Fuel management effects on wild birds in California chaparral
How mastication is changing bird communities and may be increasing Lyme Disease incidence

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California Fire Sciences Consortium Webinar
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Synthesis: landscape change, bird communities and Lyme Disease
Research Study Area

Mayacamas Mountains, North Coast Range
UCDANR Hopland Research and Extension Center
BLM South Cow Mountain Recreation Area

Image from Google Earth

Plant community: Chamise-type chaparral (*Adenostoma fasciculatum*) (65%), also containing large proportions of *Ceanothus* spp. and manzanita (*Arctostaphylos* spp.)
Plant community: Chamise-type chaparral (*Adenostoma fasciculatum*) (65%), also containing large proportions of *Ceanothus spp.* and manzanita (*Arctostaphylos spp.*).
Borrelia burgdorferi Sensu Lato Spirochetes in Wild Birds in Northwestern California: Associations with Ecological Factors, Bird Behavior and Tick Infestation

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What is Lyme borreliosis?

*Ixodes pacificus* female
(bugguide.net)

*Borrelia burgdorferi*
(MicrobeWiki)
Lyme borreliosis is North America’s top emerging vector-borne disease, with 300,000 new cases annually in the US alone.

Lyme disease in humans can cause
• Arthritis
• Fever
• Recurring headaches
• Various rashes
• Chronic fatigue
• Depression
• Cognitive impairment and memory loss
• Facial palsy

And has also been linked to autism through fetal neurological development and immunosuppression mechanisms (Bransfield et al., 2008)
Lyme Disease is present in California

Eisen L and RJ Eisen 2007. Comparison of spatial distributions of areas of California with different incidences of endemic Lyme disease (LD), 1993–2005, when calculated by A) the county spatial unit and B) the 5-digit ZIP code spatial unit.
Definitions

Emerging infectious disease – an infectious disease that has recently increased in incidence, often arising from ecological change

Zoonosis (pl. zoonoses) – Zoonoses are infectious diseases that are transmitted between non-human vertebrate species (sometimes by a vector) and humans

*Borrelia burgdorferi sensu lato* (BBSL) is a group of closely-related organisms that are also known to cause Lyme borreliosis (~37 species)

-Borrelia burgdorferi sensu stricto* (BBSS) is the main cause of Lyme borreliosis in the US

-Borrelia bissettii* (BBIS) causes a LD-like illness in some people in Europe and northwestern California
Lyme borreliosis in wildlife

**Vector**

Dusky-footed woodrat (*Neotoma fuscipes*)

**Pathogen**

**Host**
Lyme borreliosis in wildlife

Vector

Pathogen

Host

Southern alligator lizard (Elgaria multicarinata subsp. multicarinata)
Lyme borreliosis in wildlife

Vector

Pathogen

Host?

Spotted Towhee (*Pipilo maculatus*)
Life cycle of a Black-legged Tick (*Ixodes pacificus*)

Source: American Lyme Disease Foundation website

Source: Westport Weston Health District online.
Geographic ranges of birds and ticks overlap for part of the year.

Swainson's Hawk. Photo: Glenn Bartley
Haller’s organ
(University of Plymouth Electron Microscopy Centre)
Establishing wildlife disease reservoirs

To establish that a particular bird species is a reservoir for disease, we use the following facts:

(a) a bird can get spirochetes only from an infected nymph;
(b) the spirochetes survive in the reservoir bird;
(c) the reservoir bird must transmit the infection to another tick. Here we only consider transmission to larvae because they are infection-free before the attachment to a host.

We are interested in both:

INFESTATION (number of ticks on a bird) and
INFECTION (spirochetes in blood or in larvae)
Methods: data collection

Blue Jay with tick
Image courtesy Hilton Pond Center

Hermit Thrush being processed
Image courtesy Michelle RF: http://michelesphlog.blogspot.com
Results: data collection

Mist netting of birds occurred in spring of 2003-2004 at 14 sites. Nets were open for 4-8 hours following sunrise. Total mist-netting effort estimated to be >3000 hours. 623 birds were caught, with 284 ticks. Blood was drawn from each bird, the bird was marked, and ticks were removed from each bird and separated by life stage.

Ticks were preserved in 95% ethanol.

*Borrelia burgdorferi* was detected using polymerase chain reaction (PCR) assays.

23/53 bird species had *Borrelia* infection of some sort. 100/623 individual birds carried ticks.
Results: blood analysis

Prevalence (by %) of infection of birds, I. pacificus larvae and nymphs with different genospecies of Borrelia

- BBSS: 96.0%
- BBIS: 29.8%
- BBSL MIX: 8.8%
- BBSL(un): 4.8%

Borrelia genospecies

Prevalence (%)
Methods: statistical modeling

We categorized each individual bird by a number of explanatory variables

- Binomial models predict presence of infection and infestation
- Zero-inflated negative binomial models predict counts of larvae and nymphs

Explanatory variables include:
Year, Average body weight, Number of nymphs removed from bird (infection only), Main habitat type
Categorizing birds for analysis by guilds

Categories

Main food
- Insects
- Nectar
- Omnivore
- Seeds
- Birds

Foraging substrate
- Foliage Gleaner
- Bark Forager
- Ground Forager
- Flycatching
- Hovering
- Aerial Forager

Nesting substrate
- Shrub
- Tree
- Cavity
- Ground

Presence
- Breeding (year-round or summer only)
- Non-breeding (wintering or migrating)

Icons courtesy Cornell Lab of Ornithology Online: http://www.allaboutbirds.org/
What is the relative importance of behavior versus taxonomy?

