Do California Highways Act as Barriers to Gene Flow for Ground-Dwelling Mammals?

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Fraser Shilling
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2016

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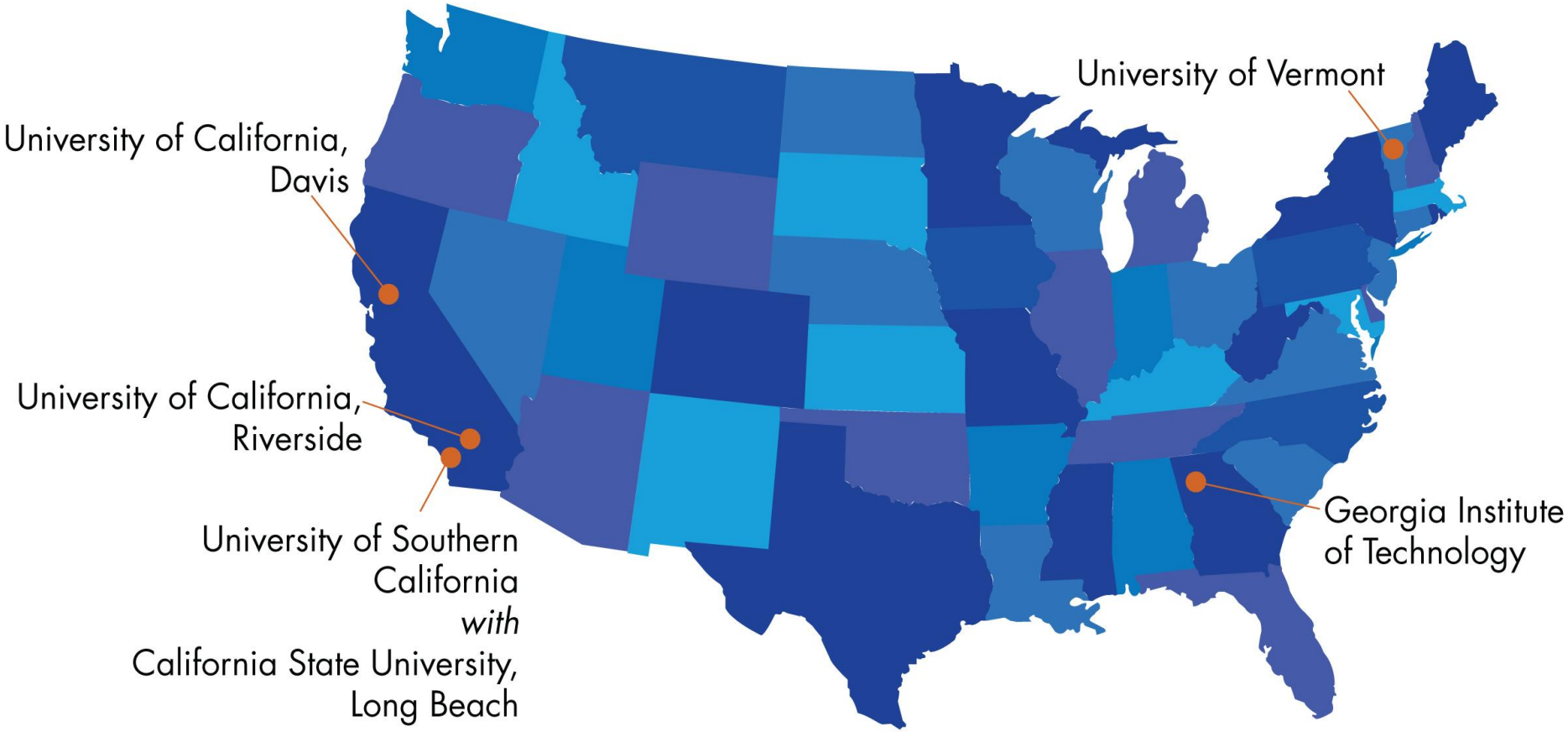
UNIVERSITY PARTNERS



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TRANSFORMING THE TRANSPORTATION SYSTEM

- **RESEARCH** – *Producing "state of knowledge" white papers and interdisciplinary research projects*
- **EDUCATION** – *Developing model curricula for graduate programs and advanced training programs*
- **ENGAGEMENT** – *Informing the policy-making process at the local, state, and federal level*

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OUTLINE

- Transportation sustainability
- Integrated wildlife monitoring
- Consequences of roads for wildlife
  - Genetic Isolation and fragmentation
- Population genetics
- Project goals and focus
- Results
- Future goals

