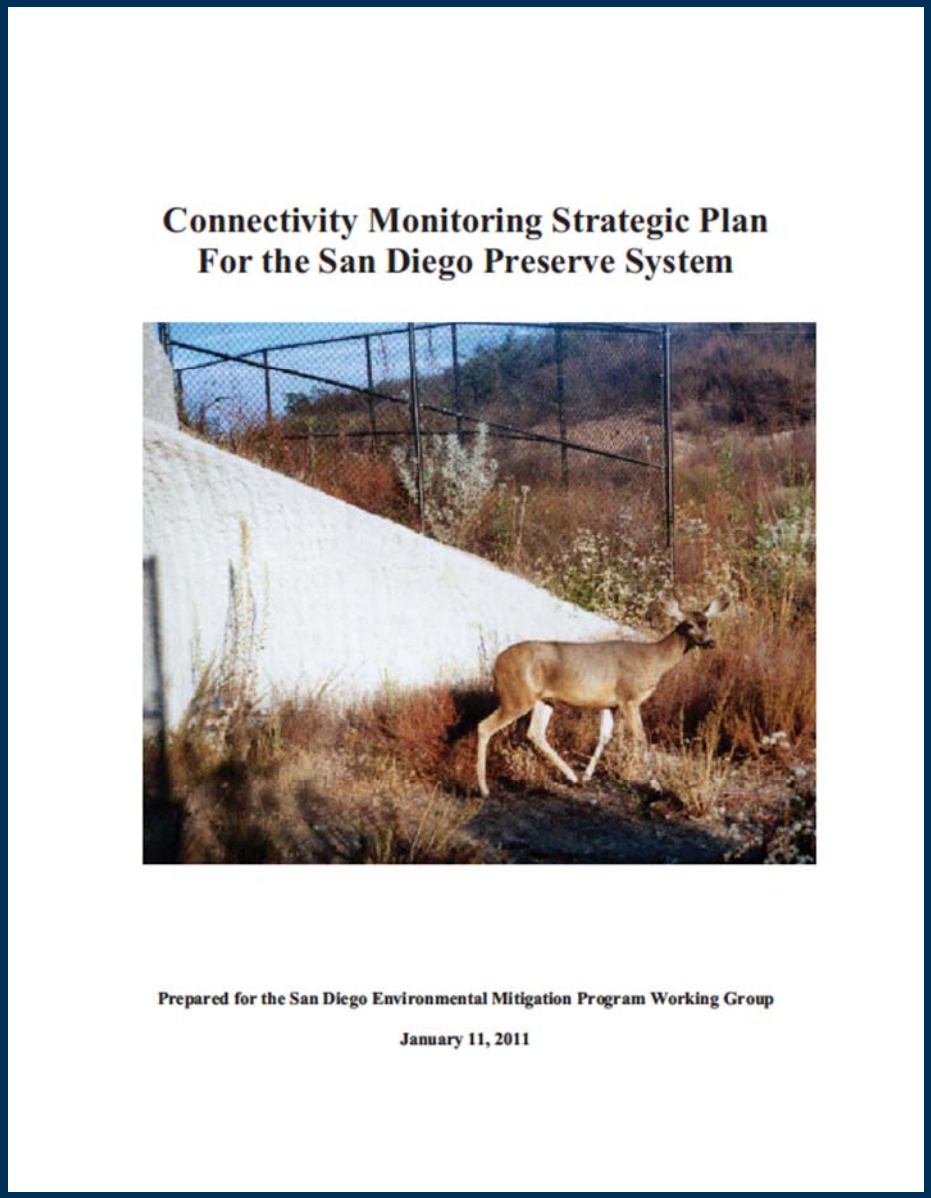

Goal:

To identify and inform adaptive management actions to *maintain, restore or improve connectivity* between conserved core areas, and thereby:

- ensure persistence of species across preserve system
- preserve ecosystem function across the landscape

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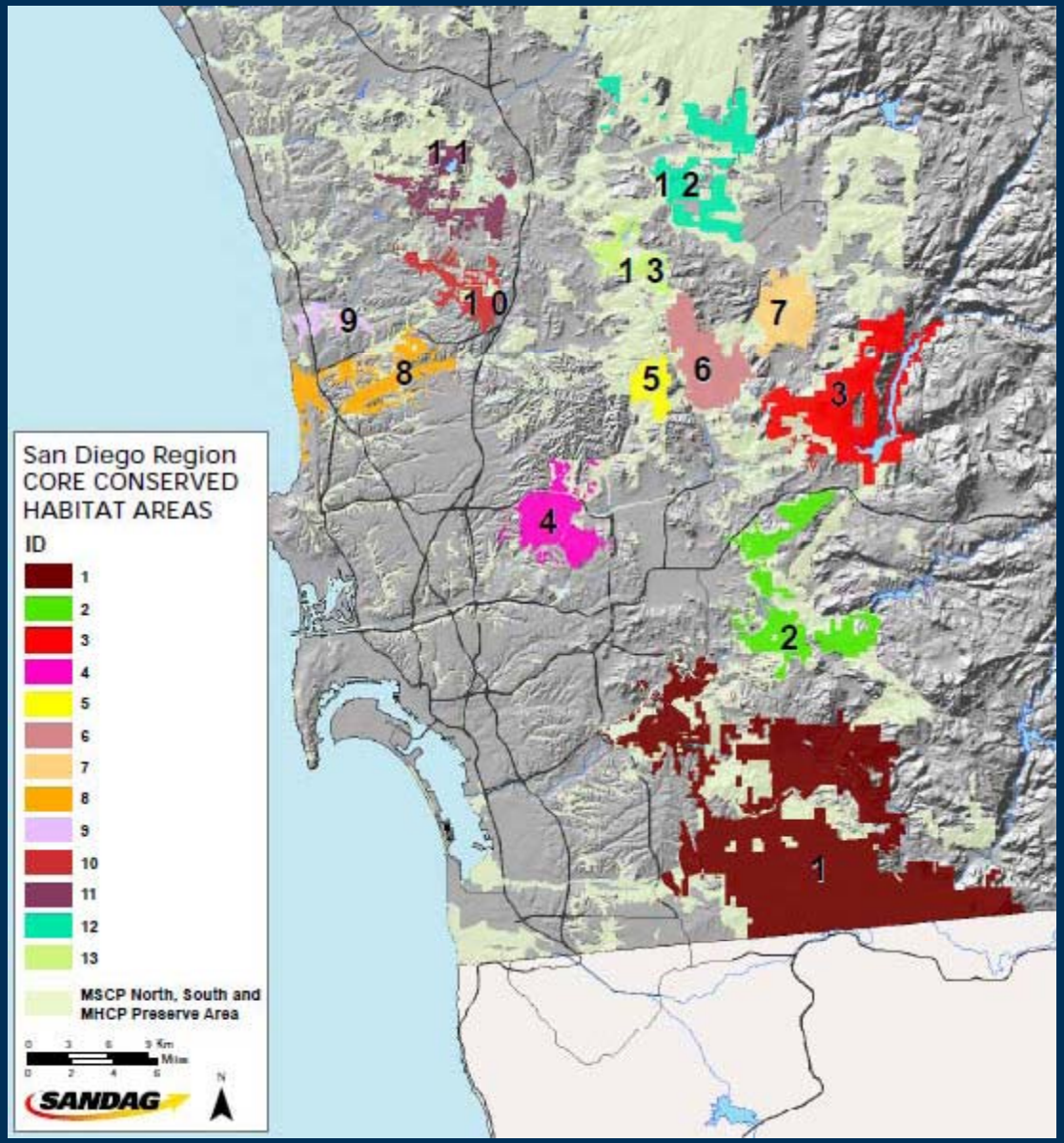

What is the functional connectivity among core areas for

- large animals
- small animals
- birds

Priority bird species:

- Coastal Cactus Wren
- California Gnatcatcher
- Least Bell's Vireo
- SW Willow Flycatcher

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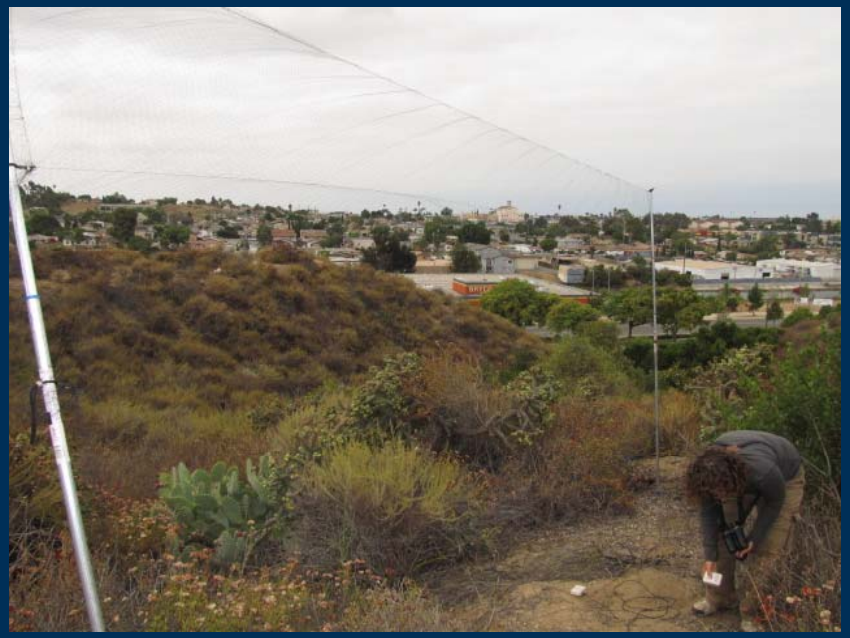
Why Study Connectivity in Cactus Wrens?

- limited strictly to cactus habitat
- cactus highly fragmented by development & fire
- connectivity maintains genetic diversity within fragments & ensures recolonization after local extinctions
- understanding current connectivity would inform cactus restoration
  - How do Cactus Wrens utilize the landscape for movement?
  - identify connectivity trouble spots



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Genetic Approach

- genetic data provide information on gene flow (movement + successful breeding)
  - Dispersal = just movement

- determine natural and anthropogenic barriers that impede gene flow

- measures genetic diversity (the raw material for adaptation)

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Study Goals:

1. Are there limitations to gene flow?
2. Identify clusters (populations or gene pools).
3. What is the genetic diversity within clusters?

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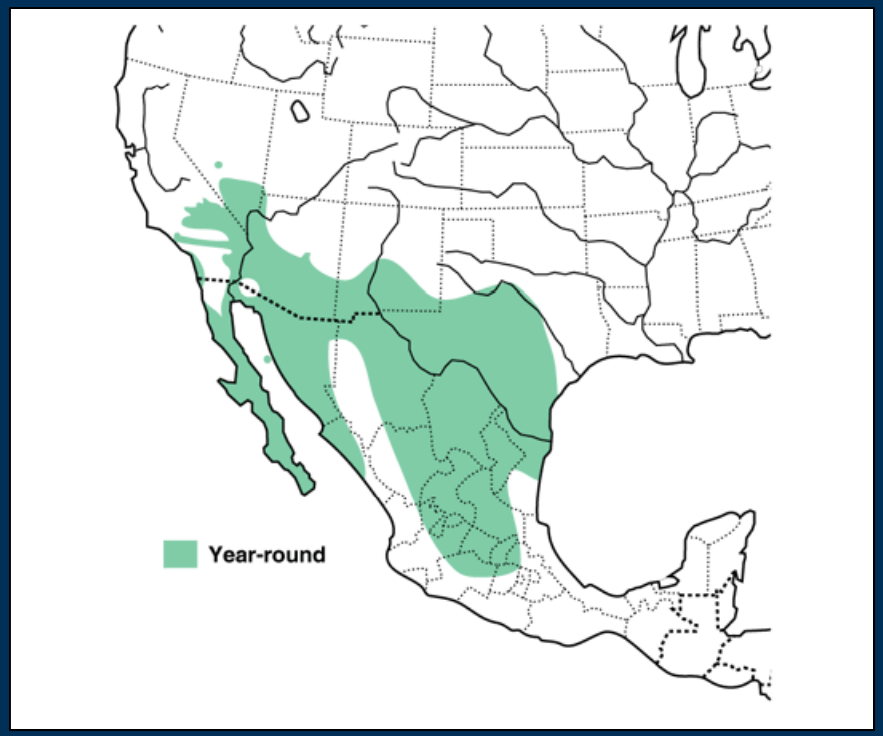
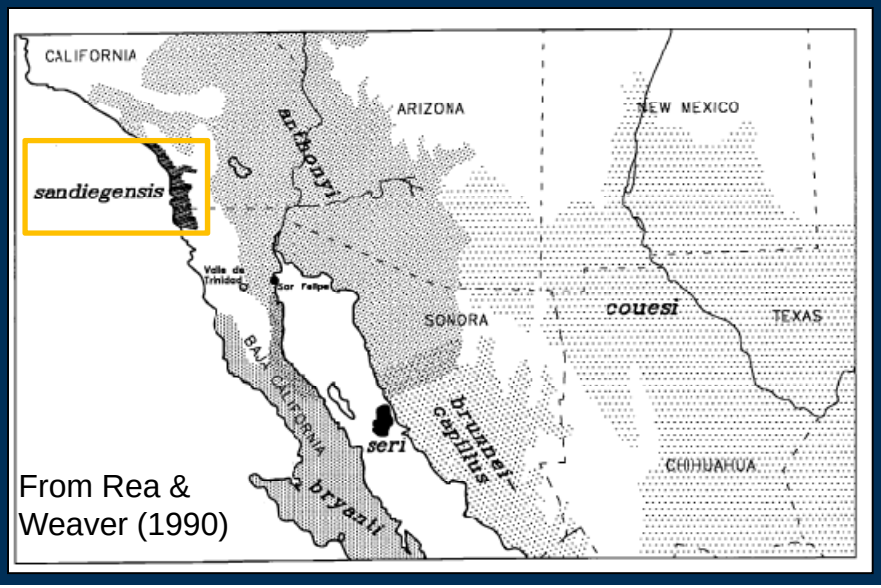
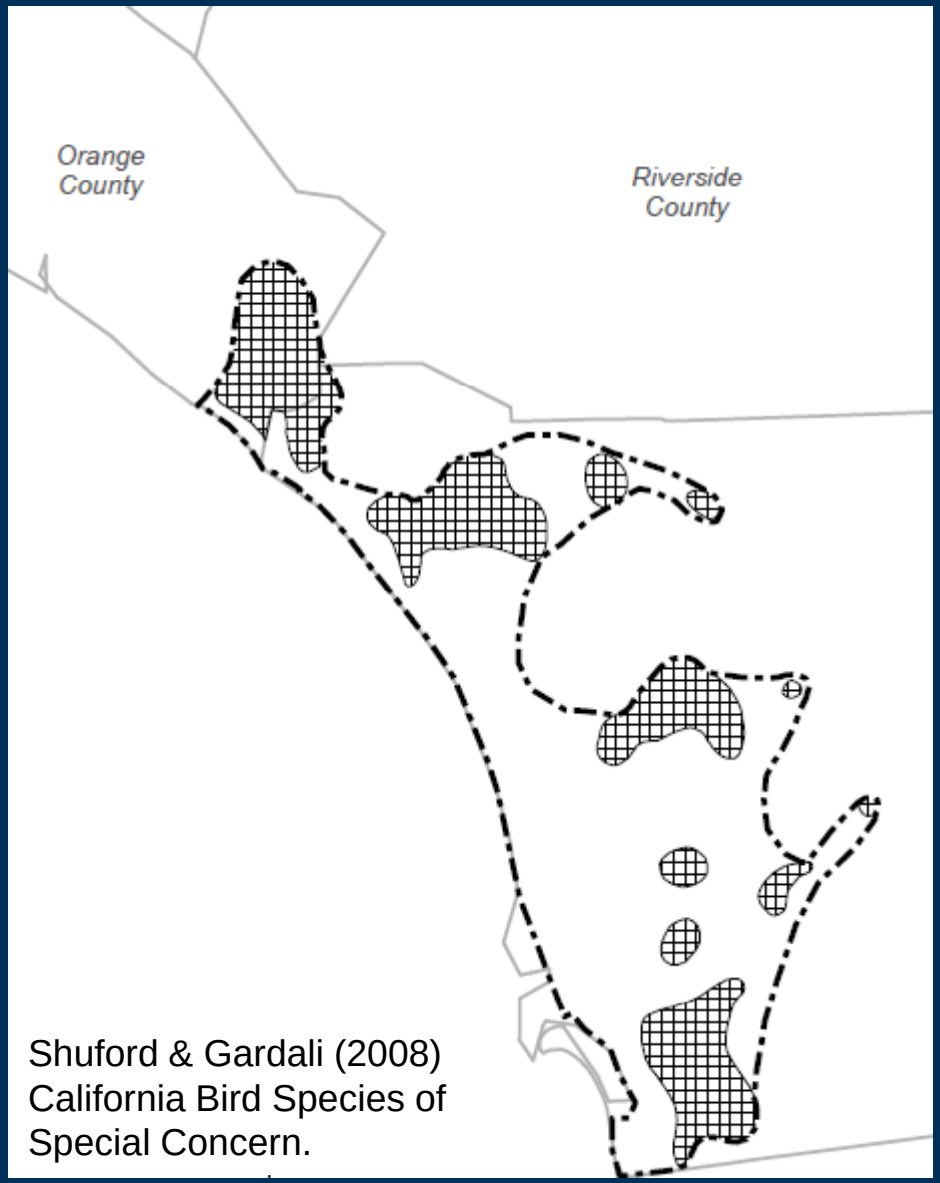




From Rea & Weaver (1990)



Shuford & Gardali (2008)
California Bird Species of
Special Concern.

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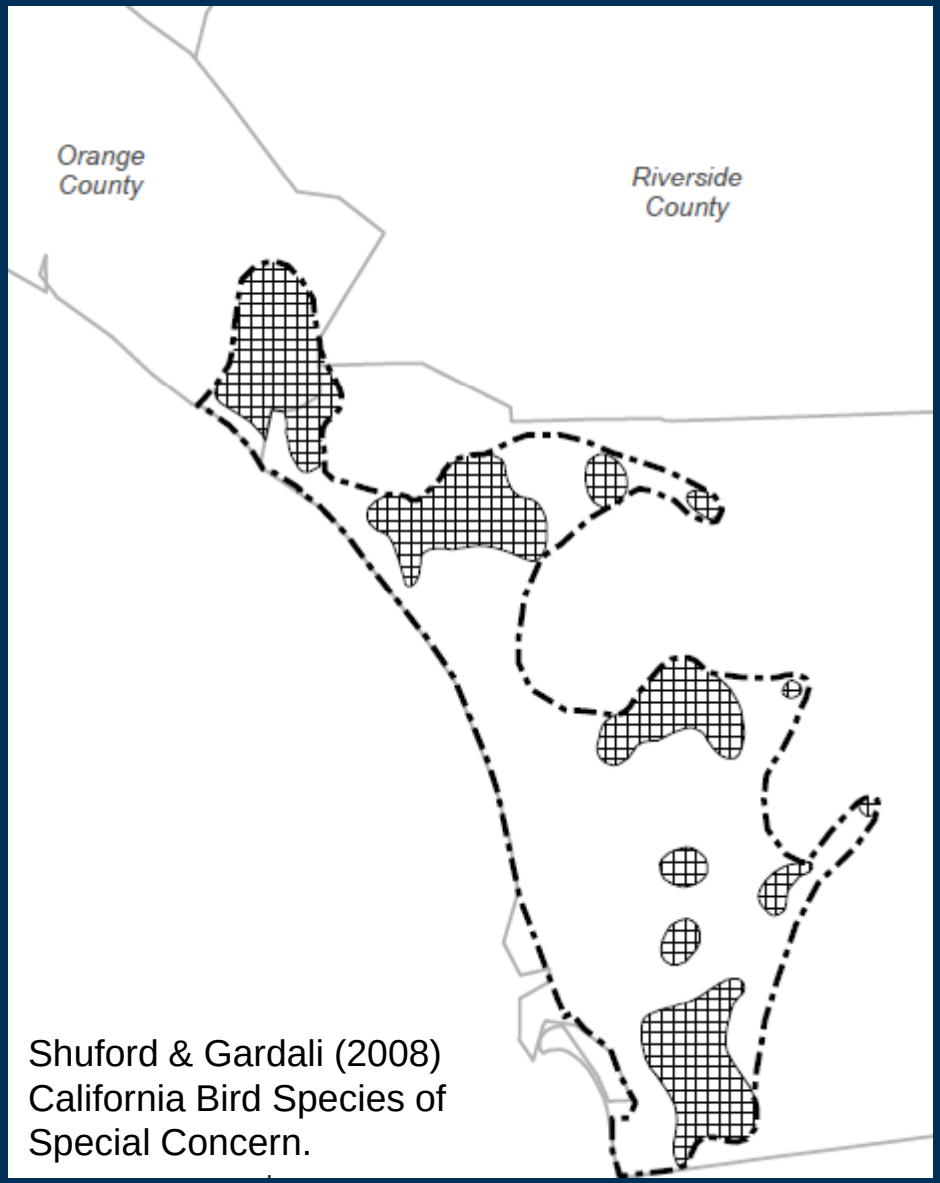

