Genetic Structure in the Cactus Wrens and California Gnatcatchers in Southern California

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Connectivity Monitoring Strategic Plan For the San Diego Preserve System

Prepared for the San Diego Environmental Mitigation Program Working Group

January 11, 2011

- Developed by SDMMP
- Technical workshop

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
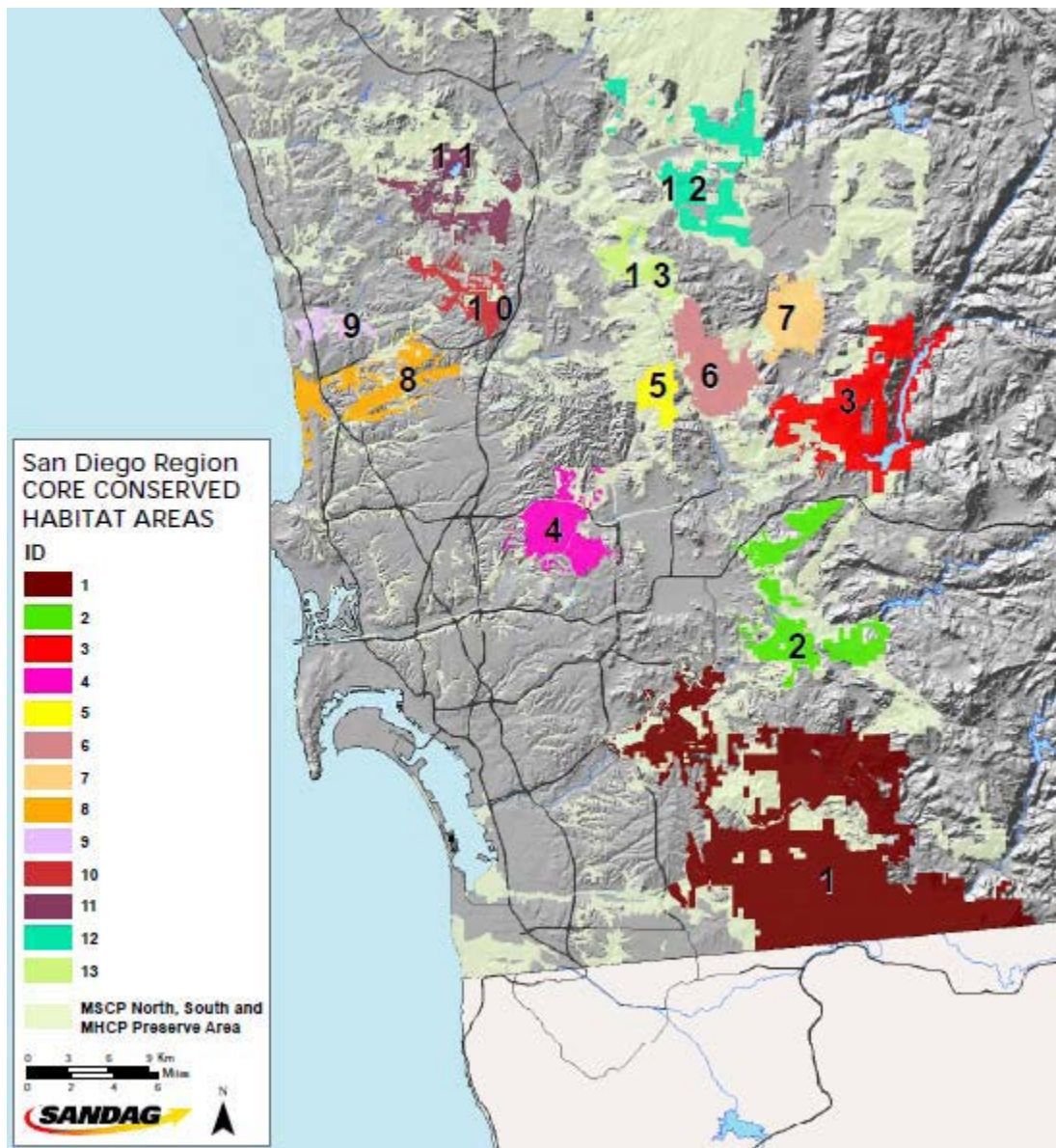
What is the functional connectivity among core areas for
- large animals
- small animals
- birds

Priority bird species:

- Coastal Cactus Wren
- Ca. Gnatcatcher
- least Bell's vireo
- sw. willow flycatcher

Coastal Cactus Wrens and California Gnatcatchers

 California species of special concern & US threatened species, listed in multiple NCCP plans throughout southern California.

- Dependent upon habitat type (scrub and cactus) that are limited in distribution

> ➢connectivity important for dispersal, (re)colonization, maintenance of genetic diversity

- Scrub habitat & cactus is highly fragmented by urbanization

- Wildfires in 2003 and 2007 have further reduced habitat

- Extensive and costly cactus patch restoration occurring that would benefit from knowledge of connectivity needs
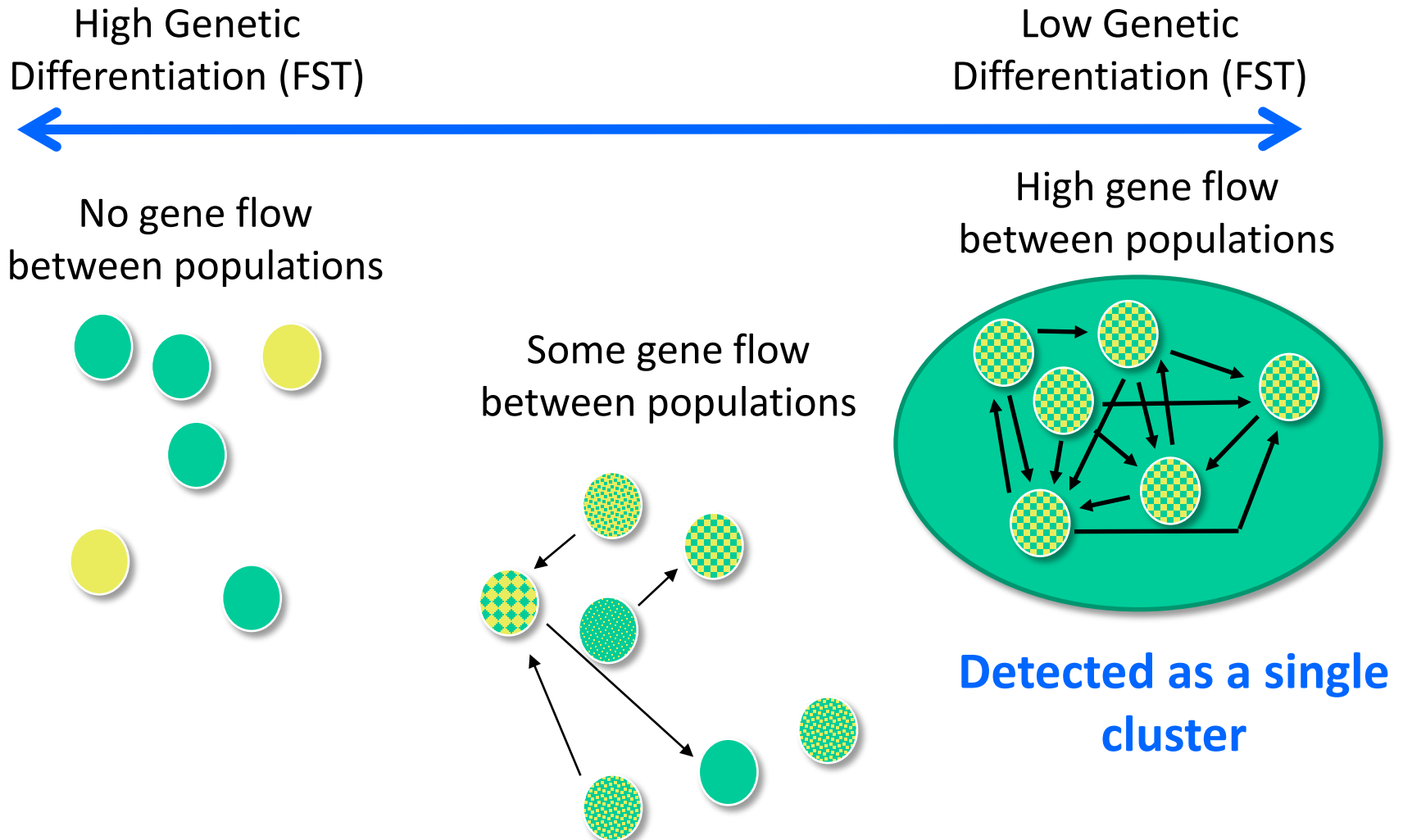
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Objectives

Goal:

To evaluate the degree of connectivity among aggregations in southern California

Do they function as interconnected metapopulations that are capable of re-establishing in extirpated patches without intervention?

Objectives:

➢ Use microsatellite markers to evaluate within- and among-population genetic variability

➢ Color banding/resighting of Cactus Wren nestlings/fledglings to investigate juvenile dispersal patterns and behavior

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Selectively neutral genetic markers provide estimates of gene flow (dispersal + successful reproduction) measured as differences in allele frequencies between populations or individuals.

