Direct and habitat effects of prescribed fire on forest bats

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BioFire
Biophysical Fire Science and Application

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

Northern RESEARCH STATION USDA Forest Service

R·I·T

1804 OHIO UNIVERSITY

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Definition:

Forest bats – bats that frequently use forests (esp. upland) for roosting and foraging

Forest Bats and fire

Fire as a risk and opportunity:

- RISK - Direct (short-term) effects of smoke and heat
  - Tree roosting bats (Apr – Oct)
    - Individuals in torpor (later)
    - Disturbance of maternity colonies
    - Flightless young (but in June, not fire season)
  - Hibernating bats (extra arousals)

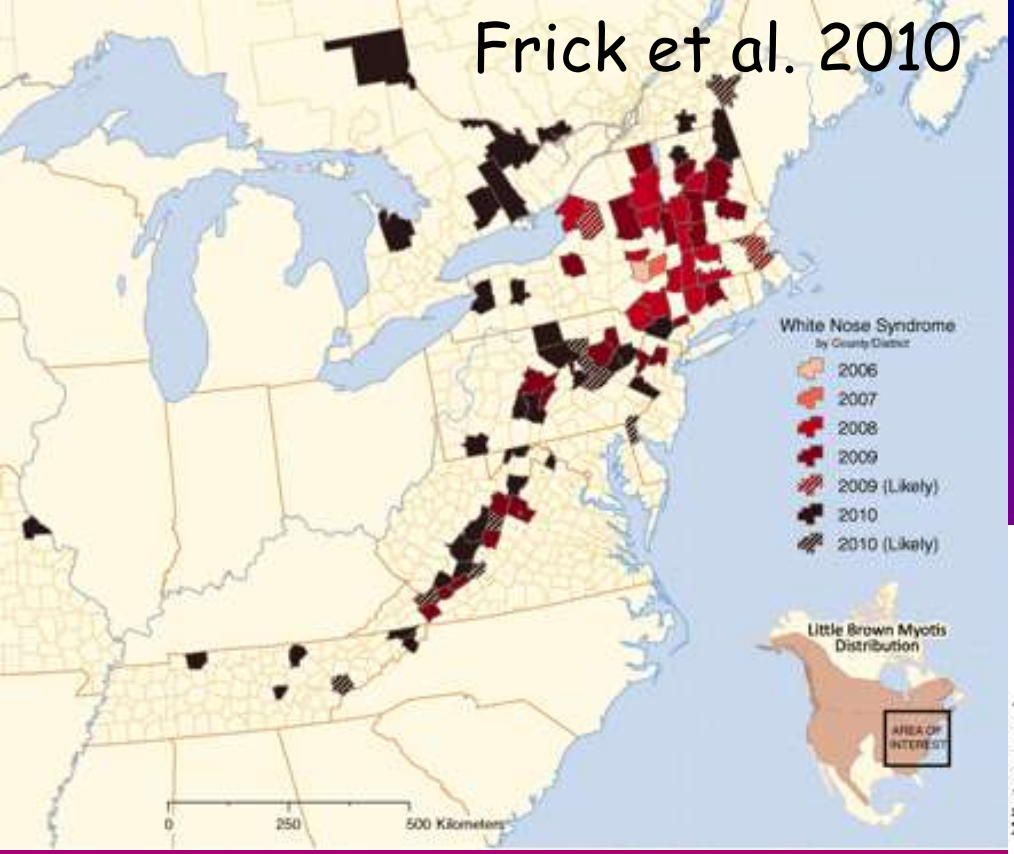
- BENEFIT - Potential (longer-term) habitat improvement
  - Foraging habitat (more prey, less clutter)
  - Roosting habitat (increased snag supply)

Currently, management is based on poor (but improving) knowledge of direct and habitat effects of fire

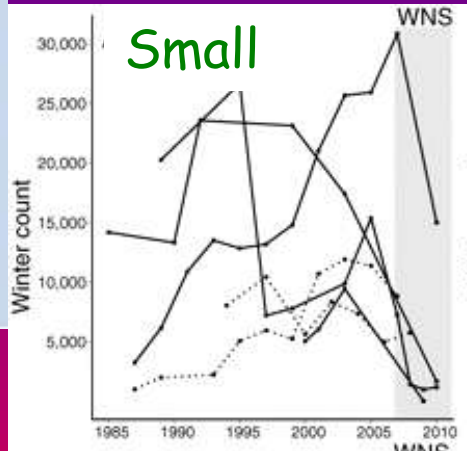
Recent or ongoing projects: Lacki et al, Lacki et al, Loeb et al, Amelon et al

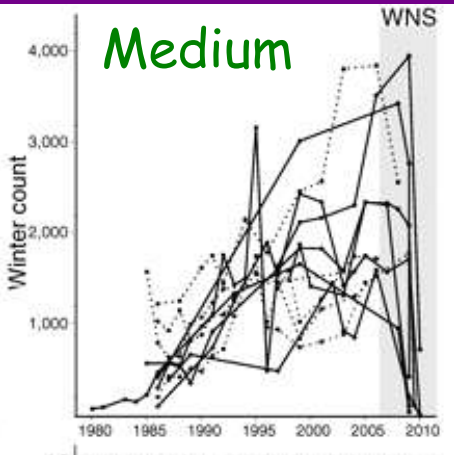
White-nose syndrome (WNS)

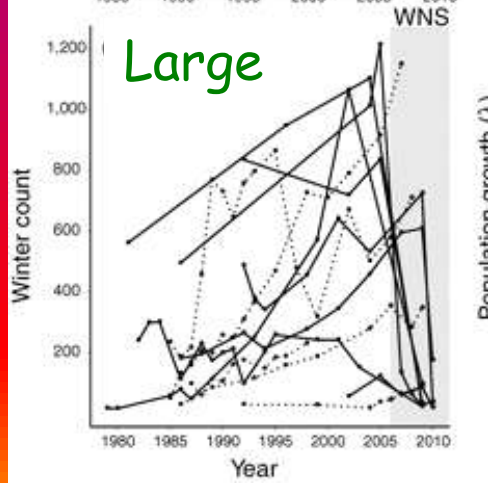
Frick et al. 2010



Little brown bat – number of hibernating bats doesn't matter







	# bats
Small	<1500
Medium	<5000
Large	>5000

Frick et al. 2010

Large bats less vulnerable than small bats?

Intersection of prescribed fire and WNS in Kentucky

	Gregarious hibernators	Tree roosting	(Upland) Forest foraging	ESA Status
Indiana bat (*Myotis, 8 g*)	Yes	3	2	Endangered
Northern long-eared bat (*Myotis, 8 g*)	Yes	2	3	Proposed
Rafinesque's big-eared bat (*Corynorhinus, 9 g*)	Yes	2	3	Not listed
Eastern pipistrelle (*Perimyotis, 6 g*)	Yes	2	1	Not listed
Little brown bat (*Myotis, 14 g*)	Yes	1	1	Not listed
Big brown bat (*Eptesicus, 18 g*)	Yes	1	1	Not listed

Intersection of prescribed fire and WNS in Kentucky

Cont.

	Gregarious hibernators	Tree roosting	(Upland) Forest foraging	ESA Status
Small footed bat (*Myotis, 6 g*)	Yes	1	1?	Proposed
Eastern red bat (*Lasiurus, 15 g*)	No	3	3	Proposed
Hoary bat (*Lasiurus, 35 g*)	No	3	3	Proposed
Silver haired bat (*Lasionycteris, 15 g*)	No	3	2	Proposed

RISKS for wildlife *vs* oak ecosystem management?

Can the tension be relieved?

