Vulnerability of chaparral plant functional types to multiple stressors: climate, fire and land use

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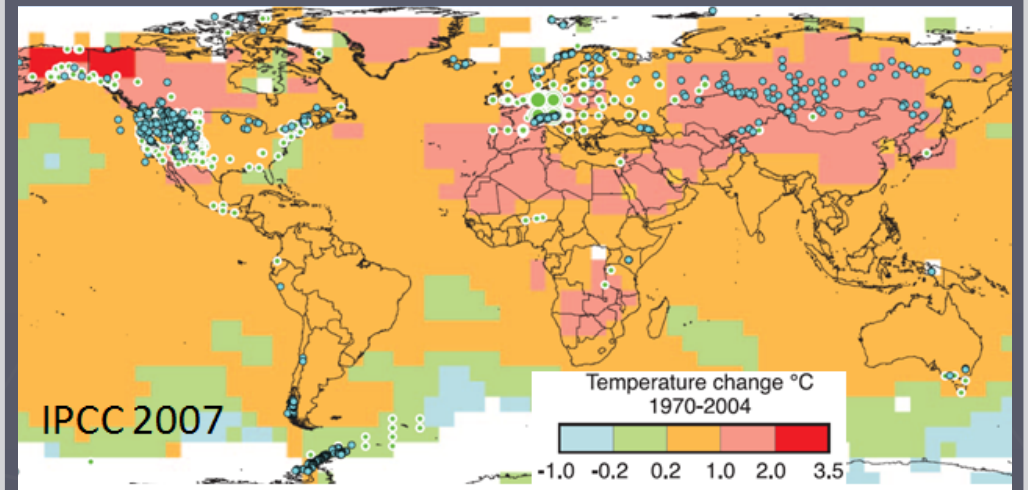
National Science Foundation

Dept. Energy Nat' l Inst Clim Chg Rsch

Agents of Global Change

Climate change



Over 90% of 28,671 studies in **biological systems** (◉) and 765 studies in **physical systems** (○) show significant results consistent with climate change.

Disturbance

Land use change

Land Use Change in Mediterranean-Type Ecosystems

- LUC has been the primary driver of biodiversity loss
- LUC in MTEs
  - Agricultural expansion
  - Urban growth
  - Agricultural abandonment

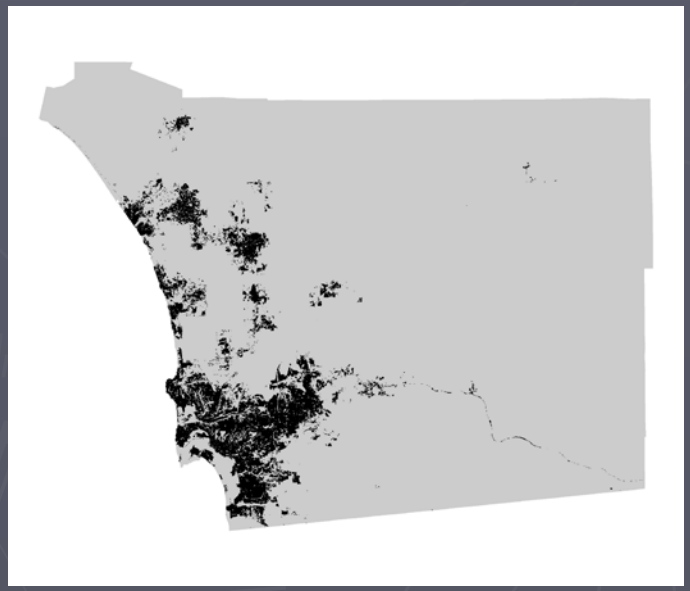
Pausas 2004
http://jgpausas.blogs.uv.es/tag/fire-history/

