

Investigating the effects of fire & forest canopy conditions on the abundance & diversity of insects at Mammoth Cave NP

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Bats at Mammoth Cave

- Variable foraging & habitat use across species¹
 - Prey availability & forest canopy structure
- White-nose syndrome
 - Now at Mammoth Cave; changing predator-prey dynamics?

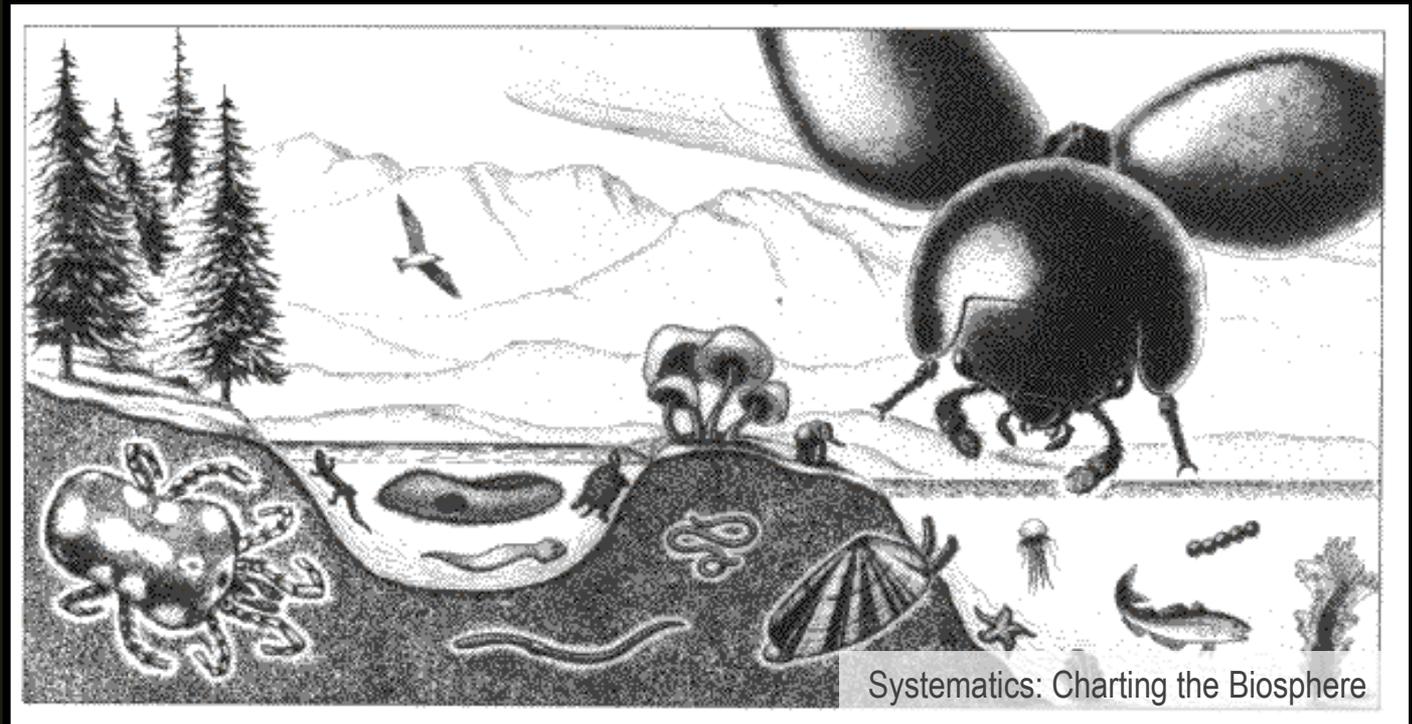


¹Swartz et al. 2003. Pp. 257-300 in: Bat Ecology.

Lacki et al. 2007. Pp. 83-128 in: Bats in Forests: Conservation and Management

Insects

Function & Role in Eastern Forests



Systematics: Charting the Biosphere

Insects

Function & Role in Eastern Forests

- Variable occurrence across habitats¹
 - Indicator species, responsive to forest management



¹Summerville & Crist. 2008. Can. Entomol. 140: 475-494.

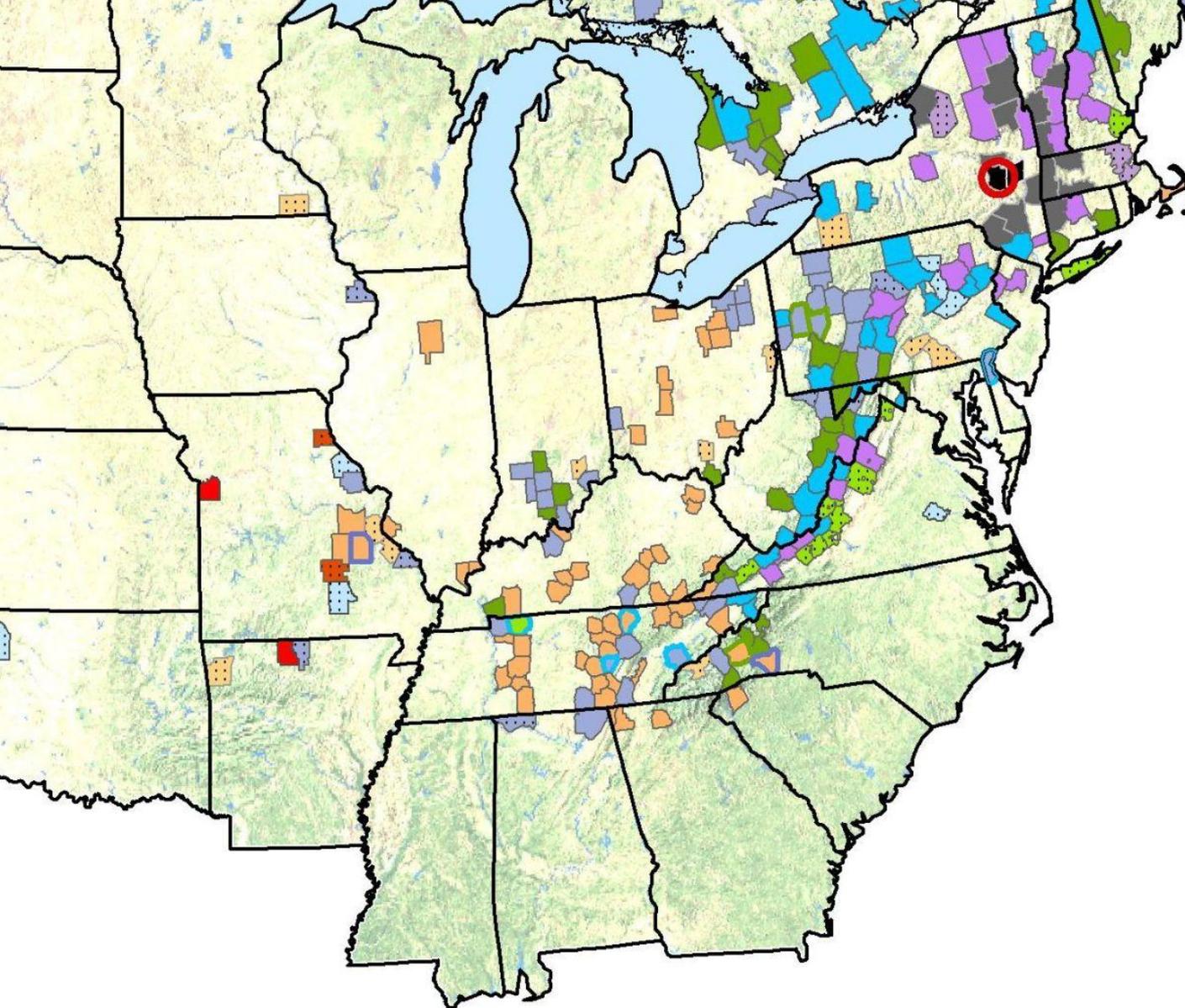
Insects

Function & Role in Eastern Forests

- Variable occurrence across habitats¹
 - Indicator species, responsive to forest management
- Conspicuous members of the community
 - Major herbivores¹, a major prey source²



¹Summerville & Crist. 2008. Can. Entomol. 140: 475-494, ²Lacki & Dodd. 2011. in USFS Gen. Tech. Report S-145.



01/28/2014

Bat

White Nose Syndrome (WNS)
Occurrence by County/District*

(or portions thereof)

 Feb. 2006: 1st detected in Schoharie Co., NY

 Mortality-Winter 2006-07

Fall/Winter/Spring

2007-2008:  Confirmed

2008-2009:  Confirmed

 Suspect

2009-2010:  Confirmed

 Suspect

2010-2011:  Confirmed

 Suspect

2011-2012:  Confirmed

 Suspect

2012-2013:  Confirmed

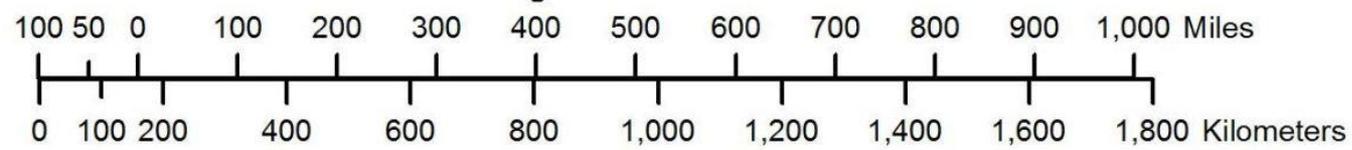
 Suspect

2013-2014:  Confirmed

 Suspect

*Confirmed
 Confirmed by State / Province.
 (outline color=suspect year)

*Suspect
 WNS symptoms reported but not confirmed by State / Province.



Map by: Cal Butchkoski, PA Game Commission

01/28/2014

Bat

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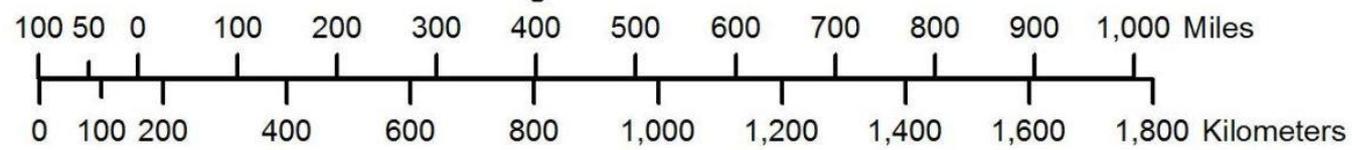
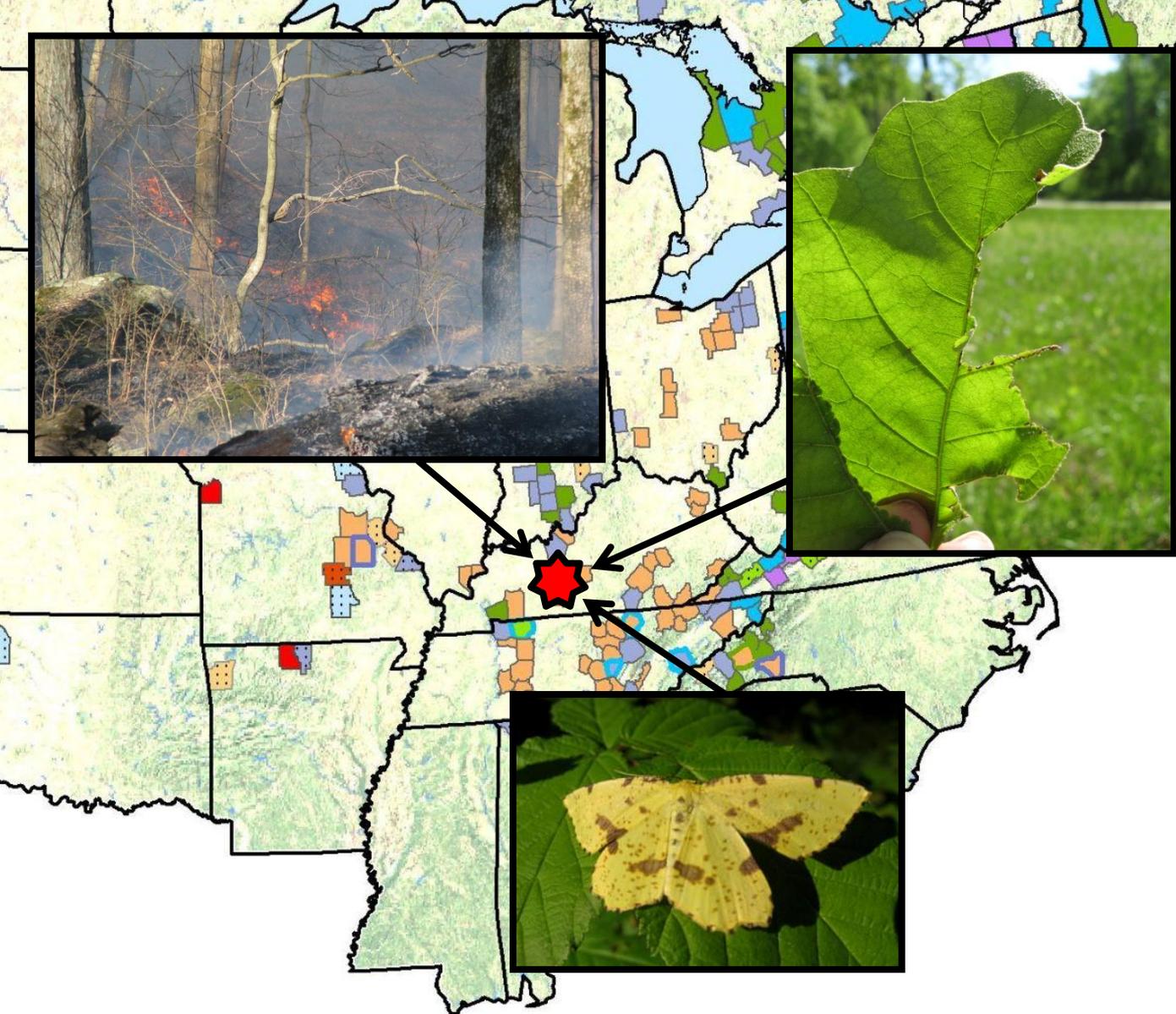
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Map by: Cal Butchkoski, PA Game Commission

