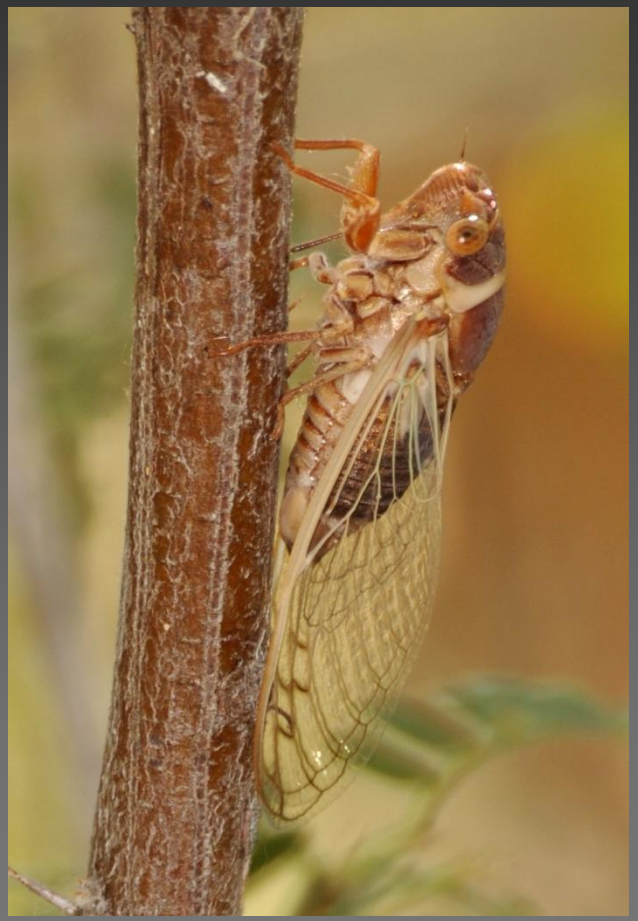
Yellow-billed Cuckoo and Apache Cicada relationships on the LCR

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

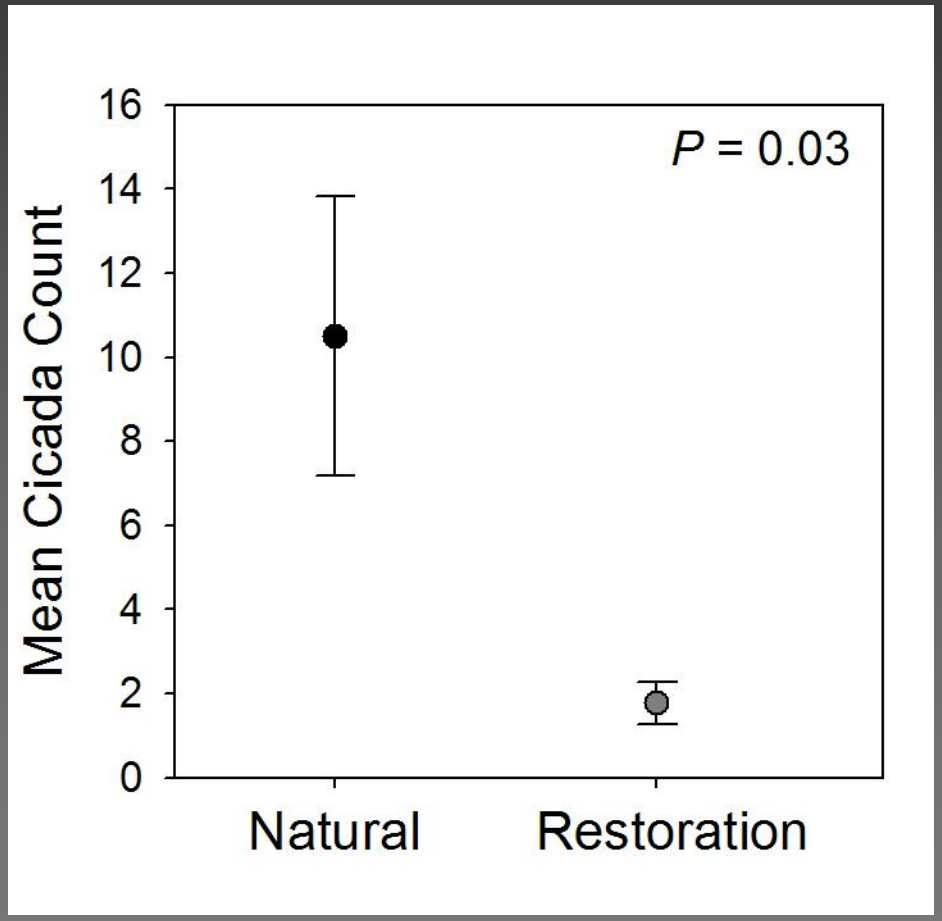
Examine the relationship between cuckoo and cicada abundance at natural and restoration sites.

Explore the relationship between cicada abundance and various habitat characteristics