Photo: J. Todd Dussault, Your Take

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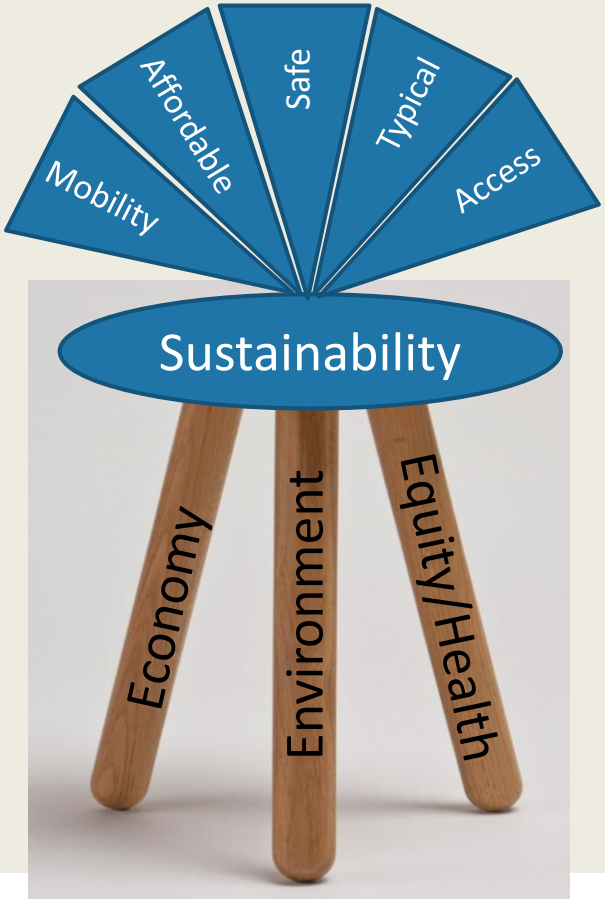
ROAD EFFECTS ON WILDLIFE: SUSTAINABLE TRANSPORTATION



Better-than-before health of the <u>environment</u>: Embrace environmental stewardship as a preeminent approach to delivering transportation services that result in a zero carbon footprint and a "better-than-before" environment. (AASHTO, accessed 4/12/2016)

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INTEGRATED WILDLIFE MONITORING

- Evaluating population genetics at landscape scales is critical to understanding development effects on wildlife and ecosystems
- Other methods for wildlife include: camera traps, track plates, scat/track surveys, roadkill/mortality surveys, collaring/tracking individuals, connectivity/disturbance modeling

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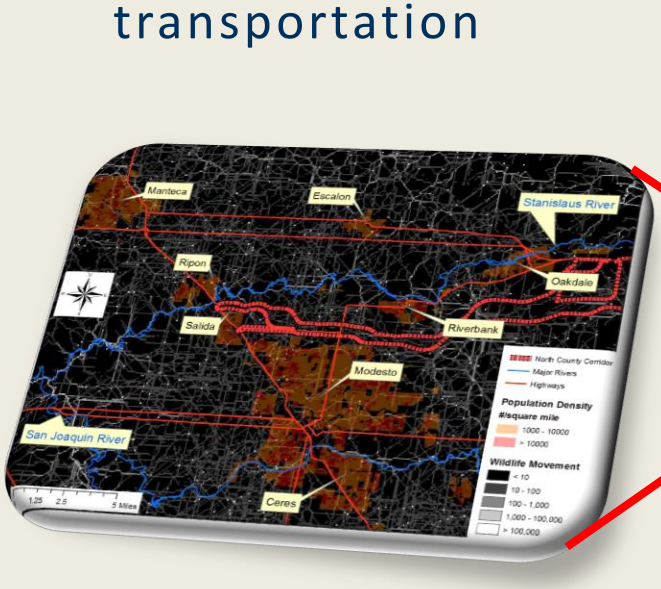
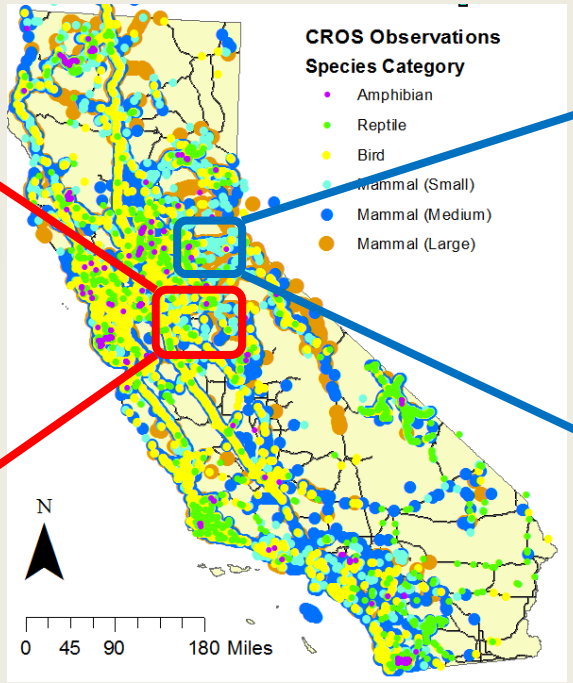
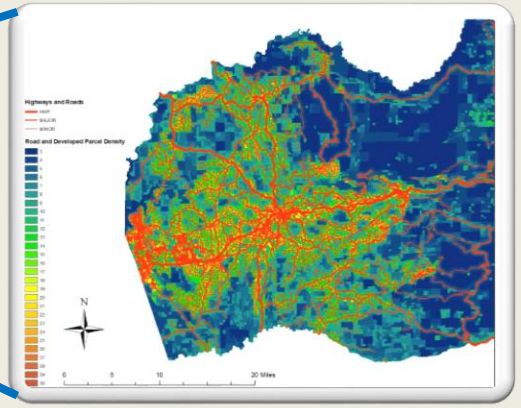
INTEGRATED WILDLIFE MONITORING

