Chaparral conservation: Manzanitas as a whole ecosystem.

V. Thomas Parker, San Francisco State University
We tend to focus on plants such as manzanitas

Santa Lucia Mountains 2500 ft  
*Arctostaphylos glauca*  
with Chamise

A. *gabilanensis*, Gabilan Manzanita  
Gabilan Mts near Fremont Peak
Regardless of the habitat

A. glandulosa, A. sensitiva

(Eastwood’s, Coinleaf Manzanitas)
Others tend to focus on the fact that they burn
And forget that they themselves are ecosystems, and are part of larger ecosystems
What’s impressive about these plants like manzanitas is that they support massive amounts of biodiversity...

...they are their own ecosystems.
Ecosystems vs. ‘fuel’ in chaparral

- Pollinators
- Insect predators
- Fruit gallers
- Seed weevils
- Leaf miners
- Leaf gallers
- Leaf fungi
- Herbivores
- Mycorrhizal fungi
- Large mammals for long-distance dispersal
- Rodents to bury seeds for short-distance dispersal
- Habitat for other mammals, invertebrates and microorganisms.
Let’s start with their flowering.
Bumblebees depend on these early flowering plants. That is especially true for early emerging Queen Bumblebees.
Osmia spp. and Bombus melanopygus depend on early flowering manzanitas...
A bee fly, *Bombylius major*

Native *Andrena* bee

From The Amateur Anthecologist website
Lots of other nectar and pollen dependent species

Anna’s hummingbird (above)
Mourning Cloak butterfly (left)
OK, we’ve got the flowers pollinated and the fruit is beginning to grow.
Now a new wave of insects arrive to lay eggs in the seed chambers and other parts of the fruit.
Some fruit survive the insect onslaught.
But looking closely, the little dark spots are insect emergence holes. Individual seed were consumed.
Good fruit has to get dispersed.
Good fruit has to get dispersed.
But this is just long-distance dispersal.
But these fruit need to get buried because they live in fire-prone regions.
Enter the second dispersal agents. *(Diplochory)*

Rodents eat seed but they also store them in small caches to eat later.

Fortunately for plants, they often don’t survive.
It’s the rodents creating the soil seed banks for these plants.

Small fruited species have high density seed banks while larger fruited species have smaller seed banks.

![Graph showing the relationship between fruit volume and seed density](image-url)
And then, post-fire, seedlings emerge from the caches.
Rodent caching is evident with every species examined so far.
And you can do field experiments to show it's the rodents doing the work.
And their caches differentially survive higher intensity fires.

Caches:
- Average depth 4.1 cm
- Range between just below the surface down to nearly 10 cm

more caches as a %
And the manzanitas have a number of fruit traits to limit loss to the rodent granivores.

- Variable nutlet fusion per fruit
- Variable seed viability per fruit
- No relationship between % fusion & % viability
Now, a closer look at the adults.
These plants represent a massive amount of food for a variety of insects.
Of the large number of insects on manzanitas, many are endemic and rare.

*Marmara arbutiella*, Madrone Skin Miner

*Epinotia subplicana*, larval host is manzanita (Tortricid moth)
Maybe you’ve seen these red galls on the edges of leaves.
These galls are caused by aphids that have co-evolved with manzanitas and are only found on them.
This is *Tamalia cowenii*. One species is specific to *A. glauca*. There are other aphids that invade their galls and kick them out.
Caterpillars of Noctuidae and Geometridae moths often are found on manzanias

From The Amateur Anthecologist website
One 5-year survey of one manzanita species found over 539 different types of insects associated with *A. patula*. (50+ spiders not included).
Fungi get in the picture as well. You might have seen these bright red stems of new growth.

Actually infected with *Exobasidium vaccinii*. 
You’ve probably seen bark stripping on manzanitas. Turns out that’s good habitat for some animals.
Large diversity of native ants make nests in these stems.

Liometopum occidentale (Marc Kummel photo)
Pseudomyrmex apache © Charles W. Melton
www.nearfamous.com
Themnothorax gallae (Alex Wild photo)
Other locals indirectly depend on manzanitas.

Sharp-tailed snake – *Contia tenuis*

Pacific Coast Rattlesnake – *Crotalus oreganus*
Many insectivorous birds live off those insects on manzanitas and other chaparral shrubs.

Other locals indirectly depend on manzanitas.

Wrentit—*Chamaea fasciata*

Black Phoebe—*Sayornis nigricans*
That’s above ground. What happens below ground?

Manzanitas usually live in poor soils low in nutrients and water.
Mutualisms with soil microbes – not all fungi are bad.