Mammoth Cave Nat'l Park

Burn Areas

 - 2010

 - 2009

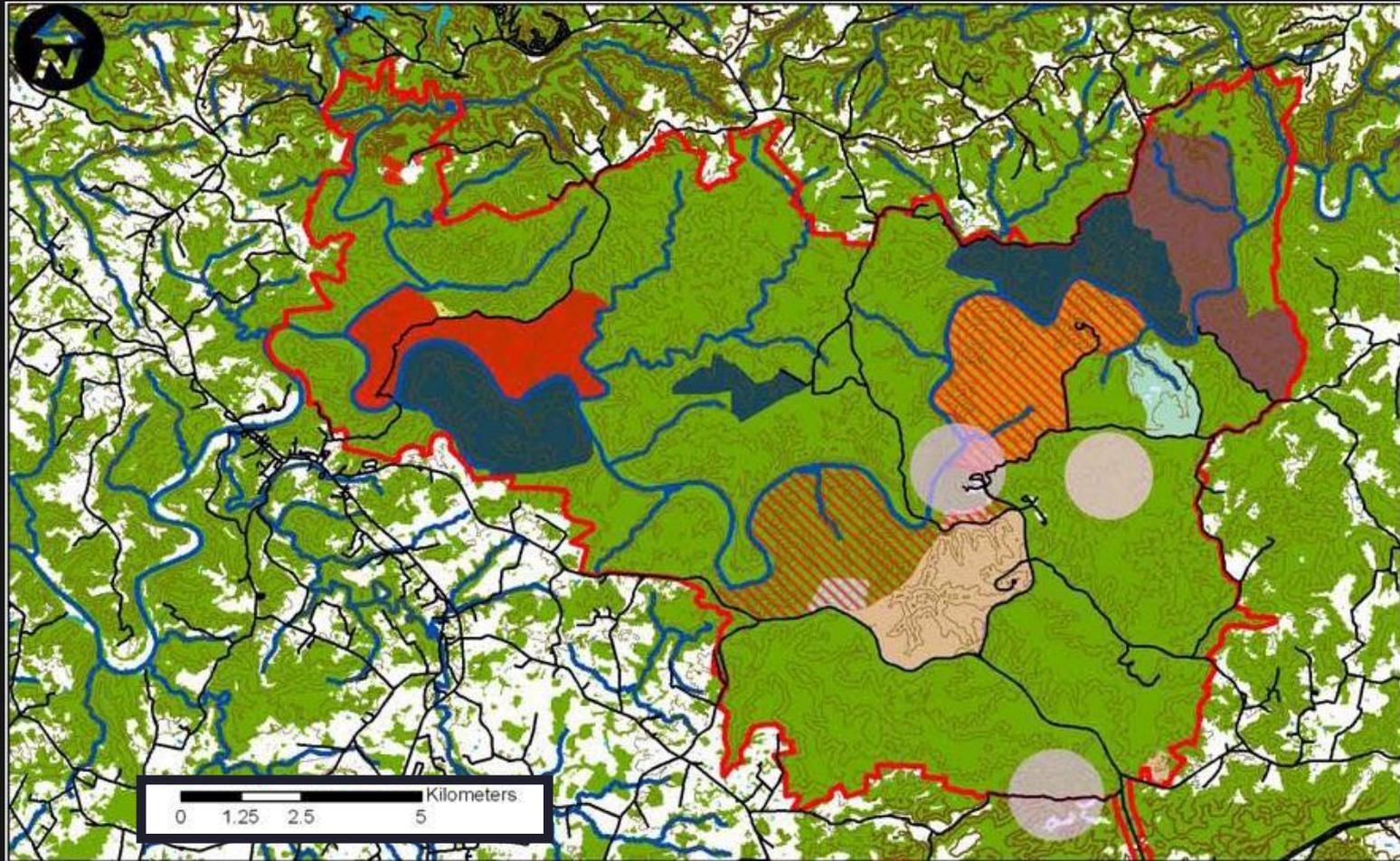
 - 2008

 - 2007

 - 2005

 - 2004

 Core
Hibernacula



Mammoth Cave Nat'l Park

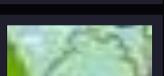
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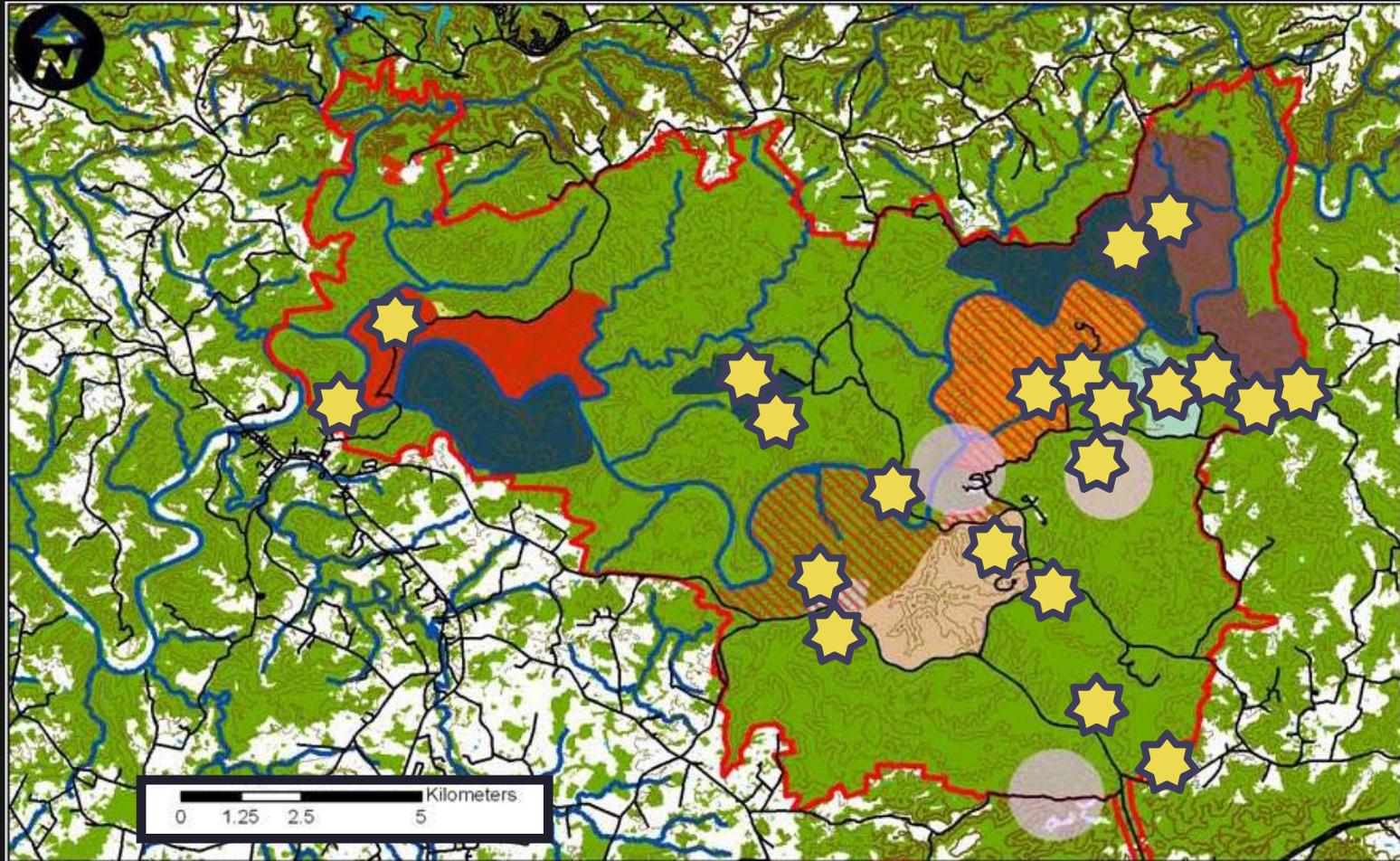
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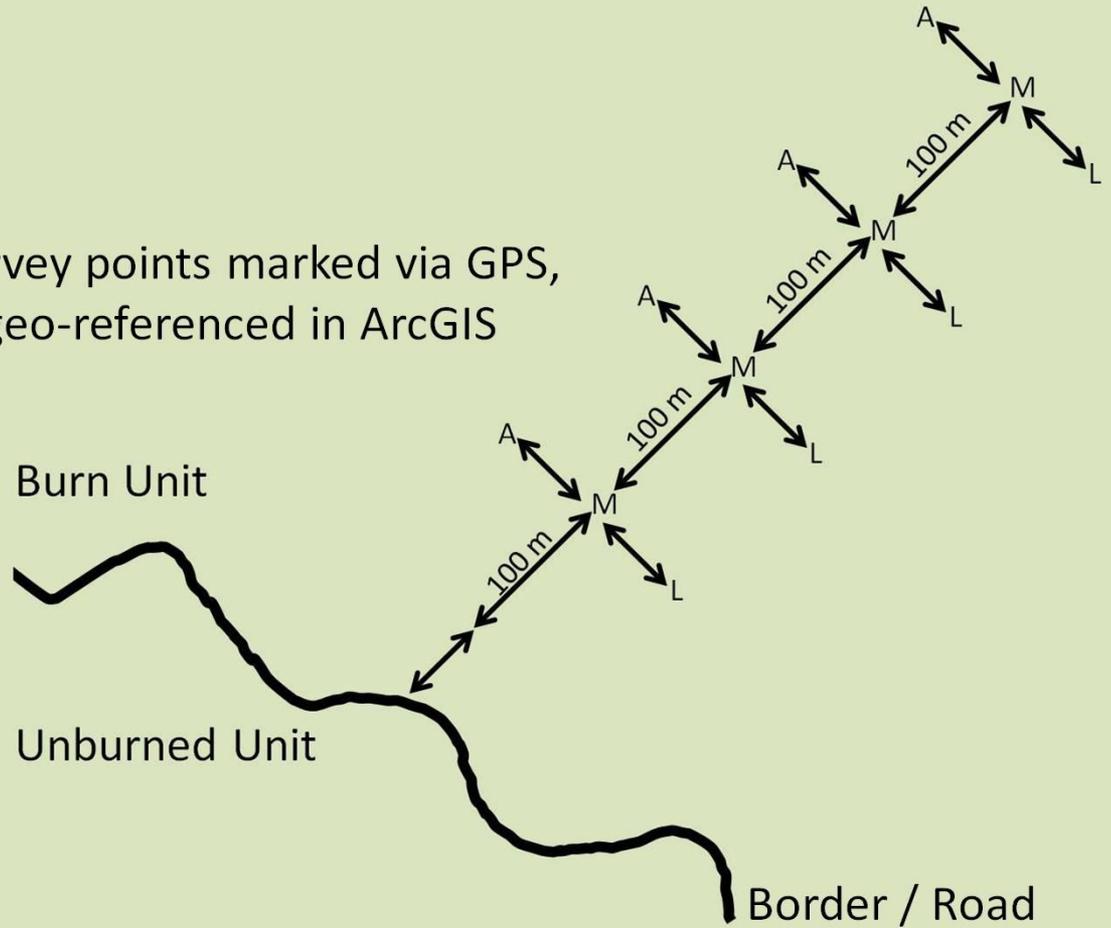
 Core
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 Survey Transects, Aug 2010 onward

Methods

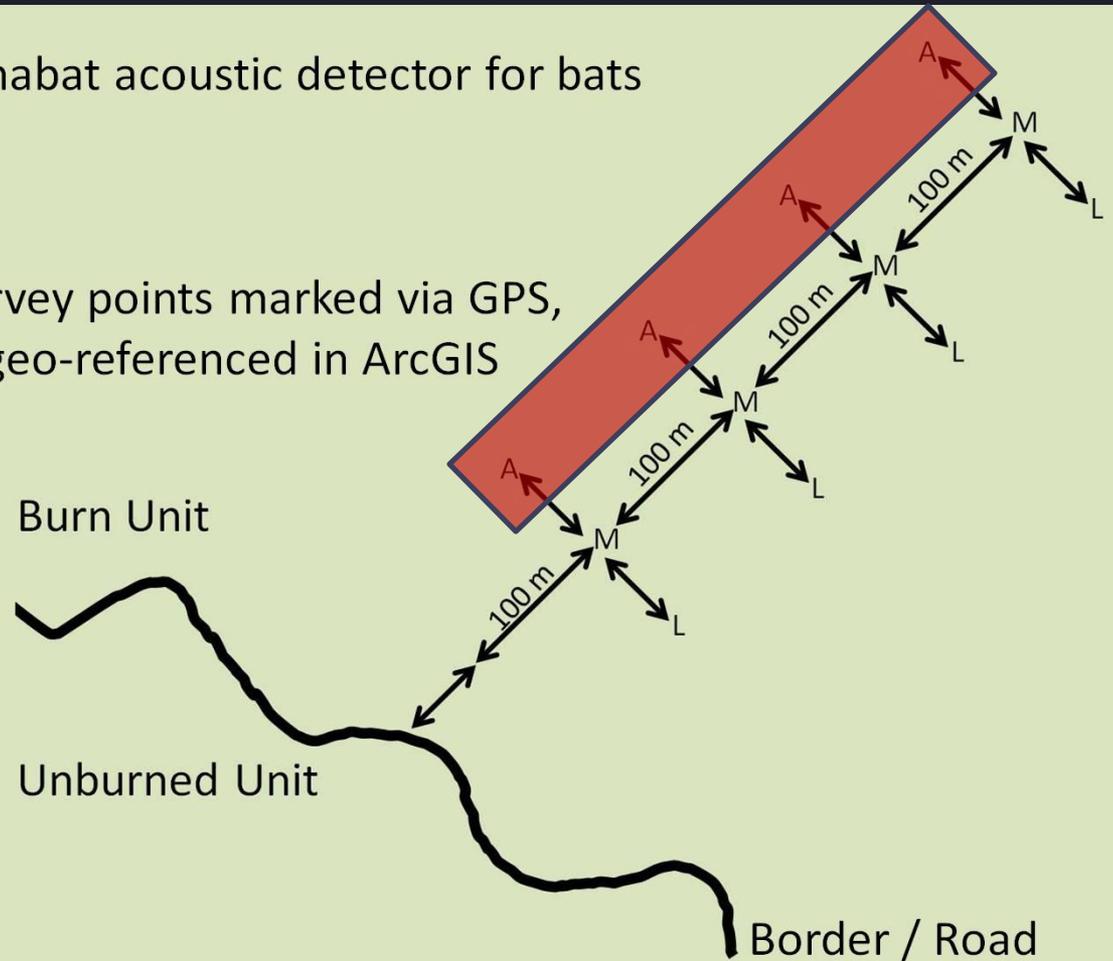
All survey points marked via GPS,
then geo-referenced in ArcGIS



Methods

A = Anabat acoustic detector for bats

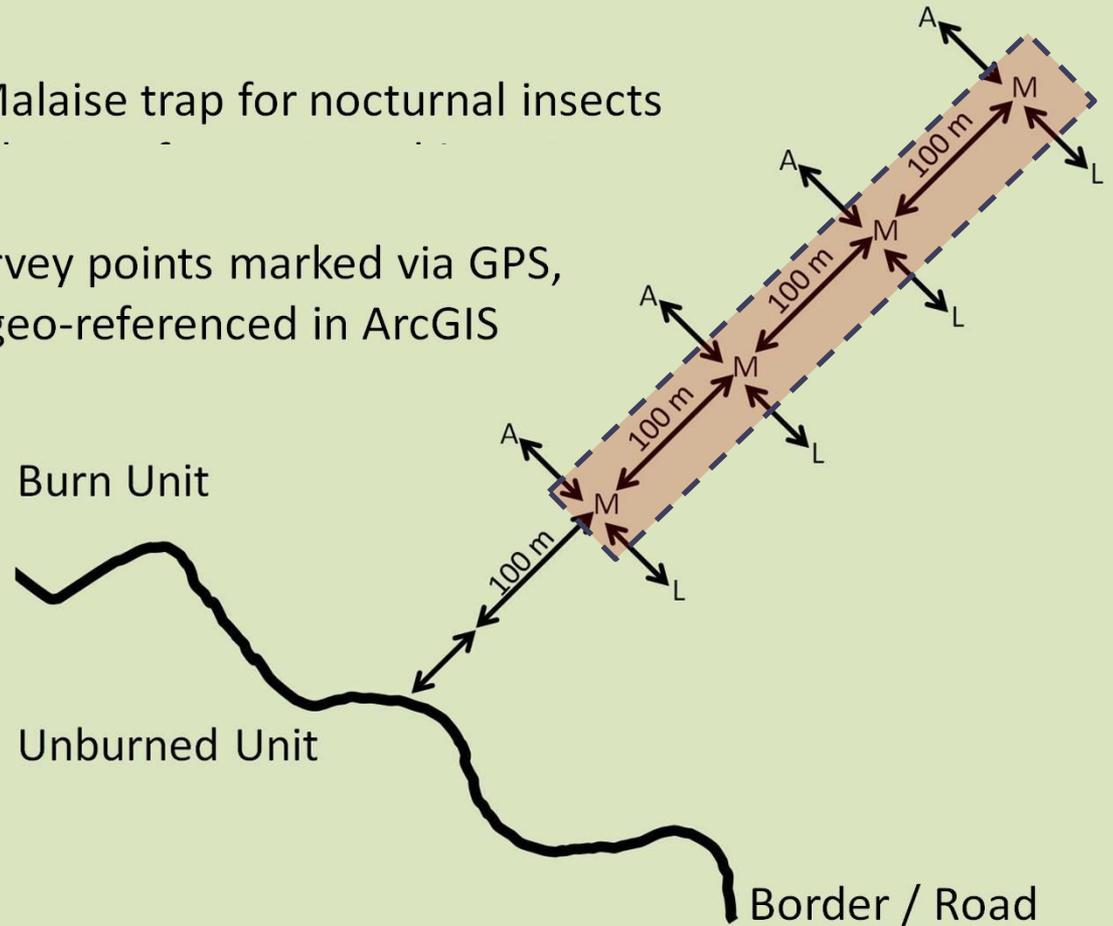
All survey points marked via GPS,
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Methods

M = Malaise trap for nocturnal insects

All survey points marked via GPS,
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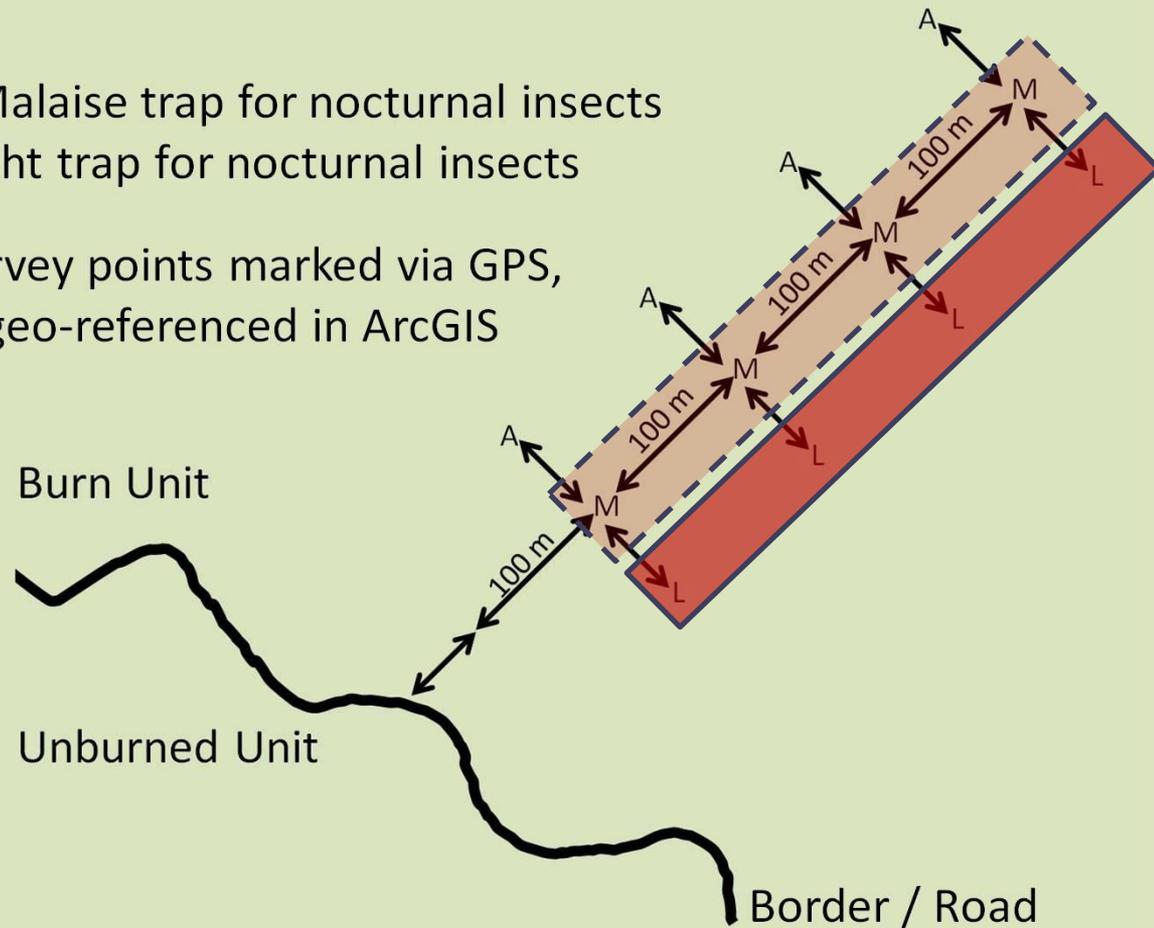