- Nuttall’s Woodpecker
- Acorn Woodpecker
- Hairy Woodpecker
- Northern Flicker
- Hutton’s Vireo
- Cassin’s Vireo
- Warbling Vireo
- Red-eyed Vireo
- Orange-crowned Warbler
- Yellow-rumped Warbler
Data exploration

Larvae per bird by main habitat

Nymphs per bird by main habitat

Blood infection rate by main habitat
Results: statistical modeling

What predicts infection incidence in birds?

- Year
- Number of nymphs removed from bird
- Order

What predicts number of larva on birds?

- Main habitat = GRASS
  - OAK WOODLAND
  - DENSE OAK WOODLAND

What predicts number of nymphs on birds?

- Main habitat = GRASS
  - OAK WOODLAND
  - DENSE OAK WOODLAND
- Feeding substrate
Results: statistical modeling

What predicts infection incidence in birds?

- Year
- Number of nymphs removed from bird
- Order

What predicts number of larva on birds?

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What predicts number of nymphs on birds?

- Main habitat = GRASS
  - OAK WOODLAND
  - DENSE OAK WOODLAND
- Feeding substrate

Chaparral is significantly negatively correlated with infestation
Other major findings

1. Among passerines, we identified 3 carrier species: American Robin, Dark-eyed Junco, and Golden-crowned Sparrow
   - Juncos and Robins have all been noted to increase in abundance with suburbanization (Shultz, Tingley, Bowie, 2012)

2. Chaparral-associated birds carry blood infection, but it is mostly *Borrelia bissettii*

3. Bird blood is not the tissue where BBSL resides
   - recommendation: extensive necropsies of birds to test spinal fluid, synovial (joint) fluids, and all organs, including skin and feather attachments
So what happens to chaparral-associated birds under management scenarios?
Bird community response to fuels management in northern California chaparral: the effects of treatment and season

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Chaparral management: two treatments

Prescribed fire
- Risk of escape
- Air quality concerns
- Public perception

Mastication
- Low slopes only
- High cost
- No remote access
Landscape following treatment

Fire (winter, spring, fall)  Mastication (spring, fall)

Treatments were implemented in 1-acre plots with 4 replicates each, for a total of 20 treatment acres and 4 control plot acres

2001: Pre-treatment monitoring
2002 - 2003: Fire and mechanical treatments implemented
2005: Post-treatment monitoring complete
Post-treatment fuel bed

Fire

Mastication
Total cover, 3 years post-treatment

Mean shrub cover: 71% ± 2

Mean shrub cover: 43% ± 4
<table>
<thead>
<tr>
<th>Study</th>
<th>Findings</th>
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<tbody>
<tr>
<td>Potts and Stephens. Biological Conservation, 2009.</td>
<td>Mastication has:</td>
</tr>
<tr>
<td></td>
<td>• highest number of non-natives</td>
</tr>
<tr>
<td></td>
<td>• 34% more non-native annual grasses</td>
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<td></td>
<td>Winter and spring fire has:</td>
</tr>
<tr>
<td></td>
<td>• lowest non-native species and abundances</td>
</tr>
<tr>
<td>Potts, Marino and Stephens. Plant Ecology, 2010.</td>
<td>By 3\textsuperscript{rd} post-treatment year:</td>
</tr>
<tr>
<td></td>
<td>• Fire treatments have higher shrub cover (71 ± 2%) compared to mastication (43 ± 4%).</td>
</tr>
<tr>
<td></td>
<td>• No treatment effect on species diversity or composition</td>
</tr>
<tr>
<td>Stephens et. al. Fire Ecology, 2008.</td>
<td>Measurements from this experiment inform fire spread models useful to firefighting and management</td>
</tr>
<tr>
<td>GAP: Effects of chaparral management on birds</td>
<td>This study</td>
</tr>
</tbody>
</table>
Nonnative annual grass abundance

Potts et al. (2009)
Bird data from point counts

• 42 species and 2520 detections total

• Control: 39 species, 1072 detections
  • 4 plots, 122 visits
    • Wrentit (n=180)
    • Western Scrub Jay (n=120)
    • Lesser Goldfinch (n=109)
    • Spotted Towhee (n=100)