Mycorrhizae permit survival for both poor soils (like serpentine) and for drought.

Large proportion of mycorrhizal fungi shared with conifers, smaller amount with oaks.
They can be quite lovely.
Wildfires happen, but current ‘fuel management’ actions are seriously impacting these populations and the other organisms associated with them.
This is a whole ecosystem, not fuel

Pollinators
Insect predators

Large mammals for long-distance dispersal

Rodents to bury seeds for short-distance dispersal

Mycorrhizal fungi

Fruit gallers
Seed weevils
Leaf miners
Leaf gallers
Leaf fungi
Herbivores

Habitat for other animals, invertebrates and microorganisms.
Manzanitas are the central player in an ecosystem of animals and microorganisms centered on their ecosystem.
Balancing Fuel Management Goals and the Ecological Impacts of Fuel Modification

Robert Fitch¹, Carla D’Antonio¹, & Nicole Molinari²
¹UCSB Dept. of Ecology, Evolution and Marine Biology
²USDA Forest Service
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California and Wildfire

Millions of people live in WUI -> mitigating risk to human communities

• Modifying/disturbing vegetation i.e., fuel
Modifying vegetation/fuel

Fuel Breaks at WUI
Modifying vegetation/fuel

Defensible Space

Type of vegetation is part of the solution (Home Hardening and Community Planning)
Fuel Mgmt. and Ecological Impacts

- Disturbed areas invaded by non-native species
- Illegal shooting ranges
- OHV use
- Dumping/littering
Fuel Mgmt. and Ecological Impacts

Plus frequent wildfire... threatens shrubland ecosystem stability
Highly Disturbed Areas

Balance fuel management and shrubland ecosystem stability
Research Program Goals

Can we balance needs?

- Fire Risk/Safety
- Native Ecosystems
Where is this work applicable?

**Wildland Urban Interface**

- Fuel Breaks
- Roadsides “ignition corridors” aka “invasion corridors”
- Defensible Space
Grass dominated and flammable

Use native species to reduce wildfire risk
### Desirable Species Traits?

<table>
<thead>
<tr>
<th>Fuel / Fire</th>
<th>Ecological</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High live fuel moisture</td>
<td>• Pollinator services</td>
</tr>
<tr>
<td>• Produces less litter</td>
<td>• Invasion resistance</td>
</tr>
<tr>
<td>• Shorter height</td>
<td>• Habitat</td>
</tr>
<tr>
<td>• Smaller fuel load</td>
<td>• Forage</td>
</tr>
</tbody>
</table>
Research Program Goals

Can we balance needs?

Fire Risk/Safety

Native Ecosystems

Restoration Project
How do native and non-native plants differ?
• Fuel (fire) characteristics
• Ecological traits
Study Location

- Los Padres National Forest
- Santa Barbara, CA
- 108, 1.25m x 1.25m plots
Plot Treatments

Out-planted Perennial community
- Asclepias eriocarpa
- Asclepias fasicularis
- Calystegia macrostegia
- Eriophyllum confertiflorum
- Melica imperfecta
- Poa secunda
- Mimulus aurantiacus
- Pseudognaphalium californicum
- Sisyrinchium bellum
- Stipa pulchra

Seeded Annual community
- Amsinckia mensenzii
- Clarkia unguiculata
- Croton setger
- Lupinus bicolor
- Phacelia cicutaria
- Salvia columbariae
- Uropappus lindleyi

Current Vegetation “Control”
- Avena barbata
- Bromus diandrus
- Centaurea solstitialis
- Erodium cicutarium
- Hirschfeldia incana
Plot Treatments

**Out-planted**
Perennial community
- Asclepias eriocarpa
- Asclepias fascicularis
- Calystegia macrostegia
- Eriophyllum confertiflorum
- Melica imperfecta
- Poa secunda
- Mimulus aurantiacus
- Pseudognaphalium californicum
- Sisyrinchium bellum
- Stipa pulchra

**Seeded**
Annual community
- Amsinckia mensenzii
- Clarkia unguiculata
- Croton setger
- Lupinus bicolor
- Phacelia cicutaria
- Salvia columbariae
- Uropappus lindleyi

**Current Vegetation**
“Control”
- Avena barbata
- Bromus diandrus
- Centaurea solstitialis
- Erodium cicutarium
- Hirschfeldia incana

Weeded weekly, every year
Desirable Species Traits?