Methods

M = Malaise trap for nocturnal insects

L = Light trap for nocturnal insects

All survey points marked via GPS,
then geo-referenced in ArcGIS





Burned in 2004

Methods

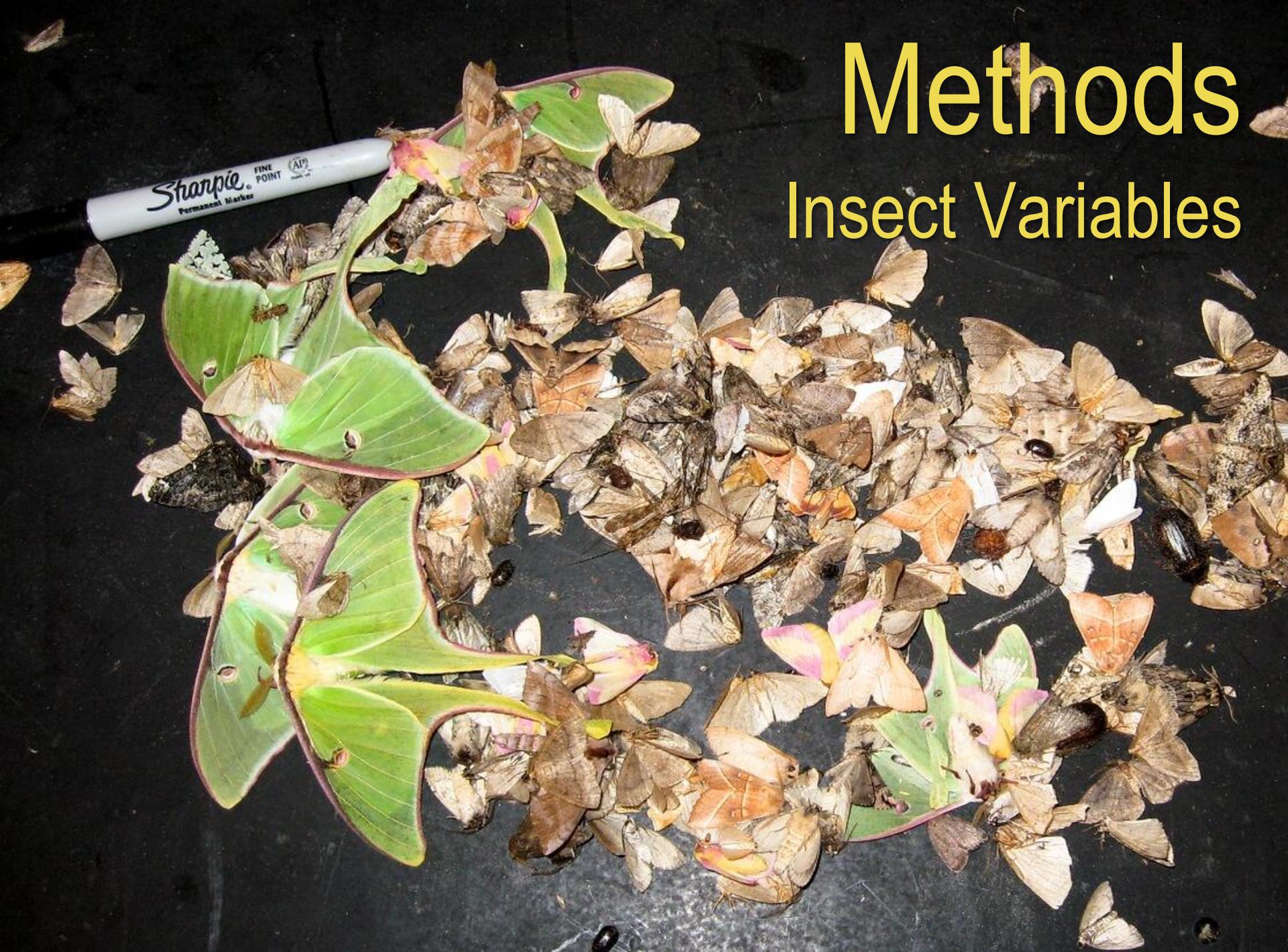
Insect Occurrence

A photograph of a blacklight trap in a forest at night. The trap is a white bucket with a black lid and a glowing blue light inside. It is surrounded by dense green foliage and trees. The background is dark, suggesting nighttime.

- Blacklight trapping
- Spanning 2010-2012 (still ongoing)
 - 25 nights (337 trap/nights)
 - Emphasis on April-May, Aug-Oct

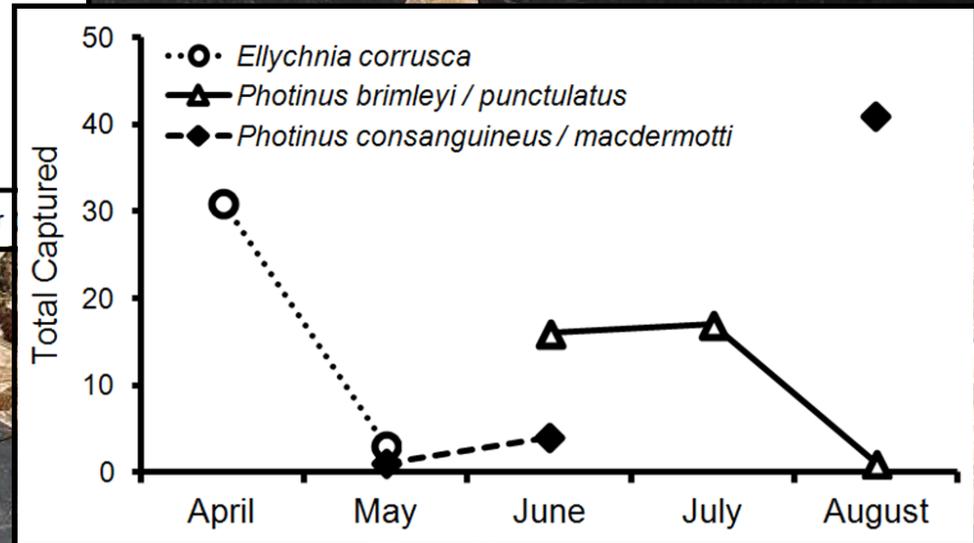
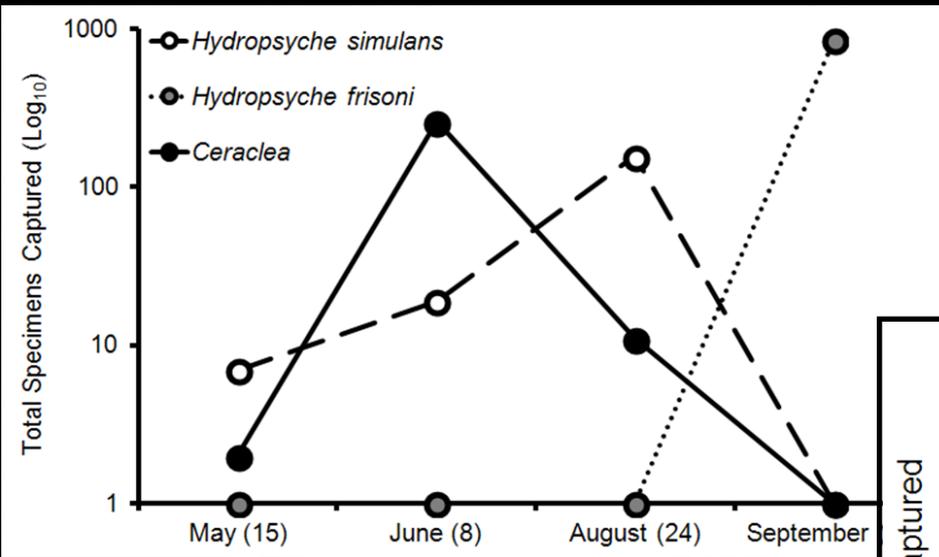
Methods

Insect Variables



Methods

Insect Variables

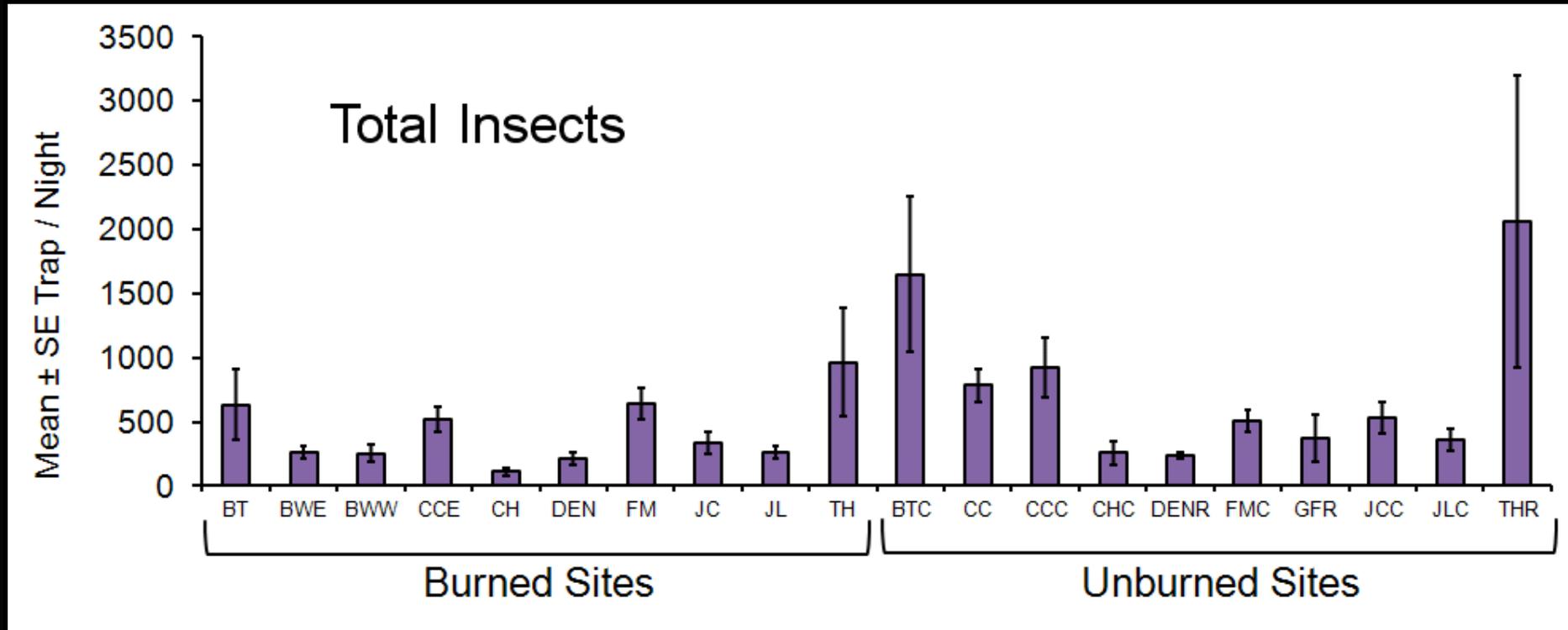


Dodd, L.E., and L.F. Faust. 2014. Seasonal occurrence and habitat affiliations of Lampyridae at Mammoth Cave, Kentucky. *Journal of the Kentucky Academy of Science*, In Press.

Dodd, L.E., M.A. Floyd, and D.A. Etnier. 2013. Seasonal occurrence and habitat affiliations of Trichoptera at Mammoth Cave National Park. *Proceedings of Mammoth Cave National Park's 10th Research Symposium* (ed Trimboli, S.R.). Pp. 44-49 (of 207 p).

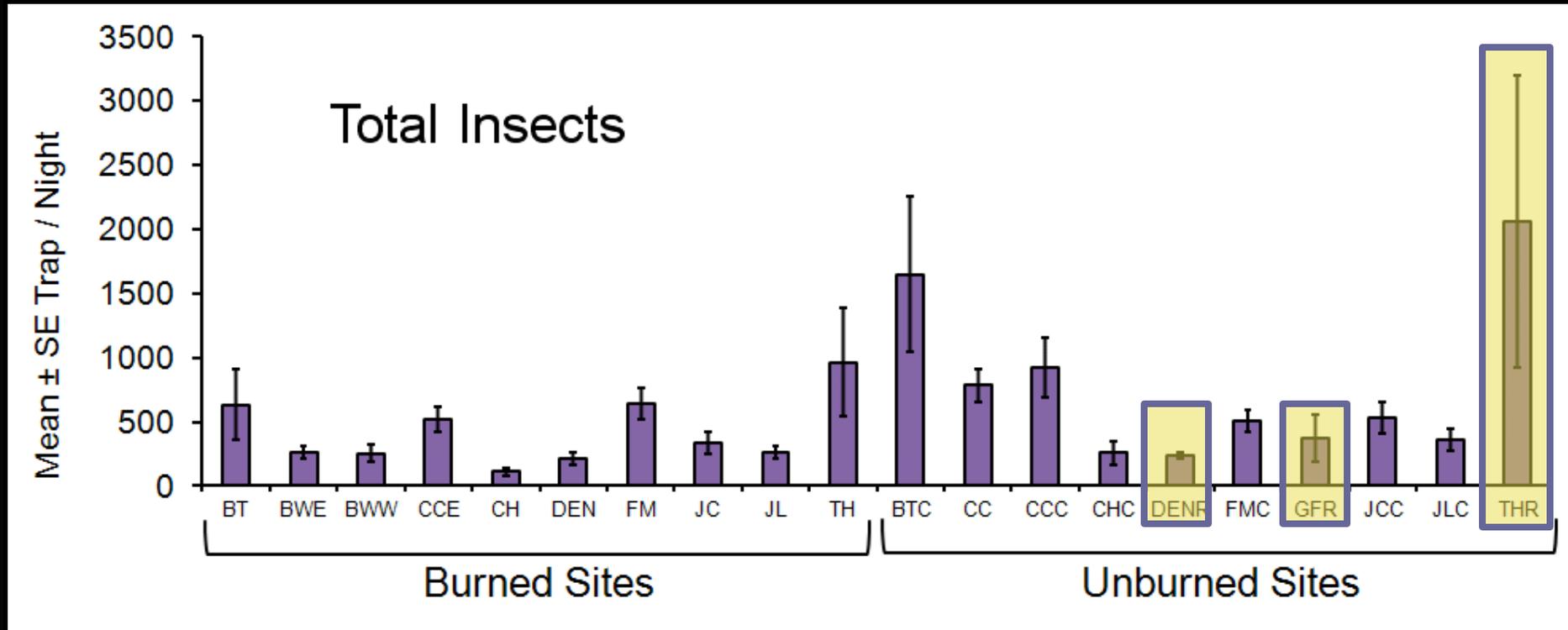
Site, Season, & Annual Effects

Site, Season, & Annual Effects



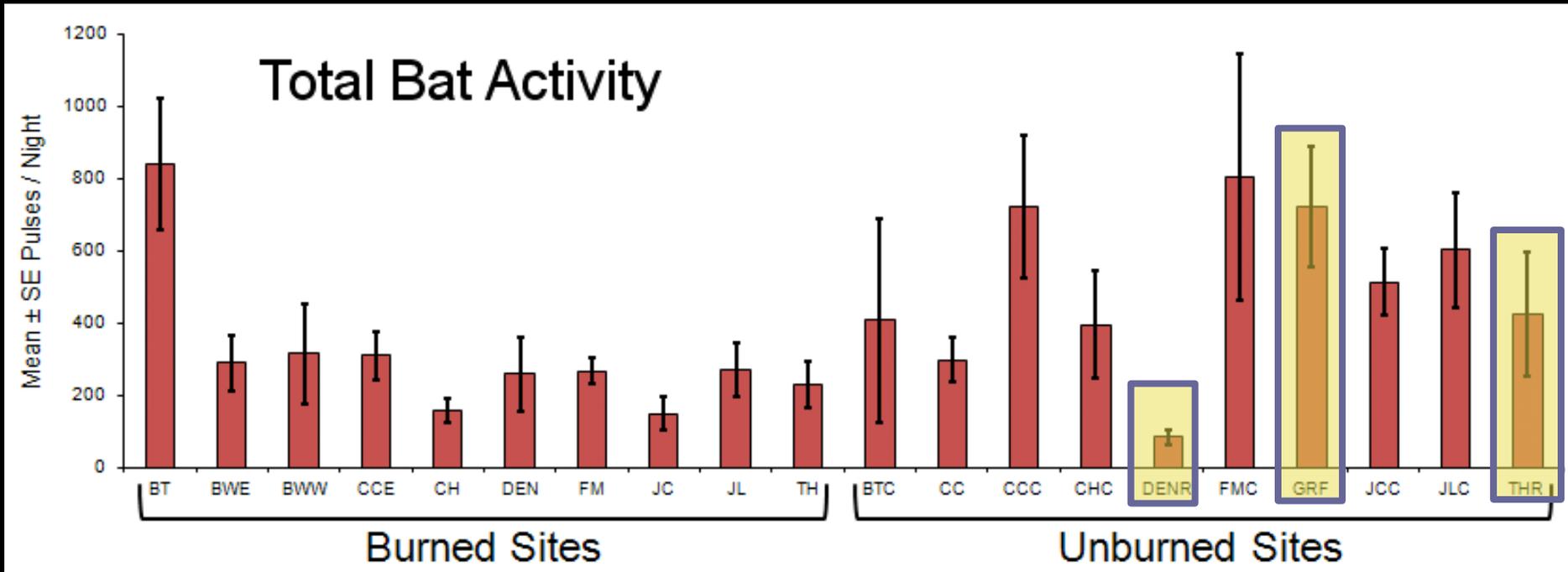
- As with bat data, lots of variation across sites!

Site, Season, & Annual Effects



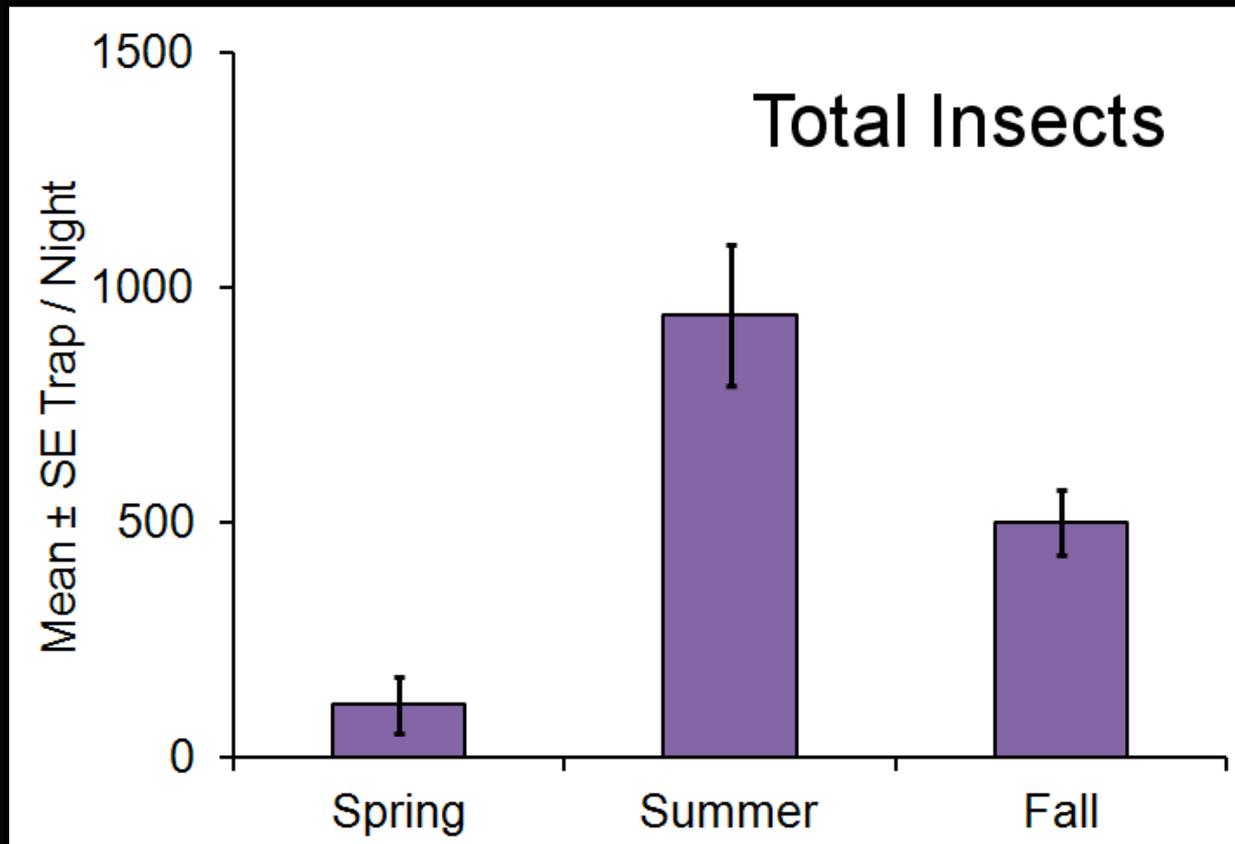
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- No clear trend with insects at riparian sites.