Cicada Exuviae Abundance

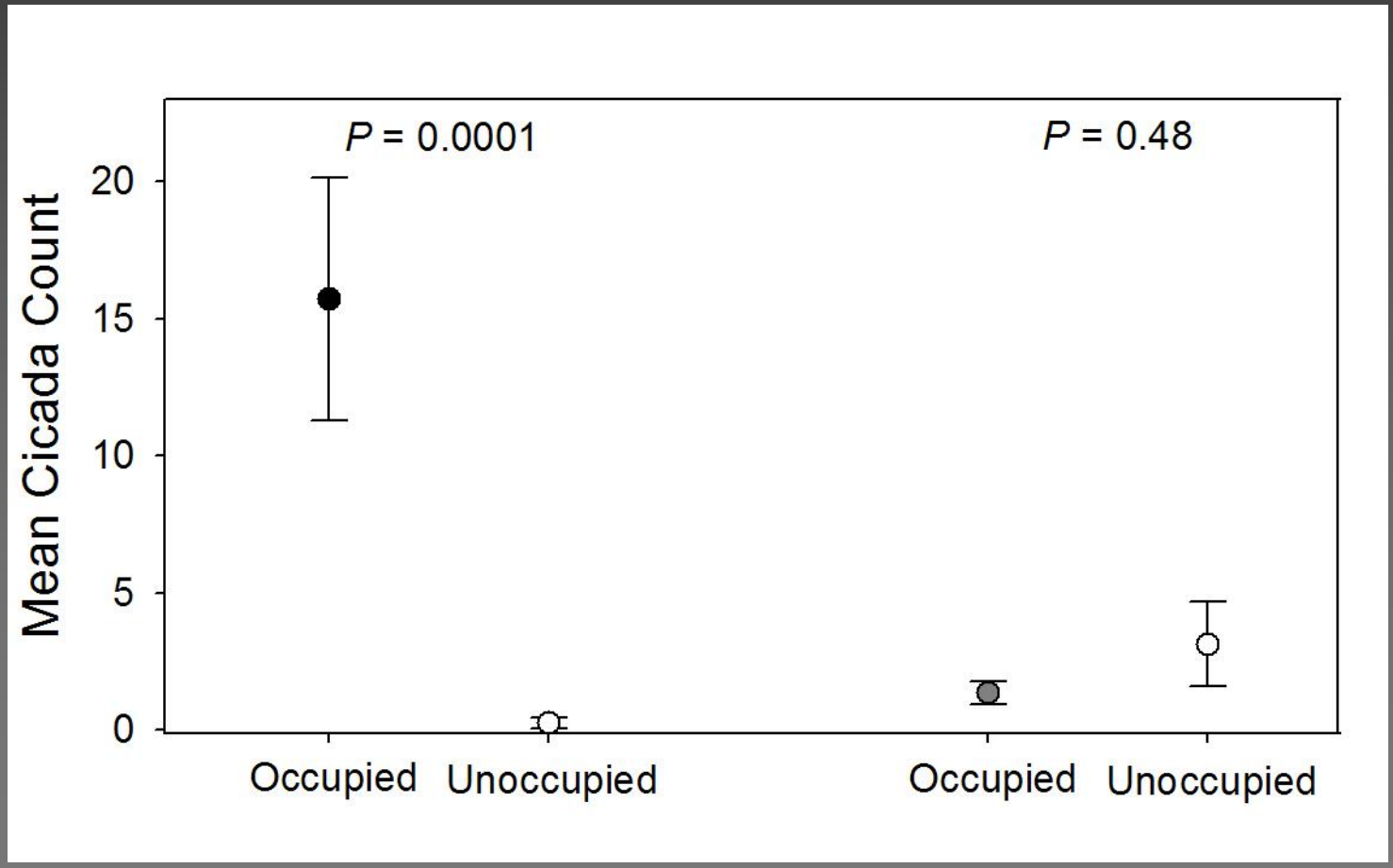
- Exuviae counts adequately measure cicada abundance (Glinski and Ohmart 1984, Andersen 1994)
- Cicada exoskeletons counted at all 132 plots
- 5 counts at each plot

