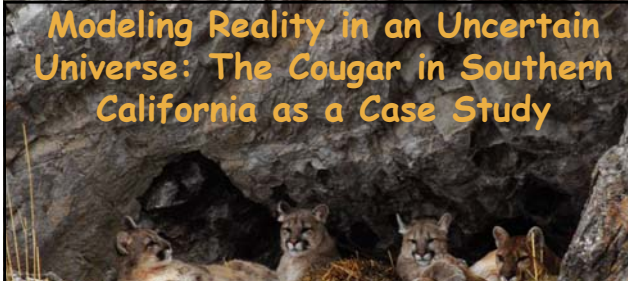## Modeling Reality in an Uncertain Universe: The Cougar in Southern California as a Case Study

Rick Hopkins
Live Oak Associates, Inc. (LOA) and The Cougar Fund
Brett Dickson, LOA/NAU
Brad McRae, LOA/NCEAS

Sierra Azul Connectivity Workshop
October 11, 2006

Acknowledgments

Contributors
– Paul Beier
– Ken Logan
– Barry Noon
– Linda Sweanor
– Steve Torres

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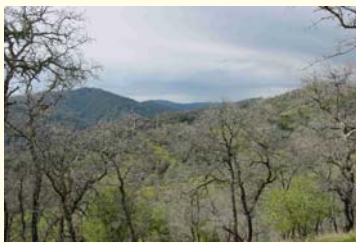-Vicki Long
-Live Oak Associates, Inc.
-The Cougar Fund

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The Mission of The Cougar Fund

- Science-based management/ conservation
- Research
- Habitat protection
- Education

www.cougarfund.org

preserve.protect.balance.

The Pure Carnivore

- Obligate carnivore
- Solitary hunters
- Ambush predator
- Crepuscular and nocturnal
- Avoids human dominated landscapes

Photo: Tom Mangelsen

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1

Are Cougars a Success Story?

Photo: Vance Hopkins

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Cougars Conflict with Humans

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Humans Conflict With Cougars

1. Extirpated the cougar east of the Rockies
2. Present development patterns fragment remaining habitat
3. Current level of sport kill highest ever

Photo: Tom Mangelsen

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Who's affecting who?

The Worm's Eye View by Gabe McIntosh

SINCE YOU BUILT YOUR HOUSE IN MY ROAMING AREA, I THOUGHT WE COULD WORK OUT A LIVING ARRANGEMENT. YOU WON'T EVEN KNOW I'M HERE... BUT I WOULD SUGGEST A BIGGER LITTER BOX

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Conservation in the Land of Oz

The Magnitude of the Problem

County	Size(km2)	Pop 1950	Pop 2004	% Increase	People/ km2
Riverside	18,580	170,000	1,871,950	1000	100
Orange	2025	200,000	2,957,800	1500	1460
TOTAL	20,605	370,000	4,829,350	1300	233

Western Riverside County Multi-Species HCP

- 146 covered species
- Coarse identification of habitats and linkages
- Coarse goals and objectives
- Limited monitoring for the cougar

Photo: Tom Mangelsen

Coachella Valley MSHCP

- 4890 km^2
- 27 covered species
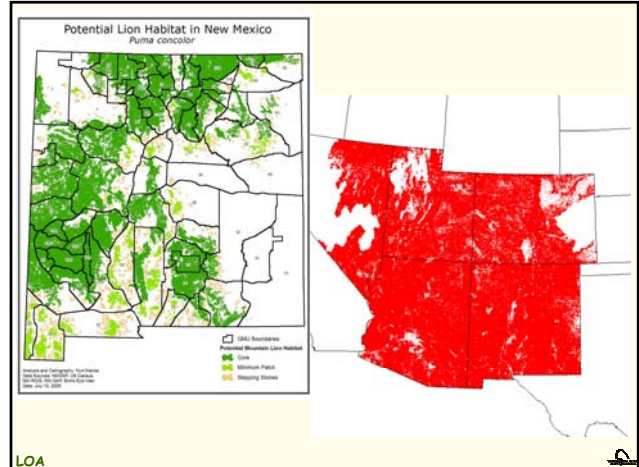- 24 natural communities will be conserved
- 2520 km^2 under some conservation

Objective for Riverside County Cougar Conservation Plan

1. **Identify "core" habitat**
2. **Identify suitable landscape linkages**
3. Develop a protocol for cougar/human conflicts
4. Develop an education/outreach program

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Potential Lion Habitat in New Mexico
Puma concolor

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Traditional Approaches

Approaches
- GIS overlays
- Judgment based
- Least-cost pathway (mostly expert-based)
- Radio-telemetry

Limitations
- Lacks realism
- Limited ecological scale
- Rarely considers width and/or distance
- Rarely evaluates multiple pathways
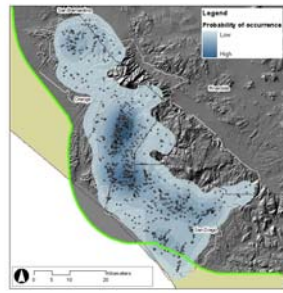
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The Study Area – Inland Empire