Land Use Change in Southern California

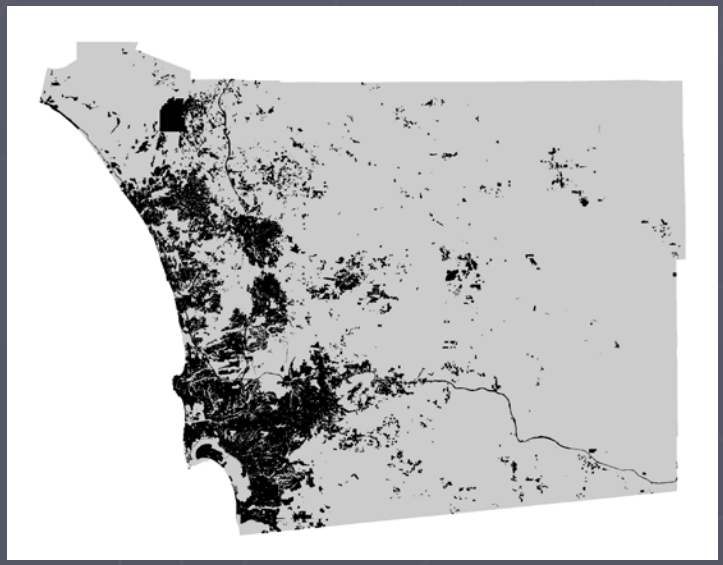
LUC = Urbanization

Recent Growth Urban Footprint San Diego County

1975



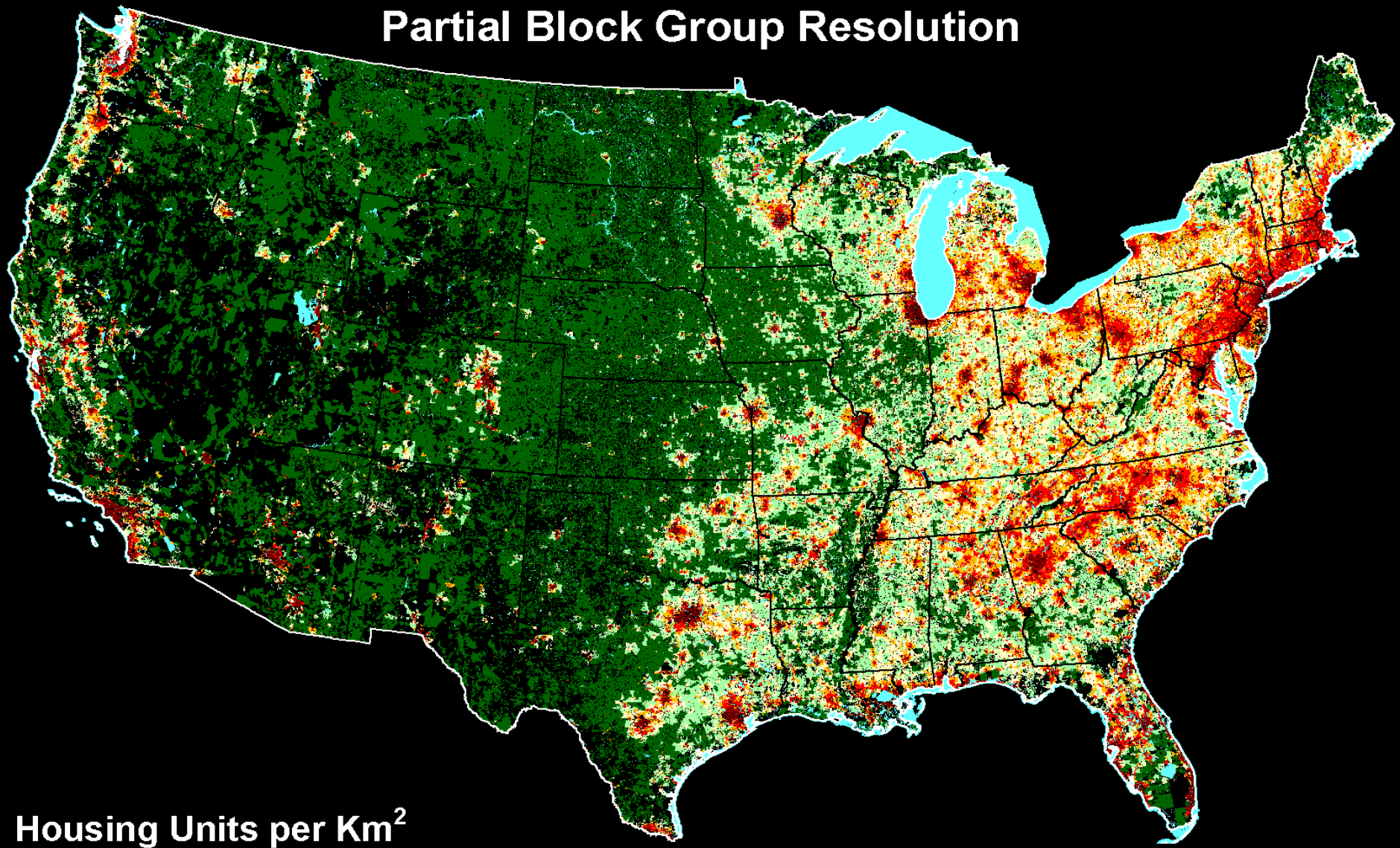
1999



Data from SANDAG
Syphard et al. 2011, *J Env Mgt*

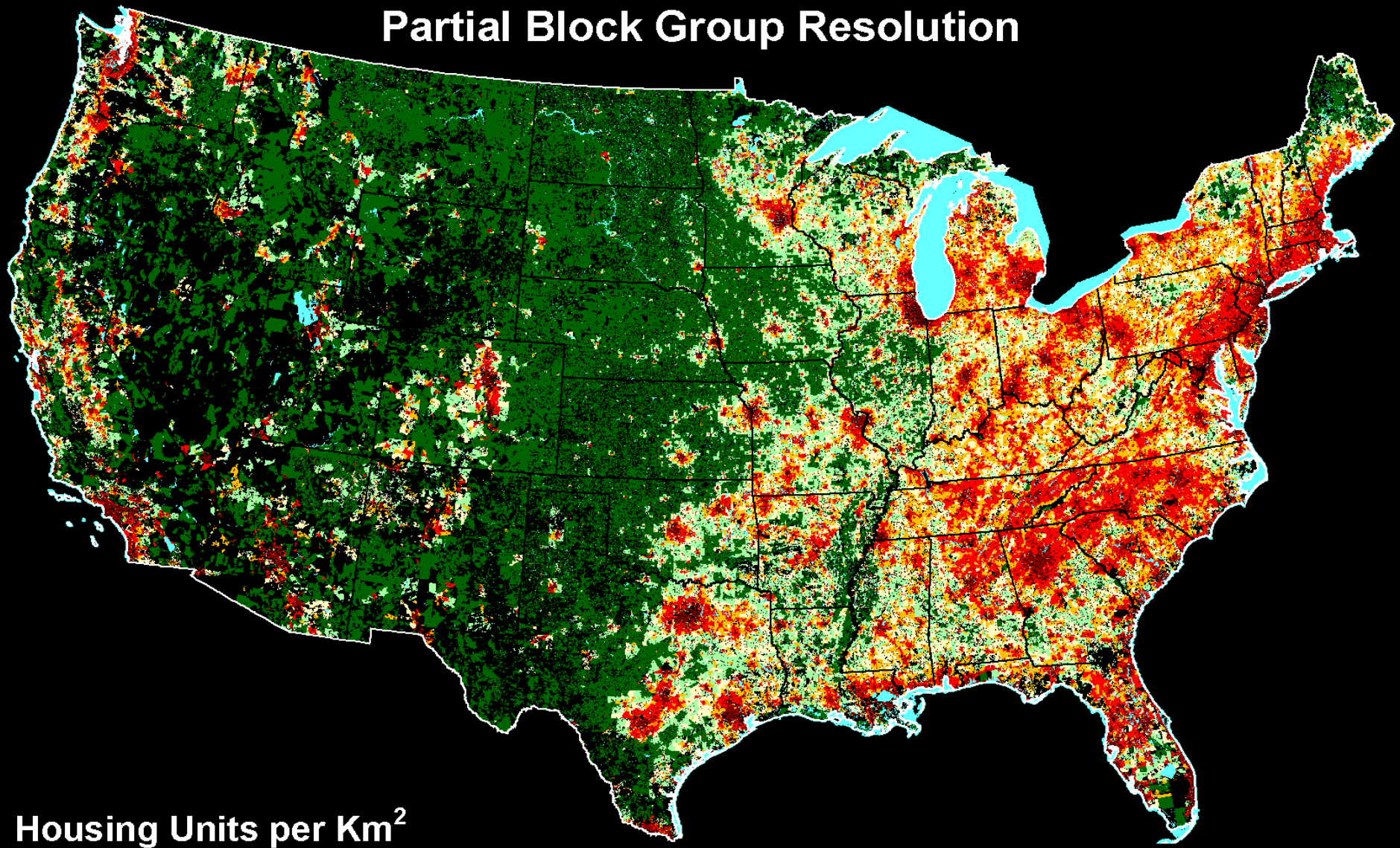
Housing Density 2000

Partial Block Group Resolution



Projected Housing Density 2030

Partial Block Group Resolution

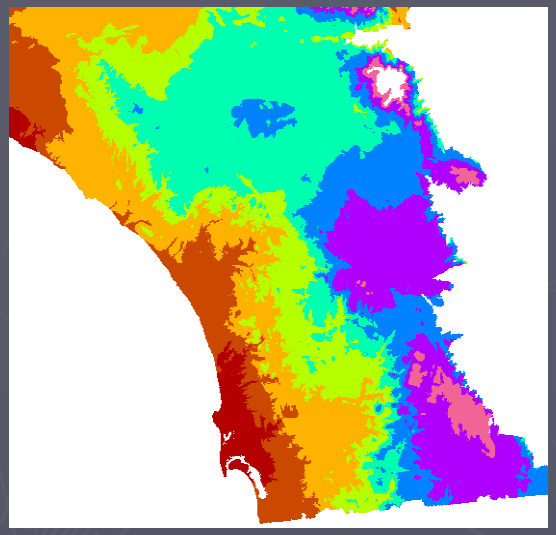


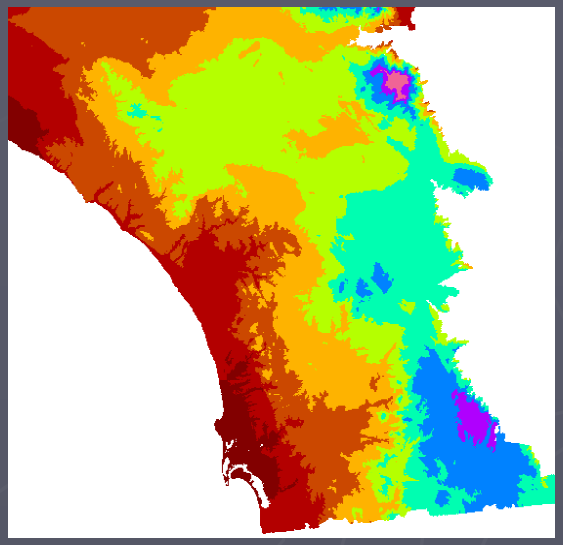
Climate Change

1971-2000

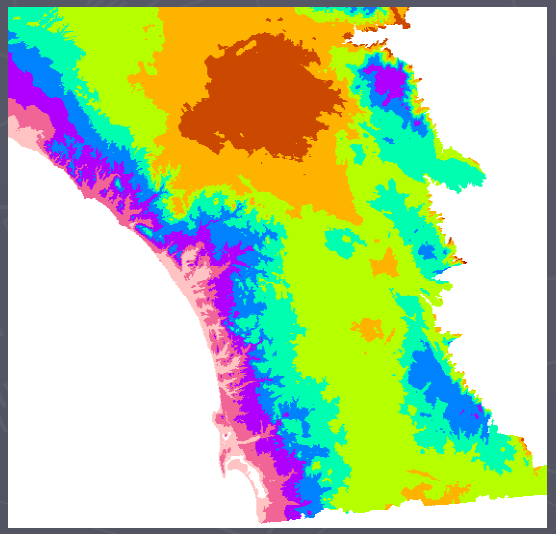
PCM 2071-2100

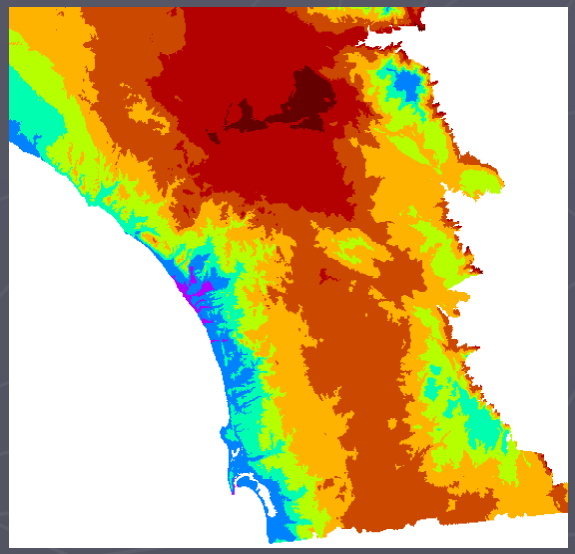
Jan
T min

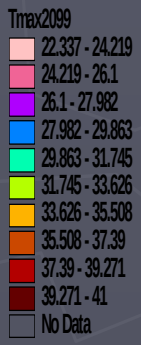




Jul
T max







Anthropogenic Climate Change

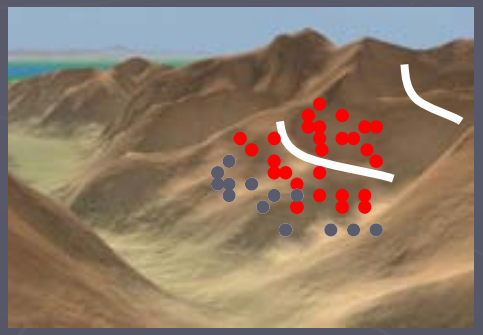
- Global warming shifts suitable habitat for species
- Urban development may impede distribution shifts

- Plant species relocating to higher elevations in the French Alps
- *Climate Change Pushes Plants Out of Their Comfort Zone*, L. Cahoon, Science, 26 -6-2008

- National Park Service, Santa Monica Mountains

How will climate change add to other effects of global change?