- All methods are necessary to understand ecological impacts and mitigation effectiveness if we are to build sustainable transportation







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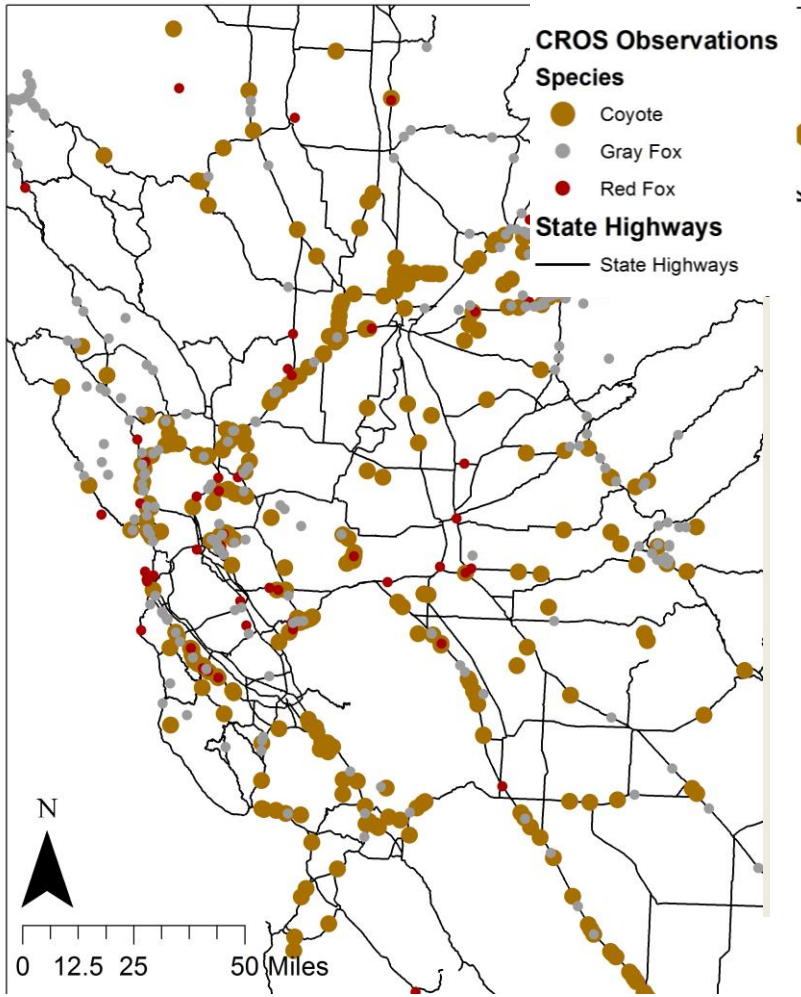
ROAD EFFECTS ON WILDLIFE

- Habitat Loss
- Aversion – organisms avoid approaching/ crossing
  - Disturbance avoidance
  - Open-cover avoidance
- Mortality
  - Population persistence risk
  - Estimated >25,000 deer collisions in CA in 2011-2012*

*State Farm statistics



Roadkill recorded along highways in California 2009-2015
Map credit: Fraser Shilling