Site, Season, & Annual Effects



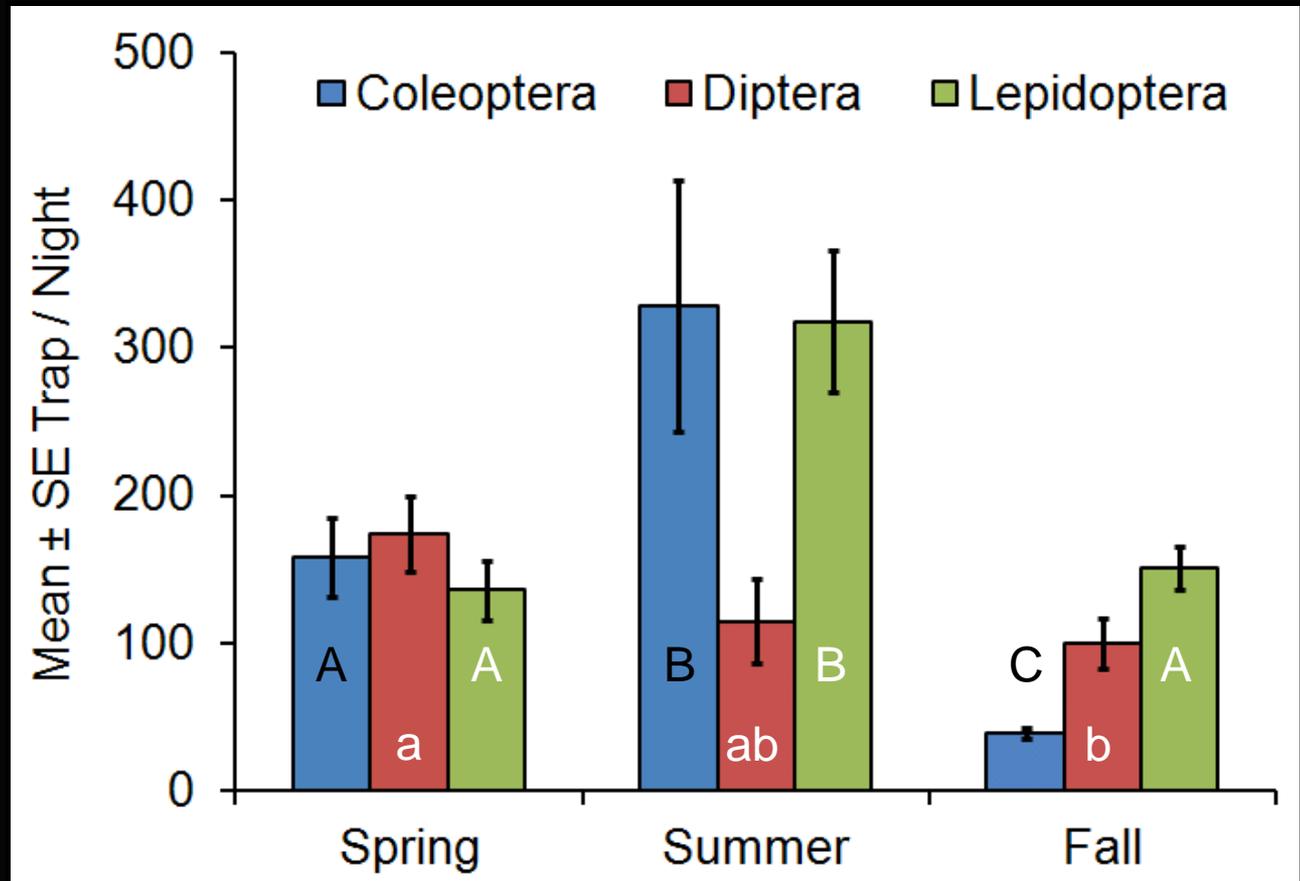
- As with bat data, lots of variation across sites!
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Site, Season, & Annual Effects



- Prey availability & WNS impacts on bat health

Site, Season, & Annual Effects



Coleoptera:

$$F_{2,334} = 27.2, P < 0.01$$

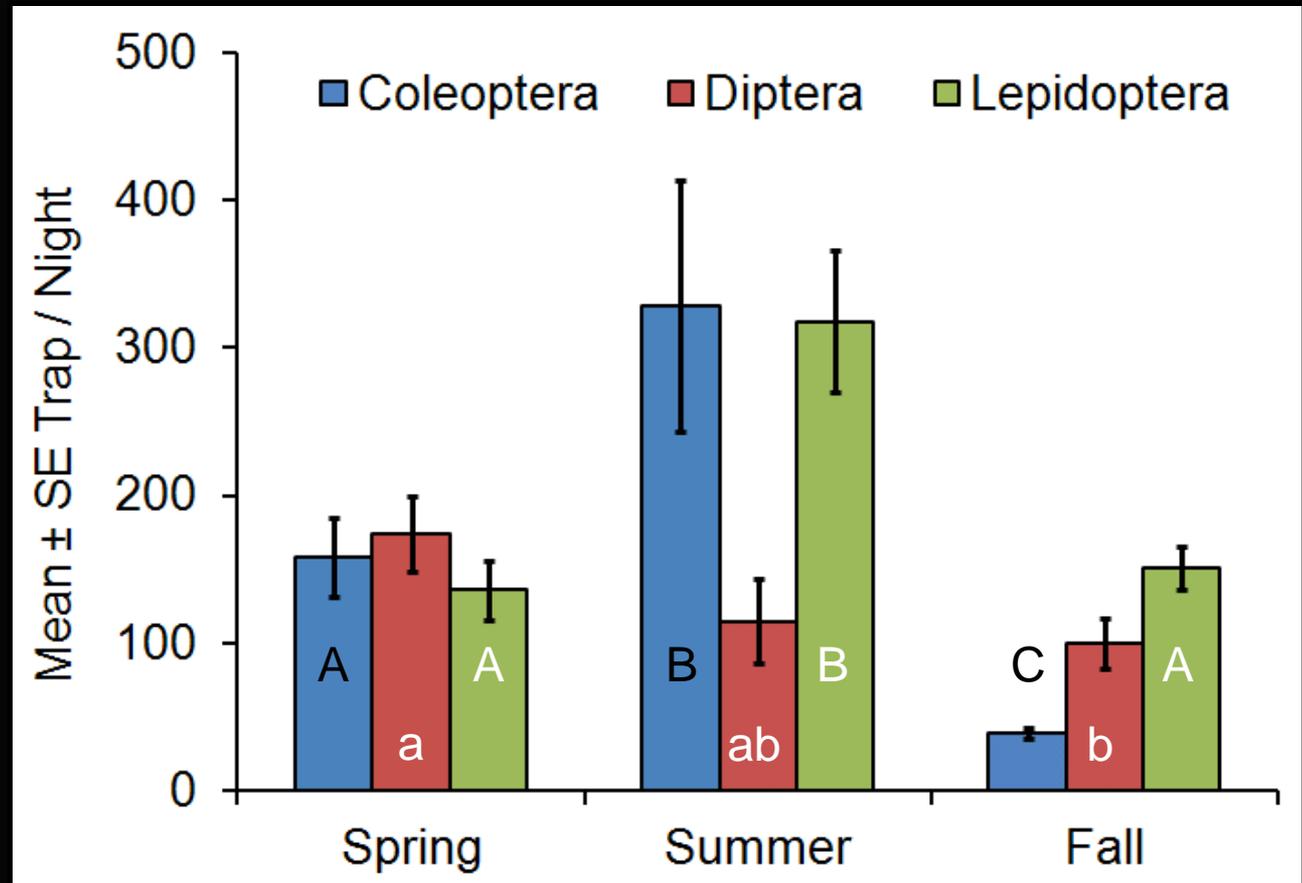
Diptera:

$$F_{2,334} = 3.4, P = 0.03$$

Lepidoptera:

$$F_{2,334} = 9.9, P < 0.01$$

Site, Season, & Annual Effects



Coleoptera:

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Reduction in the prey
we know *Myotis* eat!

Site, Season, & Annual Effects

Coleoptera:

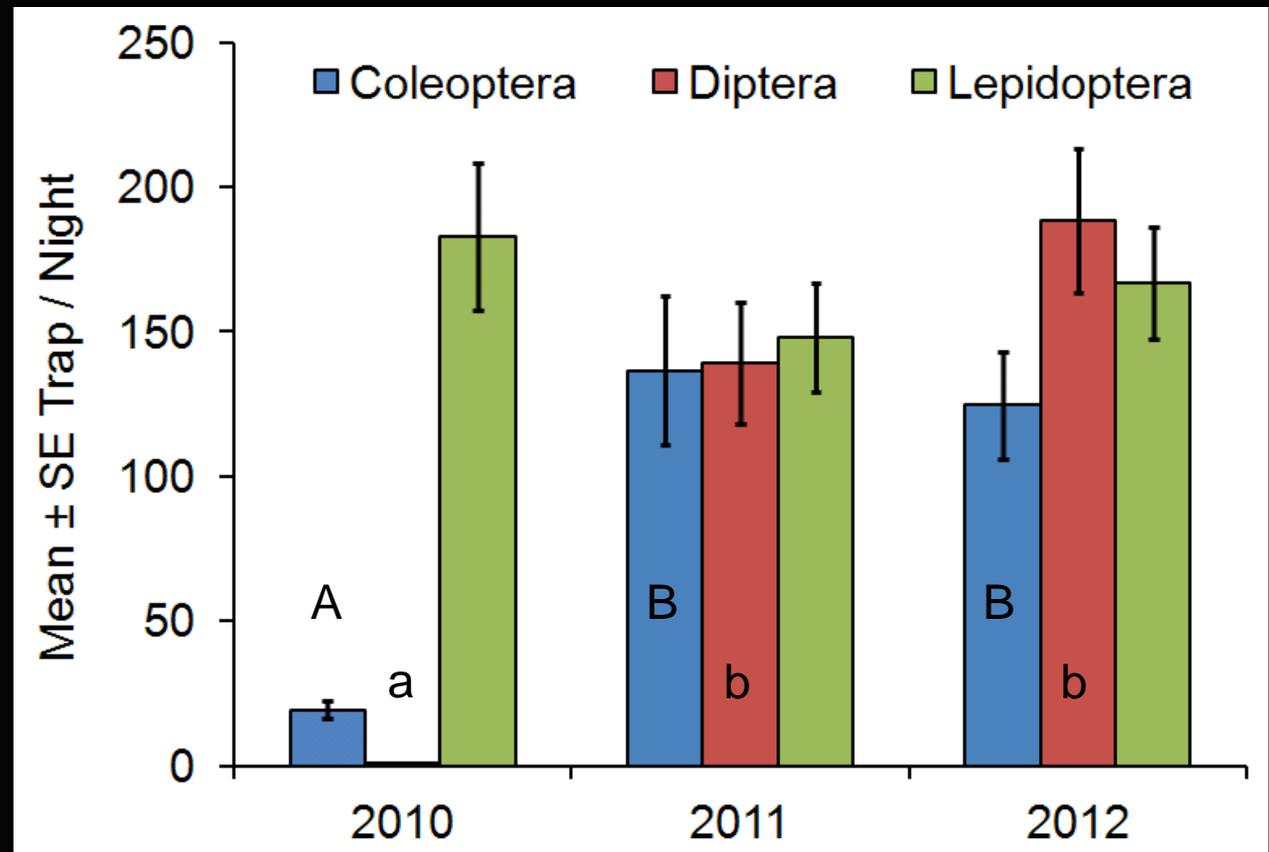
$$F_{2,334} = 6.2, P < 0.01$$

Diptera:

$$F_{2,334} = 14.8, P < 0.01$$

Lepidoptera:

$$F_{2,334} = 0.6, P > 0.05$$



Site, Season, & Annual Effects

Coleoptera:

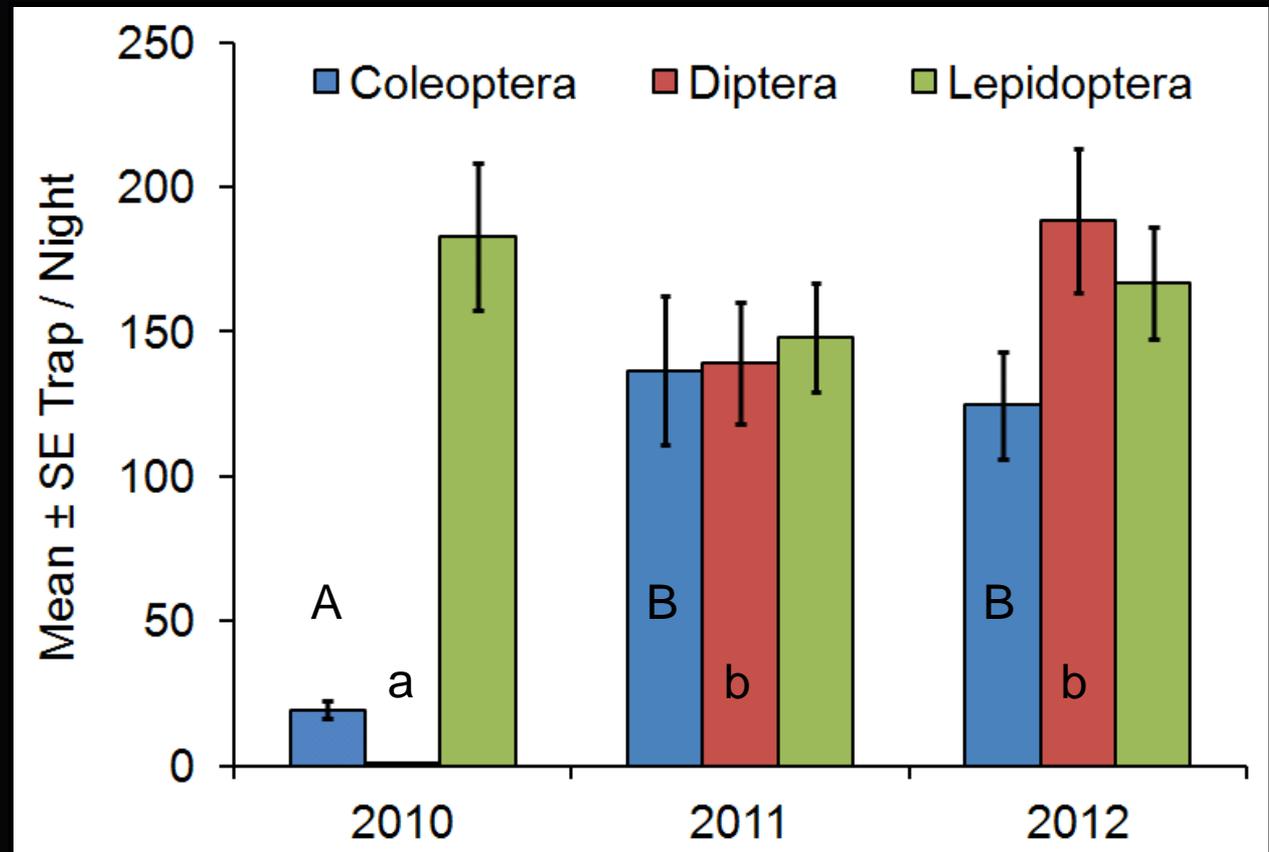
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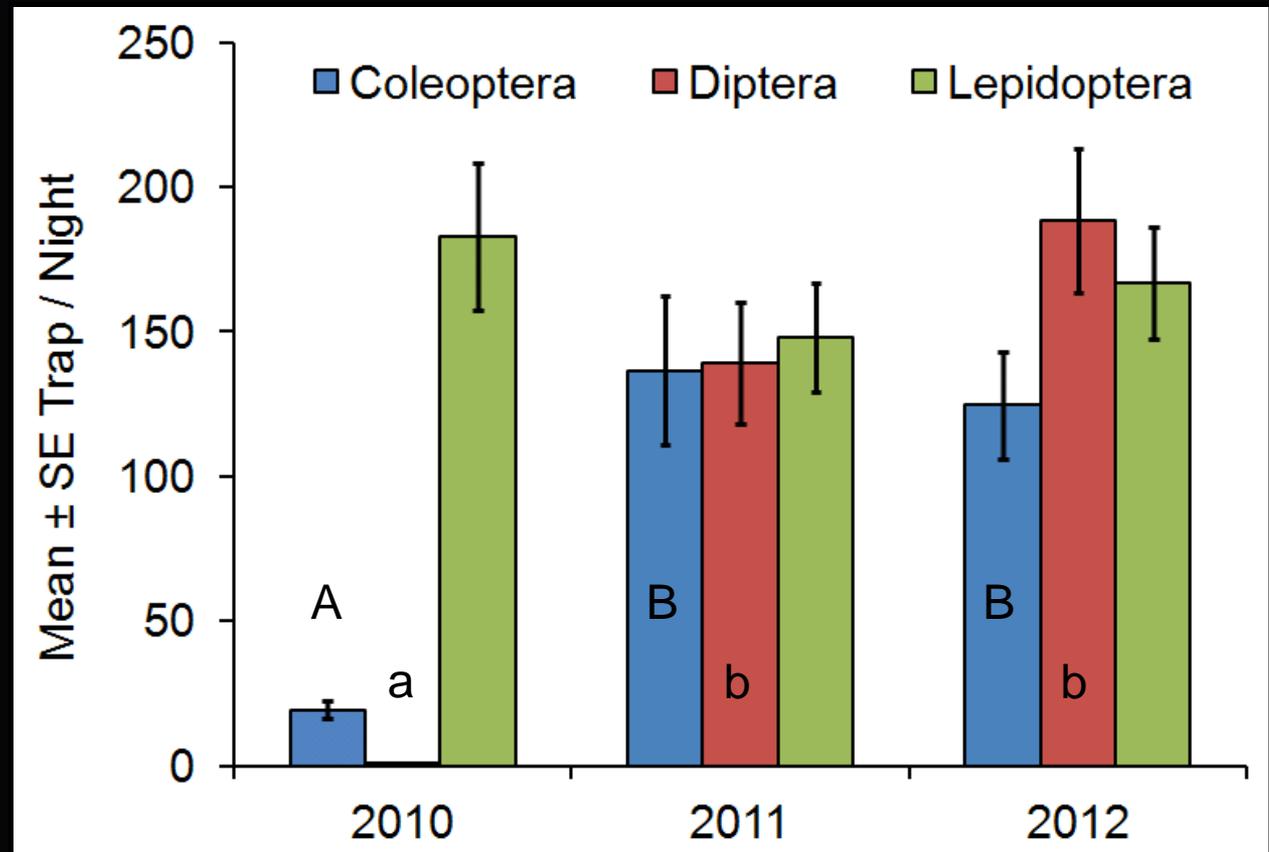
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Fewer land parcels,
Late season sampling