- 28,223 km^2
- Buffered by 10 km for a total of 37,429 Km^2
- Minimum mapping unit 100m
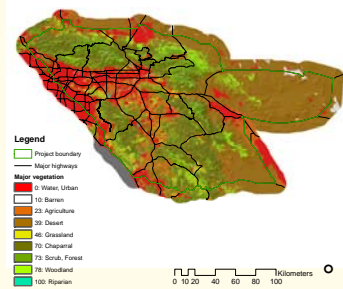
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4

Occurrence Model

- Populating the statistical models with data collected at behavioral scales relevant to each scale of conservation.
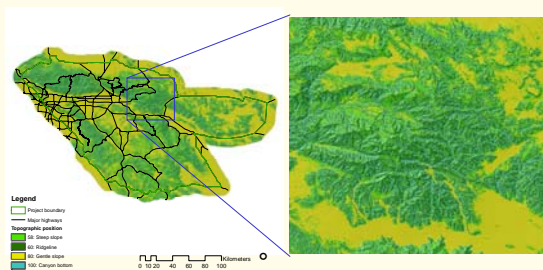- Eventually, we will include data of cougars monitored outside of the SAMR.

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Vegetation Layer

- CDF Fire Protection, Multi-source Land Cover Data (2002)
- Reclassified into 11 broad classes
- Expert ranked 9 classes
- Developed a VegContext grid – summed ranked cell values in 1 km window

Legend
Project boundary
Major highways
Major vegetation
0: Water, Urban
10: Barren
23: Agriculture
39: Desert
46: Grassland
70: Chaparral
73: Scrub, Forest
78: Woodland
100: Riparian

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Topographic Position Index (TPI)

Legend
Project boundary
Major highways
Topographic position
58: Steep slope
60: Ridgeline
80: Gentle slope
100: Canyon bottom

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Road Layers

- Distance: Major Highways - updated (Caltrans 1993)
- Density: TIGER data – updated, U.S. Bureau of the Census, 2003 (computed using 10-km circular moving window
- Distance and density classified from 10 quantiles – not experts
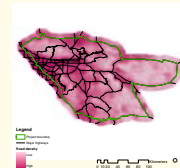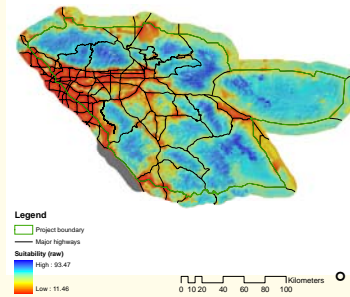

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Suitability Model - Weighting

- Used modified Weighted Linear Combination (WLC) method to address interdependencies among layers
- Averaged classes and weighted values using 5 experts

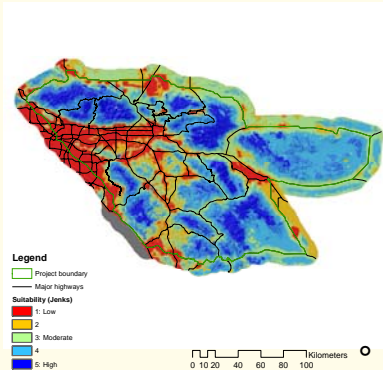([Veg-Complm]*0.5023)+([TPI_100m_rank]*0.1509)+([disthwys_rank]*0.1553)+([roaddens_rank]*0.1915)

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Landscape-scale Suitability

- New "raw" grid with values from 11.5 to 93.5
- Rescaled using 5 "natural" breaks (Jenks)

Legend
Project boundary
Major highways
Suitability (raw)
High : 93.47
Low : 11.46
0 10 20 40 60 80 100 Kilometers

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Jenks Suitability Scale

Legend
Project boundary
Major highways
Suitability (Jenks)
1: Low
2
3: Moderate
4
5: High
0 10 20 40 60 80 100 Kilometers

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Habitat Fragmentation

- Cougars require large habitat patches
- Fragmented landscapes are more the norm in Riverside County
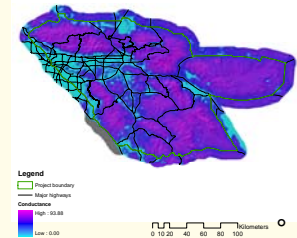- Development continues to threaten remaining landscape linkages

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Circuit-Theoretic Model

- **Holistic vs Reductionist (see Lidicker 1978)**
- **Greater connectivity predicted between core areas if connected by:**
  - multiple corridors vs. single corridors
  - wider corridors vs. narrow corridors
  - 2-dimensional habitat blocks vs. 1-dimensional habitat blocks

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Conductance Surface – Circuitscape

- Expert ranks
- Conductance surface – values 16.3 to 93.9
- Assigned Urban and water a value of "0"
- Forced major roads to values from 1 to 3

Legend
Project boundary
Major highways
Conductance
High : 93.88
Low : 0.00
0 10 20 40 60 80 100 Kilometers

$$([veg\_complim])*0.4221)+([tpi\_100m\_rank]*0.2191)+([disthwys\_rank])*0.1795)+([roaddens\_rank]*0.1794)$$