Cicada Exuviae Abundance Natural & Restoration Areas



Cicada Exuviae Abundance
Natural vs. Restoration Site Comparisons

Natural Sites Restoration Sites



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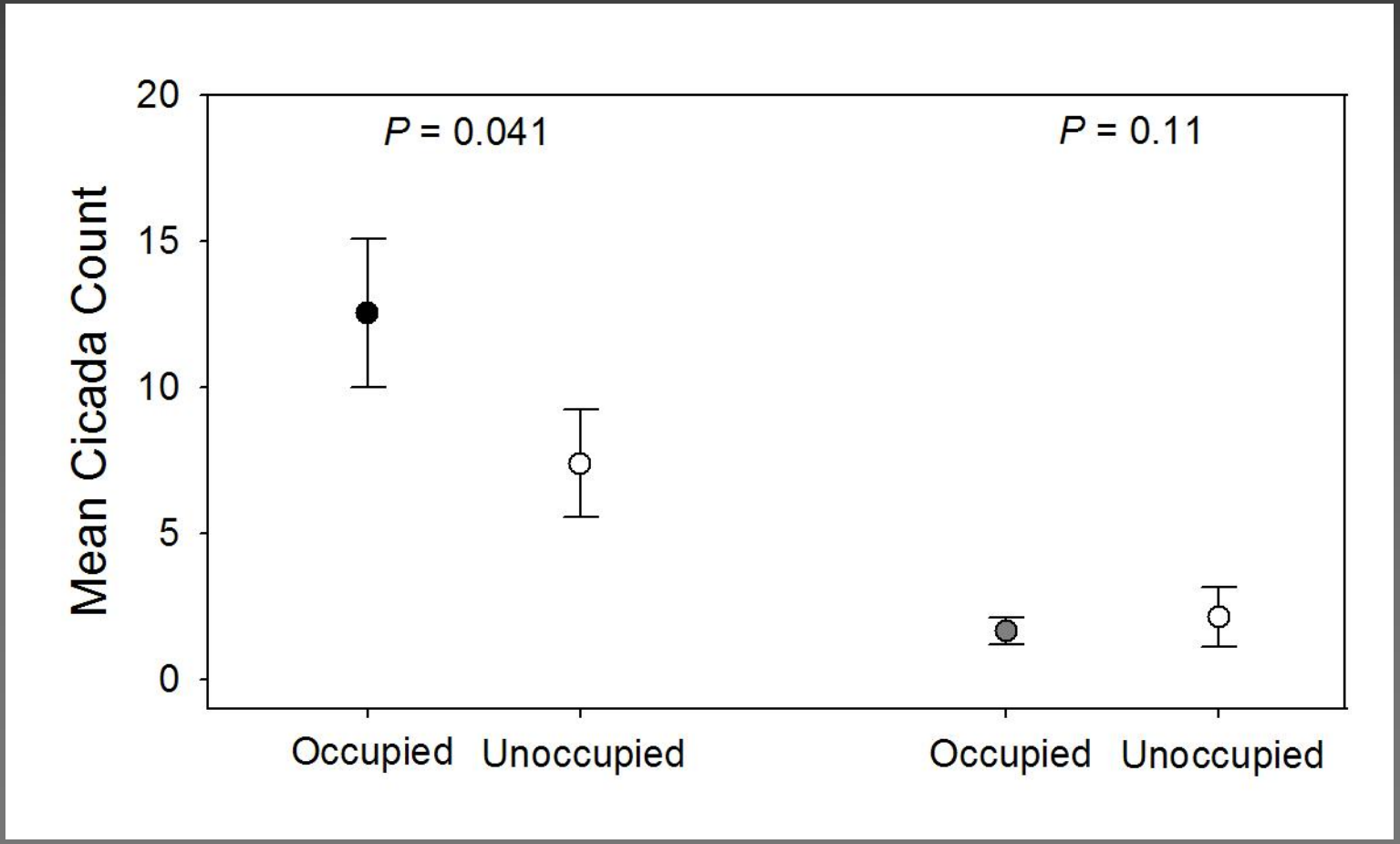
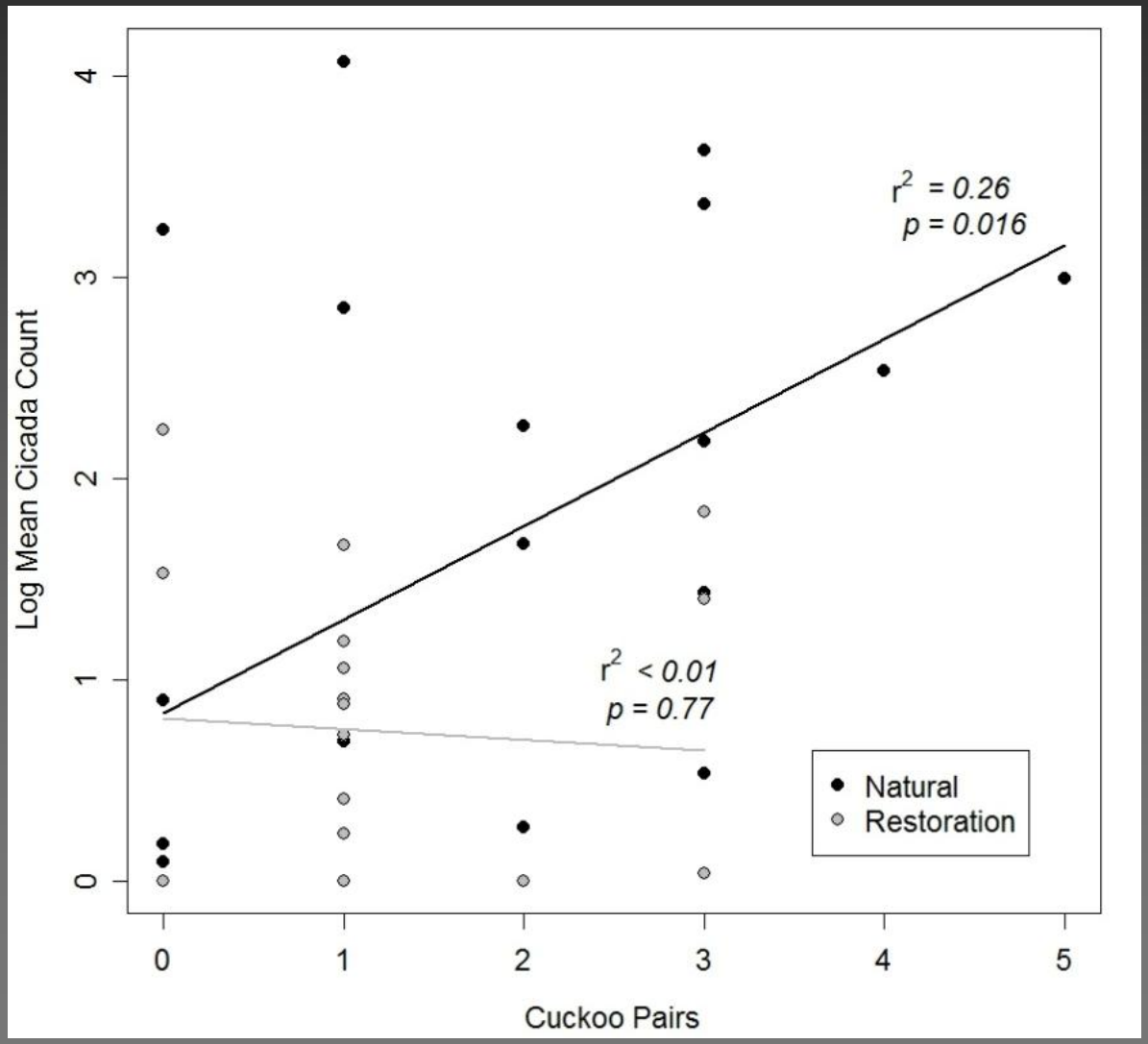