Park-wide coverage,
spanning immediate
post-burn impacts

Site, Season, & Annual Effects



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Lepidoptera:

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- Relative constancy across years with WNS arrival

Effect of Fire

Across the Landscape

Effect of Fire Across the Landscape



Survey Transect
Aug 2010 onward

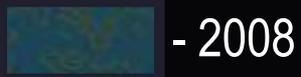
Burn Areas



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- 2009



- 2008



- 2007



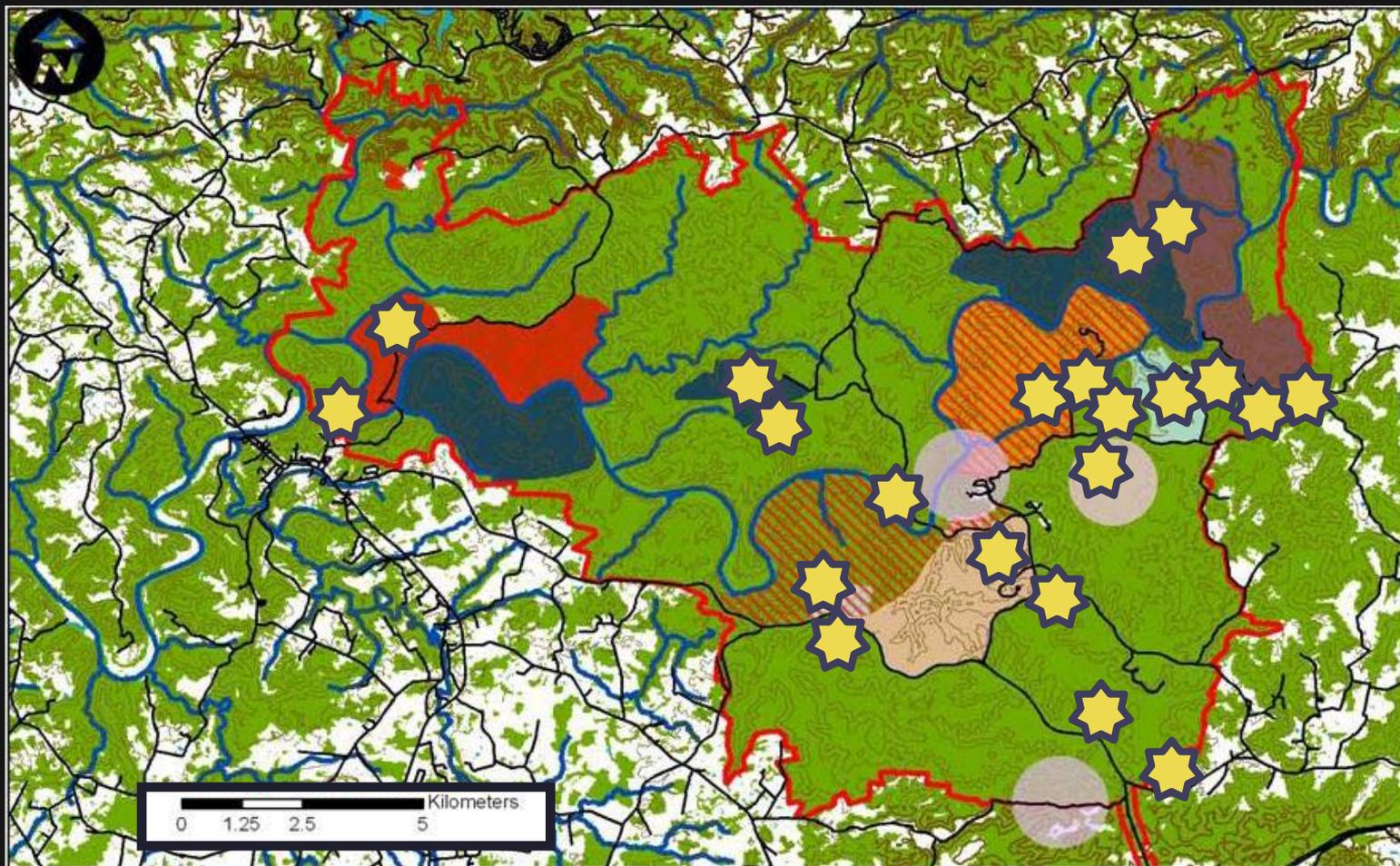
- 2005



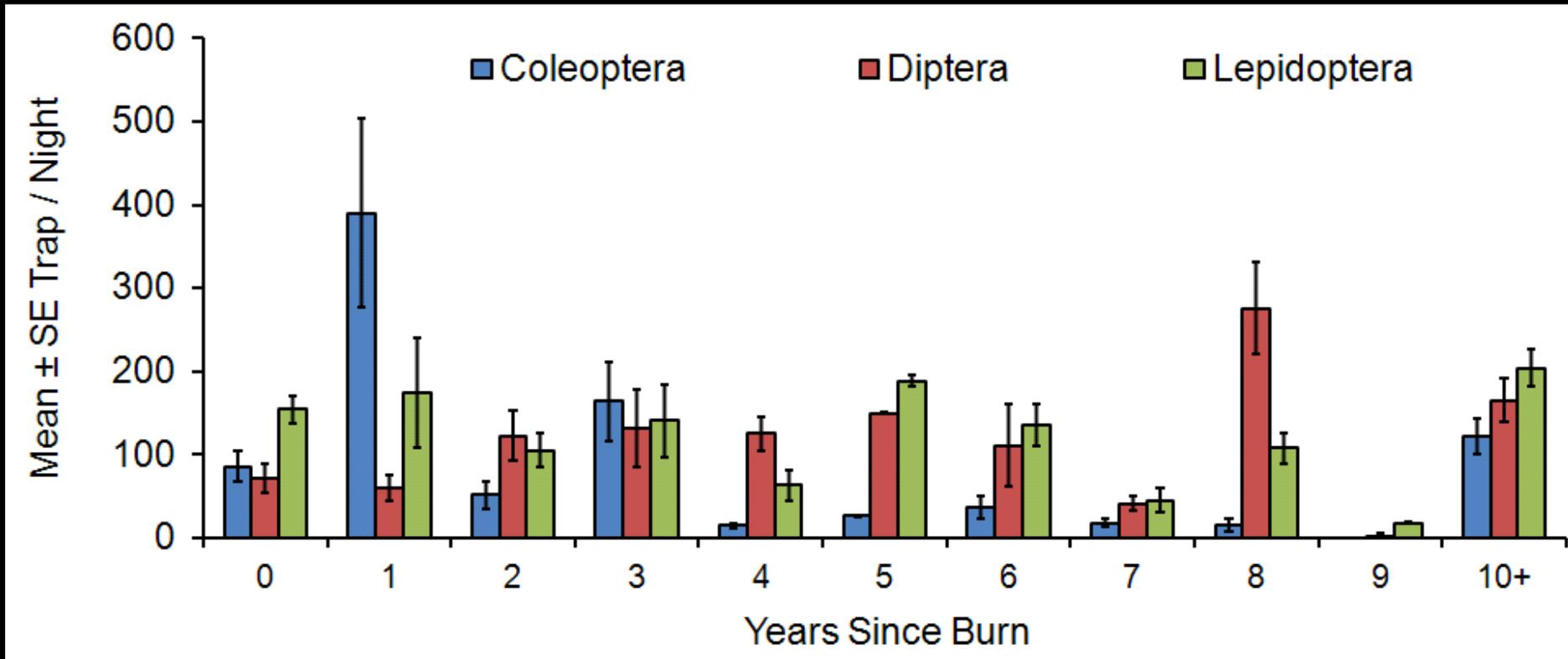
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Core
Hibernacula

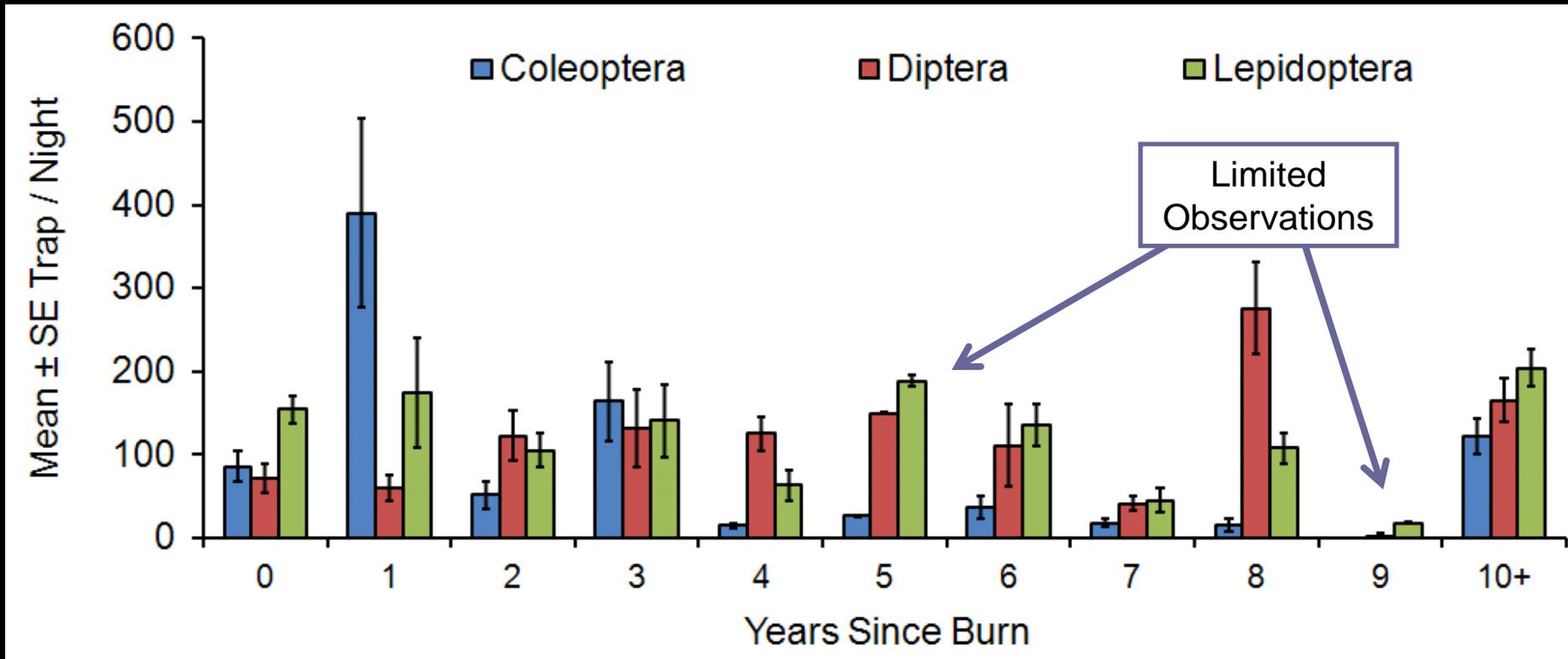


Effect of Fire Across the Landscape



- Shifts in community composition with time since burn

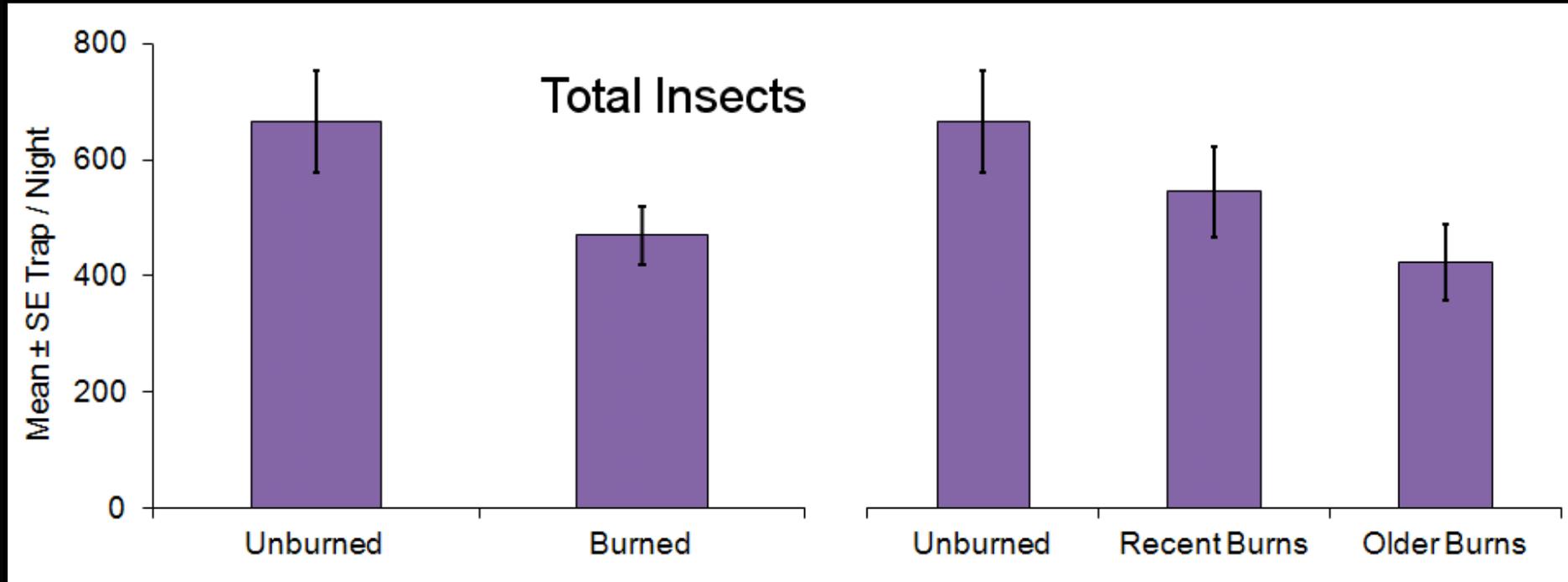
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Effect of Fire

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Effect of Fire Across the Landscape

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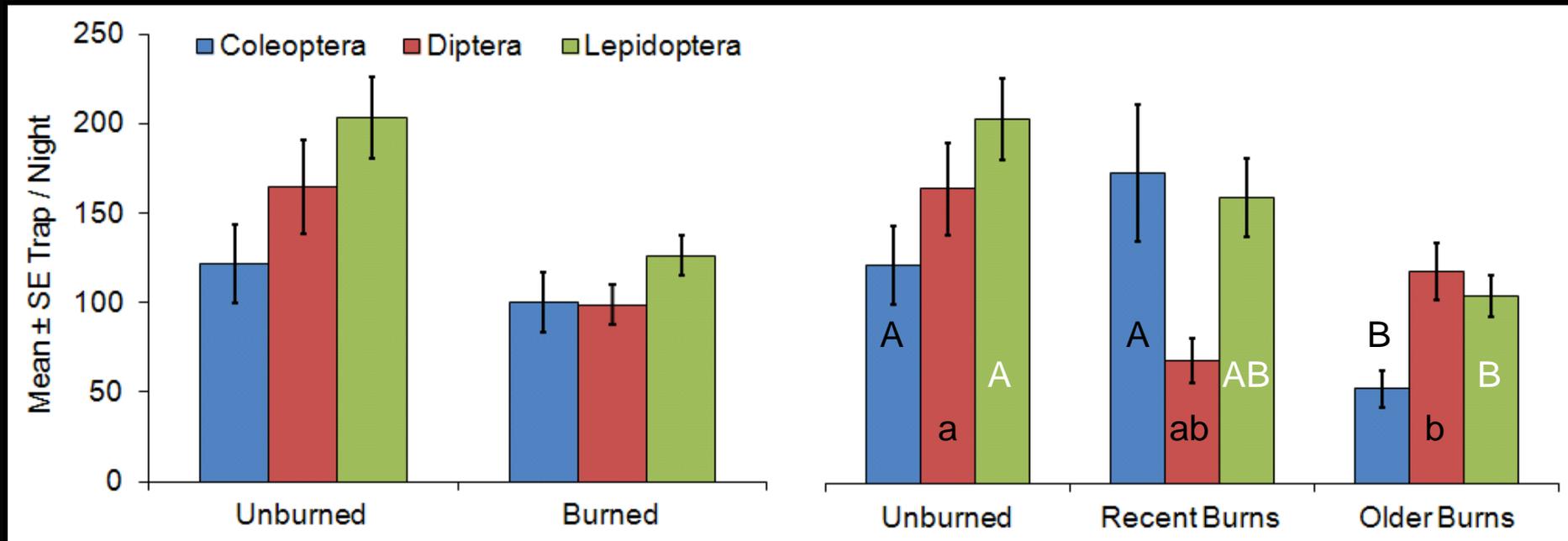
$$F_{2,326} = 5.5, P < 0.01$$