High Genetic
Differentiation (FST)

Low Genetic
Differentiation (FST)

High gene flow
between populations

No gene flow
between populations

Some gene flow
between populations

Detected as a single cluster

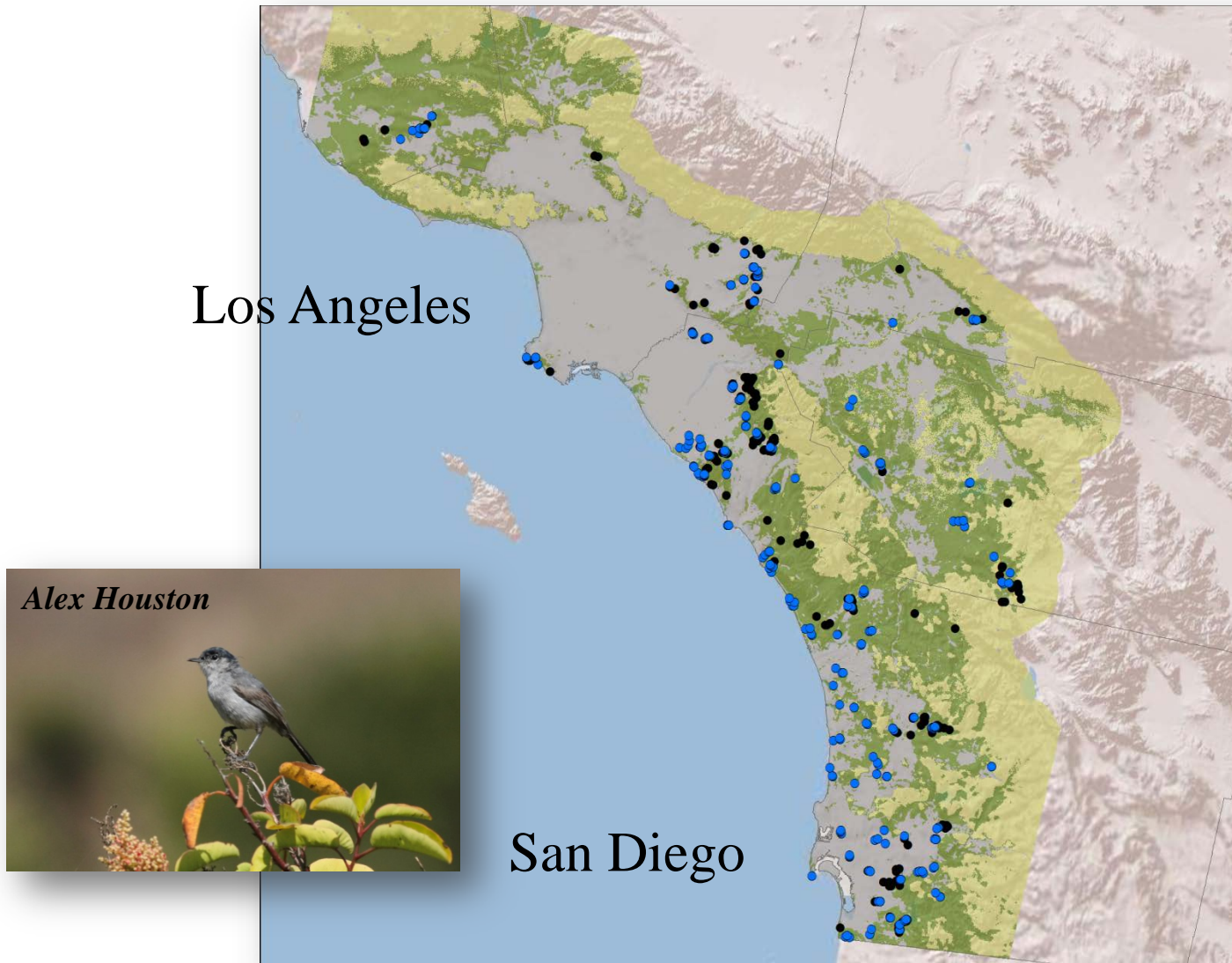# Methods: Sample Collection and Banding

Genetic Analyses

- Cactus Wrens: Developed 22 microsatellite loci, genotyped 364 individuals

- Gnatcatchers: Developed 19 loci, genotyped 268 individuals

1. Identify genetic populations or gene pools.
   - Bayesian clustering methods (Structure, Geneland)
   - Cluster individuals based on genetic similarity

2. Are there limitations to movement and gene flow?
   - Genetic isolation by geographic distance
   - Spatial autocorrelation of genetic relatedness
   - Resighting banded birds (Cactus Wrens)

3. Measure the genetic diversity within aggregations, test for recent reductions in population size.
   - Heterozygosity, number of gene copies
   - Signature of recent genetic bottlenecks
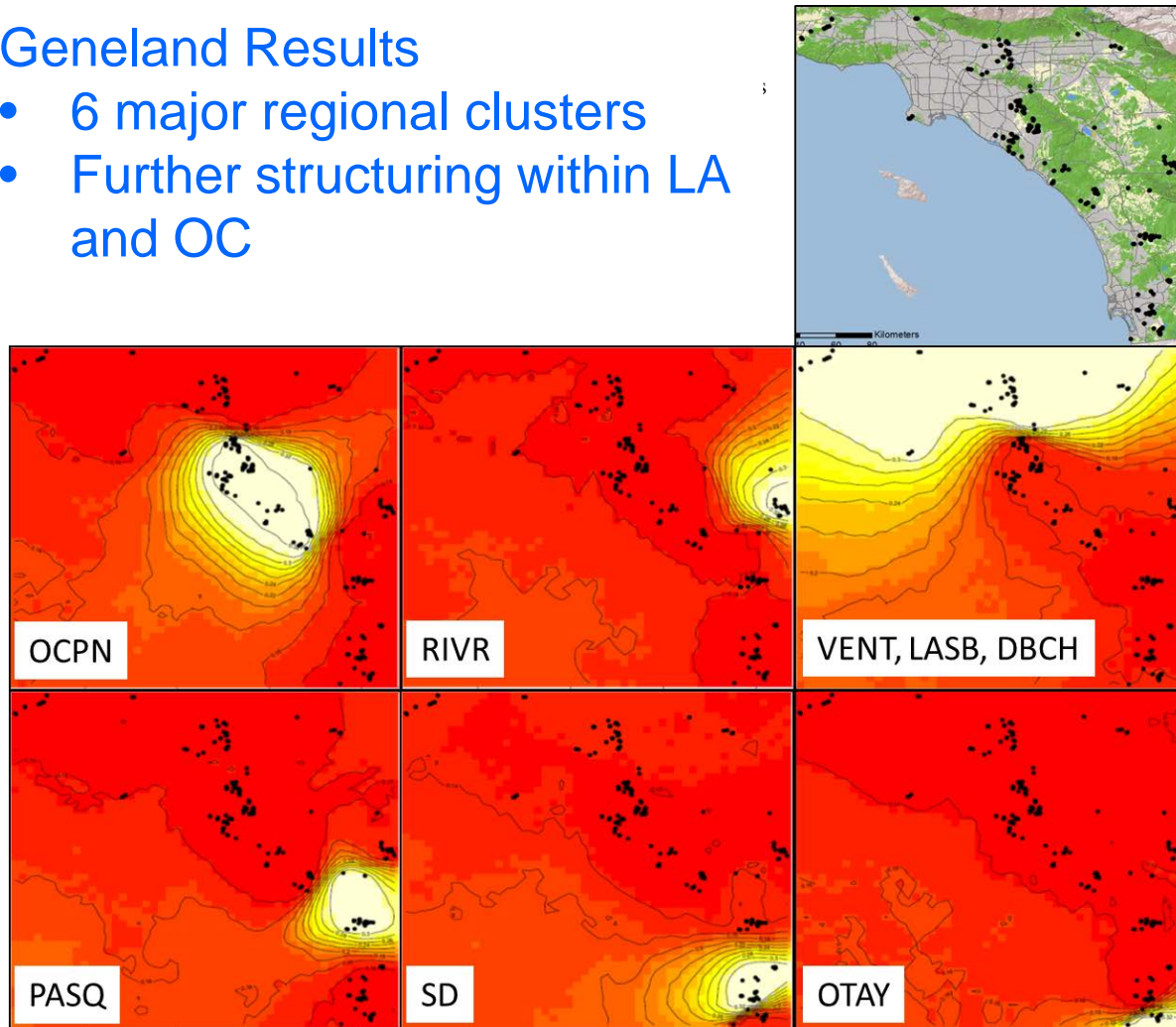
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Cactus Wren Collection Locations

Los Angeles

San Diego

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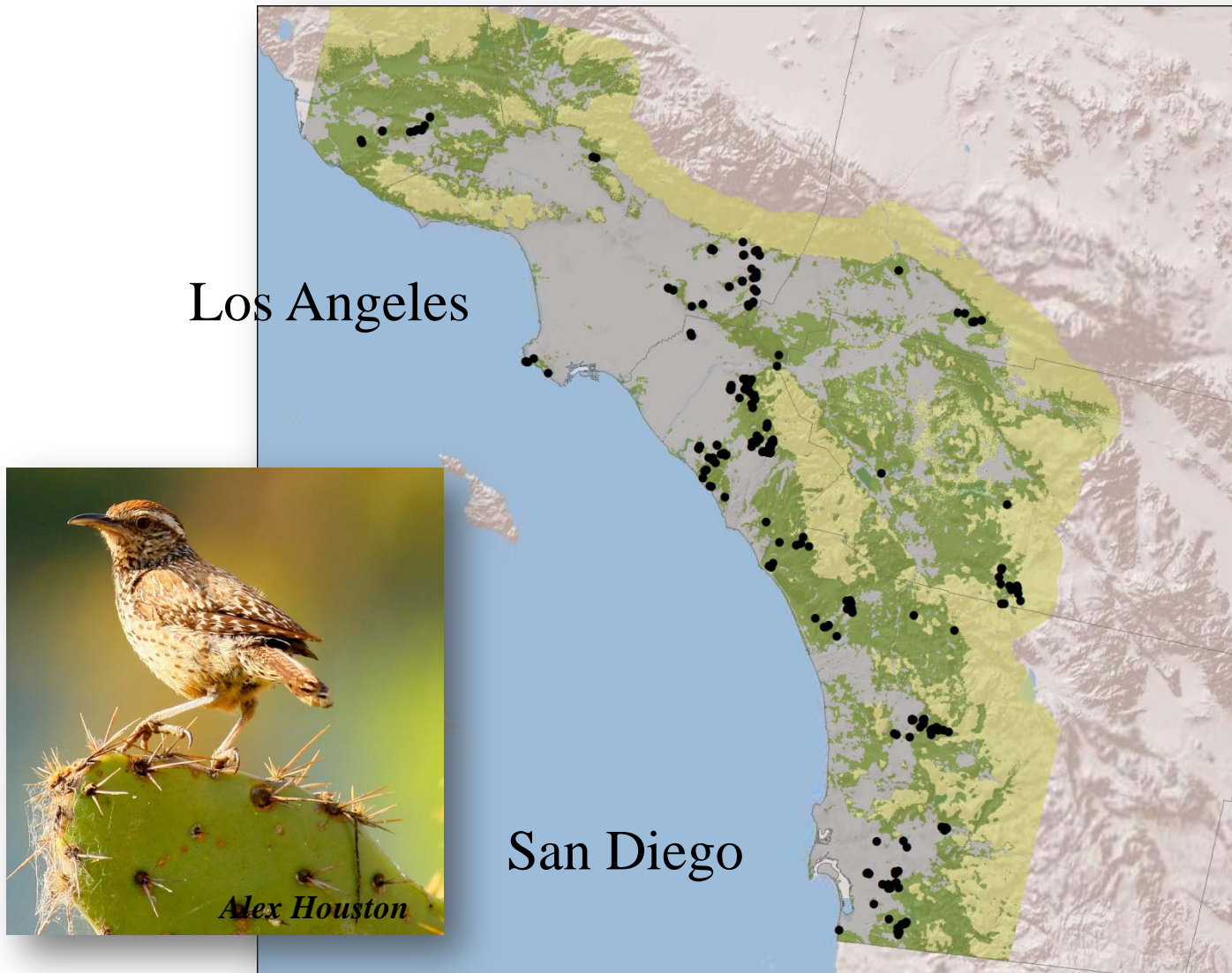
Gnatcatcher Collection Locations

