# Managing Landscape Linkages to Conserve Desert Wildlife During Climate Change

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# Linkage Terminology

- **Connectivity**: A property allowing movement by organisms or processes.
  - Physical connectivity
  - Functional connectivity
- **Linkage**: A functional landscape connection facilitating movement between core habitat areas for diverse organisms and processes.
- **Corridor**: A generally linear connection that facilitates wildlife movement between habitat patches through areas less suitable for movement (the **matrix**).
- **Crossing Structure**: A structure, such as an overpass or underpass, that facilitates wildlife movement across barriers or filters to movement, such as a highway or a canal.

# Surging Interest in Connectivity Conservation

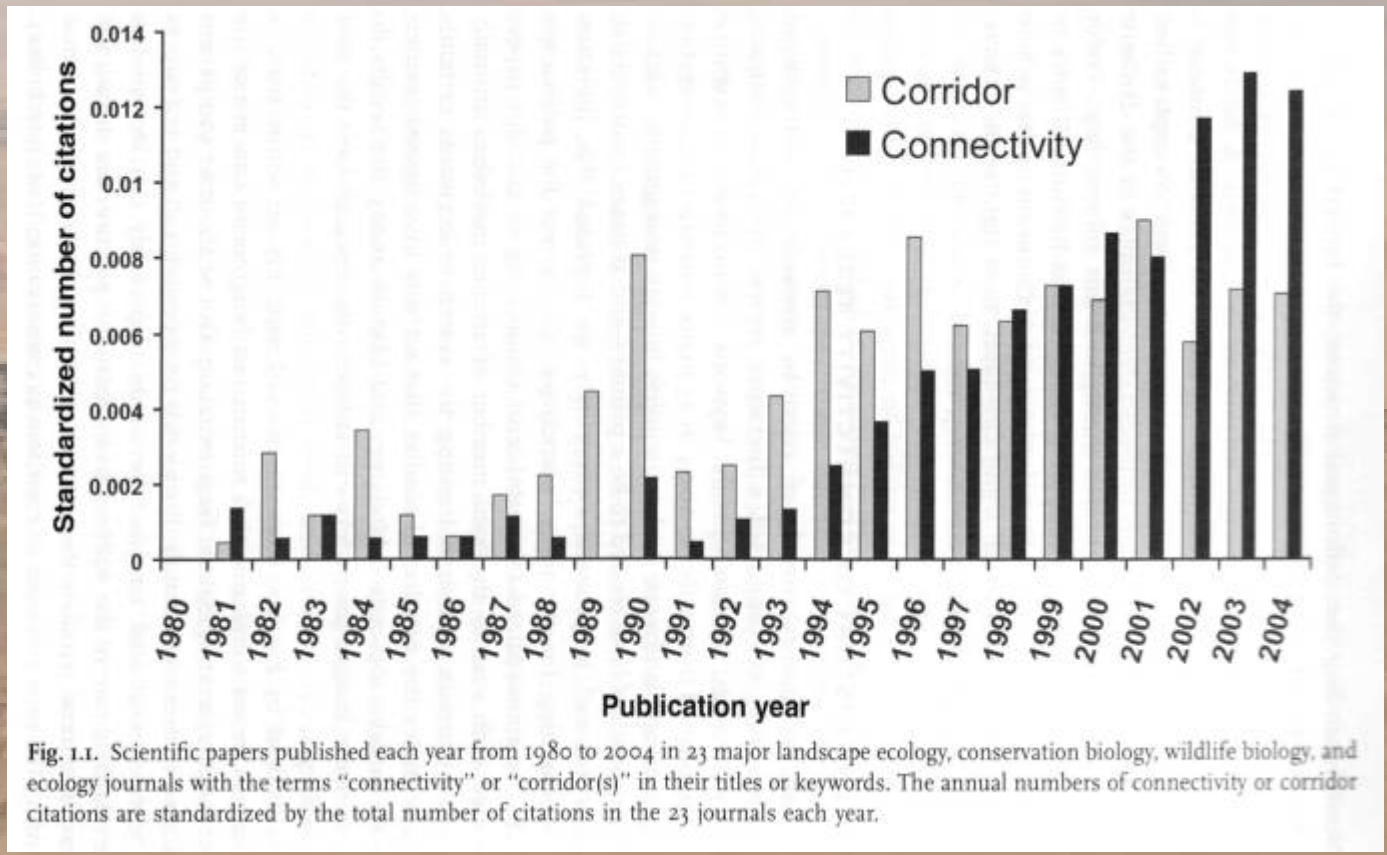
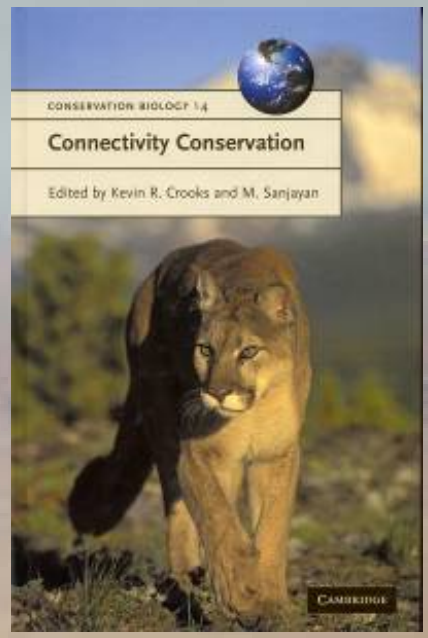
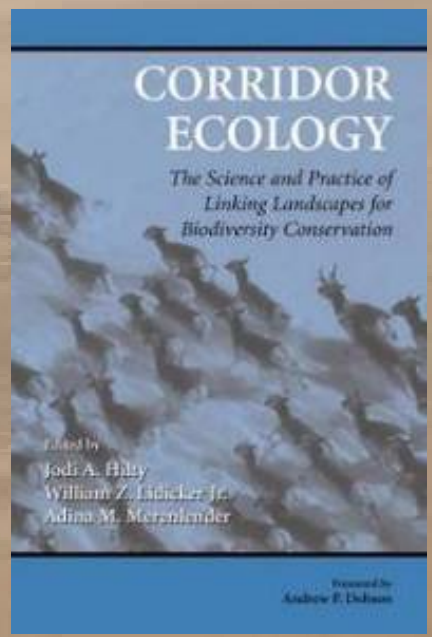