Cuckoo Pairs and Cicada Abundance at Sites

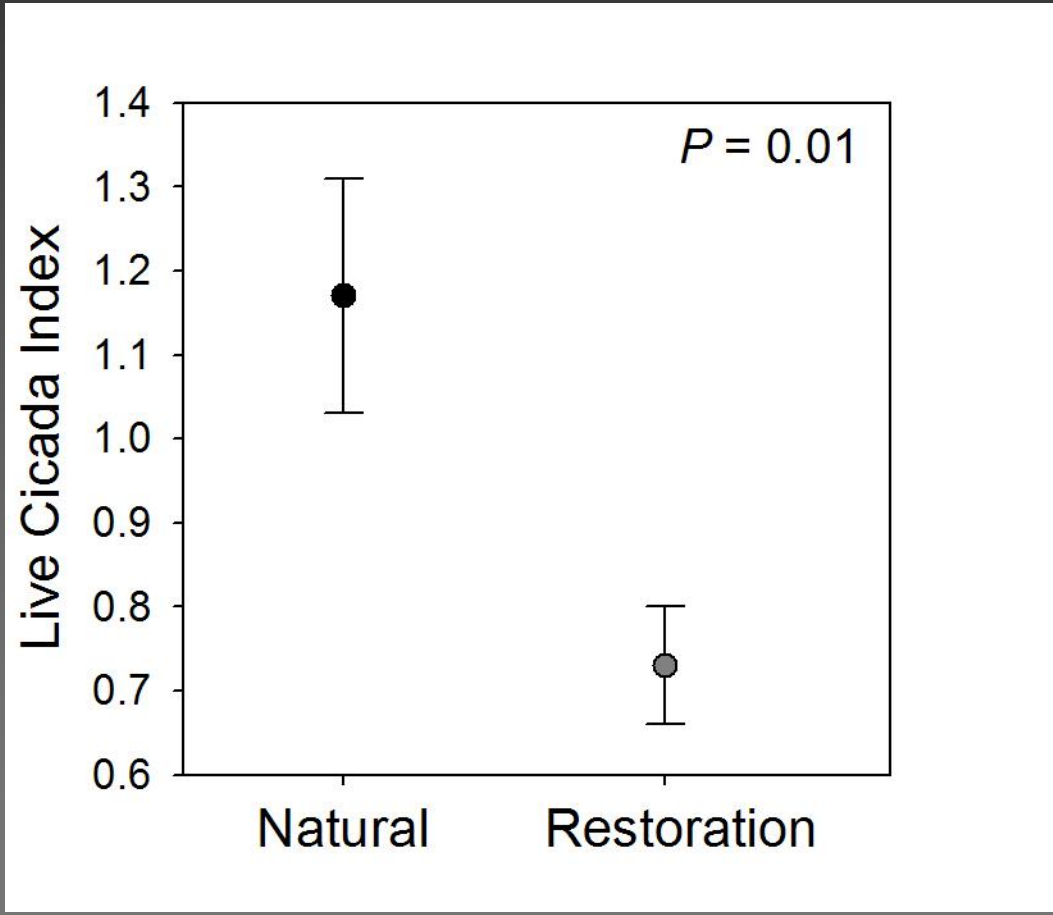


Live cicada counts

At each cuckoo survey point we estimated cicada abundance

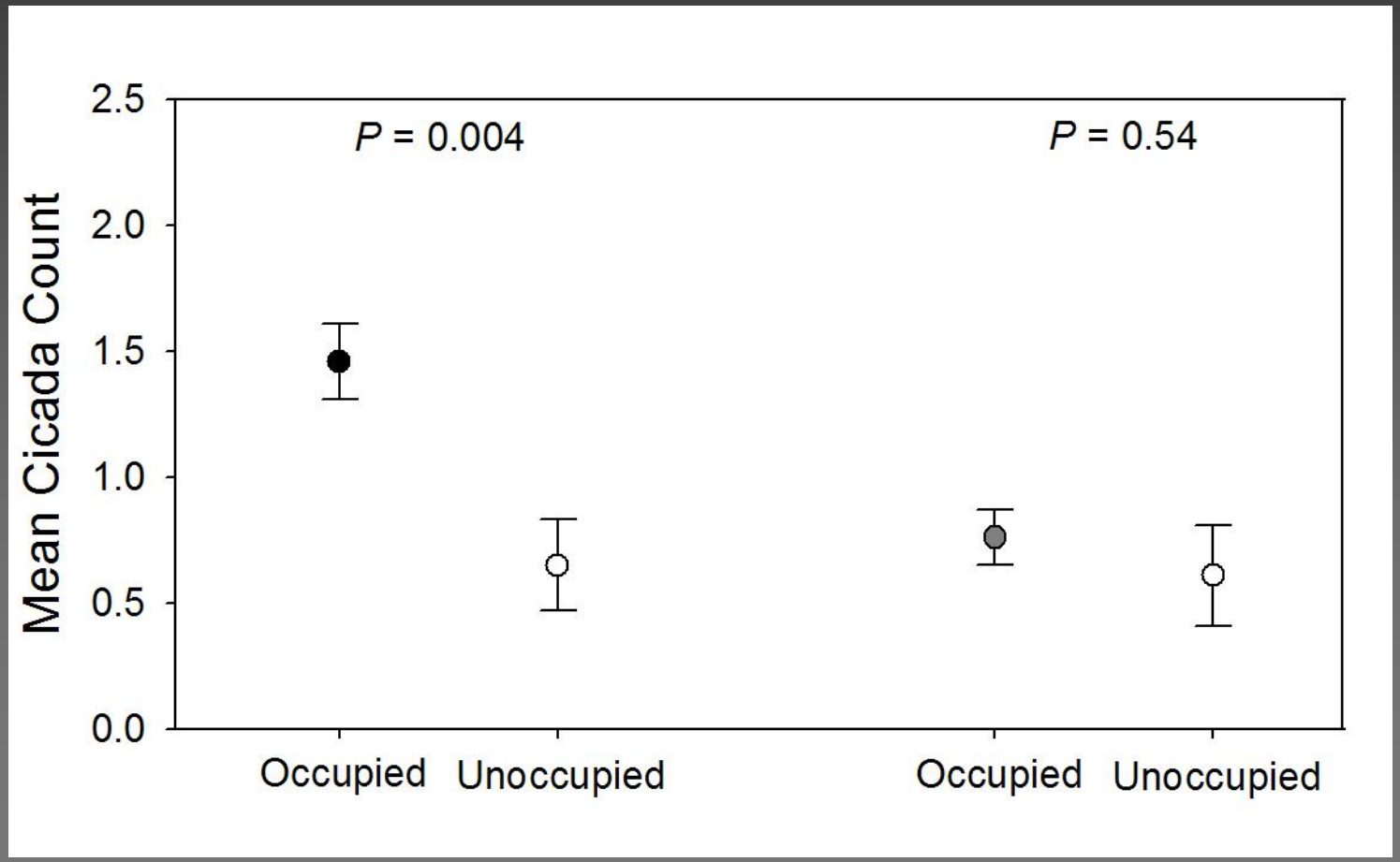
Index Value	Estimated Number of Cicada
0	0
1	1
2	2-5
3	6-10
4	11-19
5	20+