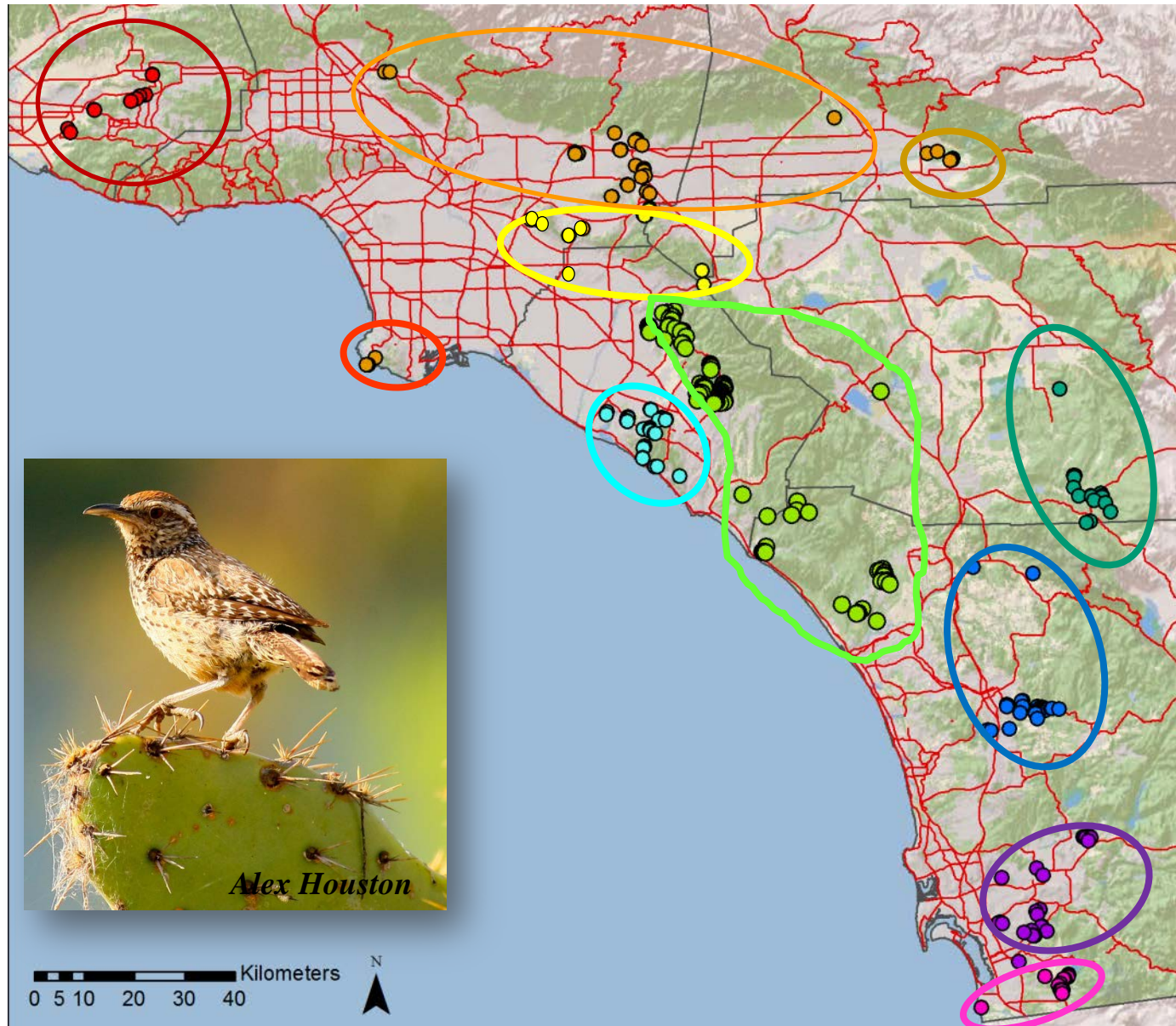Los Angeles

San Diego

Alex Houston

USGS

Cactus Wren Genetic Structuring

Geneland Results
- 6 major regional clusters
- Further structuring within LA and OC

11 Genetic Clusters

Ventura
PalosVerdes
Los Angeles
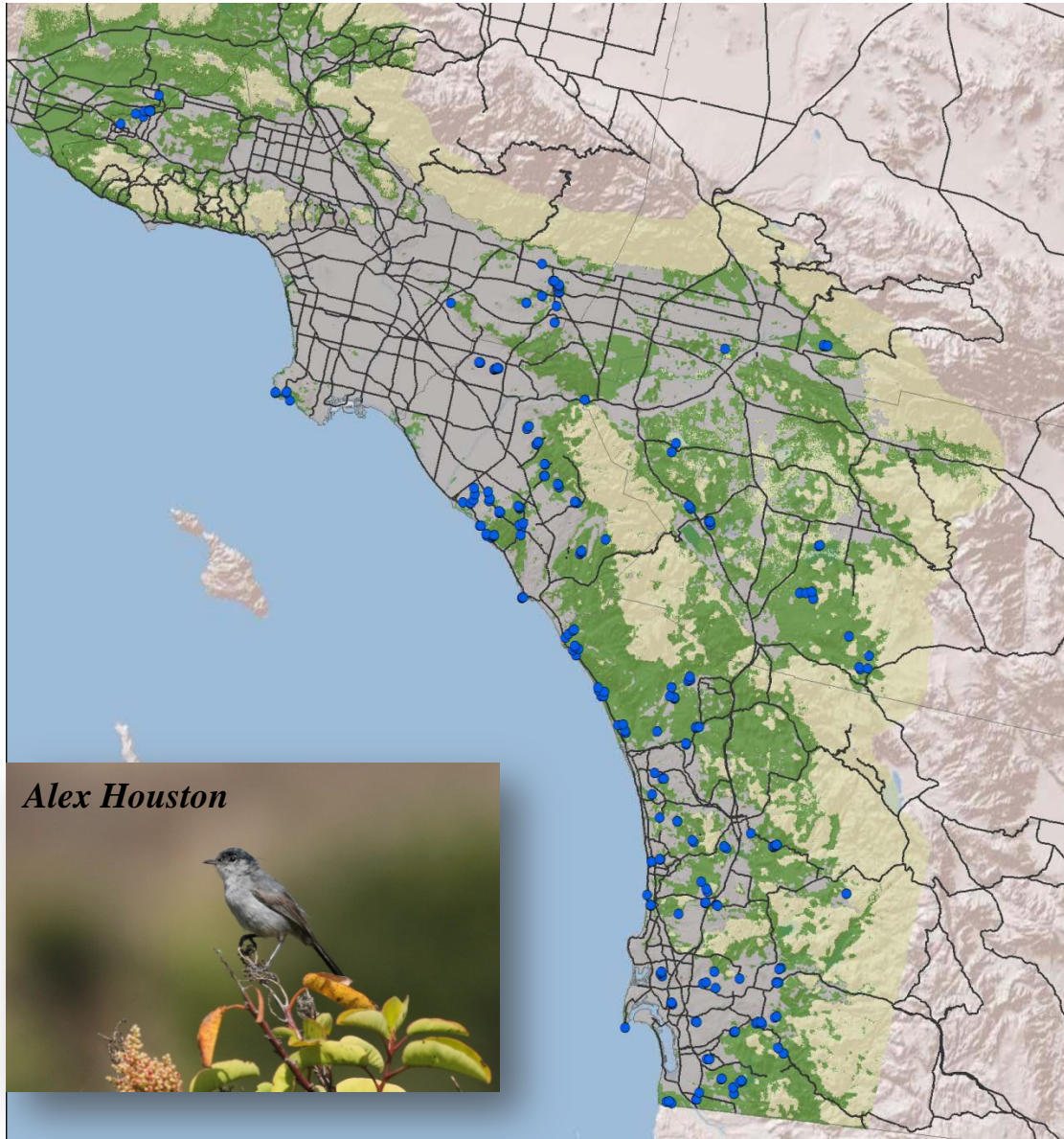Puente/Chino
San Bernardino
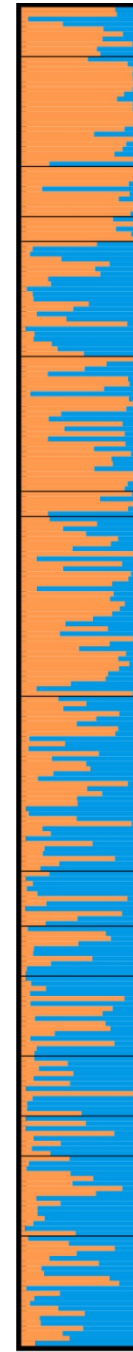Central OC
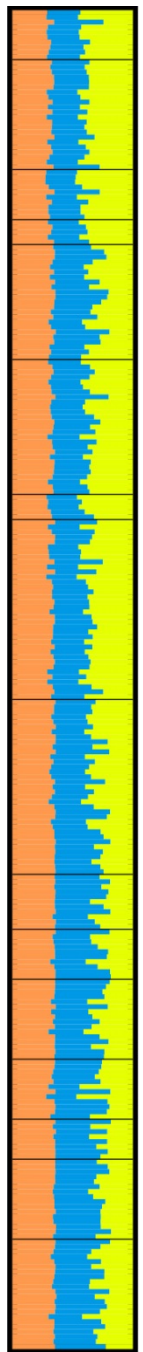Coastal OC
Riverside
San Pasqual
San Diego
Otay

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Kilometers
0 5 10   20   30   40
N