Fig. 1.1. Scientific papers published each year from 1980 to 2004 in 23 major landscape ecology, conservation biology, wildlife biology, and ecology journals with the terms "connectivity" or "corridor(s)" in their titles or keywords. The annual numbers of connectivity or corridor citations are standardized by the total number of citations in the 23 journals each year.

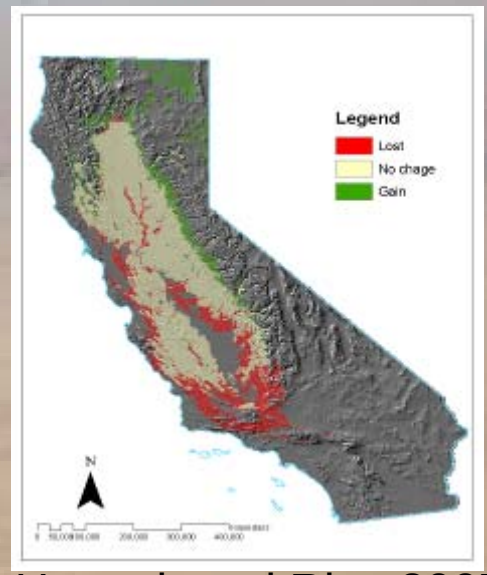


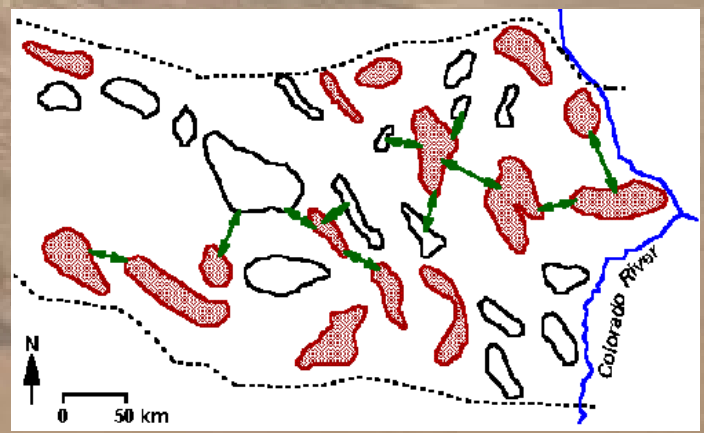

Reproduced from Crooks and Sanjayan, 2006, Connectivity Conservation.

