Effects of fire, fragmentation, and climate change on demographics of *Ceanothus verrucosus*

Dawn M. Lawson

SPAWAR SSC Pacific (U.S. Navy)

Plant Conservation Challenges

- In the US – 22% of endangered plants occur in 8% of landscape where 50% of human population resides.

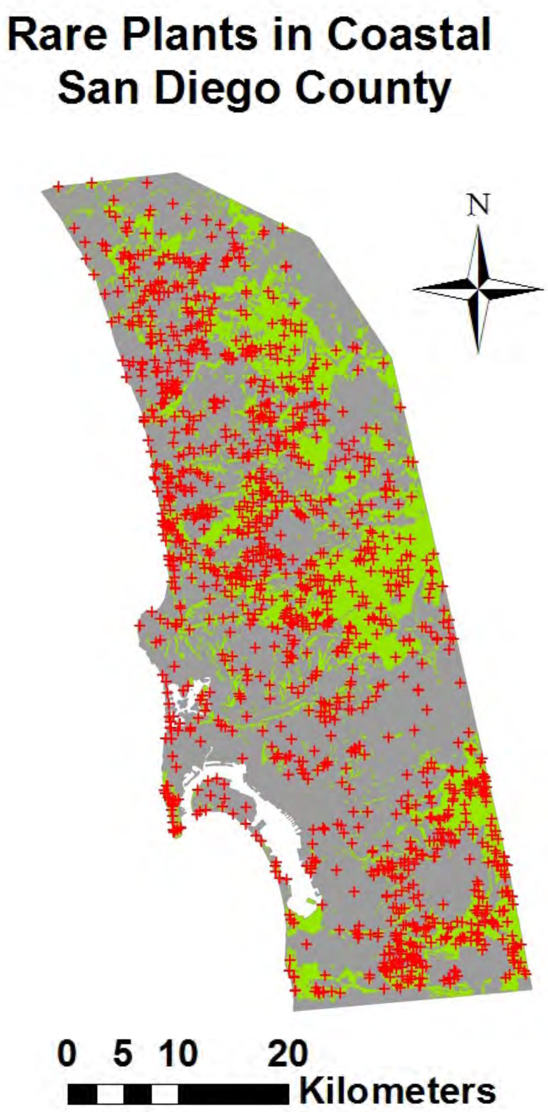
(Schwartz et al. 2002)

Plant Conservation Challenges

- Biogeographic patterns of plant endangerment differ from vertebrates.
- Highest plant diversity associated with low productivity.

Plant Conservation Challenges

- Rare plants more likely to be embedded in human dominated landscapes



Within this area

91 taxa
1,581 populations **(CNDDB 2013)**

Link Between Rare Plants and Populated Landscapes

- Human development of landscapes follows predictable patterns (Huston 2005)

- Agri
  Proc

  nary

- Urb

- Resu

  P

- Plan

  abitats

Conservation Focus on Functional Landscapes

- Conservation planning based on functional ecosystems emphasized.

- May result in exclusion of viable plant populations from conservation strategies.

Analysis of CNDDB Data

- Populations of rare plants are not on average at higher risk in urban areas. (Lawson et al. 2008; Schwartz et al. *in press*)

- Small populations are not more likely to experience negative growth rates (Lawson et al. 2008; Schwartz et al. *in press*).

- Conservation efforts are not less likely to be successful in urban environments (Schwartz et al. *in press*)

Rare Plant Conservation in Urban Environments

- This is not to say that all species are resistant to the effects of fragmentation and human development.

but rather

- There is no generalization that populations of rare species embedded in urbanized landscapes are doomed to extinction.

Conservation in Southern California

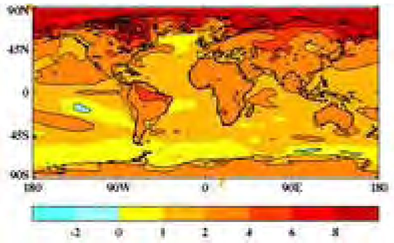
- Biodiversity Hotspot

Threats

- Rapid urbanization
  (Ewing et al. 2005)

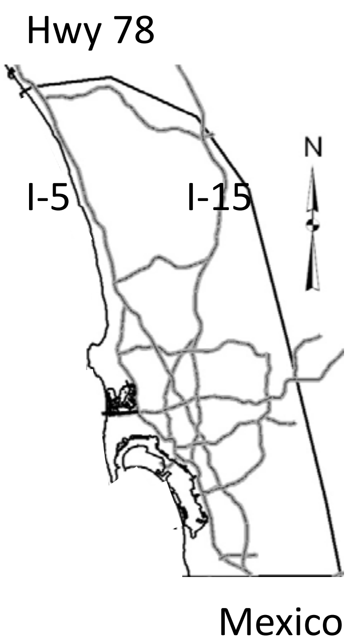
- Significant habitat loss & fragmentation (State of California (2006), Farmland Mapping and Monitoring Data)