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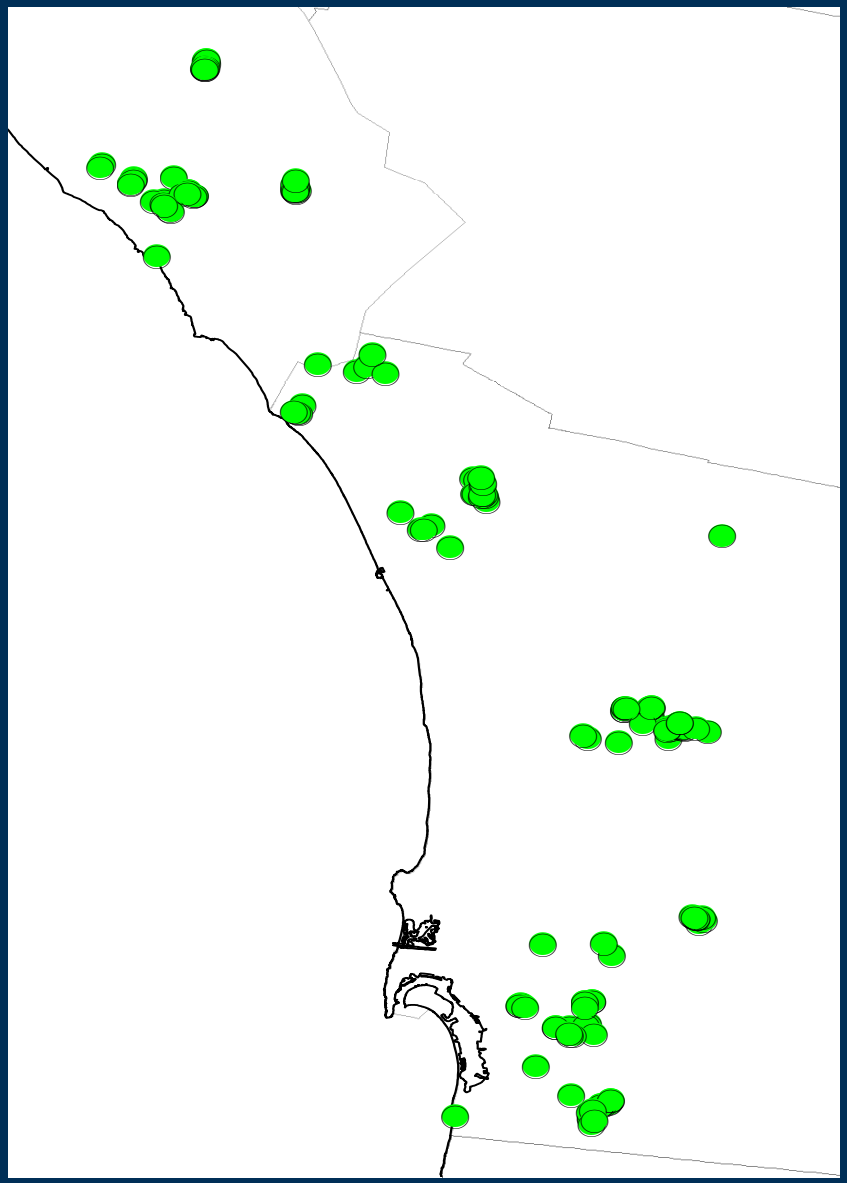

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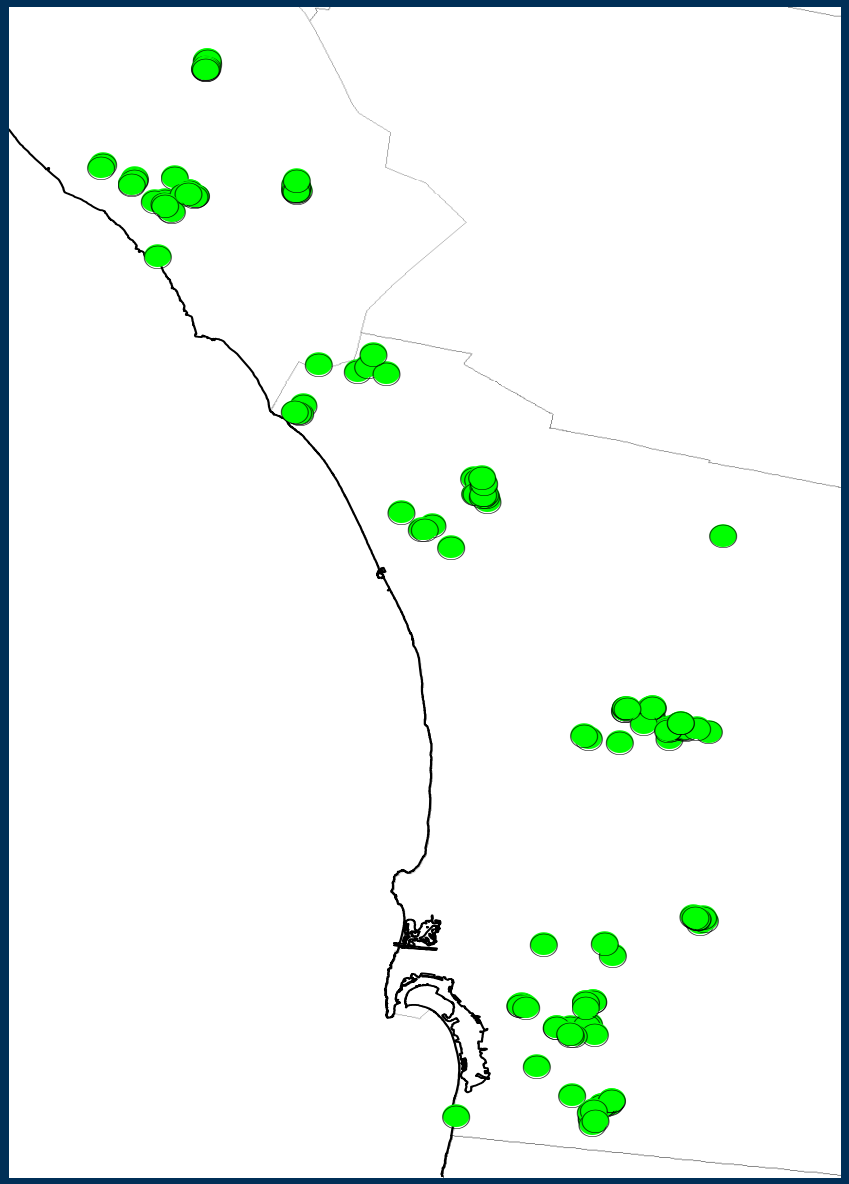

Exhaustive sampling

- USFWS cactus mapping
- SD Bird Atlas
- CACW working group

Partners & cooperators

- USFWS
- SDNWR
- CDFG
- ICR Safari Park
- CBI
- TNC
- AECOM
- Fallbrook NWC
- MCB Camp Pendleton
- SD Audobon Society
- Sweetwater Authority
- SDMMP
- San Dieguito River Valley Conservancy

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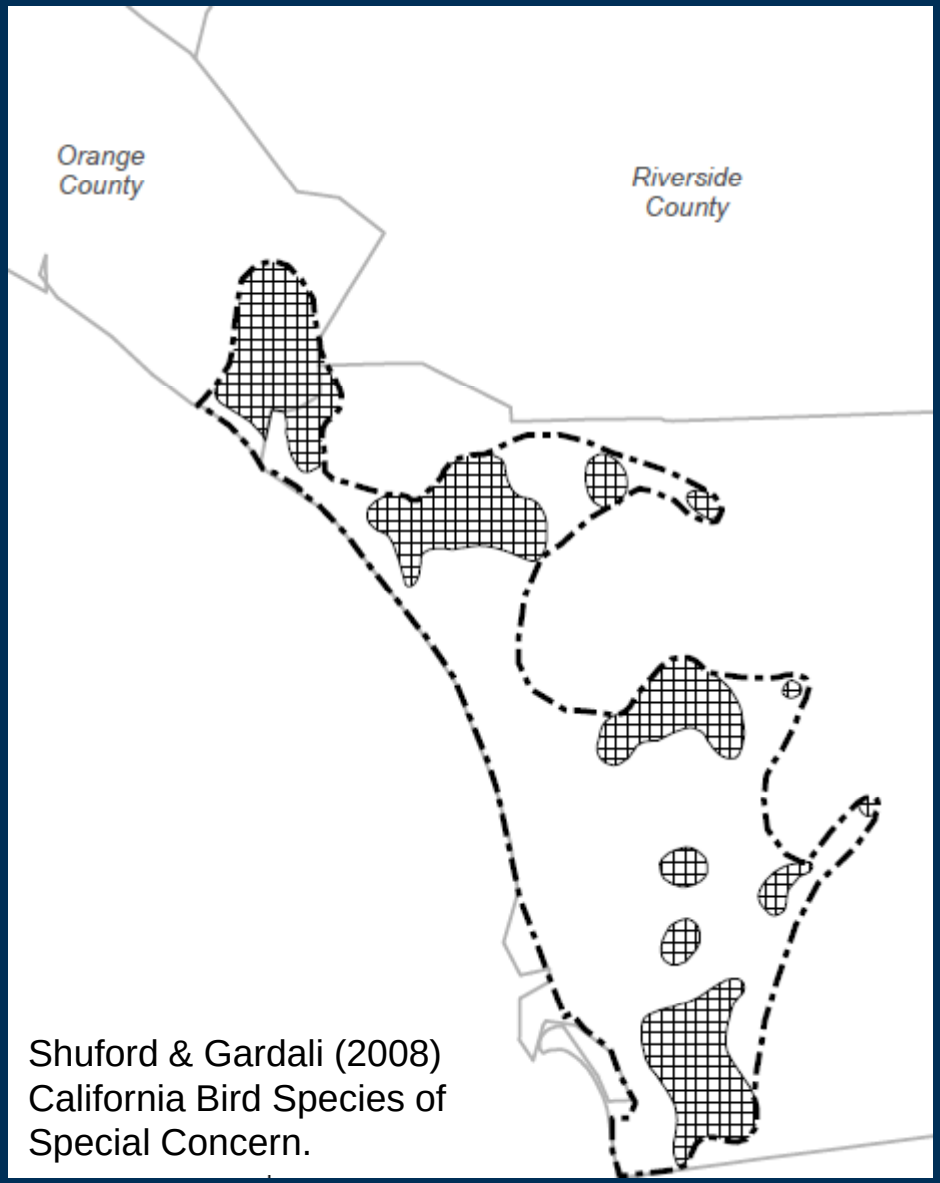

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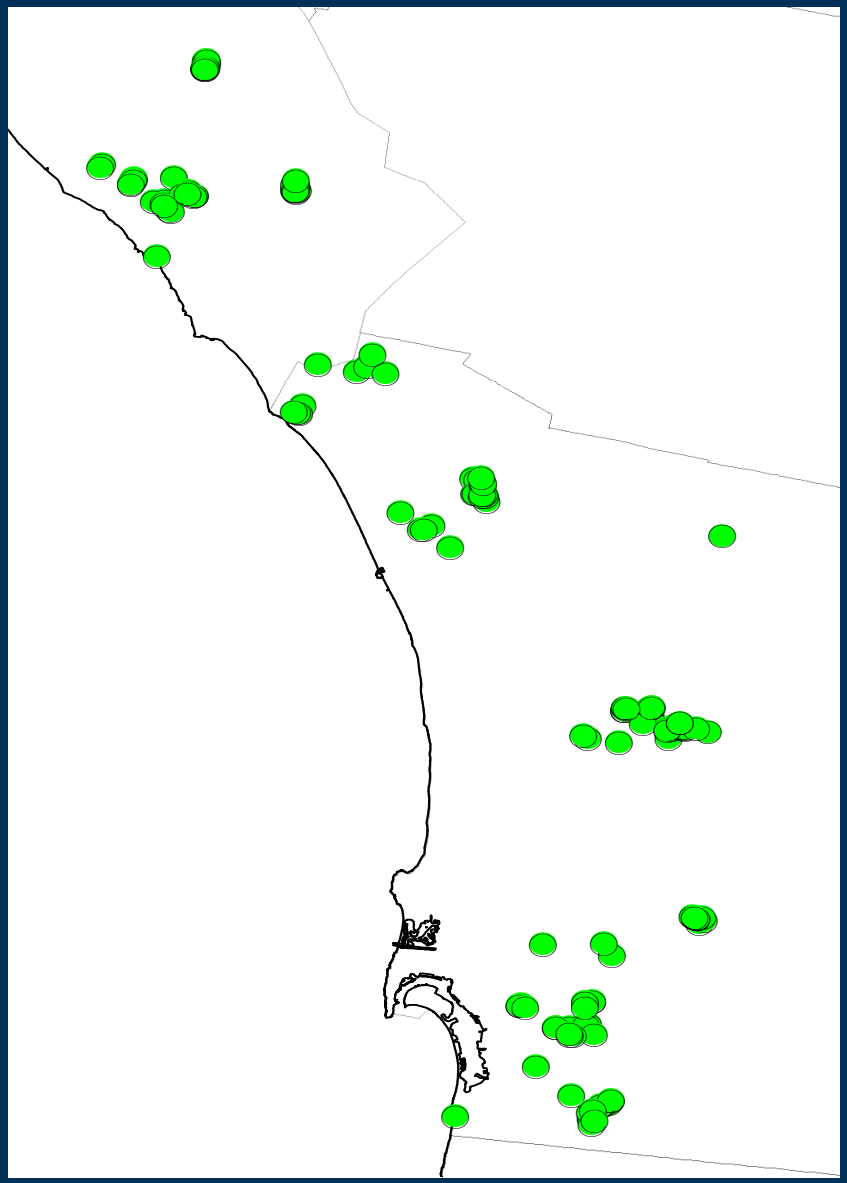

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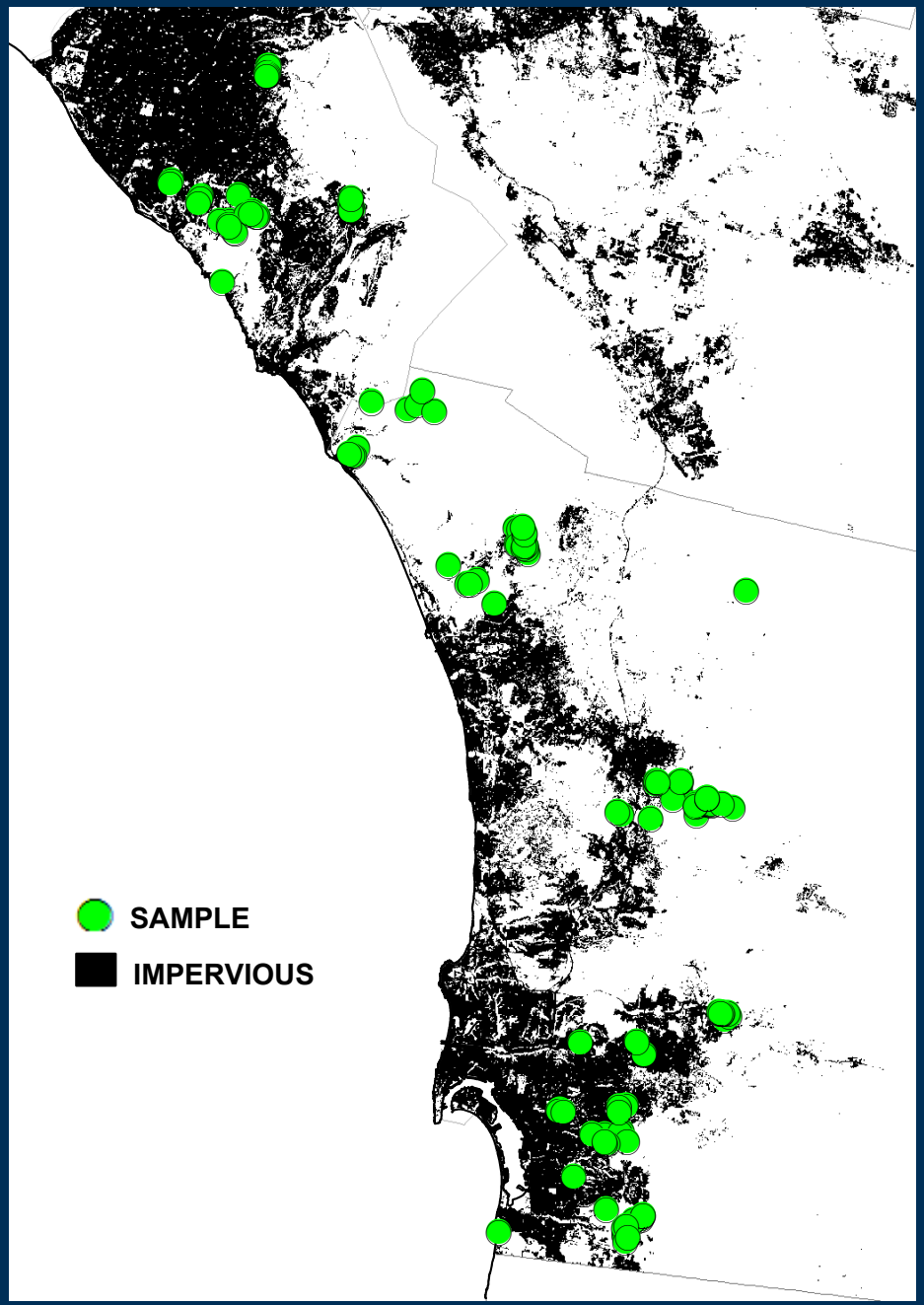

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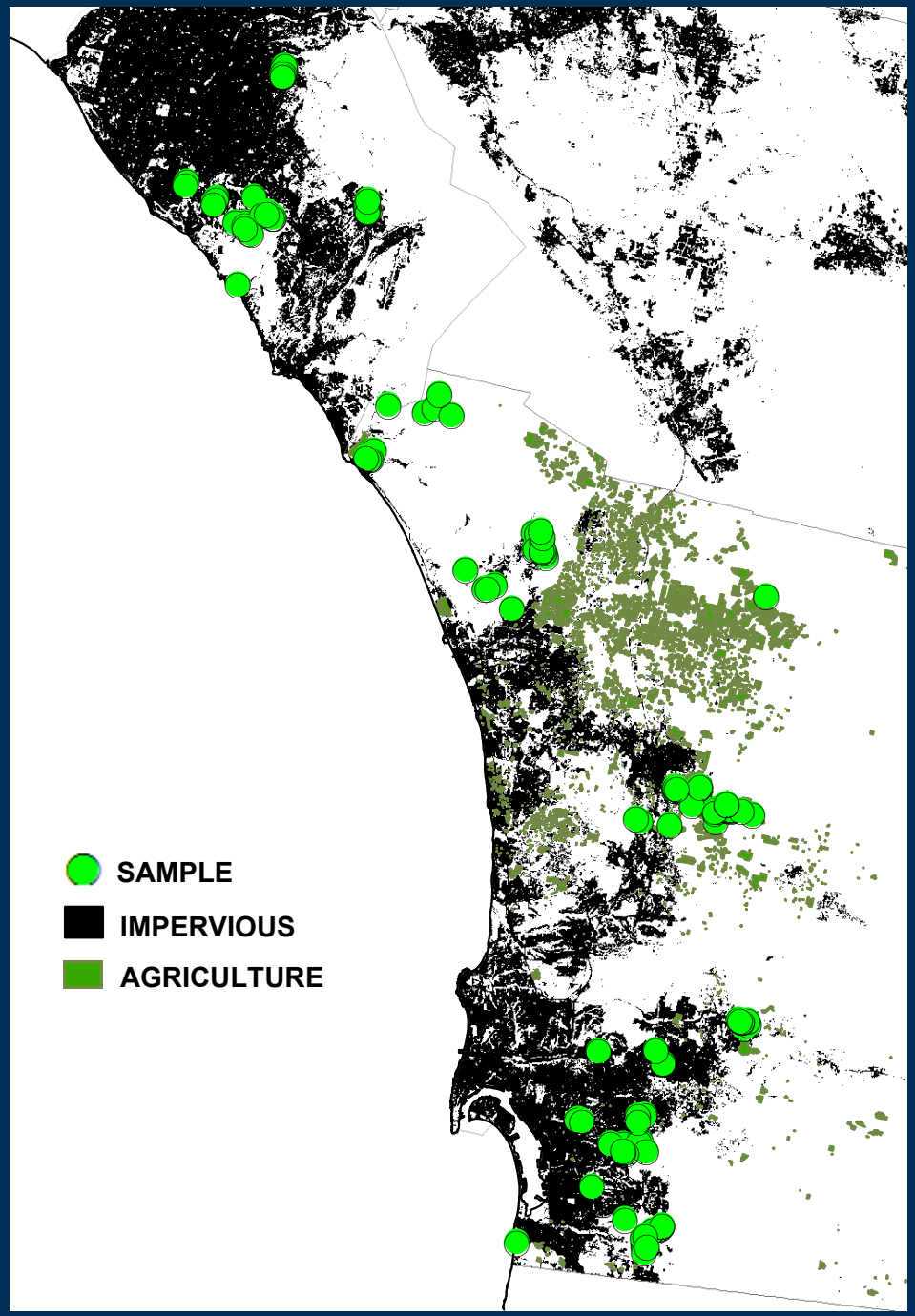