Circuit-theoretic Approach

- Polygons have zero resistance
- Treated as a single node (cell)
- Source to one or more grounds
- Probabilistic
- High current roughly equates to areas important for connectivity
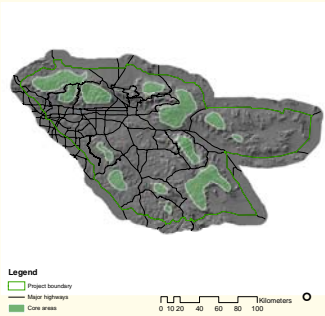- Identifies pinch points

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Regional Connectivity

- 11 individual surfaces
- Unweighted cumulative surface
  - Same number of dispersers regardless of size
  - Exits system when enters new polygon
- Weighted cumulative surface
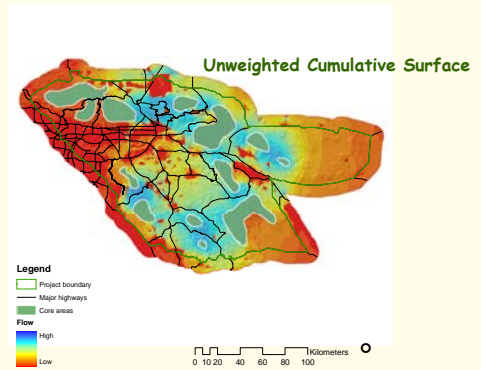 - Current dependent on size of polygon
- Alternatives – various and many

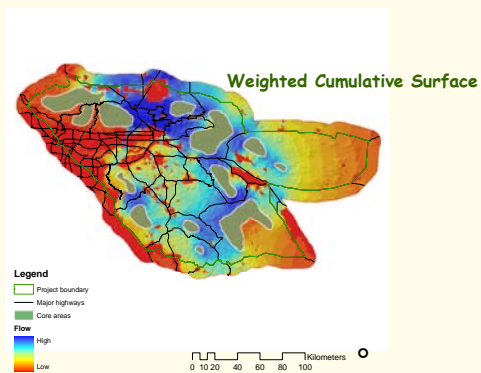## Identification of Core Habitat Areas

- Smoothed landscape using circular window majority filter using average 85% home range radius for 15 cougars from the SAMR
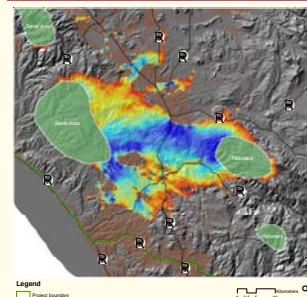- 11 primary core areas (35 km2 to 1440 km2)

Legend
Project boundary
Major highways
Core areas

0 10 20 40 60 80 100 Kilometers

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Unweighted Cumulative Surface

Legend
Project boundary
Major highways
Core areas

Flow
High
Low

0 10 20 40 60 80 100 Kilometers

LOA

Weighted Cumulative Surface

Legend
Project boundary
Major highways
Core areas

Flow
High
Low

0 10 20 40 60 80 100 Kilometers

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I-15: SAMR and the Palomar Mts

Legend
Project boundary
Major highways
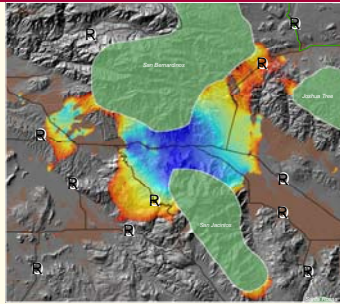Core areas

Flow
High
Low

0 2.5 5 10 Kilometers

LOA
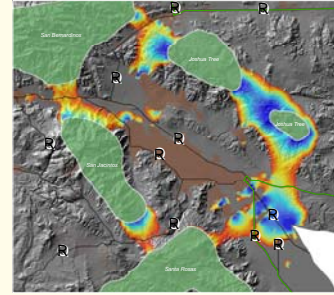
San Jacinto – San Bernardino


Santa Rosa – Joshua Trees NP

Multiple Connections – A Framework for Reality

- Statistically based
- Numerous ways of evaluating the landscape - modifiable
- Identifies multiple pathways
- Expandable to new areas of the state
- Usable and easily adapted to existing Western Riverside MSHCP and Draft Coachella Valley MSHCP

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Value of the Models

- Hypothesis generating
- Facilitates monitoring
- Is inherently adaptive
- Links scales of ecology and conservation
- Targets areas for conservation
- Allows for project specific analysis
- Permits simulations of future development patterns
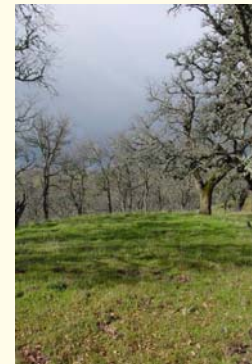
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Relevance to Santa Clara County

- Holistic approach
- Permits testing of a-priori hypotheses
- Better informs policy decisions
  - Comparisons of conservation value
  - Modifiable for different species

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Challenges for the Next Millennia

Photo: Tom Mangelsen

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