Diptera:

$$F_{2,326} = 4.0, P = 0.02$$

Lepidoptera:

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Effect of Fire Across the Landscape

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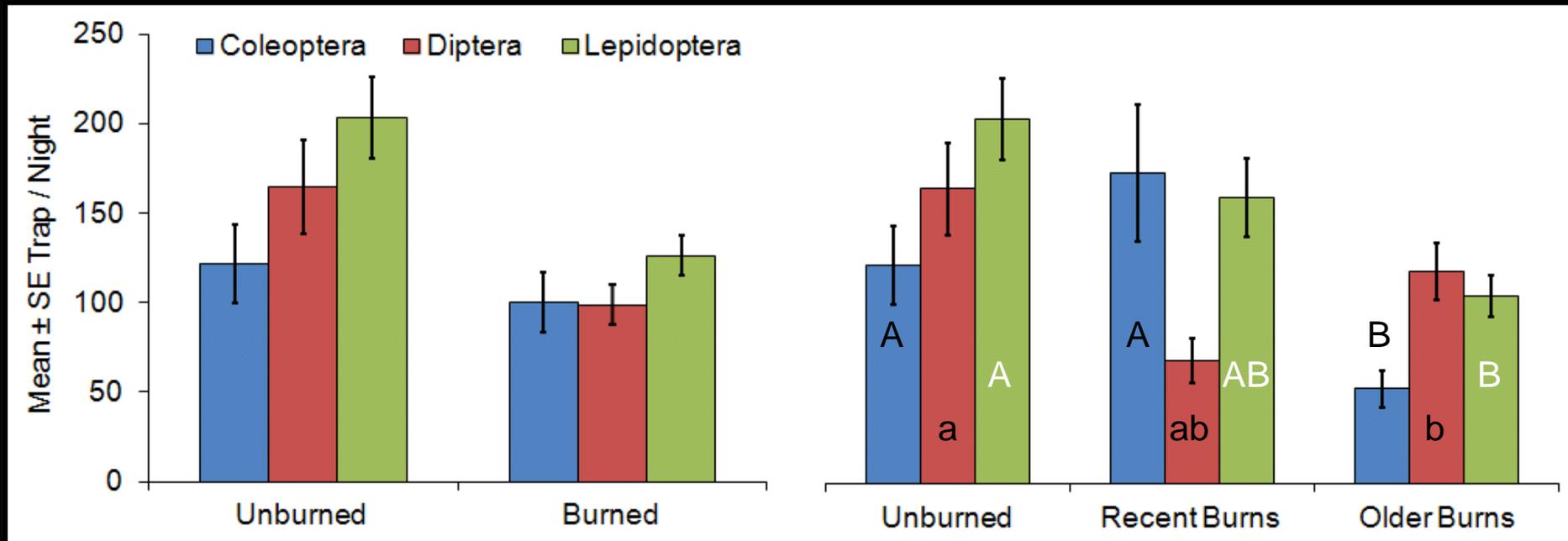
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- Diversity & similarity across sites likely plays a role...

Effect of Fire

Burn Areas

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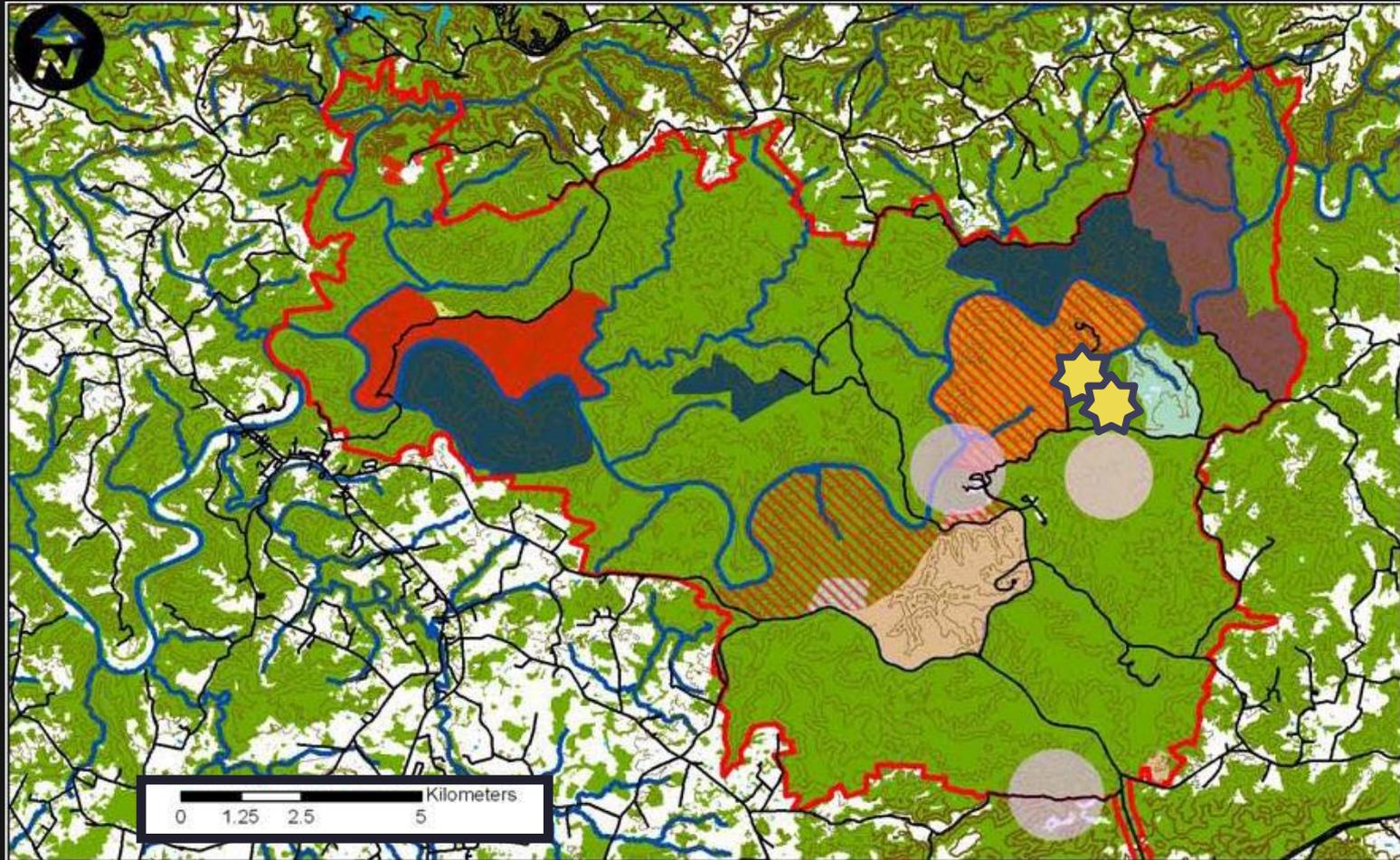
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 → Survey Transects, Aug 2010 onward

Effect of Fire

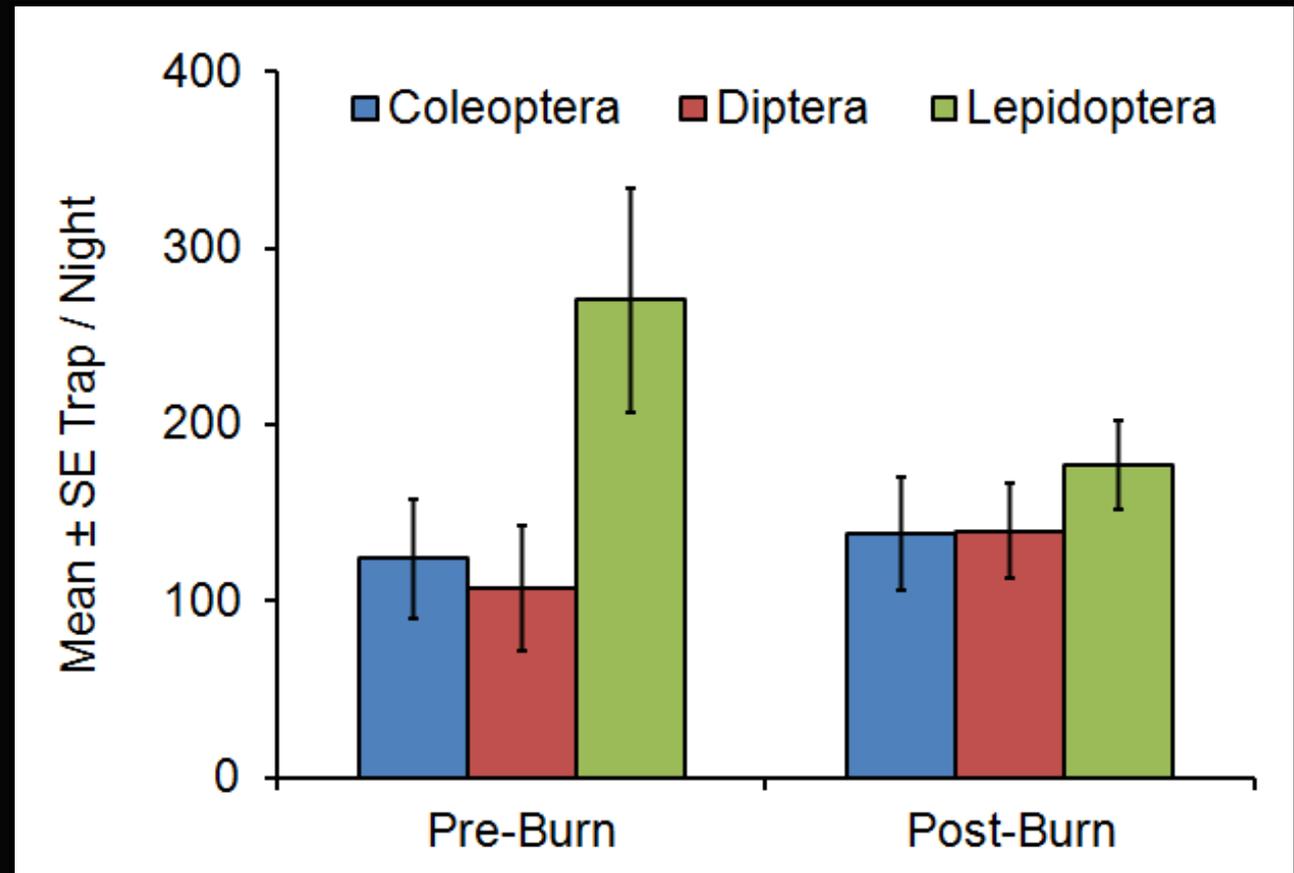
Across the Landscape



Analyses pending

Effect of Fire

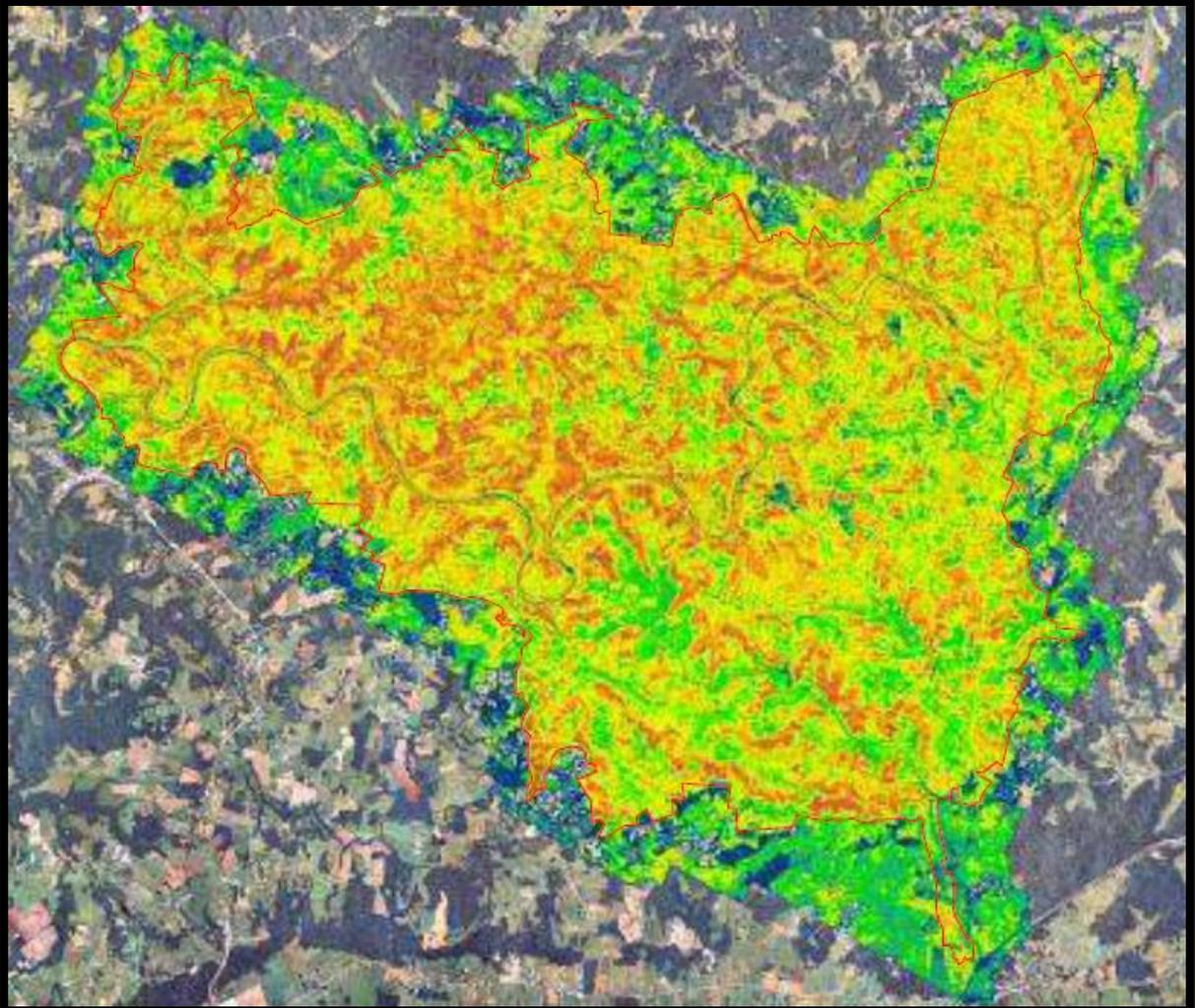
Across the Landscape



Analyses pending

Methods

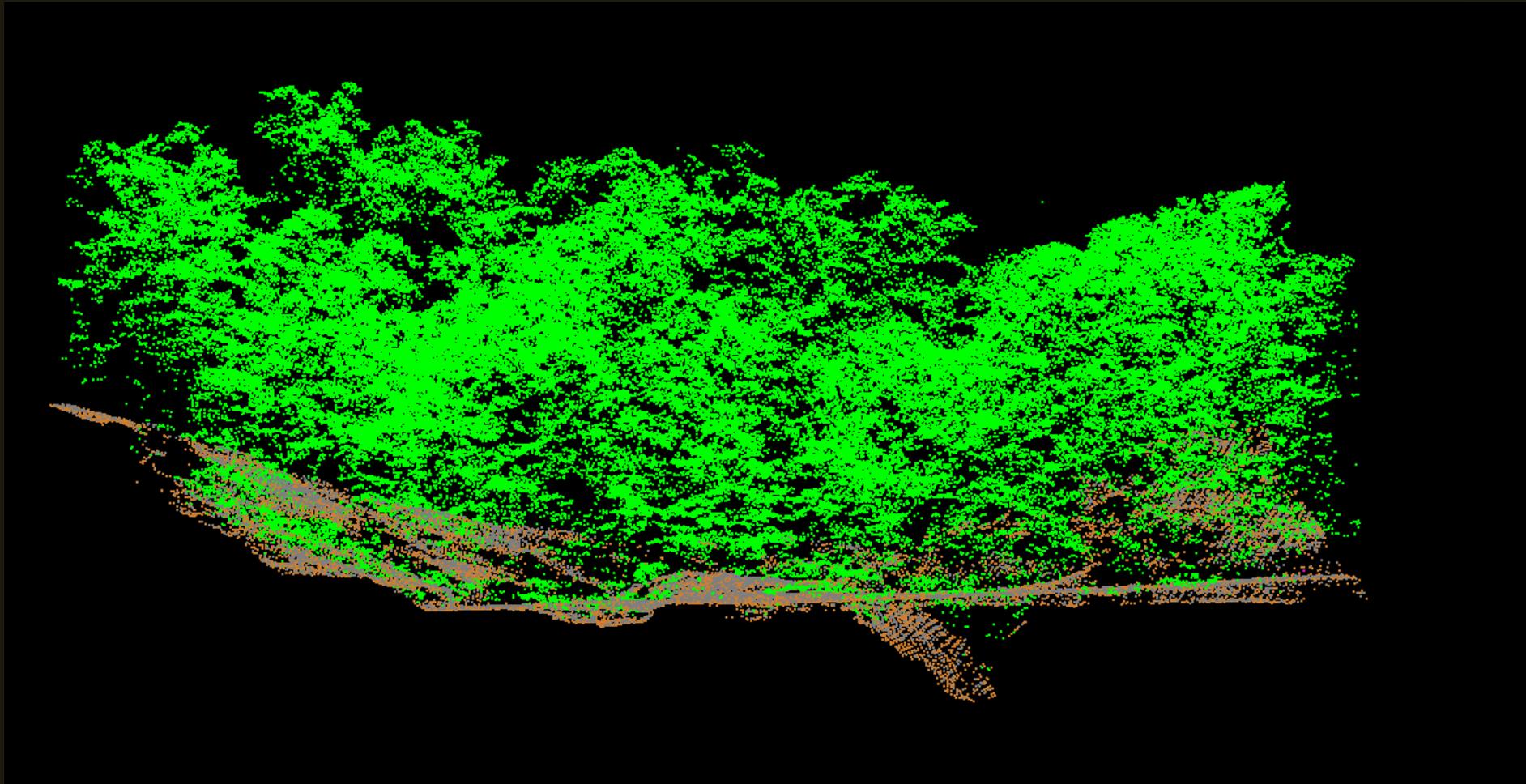
LiDAR Survey



Methods

- What scale is meaningful?

