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

Janet Franklin¹
Helen Regan¹, Alexandra Syphard²

¹ U.C. Riverside
² Conservation Biology Institute

Funding:
National Science Foundation
Dept. Energy Nat’l Inst Clim Chg Rsch
Agents of Global Change

Disturbance

Climate change

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

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*
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

- 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

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
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

2 yrs to mature
Reproduction
Survival

3-30 yrs
1-2 yrs
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)**

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
Average Dispersal Distance = 1 km
Maximum Dispersal Distance = 4km
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

c) PCM climate scenario
Results – *Ceanothus verrucosus*

**Add Reserves**

c) PCM climate scenario

![Graph showing the relationship between EMA (Thousands) and Average Fire Return Interval (Years) for different climate scenarios.](image)

- **No habitat change**
- **Urban+Reserve**
- **PCM**
- **Urban**
- **PCM+Urb+Reserve**
- **PCM+Urban**
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

Regan et al. 2012 Glob Chng Biol
Assisted Dispersal vs. Less Fire Seedling Translocation - Tecate Cypress

80% translocation survival

- 10% translocated
- 20% translocated
- 30% translocated
- no translocation

Fire return interval

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
► M. A. Hawke, SDNHM, species records
► A. and L. Flint, USGS, future climate data
► F. Davis M. Ikegami, UCSB, bioclimate variables
► L. Hannah, CI, climate change and biodiversity
► R. Shaw, TNC, climate change and biodiversity
► P. Zedler, J. Keeley, D. Lawson, species expertise
► Lisa Markovchick-Nicholls, population modeling
► Resit Akcakaya, modeling expertise
► David Keith, modeling expertise