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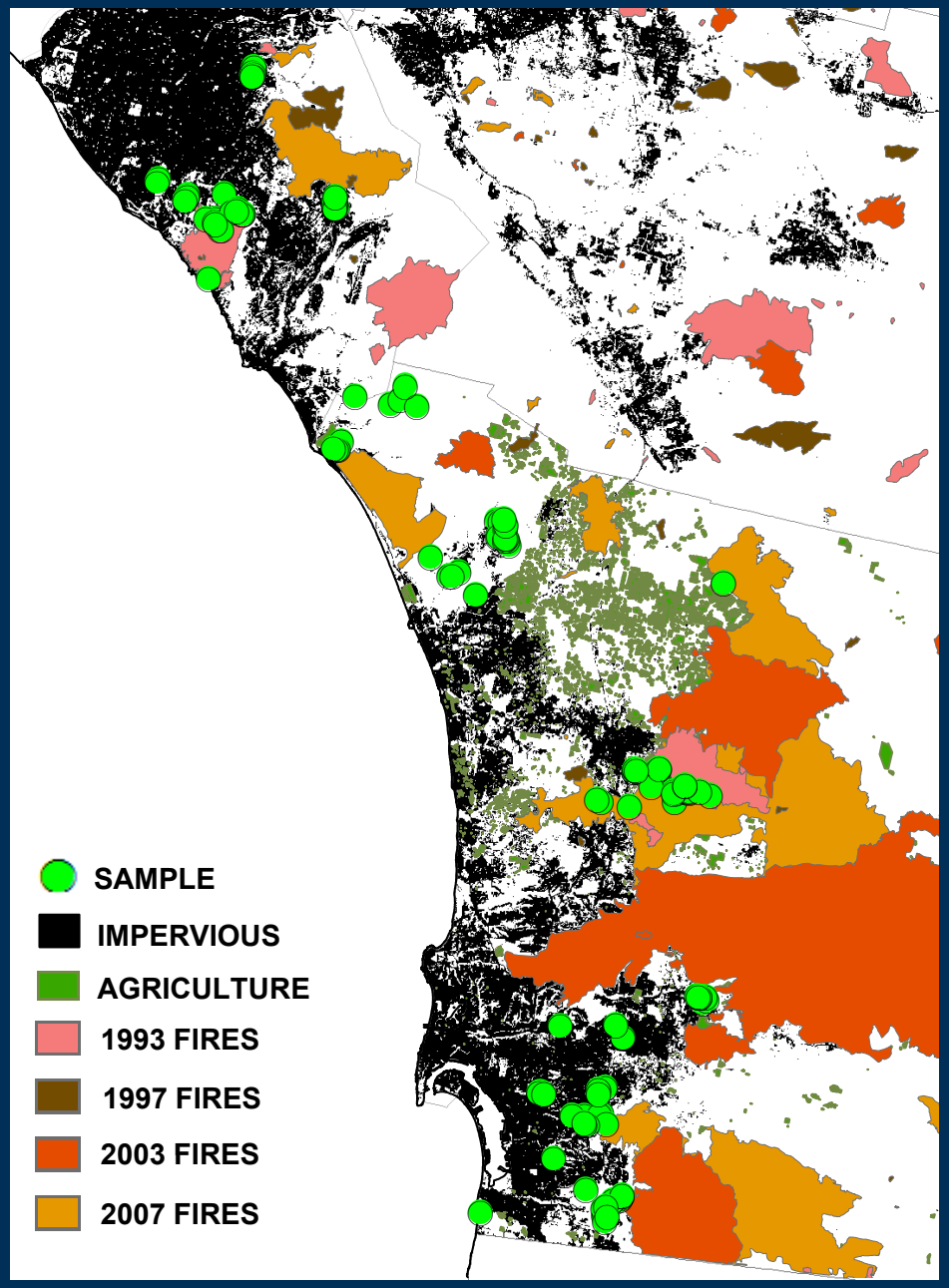
SAMPLE
IMPERVIOUS
AGRICULTURE
1993 FIRES
1997 FIRES
2003 FIRES
2007 FIRES

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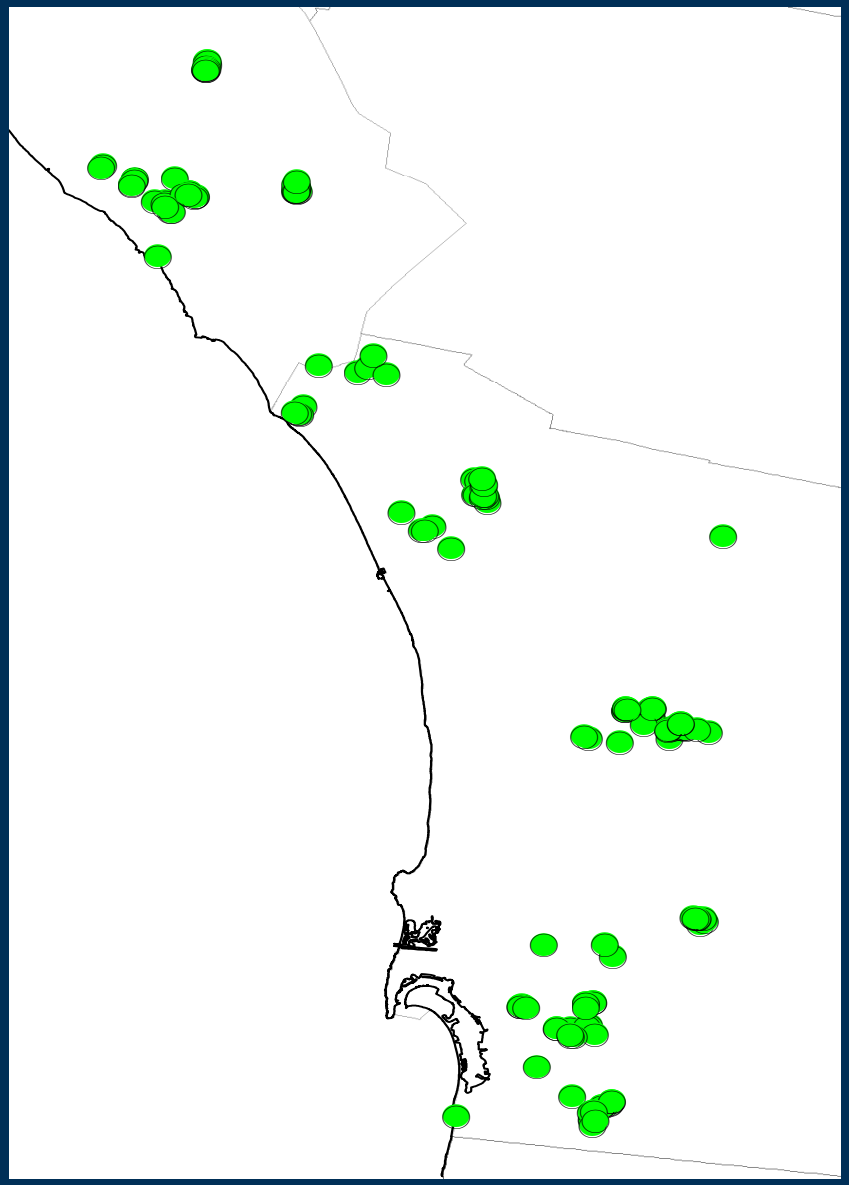

420 TOTAL BIRDS SAMPLED

165 INDIVDUALS ANALYZED

- 1 NESTLING
- 1-2 ADULTS

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Nestling feathers

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Toenail clip

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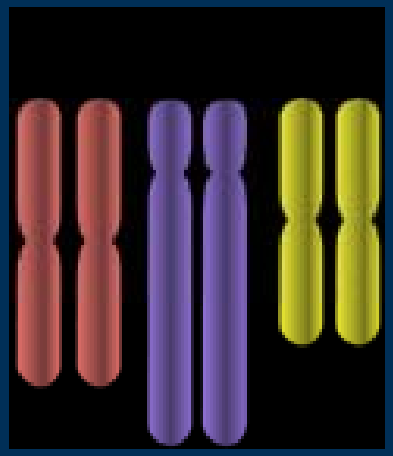
A Little Genetics….

- Diploid



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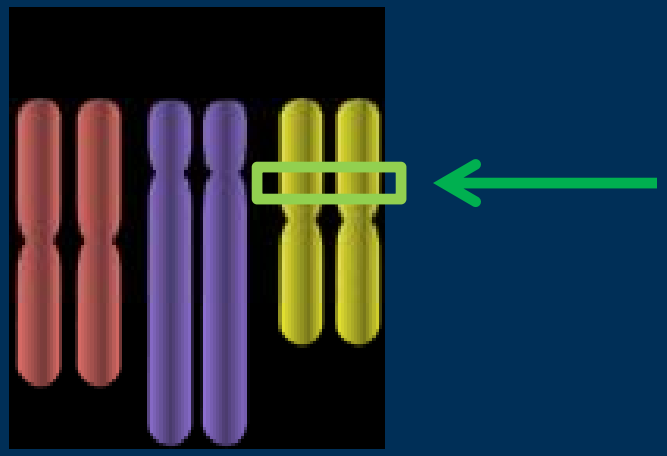
A Little Genetics….

- Diploid
- Locus (loci)



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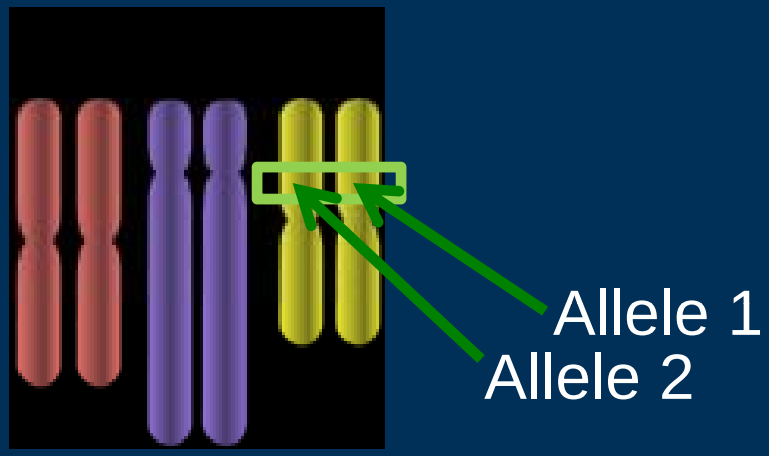
A Little Genetics….

- Diploid
- Locus (loci)
- Alleles



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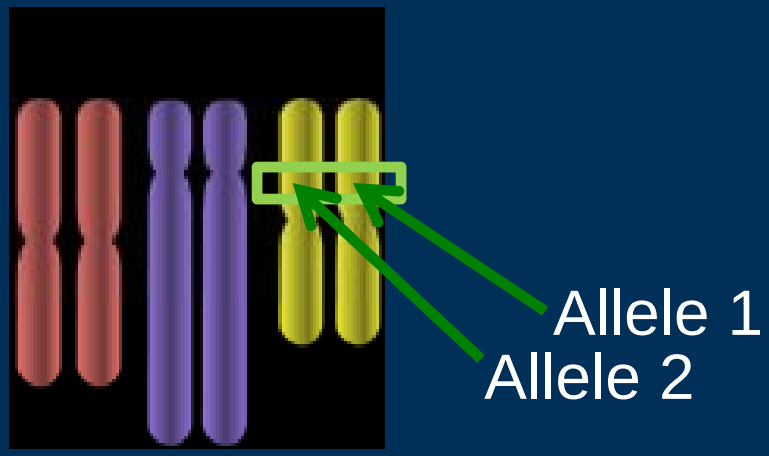
A Little Genetics….

- Diploid
- Locus (loci)
- Alleles
- Homozygous:
  - Allele 1 = Allele 2
- Heterozygous:
  - Allele 1 ≠ Allele 2



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Types of Markers…

- DNA Sequence
- SNPs
- Microsatellites
  - High mutation rate = high polymorphism
  - Selectively neutral
  - Using many markers covers more genome
  - 20 microsatellites analyzed here

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Classes of Analyses

- Cluster analyses
  - Individual-based
  - Infers number of clusters (K)
  - Multiple methods used to confirm results
    - STRUCTURE
    - GENELAND
- Landscape analyses
  - Groups of individuals
  - Genetic distance versus geographic distance
  - Intervening habitat
- Genetic diversity within clusters

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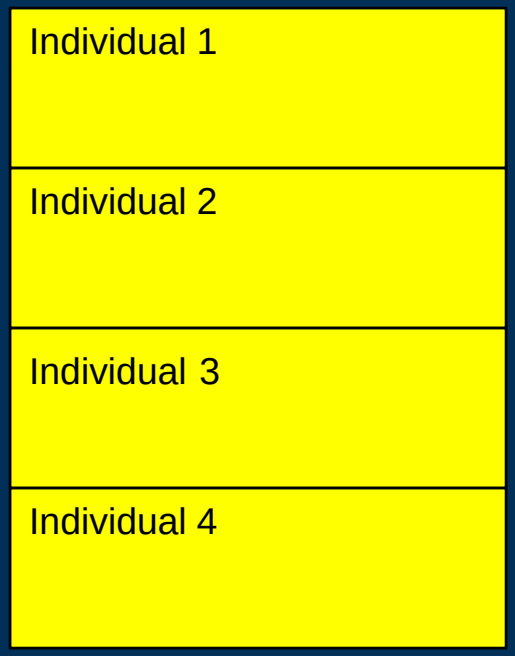
STRUCTURE



K = 1

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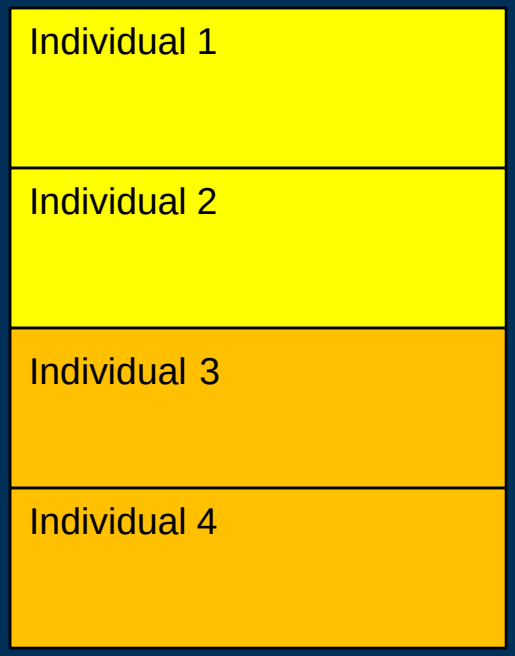
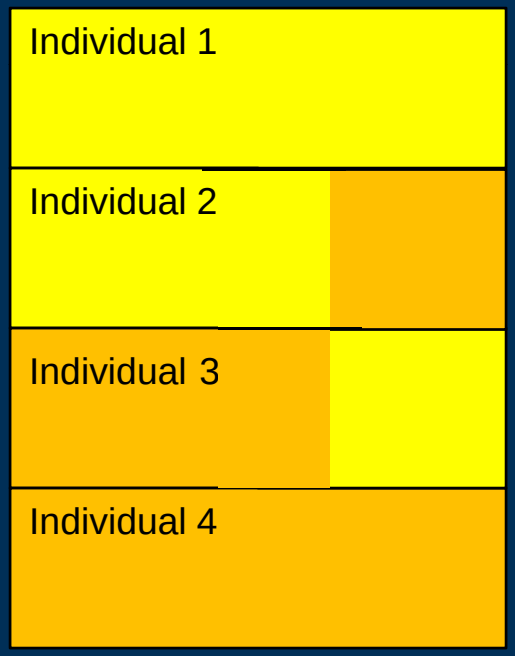
STRUCTURE



K = 2

USGS

STRUCTURE



K = 2

Admixture:

- Recent gene flow
- Common ancestry

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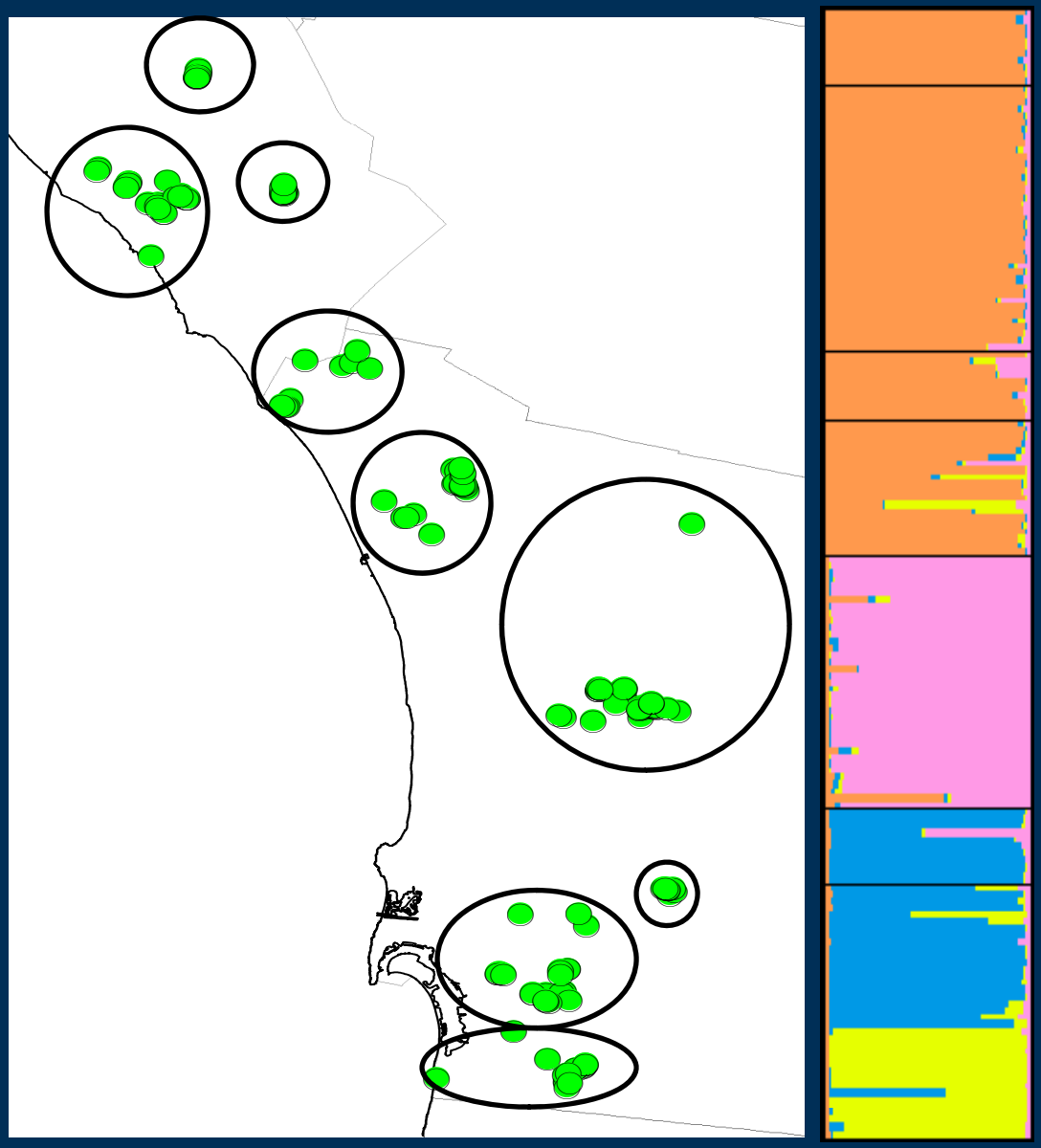
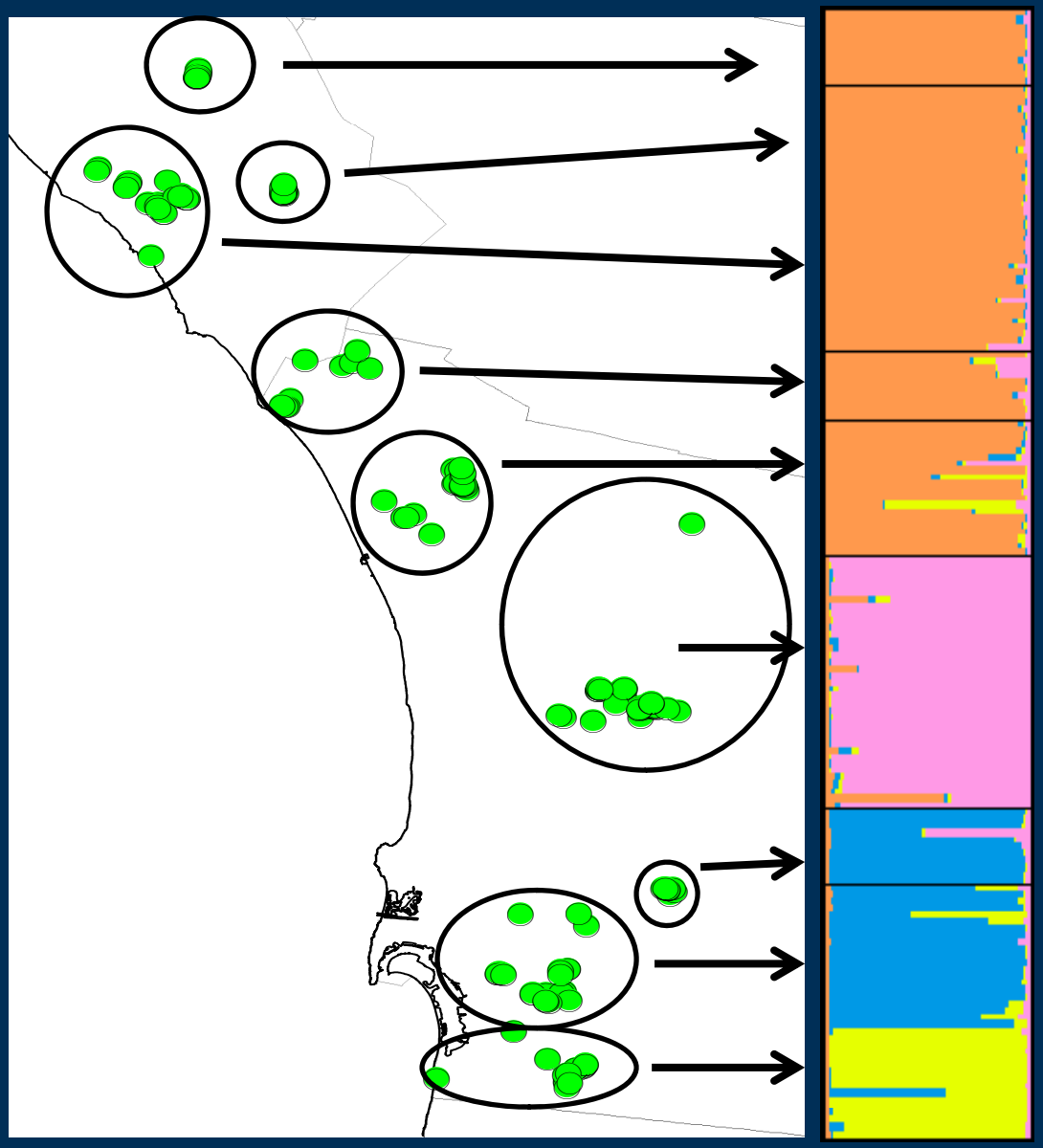