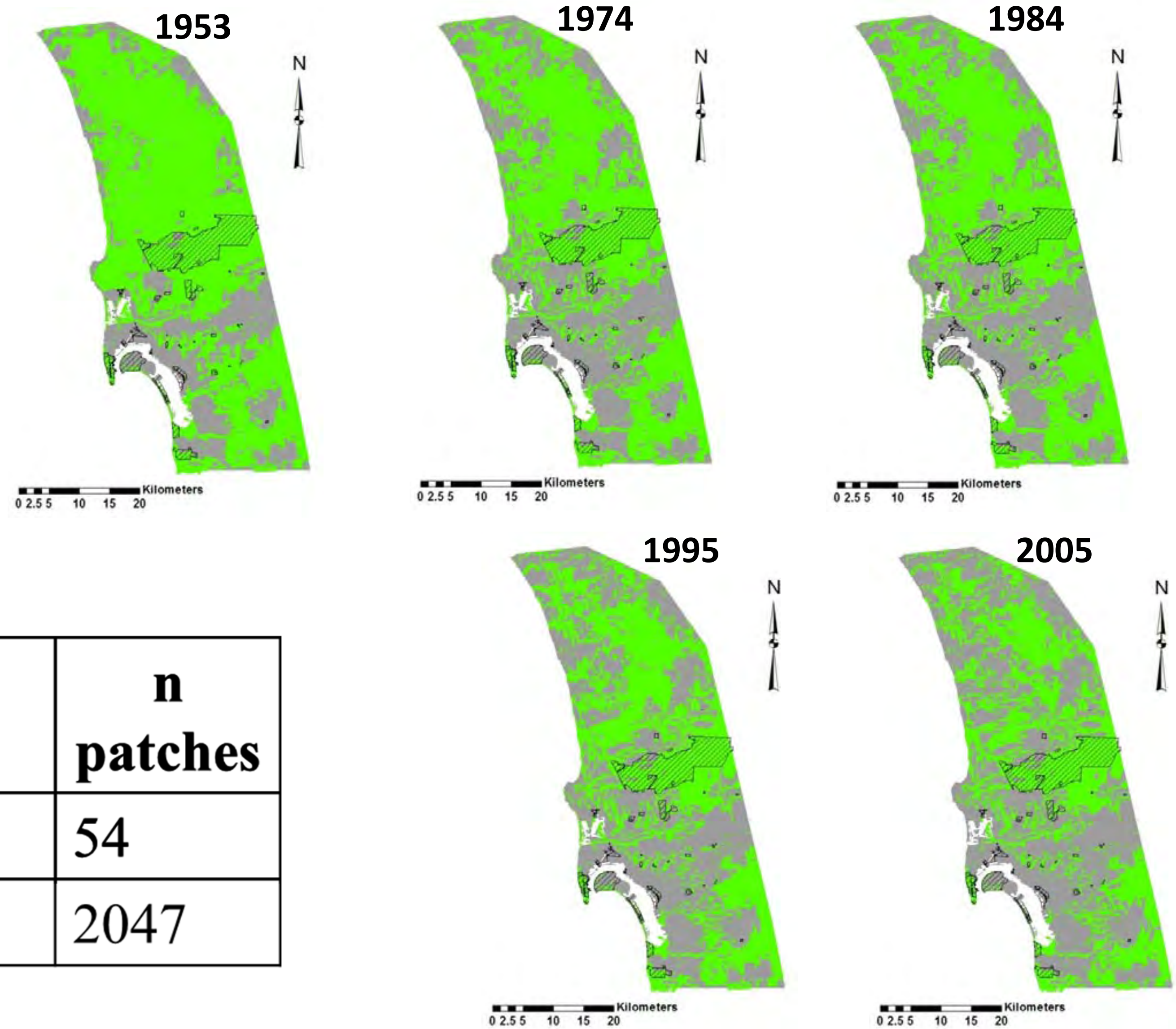
- Altered fire regimes
- (Syphard et al. 2007)



- Climate change (Christensen et al. 2007, Cayan et al. 2008)

Habitat loss and fragmentation western San Diego county





Year	ha	n patches
1953	102K	54
2005	54K	2047

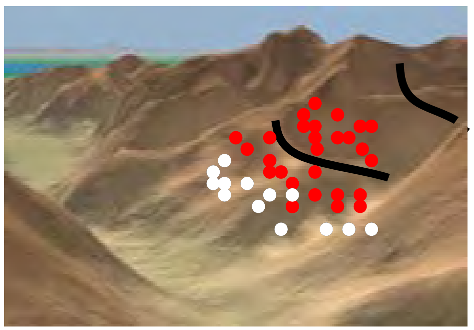
Existing Threats
Under Present Climate

- *Too frequent*

- *Too infrequent*

Effects of Climate Change

Distribution shifts



Distribution contractions

(Loarie et al. 2008, Schwartz et al. 2006)

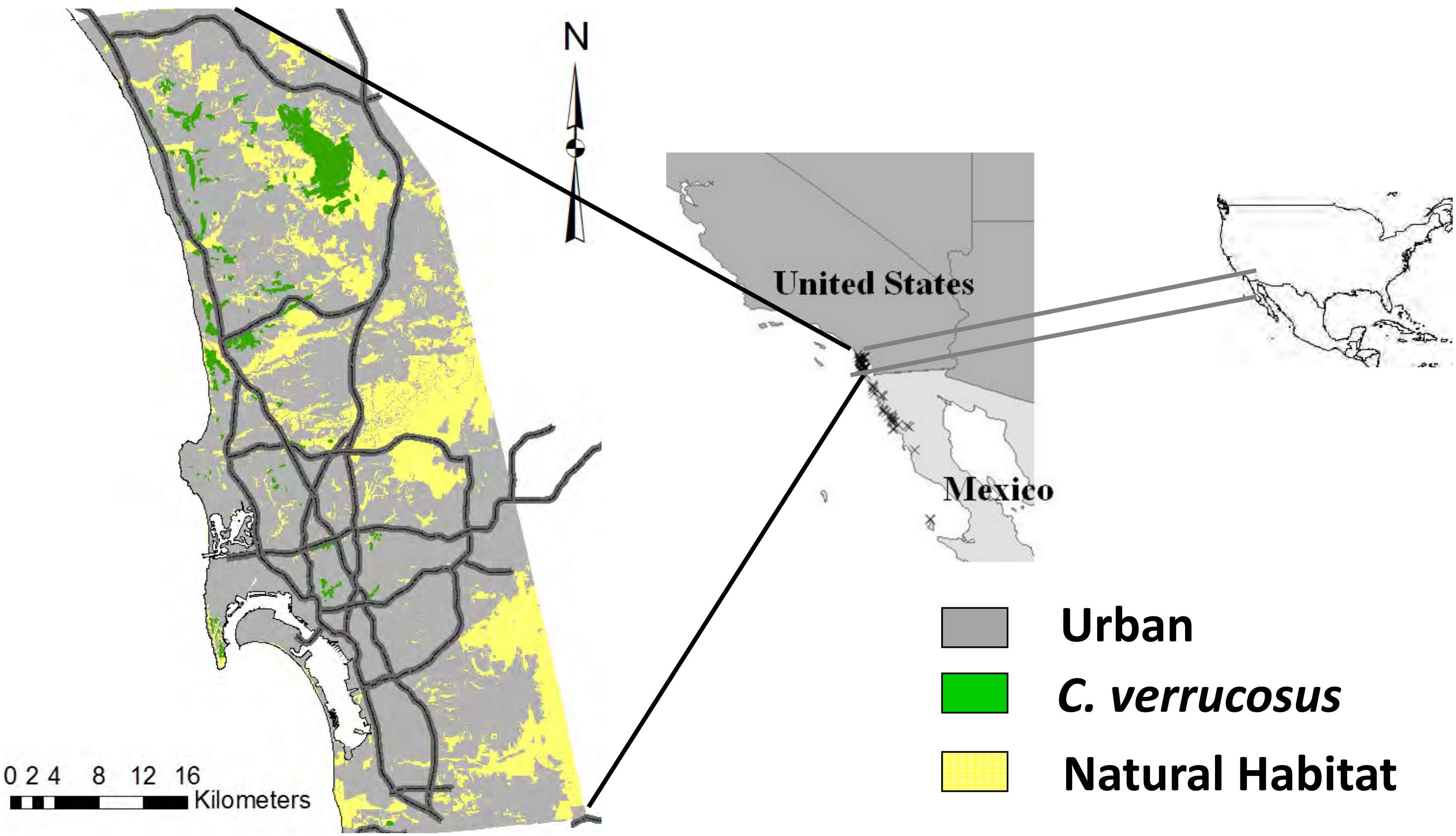
Distribution expansions
(Bradley et al. 2009)