Distribution shifts



Distribution contractions

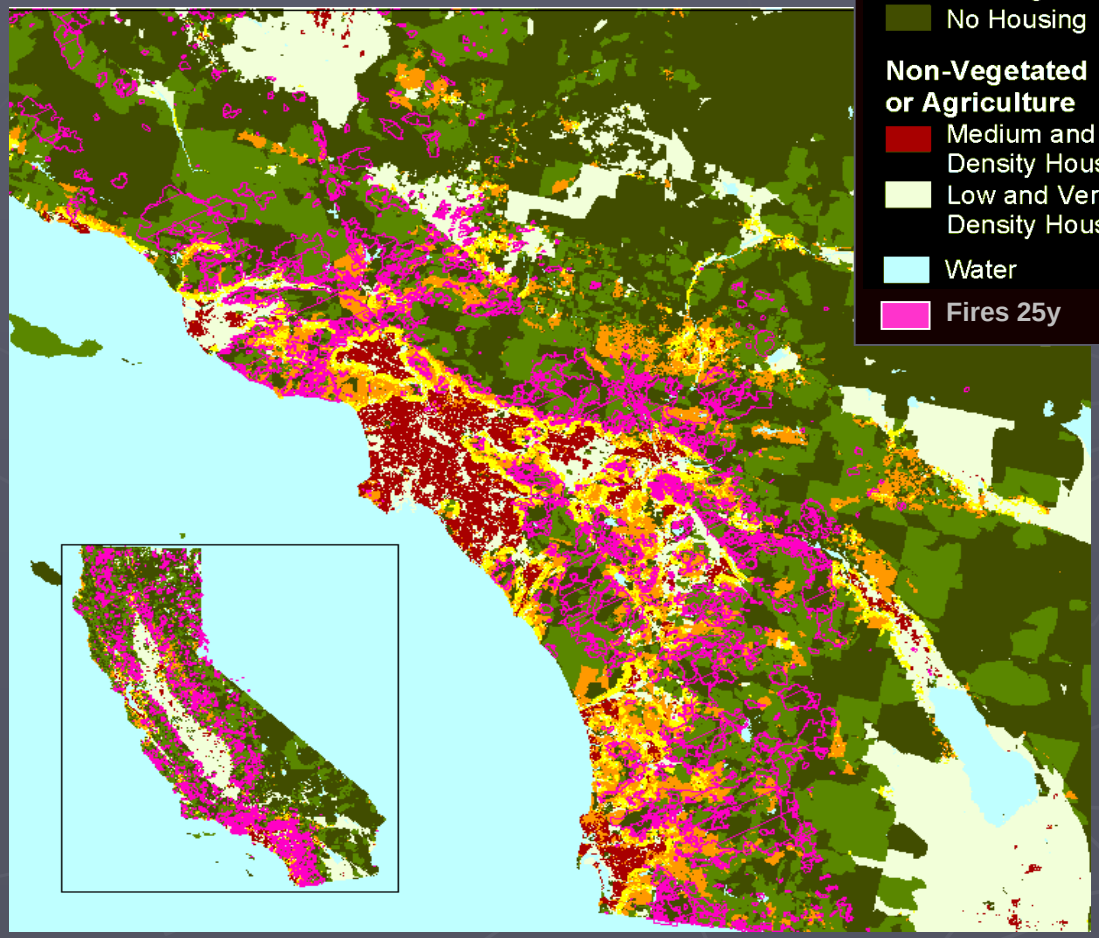
– Exacerbate habitat loss and fragmentation

Rare plants highly susceptible to distribution changes

Fire Regime

- Human-altered fire regimes threaten MTE biodiversity
- In California, fire frequency increasing at Wildland-Urban Interface
- May be exacerbated by climate change

WUI and areas burned in last 25 yr



Syphard, Radeloff et al. 2007 Ecol Applic

(Most of these photos are from the *SD Union Tribune*)

Fire Response Plant Functional Types

- Obligate Seeders (OS)
  - Fire-stimulated germination
  - Fire-free period to mature
  - Poor dispersers
    - ***Ceanothus verrucosus*** **(Warty-stem Ceanothus)**
    - ***Ceanothus greggii*** **(Cup-leaf Ceanothus)**
    - *Hesperocyparis forbesii* (Tecate cypress)

Fire Response Plant Functional Types

- Obligate Resprouters (OR)
  - Resprout following fire
  - Dispersal, establishment between fires
  - More resilient?
    - ***Quercus engelmannii*** **(Engelmann Oak)**

Objective

- Predict separate and combined impact of urban growth, climate change, and altered fire regime on key plant functional types in California's MTE woodlands and shrublands
  - Fire responses
    - Obligate seeders
    - Obligate resprouters
  - Geographical distributions
    - Rare versus widespread
    - Near versus far from urbanization

D

C

A

B

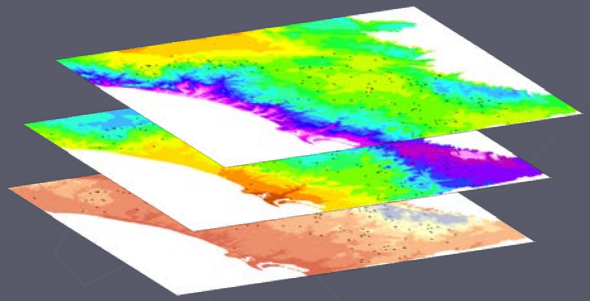
T1

T2

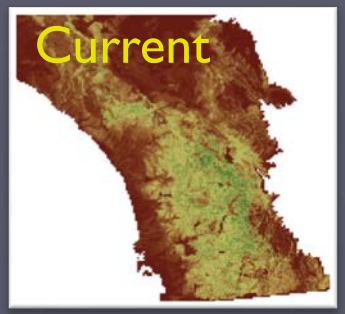
Coupled SDM-Population Model

Species Distribution & Urban growth models

Species locations, Climate Variables

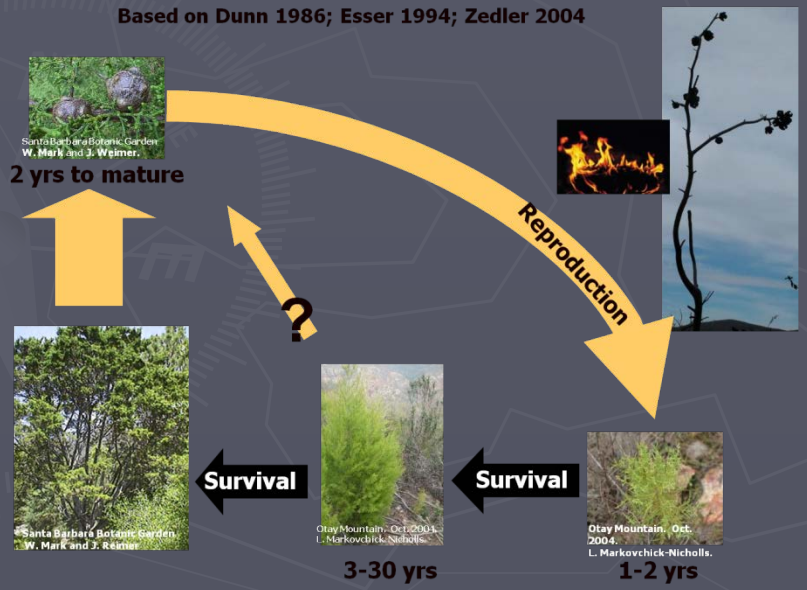


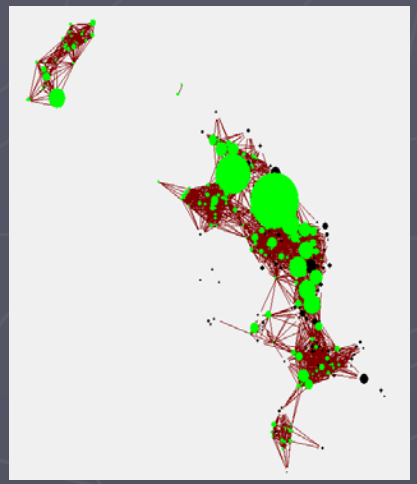
Habitat Suitability Map



Population Model

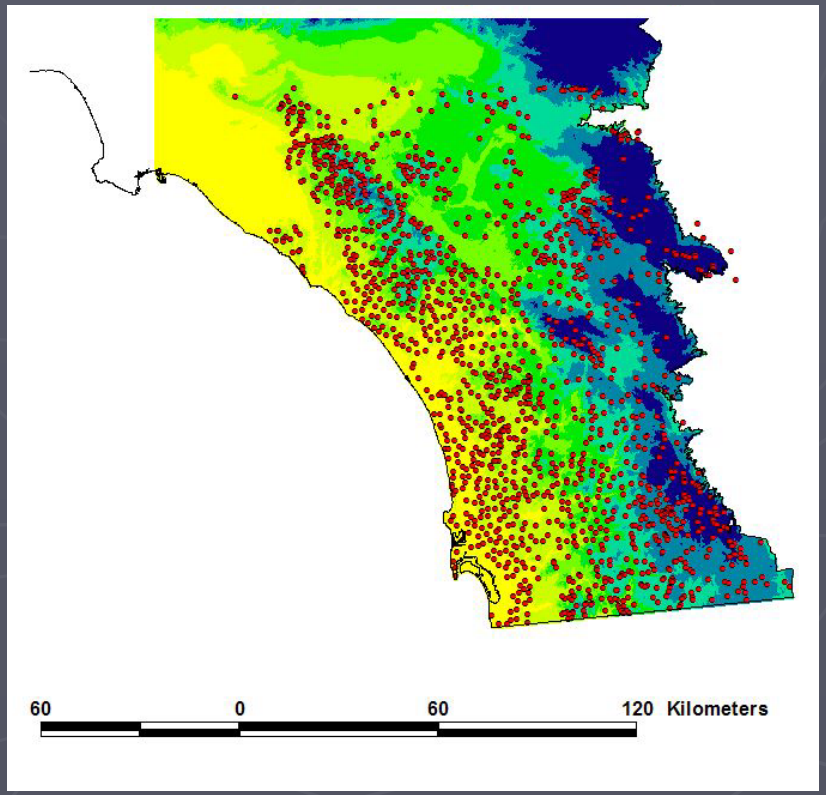
Based on Dunn 1986; Esser 1994; Zedler 2004