# Climate Change Re-emphasizes Importance of Ecological Connectivity

- Ecological Migration
  - Geographic range shifts
  - Community composition shifts
- Metapopulation dynamics
  - Source-sink dynamics
  - Rescue effects
- Life History Adaptations
  - Phenological shifts
  - Seasonal migrations




Hannah and Ries 2007




Bleich et al. 1990

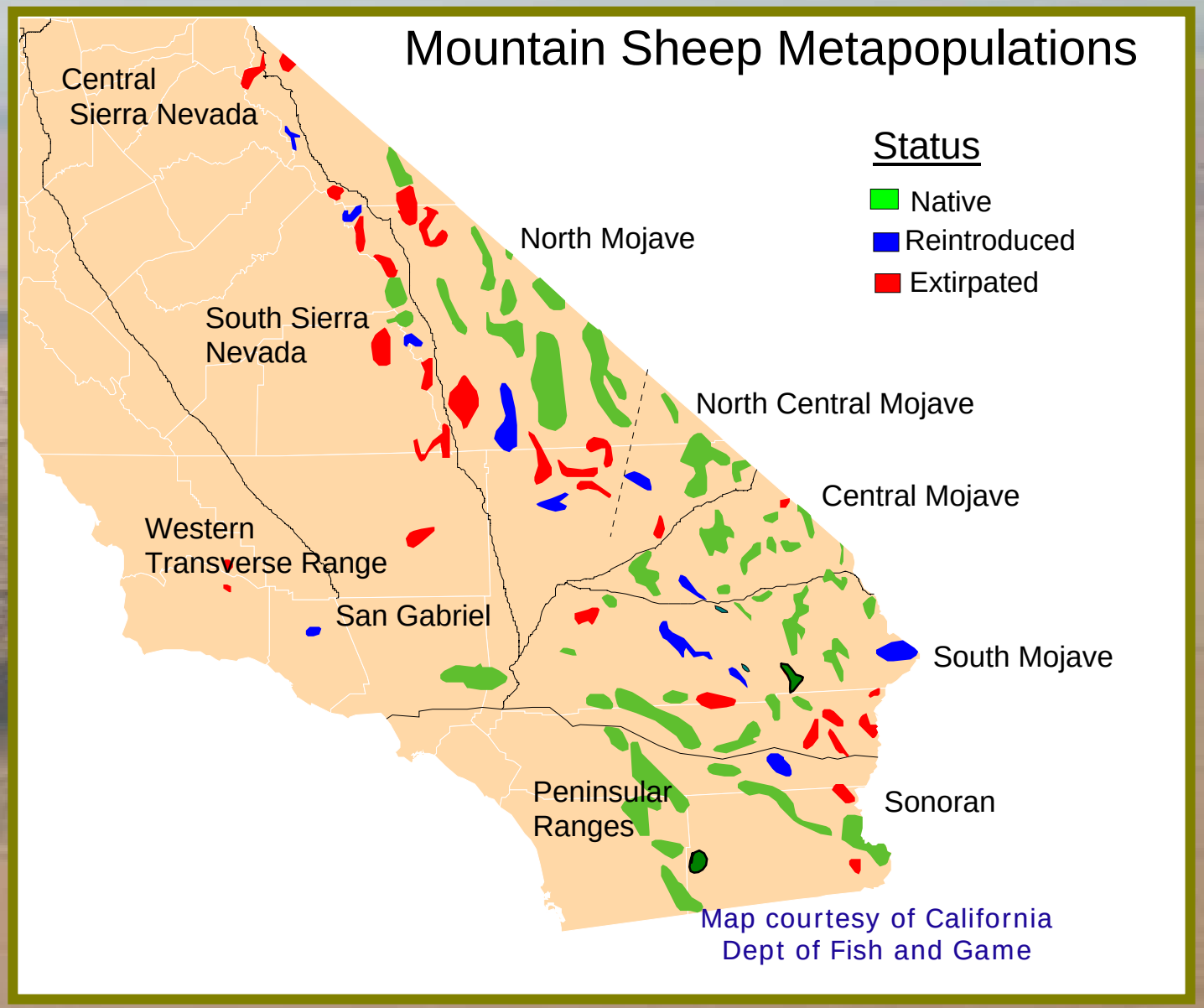
# Species Most Vulnerable to Extirpation by Climate Change?

- Mountain-top dwellers
- Less mobile species?
- Narrow endemics?
- Water-limited species?
- Soil specialists?

# Can Connectivity Conservation Help?

- **Premise**: Maintaining broad ecological connectivity, and minimizing movement barriers, seems necessary to conserve species and ecological processes in the face of climate change….
- … but is certainly not sufficient for all species and processes.

# Desert Bighorn as an Example



Epps et al. 2004. Effects of climate change on population persistence of desert-dwelling mountain sheep in California.

- Bighorn population persistence in 20th century related to
  - Elevation
  - Precipitation
  - Water availability
- A 2° C increase and 12% precipitation decrease predicts average extinction risk increasing from 21% to 30%.
- Management implications:
  - Prioritize reintroduction sites
  - Create more artificial water sources?
  - Maintain linkages?