Risk to wildlife ← → *Oak mgmt*

Fall Migration

tree roosting/foraging

Fall Migration

Young become Volant

flightless period

Young Born

Maternity Colony Formation

10's to 100's in aggregation

Summer habitat use

tree roosting/foraging

Summer habitat use

tree roosting/foraging

Spring Emergence & Migration

N S

Hibernation

caves & mines

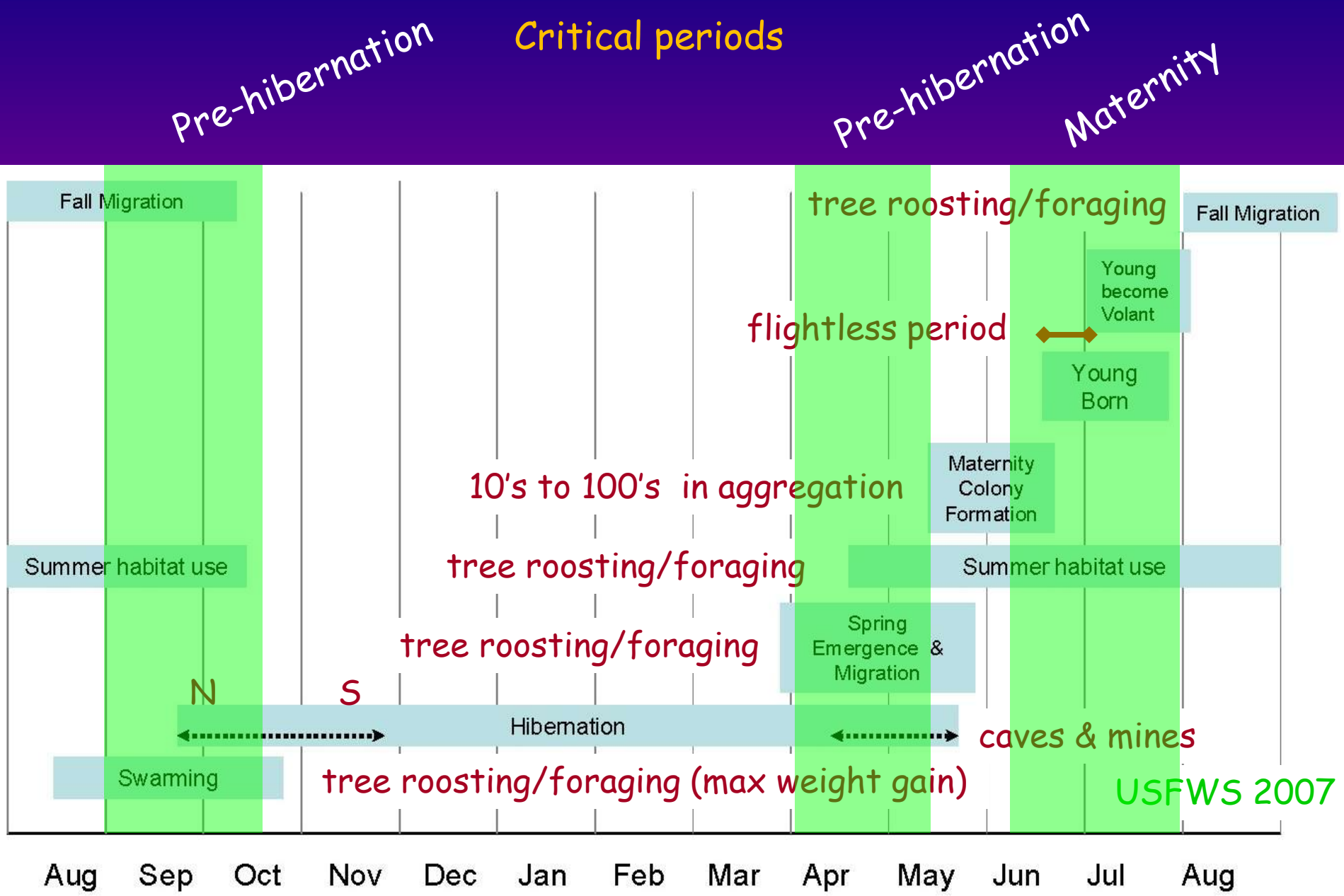
Swarming

tree roosting/foraging (max weight gain)

USFWS 2007

Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug

BENEFITS of fire to roosting and foraging habitat?



Forest Bats & Fire - Direct & Habitat Effects

Direct effects of fire
- Tree roosting & torpor
- Modeled plume effects
  - Plume temperatures
  - Gas toxicology
- Mitigating risk

Habitat effects of fire
- ~~Roosting habitat~~
- Foraging habitat
  - Prey availability
  - Canopy structure

Questions

James Kiser, USFS

Tree roosting behavior

Indiana and northern long-eared *Myotis*

Frequent roost switching

Primary (maternity) roosts (females)

Larger is better

Secondary roosts (males and females)

Other bat species:

- Foliage
- Hollow trees
- Litter

Roosting location highly uncertain

Torpor

Body temperature tracks roost temperature

Bats avoid smoke if they can, but can't fly until they arouse from torpor

Used for energy conservation:

- Male bats, regularly
- Females during poor foraging periods (cool or wet)

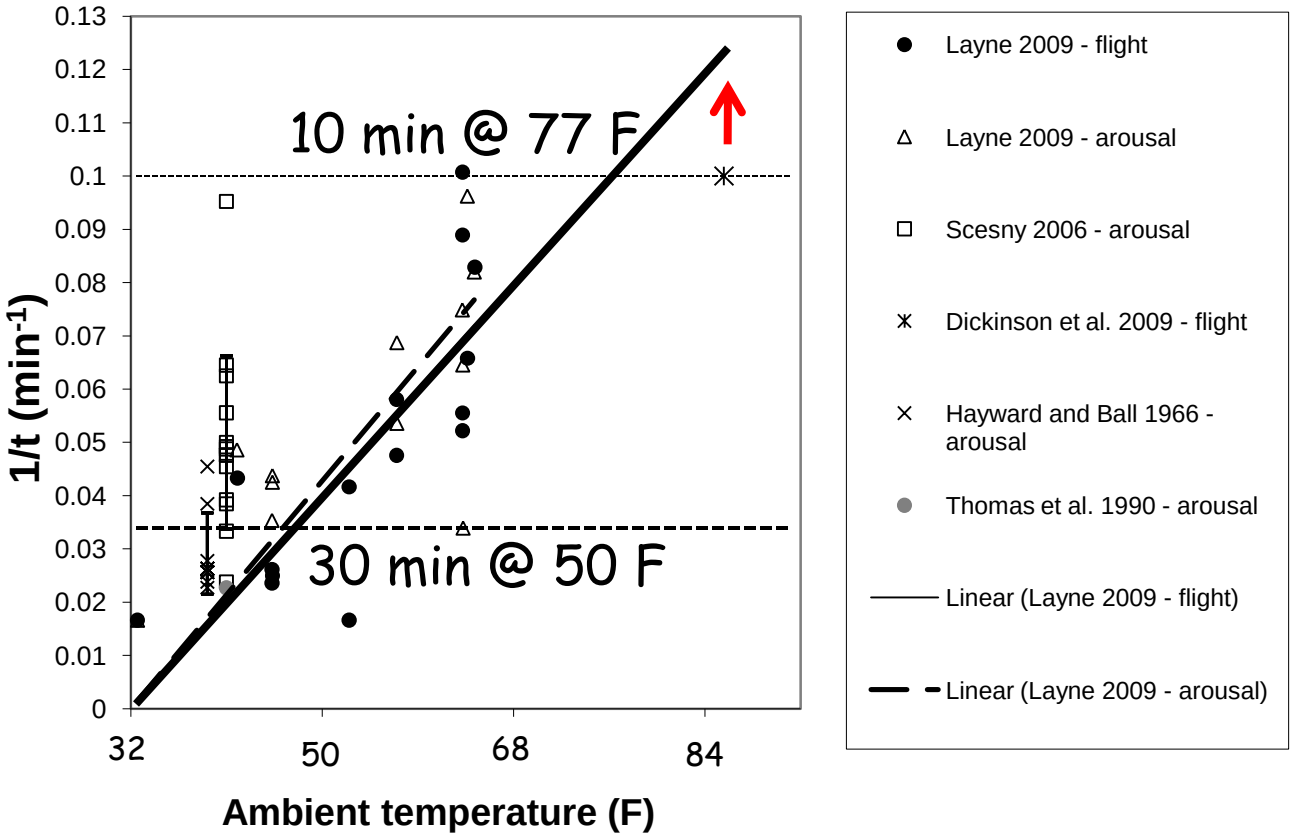
Red bat (*Lasiurus borealis*)
(JT Layne, MSU)

- Arousal cues
  - Red bats - sound and smell of fire
  - Assume other bats respond the same way

Time to arousal from torpor

- Arousal time (t) an inverse function (1/t) of body temperature
- Half an hour to <10 minutes in relevant temperature range