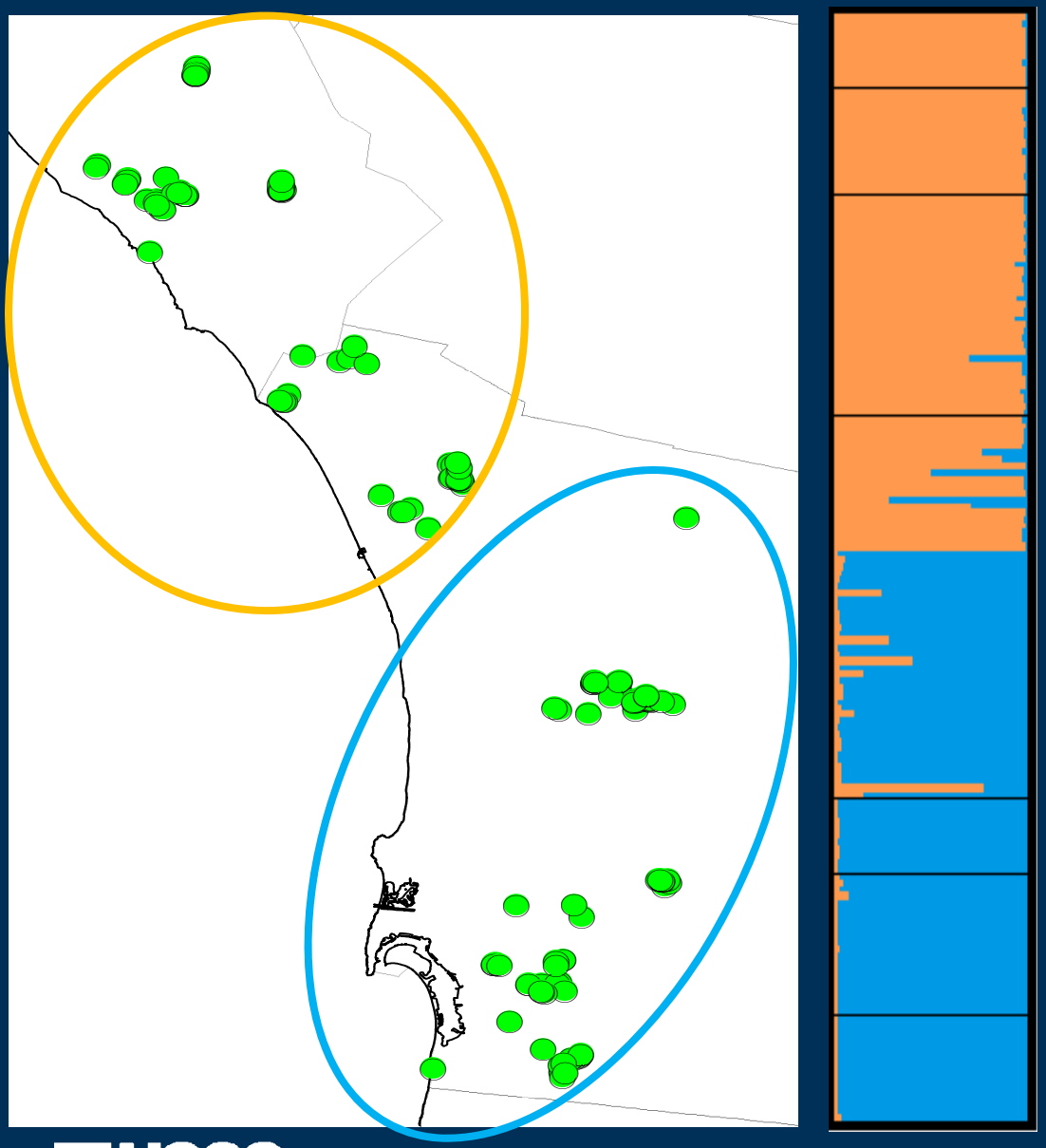
USGS

K = 4

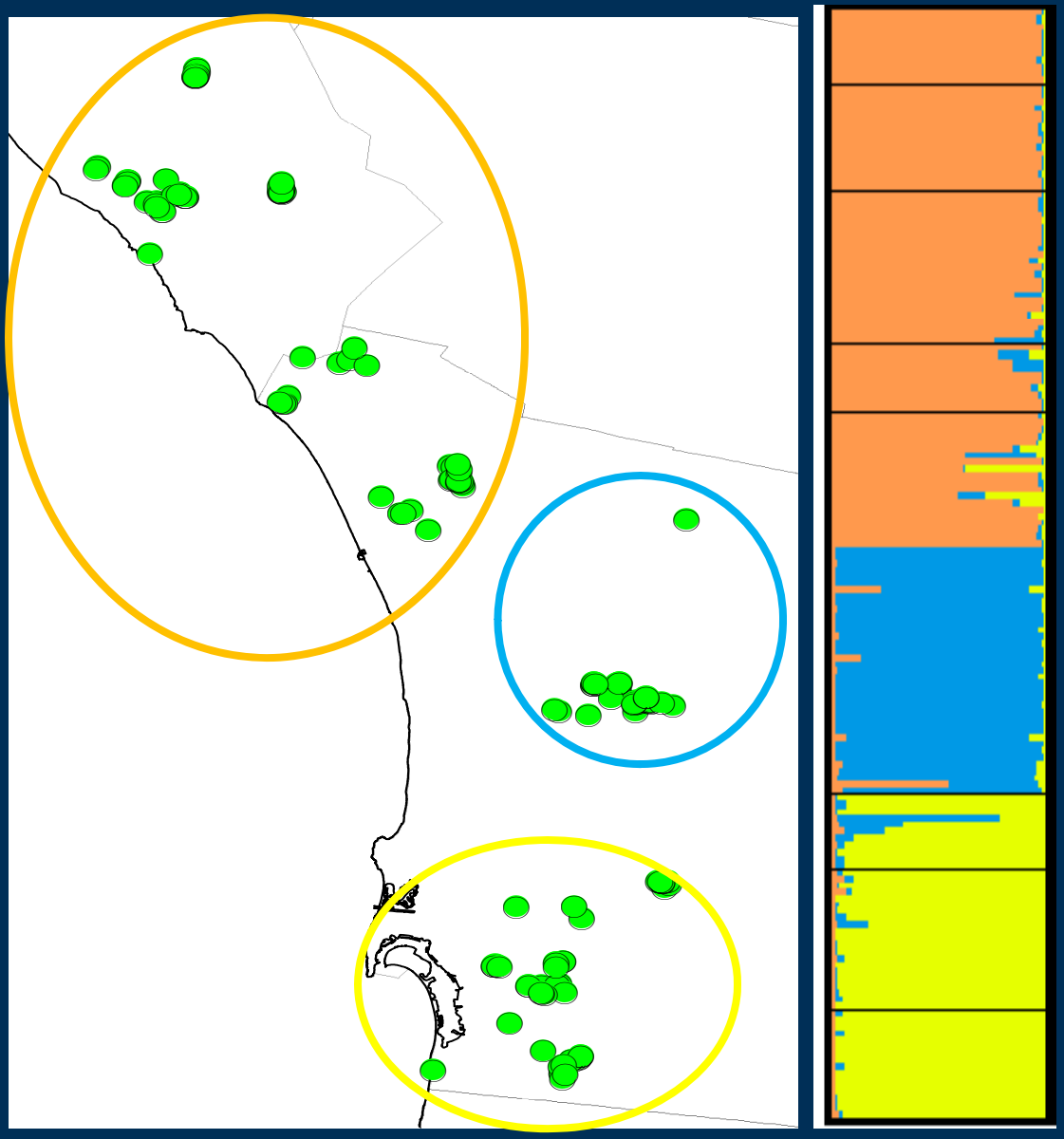


USGS

K = 4

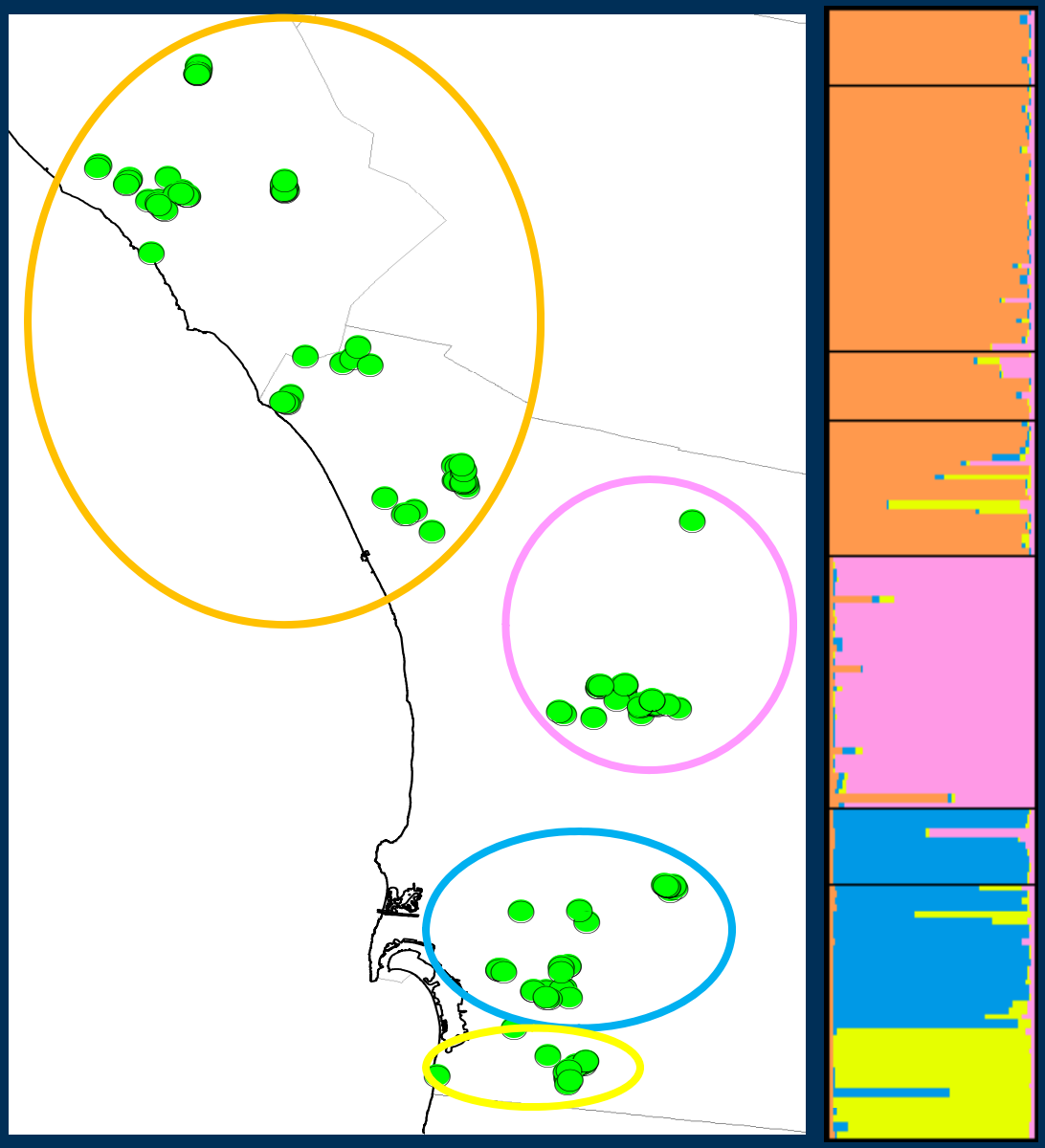


K = 2



USGS

K = 3



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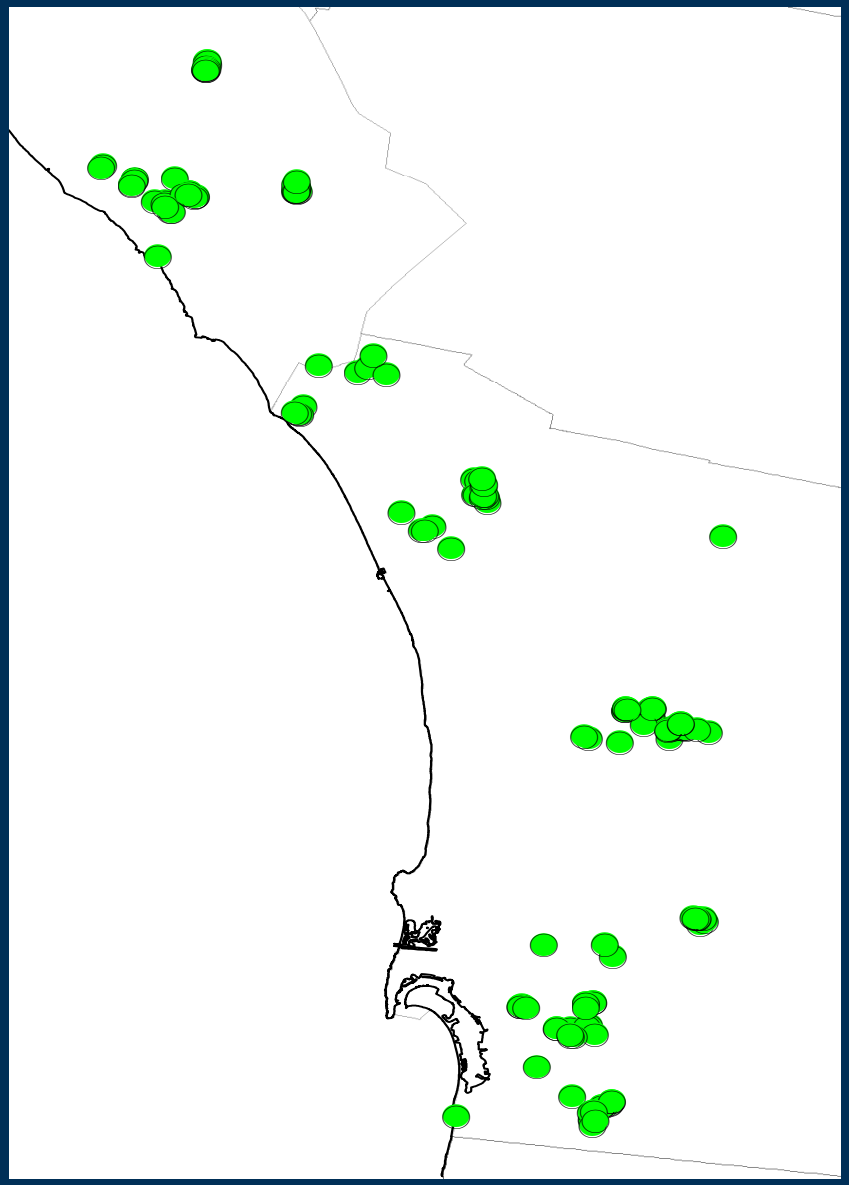
K = 4



GENELAND

- Individual-based cluster analysis
- Considers a spatial component

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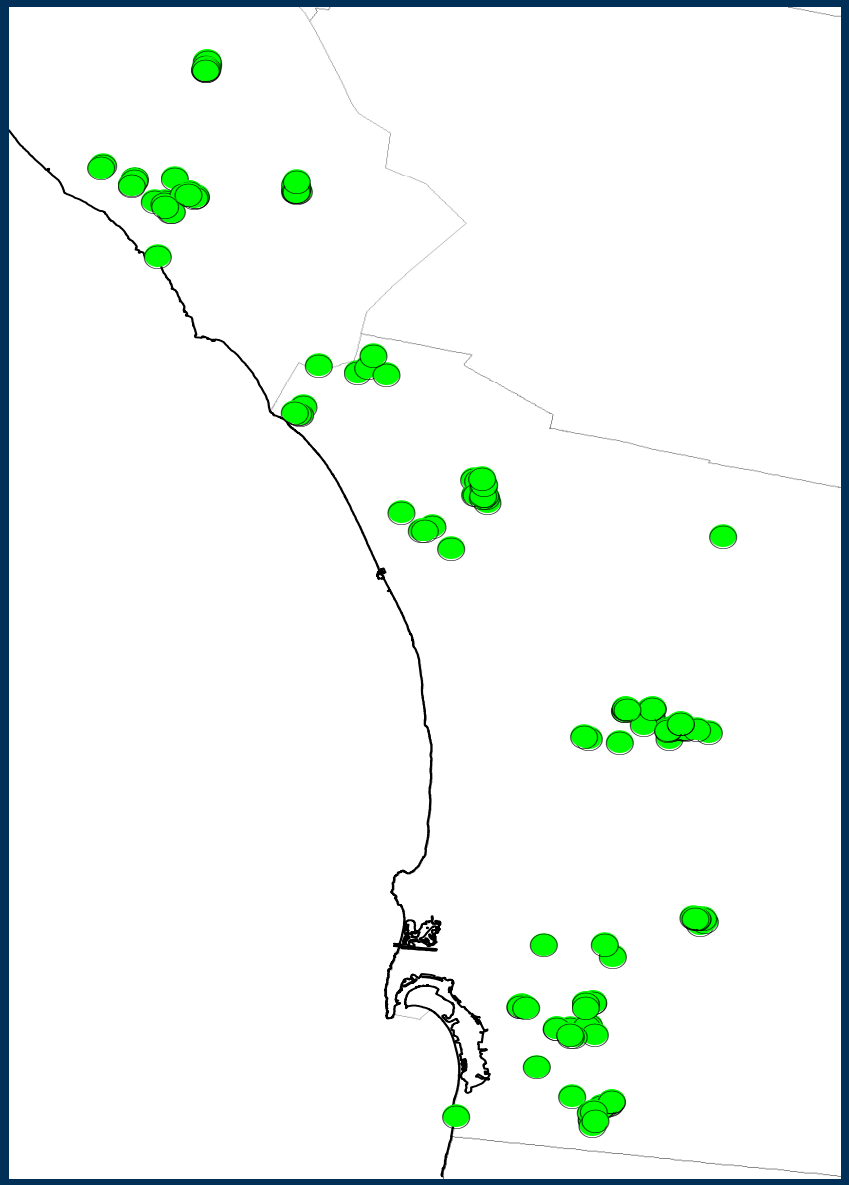

