Yellow-billed Cuckoo and Apache Cicada relationships on the LCR

John Stanek, Shannon McNeil, Diane Tracy and Murrelet Halterman

Southern Sierra Research Station
Apache Cicada (*Diceroprocta apache*)

natural history

- Reside in Sonoran Desert riparian areas
- 2-3 year nymph stage as a below ground herbivore
- Emerge to surface and molt into a winged adult to mate
- Poor fliers and lack defenses
- Provide a near limitless food resource
Yellow-billed Cuckoos and Apache Cicadas

Cuckoo fledging and peak cicada abundance occur in July (Rosenberg et al. 1982)

Positive relationship between the number of cuckoo pairs with cicada abundance (McNeil et al. 2010)
Today’s Presentation

Examine the relationship between cuckoo and cicada abundance at natural and restoration sites.

Explore the relationship between cicada abundance and various habitat characteristics.
Cicada Exuviae Abundance

- Exuviae counts adequately measure cicada abundance (Glinski and Ohmart 1984, Andersen 1994)
- Cicada exoskeletons counted at all 132 plots
- 5 counts at each plot
Cicada Exuviae Abundance
Natural & Restoration Areas
Cicada Exuviae Abundance
Natural vs. Restoration Site Comparisons

Natural Sites

Restoration Sites

Mean Cicada Count

P = 0.0001

P = 0.48
Cicada Exuviae Abundance
Natural vs. Restoration Plot Comparisons

![Graph showing mean cicada count comparison between natural and restoration sites.](image)
Cuckoo Pairs and Cicada Abundance at Sites

The graph shows a positive correlation between the number of Cuckoo Pairs and the log mean Cicada count. The regression line is statistically significant with an $r^2$ value of 0.26 and a p-value of 0.016.

Additionally, there is a scatter plot indicating a lack of correlation between Cuckoo Pairs and Cicada Abundance in the Restoration sites, with an $r^2$ value of less than 0.01 and a p-value of 0.77.
## Live cicada counts

At each cuckoo survey point we estimated cicada abundance

<table>
<thead>
<tr>
<th>Index Value</th>
<th>Estimated Number of Cicada</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2-5</td>
</tr>
<tr>
<td>3</td>
<td>6-10</td>
</tr>
<tr>
<td>4</td>
<td>11-19</td>
</tr>
<tr>
<td>5</td>
<td>20+</td>
</tr>
</tbody>
</table>
Live Cicada Index Values
Natural & Restoration Areas

![Graph showing live cicada index values for natural and restoration areas with a p-value of 0.01.](image-url)
Live Cicada Index Values
Natural vs. Restoration Site Comparisons

Natural Sites

Restoration Sites

\[ P = 0.004 \quad P = 0.54 \]
Cicada activity over time
Cicada activity over time

$p = 0.03$
Cicada activity over time

![Graph showing cicada activity over time with peaks on 15th July and 30th July for natural sites and restoration sites.]

- **Date**
  - 15-Jun
  - 30-Jun
  - 15-Jul
  - 30-Jul
  - 14-Aug
  - 29-Aug
- **Mean Cicada Index**
- **Natural Sites**
- **Restoration Sites**
- **Natural 1st Fledge Dates**
Cicada activity over time

- Mean Cicada Index
- Natural Sites
- Restoration Sites
- Natural 1st Fledge Dates
- Restoration 1st Fledge Dates
Cuckoo Cicada Summary

• Greater cicada abundance at Natural Areas
• Positive relationships at Natural Areas
• No relationships at Restoration Areas
Does the lack of cicadas at Restoration sites affect cuckoos?