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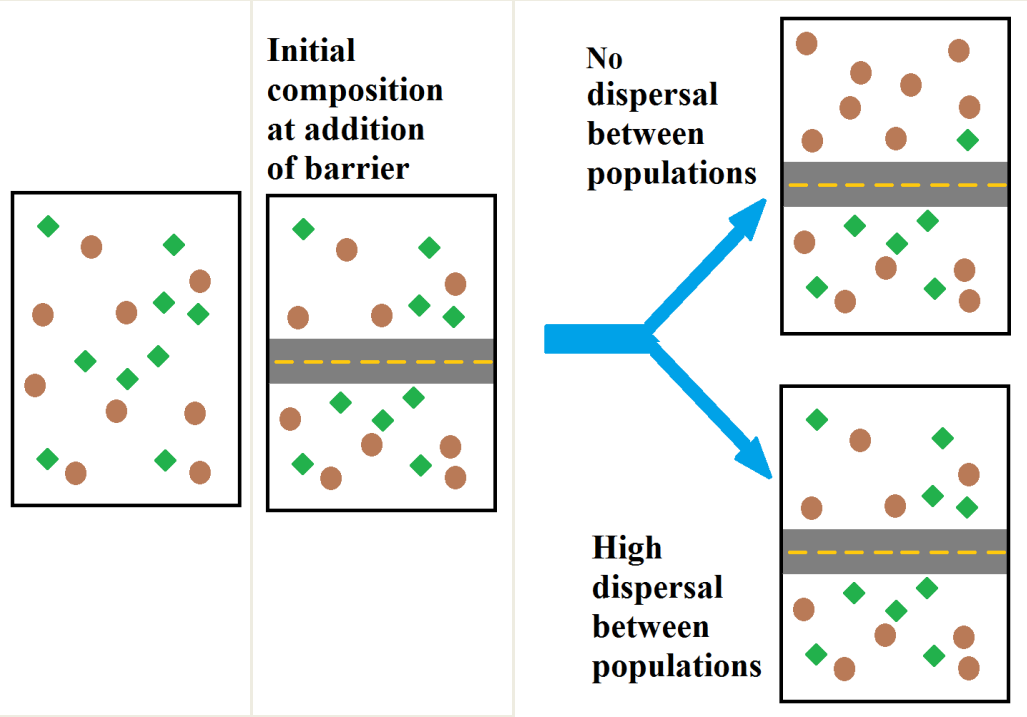
ROAD RELATED MORTALITY/AVERSION

- Decreased dispersal success in bisected populations
  - Degree depends on:
    - Permeability of barrier
    - Wildlife behavior
- Genetic Drift
  - Random changes in genetic composition of population over time
  - Gene pool reduced



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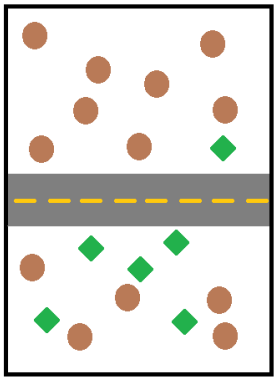
GENETIC ISOLATION

- Inbreeding increases the chances of sharing gene copies from a common ancestor
  - Isolated, fragmented populations
- Accumulation of deleterious genes due to inbreeding depression
  - Example: Isle Royale Wolves
    - Small population
    - Isolated from the mainland
    - Express vertebral deformities
    - Decreased survival
    - Lower reproduction



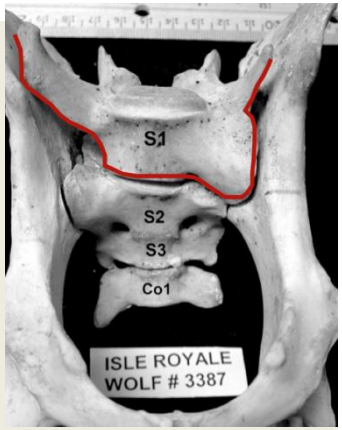


Photo Credit: isleroyalewolf.org

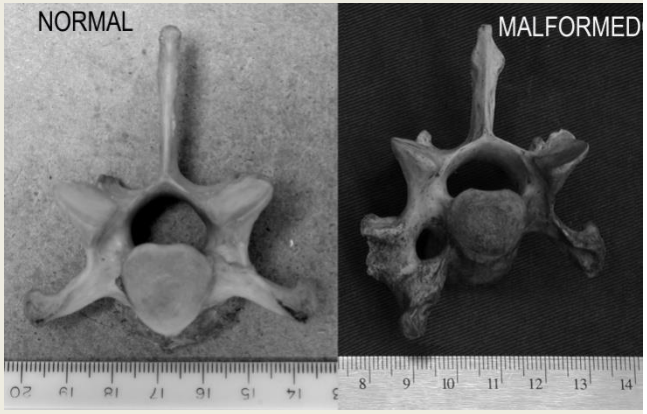


Photo Credit: Michigan Technological University

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STUDY QUESTION: ARE HIGHWAYS DISPERSAL BARRIERS?

- Riley et al, 2006 – Highway in Southern California fragmented coyote and bobcat populations
- Examine population genetics of coyotes across major highways
  - Widely distributed, common, highly mobile, capable of urban-association
    - Conservative model
  - Detect disrupted gene flow
    - Implications for less common species
  - Detect connectivity
    - Potential dispersal paths
    - Highway characteristic
    - Organismal trait

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METHODS

- Hike trails in open space areas within 10km of study highways
  - Bay Area = 580 and 680 >180,000 vehicles/day
  - Sierra Nevada Foothills = 50 & 80 >140,000 vehicles/day
- Collect scats
  - Coyotes use scat as a territorial signal
  - GPS locations of samples
- Extract DNA from fecal samples
  - Confirm samples originated from coyote
- 13 microsatellite markers
  - Used to DNA fingerprint individuals
    - 31 individuals = Bay Area
    - 52 individuals = Sierra Nevada Foothills