LiDAR Variables

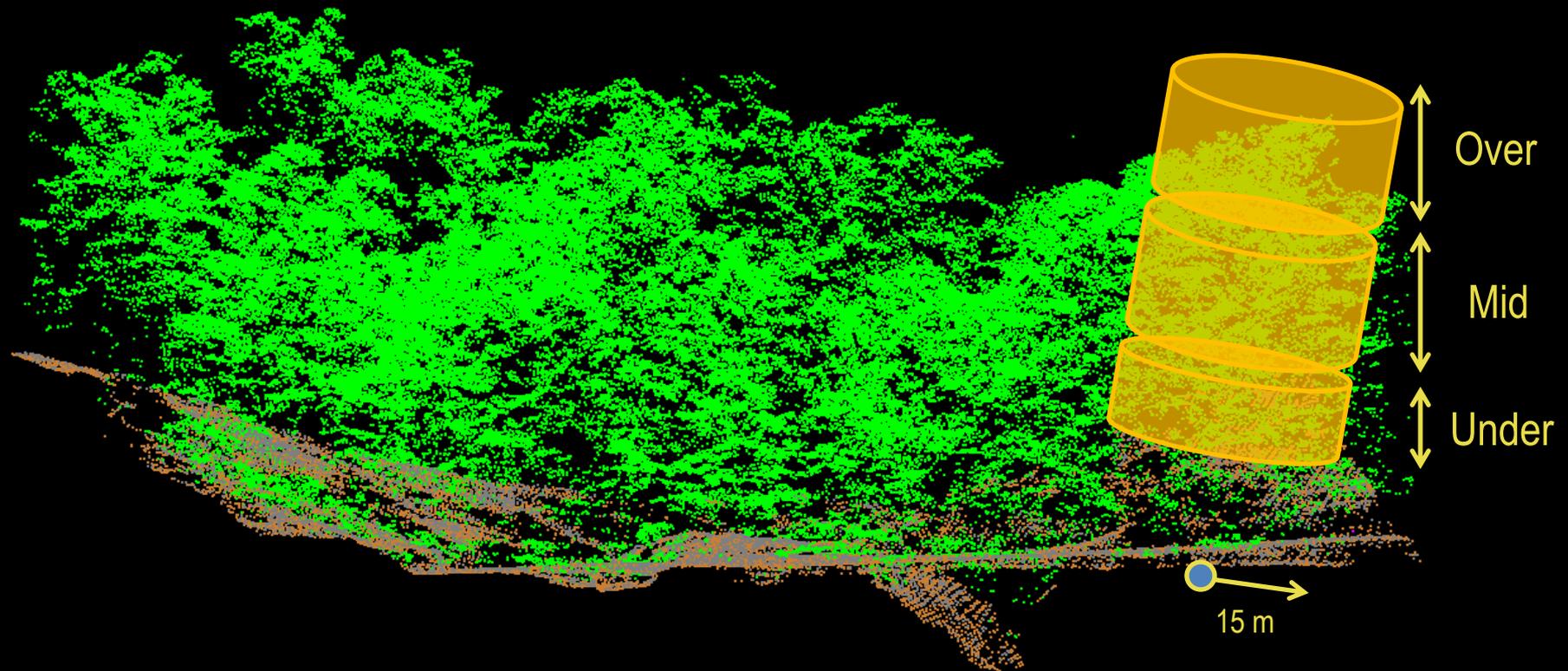


Methods

- Laser returns across over-, mid-, & understory strata¹

LiDAR Variables

- 15 m radii around survey points¹

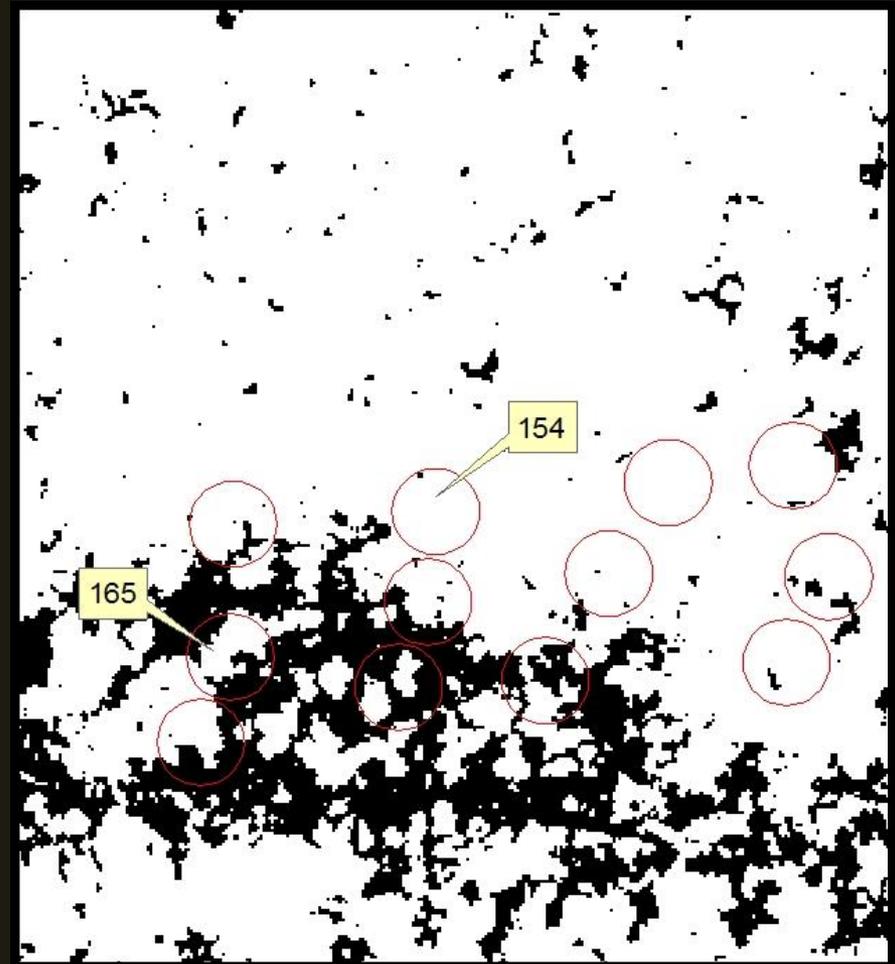


¹Lesak et al. 2011. Remote Sensing of Environment 115: 2823-2835

Methods

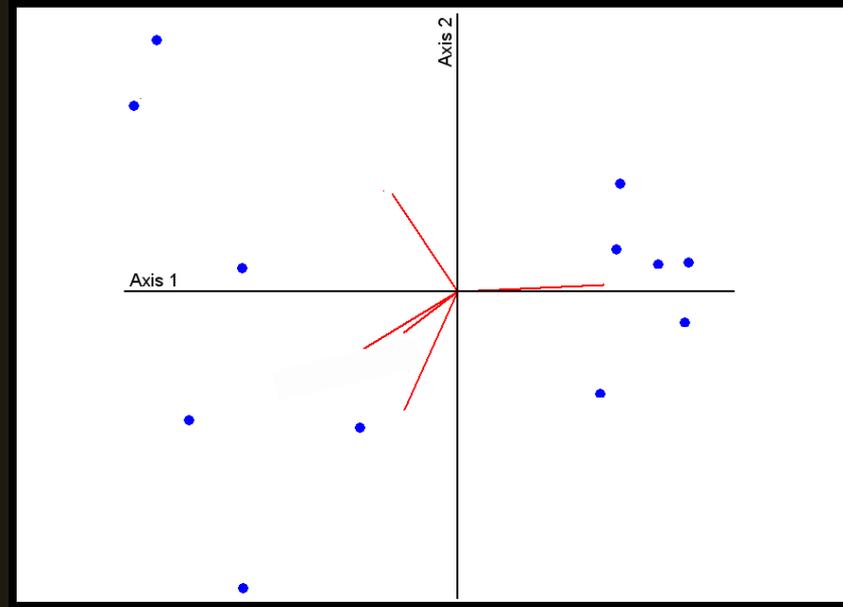
LiDAR Variables

- 0-10 m
- 10-20 m
- 20-30 m
- 30-42 m
- Understory Ratio
 - 0-10 m CHP / Total CHP
 - Indicator of canopy “shape”
- Gap Index
 - Percentage of pixels with no laser returns >3 m height



Analysis

Insects + LiDAR



- Today's talk... Canonical Correspondence Analysis
 - Standard ordination techniques following ter Braak¹
 - PC-ORD v. 4.25; default settings; 300 iterations
- Ongoing efforts... MLRs to mirror bat data presented yesterday

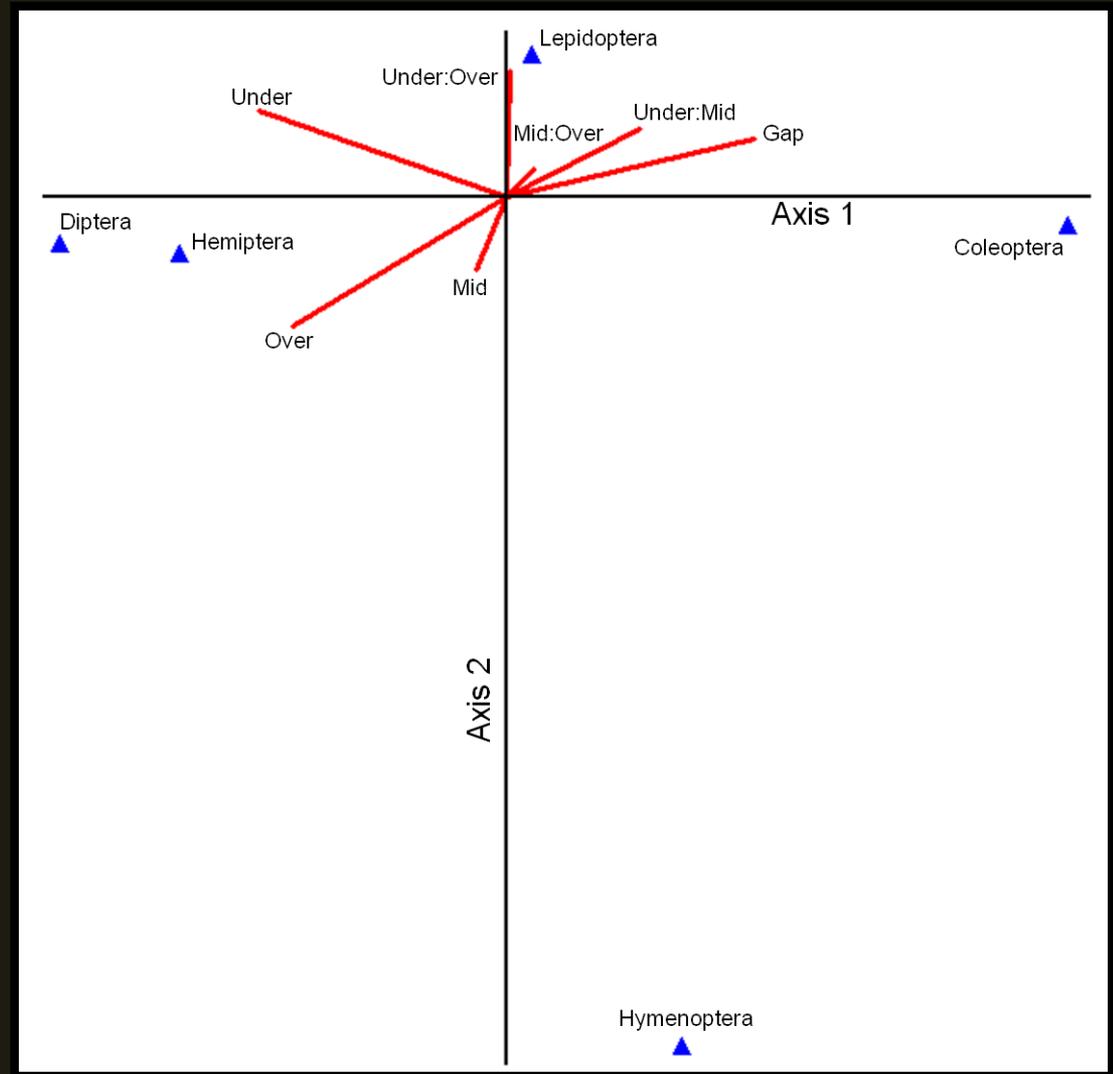
¹McCune & Grace. 2002. Analysis of Ecological Communities. MJM Software Design

Results



Results

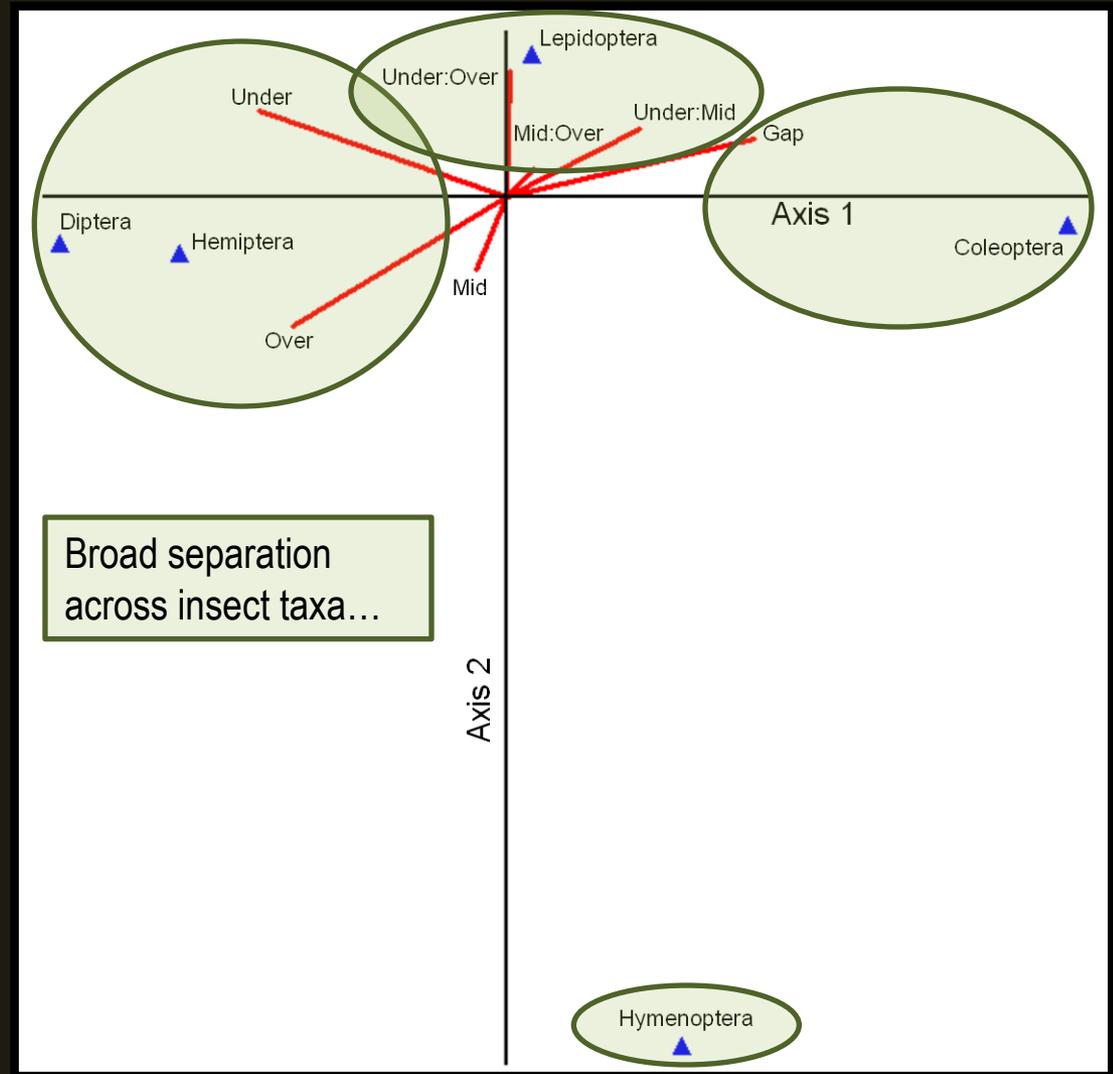
Insects + LiDAR



- 1st Axis ($P \leq 0.05$)
- 11% variation explained
- “Inertia” of the data: 1.03