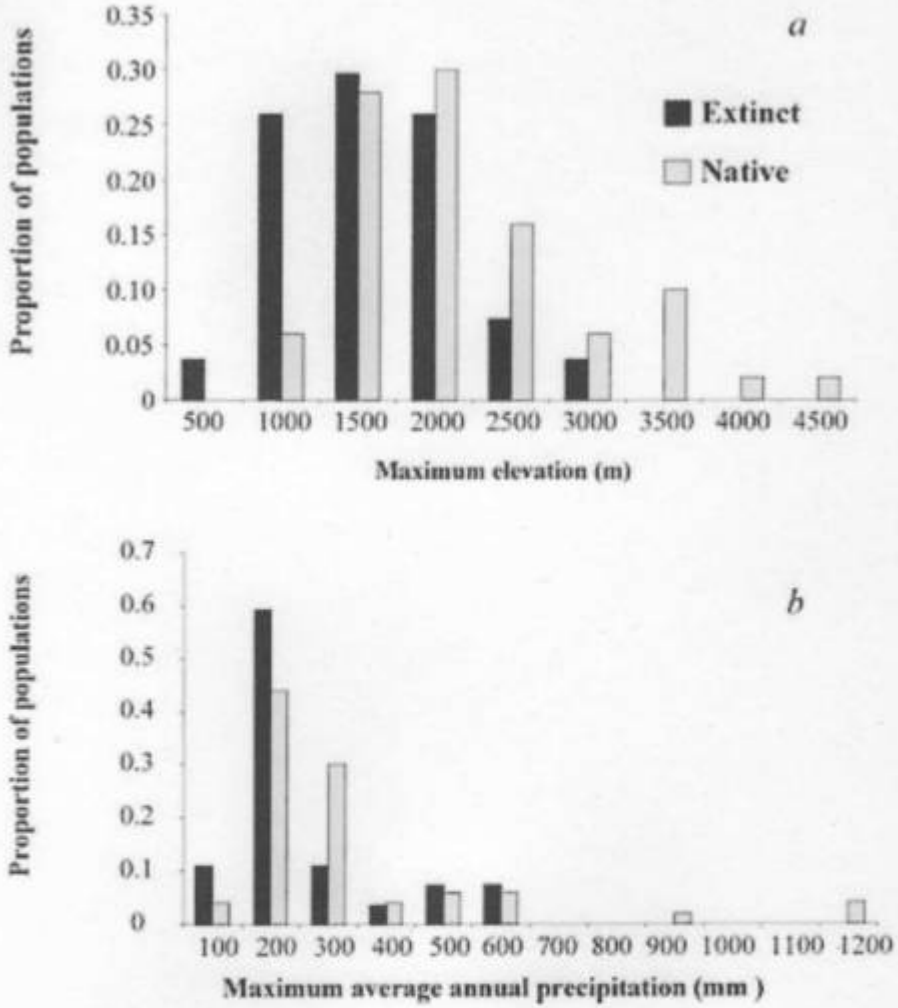



*Figure 2. Distribution of (a) maximum elevation and (b) maximum average precipitation values for ranges of native and extinct bighorn sheep (*Ovis canadensis nelsoni*).*

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# Setting Priorities for Linkage Conservation and Management in Deserts: An exercise in bet-hedging

- Maintain broad ecological gradients in contiguous landscapes:
  - Elevation
  - Latitude
  - Hydrology
  - Geology
  - Etc.
- Eliminate or mitigate barriers where possible with crossing structures
- Consider translocations as a last resort.

# A Case Study in Planning for Ecological Connectivity

- The South Coast Wildlands Missing Linkages Project:
  - Multi-species linkage planning in the most urbanized ecoregion in California
  - Focal species approach to accommodate movement needs of diverse species
  - Bottom-up and top-down planning, with input and guidance from diverse partners and scientists.

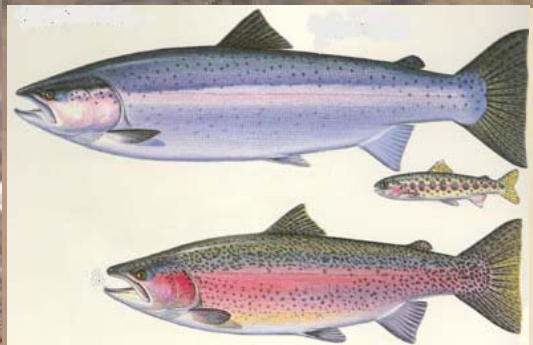
Visit www.scwildlands.org for reports and details.