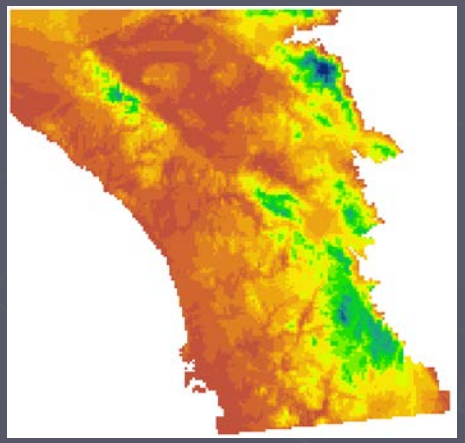
Species Distribution Modeling

- Plant species
- 1471 shrubland vegetation plots

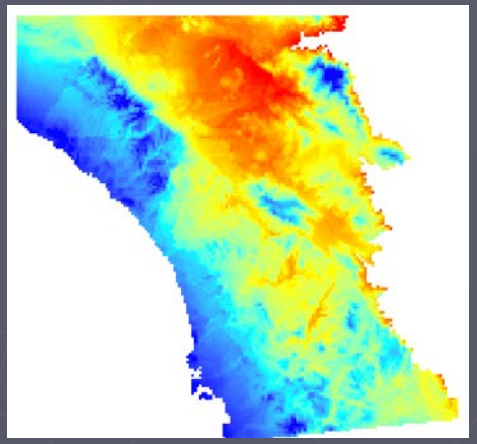


Environmental Data

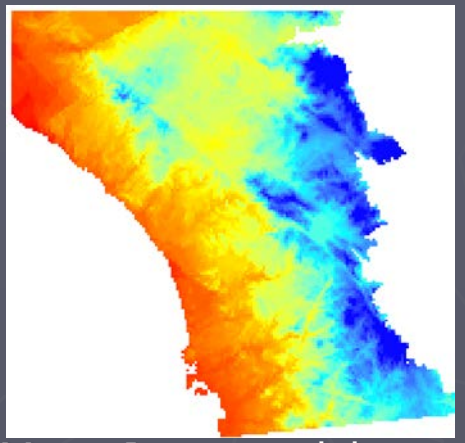
Percent slope



Mean Annual Precipitation

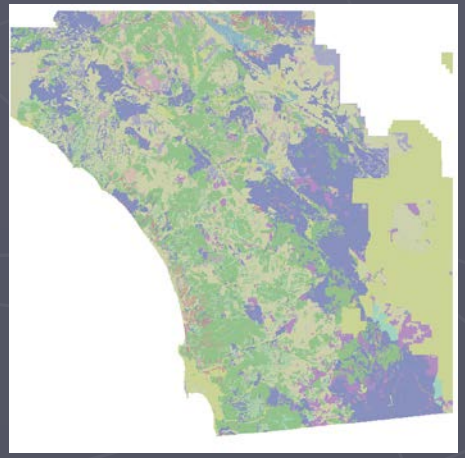


Mean July Maximum

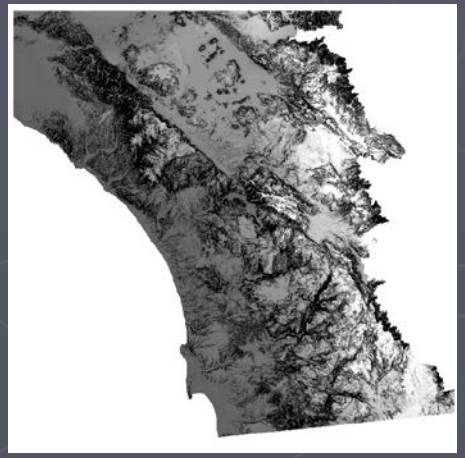


Mean January minimum

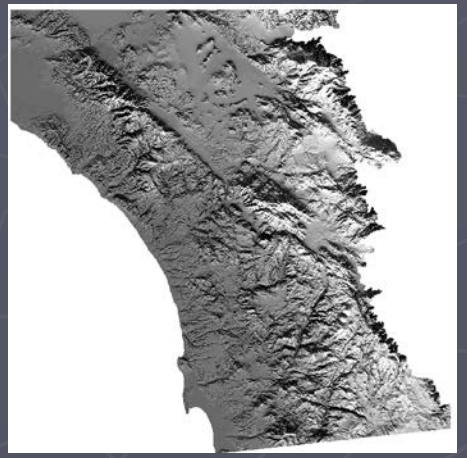
Topographic Moisture Index



Soil Order



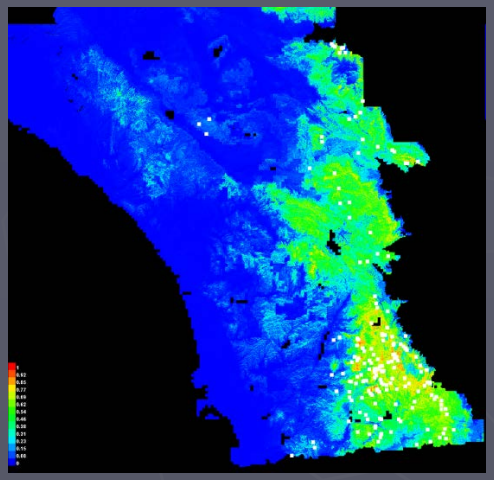