Increasing time



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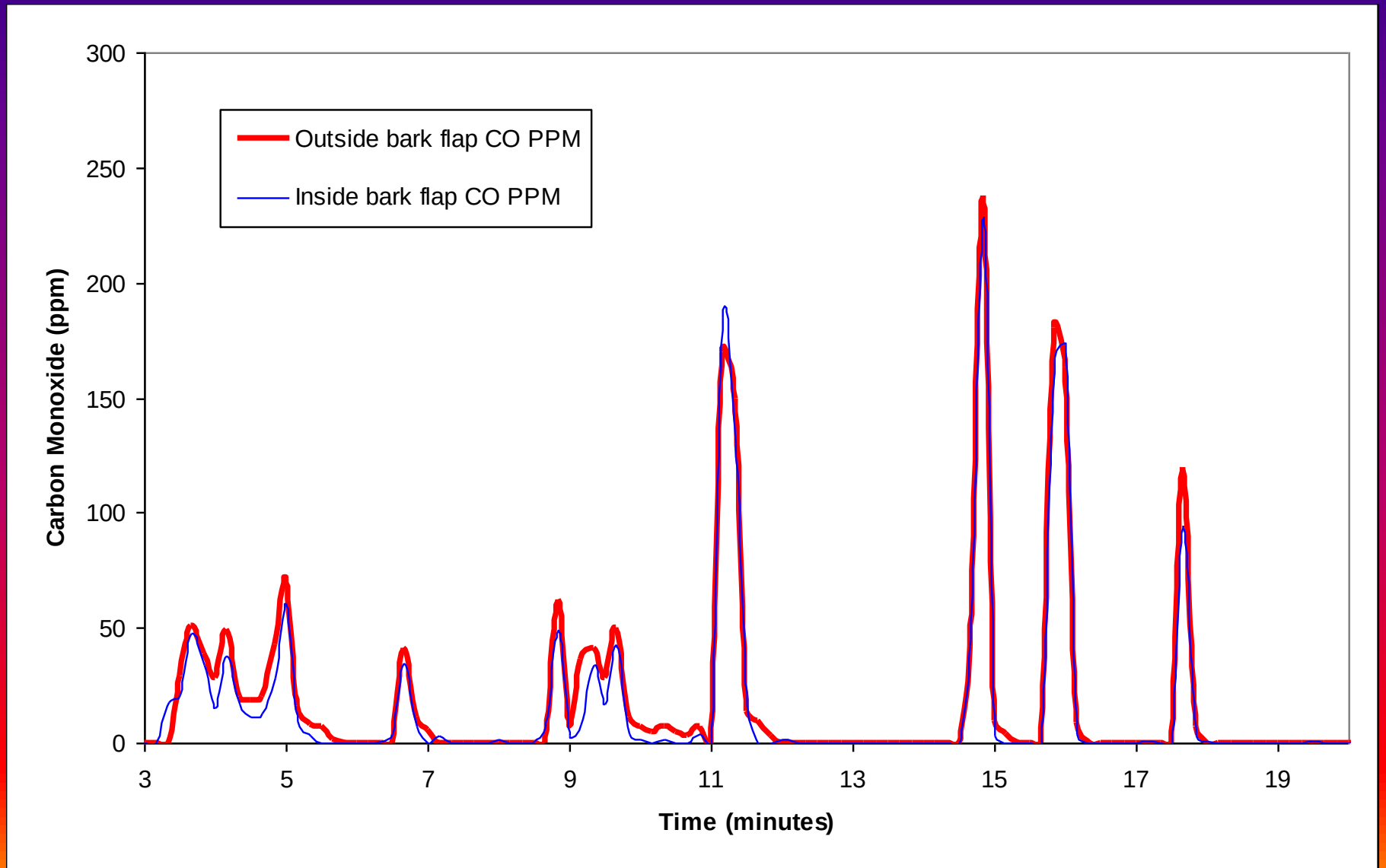
Risk from heat and gases in plume – combined function of torpor status & fire behavior

A bat in torpor would be exposed to the plume

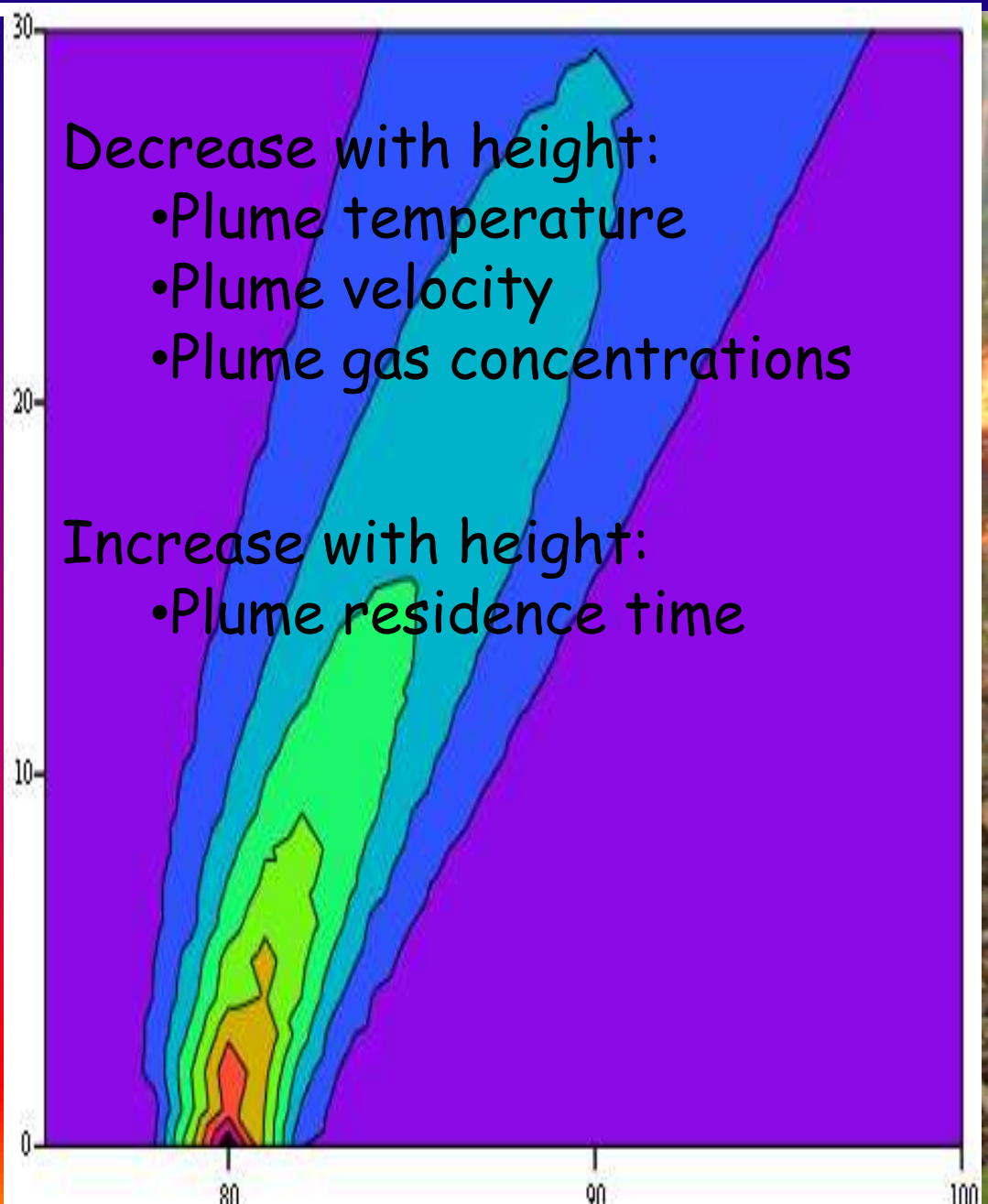
Even without torpor, fire may increase maternal stress and predation risk

Exposures below sloughing bark

Assume bats get full exposure to plume gas concentrations, temp, & velocity (conservative)



Mix of field data (OH & KY) and plume modelling



Decrease with height:

- Plume temperature
- Plume velocity
- Plume gas concentrations

Increase with height:

- Plume residence time

Indiana bat - predicted carboxyhemoglobin (COHb) concentrations during prescribed fires

- COHb – CO bound to oxygen-exchange sites, incapacitation @ 50% assumed

- **TRIVIAL**

					COHb (%)	
Site	Plot	Behavior	Code	Fireline intensity (BTU ft^{-1} s^{-1})	20 ft	8 ft
PM	9	Heading uphill	1	257	5	45
BW	Ex4	Missing	4	197		
BW	2	Missing	4	179	16	43
TH	4	Flanking across slope	3	162	7	25
TH	6	Heading across slope	1	120	1	13
PM	1	Missing	4	89	3	11
PM	8	Downhill with flanking wind	2	57	2	0
TH	1	Backing against light wind, downhill	3	37	1	2
BW	3	Missing	4	36	4	16
PM	3	Missing	4	35		
WP	25	Backing, moderate wind, downhill	3	34	0	1
TH	100	Flanking across slope	2	31	4	3
BW	1	Heading uphill	1	28	4	5
WP	20	Missing	4	27	1	6
WP	27	Missing	4	26	0	1
WP	24	Backing, light wind, downhill	3	26	0	2