# South Coast Missing Linkages:

## Restoring Wildland Connectivity to Southern California


# 109 Focal Species Selected to Represent 15 priority linkages

- Diverse taxa
- Diverse movement modes
- Diverse habitat needs
- Linkage traversers as well as linkage dwellers
- Single generation and multi-generation movers



# Conservation Design

Landscape Permeability Analyses

Habitat Suitability Analyses

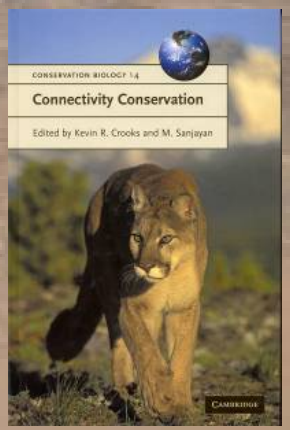
Patch Size Analyses

Configuration Analyses

Field Investigations

Final Refinements

= Linkage Design




See Beier et al. (2006 and In Press) for details.

# Landscape Permeability Analysis

**Goal: Define area with lowest relative cost of travel for focal species between protected core areas.**

(Walker and Craighead 1997, Craighead et al. 2001, Singleton et al. 2002)

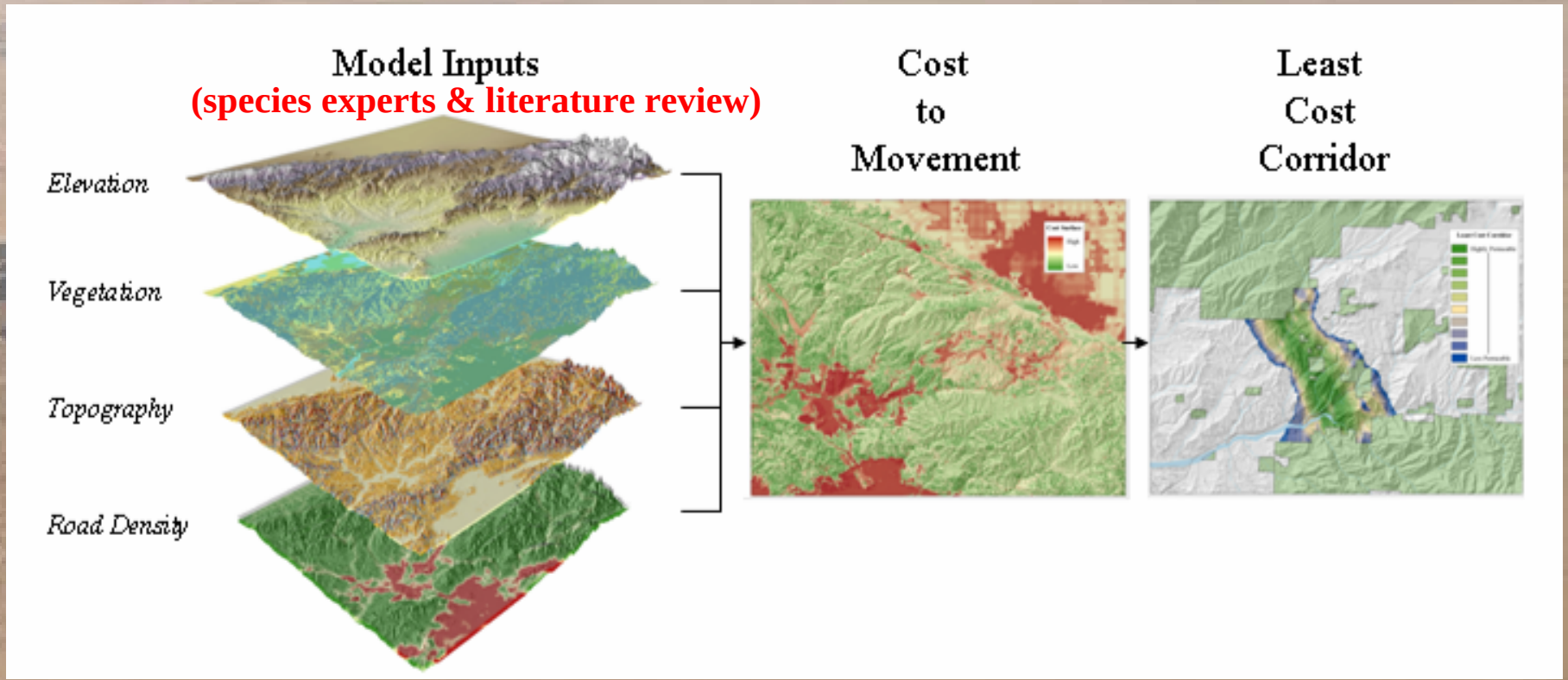
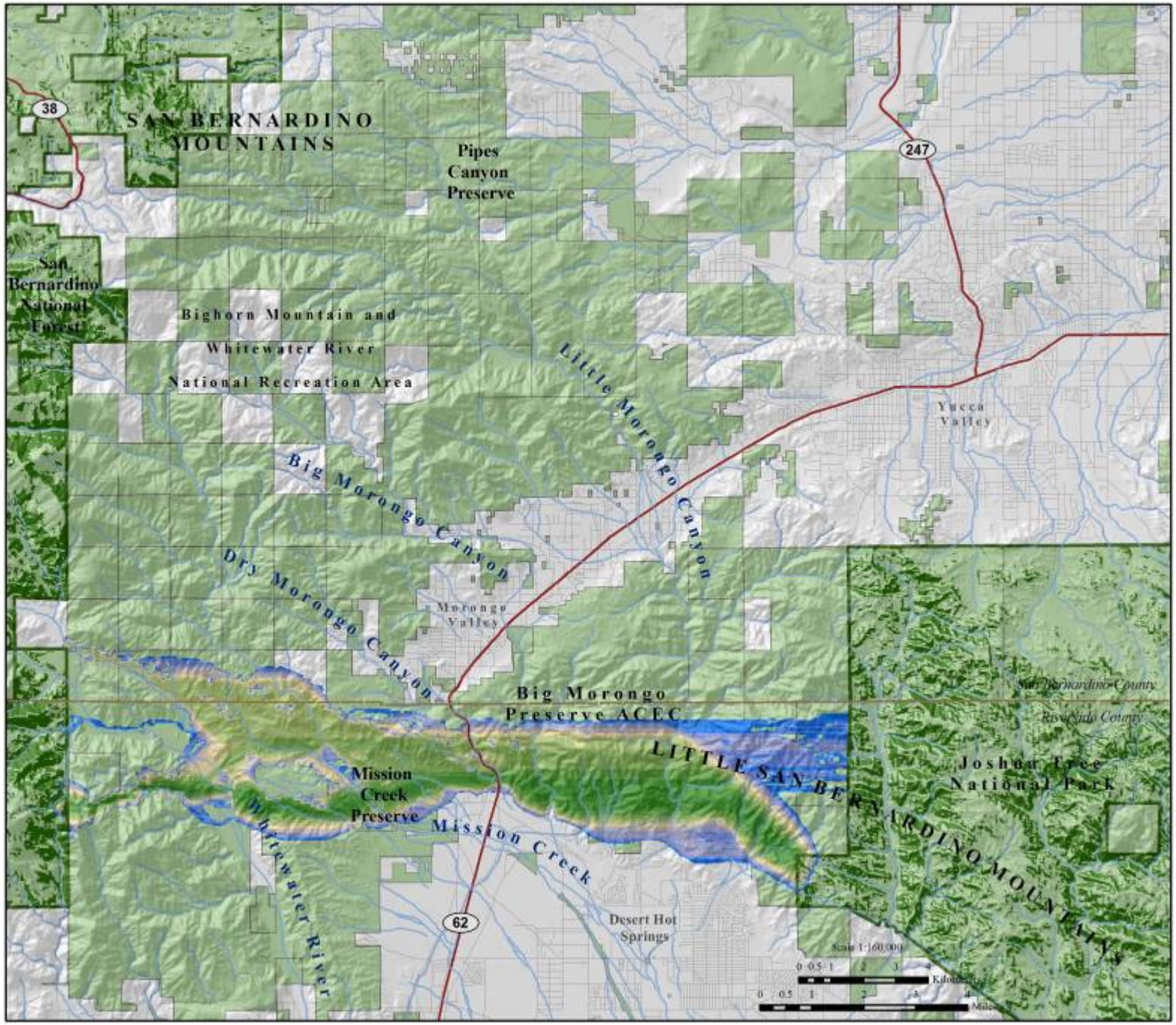