Gnatcatcher: 1 Genetic Cluster

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K=2

K=3

Stepping Stone Gene Flow

Cactus Wren

r = 0.63, p < 0.001

Gnatcatcher

r = 0.49, p < 0.001
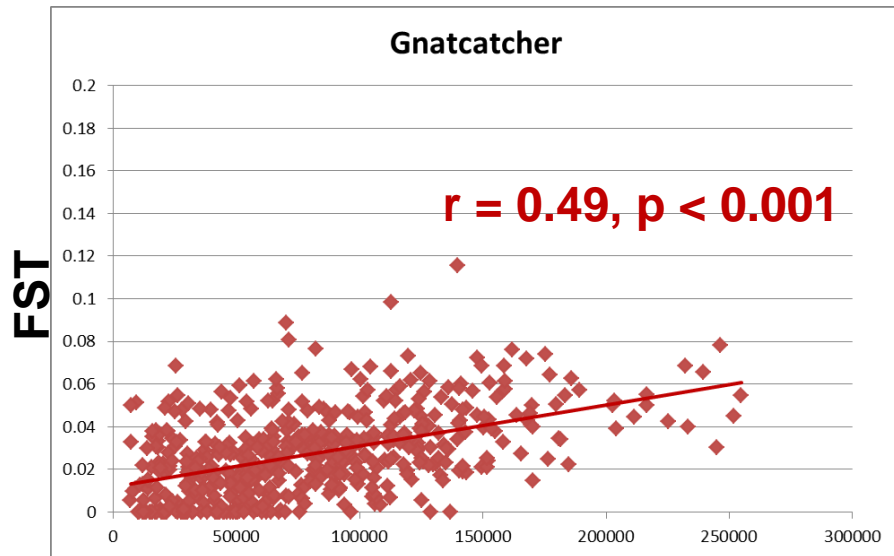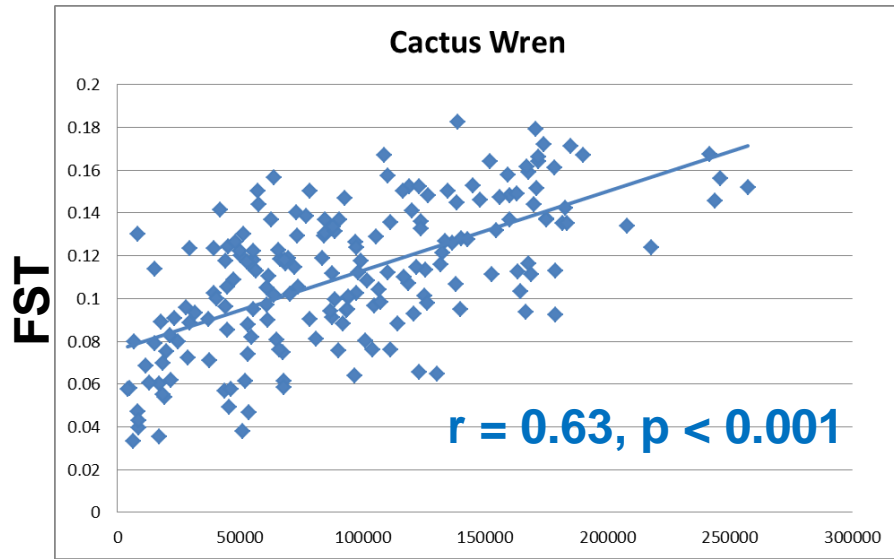
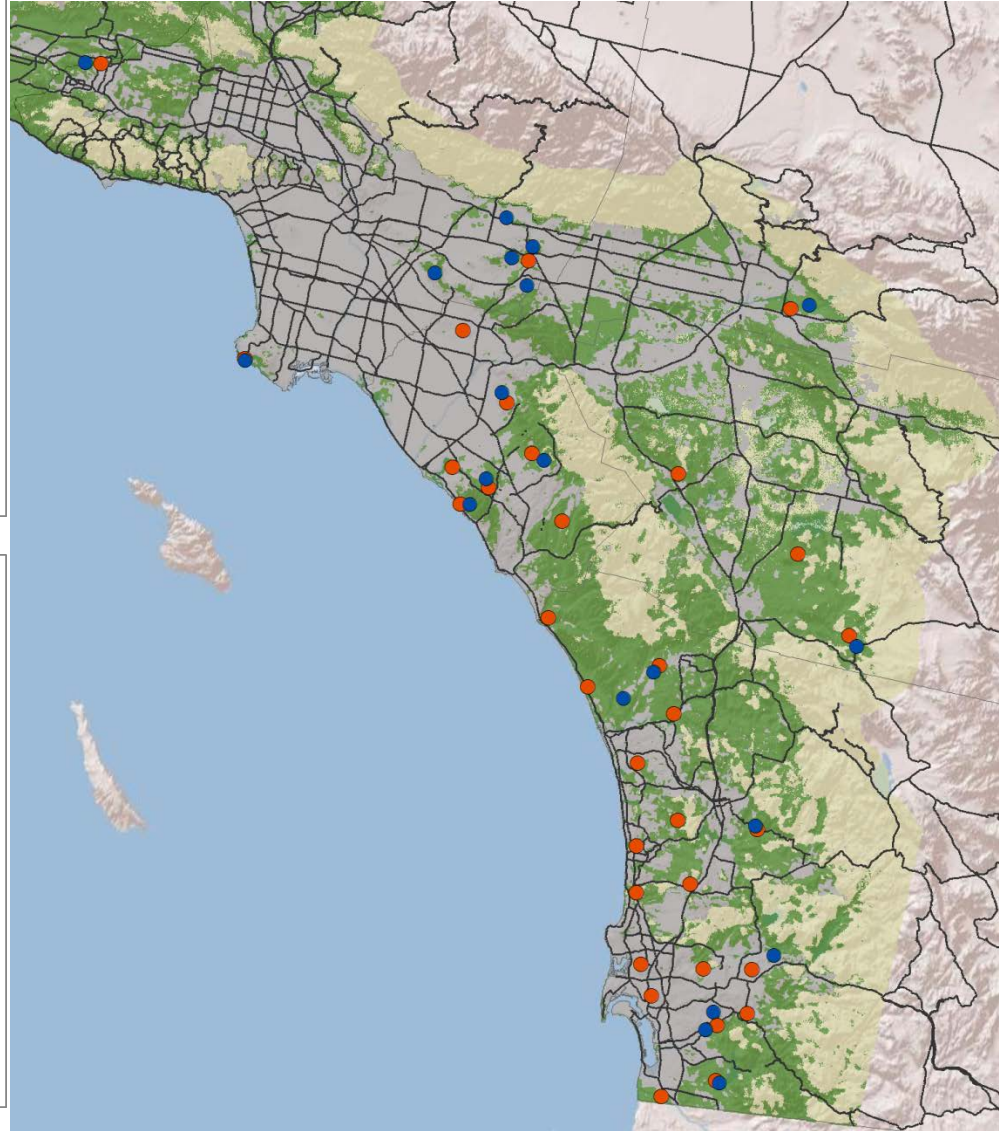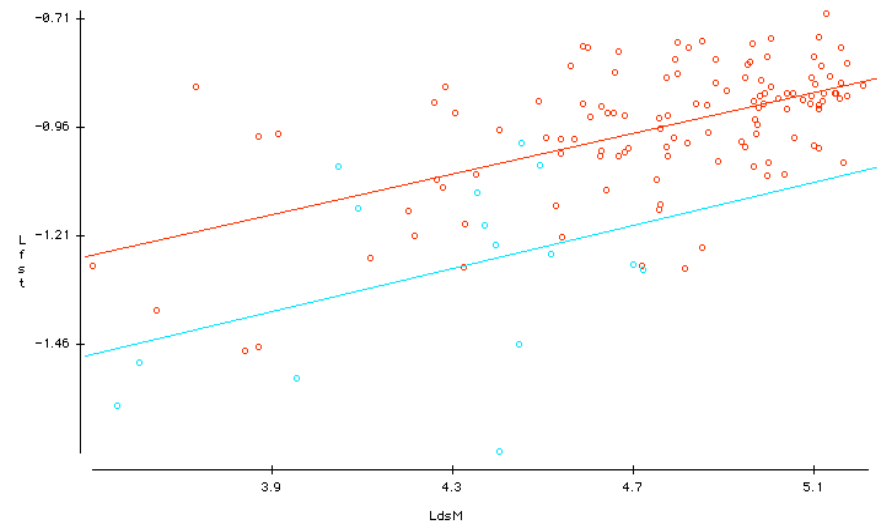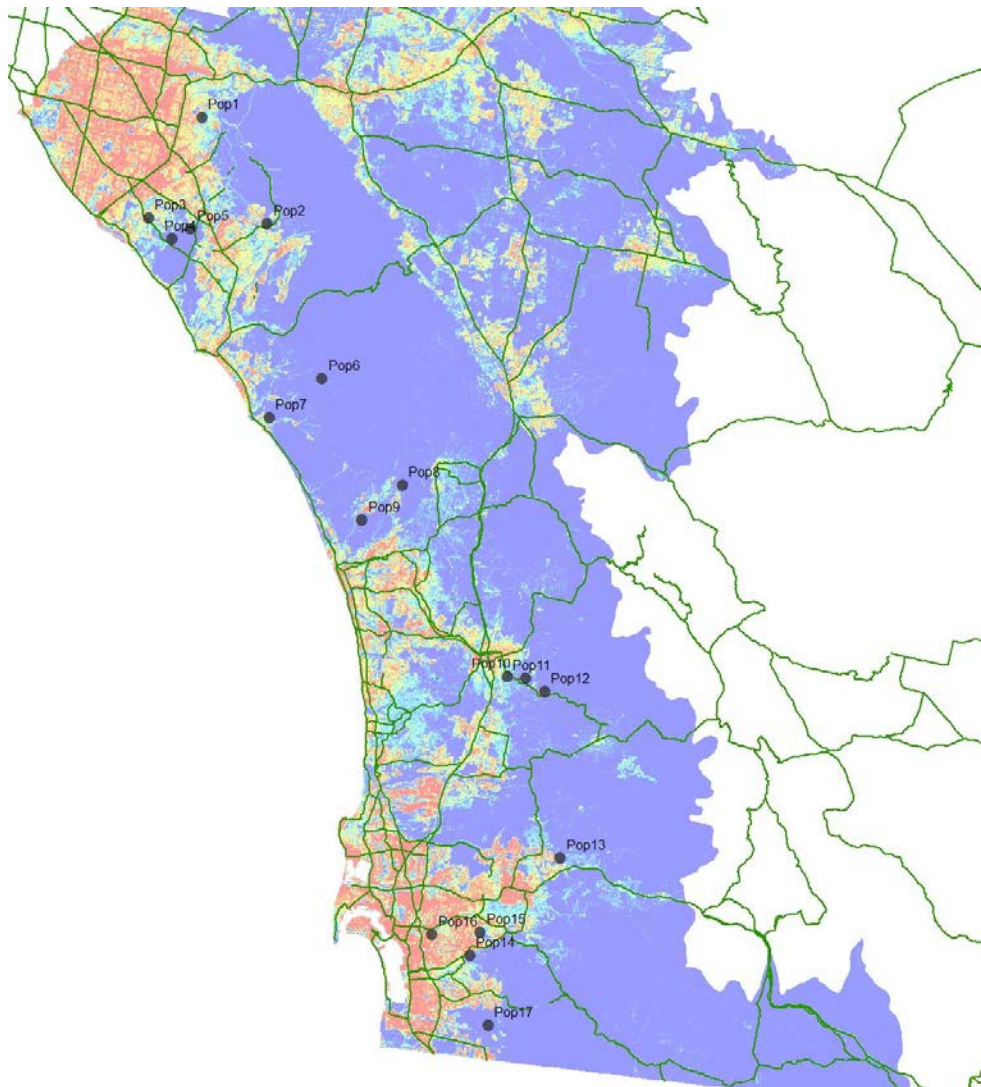**Geographic Distance**