Indiana bats - modeled effects of plume temperatures and velocities

Bat ears most vulnerable appendage

Plume temperatures & velocities from plume model

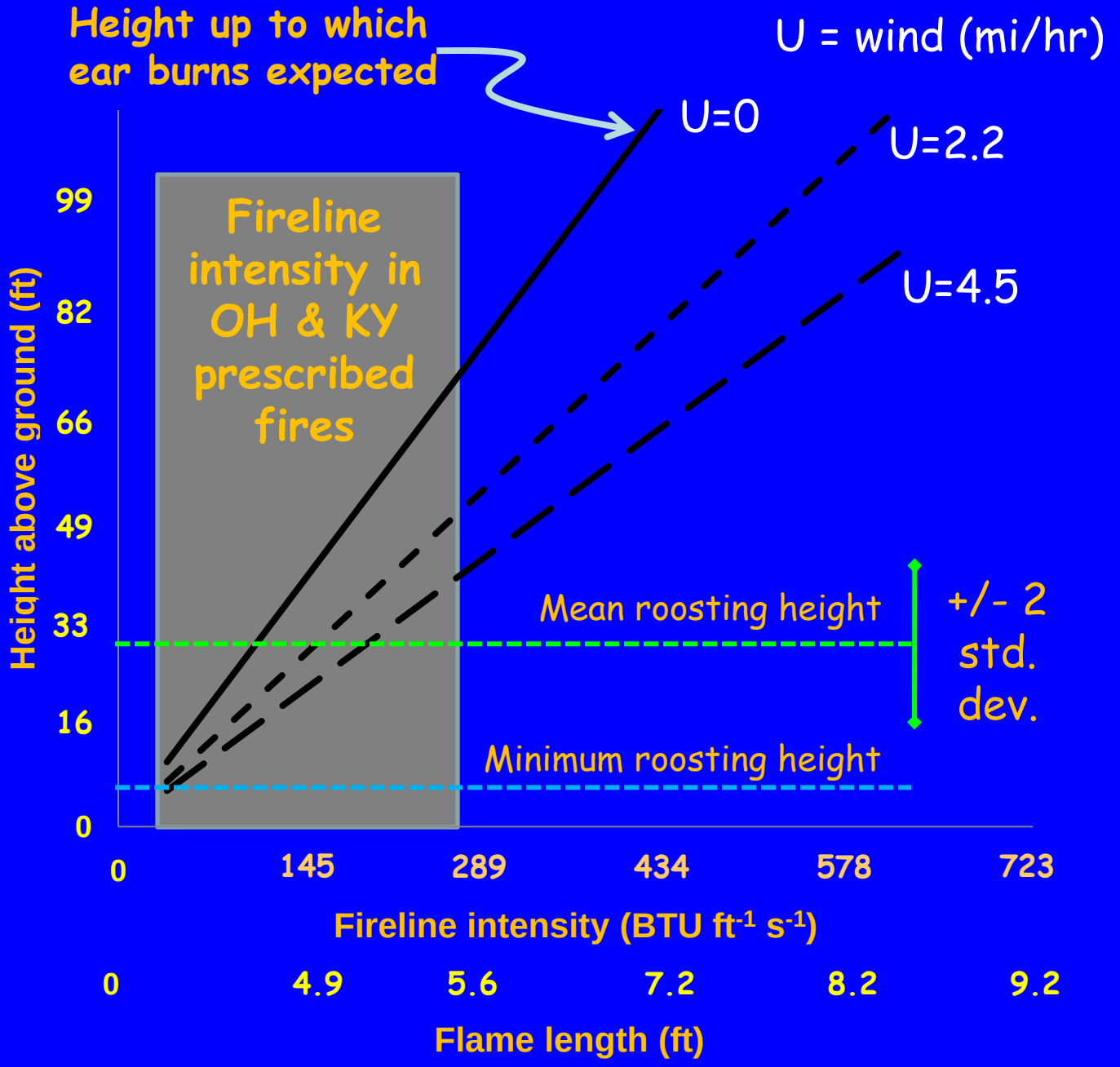
Heat transfer model assumes that ears are thermally thin and minimally insulated by hair

Indiana bats - modeled effects of plume temperature

Increase risk
- Fireline intensity

Reduce risk
- Wind
- Roost height

Rule of thumb: scorching foliage & killing twigs…



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Direct effects of fire
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- Mitigating risk

Habitat effects of fire
- ~~Roosting habitat~~
- Foraging habitat
  - Prey availability
  - Canopy structure

Questions

Mitigating risk – pre-burn surveys

If bats of concern aren't present, then OK

Mitigating risk – season of burn

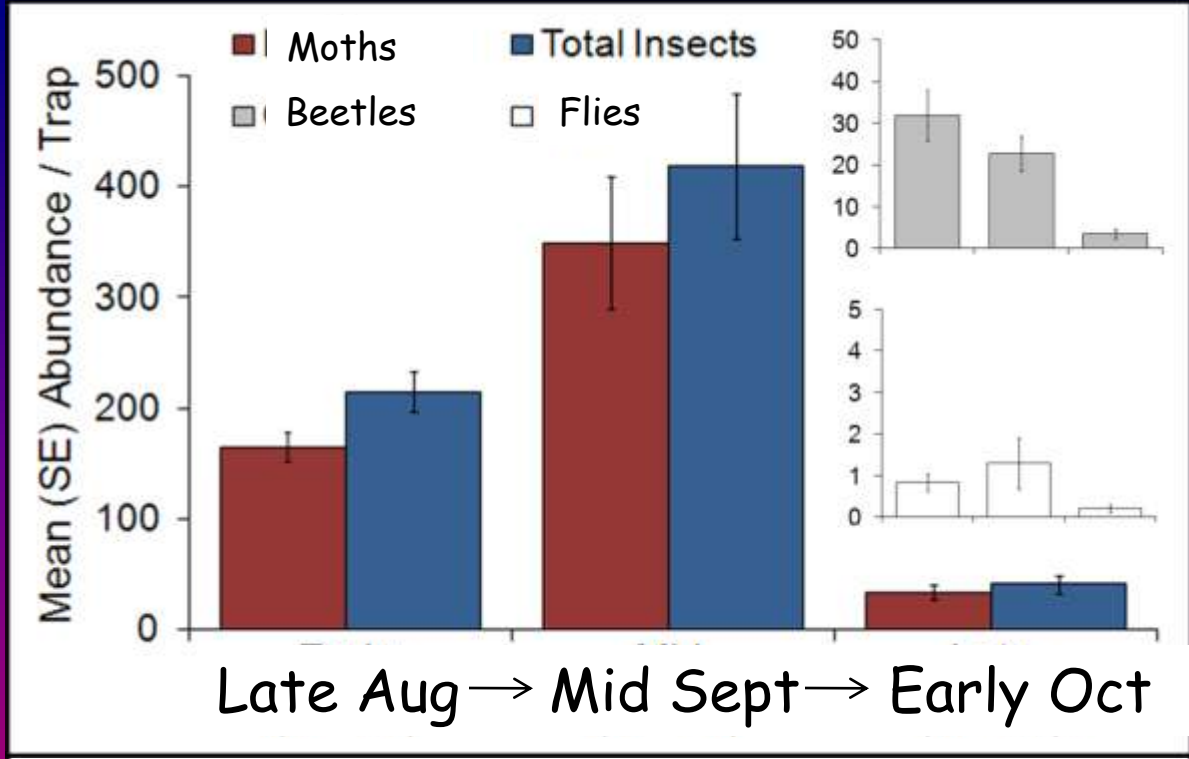
Bat nocturnal prey drop off fast

Reduced bat numbers:
- Late winter - pre-emergence
- Fall – beginning of hibernation

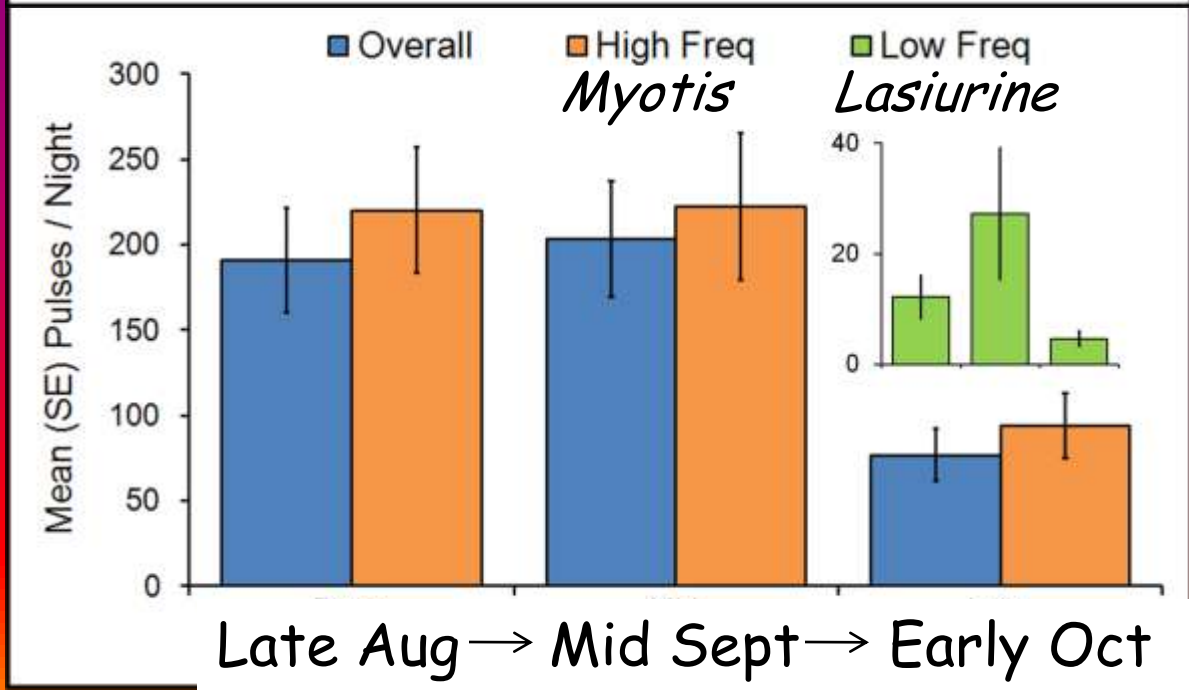
- *Myotis* - small hawking and gleaning, high freq. calls

- *Lasiurine* (red and hoary bats) - larger hawking, low freq. calls

Light traps



Echolocation (Anabat)



For tree-roosting bats, later spring is better (higher ambient temps)

Can the tension be relieved?