Summer Radiation

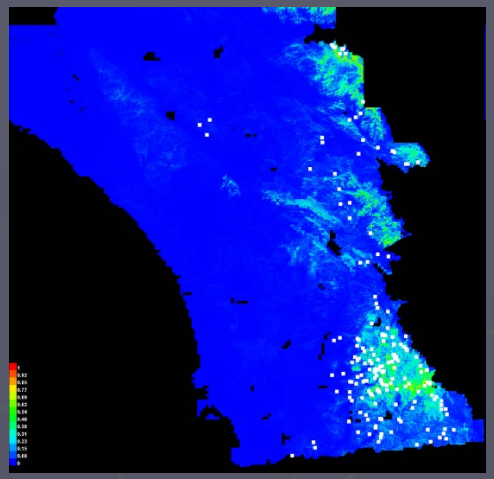


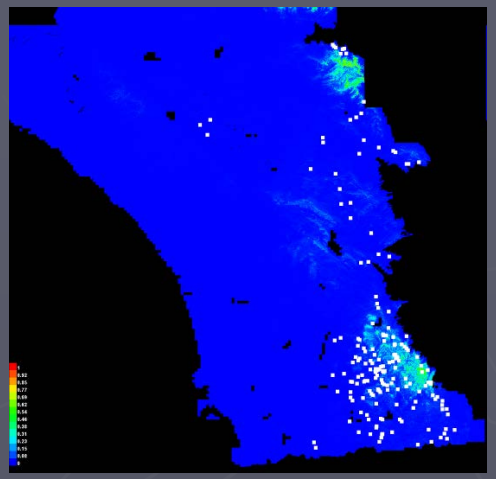
Winter Radiation

Current and Future Suitable Habitat

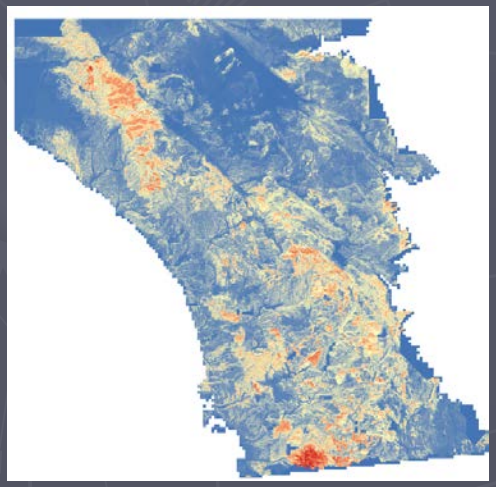
Ceanothus greggii

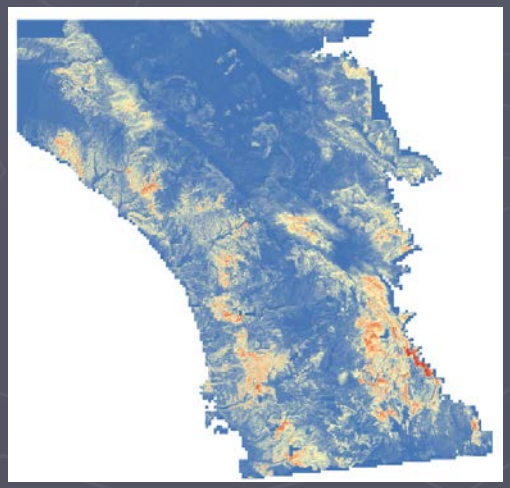


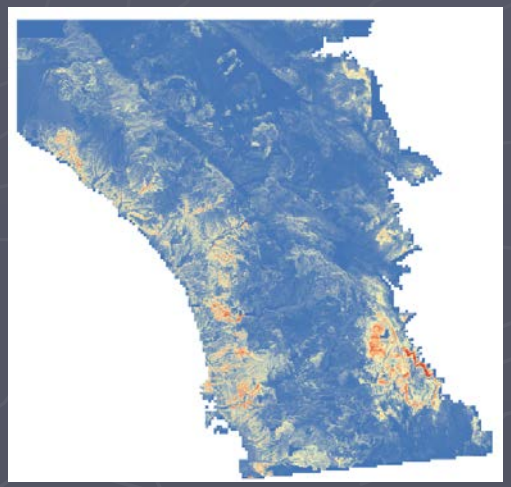




Tecate Cypress *(H. forbesii)*





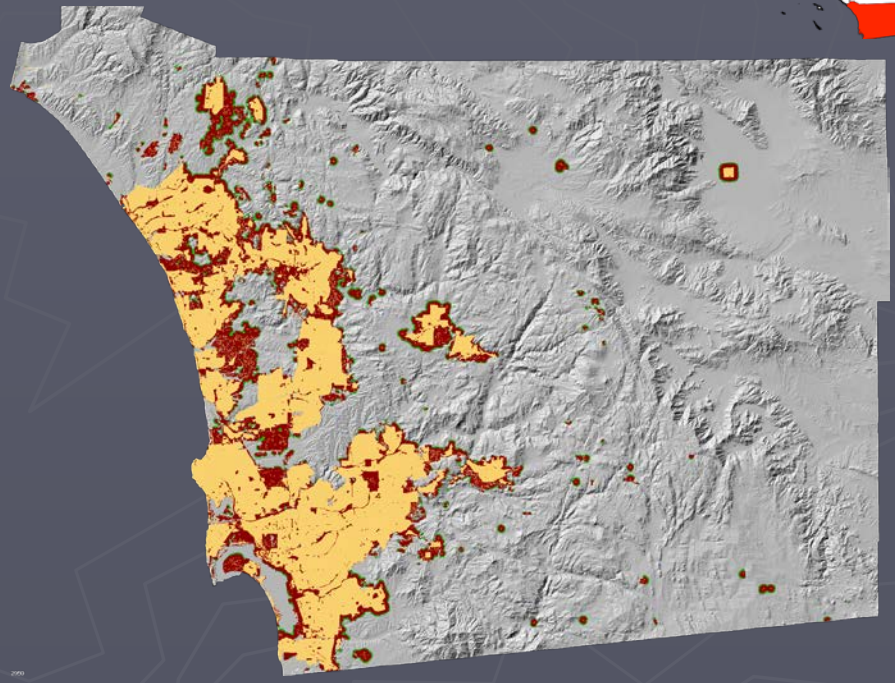


Current (2000)

Future PCM A2

Future GFDL A2

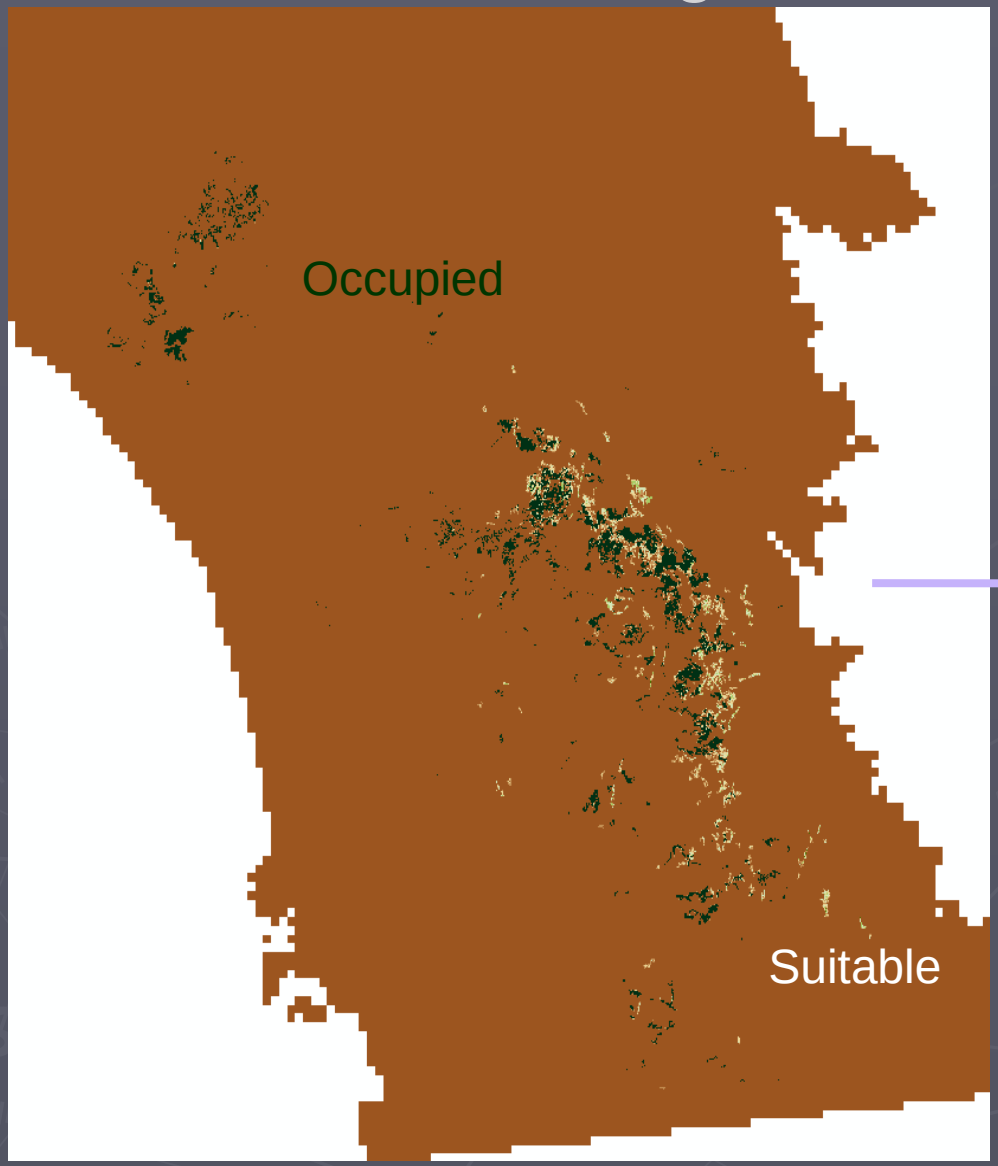
Projected Urban Growth San Diego County 2050