Research Questions

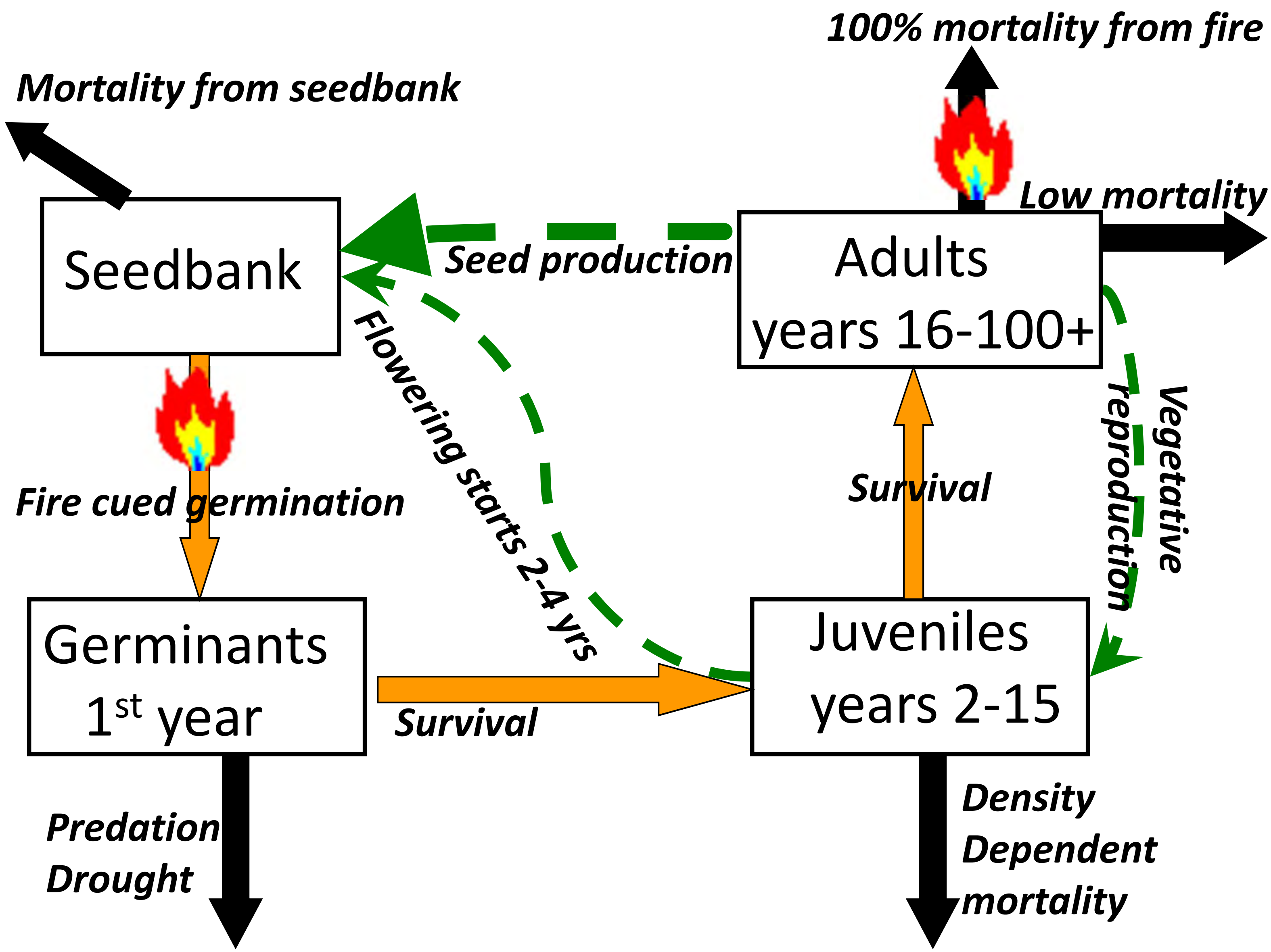
- What are the population-level effects of:
  - Altered fire regime?
  - Habitat loss and fragmentation?
- How do climate change projections alter the probability of species persistence?
- Does climate change pose a larger risk to species persistence than existing threats?