Risk to wildlife ← → *Oak mgmt*

Fall Migration

tree roosting/foraging

Fall Migration

Young become Volant

flightless period

Young Born

Maternity Colony Formation

10's to 100's in aggregation

Summer habitat use

tree roosting/foraging

Summer habitat use

tree roosting/foraging

Spring Emergence & Migration

N S

Hibernation

caves & mines

Swarming

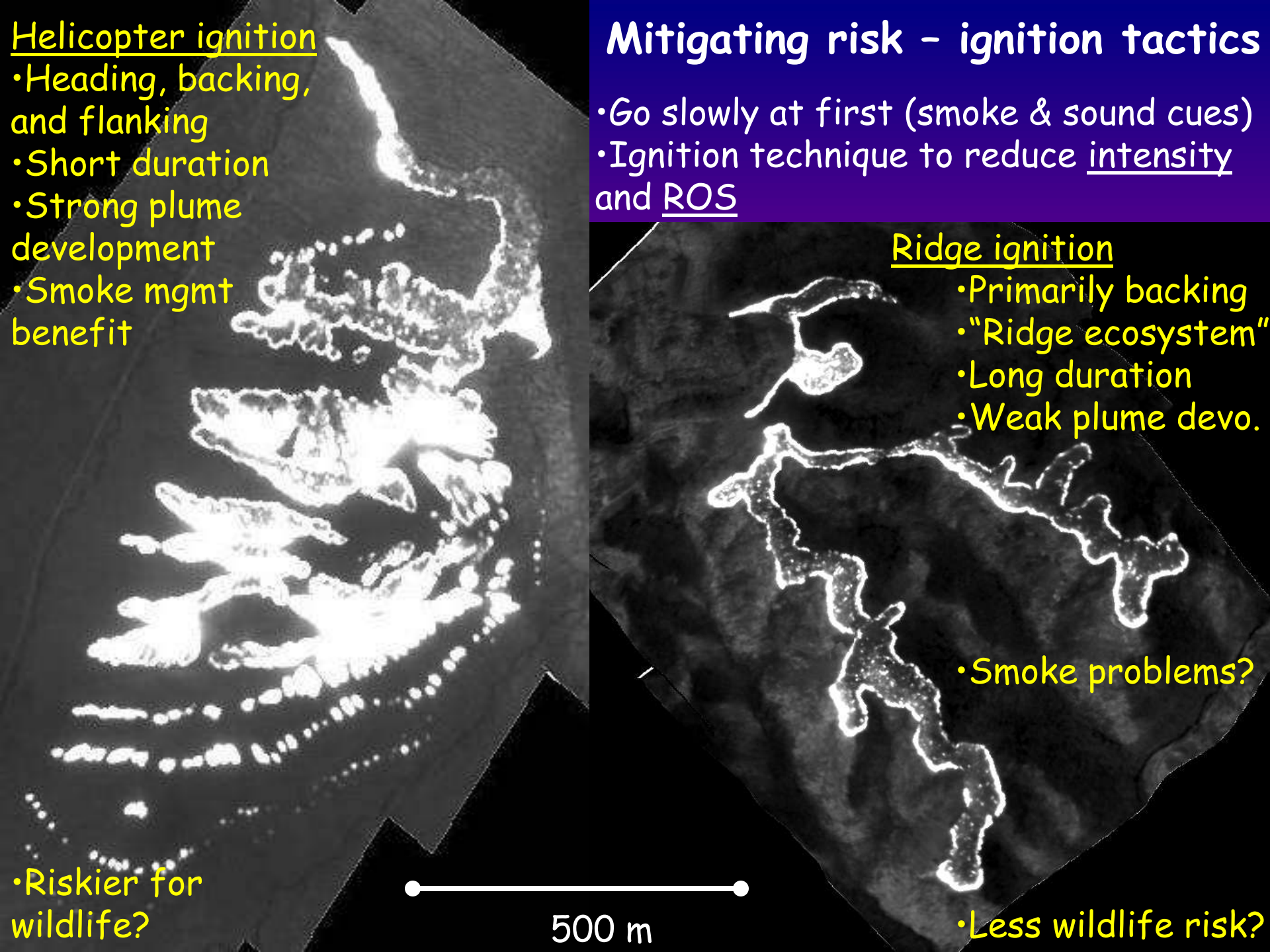
tree roosting/foraging (max weight gain)

USFWS 2007

Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug

Mitigating risk – ignition tactics

- Go slowly at first (smoke & sound cues)
- Ignition technique to reduce intensity and ROS



Mitigating risk – more and larger roost trees (esp. snags)

Roosting height increases with tree size (esp. height) – fire risk may be reduced if bats are using larger roost trees

Relationships based on published Indiana bat roosting data

	R^2	F	P
Roost Height = 0.163(TreeDiam) + 2.75	0.27	4.15	0.07
Roost Height = 0.363(TreeHeight) + 1.77	0.33	5.47	0.04

A good supply of large snags might also reduce stress of dislocation during fires and reduce predation concern

Forest Bats & Fire - Direct & Habitat Effects

Direct effects of fire
- Tree roosting & torpor
- Modeling smoke effects
  - Plume temperatures
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- Mitigating risk

Habitat effects of fire
- ~~Roosting habitat~~
- Foraging habitat

Act jointly
- Reduced "clutter"
- Prey availability

Questions

Fire and foraging habitat

Questions

- Is reduced "clutter" good?
- Do fires increase prey availability?
- How do bats respond to joint effects?

Foraging habitat – canopy "clutter"

- Hypothesis: Bats should prefer reduced canopy "clutter" because it impedes flight
  - Large bats – clear advantage of more open stands
  - *Myotis* bats – forage in and around canopies, so should benefit

- Thus: Fire should be good

Ohio Hills Ecosystem Management Study - Arch Rock Infrequent Burn

"Clutter" declines with number of fires

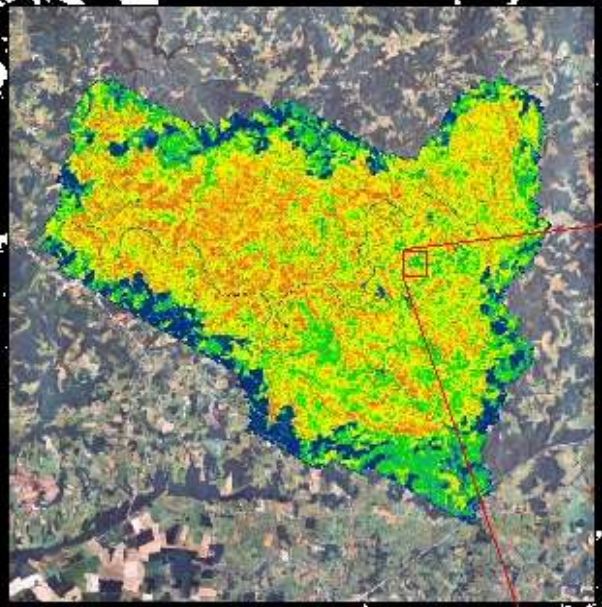
Pre-fire

Year 4, burned 2x

Year 13, burned 3x

Todd Hutchinson

Jump-start "clutter" reduction?
Prescribed fire X Ice storm disturbance



Fire and foraging habitat

Questions

- Is reduced "clutter" good?
- Do fires increase prey availability?
- How do bats respond to joint effects?