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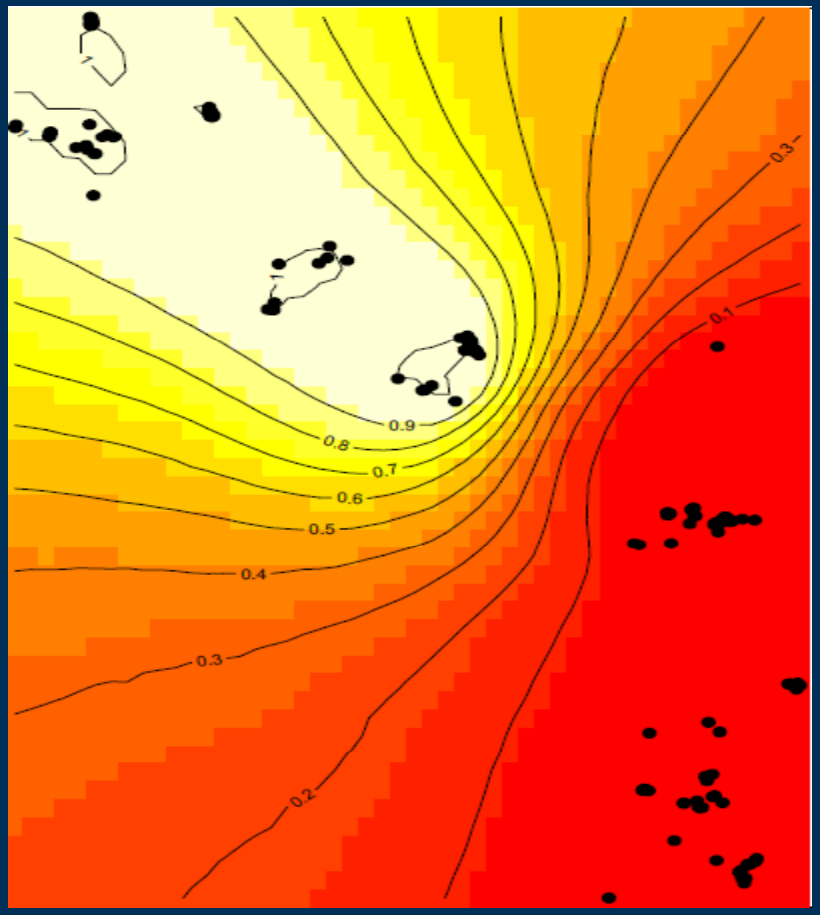

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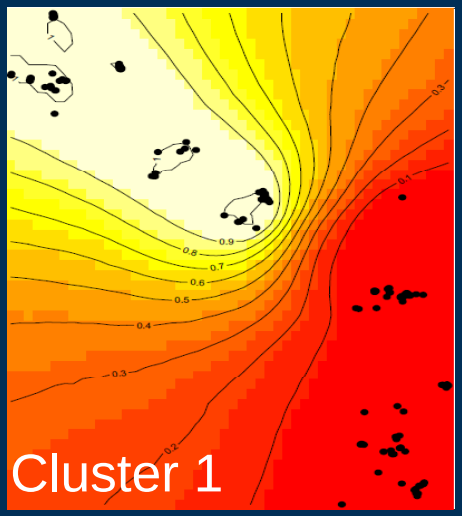

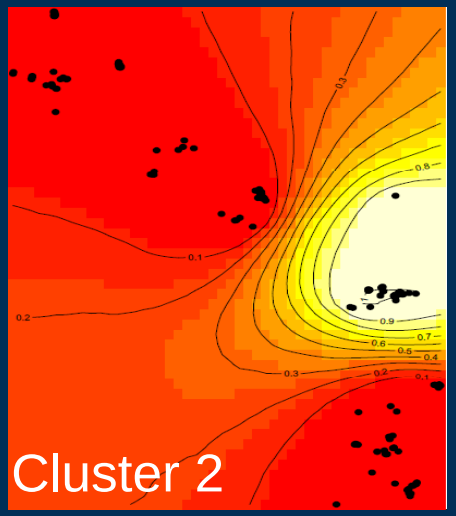

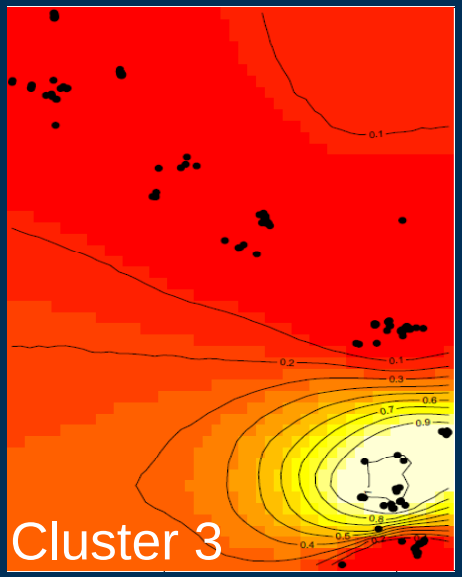

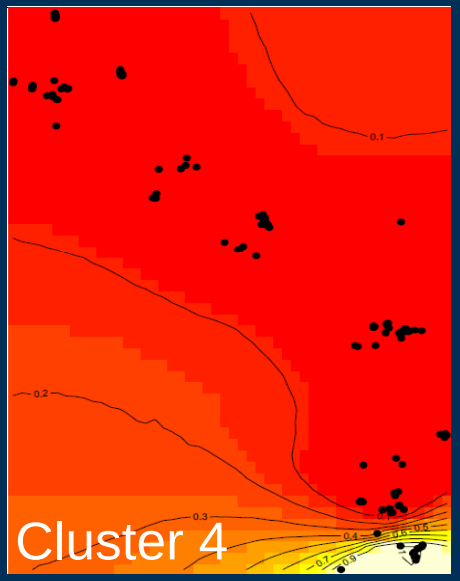

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Landscape Perspective?

- F_{ST}
  - Genetic differentiation between groups
  - Scales 0 to 1
    - 0 = no genetic differences

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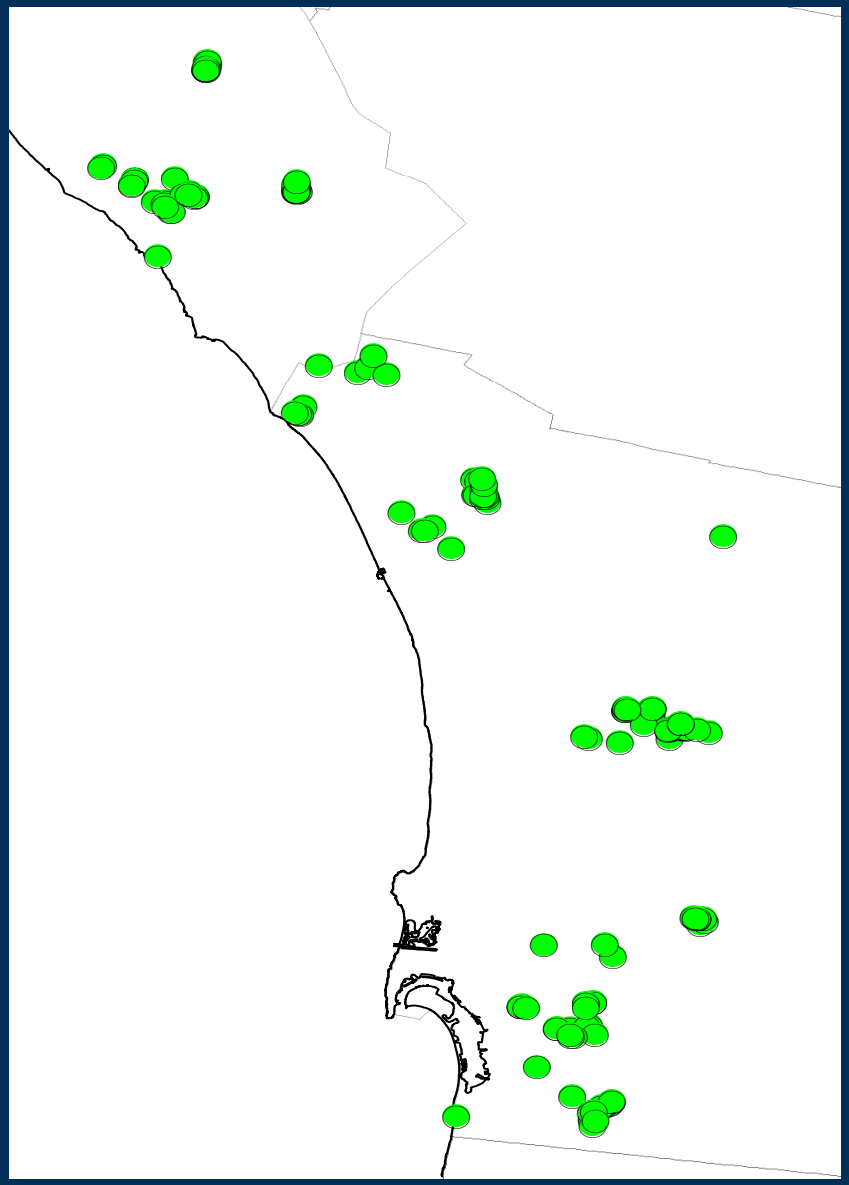

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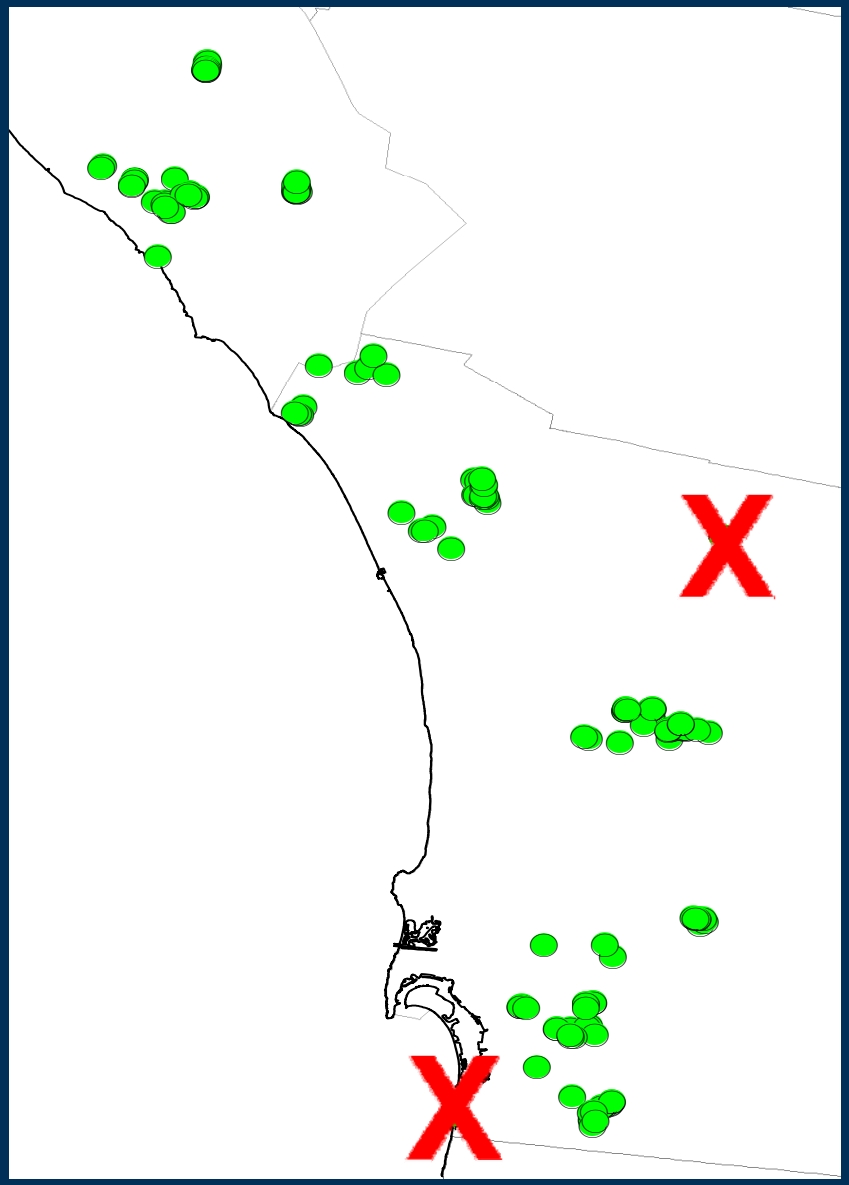

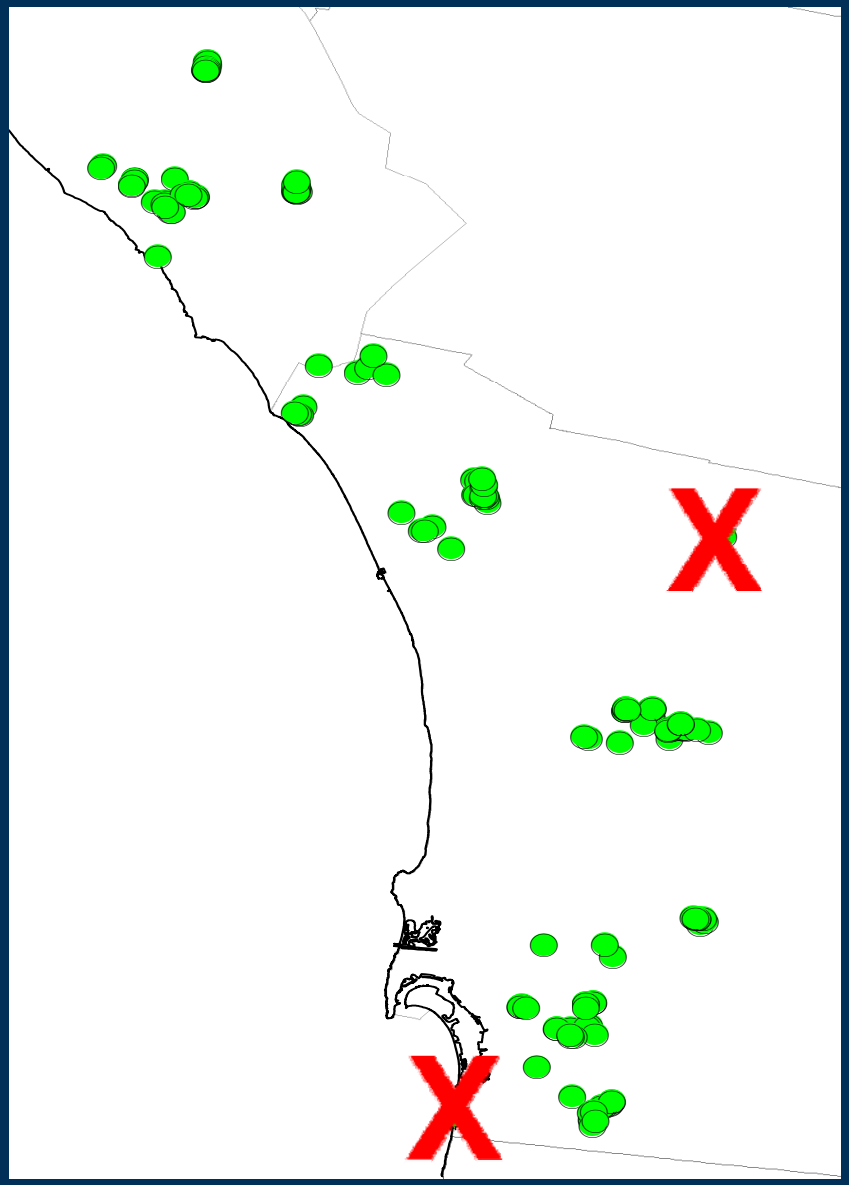

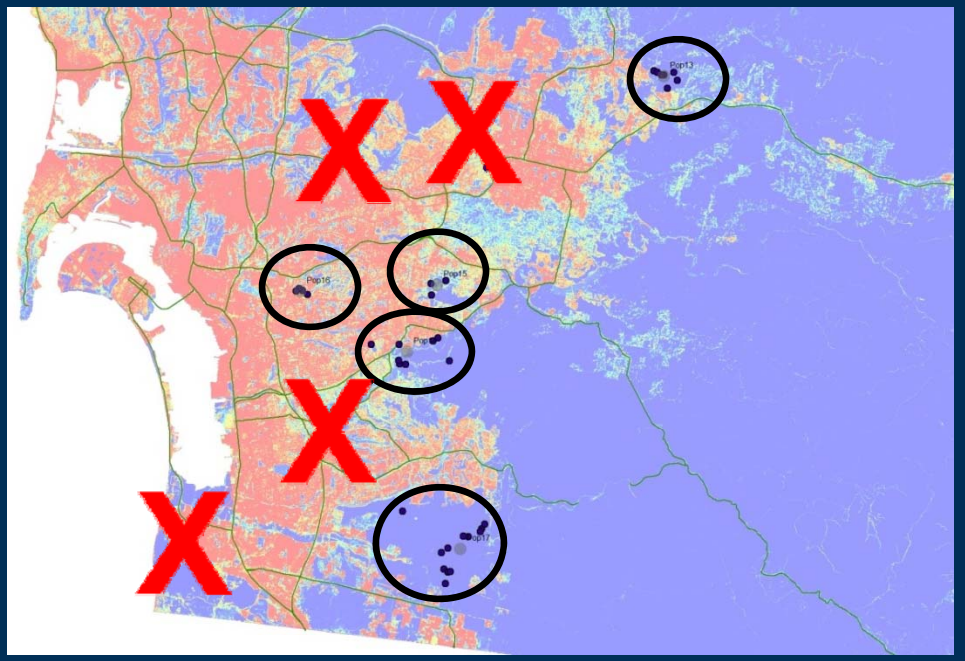

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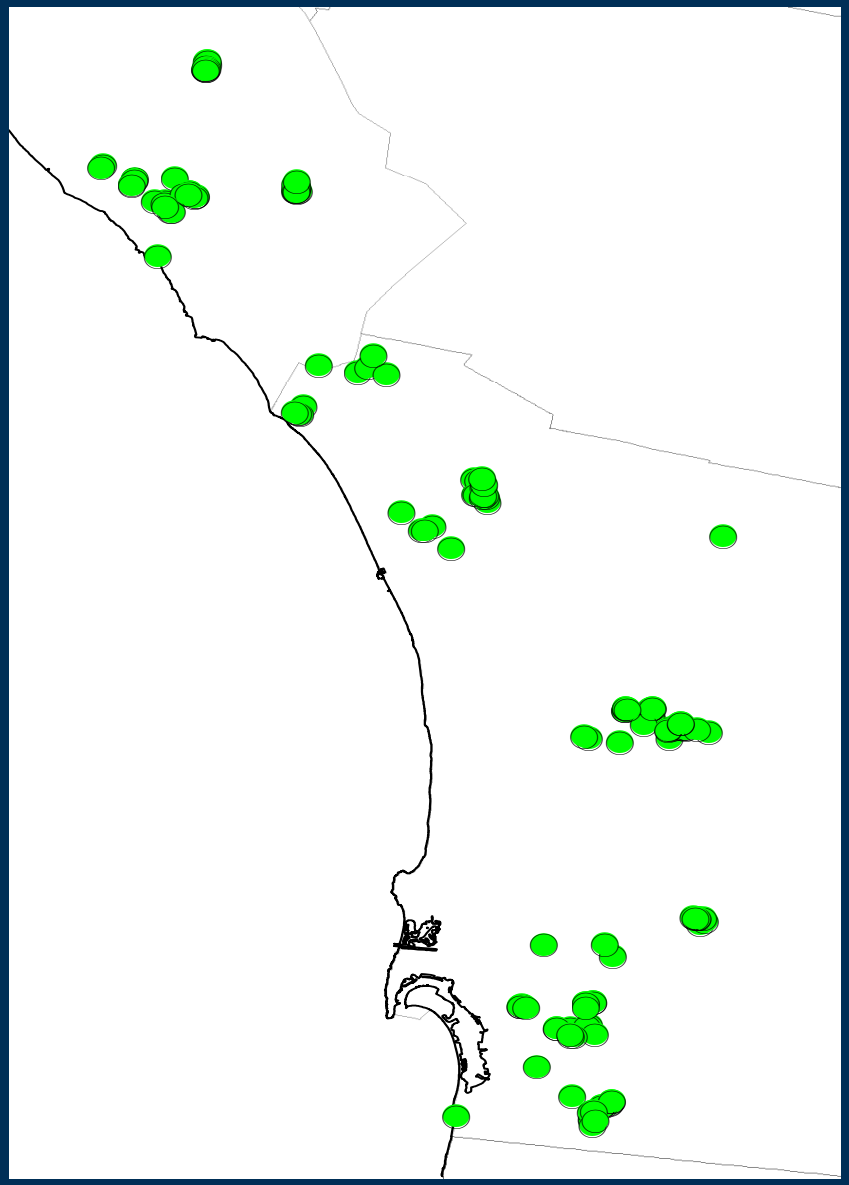