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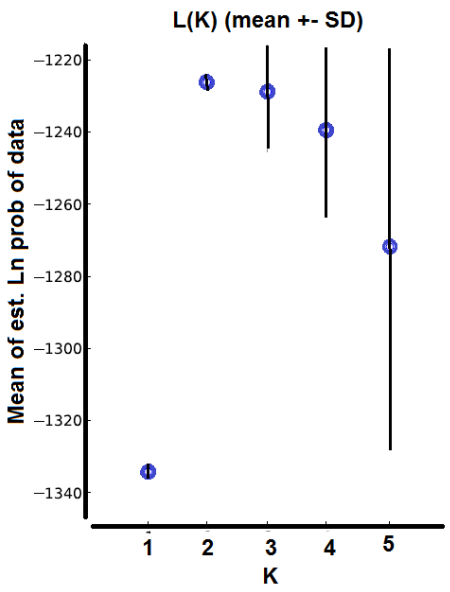
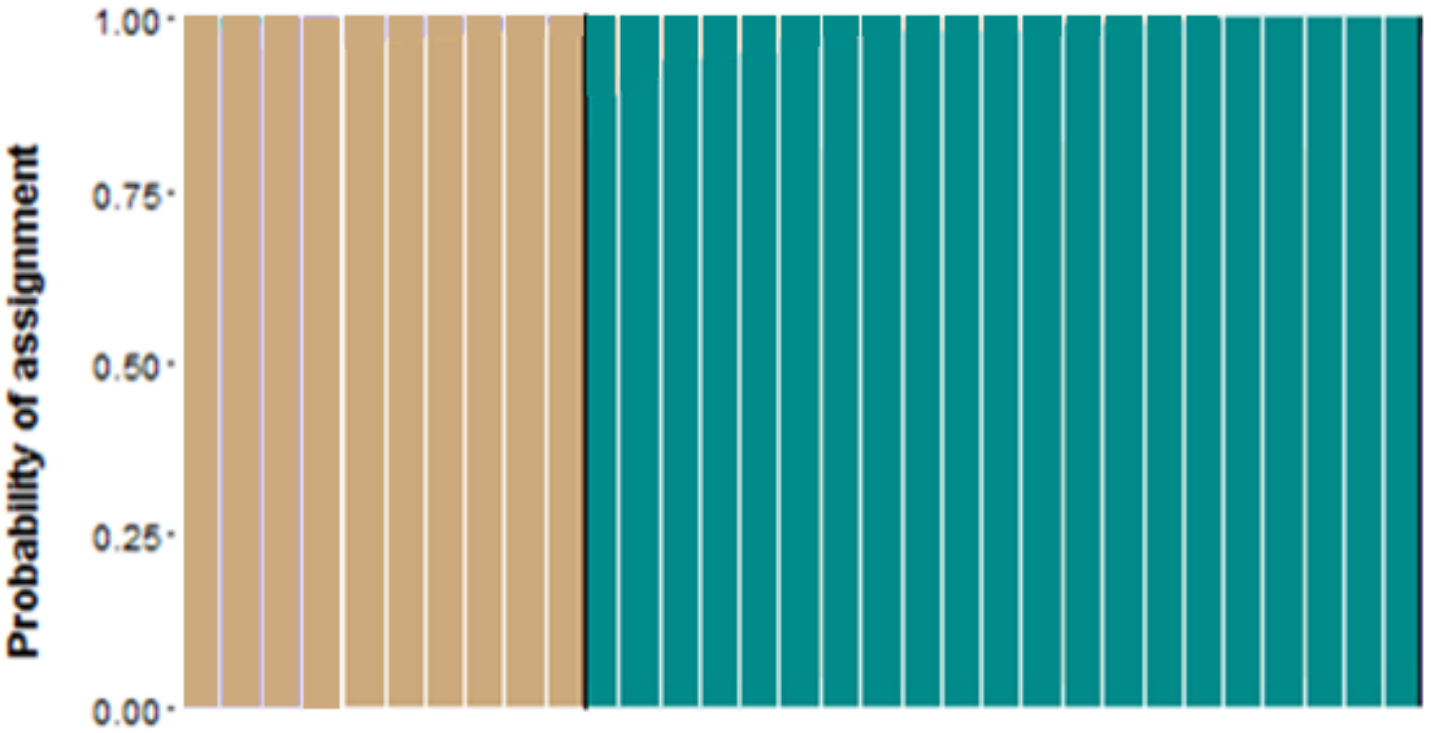
EXPECTED RESULTS