Ceanothus verrucosus

Embedded in Urban Landscape



Life History



Population Model

- Spatially explicit (151 populations)
- Age-based matrix model
- Fecundity and survival based on age
- Carrying capacity based on size of plants
- Stochastic
- Linked to fire hazard functions (Moritz 2003)
- Explicit response to fire

Model Parameterization

- Models can be difficult to parameterize due to sparse data
  - Data Sources
    - Use of data from con-generics
    - Expert opinion
    - Collect data where feasible

Data Sources for Vital Rates

- Fecundities
  - Seed Prod
  - Veg. repro
- Survival Rates
  - Longevity of seedbank
  - Seed Germination
  - Survival years 1-15
  - Survival from age 16-95
  - Survival from age 96

(green)	*Species Specific*
(blue)	*Con-generic*
(orange)	*Expert opinion*

Demography of Long-lived Plants

- Most knowledge of plant population dynamics based on studies of short-lived species

- Population trends of long-lived species difficult to detect on time scales convenient for human observation

Seed Production (seedbank input)

Seedbank Longevity

- Leveraged seedbank study (Cummins 2003)
  - quantified seedbank under live & dead pairs of CEVE

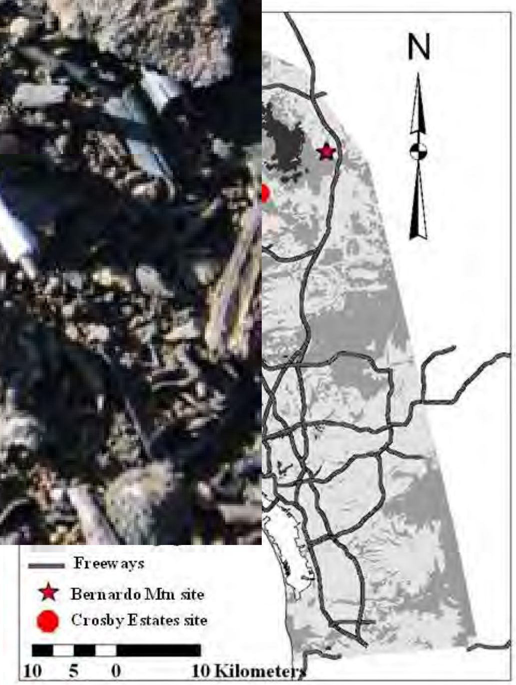
- Used ring counts to age dead CEVE and establish lower bound on seedbank longevity (Lawson 2011).

- Longevity lower bound = 44 years

Seed Germination

Germinant survival

- F 2007
  v



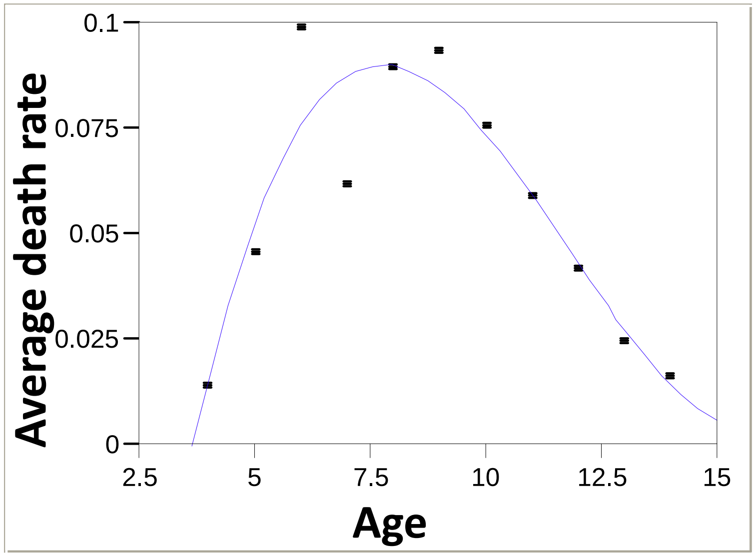
  - Stdev = 19%

Survival age 3-5

Survival age 6-15

- Data for *C. megacarpus* from (Schlesinger and Gill 1978)

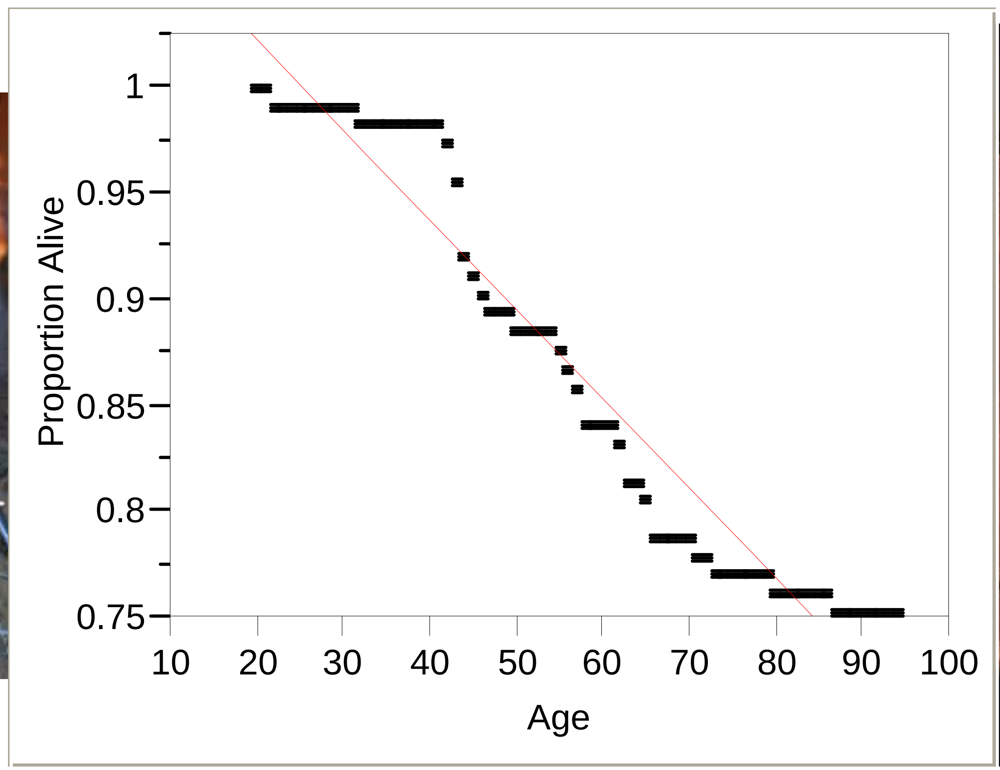
- Mean mortality=0.160-0.0084*age-0.0028(age-9)^2+0.00034 (age-9)^3

