Post-fire Associations of Butterfly Behavior, Occupancy, and Abundance with Environmental Variables and Nectar Sources in the Sierra Nevada, California

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Chapter 1: Sugars in nectar sources and their use by butterflies in the Sierra Nevada, California

Chapter 2: Factors associated with post-fire butterfly occupancy and nectar attributes in the Sierra Nevada, California
Study Area: Rim Fire

The Rim Fire Threatens National Park

- Acres burned: 105,620
- Structures threatened: 4,500
- Cost to date: $5.4 million

Nearly triple in size since Aug. 21, the blaze is spreading west and east toward Yosemite National Park.
Study Area

Rim Fire

- August- October 2013
- One of the largest in CA history
- Burned more than 1040 km² (257,000 acres)
**Background Information**

- Historical fire suppression
- More frequent, large fires
- Fire as a management tool
  - Endangered species management

(King 2003) (Schultz and Dlugosch 1999)
Background Information
Chapter 1: Sugars in nectar sources and their use by butterflies in the Sierra Nevada, California
Background Information

- Adult butterflies like nectar
- Important for population size, survival, and fecundity
- Nectar = water, sugars, amino acids
Background Information

• Not all nectar created equally

• 3 main sugars: sucrose, glucose, fructose

• Composition varies by species
• Fire affects nectar

• Abundance, volume, concentration highest after fire

• Prescribed fire for butterfly management
Background Information

• Butterflies are picky... in the lab

• Some species prefer sucrose

Sucrose

Glucose and Fructose
Is this realistic?

Does the lab represent natural settings?

Equal resource access in lab experiments
Objectives

• What sources do butterflies use in a natural setting?

• Nectar use associated with:
  • Total sugar mass?
  • Total sucrose mass?
  • Proportion of sucrose to total sugars?
Field Methods

- 2014: 8 transects
- 2015: 12 transects
- 300-500m in length
- Separated into 20-m segments
- Five surveys (visits) each
Field Methods

Butterflies

• Record every individual within 10 meters

• Note if taking nectar & nectar source
Field Methods

Vegetation

• Random 1 m² in each segment
  • Canopy cover
  • Percent live ground cover
  • # florets of nectar sources
Field Methods

Vegetation

• Collect florets
  • 5 per species
• Bag overnight
• Shake in 2ml dH₂O
• Freeze for analysis

(Bentley and Ellas 1983, Grunfeld et al. 1989, Morrant et al. 2009)
Analytical Methods

- Volume in sources too low for traditional methods
- High performance liquid chromatography- mass spectrometry (LC-MS)
Analytical Methods

- Prepared known concentrations
  - 0.0005 – 0.30 mg/ml
  - Generated calibration curve
Analytical Methods

• Compare samples to calibration curve
• mg/ml of sugar solution
• x2 (ml) to calculate sugar mass
Analytical Methods

• Linear regression to test intensity of use vs.
  • Total sugar mass
  • Total sucrose mass
  • Relative proportion of sucrose to overall sugars
Results

• 45 species of butterflies
  • 32 taking nectar

• 20 nectar sources
  • 314 observations of feeding

• Sugar mass from 0.004-0.913 mg
Results

Intensity of use vs. sugar mass

(R^2 < 0.01, p = 0.92)
Results

Intensity of use vs. sucrose mass

$R^2 < 0.01, p = 0.96$
Results

Intensity of use vs. sucrose proportion

(R² < 0.01, p = 0.76)
Conclusions

• No evidence for nectar use based on sugar content
• Generalists
• Lab not representative of natural setting

Sucrose

Glucose and Fructose
Conclusions

- Nectar is widely available after fire
- Fire for butterfly and nectar source management
- Natives vs non-natives
Chapter 2: Factors associated with post-fire butterfly occupancy and nectar attributes in the Sierra Nevada, California
Objectives

• Why are butterflies found where they are after a fire?

• What environmental factors determine spatial distribution of butterflies?
Objectives

• Do environmental attributes affect butterfly:
  • Occupancy?
  • Abundance?

• Does fire severity affect environmental attributes?
  • Vegetation burn severity
  • Soil burn severity
Fire Severity

Vegetation Burn Severity
- U.S. Forest Service
  - Relative differenced normalized burn ratio

Soil Burn Severity
- U.S. Forest Service
  - Difference in spectral reflectivity
• Detection < 1

• Key assumption: Closure

• Occupancy with relaxed closure
  • Probabilities of entry and departure

(MacKenzie et. al 2002)
Analytical Methods

• Detection
  • probability of detecting the species at a site if it is present during sampling

• Occupancy
  • expected probability that the species is present at a given site
Analytical Methods: Covariates

Occupancy with relaxed closure (Kendall et al. 2013)

Detection:
• Survey-specific number of florets
• Visit number

Occupancy:
• Canopy cover
• Live ground cover
• Nectar: categorical (ordinal), total florets
Analytical Methods: Models

• Step 1: Covariate effects on probability of entry, departure, detection
  • Occupancy held constant

• Retain highest or most parsimonious model

• Step 2: Covariate effects on probability of occupancy
Analytical Methods: Abundance

- Negative binomial generalized linear models
  - Canopy cover
  - Live ground cover
  - Number of florets
  - Categorical (ordinal) nectar
Analytical Methods: Fire Severity

- ANOVA
  - Vegetation and Soil Severity
    - None, low, moderate, high

- Canopy cover
- Live ground cover
- Number of florets

- Tukey’s pairwise comparisons
Models

45 total species observed

Icaricia lupini (lupine blue)

Junonia coenia (common buckeye)

Phyciodes mylitta (mylitta crescent)

Erynnis persius (persius duskywing)

Colias eurytheme (orange sulphur)
### Occupancy Results

#### Probability of Detection

<table>
<thead>
<tr>
<th>Species</th>
<th>Survey-specific number of florets</th>
<th>Visit number</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Colias eurytheme</em> (2015)</td>
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### Occupancy Results

#### Probability of Occupancy

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<thead>
<tr>
<th>Species</th>
<th>Canopy</th>
<th>Live ground cover</th>
<th>Categorical nectar</th>
<th>Number of florets</th>
</tr>
</thead>
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<tr>
<td><em>Colias eurytheme</em> (2015)</td>
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# Nectar Results

## Nectar Attributes

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<td>Species and year</td>
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<td>Live ground cover</td>
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Fire Severity Results

2014

- Vegetation Severity
  - Canopy cover
  - Unburned > low, moderate, high
2015

Vegetation Severity

Canopy Cover
• Unburned > low > moderate > high

Live Ground Cover
• Moderate, high > unburned, low

Number of florets
• High > unburned, low
Fire Severity Results

Soil Burn Severity

2014
• None

2015

Canopy Cover
• Unburned, low > moderate

Live Ground Cover
• Moderate > unburned, low, high

Number of inflorescences and sugar mass
• Moderate > unburned, low
Conclusions

• Attributes associated with occupancy
  • Canopy cover
  • Live ground cover

• Likely changes in first few years after fire

• Number of florets is a better predictor of occupancy than nectar categories
Conclusions

- Abundance associated with
  - Canopy cover
  - Live ground cover
  - Categorical nectar

- Nectar measures more often associated with abundance than occupancy
Conclusions

• Fire affects environmental attributes

• Moderate or high severity has largest positive effect for butterflies
Conclusions

• Management implications

• Butterflies and fire
  • More than just host plants and nectar

• Abundance and Occupancy
  • Some same, some different
Acknowledgements

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Questions?