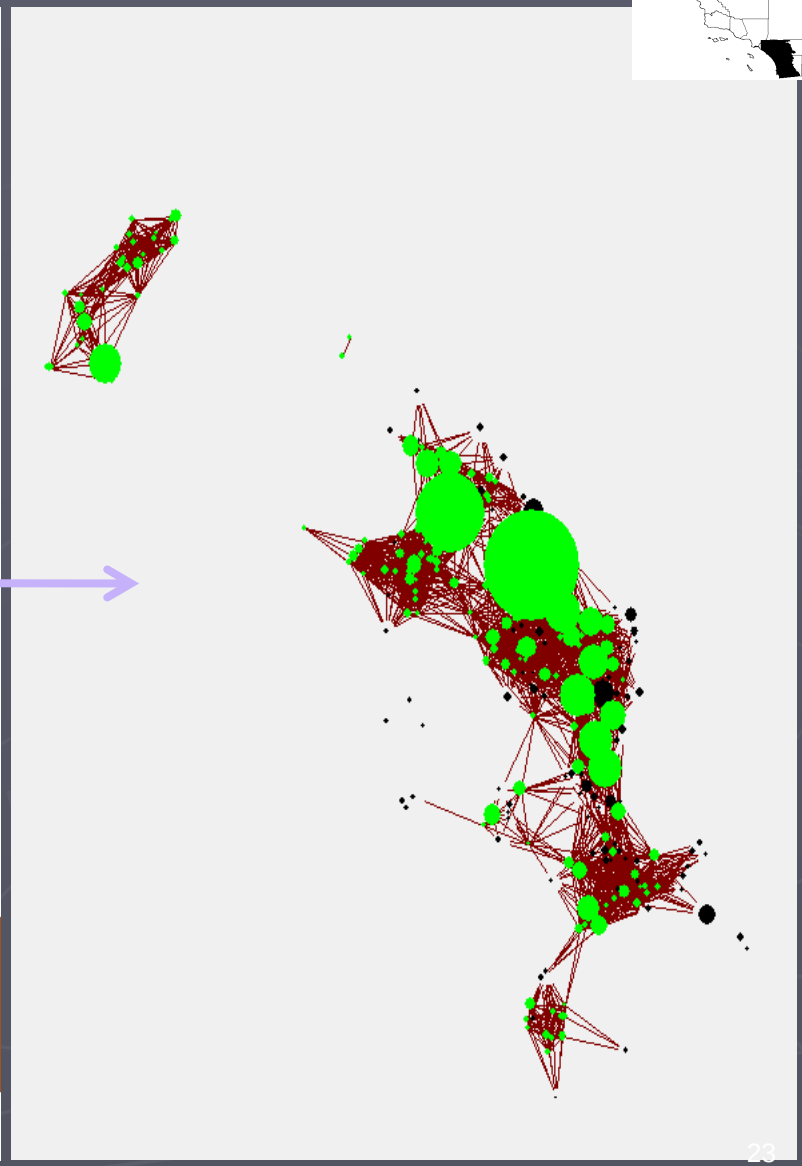


- SoCal population to double in 50 yr
- 20 m to 40 m

Syphard et al. (2011) J Env Mgt

Habitat suitability maps to metapopulation patches
Engelmann Oak

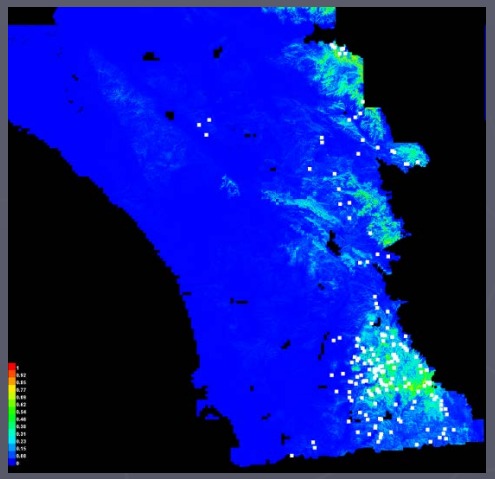


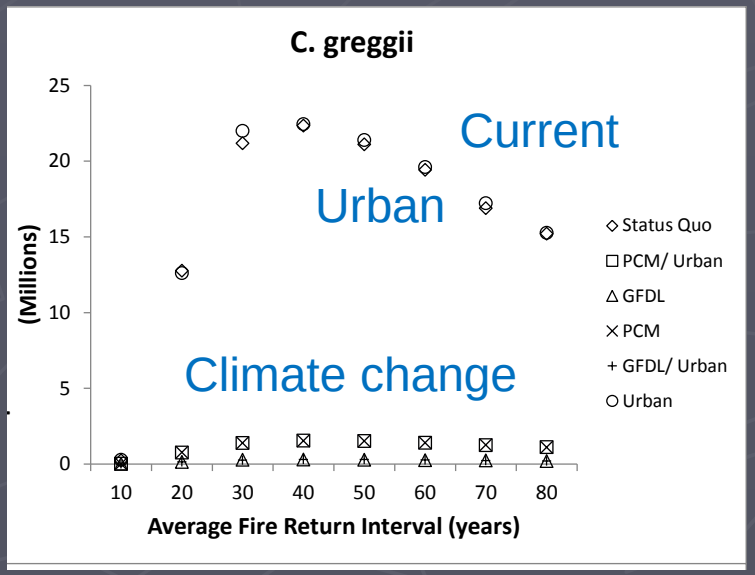


Conlisk et al. 2012 PONE

Results -- *Ceanothus greggii*

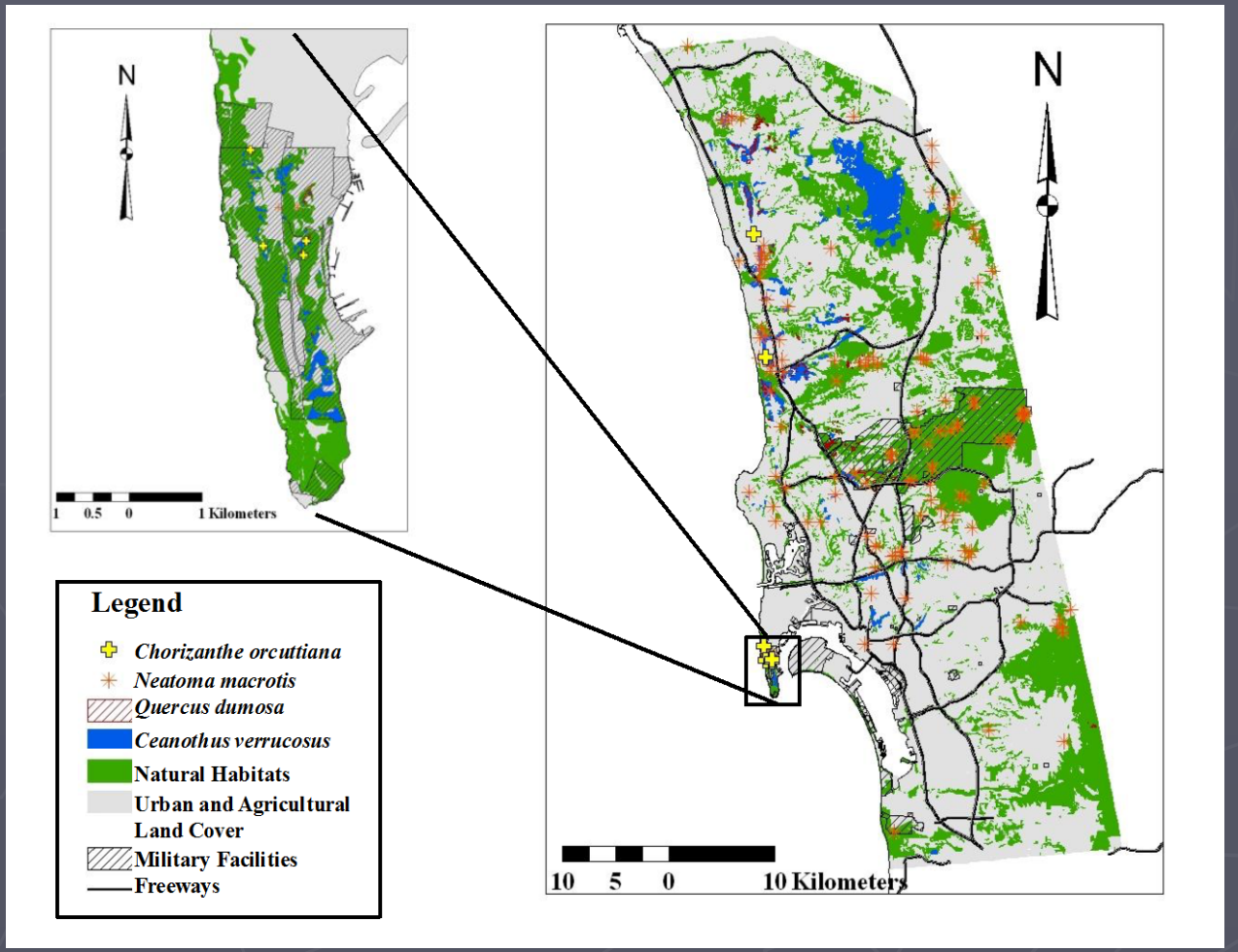
- **OS**
- **In areas not likely to be urbanized**
- **Widespread**
- **Mountain**
- Climate change habitat loss 10-fold decrease
- Increased fire < 20 yr FRI dramatic decrease