Cactus Wren: effect of urban fragmentation

Partial corr. of F_{ST} and urban barriers (controlled for geographic distance):

r = 0.4292 p = 0.0001

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Gnatcatcher: No Correlation

Partial corr. of F_{ST} and urban barriers (controlled for geographic distance):

r = 0.08 (NS)

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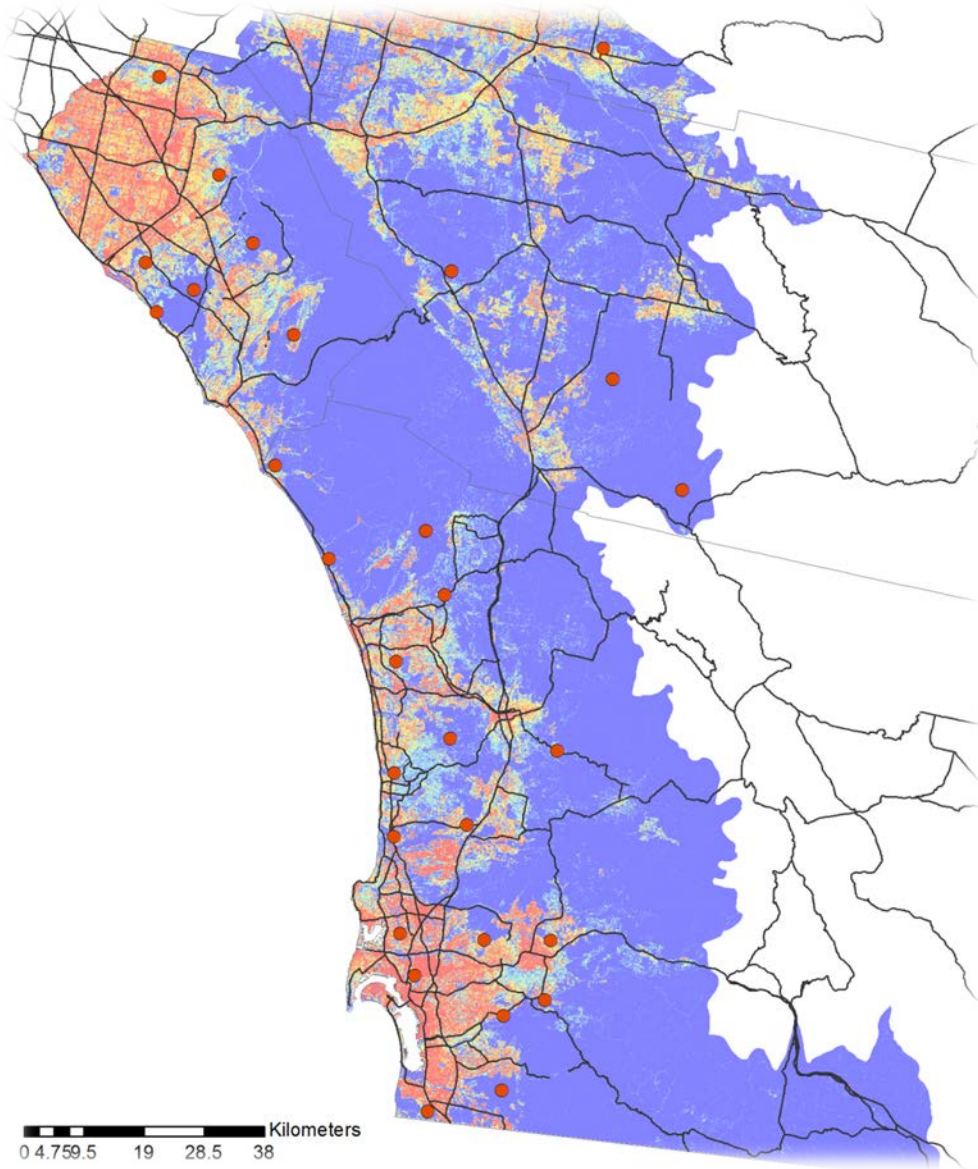
Spatial Autocorrelation Analysis:

- Plot the genetic relatedness among individuals grouped at different distance classes
- Positive observed values (blue) indicate that individuals are more similar genetically than by chance alone (red dashed lines)

Central OC

8 km

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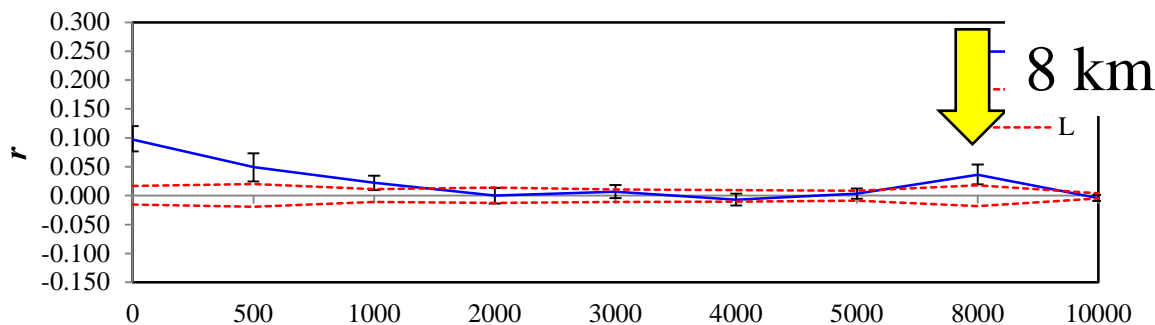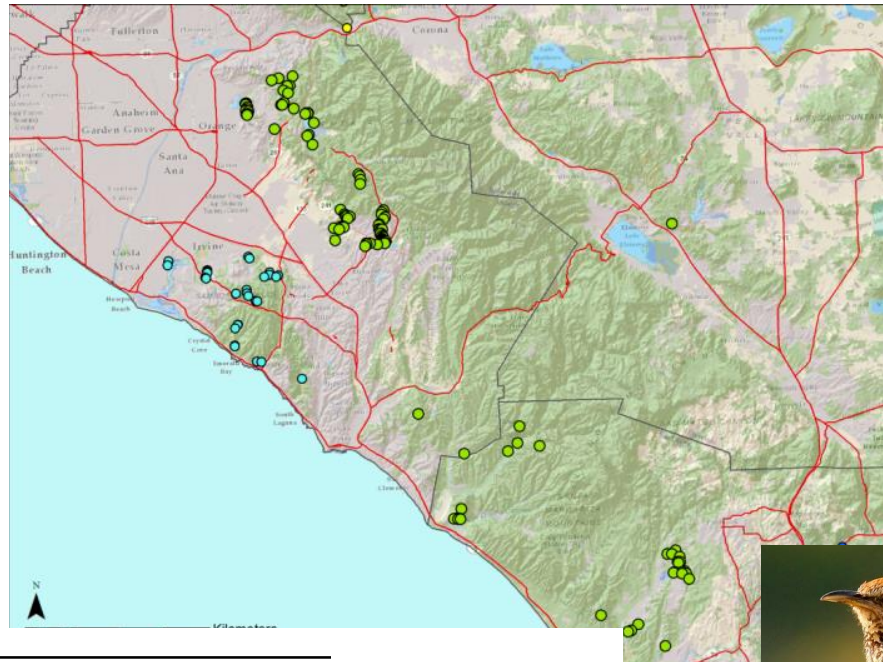
Spatial Autocorrelation Analysis

San Diego

2-4 km

R

DISTANCE CLASS (METERS)

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Cactus Wren Dispersal

Photo by Steve Brad

N = 18

N = 44

Percent Resighted

0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00

Juvenile   Adult

Age at Banding

USGS
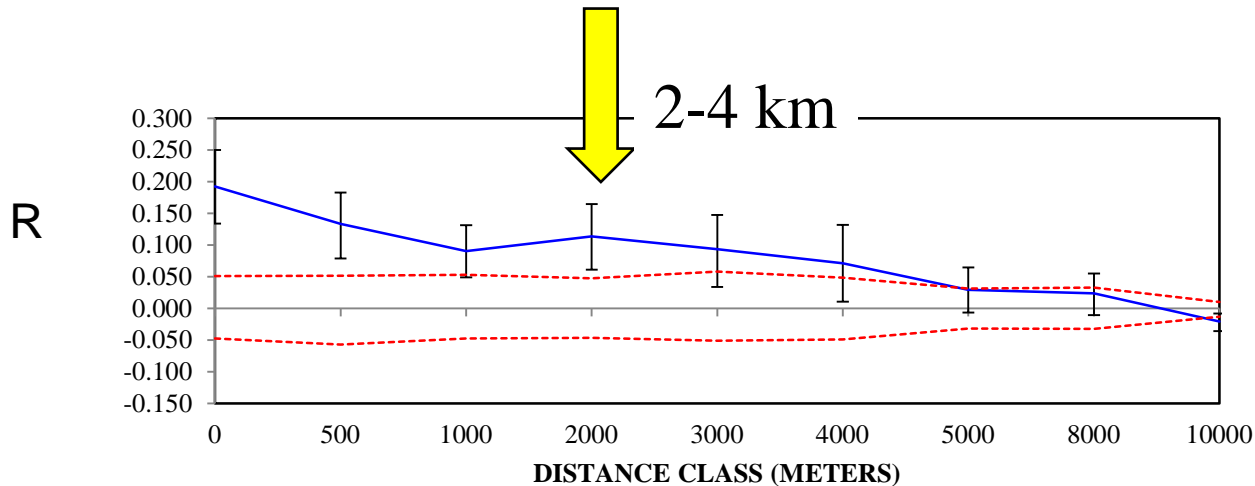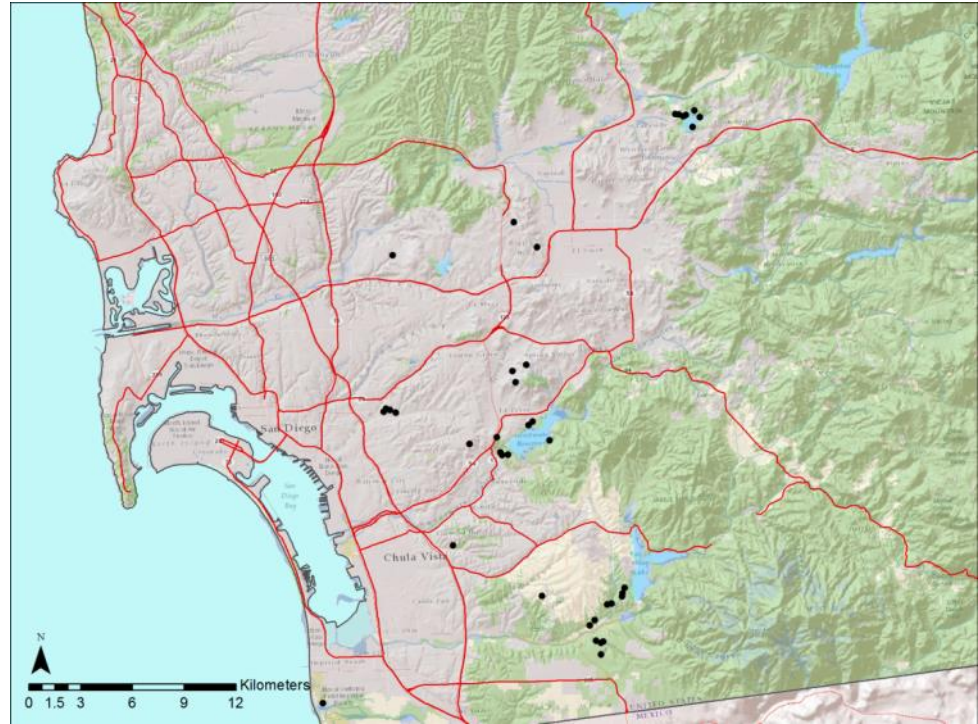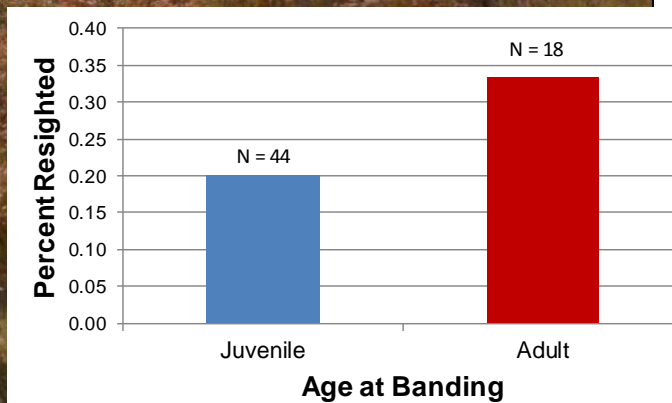
San Diego Dispersals