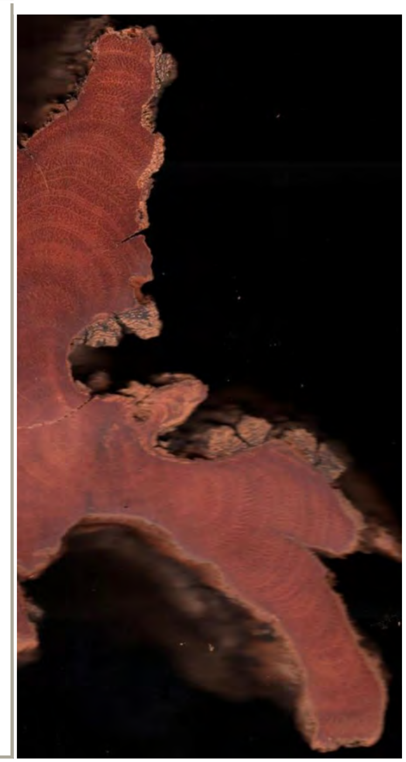


- Mean survival = 1- mean mortality
- Stdev = 10% of mean survival

Survival at 16 to end of life span

- Lawson (2011) ring counts of dead individuals at Pt. Loma (CNM and Navy Lands)





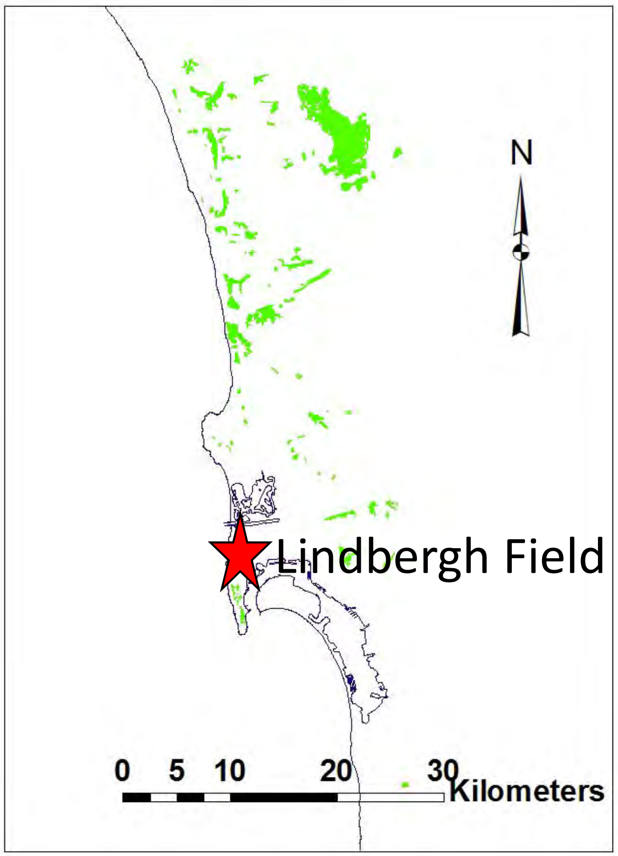
- Survival = 98.8% Stdev 0.646%

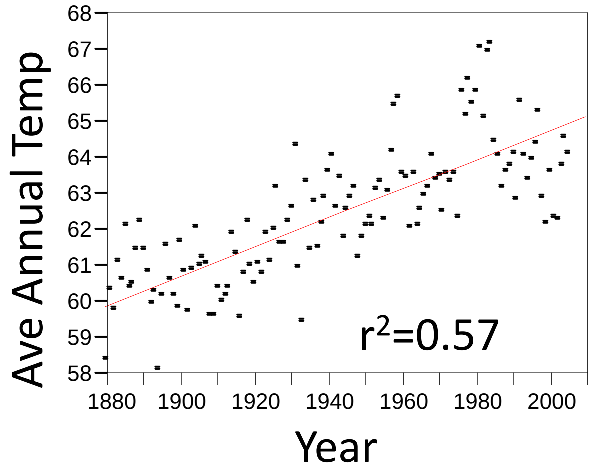
Longevity of adults

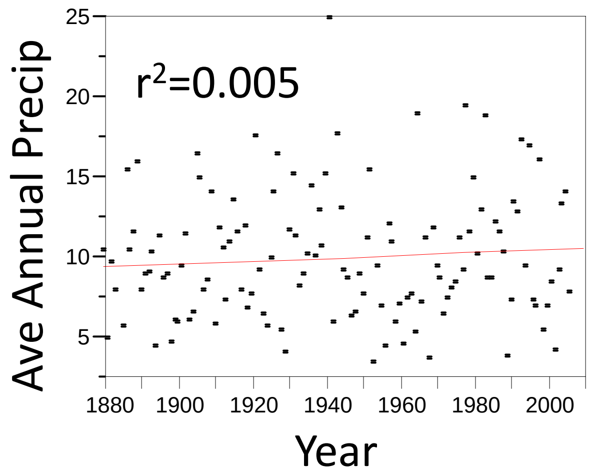
- 85-155 yea nd Zedler 1993)
- Based on r stand age is approxima a (Zedler 1995) and MCAS 11).
- Tested 100 rs in sensitivity

Vegetative Reproduction

Climate







(Western Regional Climate Center 2009 a & b)

Climate Models

- NOAA GFDL CM2.1 SRES A2
- Medium High Emissions Scenario
- Predicts hotter and drier climate