**Fuel / Fire**
- High live fuel moisture
- Produces less litter
- Shorter height
- Smaller fuel load

**Ecological**
- Pollinator services
- Invasion resistance
- Habitat
- Forage
Desirable Species Traits?

**Fuel / Fire**
- High live fuel moisture
- Produces less litter
- Shorter height
- Smaller fuel load

**Ecological**
- Pollinator services
- Invasion resistance
- Habitat
- Forage
Summary:

By three years,

• Native perennials and non-natives were **EQUAL** in fuel load and max height

• Native annuals are the smallest.
Summary:

For ALL three years,

- Non-native species, most litter cover and depth
- Litter depth did NOT change for native communities
Summary:

- LFM is driven by fewer species as the summer drought progresses.
- Native communities retain LFM for longer over summer.
  - 6 months!

YST removed from data.
Ecological Benefits?

Animals and Insects
## Balance? - What was gained/lost?

<table>
<thead>
<tr>
<th>RESULT</th>
<th>TRAITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native</td>
<td>Fuel / Fire</td>
</tr>
<tr>
<td>High summer LFM</td>
<td>- Fuel moisture content</td>
</tr>
<tr>
<td>Break even</td>
<td>- Fuel load</td>
</tr>
<tr>
<td>Less Litter</td>
<td>- Litter</td>
</tr>
<tr>
<td>Break even</td>
<td>- Vegetation height</td>
</tr>
<tr>
<td>Compared to...</td>
<td>Ecological</td>
</tr>
<tr>
<td>Yellow star thistle</td>
<td>- Pollinator services</td>
</tr>
<tr>
<td>Mustard</td>
<td>- Invasion resistance</td>
</tr>
<tr>
<td>Brome grasses</td>
<td>- Habitat</td>
</tr>
<tr>
<td></td>
<td>- Forage</td>
</tr>
</tbody>
</table>
Wrap Up

Conclusion:

• Significant **benefits for reducing fire hazard** by having **herbaceous native species** in fuel modified habitats within the WUI
Got Bots? A survey of latent fungal pathogens and dieback in big berry manzanita (*Arctostaphylos glauca*) during an historic southern California drought

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\textsuperscript{2}Westmont College, Santa Barbara, California

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Exceptional drought and chaparral shrublands

Aug. 12, 2014

Santa Barbara

Consequences of plant mortality:
- Vegetation type-conversion
- Increased fire risk
- Changes in hydrology
- Shifts in local food web structure

Chaparral shrubland in Santa Barbara County
Drought and predisposition to disease

Drought and predisposition to disease

Effects of Russian wheat aphid infestation on barley plant response to drought stress

Walter E. Riedell


Acute Drought Is an Important Driver of Bark Beetle Infestation in Austrian Norway Spruce Stands

Leaf Morphological and Biochemical Responses of Three Potato (Solanum tuberosum L.) Cultivars to Drought Stress and Aphid (Myzus persicae Sulzer) Infestation

by Peter Quandahor, Chunyan Lin, Yuping Gou, Jeffrey A. Coulter, and Changzhong Liu

DOI: 10.1051/forest:2006040

Interactive effects of drought and pathogens in forest trees

Marie-Laure Desprez-Loustau, Benoit Marçais, Louis-Michel Nageleisen, Dominique Piou, and Andrea Vannini
Manzanita dieback and mortality
Manzanita dieback and mortality

Arctostaphylos glauca
Evidence of fungal disease:

- Dieback of leaves and branches
  - Grey/black leaf discoloration
- Wood cankers
Evidence of fungal disease

Preliminary survey found:

- *Neofusiccocum australe*
- *Botryosphaeria dothidea*  (Schultheis et al. 2018)

Botryosphaeriaceae (Bot) family
About *Bot* fungi

- Phylum Ascomycota (sac fungi)
- Currently over 200 species (~20 genera) described
- Widespread
- Opportunistic
- Important agricultural pest

Examples of “Bot rot” on fruit

Bot canker and leaf disease on grapevines


*Photo: DiCicco (2019)*
Greenhouse Experimental Design

Drought + Fungus (D+)

Watering + Fungus (W+)

Drought, no fungus (D-)

Watering, no fungus (W-)

(Control)
Effects of drought and *Bot* infection on young *A. glauca*
Question:
What are the patterns and distribution of *Bots* (and *Bot*-related dieback) in *A. glauca* across the landscape?
Methods: Study area

Pacific ocean
Methods: Abundance and distribution of *Bots*

**Sampling design**

<table>
<thead>
<tr>
<th>Elevation range (m)</th>
<th>Mean annual precip. (cm)</th>
<th># sites</th>
<th># individuals sampled/site</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>≤ 700</td>
<td>10</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Intermediate</td>
<td>701 - 950</td>
<td>10</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>High</td>
<td>≥ 951</td>
<td>10</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Total range</td>
<td>~700</td>
<td>30</td>
<td>10</td>
<td>300</td>
</tr>
</tbody>
</table>

- Random selection of individuals using ArcMap
- Samples cultured in lab and Sanger sequenced at UC Berkeley
  - ITS and β-tubulin regions

![Random points in ArcMap](image1.png)

![Bot cultures in the lab](image2.png)
Methods: Dieback severity

- Severity = total % canopy affected (at stand level)
- Assessed by 2-3 people at each site
- Examples:
Data collection (bushwhacking)
Results: *Bots* are abundant!