**Figure 12.**
**Least Cost Corridor**
**for**
**Nelson's bighorn sheep**
***(Ovis canadensis nelsoni)***




Highly Permeable

Less Permeable

Suitable Habitat*

Ownership Boundaries

Hydrography

Roads

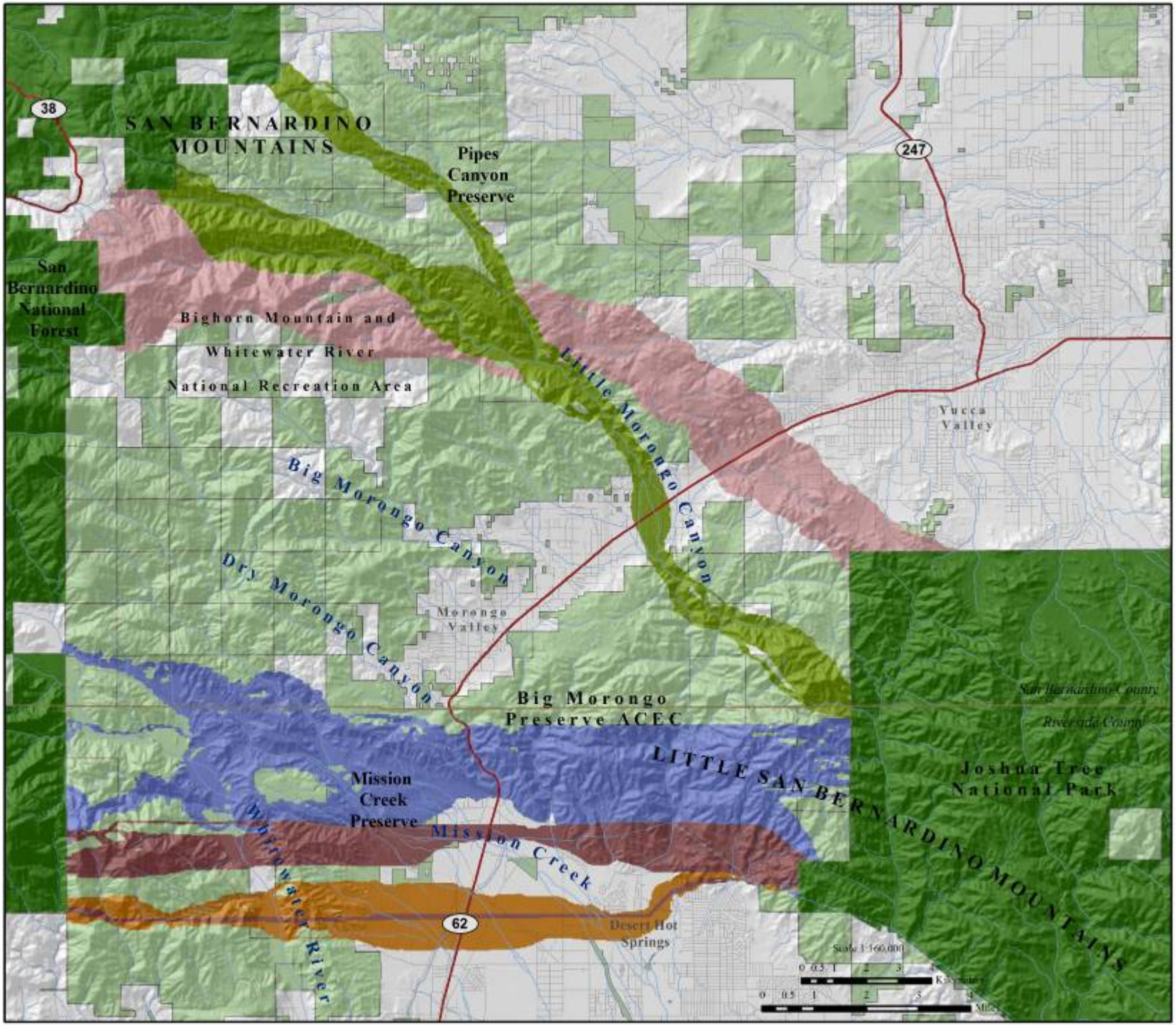
*This analysis was run from medium to high suitable habitat within San Bernardino National Forest and Joshua Tree National Park.

Map Produced By:

SOUTH COAST WILDLANDS

July 2005
www.scwildlands.org

**Figure 8.**
**Least Cost Union Displaying Species Overlap**




- Mule deer
- Mountain lion
- Nelson's bighorn sheep
- Pacific kangaroo rat
- Badger
- Ownership Boundaries
- Target Areas*
- Hydrography
- Roads

*Analysis was run between the San Bernardino National Forest and Joshua Tree National Park.