Live Cicada Index Values Natural & Restoration Areas

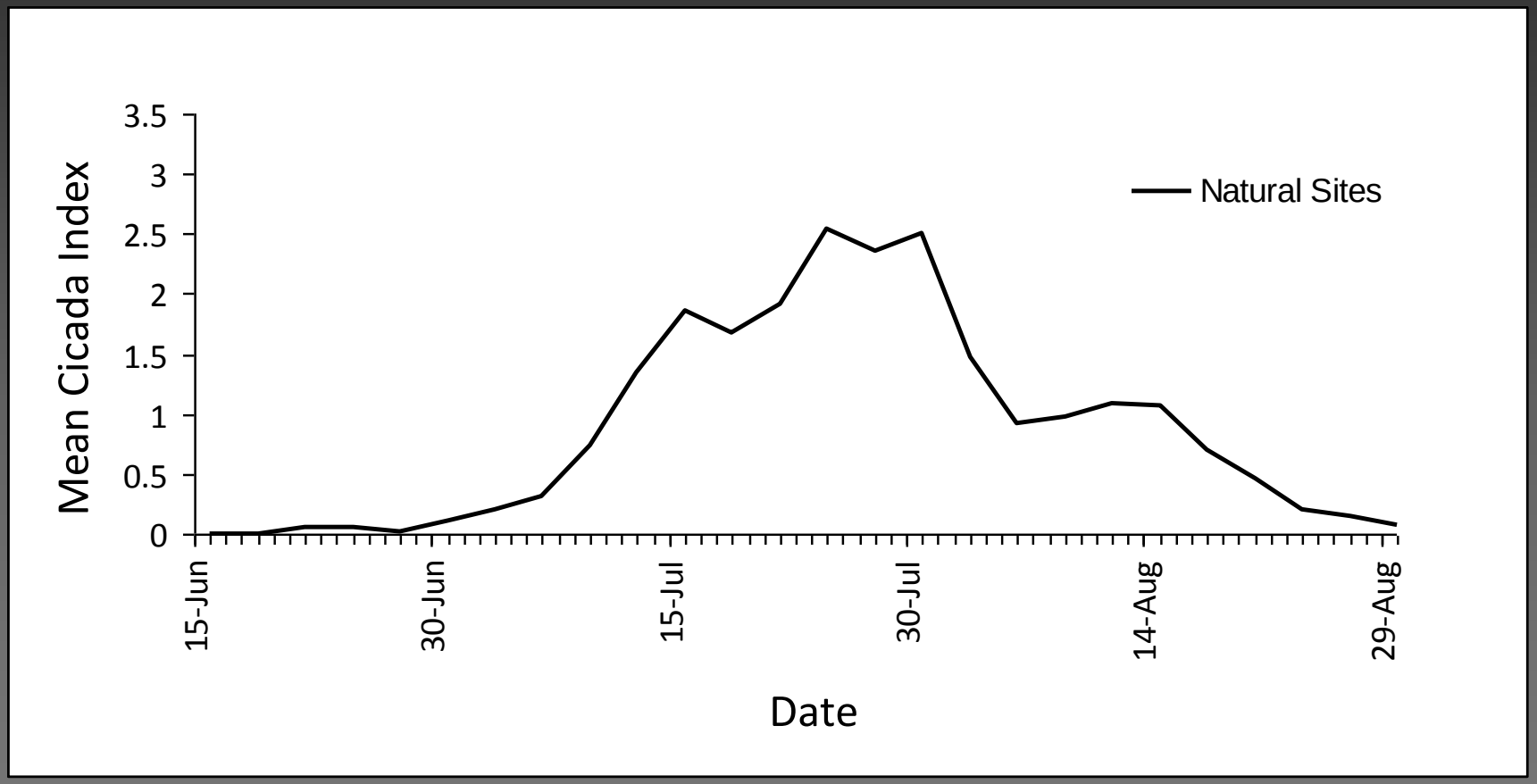


Live Cicada Index Values
Natural vs. Restoration Site Comparisons

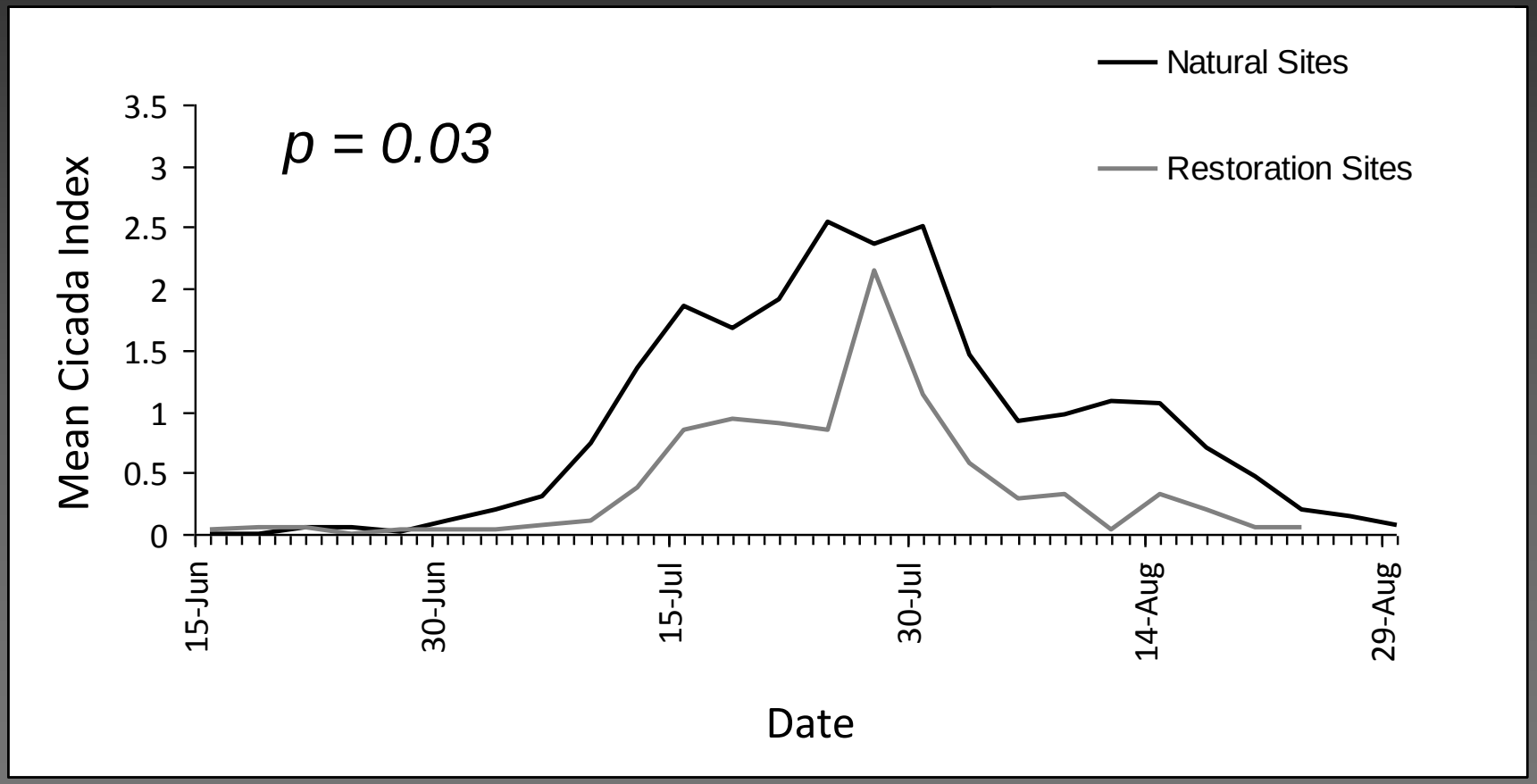
Natural Sites Restoration Sites



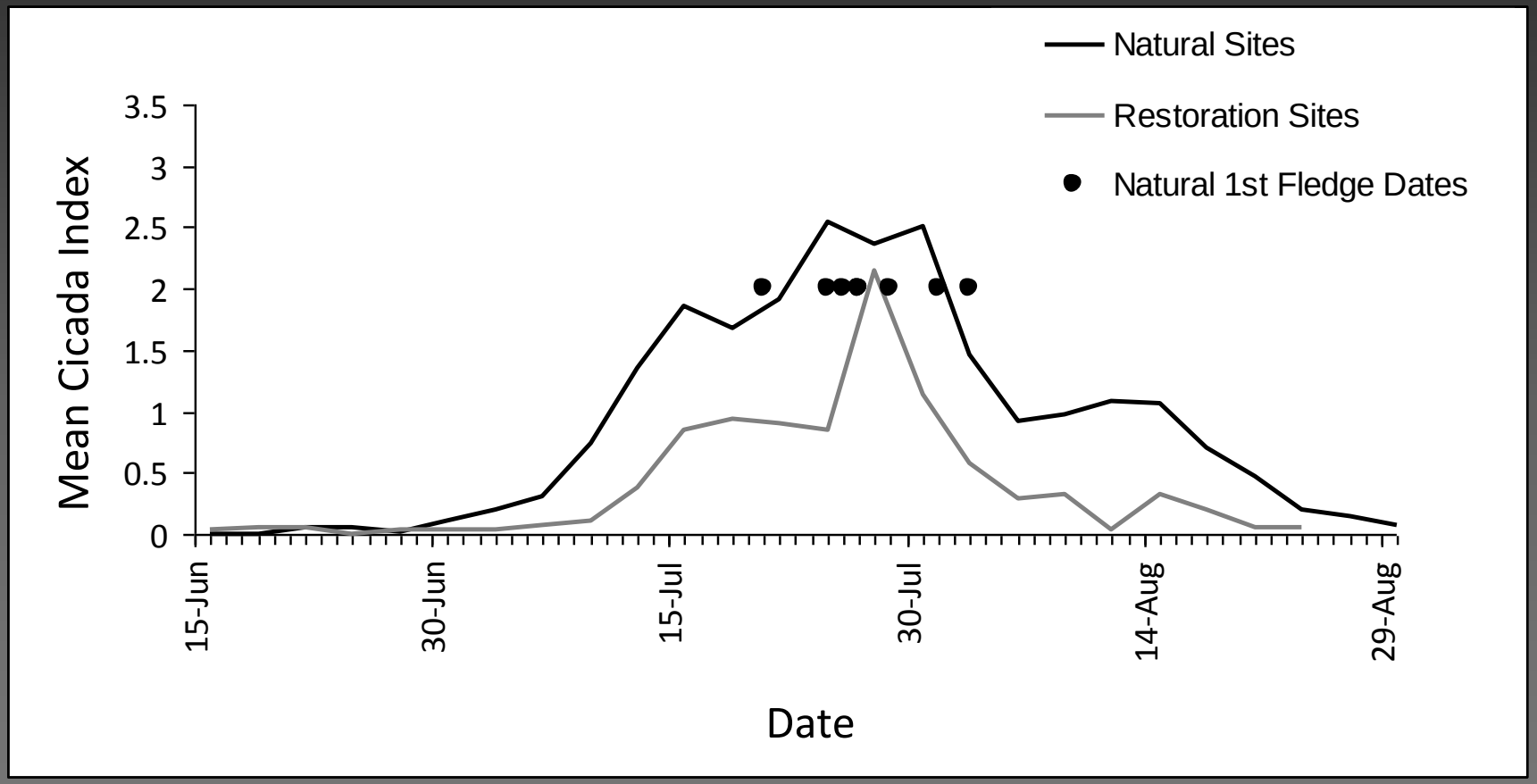
Cicada activity over time



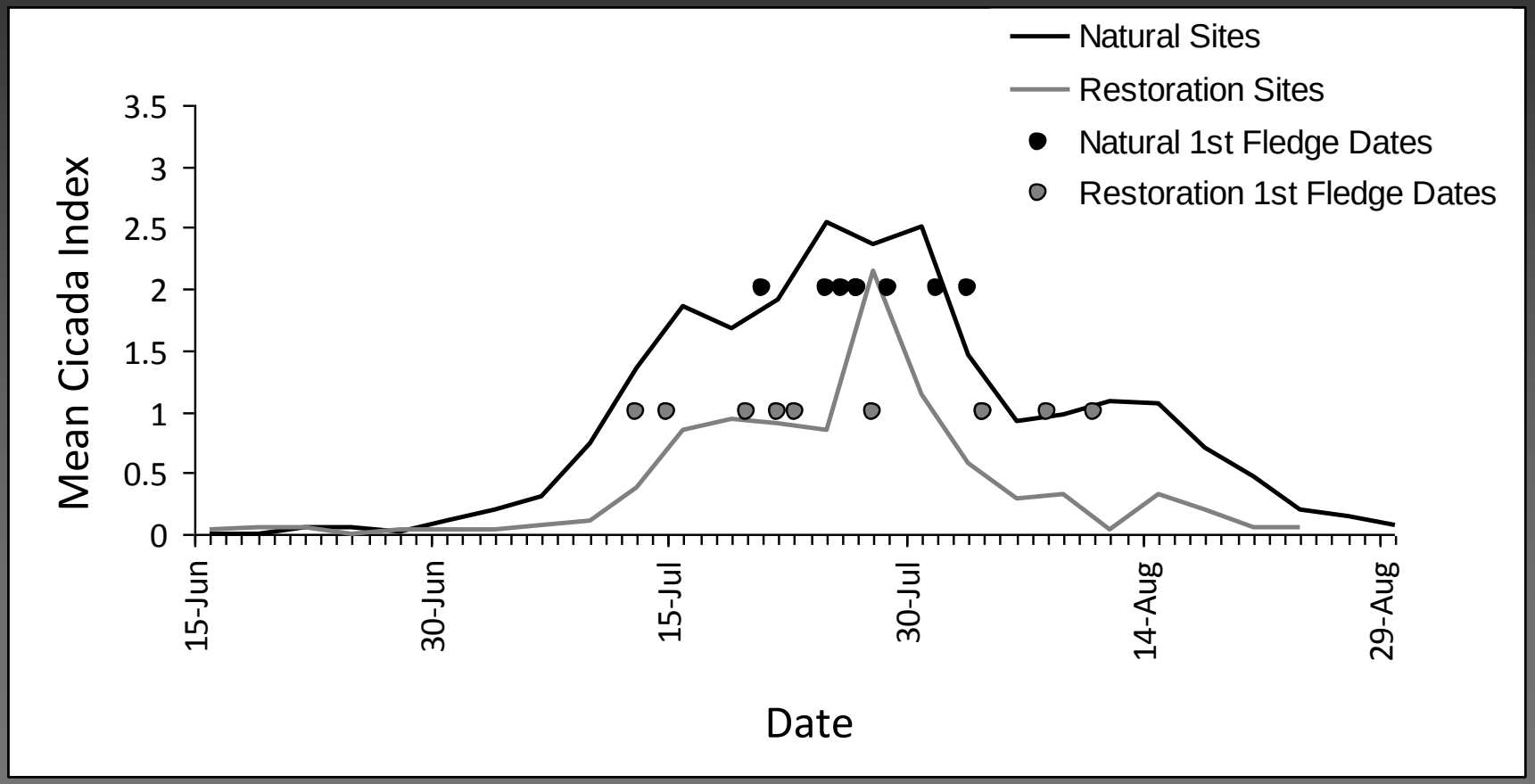
Cicada activity over time



Cicada activity over time



Cicada activity over time



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
  (Koenig and Liebhold 2005, Barber et al. 2008, McNeil et al. 2011)
- 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

Variable	Coefficient	Standard Error
Site Type	-9.01	1.96
Area	0.066	0.039
Native Large Tree Density	11.9	4.33
Soil Moisture	-0.073	0.036
Marsh Vegetation Percent	-0.252	0.117
Year Sampled	3.78	2.15

Cicada predictor variables

Variable	Variance Explained	AIC Relative Ranking
Site Type	39.62	1
Area	19.37	5
Native Large Tree Density	15.68	2
Soil Moisture	11.43	3
Marsh Vegetation Percent	8.55	6
Year Sampled	5.35	4

Native Large Trees

- Positive relationship with native large trees
  (Ellingson and Andersen 2002, Smith et al. 2006)
- May be preferred by adult females as oviposit 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
  (Lloyd and Dybas 1966, Karban 1982, Glinski and Ohmart 1984, Koenig and Liebhold 2005)

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

Acknowledgements

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Questions?