*Bots cultured*: 314 (63.8%)

*Bots sequenced*

*N. australe*: 106

*B. dothidea*: 55

*N. luteum*: 3

Drake- Schultheis et al. (In publication). *Phytopathology.*
Results: *Bots* are abundant!

*Bots* cultured: 314 (63.8%)

*Bots* sequenced

*N. austral*e: 106

*B. dothidea*: 55

*N. luteum*: 3

<table>
<thead>
<tr>
<th></th>
<th><em>B. dothidea</em> (%)</th>
<th><em>N. austral</em>e (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower</td>
<td>34.6± 10.3</td>
<td>64.1 ± 10.5</td>
</tr>
<tr>
<td>Inter.</td>
<td>38.8± 4.3</td>
<td>61.2 ± 4.9</td>
</tr>
<tr>
<td>Upper</td>
<td>31.8 ± 8.2</td>
<td>65.2 ± 9.5</td>
</tr>
</tbody>
</table>

* Means (+ SE) expressed as the percent of total Bot isolates sequenced per site (n = 9, 8, and 9 sites, respectively, as four sites did not produce isolates that were sequenced).

Drake- Schultheis et al. (in publication). *Phytopathology.*
Results:
Aspect, but not elevation, correlated with infection frequency

### Results of simple linear model regression for Bot infection*.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t-value</th>
<th>F-value</th>
<th>Prob &gt; F</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>-0.0001</td>
<td>0.0002</td>
<td>-0.266</td>
<td>0.071</td>
<td>0.79</td>
<td>0.003</td>
</tr>
<tr>
<td>SW</td>
<td>-0.002</td>
<td>0.001</td>
<td>-2.356</td>
<td>5.552</td>
<td><strong>0.03</strong></td>
<td><strong>0.17</strong></td>
</tr>
</tbody>
</table>

* Bot infection is the proportion of cultures consistent with Bots per site

a Factor codes: elevation, E; aspect (southwestness), SW

Drake-Schultheis *et al.* (In publication). *Phytopathology.*
Results: Dieback varies with elevation

Less dieback

More dieback

n = 30
$R^2 = 0.61$
P < 0.0001

Drake-Schultheis et al. (In publication). Phytopathology.
Results: Predicting dieback

Table 5. GLMs describing percent dieback*. The model that best describe percent dieback, i.e. with the lowest Akaike Information Criterion (AIC) scores, is marked in bold.

<table>
<thead>
<tr>
<th>Factors</th>
<th>t-value</th>
<th>Prob &gt; t</th>
<th>D²</th>
<th>AIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>-6.97</td>
<td>&lt;0.0001</td>
<td>0.61</td>
<td>87.2</td>
</tr>
<tr>
<td>PB</td>
<td>1.24</td>
<td>0.22</td>
<td>0.05</td>
<td>114.5</td>
</tr>
<tr>
<td>SW</td>
<td>-1.24</td>
<td>28</td>
<td>0.06</td>
<td>114.4</td>
</tr>
</tbody>
</table>

* Percent dieback data were square root-transformed to meet assumptions of normality

a Factor codes: elevation, E; proportion of Bots, PB; aspect (southwestness)
Summary

• *Bots* are present and abundant across the landscape
  - *Bots* found at all 30 sites across elevation
  - *N. austral* nearly 2x more than *B. dothidea*
  - Aspect may influence infection frequency

• Dieback greatest at lower elevations
1. Bot pathogens a threat to *A. glauca* shrublands in Santa Barbara County
   - Especially *N. australis*

2. Lower elevations most vulnerable, either due to:
   - hotter, drier conditions,
   - proximity to inoculum sources,
   - both
Conclusions

1. Bot pathogens a threat to *A. glauca* shrublands in Santa Barbara County

2. *N. australis* dominant in the area

3. Lower elevations most vulnerable, either due to:
   - hotter, drier conditions,
   - proximity to inoculum sources, or
   - both

Good news?
No new mortality during study!
Questions?
Results: Haplotyping

B. dothidea (n = 60)

N. australis (n = 101)

10 haplotypes

2 haplotypes