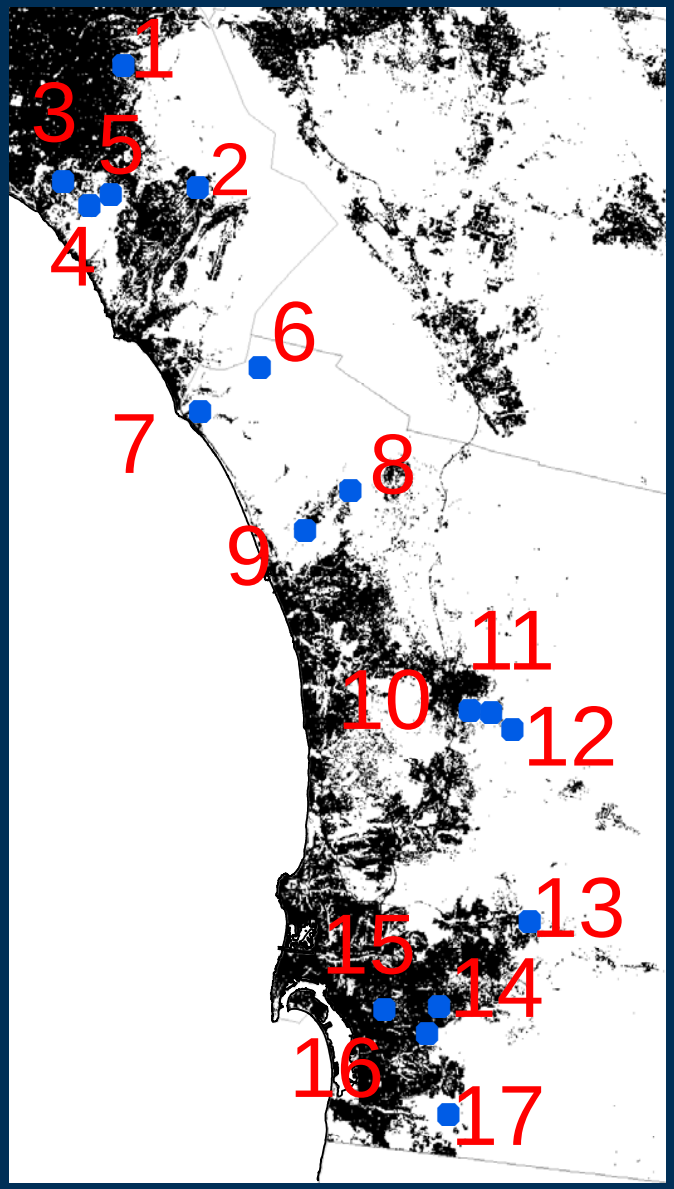

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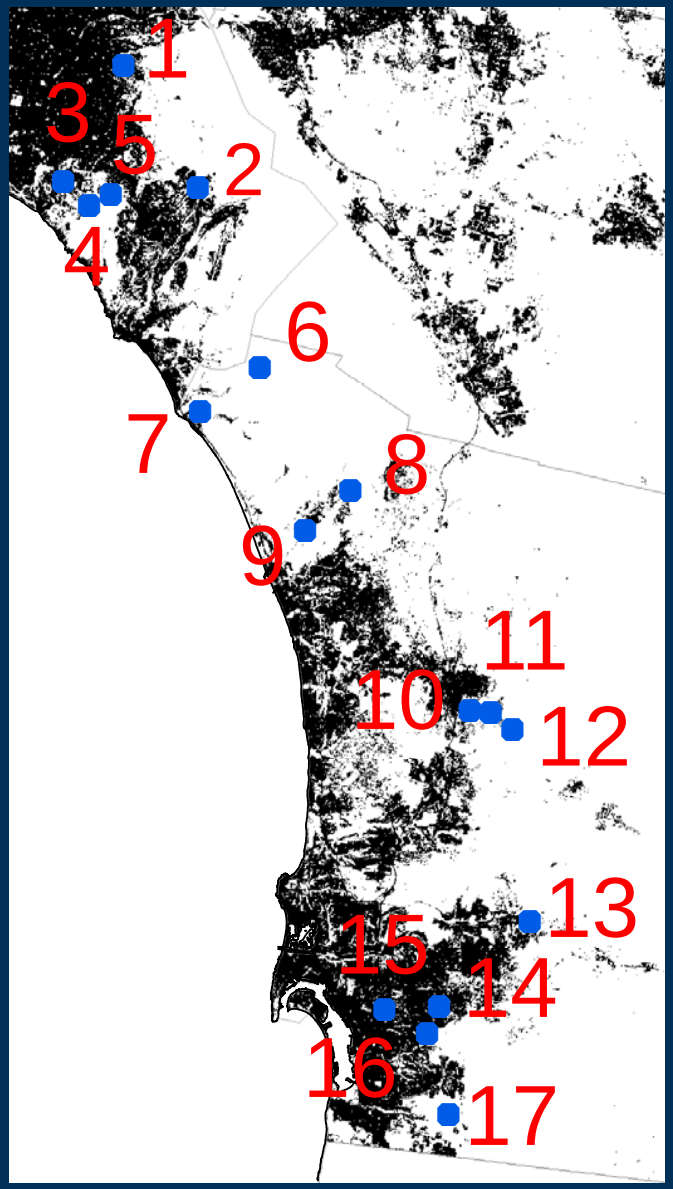

F_{ST}?

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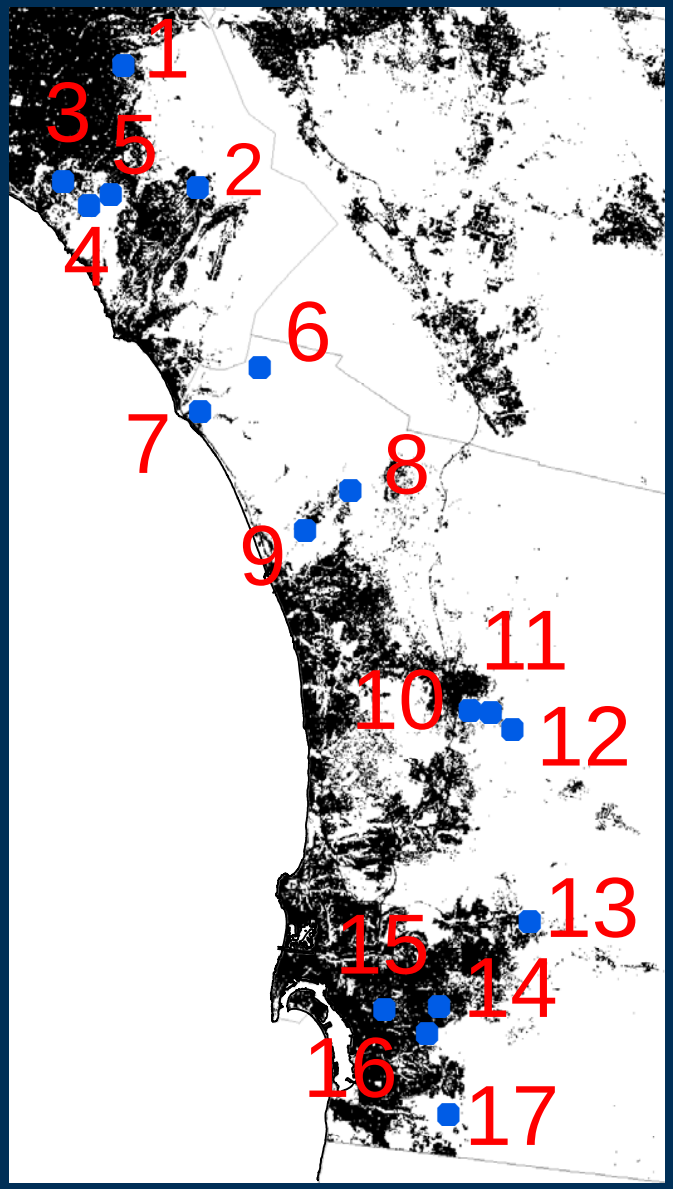
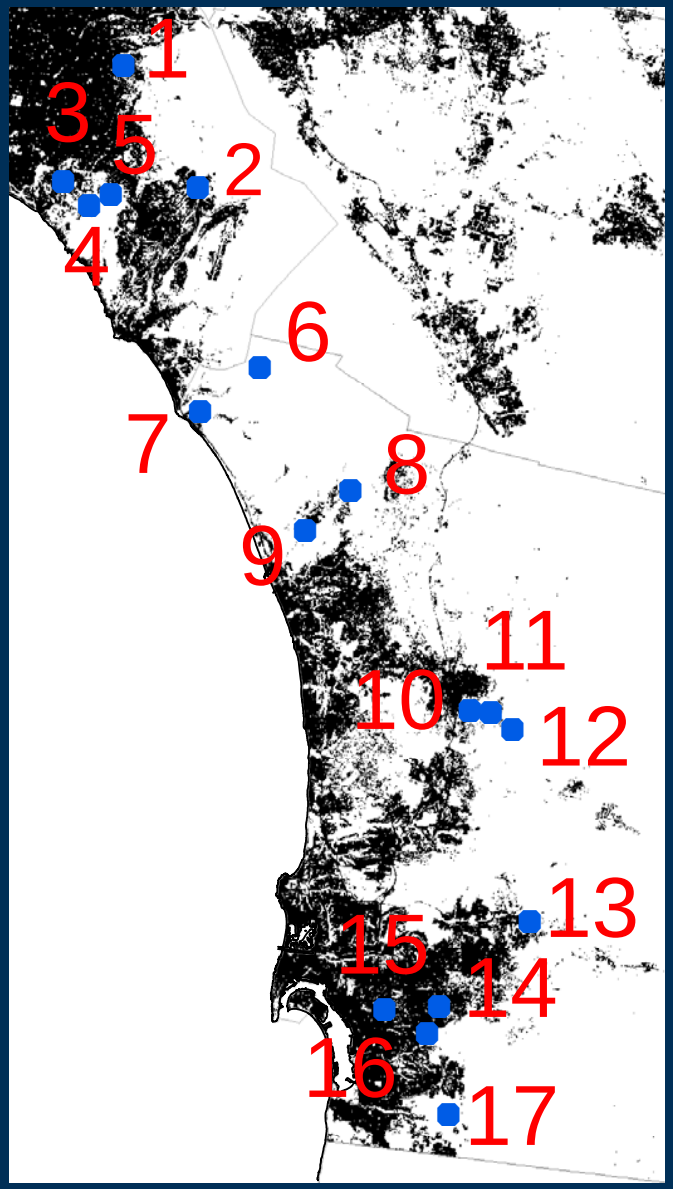
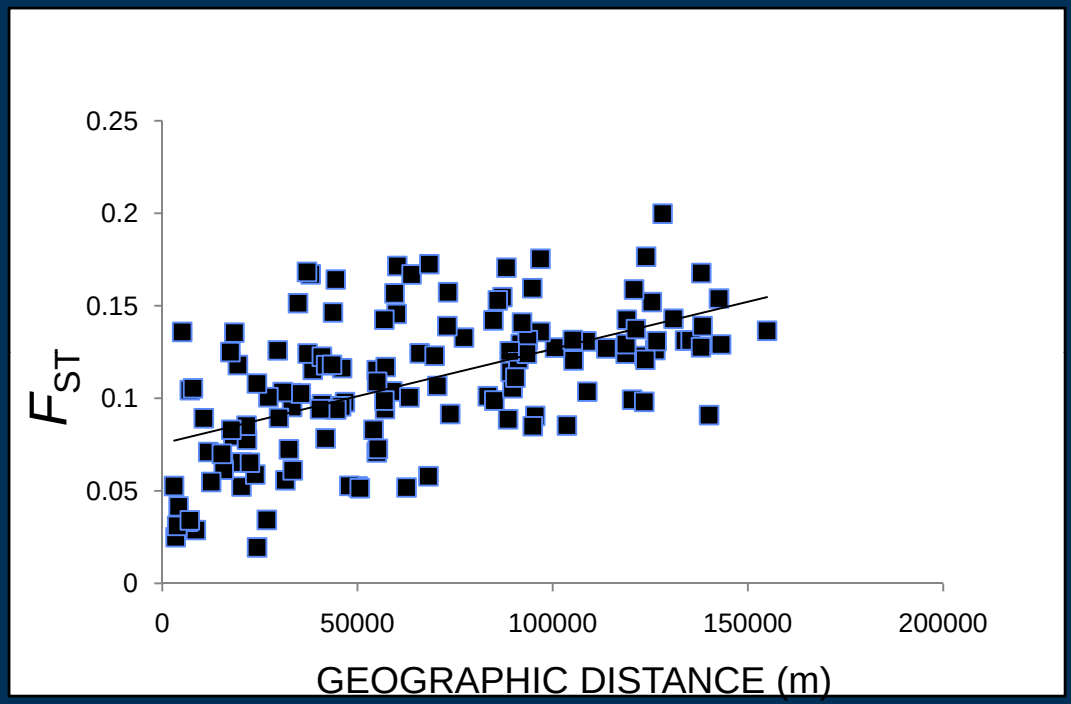