Results – *Ceanothus verrucosus*

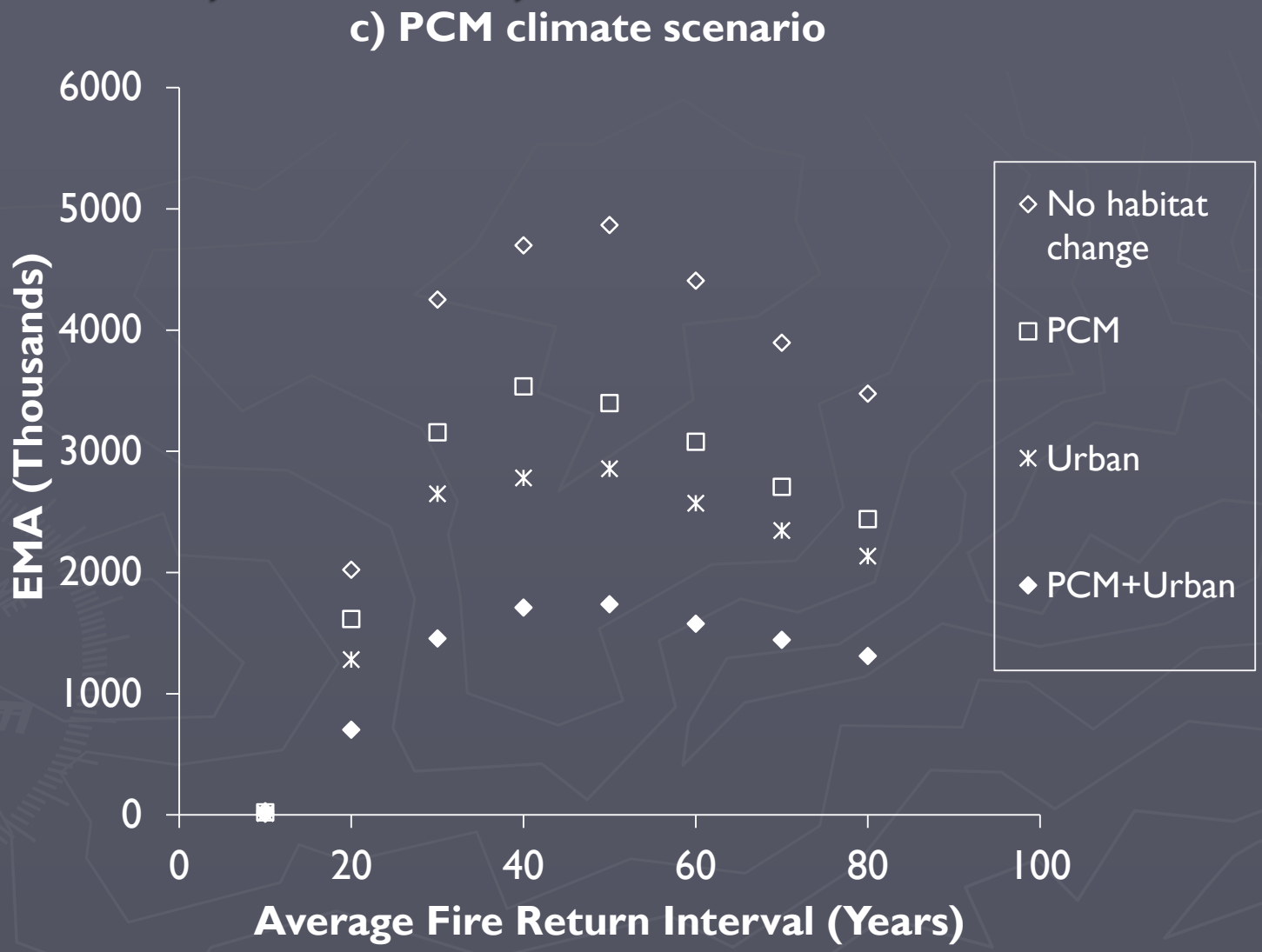
- **OS**
- **Surrounded by urbanized**
- **Very Rare**
- **Coastal**



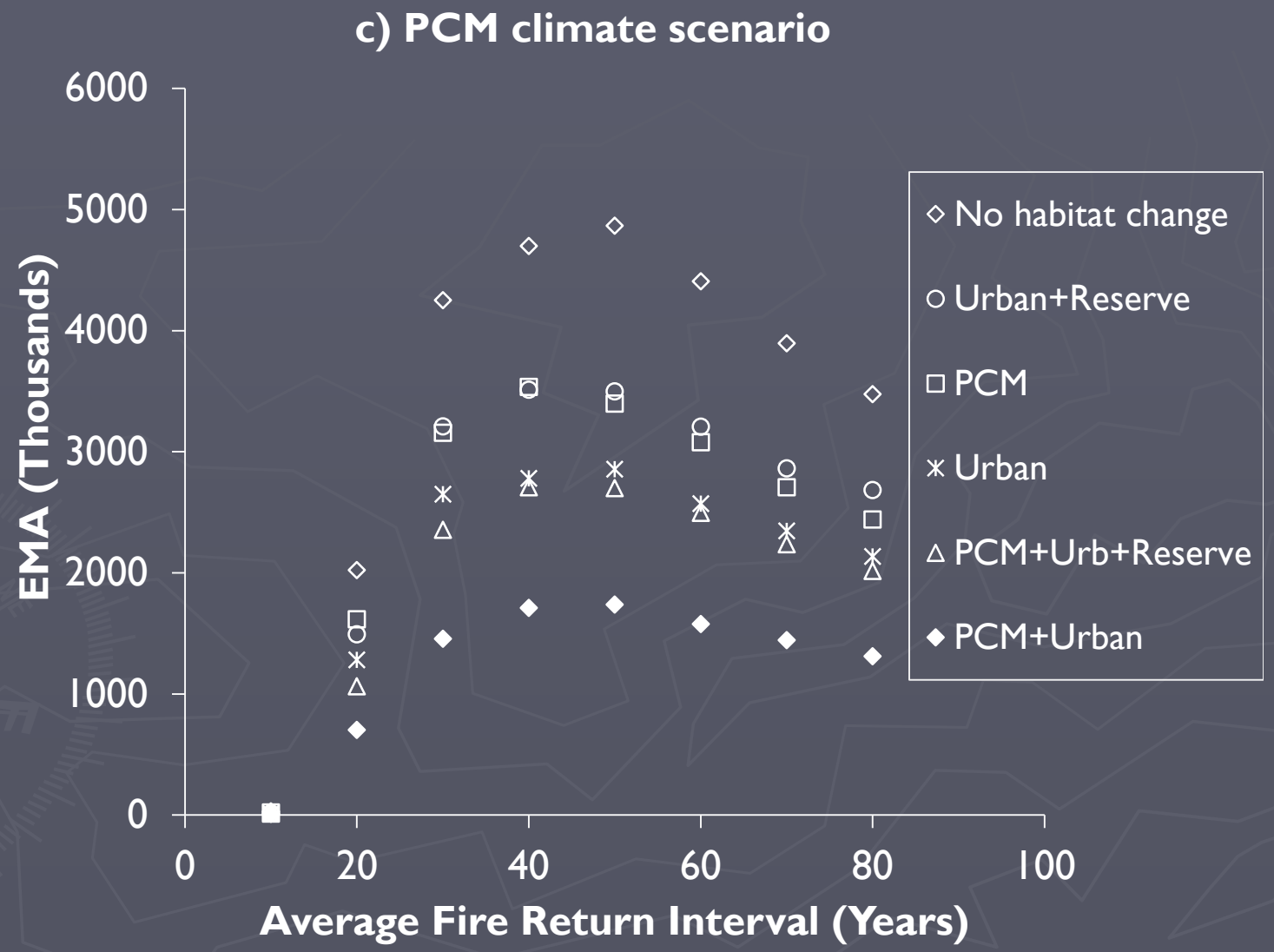
- Blue: *C. verrucosus*
- Gray: urban
- Green: natural habitat

Lawson et al. 2010 Glob Chng Biol

Results – *Ceanothus verrucosus* Fire, Climate, Urban Growth

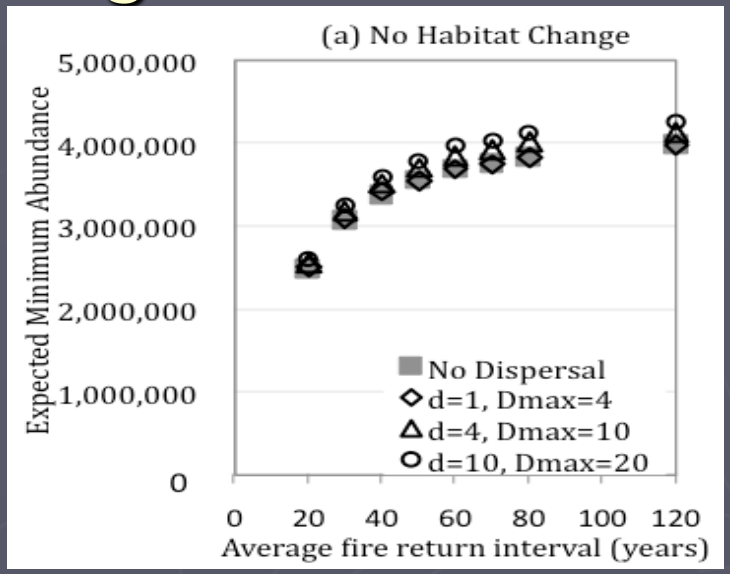


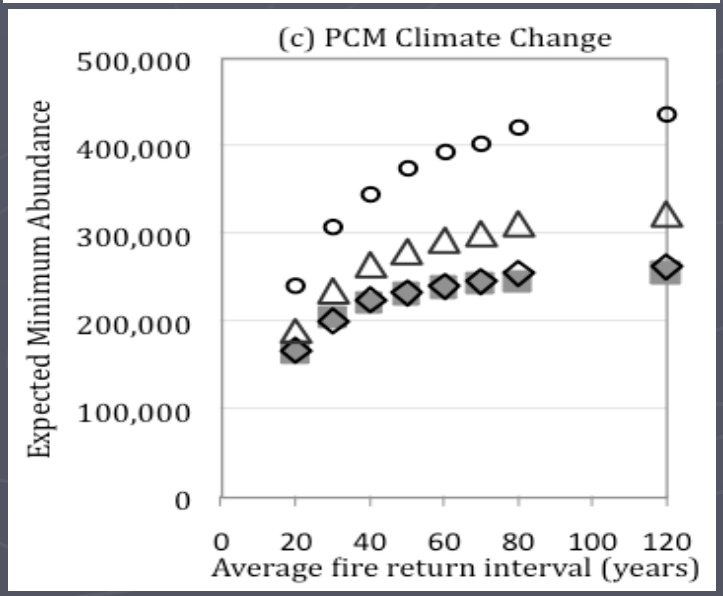
Results – *Ceanothus verrucosus* Add Reserves