• Fire: 41 species, 1339 detections
  • 12 plots, 190 visits total
    • Wrentit (n=190)
    • Western Scrub Jay (n=172)
    • Lesser Goldfinch (n=115)
    • Spotted Towhee (n=110)

• Mastication: 20 species, 109 detections
  • 8 plots, 39 visits total
    • Wrentit (n=16)
    • Spotted Towhee (n=13)
    • Anna’s Hummingbird (n=11)
    • Western Scrub Jay (n=11)

Images: Bruce Finocchio; Wikipedia; Brain E. Small; Paul Higgins
Assessing total diversity must account for unequal survey effort.
CONTROL plots always have significantly more bird diversity.
FIRE treatments most resemble CONTROL plots for community diversity and evenness.
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FIRE treatments most resemble CONTROL plots for community diversity and evenness.
Birds in CONTROL plots (39 species total)
Birds in MASTICATED plots (21 species total)
Bell’s Sparrow
*Artemisiospiza belli*
(previously *Amphispiza belli*)

![Image: birdguy.net]
Categorizing birds for analysis by guilds

**Categories**
- Main food
- Foraging substrate
- Nesting substrate

**Levels**
- Insects
- Nectar
- Omnivore
- Seeds
- Birds
- Foliage Gleaner
- Bark Forager
- Ground Forager
- Flycatching
- Hovering
- Aerial Forager
- Shrub
- Tree
- Cavity
- Ground

**Presence**
- Breeding (year-round or summer only)
- Non-breeding (wintering or migrating)

Icons courtesy Cornell Lab of Ornithology Online: http://www.allaboutbirds.org/
Proportions of birds vary between plots by main food item preference
Pairwise Chi-square and Fisher’s exact test results show differences between bird use of plots by food preference

<table>
<thead>
<tr>
<th>Plot</th>
<th>Insectivores</th>
<th>Granivores</th>
<th>Nectarivores</th>
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</thead>
<tbody>
<tr>
<td>FIREFALL</td>
<td>Fewer</td>
<td>More</td>
<td></td>
</tr>
<tr>
<td>FIREWINTER</td>
<td>Fewer</td>
<td>More</td>
<td></td>
</tr>
<tr>
<td>FIRESPRING</td>
<td>Fewer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MASTSPRING</td>
<td>More</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MASTFALL</td>
<td>More</td>
<td></td>
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</tr>
</tbody>
</table>

- **FIREFALL** has fewer insectivores than expected \( p = 0.048 \) *
- and more granivores than expected \( p = 0.095 \)
- **FIREWINTER** has fewer insectivores than expected \( p = 0.007 \) **
- and more granivores than expected \( p = 0.018 \) *
- **FIRESPRING** has fewer granivores than expected \( p = 0.007 \) **
- MASTSPRING and MASTFALL have more nectarivores than expected
  - **MASTSPRING** \( p_{Fe} = 0.074 \)
  - **MASTFALL** \( p_{Fe} = 0.042 \) *
There are no “flycatchers” in the masticated plots…

Ash-throated flycatcher (*Myiarchus cinerascens*)

Pacific-slope Flycatcher (*Empidonax difficilis*)
...just flycatching birds.
Small, gallinaceous walking birds are declining globally.
Three mechanisms by which Lyme borreliosis becomes more prevalent in California wildlife with chaparral removal:

1. Chaparral-associated birds have fewer ticks compared to birds primarily associated with other habitats.

2. Competent carriers of BBSS (primarily not chaparral birds) disproportionately pass that bacteria back to ticks.

3. Competent wildlife hosts of BBSS (such as American Robins, Dark-eyed Juncos) replace non-competent hosts in masticated areas of chaparral.
Synthesis II

- Land use is tied to emerging infectious diseases; fire management also affects disease ecology.

- Fire management in chaparral is detrimental to bird abundances generally, and to a large number of species. Mastication is more harmful than fire as a management tool.

- Fire management choices may be influencing the incidence rate of Lyme Disease, and fire managers should not overlook disease ecology consequences.
Policy and management recommendations

Chaparral biodiversity is threatened by mastication (this study), too-frequent fire (Keeley et al., 2005; Syphard et al., 2006), and habitat fragmentation (Soulé et al., 1988; 1992)

The consequences of management activities on disease ecology, including Lyme Disease, are just beginning to be known

Therefore, management activities in chaparral should be limited to what is essential for protection of human health and well-being
Scroll down for reserve slides
Phylogenetic relationships of bird species sampled at Hopland Research and Extension Center in Newman, et al. (2014)
Chaparral fuel reduction strategies: three seasons

Arrows indicate the three different seasons of treatment implementation

Bird data: methods

- Bird community composition and abundance were measured using variable-circular point counts (Reynolds et al. 1980)

- Each observer stands at a fixed point for 10 minutes and records every bird detection (visual, call and song) and its distance from the observer (DeSanto 1981)

- Two point counts were conducted simultaneously in each treatment unit, with at least 100 meters between counting sites

- 6 annual count sessions (winter, early spring, mid-spring, late spring, summer)