36% increase in temperature

26% decrease in precipitation

- NCAR PCM1 (DOE) SRES A2
- Medium High Emissions Scenario

17% increase in temperature

8% increase in precipitation

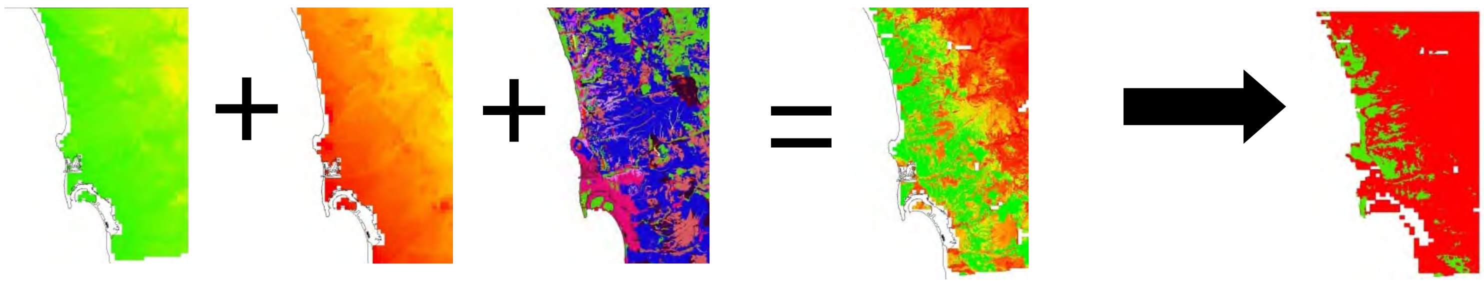
Cayan et al. 2008

Applying HSMs to Climate Change Questions

- Common approach - Prediction of range shifts using bioclimatic envelopes.
  (Loarie et. al. 2008; Thomas et. al. 2004).
- Limitations
  - Shifts and contractions of suitable climates do not easily translate into extinction risks
  - Ignores demographic processes
- Recent approach - Link dynamic bioclimatic envelopes with stochastic demographic models.
  (**Anderson et al. 2009, Keith et al. 2008)**

Methods
Effects of Climate Change

- Habitat suitability models

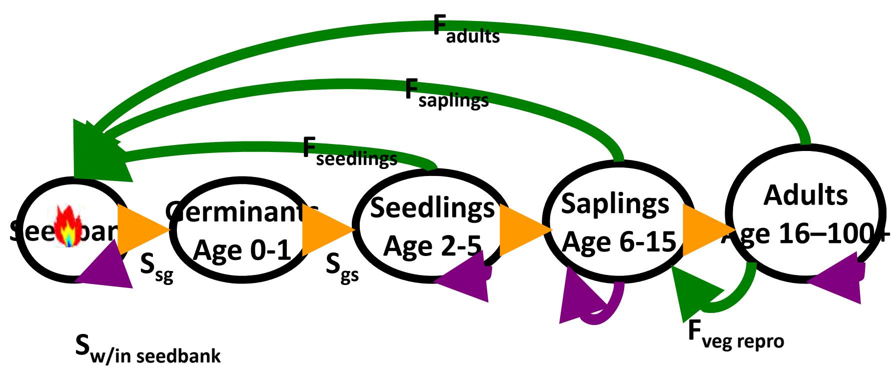


Current

Future

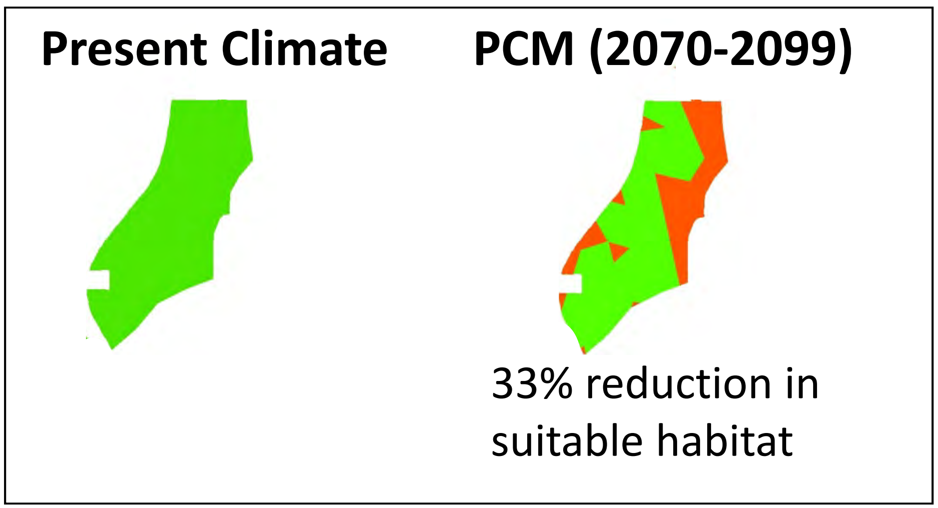
combined with

- Spatially explicit population viability models



Linking HSM to Population Model

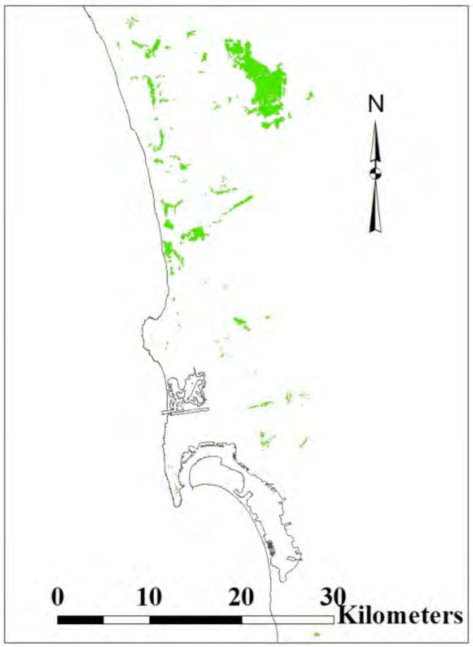
- Used temporal trend in K.
- Calculate % habitat loss per patch based on sequential HSM predictions.



- Reduce K by a constant amount per time step to achieve projected decline.