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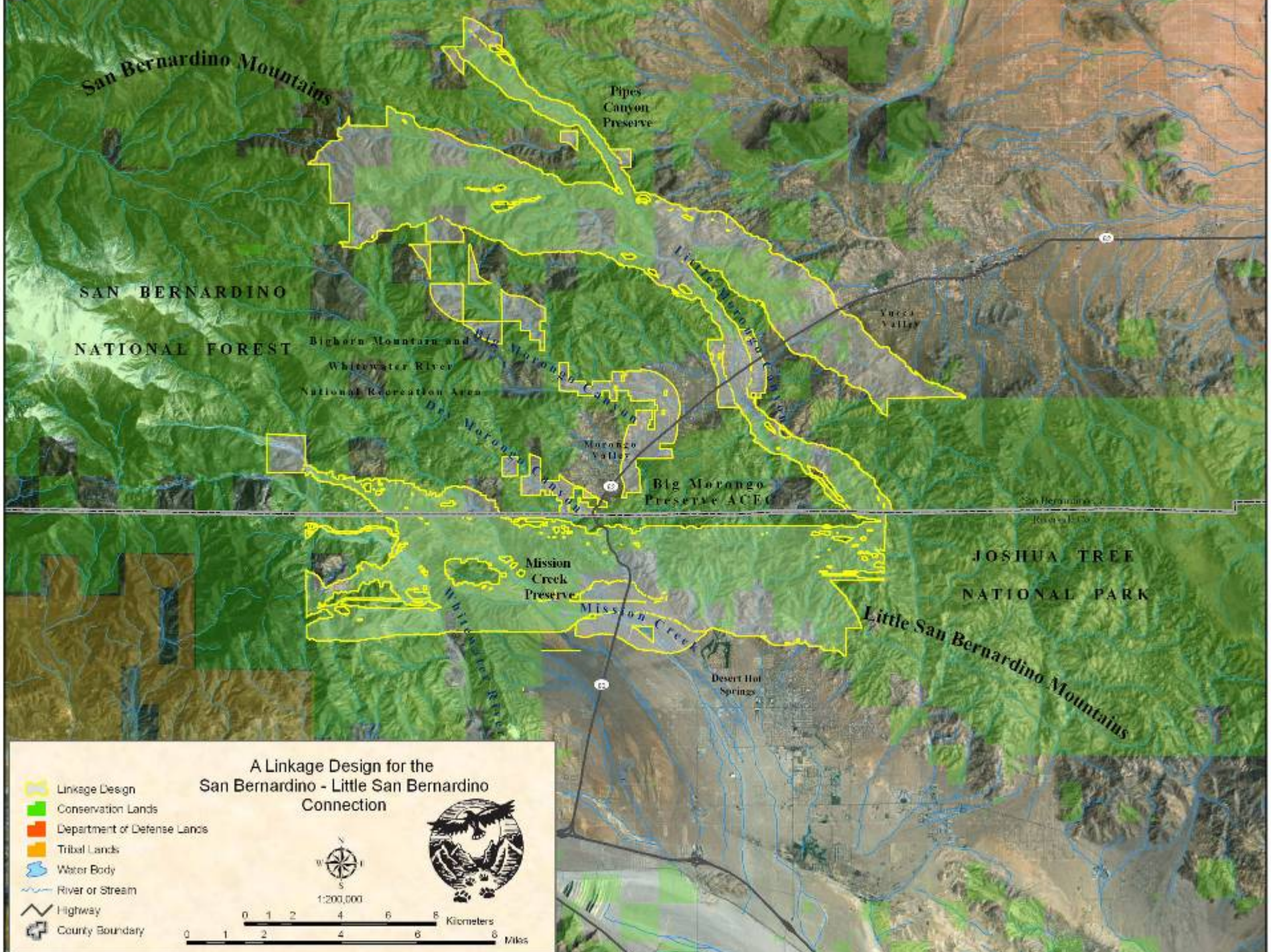
San Bernardino Mountains
Pipes Canyon Preserve
SAN BERNARDINO
NATIONAL FOREST
Bighorn Mountain and Whitewater River
National Recreation Area
Big Morongo Canyon
Dry Morongo Canyon
Morongo Valley
Big Morongo Preserve ACEC
Yucca Valley
Mission Creek Preserve
Mission Creek
Whitewater River
Desert Hot Springs
JOSHUA TREE
NATIONAL PARK
Little San Bernardino Mountains
A Linkage Design for the
San Bernardino - Little San Bernardino
Connection
Linkage Design
Conservation Lands
Department of Defense Lands
Tribal Lands
Water Body
River or Stream
Highway
County Boundary
1:200,000
0 1 2 4 6 8 Kilometers
0 1 2 4 6 8 Miles


Mitigating barriers to movement…

# Roads as barriers, filters, and population sinks

# Road Effect Zones Can Extend Hundreds of Meters

- Roadkill
- Behavioral modification
- Physical changes to environment
- Chemical changes to environment
- Spread of exotic species
- Fragmentation and population isolation
- Changes to hydrology and aquatic habitats
- Increased human access

# Mitigating Road Effects

# Closing Thoughts

- Maintaining landscape connectivity is necessary, but not sufficient, to conserve desert biodiversity during climate change.
- Although we can make informed guesses about climate change effects on species and ecological processes…
  - We cannot anticipate all changes
  - We cannot counter all changes
  - We need to pick our battles

# Closing Thoughts

- Ecological migration will occur at different rates, and in different patterns, for different organisms.
  - Some species may not be able to keep up.
  - New species will arrive.
  - New community compositions will yield surprises.
- Shifting “climate-envelope” models are too simplistic to predict range shifts for most species due for example to:
  - Decoupling of life requisites
  - Swamping effects of invasive species and increasing fire
- Improving crossing structures for wildlife is one positive action to take, but the cost/benefit ratio, relative to other actions, is unknown.