Spatial pattern of mixed evergreen forest composition and tree mortality in the Santa Lucia Mountains, CA

Frank W. Davis & Mark Borchert
May, 2009
The need for better description of mixed evergreen forest in the Big Sur region

- Poorly studied but biologically diverse forest assemblages
- Currently undergoing extensive transformation due to *P. ramorum*
- Opportunity to investigate landscape-scale coupling of vegetation, environment, fire and disease

Tree diseases and landscape processes: the challenge of landscape pathology

Ortmar Holderegger1, Marco Pautasso1,2, Peter J. Wielberg1 and David Lonsdale2

1Institute of Forest Pathology and Entomology, Department of Environmental Sciences, Federal Institute of Technology, 8092 Zurich, Switzerland
2University of Sheffield and Macromolecular Centre, Department of Animal and Plant Sciences, University of Sheffield, Sheffield, UK, S10 2TN
3Institute of Natural Resources and Environmental Studies, University of Tsukuba, Ibaraki 305-8575, Japan
4Independent consultant on tree diseases, 313 Saga Road, Alnwick, Northumberland, UK, NE66 1XJ
Questions

1. How does mixed evergreen forest structure and composition vary across the region as a function of environmental factors and fire history?
2. What are the characteristic spatial scales of tree mortality?
3. How does tree mortality vary as a function of forest composition and site factors?
4. How is forest composition changing as a function of SODS?
Study Region Geology and Soils

Generalized geology

Soil series (see inset to left)
Topography and Precipitation
Steep topo-climatic gradients at Big Creek reserve, 0 – 800 m elevation
Fire history
Vegetation Mosaics
Prior research on Central Coast Mixed Evergreen Forest

• Cooper (1922)
  – Patchiness of MEF
  – Intergradation with Douglas fir and Coast redwood forests at wetter end; chaparral at drier end
  – Importance of water balance and soil moisture
  – MEF as “postclimax” to chaparral due to fire.
Prior research (cont’)

- Waring and Major (1964)
  - Moisture gradient analysis
- Campbell (1990)
  - Phytosociology of southern CA hardwood forests
- Hunter (1992)
  - Gap disturbance processes, species traits
- Recent SOD research
  - Meentemeyer et al. (2002-present) on landscape patterns of disease incidence
  - Rizzo et al. on disease ecology, impacts and management

![Image](Fig. 3. Distribution of selected species in relation to the Minimum Available Moisture (Minimum AM).)
Research “hypotheses”

- Species respond individualistically to environmental gradients
- Vegetation patchiness results from local topoclimatic factors, soil properties and disturbance history (fire, disease)
- Tree mortality increases with forest continuity and relative abundance of Bay laurel
PLOT DISTRIBUTION & STRATIFICATION CRITERIA

- 300 plot locations
- 4 variables
- 24 strata

Ownership & Forest Types
- Public Mixed Evergreen
- Public Redwood Types
- Private Mixed Evergreen
- Private Redwood Types

- watershed
- land ownership
  - private
  - public
- forest type
  - mixed evergreen
    - overlapping fires
      - 1 - 2
        - tree mortality
          - 0
          - 1 - 3
          - > 3
      - > 2
        - tree mortality
          - 0
          - 1 - 3
          - > 3
  - redwood types
    - overlapping fires
      - 1 - 2
        - tree mortality
          - 0
          - 1 - 3
          - > 3
      - > 2
        - tree mortality
          - 0
          - 1 - 3
          - > 3
Data for this study

• 58 sites from “Mixed evergreen forest” stratum, 7 basal area plots per site. Samples taken to span north-south climate gradient and fire history
  – 398 plotless samples of species basal area (live, standing dead, recently down dead)

• Environmental factors
  – Elevation
  – Distance to coast
  – Time since fire
  – Topographic moisture index
  – Annual solar radiation and heat load
  – Interpolated minimum and maximum monthly temperature and annual precipitation analyzed, but not reported
Location of sampling sites
Variable radius plot array
Analysis

• Spatial autocorrelation analysis of community data (Goslee and Urban 2007)
  – Total basal area and live basal area
• Multi-scale ordination (Wagner 2006)
  – Species basal area, Hellinger-transformed
• Non-parametric niche modeling for dominant tree species (McCune 2006)
• Niche modeling and spatial autocorrelation analysis of tanoak mortality
Mixed evergreen forest samples vs. Big Sur Study Area. MEF with tanoak is associated with north slopes, steeper slopes, and mid-elevations slightly closer to the coast.
Tree basal area in plots is dominated by tanoak and coast redwood. Most dominants are SOD hosts (which are all vigorous stump sprouters). Mortality is much higher in tanoak than other host species.
Vegetation is patchy at all scales. Recent mortality has slightly increased patchiness at scales > 250 m.

Multivariate correlogram, vegetation dissimilarly as a function of lag distance.

Vegetation dissimilarly as a function of plot separation distance. Line is best-fit locally weighted regression.
Correlations among environmental factors

1. North south gradients:
   • Northern plots further from coast
   • Fire frequency increases from north to south
   • Time since burning greater for more northern plots

   • Coast-interior gradients
     • Increasing elevation with distance to coast
     • Inland plots on more southerly slopes than coastal plots.
Summary of species-environment relationships in mixed evergreen forest with tanoak component

- Tanoak occurs with many different species
- Fairly predictable turnover in species importance along coast-interior gradient, interacting with local elevation and drainage
  - comparable strength of relationship with mapped precipitation, minimum and maximum temperature
- Only Ceanothus spp and Bay laurel show clear relationship between relative basal area and time since fire
Coast redwood and Bay laurel increase towards the coast at low elevations and creeksides.
Canyon live oak (R² = 0.45)

Black oak (R² = 0.58)

Madrone (R² = 0.59)

Canyon live oak, black oak and madrone increase with greater distance from the coast and at higher elevation.
Coast live oak and Shreve oak increase at mid-to-high elevations. Coast live oak is associated with deeper soils, closer to the coast.
Ceanothus spp. both reach peak abundance 10-30 years after fire but segregate by elevation and distance from coast.
Spatial patterns and environmental relationships of tanoak mortality: % dead basal area increases near coast and in southern sites.

$r^2 = 0.24$
$p < 0.005$
Spatial patterns and environmental relationships of tanoak mortality: % dead basal area increases with increasing site-scale bay laurel basal area.

At plot scale, $r^2=0.07$
Tanoak sapling/sprout recruitment
Sapling class is abundant at all times since burning, at low and high LIDE basal area
Summary of results

• Tanoak co-dominated mixed evergreen forest is patchily distributed on low-radiation sites.
• Species associated with tanoak show clear trends on environmental gradients from low-near coastal to high-interior sites. Climate variables are not well enough measured or mapped to allow direct interpretation.
• Fire history not strongly related to forest composition except in cases where severe burning has resulted in post-burn Ceanothus chaparral (mainly in higher/more interior areas).
Results (2)

- In 2006, 30% of tanoak basal area was in standing dead or down dead trees.
- Tanoak mortality was correlated with many environmental factors but most factors (including spatial autocorrelation) not significant after accounting for site-level basal area of Bay laurel.
- Tanoak exhibits abundant re-sprouting and sapling recruitment in a range of environments.