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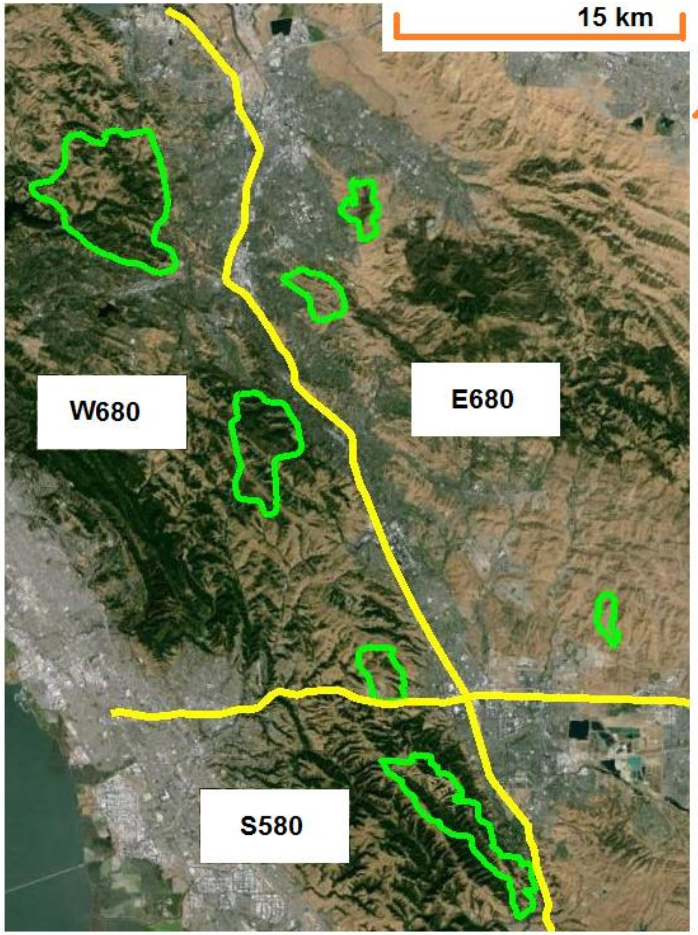
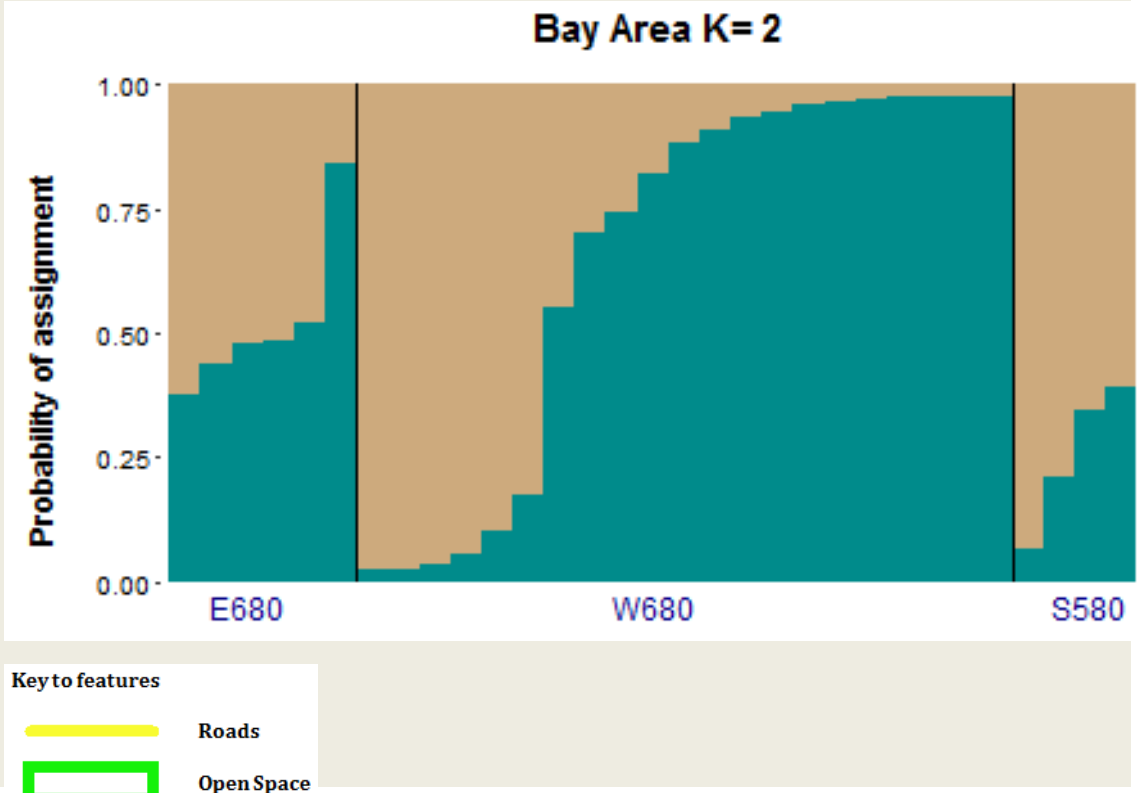
RESULTS:
No structuring of populations across highways