- Number of Cuckoo pairs

- Cuckoos show plasticity in their diet

- Ecological processes may be different
Why do Restoration sites have far fewer cicadas?
Cicada and Habitat Hypotheses

1. Cicada population growth may be slow at newly suitable habitat at restoration sites

2. Cicada population growth could be slowed by suboptimal soil habitat conditions

3. Fragmentation, patch size, and distance from source populations may affect colonization of new sites

4. Cicadas’ density-dependent growth rate may be low at restoration sites
Data Analysis

- Hypotheses explored using LCR cicada and habitat data from 2008 and 2009

- 24 habitat variables used to build regression models

- Information Theoretic Approach to rank our models
  - averaged top models
Hypothesized habitat variables most important to Apache cicadas

- Large native tree density
- Fremont cottonwood density
- Goodding’s willow density
- Mesquite density
- Percent soil moisture
- Percent marsh vegetation
- Site area
- Site type
- Year sampled
# Cicada predictor variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
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</thead>
<tbody>
<tr>
<td>Site Type</td>
<td>-9.01</td>
<td>1.96</td>
</tr>
<tr>
<td>Area</td>
<td>0.066</td>
<td>0.039</td>
</tr>
<tr>
<td>Native Large Tree Density</td>
<td>11.9</td>
<td>4.33</td>
</tr>
<tr>
<td>Soil Moisture</td>
<td>-0.073</td>
<td>0.036</td>
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<tr>
<td>Marsh Vegetation Percent</td>
<td>-0.252</td>
<td>0.117</td>
</tr>
<tr>
<td>Year Sampled</td>
<td>3.78</td>
<td>2.15</td>
</tr>
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</table>
## Cicada predictor variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variance Explained</th>
<th>AIC Relative Ranking</th>
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</thead>
<tbody>
<tr>
<td>Site Type</td>
<td>39.62</td>
<td>1</td>
</tr>
<tr>
<td>Area</td>
<td>19.37</td>
<td>5</td>
</tr>
<tr>
<td>Native Large Tree Density</td>
<td>15.68</td>
<td>2</td>
</tr>
<tr>
<td>Soil Moisture</td>
<td>11.43</td>
<td>3</td>
</tr>
<tr>
<td>Marsh Vegetation Percent</td>
<td>8.55</td>
<td>6</td>
</tr>
<tr>
<td>Year Sampled</td>
<td>5.35</td>
<td>4</td>
</tr>
</tbody>
</table>
Native Large Trees

- Positive relationship with native large trees (Ellingson and Andersen 2002, Smith et al. 2006)

- May be preferred by adult females as ovipositing sites (Glinski and Ohmart 1984)

- May provide suitable subterranean nymph habitat (Glinski and Ohmart 1984; Karban 1981; Lloyd and White 1976, 1979)

- We observed no relationship with Tamarisk (Ellingson and Andersen 2002)
Subsoil Habitat

• Soil compaction, texture, moisture and temperature affect fossorial insect survival rates (Glinski and Ohmart 1984, Andersen 1987)

• Drought and flooding negatively affect below-ground herbivores (Andersen 1987)

• Soil Moisture, Marsh Vegetation Habitat and Open water

• Soil Texture and Litter cover (Ellingson and Andersen 2002)
Patch Size

• Positive relationship between area and cicada abundance

• Habitat fragmentation and distance
  Karban (1981)
Site Type

- Cicadas exhibit a negative relationship to restoration sites

- May be related to cicadas’ density-dependent reproductive success
Summary and Future Research

• Found support for our three hypotheses

• Further explore the relationship between cicadas and their habitat at restoration sites.

• Learn more about the prey base at restoration areas
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Slides not used
Yellow-billed Cuckoo
natural history

- Riparian obligate in the SW deserts
- Limited distribution
- Recognized as warranted for protection under ESA
- Listed as endangered in CA and a species of special concern in AZ

Range map here
Cicada Exuviae Abundance
Natural vs. Restoration Plot Comparisons

Natural Sites

Restoration Sites

$P = 0.041$

$P = 0.11$
Cicada measurement correlation
Non-significant Predictor Variables

- Litter depth
- percent bare ground
- percent leaf litter
- native small tree density
- Fremont cottonwood density
- Goodding’s willow density
- mesquite spp. density
- tamarisk density
- large tamarisk density
- small tamarisk density
- tamarisk sapling
- total cover percent
- total canopy cover average height
- high canopy cover percent
- high canopy cover average height
- main canopy cover percent
- main canopy cover average height
- water percent