Results – *Quercus engelmanni*

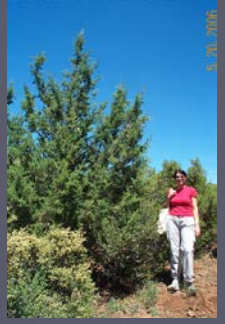
- **OR**
- **In areas not likely to be urbanized**
- **Restricted**
- Climate change habitat loss decrease 10-fold
- Increased fire some decrease
- Greater dispersal buffers impact of habitat loss



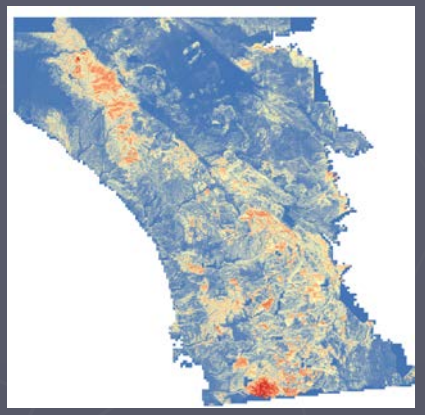


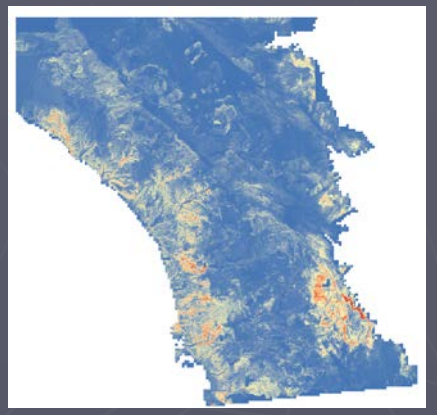
Conlisk et al. 2012 PONE

Results – Tecate Cypress

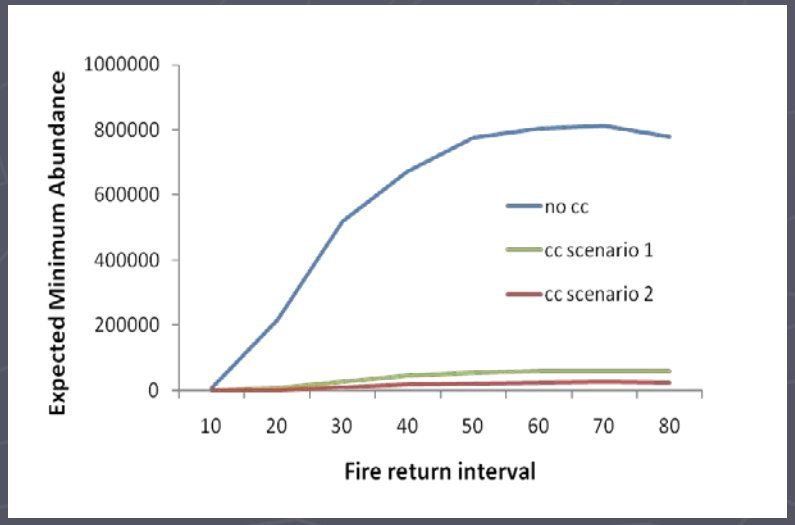


- **OS**
- **In areas not likely to be urbanized**
- **Rare**
- **Foothills**
- Climate change habitat loss 10-fold decrease
- Decrease fire frequency 70-20 yr 5-fold decrease



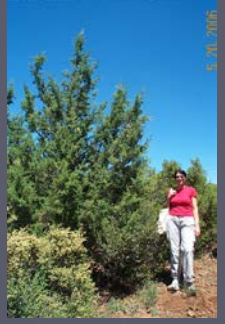


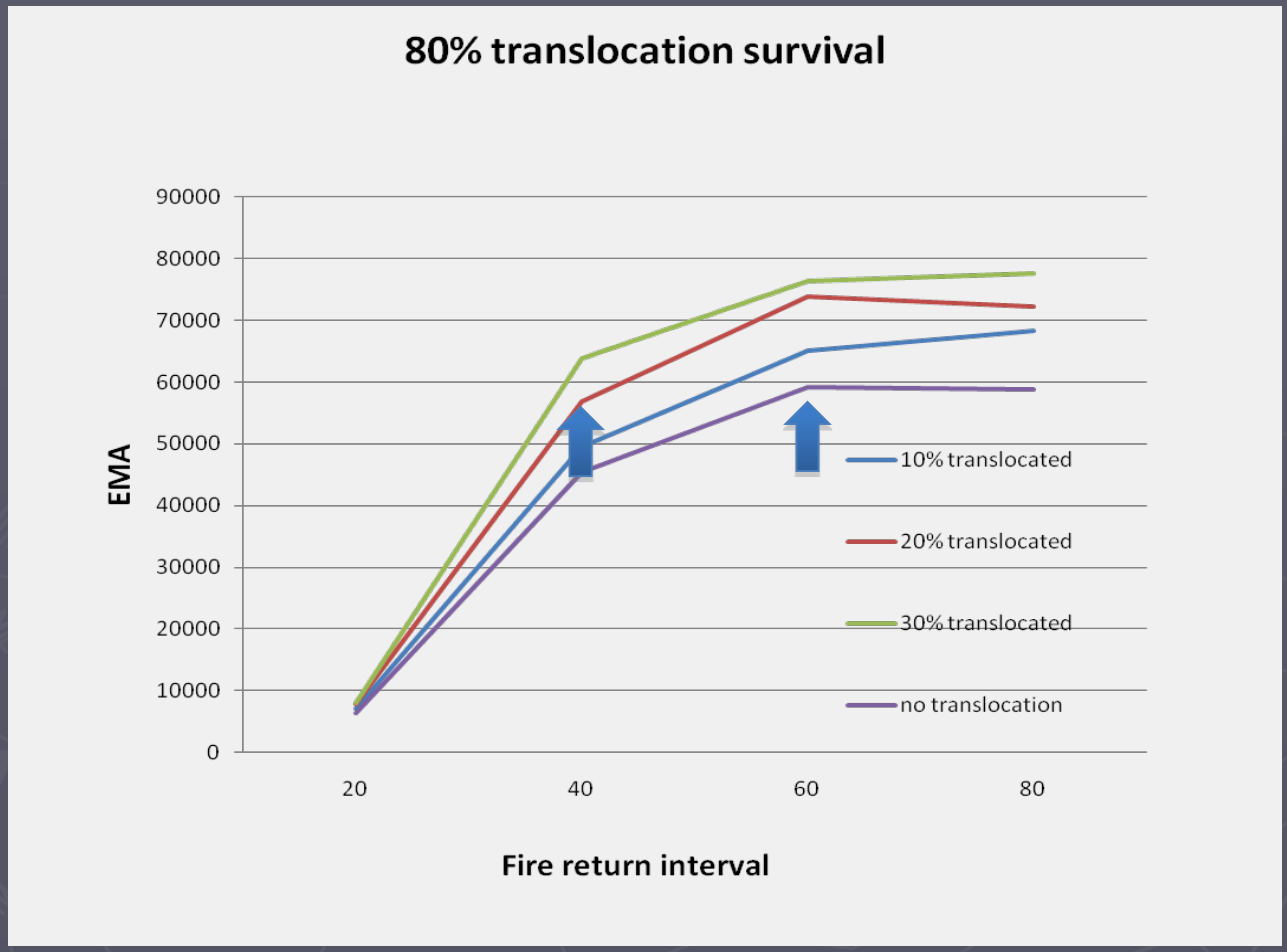
Current (2000) Future (hot, dry)



Regan et al. 2012 Glob Chng Biol

Assisted Dispersal vs. Less Fire Seedling Translocation - Tecate Cypress





Regan et al. 2012; Bonebrake et al. 2014

Summary

- Large climate change impacts predicted
  - Caveat: correlations, current distributions
- Urban growth has greatest impact at current urban margin
- Too frequent fire large impact on OS, also OR
- Increased fire more immediate threat than climate change
- (Urban growth affects fire frequency…)

Management Response

- Modeling of multiple threats allows ranking priorities
  - Land use planning
  - Fire management
  - Climate change mitigation
  - Assisted colonization

Acknowledgements

- Rebecca Swab, UC-R, population modeling
- Erin Conlisk, UC-R, population modeling
- Tim Bonebrake, UC-R, population modeling
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- F. Davis M. Ikegami, UCSB, bioclimate variables
- L. Hannah, CI, climate change and biodiversity
- R. Shaw, TNC, climate change and biodiversity
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- Lisa Markovchick-Nicholls, population modeling
- Resit Akcakaya, modeling expertise
- David Keith, modeling expertise