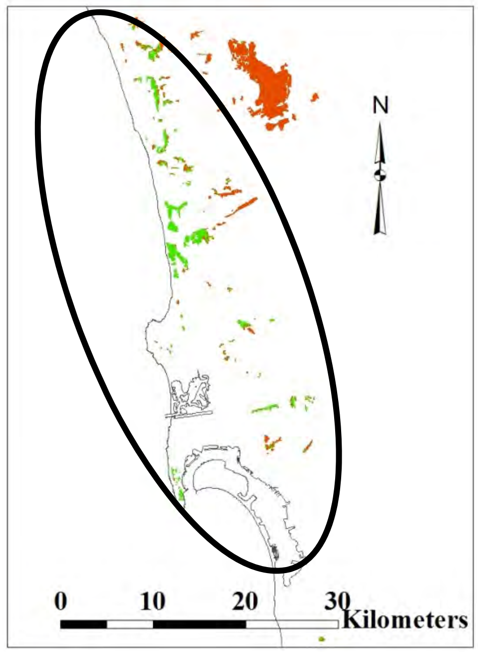
Results - Habitat Suitability Model

Present Climate

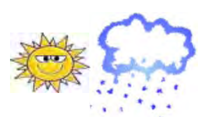


(151 populations)

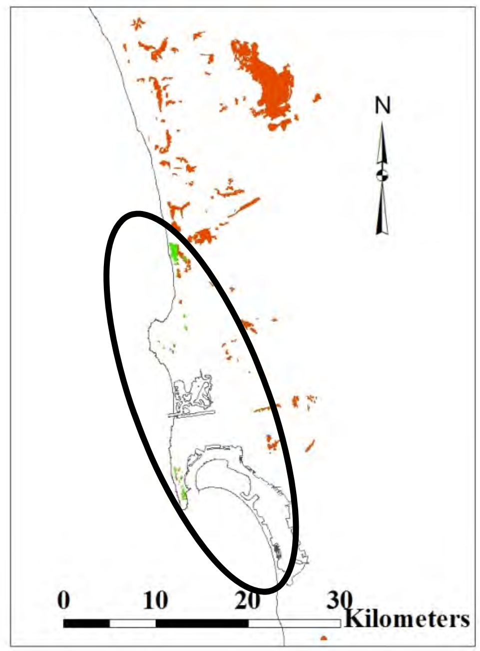
PCM Prediction 2100



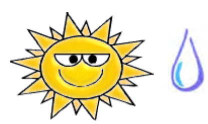
(85 populations)



GFDL Prediction 2100



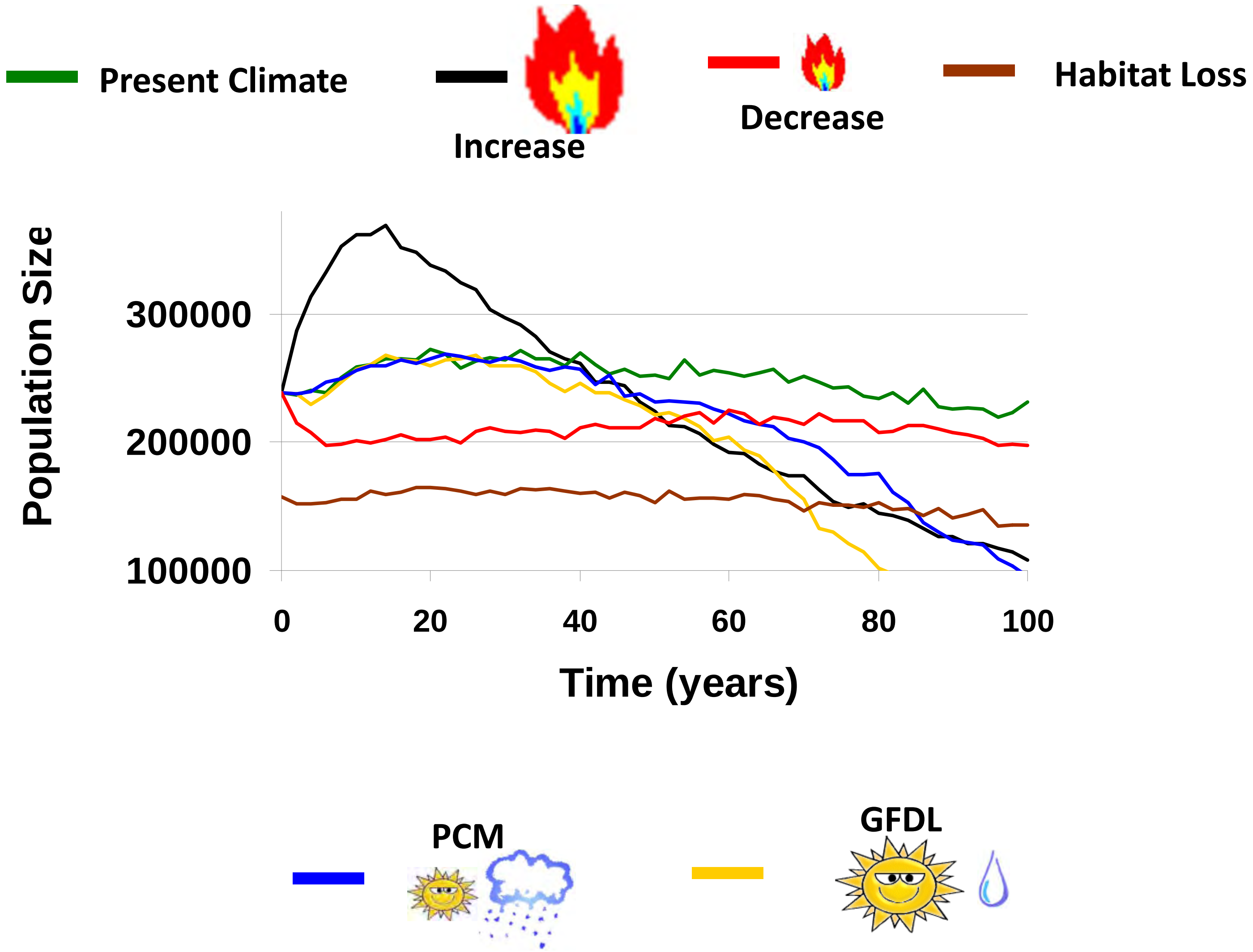
(29 populations)