Legend

🔴 2011 Adult CACW

🔵 2011 Hatch Year CACW

🟩 USFWS Mapped Cactus

🔺 2011 Adult - 2012 Location

🔺 2011 Hatch Year - 2012 Location

0.7k

0.3k

N
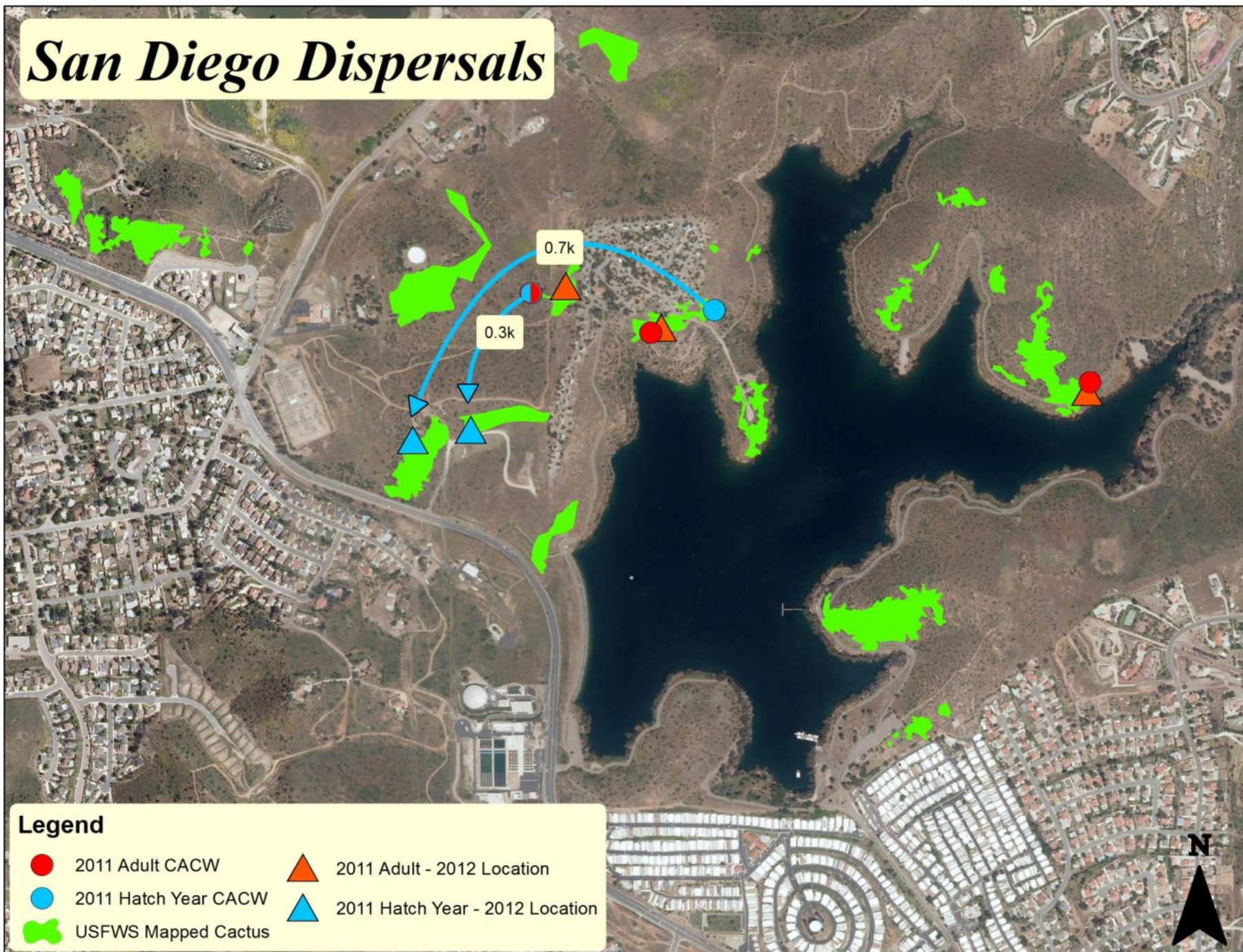
Sweetwater Dispersals

0.2k

0.2k

Legend

- 🔴 2011 Adult CACW
- 🔵 2011 Hatch Year CACW
- 🟢 USFWS Mapped Cactus
- 🔺 2011 Adult - 2012 Location
- 🔺 2011 Hatch Year - 2012 Location

N
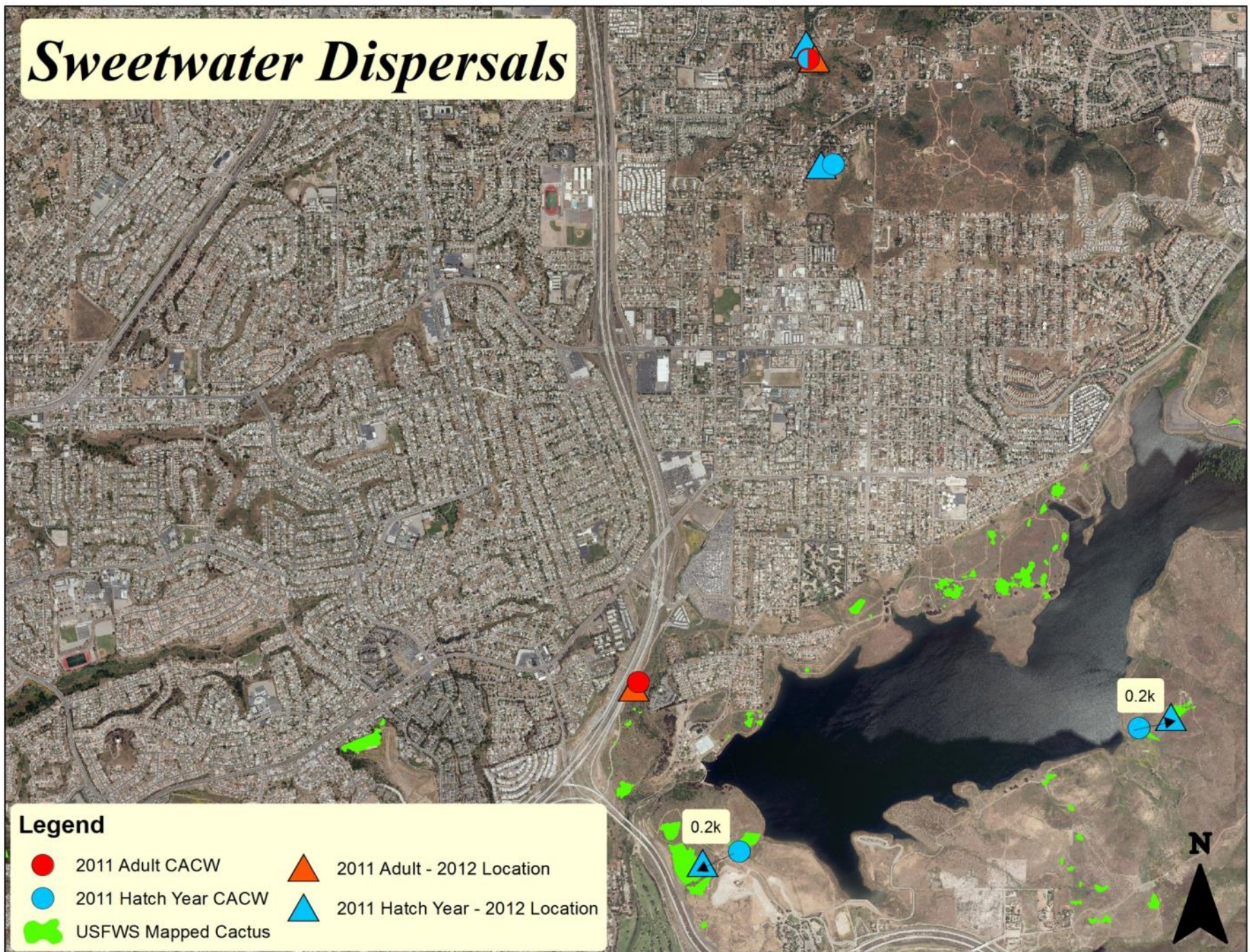
South MCBCP & Det. Fallbrook NWS Dispersals
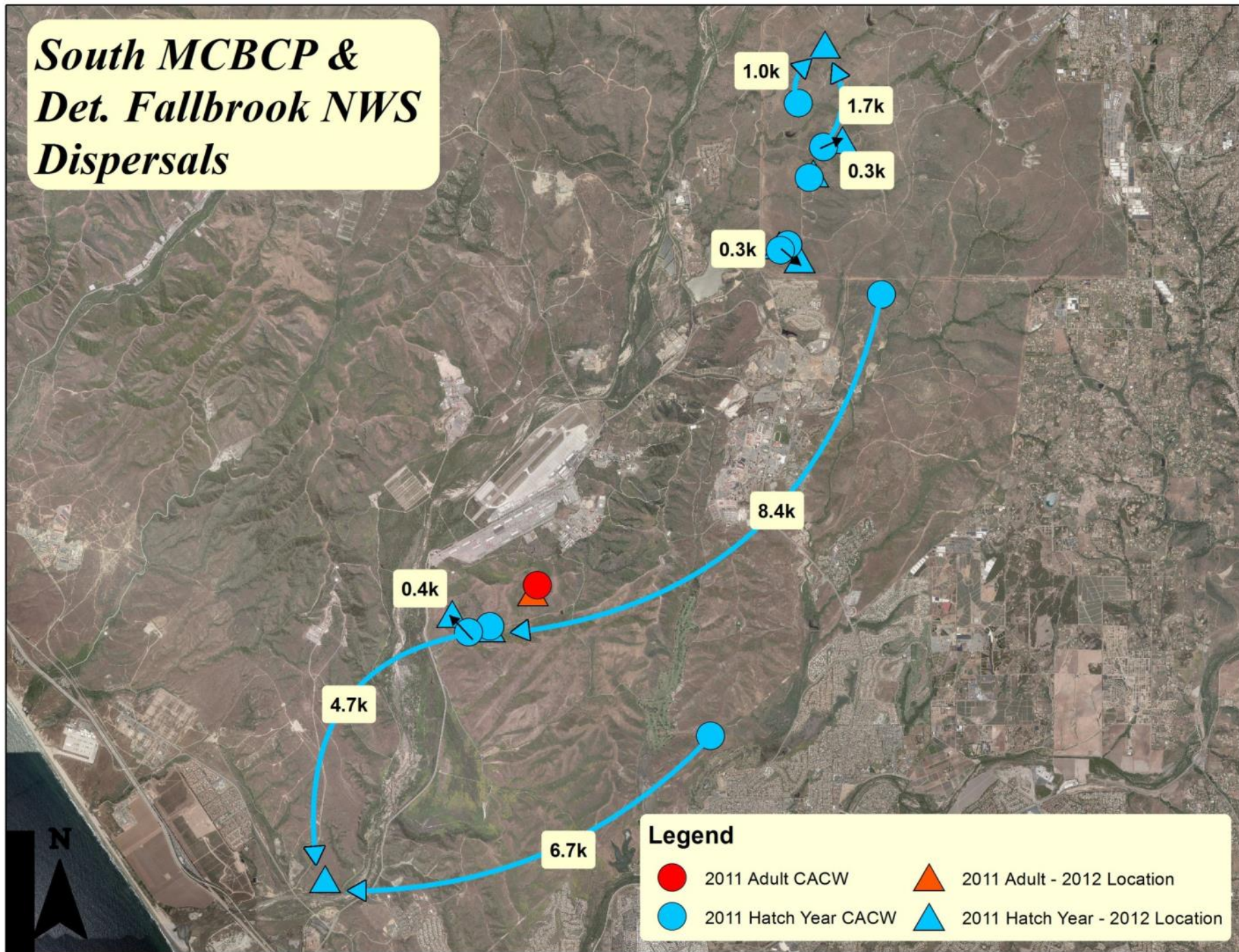
North MCBCP Dispersals