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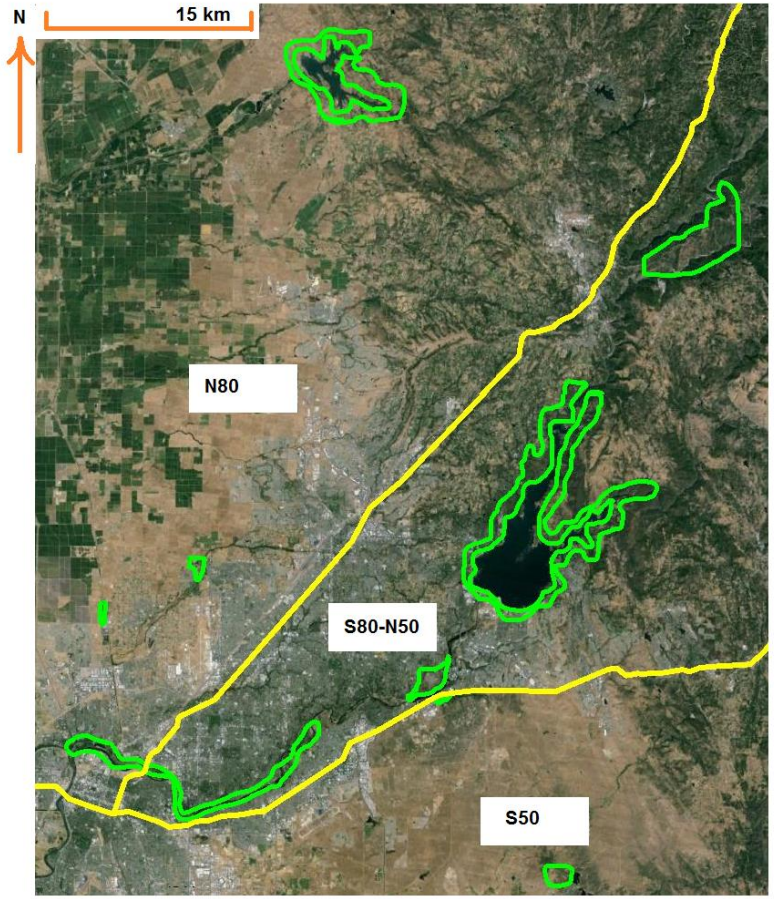

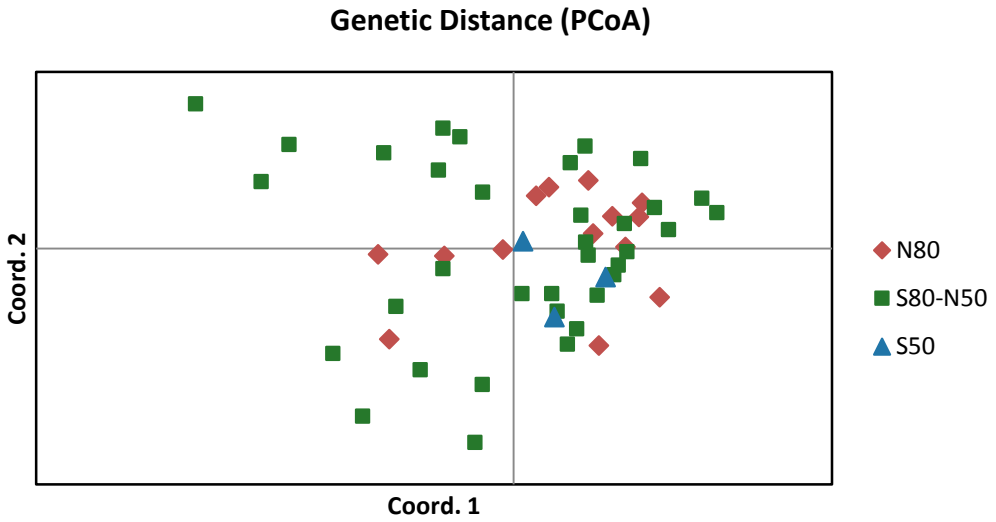

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SUMMARY

- Populations of coyotes in both regions show genetic connectivity
  - Evidence for weak substructure = increased relatedness
  - Sierra Nevada Foothills connectivity > Bay Area
- Genetic connectivity
  - Due to passage?
    - Camera trap data ≠ coyote use of culverts in region
    - Crossing on road surface?
  - Large populations take longer to display evidence of fragmentation

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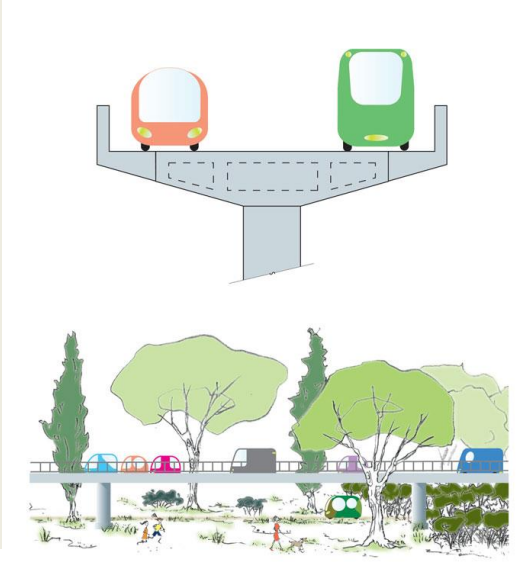
FUTURE DIRECTIONS

- Examine genetic structure across State Road 49
  - 2 lane highway, few passage points below road surface
- Look at differences in genetic connectivity relative to
  - Body size
  - Dispersal distance
  - Disturbance tolerance
- Compare with Southern California results
  - What is different about highways in study areas that leads to different results

SUSTAINABLE TRANSPORTATION

- Existing structures provide some solutions, mitigation structures even more, but we may need to re-design the infrastructure to allow social and ecological processes to flourish

VS.