Two case studies

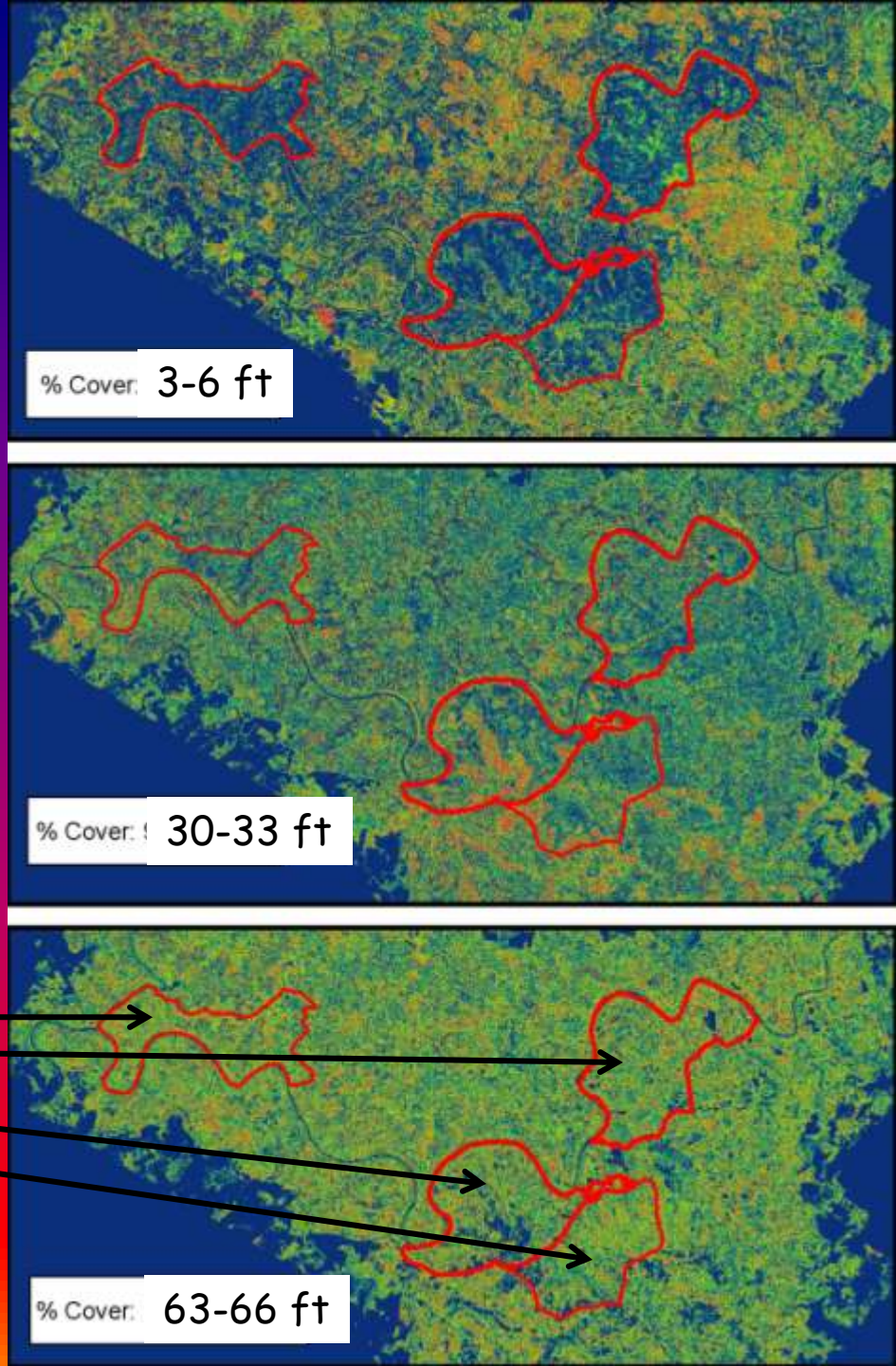
- Mammoth Cave National Park (MACA)
- DBNF (Bear Waller)

MACA – prey abundance and bat habitat usage

Vegetation structure from LiDAR

Data from 2009 and 2010 fires (first entry) and adjacent areas

~1000 acre burn blocks, internally consistent

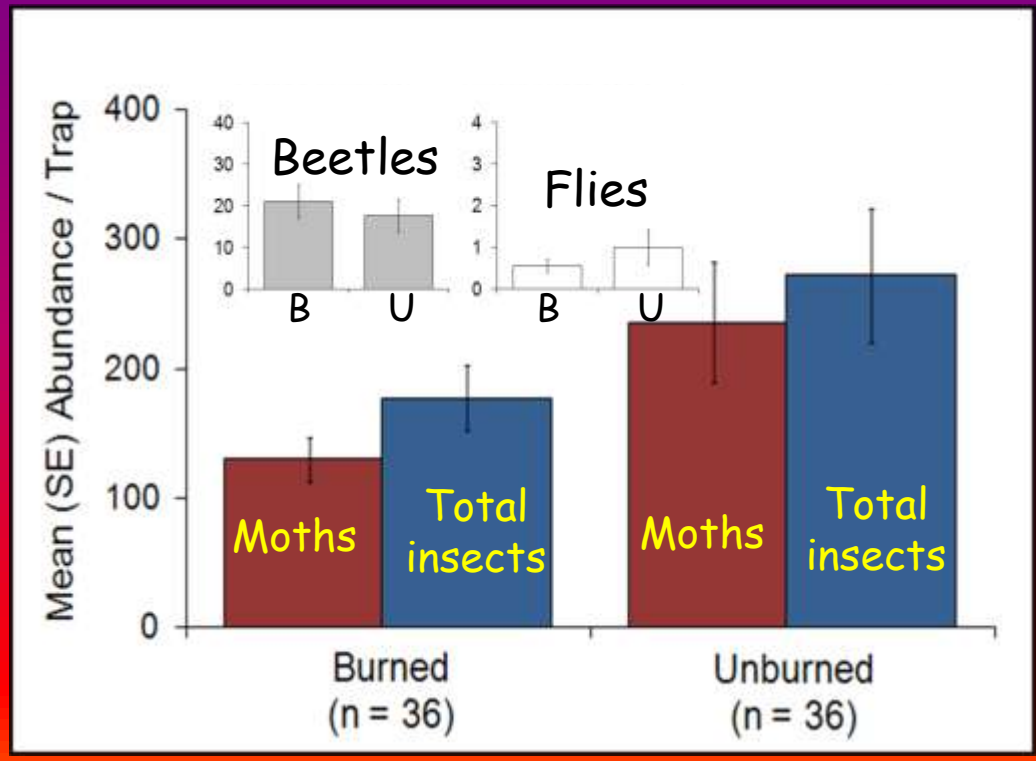


MACA – prey abundance

- In progress (Lacki et al.)
- Preliminary & short-term results

Late summer and fall after spring fire (<1 year postfire)