Adult banded 2009
Caspers Regional Park
Orange Co.
10.2k

2.8k

2.7k

Legend

🔴	2011 Adult CACW	🔺	2011 Adult - 2012 Location
🔵	2011 Hatch Year CACW	🔺	2011 Hatch Year - 2012 Location

N

1.0k 0.3k

0.4k
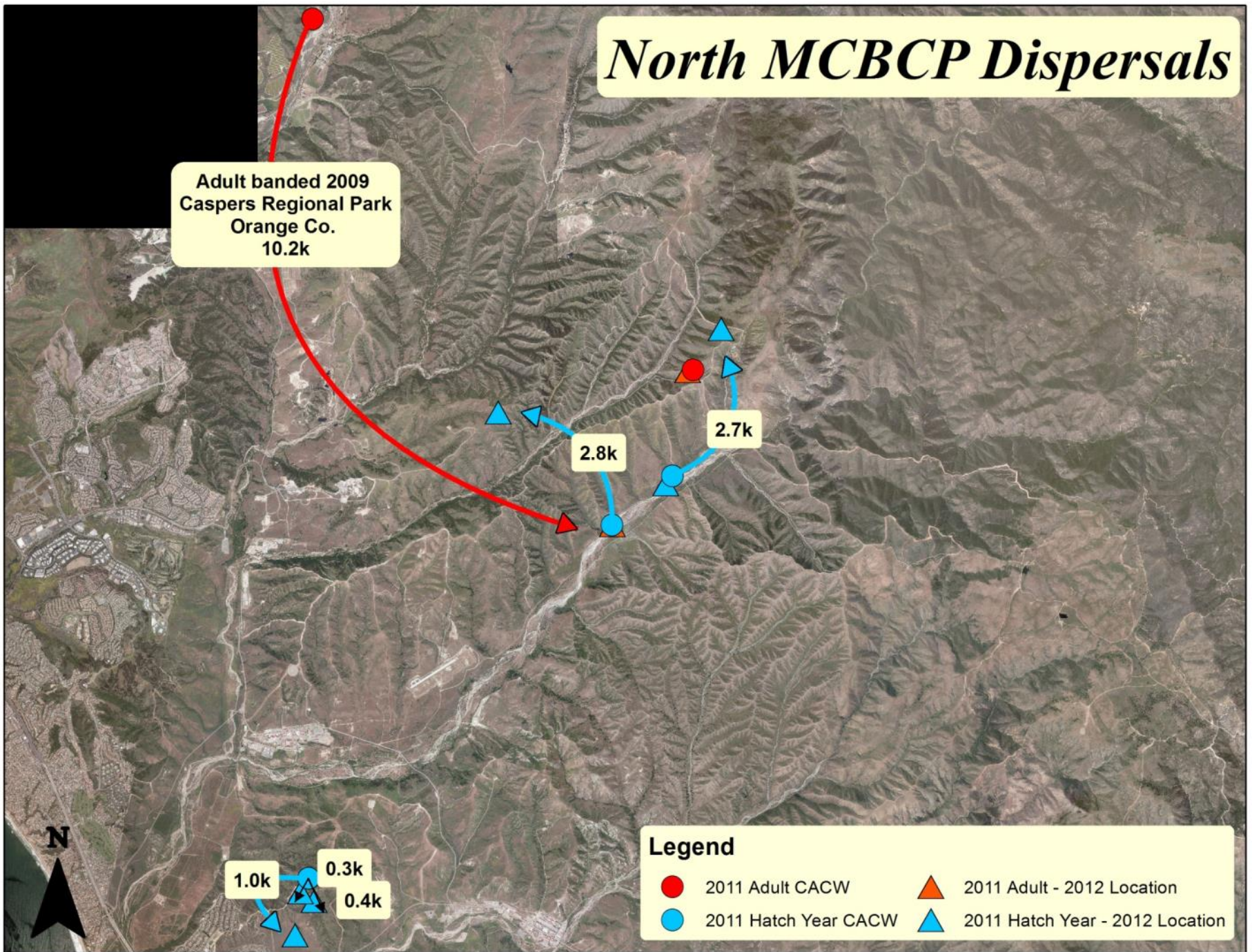
Summary and Implications for Recovery

Cactus Wrens

- Highly structured across southern California

- Gene flow and dispersal appear limited in urban areas

- Lower intrinsic ability to recolonize recovered habitat

- Restore connectivity- Cactus restoration and translocation

Gnatcatchers

- Single genetic population across range

- No detectable limitations

- Higher intrinsic ability to recolonize recovered habitat

- Monitor for recolonization in recovered areas

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Restoration in San Diego Preserve System

- Plans being developed to restore cactus within and between major aggregations

CACW Detected in 2011
- Yes
- No
- Management Units
- Urban
- Undeveloped, Not Conserved

Habitat Suitability on Conserved
- 0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1

Sources: SANDAG, SanGIS, USFWS
Ceated by: SDMMP

3 Miles

Coastal Cactus Wren

Created September 2013

Photo by Steve Brad
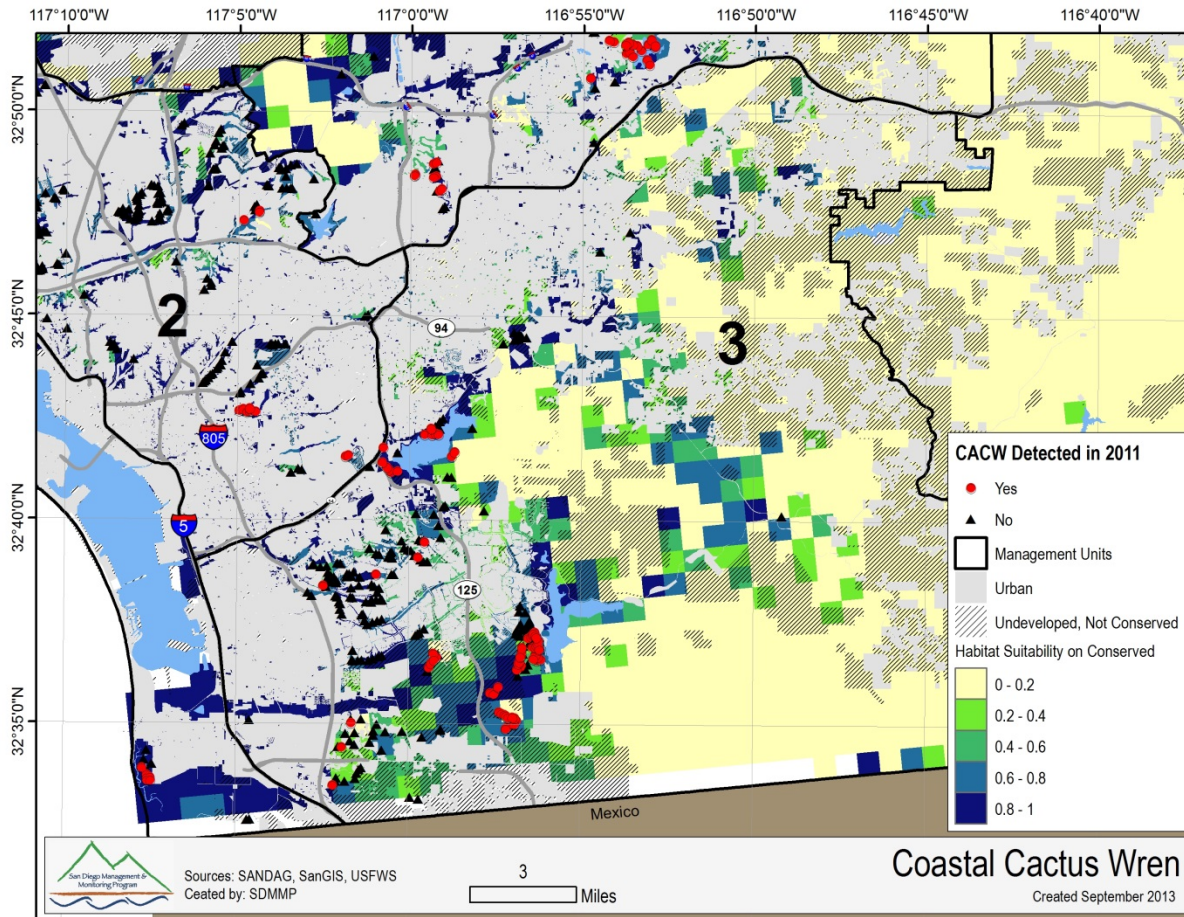
Genetic Diversity and Bottlenecks