(Forman and Sperling, 2011)

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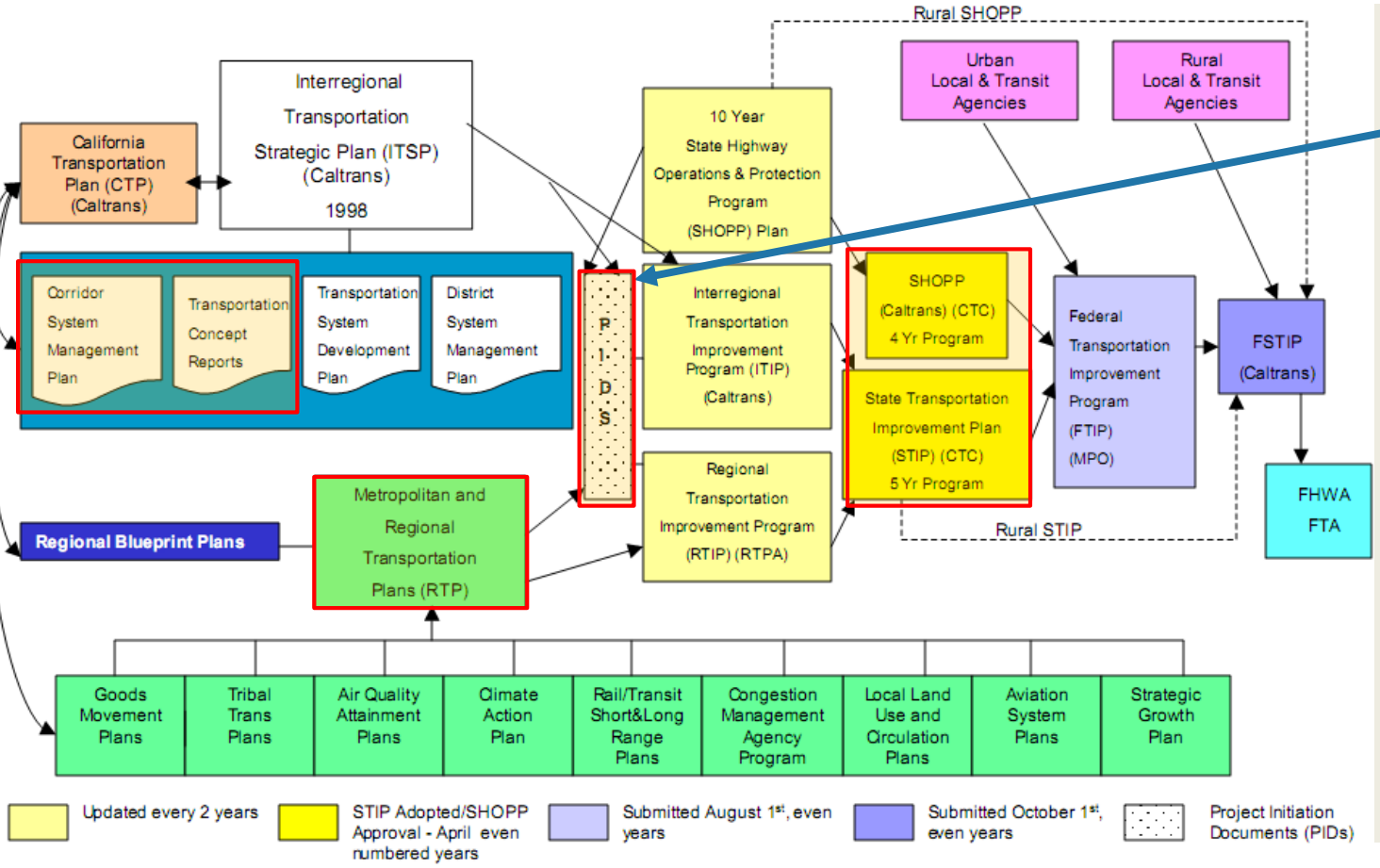
SUSTAINABLE TRANSPORTATION: PLANNING



Identify Project Need

Prepare Initiation Document

Form PDT, Prepare PSR, Prepare Draft Project Report

Perform Environmental Studies

Secure Project Approval

Obtain Approvals, Agreements, Permits. Prepare PS&E, Acquire ROW

Complete Project Design, Advertise Contract

Conduct and Complete Construction

Planning opportunities for sustainability for wildlife

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