Light trap

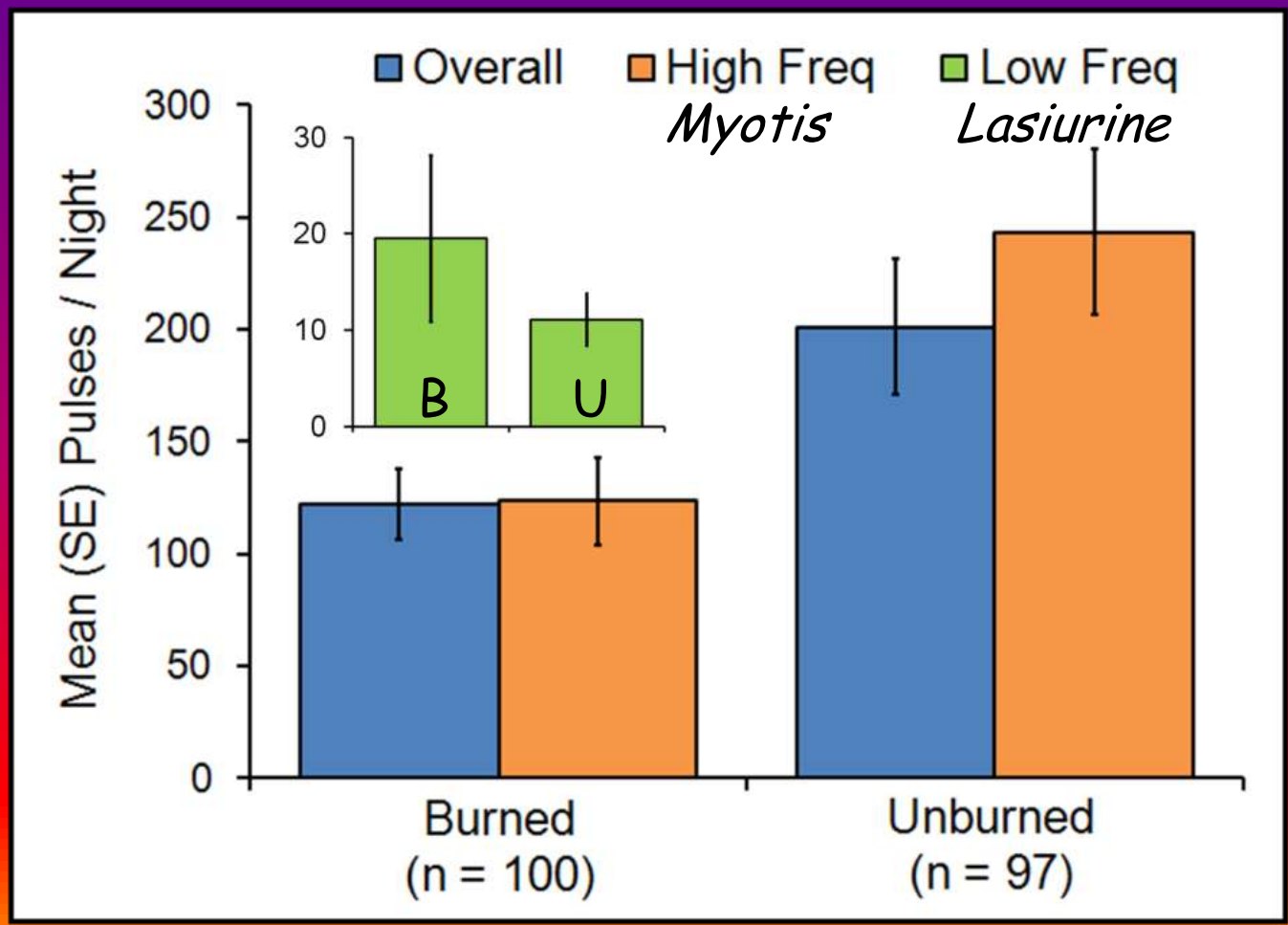


MACA – bat habitat usage

- Are *Myotis* bats preferentially using unburned sites because of higher moth abundance?
- *Myotis* bats not hindered by "clutter"?
- *Lasiurine* bats perhaps preferring burned sites

Late summer and fall after spring fire (<1 year postfire)

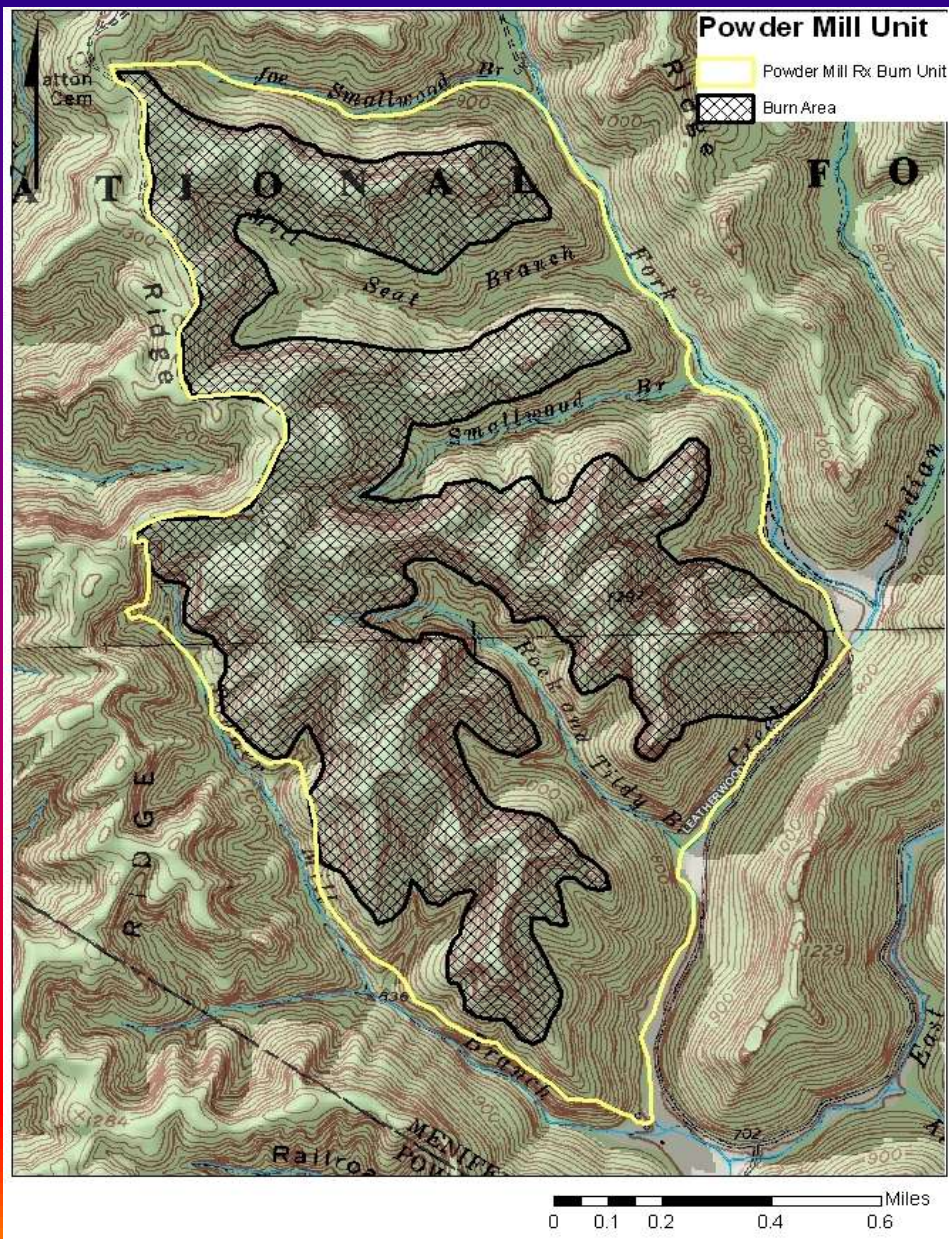
Echolocation (Anabat)



DBNF – prey abundance

- DBNF study on fire, prey, foraging, and roosting (Lacki et al. 2009)
- Somewhat contrasting results
- Again, <1 yr postfire

DBNF Ridge Ignition burn pattern



DBNF – prey abundance

Increase in newly dead wood-using insects

Overall increase in prey abundance

	All insects	Beetles	Moths	Flies
Preburn (N=43)	140	8.0	126	1.0
Postburn (N=84)	188	24.3	154	2.4
F-stat (P-value)	4.1 (0.04)	20.3 (0.001)	0.3 (0.6)	12.2 (0.001)