F_{ST} = 0.019 to 0.2

USGS

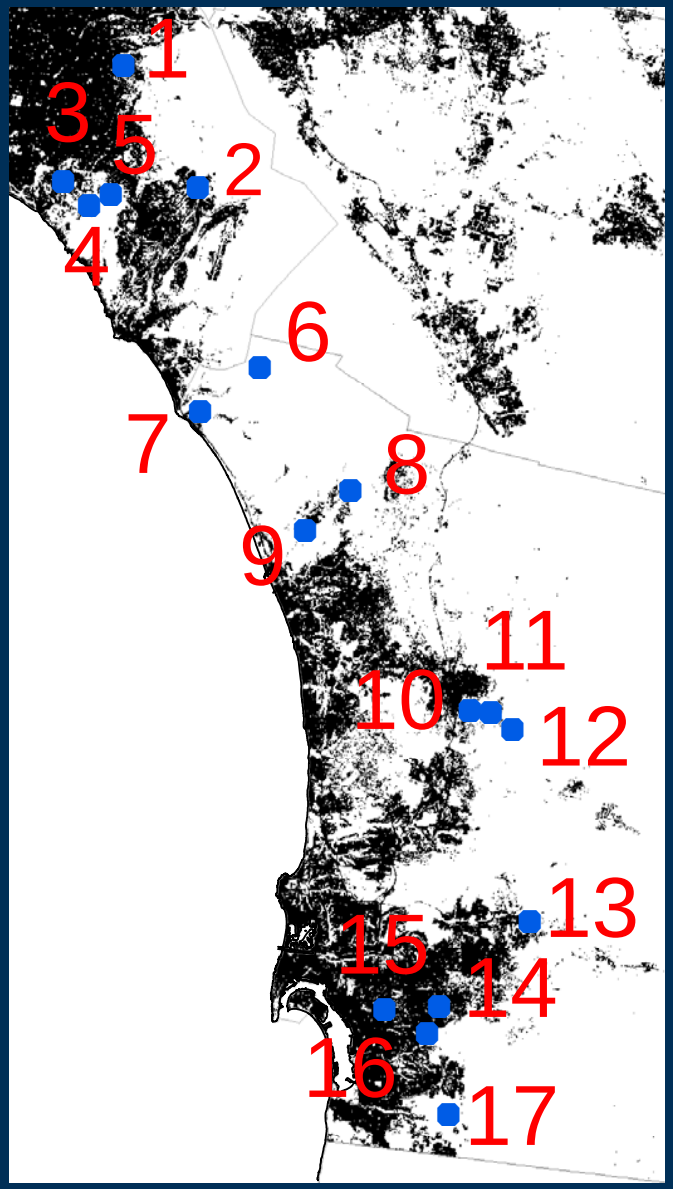


F_{ST} = 0.019 to 0.2

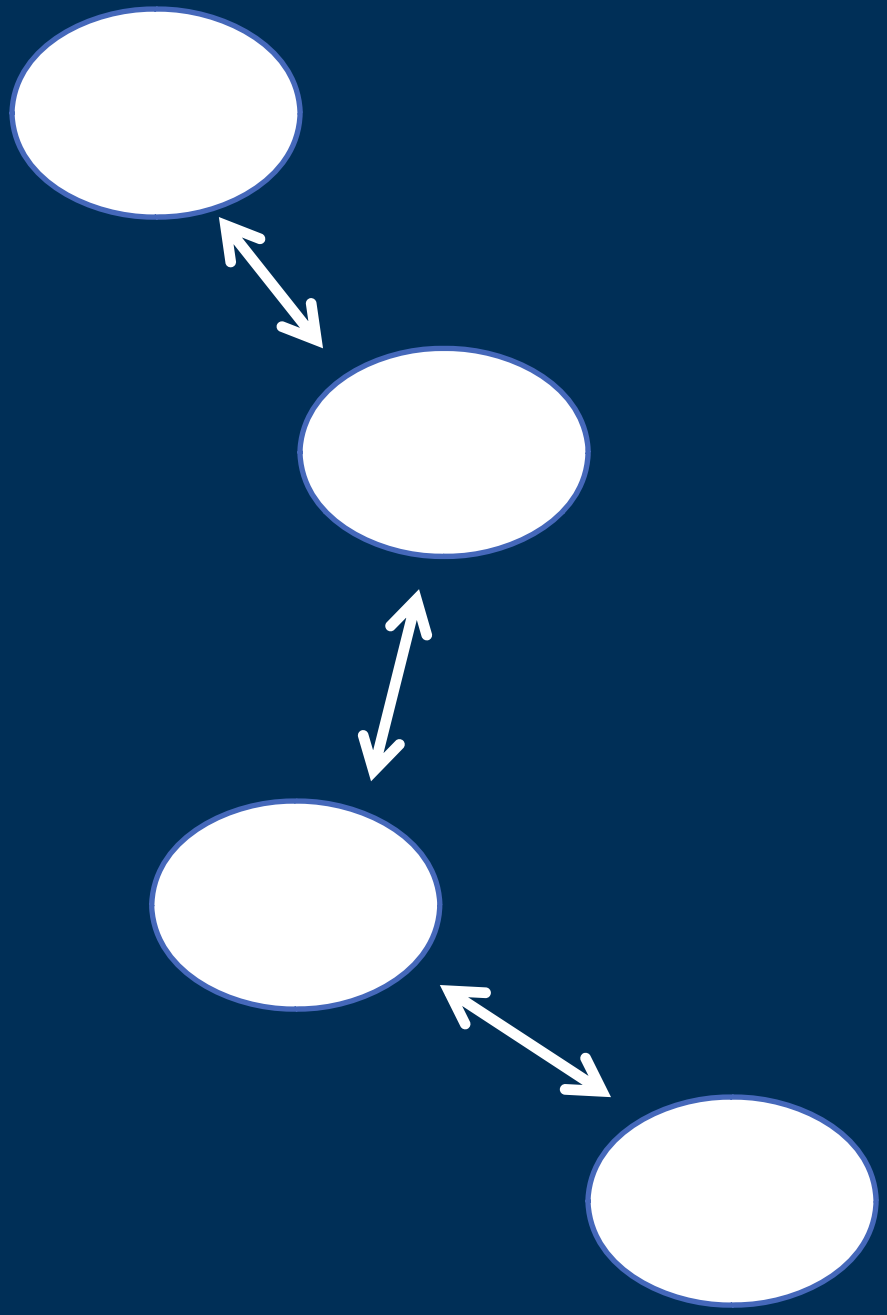


P < 0.001

USGS



STEPPING STONE GENE FLOW



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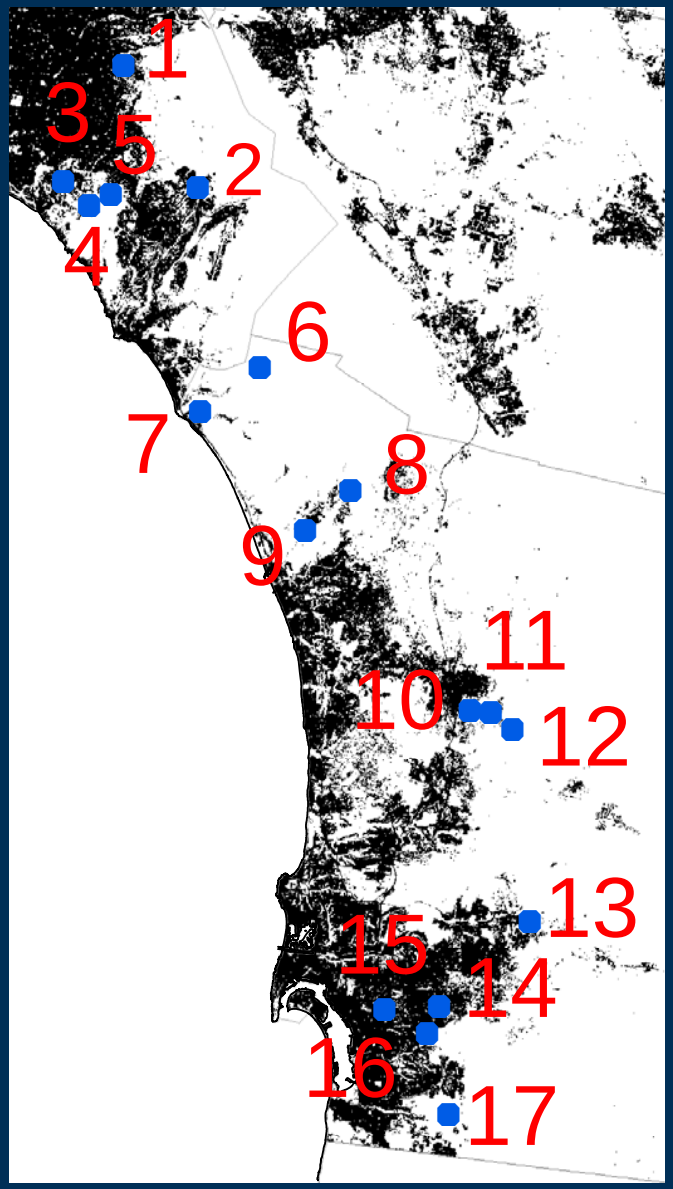
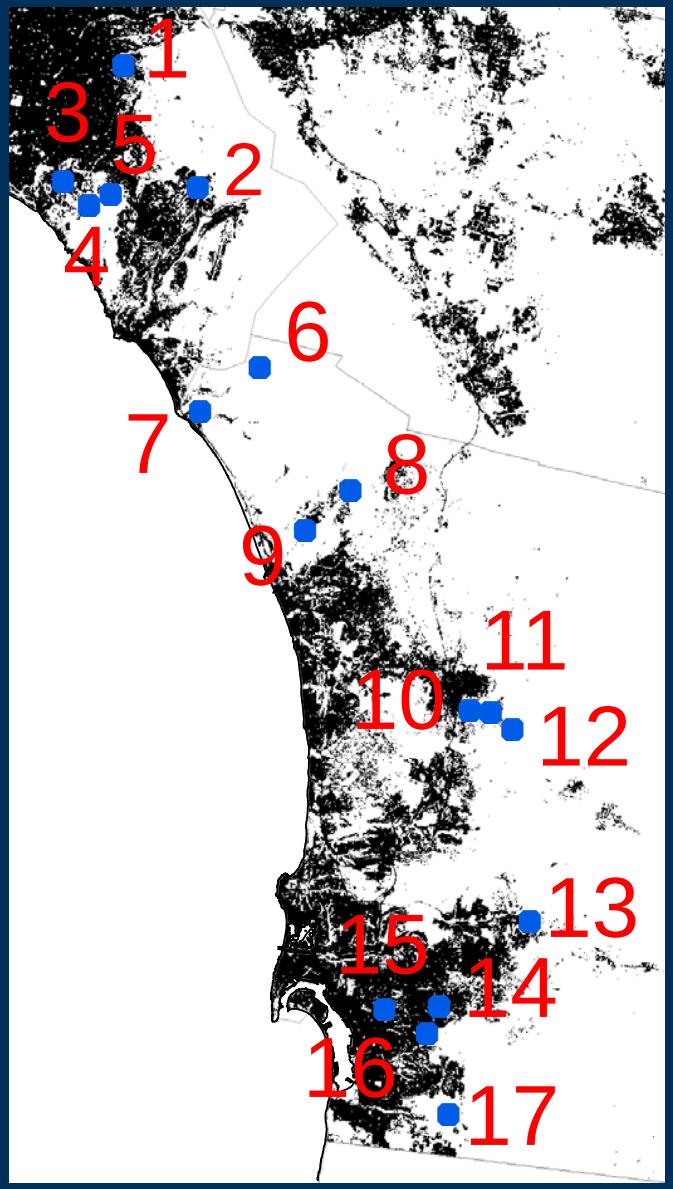


Does anything else explain differentiation other than geographic distance?

USGS



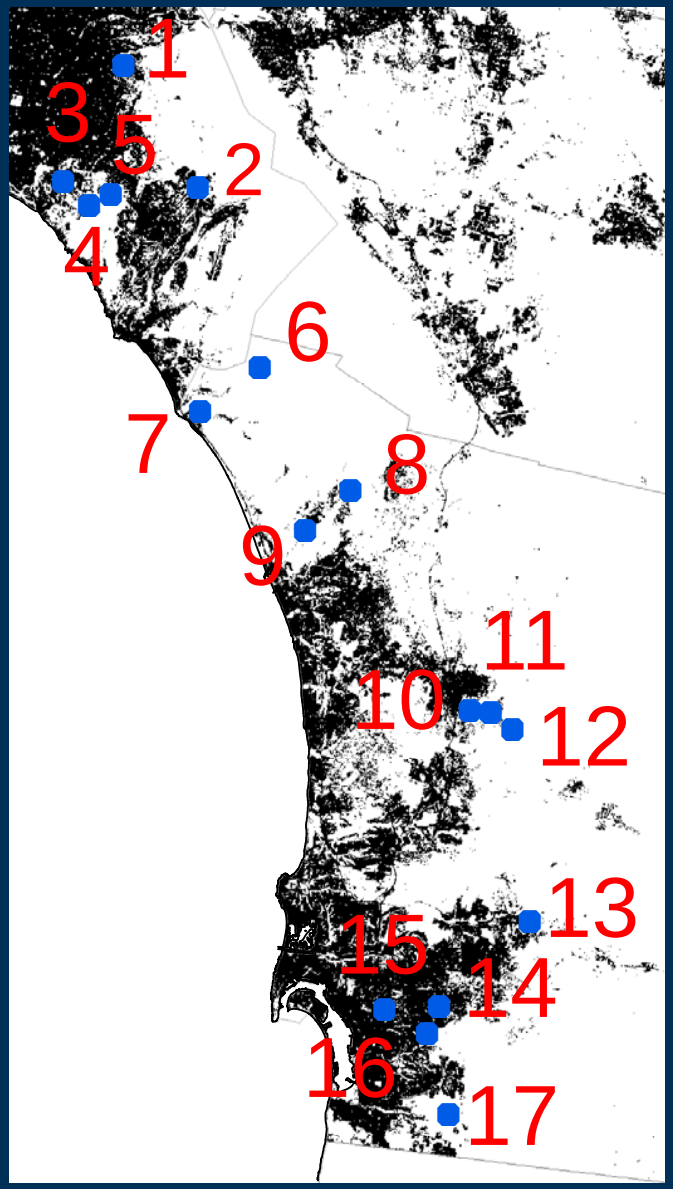
Does anything else explain differentiation other than geographic distance?

Pairwise matrix

0 = no fragmentation

1 = fragmented

USGS



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Differentiation versus geo dist:

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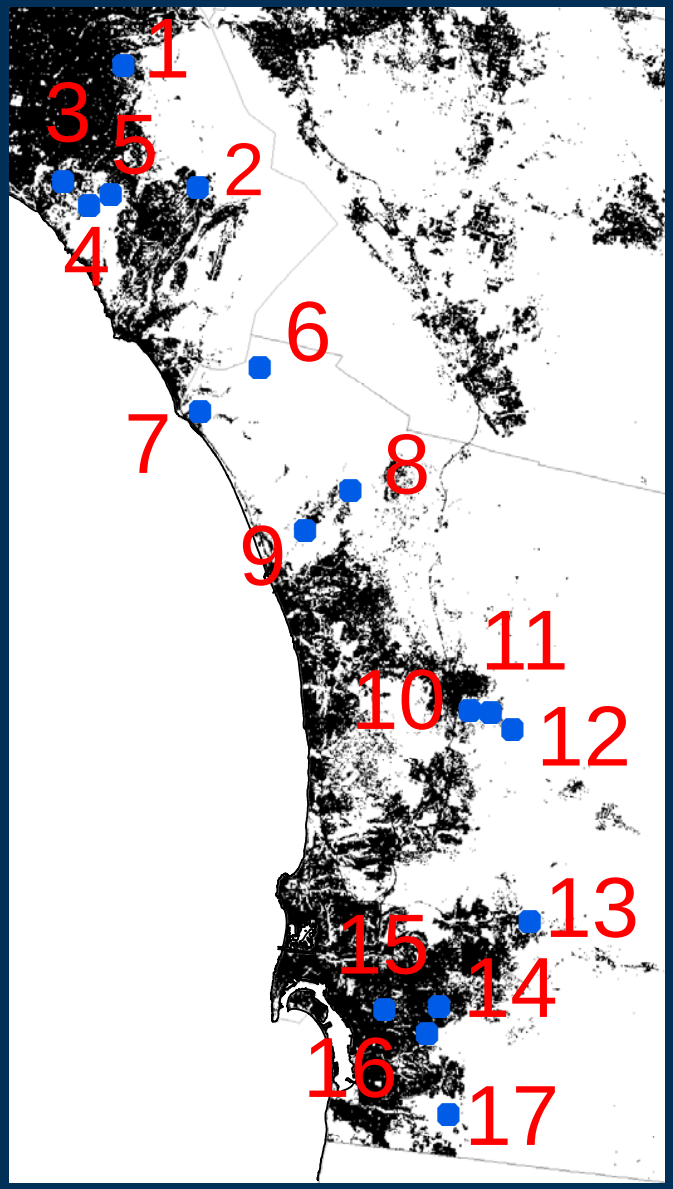
USGS



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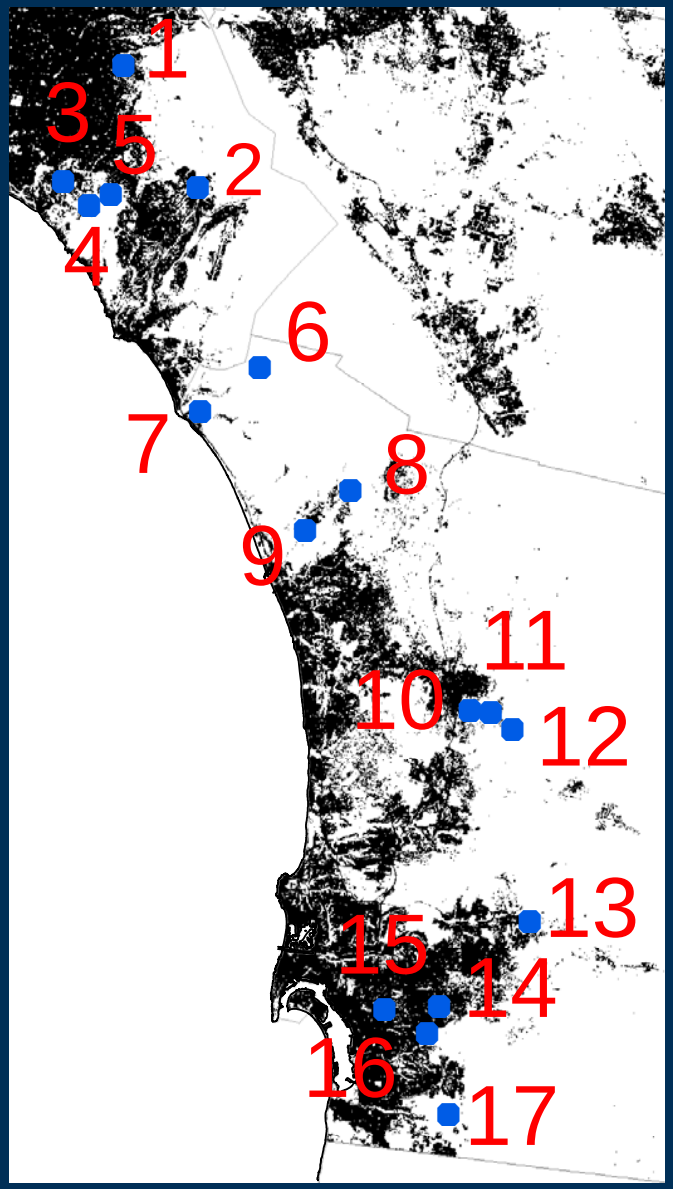

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Differentiation versus fragmentation:

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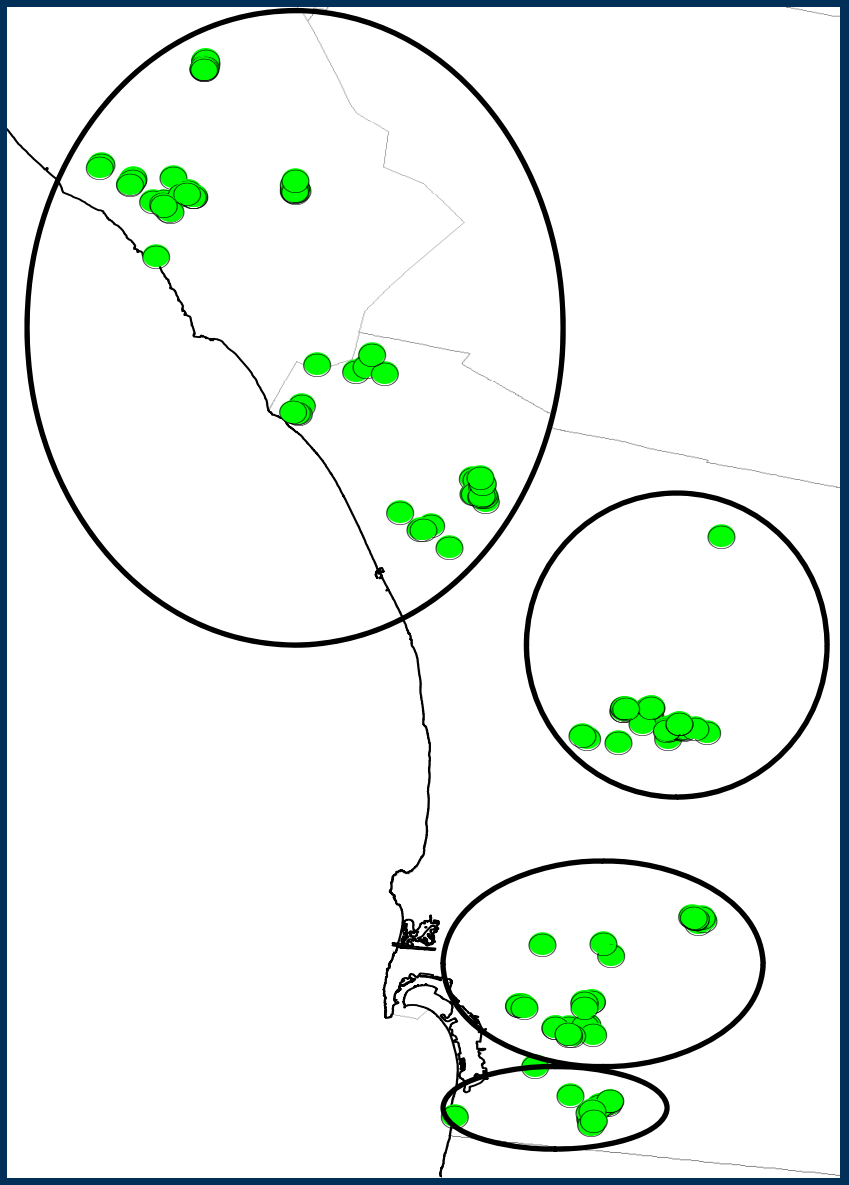
Differentiation vs. frag. (controlling for geo dist):

$p = 0.0001$

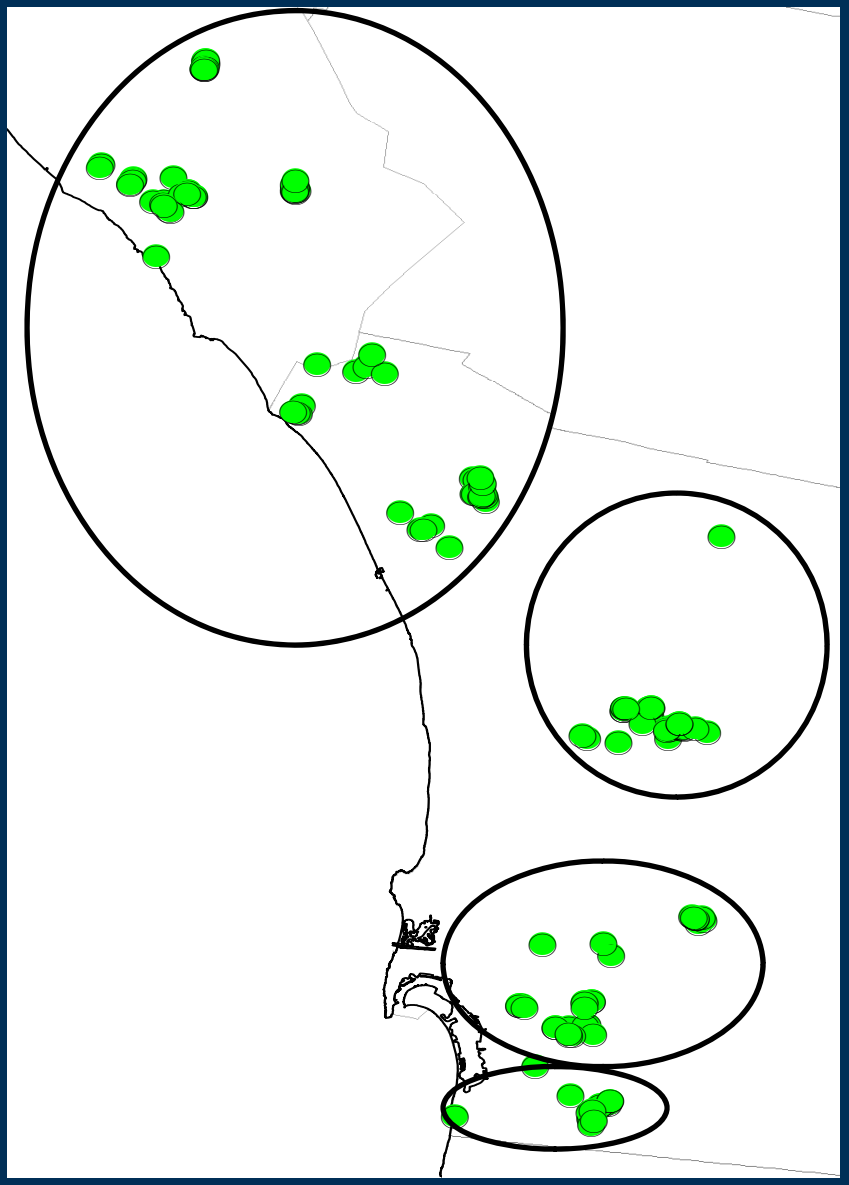
USGS



GENETIC DIVERSITY

Cluster	Samples
OC-PEN	80
PASQUAL	37
SD	32
OTAY	16

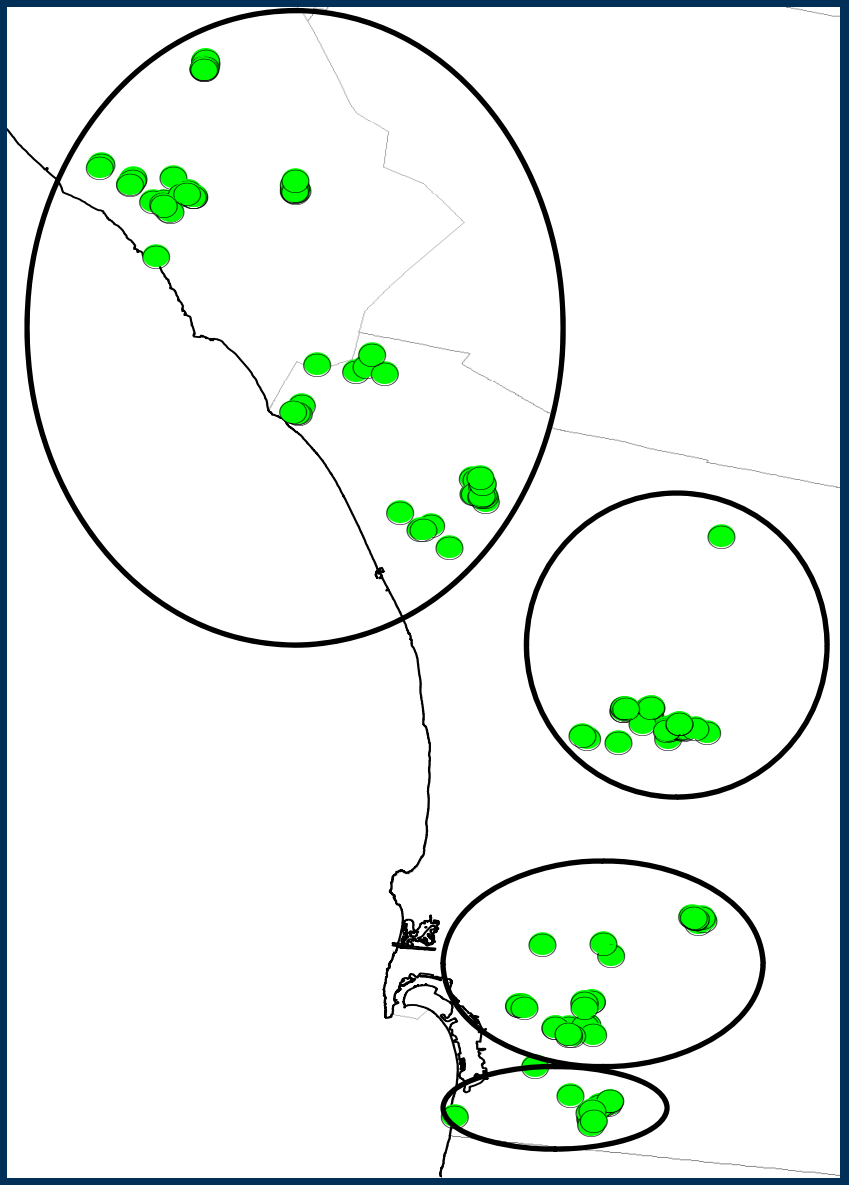
USGS



GENETIC DIVERSITY

Cluster	Samples	H_E	*A*
OC-PEN	80	0.64	5.5
PASQUAL	37	0.66	5.1
SD	32	0.63	5.4
OTAY	16	0.65	5.0