Results

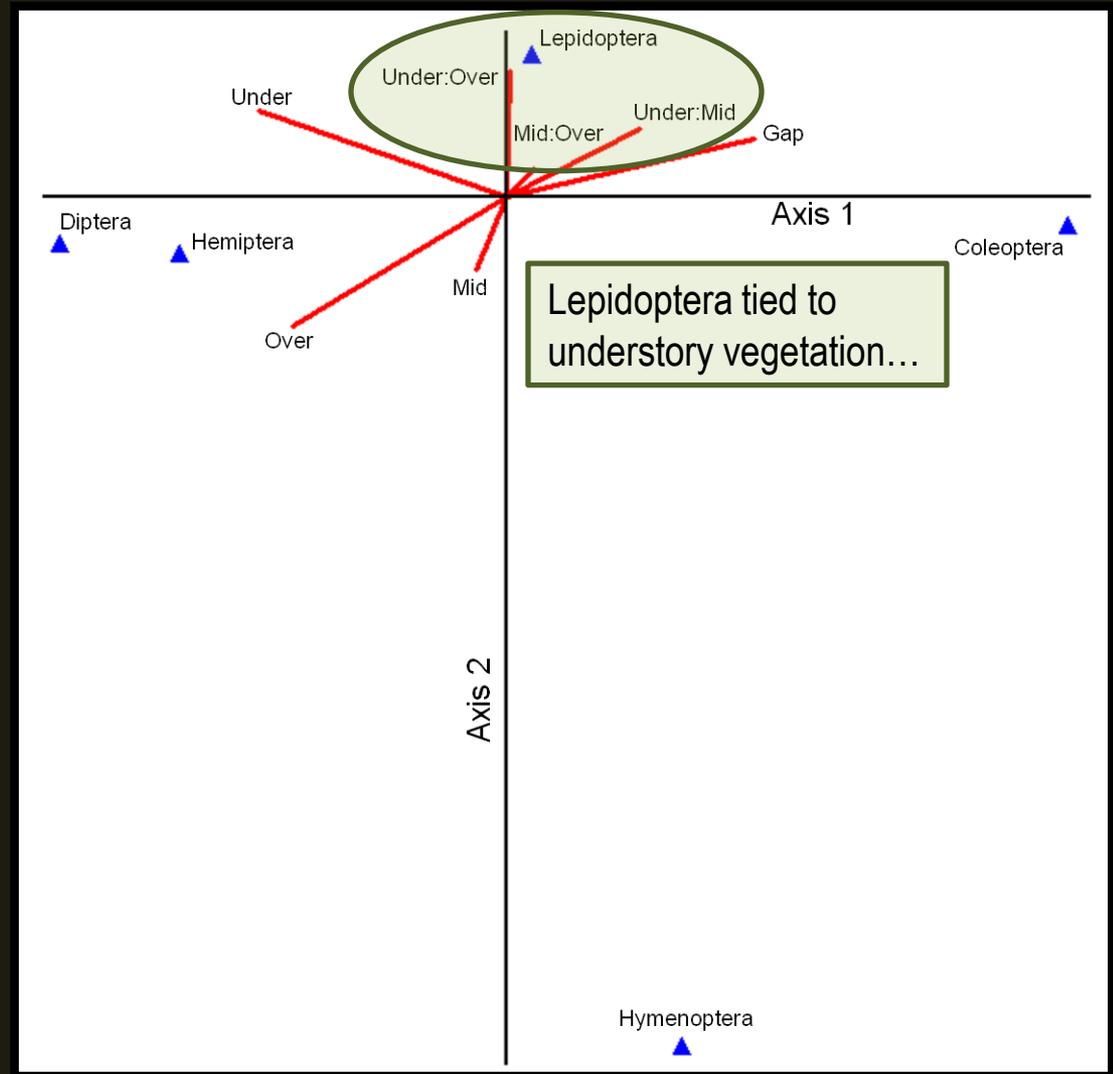
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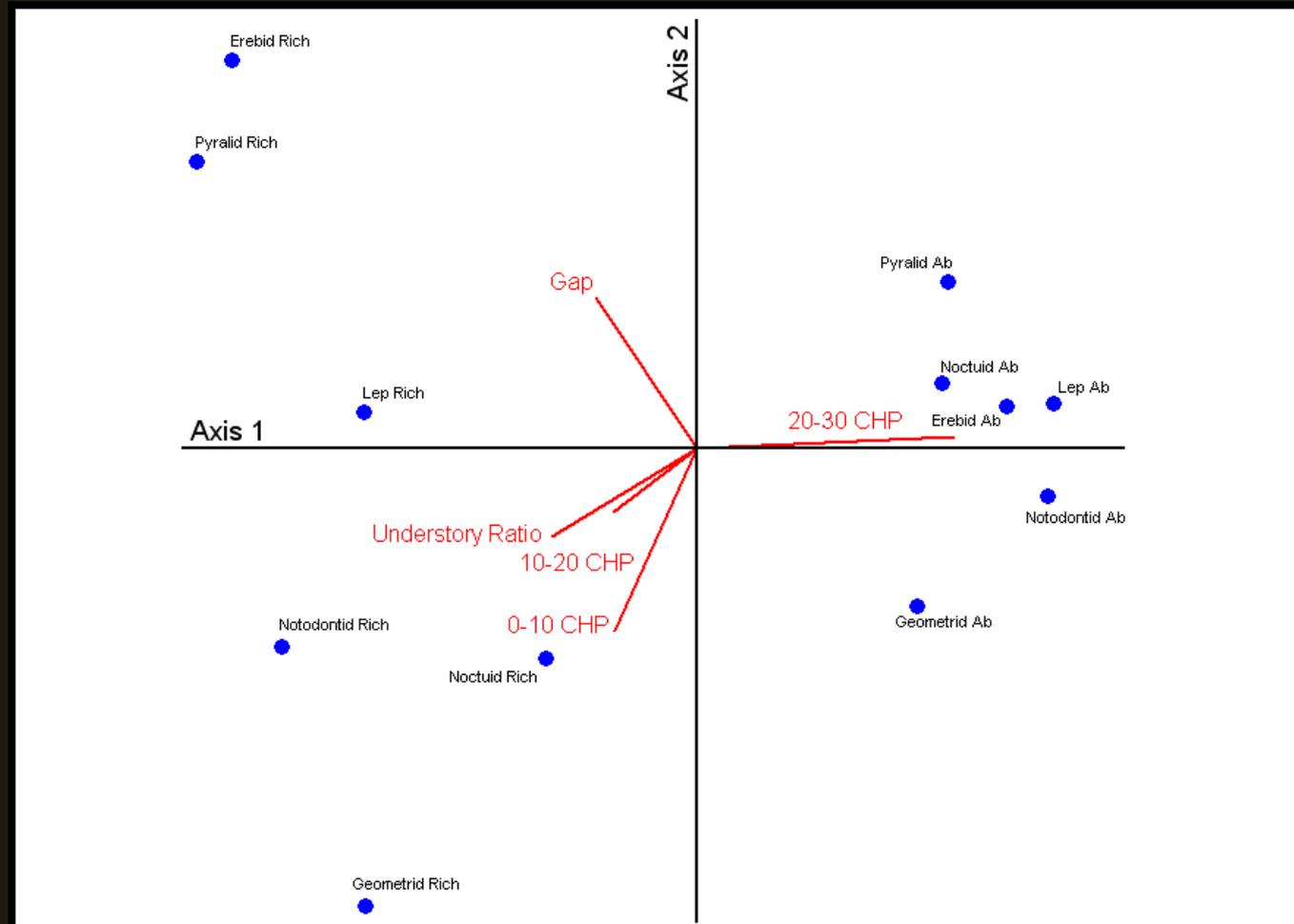


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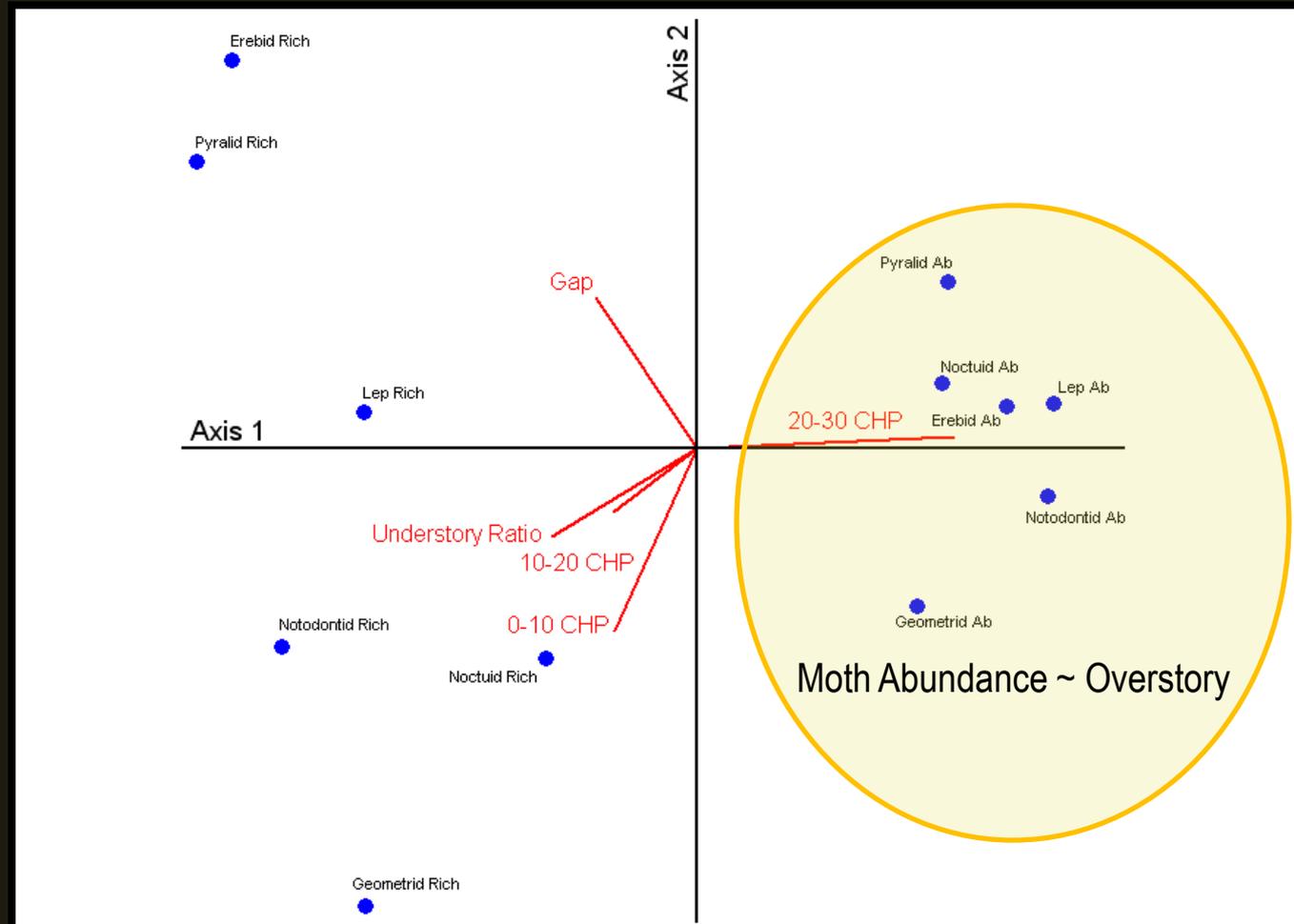
Moth Diversity

- 1st & 2nd Axes significant ($P \leq 0.01$)
- 12% dataset's variation explained
- "Inertia" of the dataset: 0.31



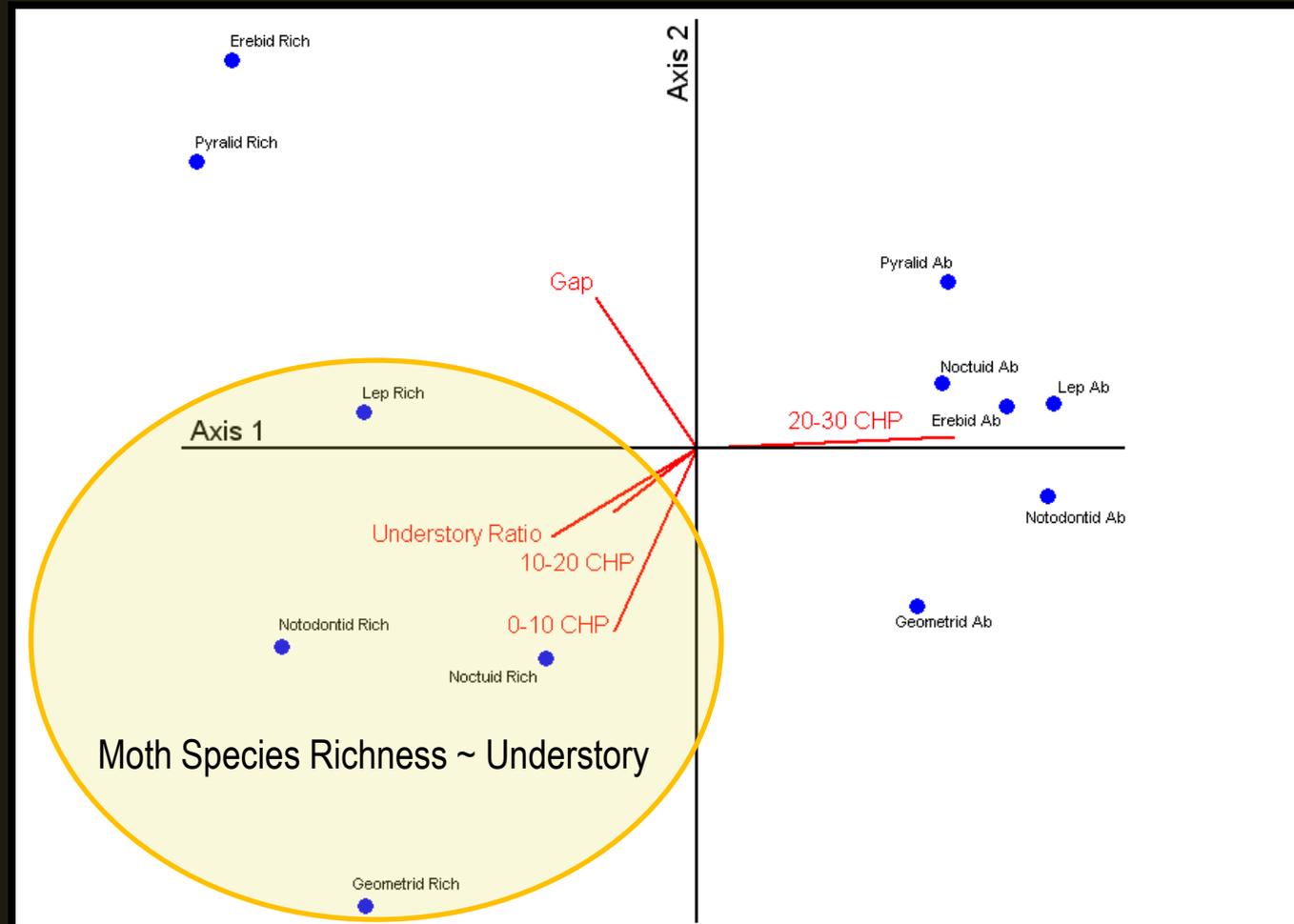
Results

Moths + LiDAR



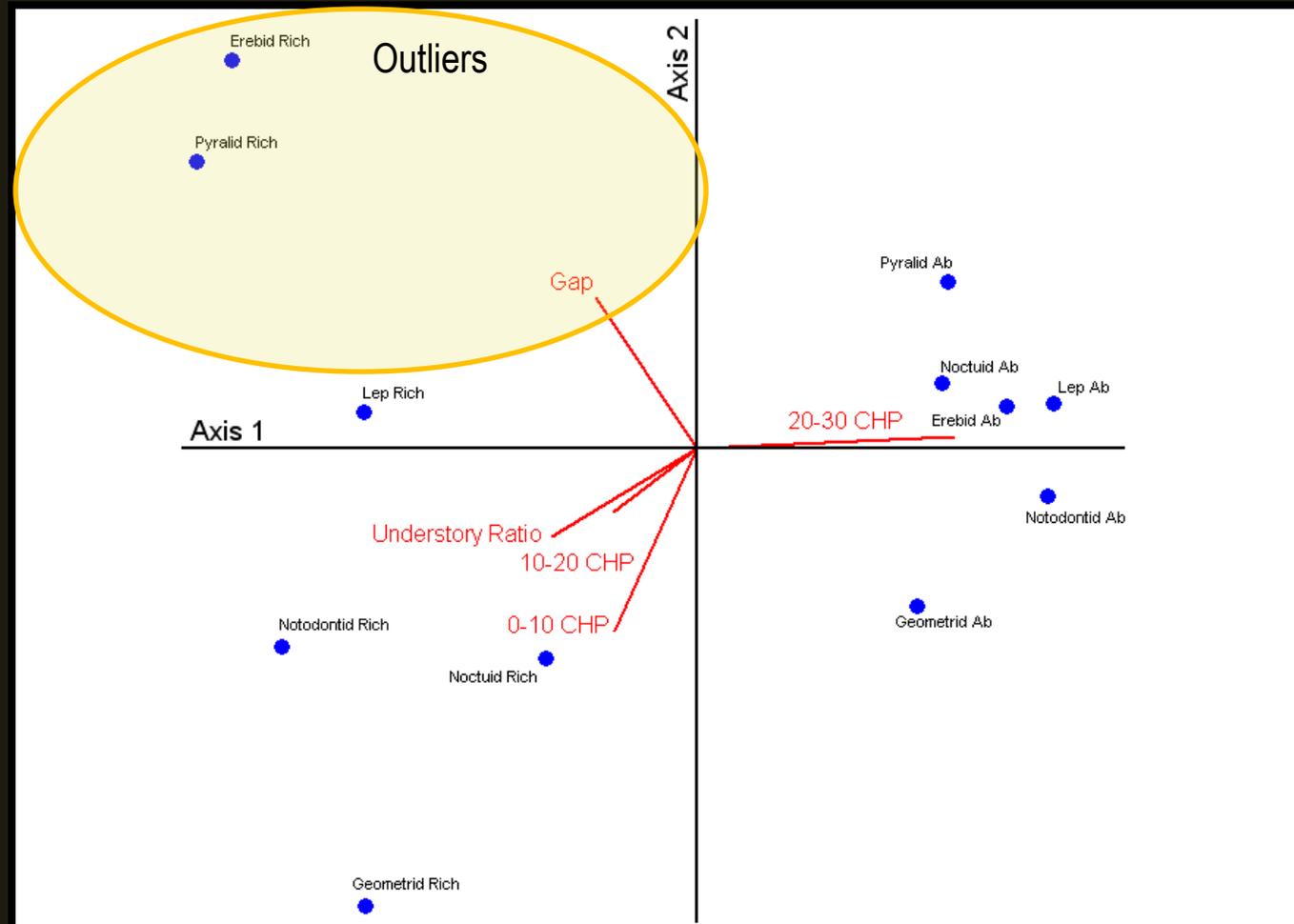
Results

Moths + LiDAR



Results

Moths + LiDAR



Discussion & Implications

- Findings to date...
 - Abundance associated with overstory (& stand age?)
 - Diversity associated with understory

Discussion & Implications

- Findings to date...
 - Abundance associated with overstory (& stand age?)
 - Diversity associated with understory
- Lep diversity driven by floral diversity in the understory
 - Riparian habitats^{1,2,3}
 - Logged upland sites³

¹Ober & Hayes. 2010. Biodivers. Conserv. 19: 761-774

²Dodd et al. 2011. J. Kansas Entomol. Soc. 84: 271-284.

³Dodd et al. 2012. Forest Ecol. Manage. 267: 262-270.

Discussion & Implications

- Findings to date...
 - Abundance associated with overstory (& stand age?)
 - Diversity associated with understory
- How does occurrence of prey mesh with the predators?
 - Habitat structure vs. prey availability^{1,2,3}
 - Harvest vs. fire

¹Morris et al. 2010. J. Wildlife Manage. 74: 26-34.

²Dodd et al. 2012. Forest Ecol. Manage. 267: 262-270.

³Muller et al. 2012. Oecologia 169: 673-684.

Thanks!

- Funding
 - Joint Fire Science Program
- NPS Personnel
 - Dr. Rick Toomey
 - Steve Thomas
 - Shannon Trimboli
- Tech Support!
 - Tracy Culbertson
 - Klint Rose
 - Jennifer Winters