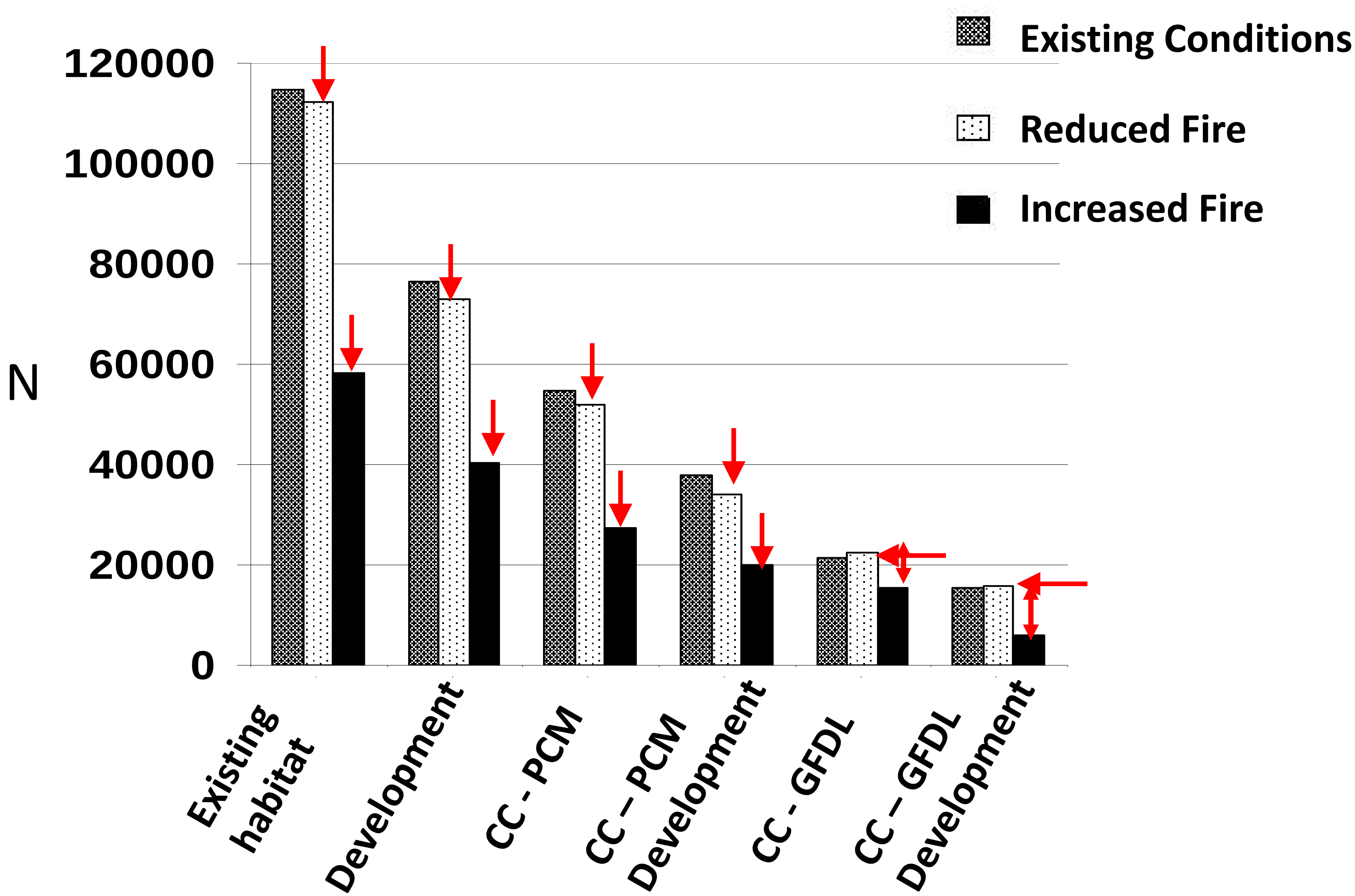
Suitable Habitat

Not Suitable Habitat

Population Trajectories



Expected Minimum Abundance



Conclusions

- More frequent fires are bigger risk than less frequent fires
- Even though fire frequency is increasing, species can be threatened by extended fire intervals
- Development reduces abundance but population trajectory stable
- Climate change poses greatest risk

Conclusions

- Range shifts unlikely due to fragmented landscape and poor dispersal

- Interactions among threats may alter relative risks

- Plant conservation must address uncertain future objectives as climate change unfolds

- Impacts to obligate seeders can provide insights to community and ecosystem level effects of climate change

Are the model results "true"

- Does climate change really pose the greatest risk?
- Maybe not in the near term.
- There are huge uncertainties.
- Models are useful in adaptive management to:
  - synthesize what we know.
  - prioritize data collection.
  - generate hypotheses.
- Models are not the truth.

Conservation Decision Making

- Complex
- High Uncertainty

- Expert opinion only gets us so far
  - Biased risk estimates (Kahneman and Tversky)
  - Over-confidence in opinions (Tetlock)

- Quantitative tools needed for transparency, repeatability and accountability

Acknowledgements

- Helen Regan
- Janet Franklin
- Alex Syphard
- Paul Zedler
- DoD SERDP
- Kevin Cummins
- San Diego 2050 Project
- SDNHM
- SDRVC
- CNLM
- Keith Lombardo
- Dave Boyer
- JoEllen Kassebaum
- Jason Giessow
- Julie Lambert
- Resit Akçakaya
- Kim O'Connor
- Andrea Compton
- Stephen Phillips
- Jerre Stallcup
- Marti Whitter
- Andy Wastel
- Andrea Compton
- Darren Smith
- John Crookston
- Tony Mizerek
- Lisa Markovcek
- Tuyu Mwampamba
- Tasila Banda
- John Williams
- Josh O'Bryan
- Francis Bozzolo
- Liz Santos
- Erin Bergman
- TDI

and others