USGS

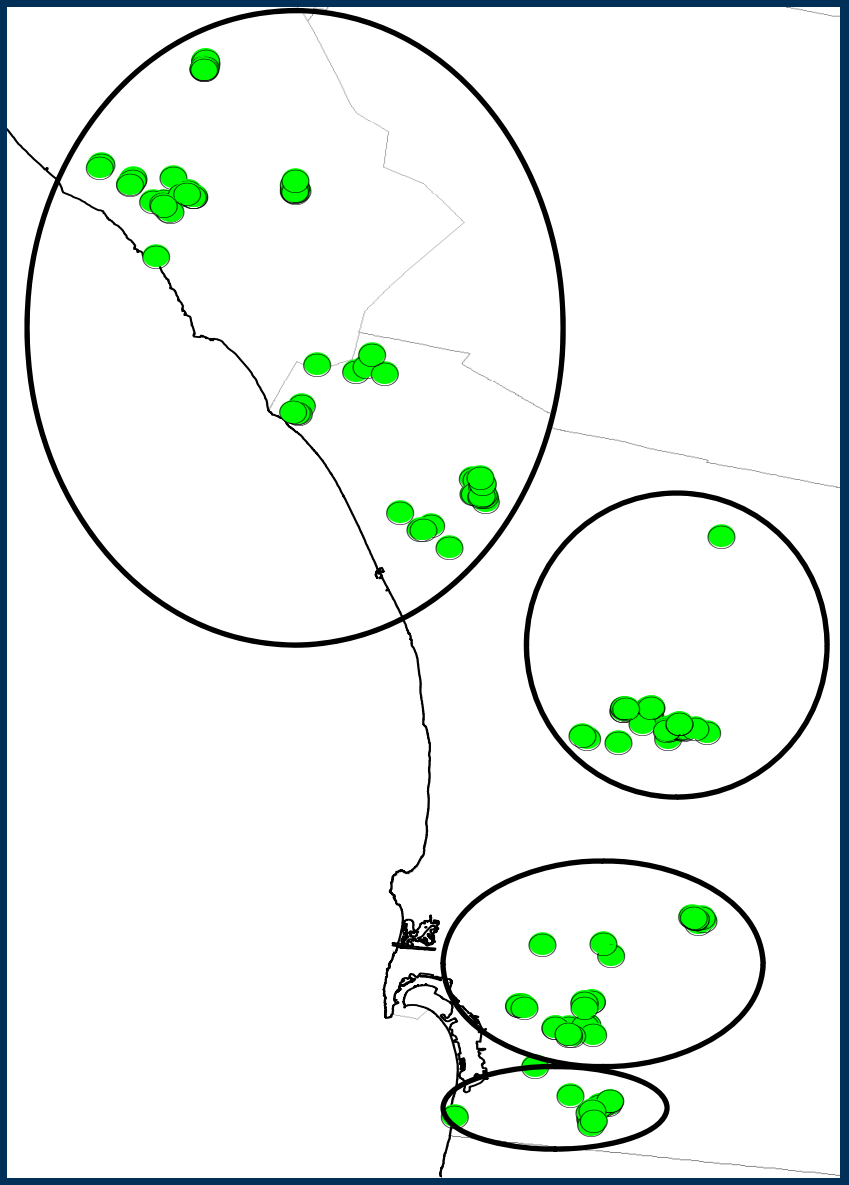


GENETIC DIVERSITY

Cluster	Samples	H_E	*A*	Ne
OC-PEN	80	0.64	5.5	94 (68 - 129)
PASQUAL	37	0.66	5.1	52 (33 - 84)
SD	32	0.63	5.4	59 (40 - 91)
OTAY	16	0.65	5.0	34 (18 - 92)

Ne << Nc

USGS



GENETIC DIVERSITY

Cluster	Samples	H_E	*A*	Ne
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PASQUAL*	37	0.66	5.1	52 (33 - 84)
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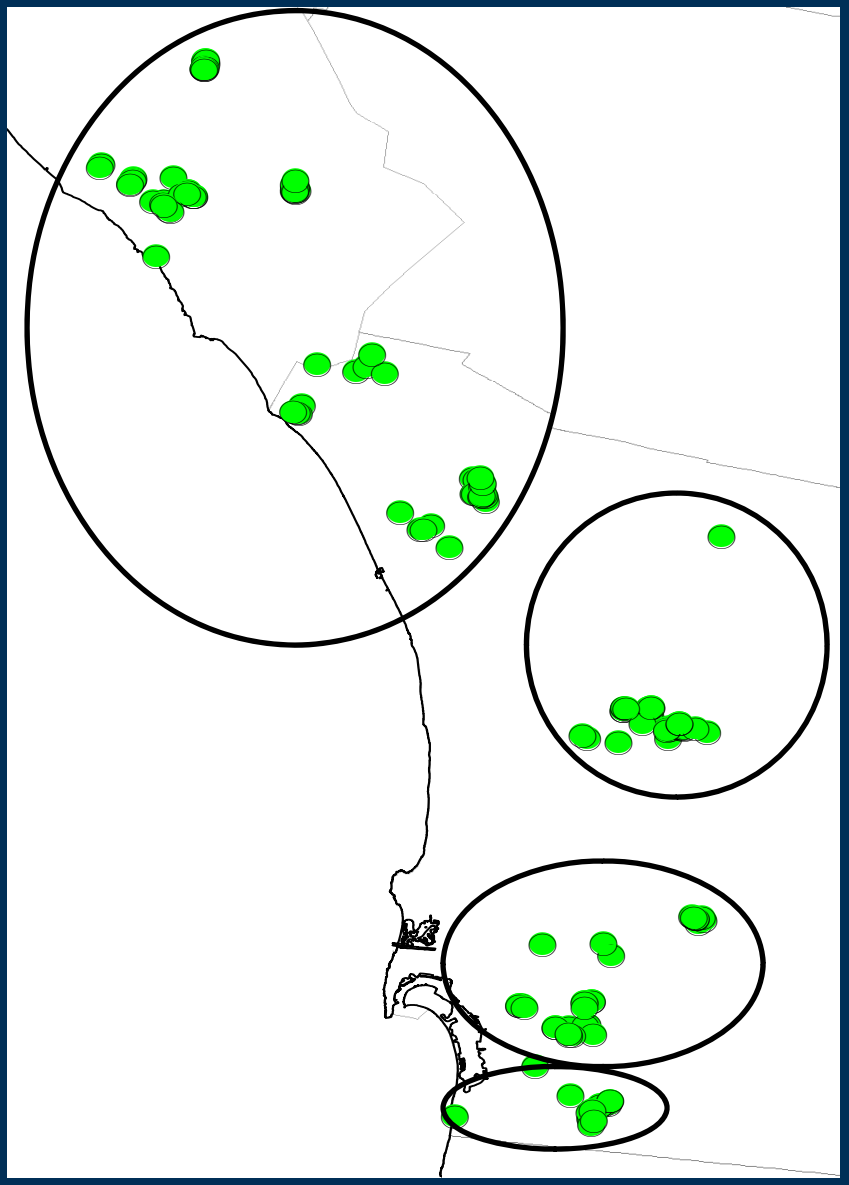
OTAY*	16	0.65	5.0	34 (18 - 92)

Bottleneck*

USGS

TAKE HOME MESSAGES……

USGS



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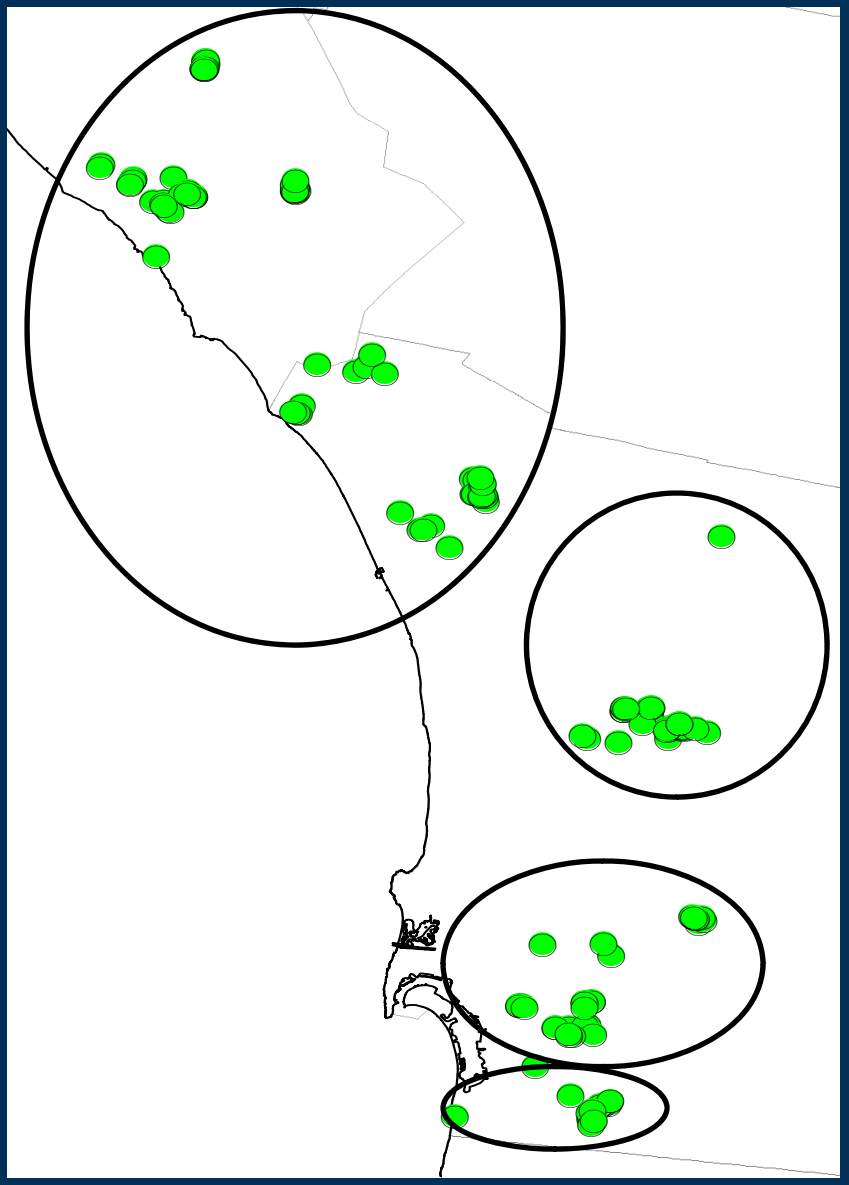

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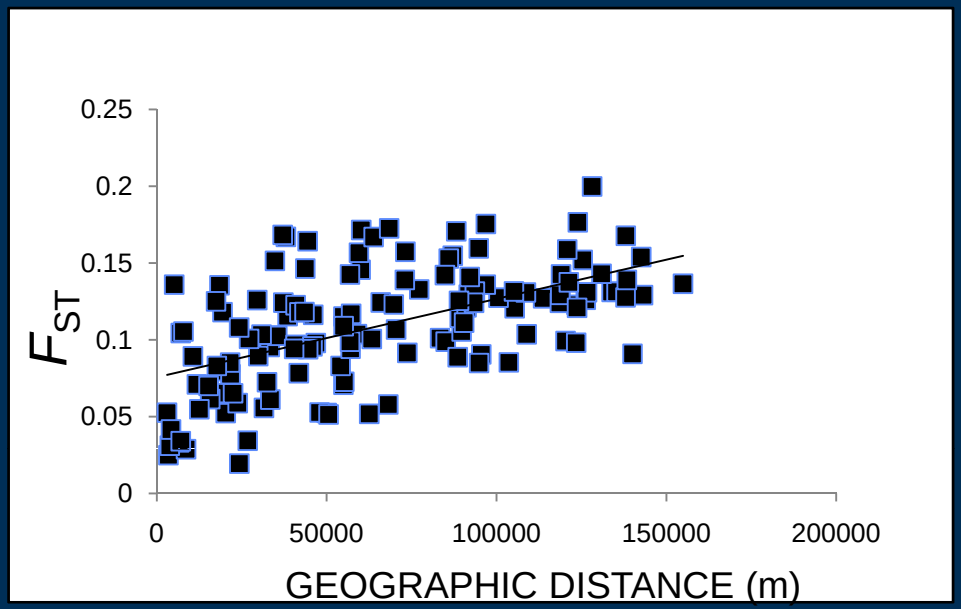
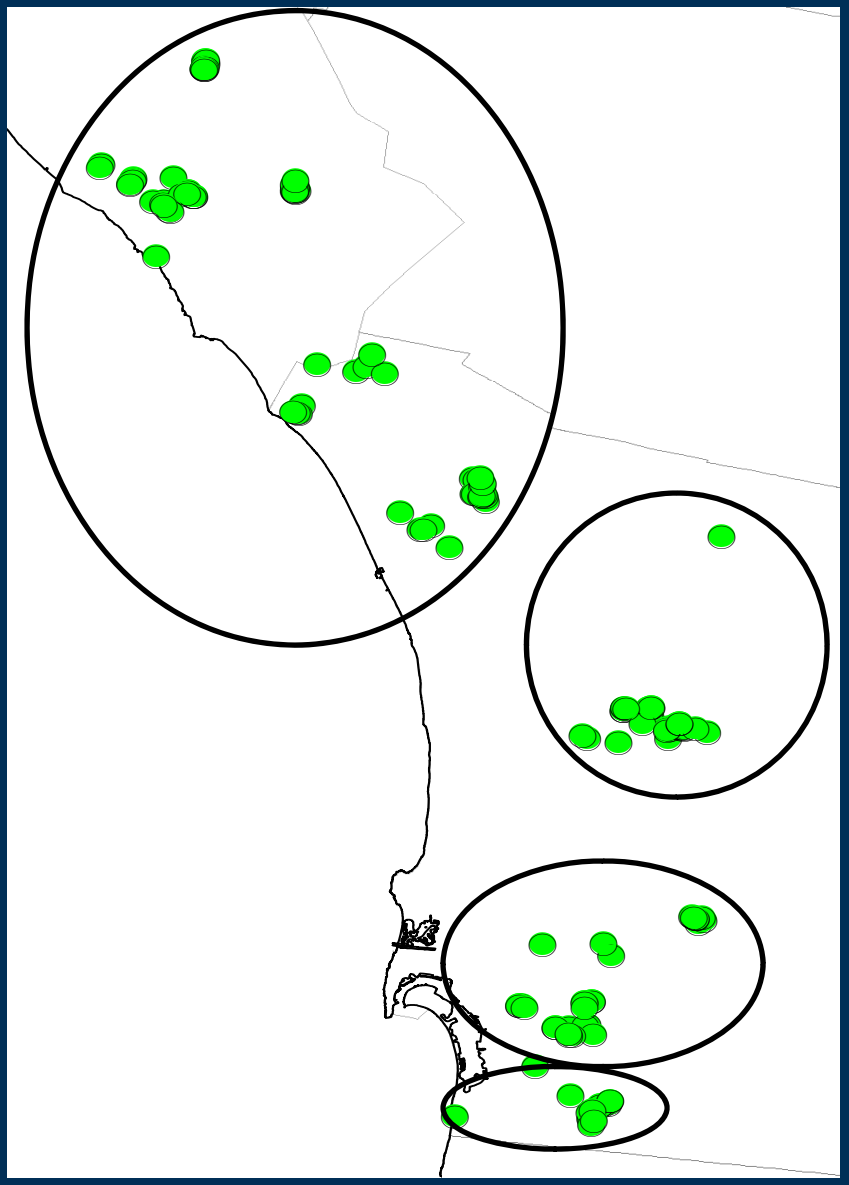


USGS



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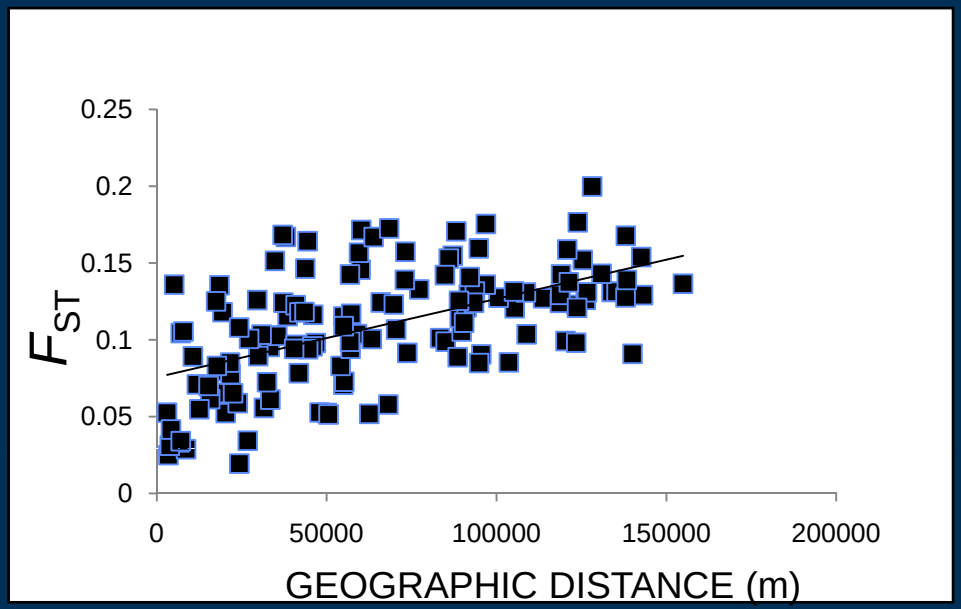

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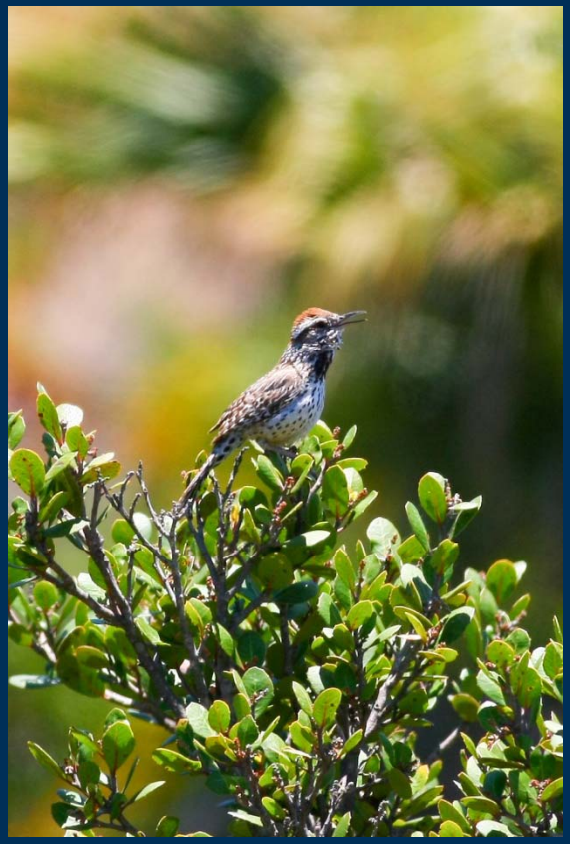
USGS

NEXT?

- Resighting study
- Expanding sampling into San Bernardino, LA, Ventura, and additional Orange County sites
  - CDFG
- Cactus habitat model & deeper landscape analyses
- Individual-based genetic distances
- Museum samples
- California Gnatcatcher genetic connectivity

USGS



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USGS