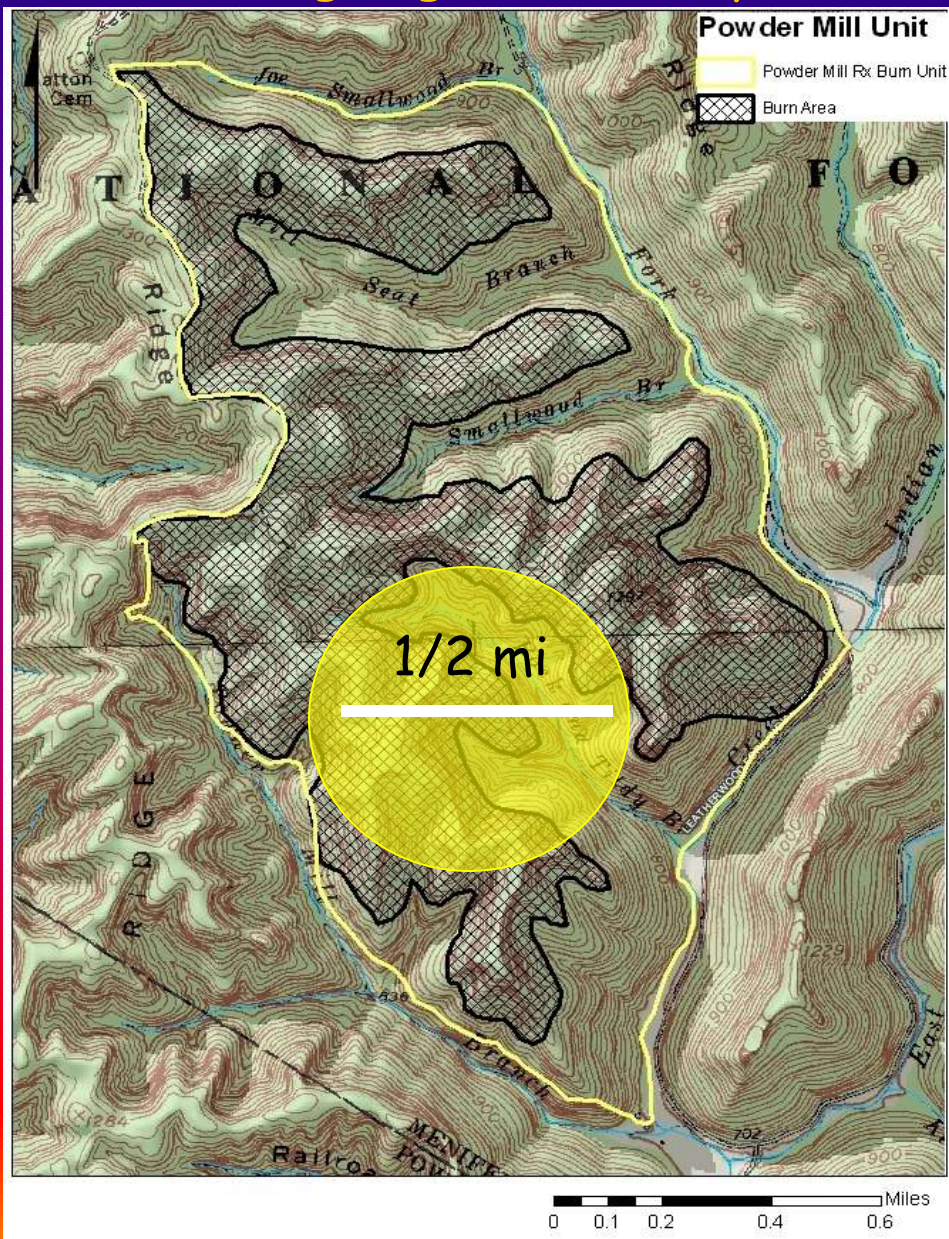
DBNF – roosting and foraging

DBNF study on fire, prey, foraging, and roosting (Lacki et al. 2009).

<u>Roosting and foraging ranges unchanged</u> (over days and months) for northern long-eared bat (*Myotis septentrionalis*)

Approximate northern bat home range size

DBNF Ridge Ignition burn pattern



Fire & foraging habitat

MACA

- Regular-shaped burn blocks
- Reduced moth abundance <1 yr postfire
- *Myotis* bats prefer unburned sites
- *Lasiurine* bats may prefer burned sites

DBNF

- Highly irregular burn pattern
- Increased dead-wood insect abundances
- Little effect on *Myotis septentrinoalis* foraging and roosting

Questions / Answers

- Is reduced "clutter" good?
  - *Lasiurine* – yes
  - *Myotis* may not care]
- Do fires increase prey availability?
  - Landscape context important
  - Short *vs* long-term effects]
- How do bats respond to joint effects?
  - *Lasiurine* – positive / *Myotis* – *positive and negative*
  - Change with time-since-fire & # burns

Indiana (and Other) Bats & Fire - Direct & Habitat Effects

Life history, conservation, & fire ← Numbers going down (WNS) More ESA listings?

Direct effects of fire
- Tree roosting & torpor ← Arouse more quickly in warmer temps (& w/fire cues)
- Modeled smoke effects
  - Gas toxicology ← Irrelevant
  - Plume temperatures ← If you're scorching foliage…
- Mitigating risk ← Survey, ignition tactics, season, large roosts

Habitat effects of fire
- Roosting habitat ← More large snags with sloughing bark
- Foraging habitat
  - Canopy structure ← "Clutter" for Lasiurine, not for *Myotis*
  - Prey availability ← Wood-using beetles and flies *vs* moths

Habitat heterogeneity at landscape scale for bat conservation

Some papers

•Dickinson, M. B., Lacki, M. J., Cox, D. R. 2009. Fire and the endangered Indiana bat. In: T. Hutchinson, ed., Proceedings of the Fire in Eastern Oak Forests Conference. USFS, Northern Research Station, GTR-NRS-P-46.

•Lacki, M. J., Cox, D. R., and Dickinson, M. B. 2009. Meta-analysis of summer roosting characteristics of two species of *Myotis* bats. American Midland Naturalist.

•Lacki, M. J., Cox, D. R., Dodd, L. E., and Dickinson, M. B. 2009. Response of northern bats (*Myotis septentrionalis*) to prescribed fires in eastern Kentucky forests. Journal of Mammalogy.

•Dickinson et al. 2010. Modeled effects of forest fire smoke on tree roosting bats . Canadian Journal of Forest Research.

•Ongoing project at Mammoth Cave National Park (JFSP)

Northern Research Station
USDA Forest Service

Joint Fire Science Program

nfp National Fire Plan

Acknowledgements

Partners at DBNF who helped us get data on smoke and bats

- EJ Bunzendahl
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- Chris Owens
- Fire crews
- Others (GIS support, etc.)

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Joint Fire Science Program

Ohio Department of Natural Resources for working with us on burn monitoring

- Mike Bowden
- Bob Boyles
- Fire crews
- Others (GIS support, etc.)

nfp National Fire Plan

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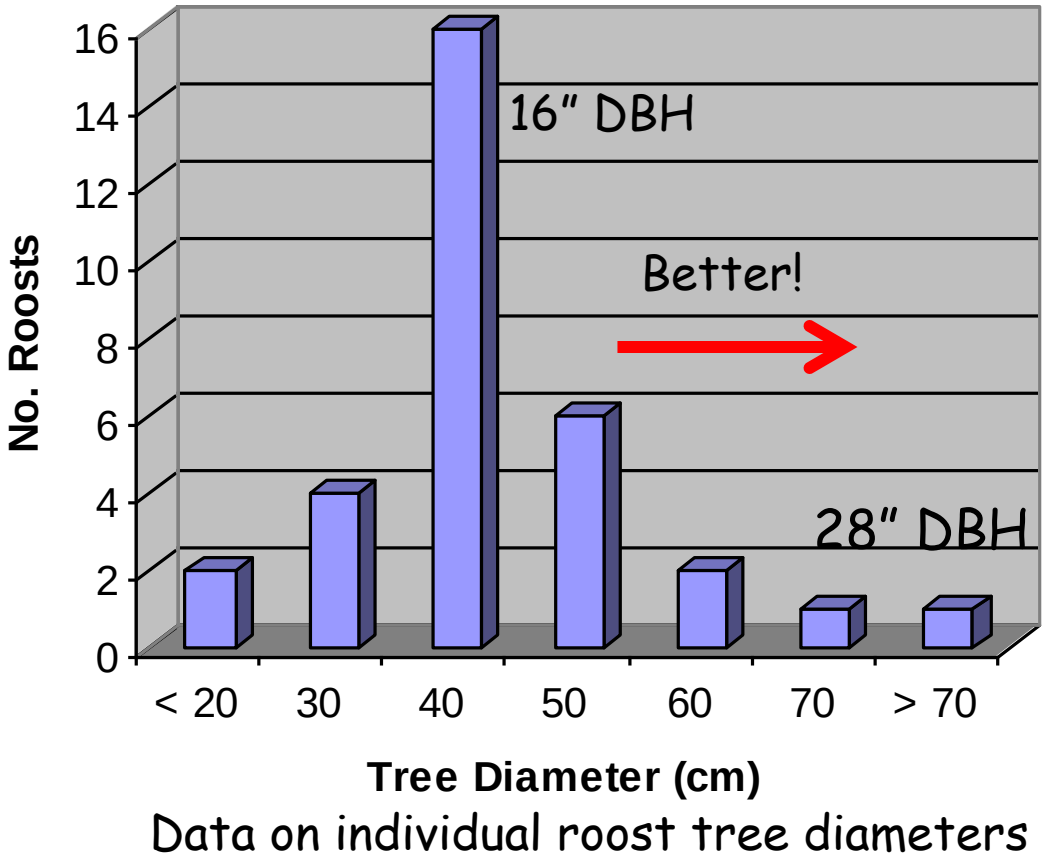
Discussion

Roosting habitat - roost size

Goal:
Enough large live trees on landscapes to provide sustainable supply of large snags at adequate density

Snag demography poorly known: fires create and destroy

Snags bats use cannot be construed as ideal (esp. for maternity habitat)



Data on individual roost tree diameters

Sampling within 1-2 years of harvest

Marne A. Titchenell, Roger A. Williams, Stanley D. Gehrt. 2011. Bat response to shelterwood harvests and forest structure in oak-hickory forests. Forest Ecology and Management 262, 980–988

- Large bats preferred harvested sites
- *Myotis* bats showed no preference

Luke E. Dodd, Michael J. Lacki, Eric R. Britzke, David A. Buehler, Patrick D. Keyser, Jeffrey L. Larkin, Amanda D. Rodewald, T. Bently Wigley, Petra B. Wood, and Lynne K. Rieske. 2011. Forest structure affects trophic linkages: how silvicultural disturbance impacts bats and their insect prey. Forest Ecology and Management, in review.

- Moths more abundant in unharvested
- Fly (diptera) abundance greater in harvested
- All bat groups (*Lasiurine* & *Myotis*) preferred harvested