Cactus Wrens

Cluster	N	Ar	H	Ne
Vent	15	3.75	0.587	26 (14-58)
PV	8	3.34	0.589	37 (13-inf)
LA	30	4.26	0.562	51 (30-117)
PUE/CHI	22	4.38	0.640	42 (29-70)
SB	8	3.65	0.568	51 (17.5-inf)
RIV	15	4.1	0.555	104 (31-inf)
Cent. OC	141	4.66	0.652	104 (51-339)
Coast OC	31	4.27	0.602	25 (19-35)
PASQ	35	4.31	0.657	107 (55-566)
Jennings	12	4.05	0.572	13 (9-21)
SD	21	4.47	0.617	47 (32-81)
OTAY	15	4.24	0.697	17 (12-27)

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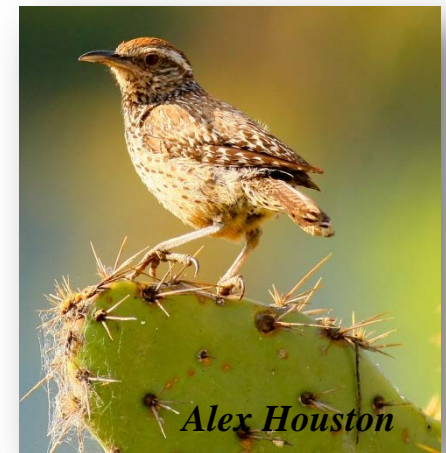
- **Sig. Heterozygote Excess: expected with a recent reduction in population size**
- **Northernmost, outlying populations (Ventura, Palos Verdes, San Bernardino) have lowest genetic diversity**
- **Effective population sizes largest in San Pasqual, Central OC, Riverside**

Recent Wildfire

- Measured habitat loss and demographic declines.

Genetic Bottlenecks

Wildfire
fire perimeter
YEAR_

- 1990
- 1991
- 1992
- 1993
- 1994
- 1995
- 1996
- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010

Kilometers
0 5 10 20 30 40

N
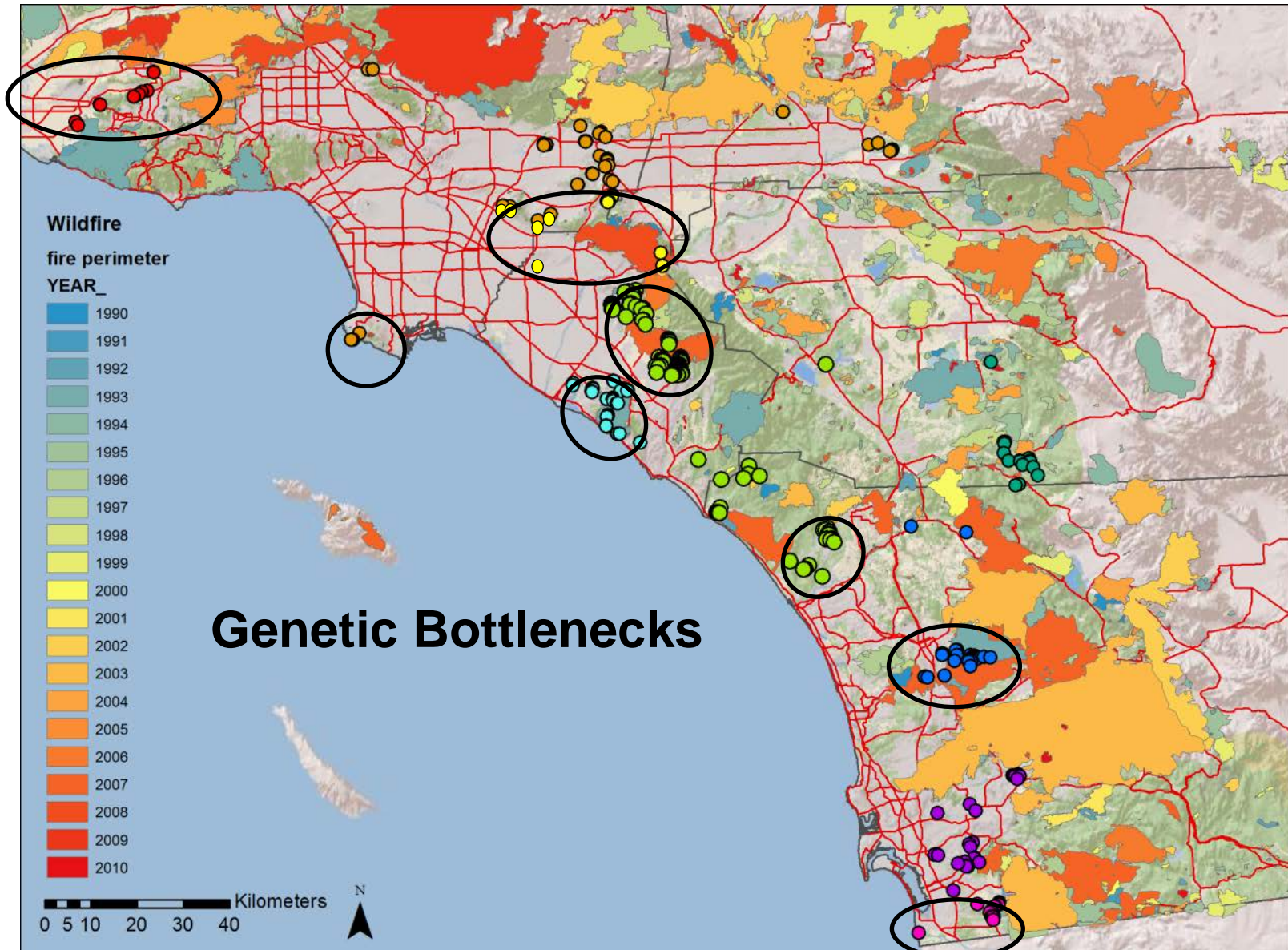
Genetic Diversity and Bottlenecks

Gnatcatchers

	N	Ar	Ho	Ne
Ventura	10	4.13	0.747	7.6 (5.2 - 10.5)
Los Angeles	32	4.68	0.712	27.5 (3.3 - 76.6)
San Bernardino	5	4.37	0.653	12.9 (5.4 - 23.6)
Riverside	23	4.92	0.767	24.3 (5 - 58.4)
Inland OC	27	4.79	0.733	31.5 (2.3 - 98.2)
Palos Verdes	5	4.05	0.705	11.6 (3.5 - 24.6)
Coastal OC	36	4.7	0.751	inf (inf)
Pendleton	35	4.97	0.746	inf (inf)
North SD	37	4.91	0.723	inf (inf)
SD	58	5	0.721	20.7 (9.5 - 36.2)

- **Overall: Signature of Bottleneck**
- **Northernmost, outlying aggregations (Ventura, Palos Verdes, San Bernardino) have lowest genetic diversity**
- **Effective population sizes largest in middle of range (San Diego – Orange County**

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ACKNOWLEDGMENTS

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California Department of Fish & Wildlife
CalTrans
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Conservation Biology Institute
The Nature Conservancy
Center for Natural Lands Management
Bureau of Land Management
AECOM
City of San Diego
County of San Diego
City of Chula Vista
San Diego Gas & Electric
San Dieguito River Park
San Dieguito River Valley Conservancy
Pala Band of Mission Indians
Helix Water District
San Diego National Wildlife Refuge
San Diego Zoo Institute for Conservation Research
Fallbrook Naval Weapons Station
Marine Corps Base Camp Pendleton
San Diego Audubon Society
Sweetwater Authority
City of Carlsbad
City of Escondido
Santa Ana Watershed Association
Many Private Landowners

Riverside County Parks
W. Riverside Co. Regional Conservation Authority
Riverside Co. Habitat Conservation Authority
Riverside Co. Economic Development Agency
W. Riverside Co. MSHCP
Outdoor Resorts Rancho California, Inc.
Audubon California Starr Ranch Sanctuary
City of Irvine
Irvine Ranch Conservancy
Crystal Cove State Park
Orange County Parks
Southern California Edison Viejo Conservation Easement
UC-Irvine Ecological Preserve
City of Fullerton
Orange Co. Water District
San Bernardino Co. Flood Control District
San Bernardino Co. Water Conservation District
San Bernardino Co. Dept. of Public Works
San Bernardino Valley Municipal Water District
Vulcan Materials Company
North Etiwanda Preserve
City of Los Angeles, Dept. of Recreation and Parks
County of Los Angeles, Dept. of Parks and Recreation

Palos Verdes Peninsula Land Conservancy
Puente Hills Habitat Preservation Authority
City of Glendora
City of Diamond Bar
City of San Dimas
City of Whittier
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California State University, Channel Islands
City of Moorpark
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Field Crew

NROC: K. Moore & D. Kamada

USGS: K. Allen, L. Allen, K. Ferree, A. Houston, S. Howell, S. Lynn, M. Madden, R. Pottinger, T. Dixon, P.J. Falatek , A. Gallagher, M. Lipshutz, S. Nichols, J. Pietrzak, A. Shipley, A. Winters