Slides not used

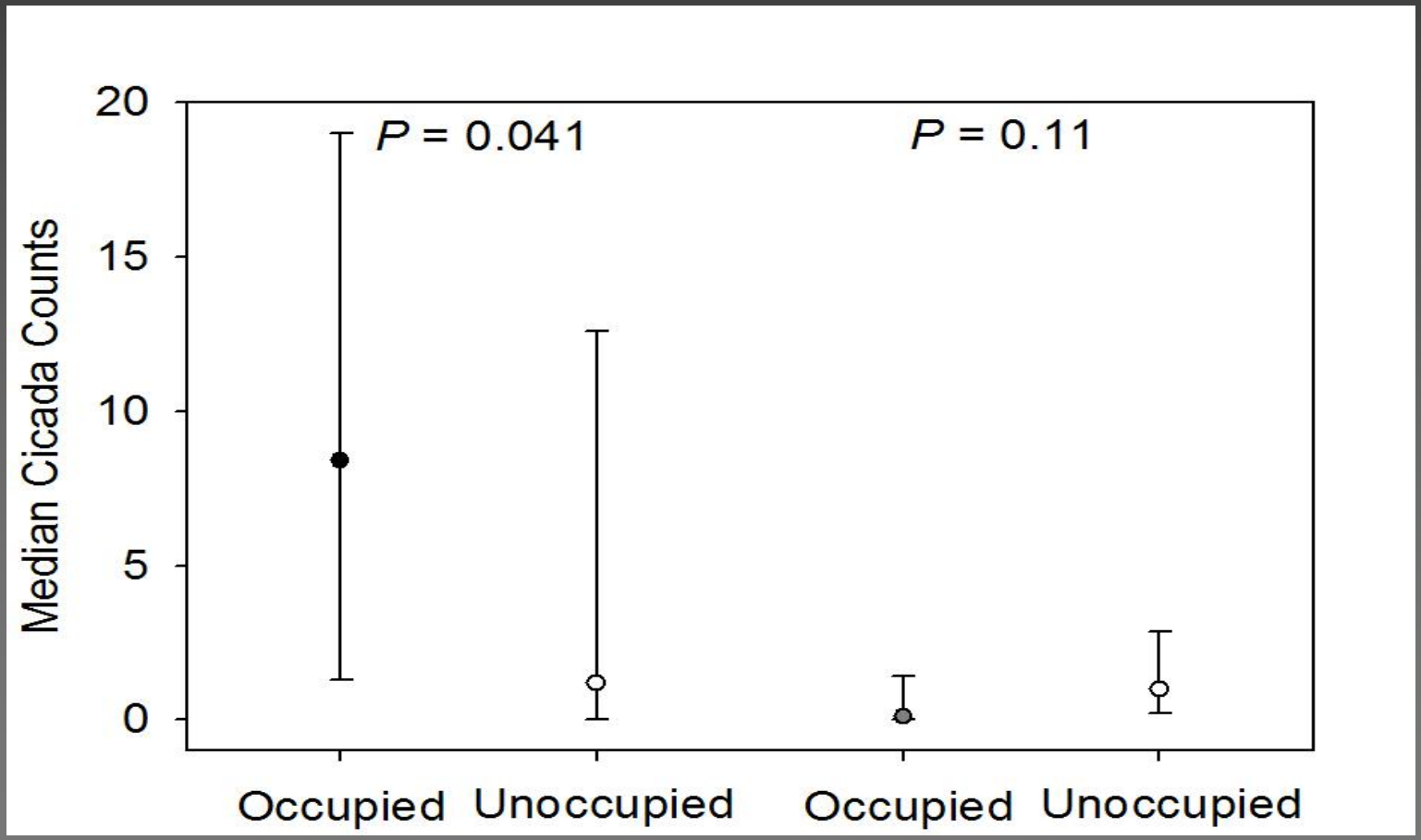
Yellow-billed Cuckoo natural history

- 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

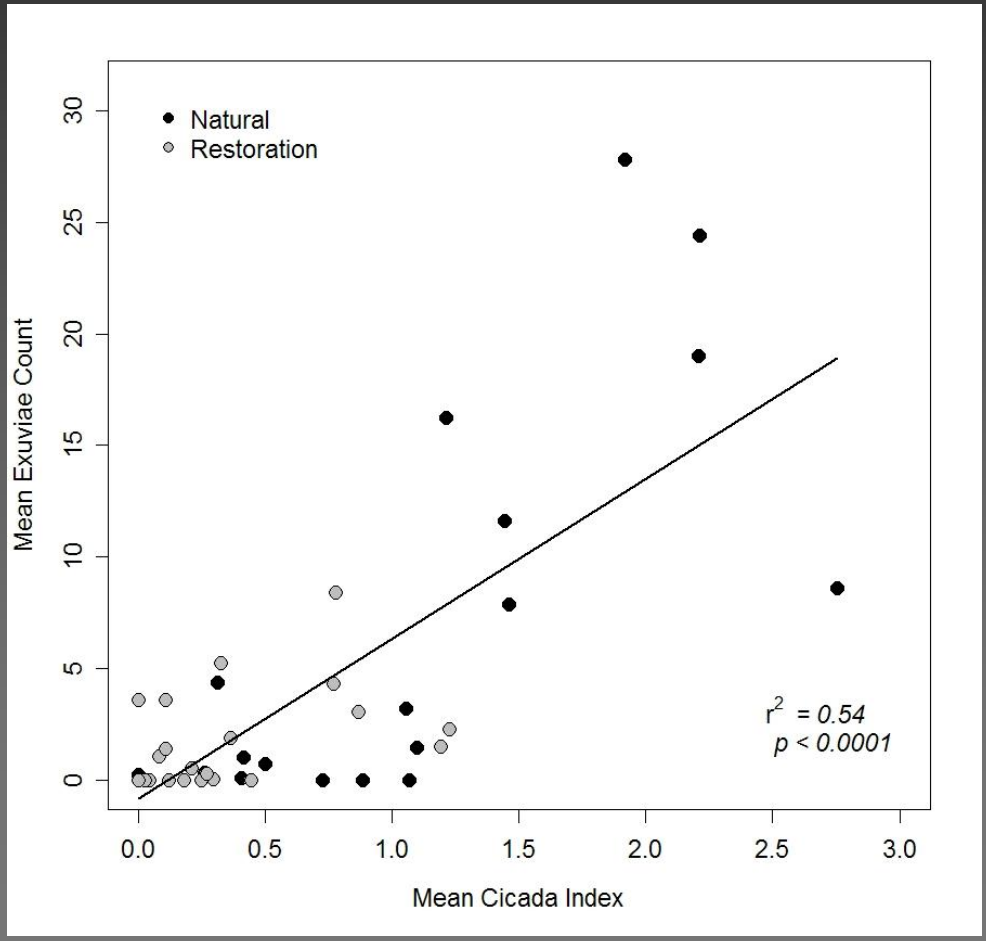
Range map here

Cicada Exuviae Abundance
Natural vs. Restoration Plot Comparisons

Natural Sites Restoration Sites



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