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science for a changing world

Decline of the Karner blue butterfly

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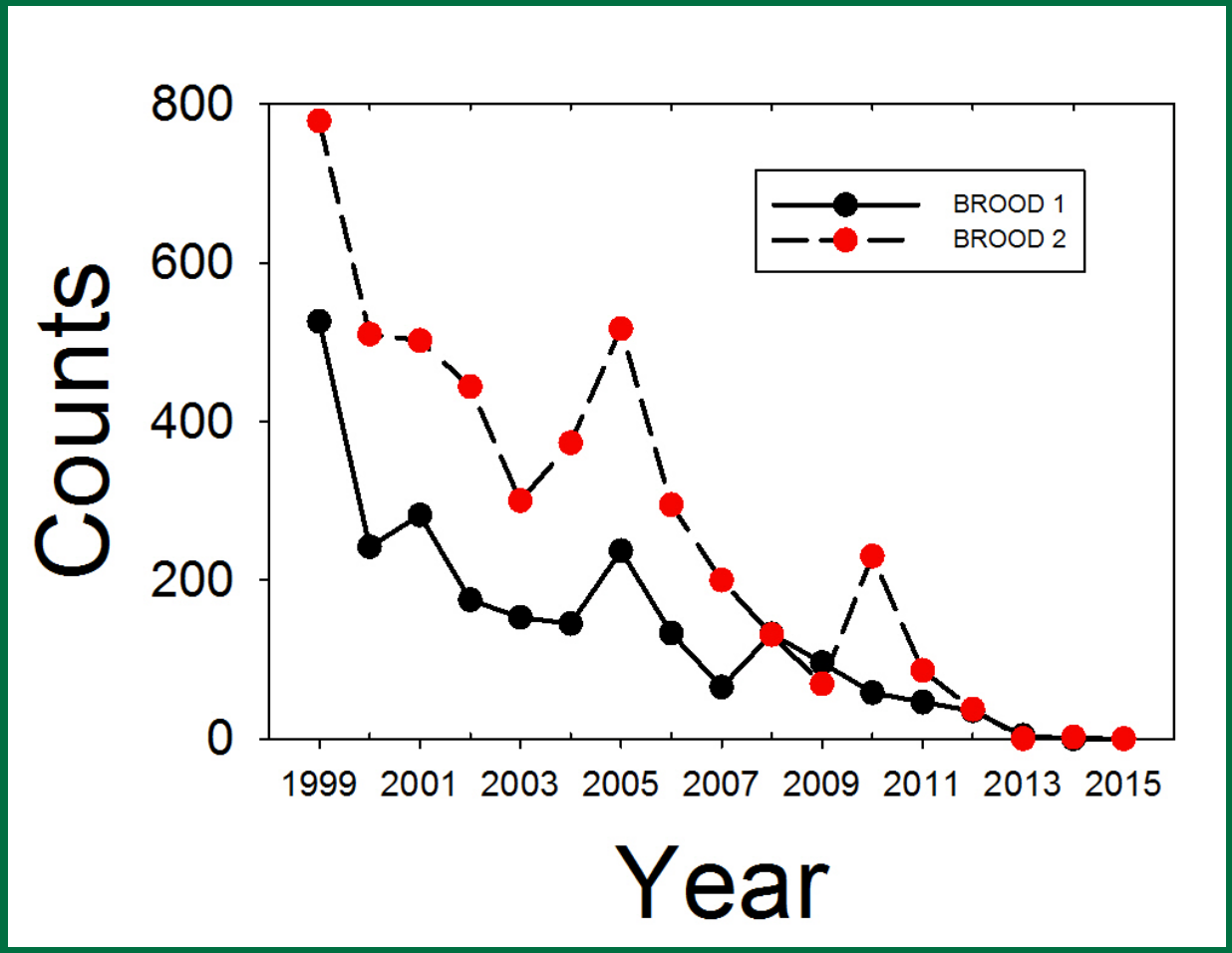
Karner blue counts by year and brood at Indiana Dunes National Lakeshore – What Happened?



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NPS Activities to Aid the Karner blue Decline despite much management

- Thinned over 1020 acres to achieve or maintain oak savanna cover in the last 20 years (INDU = 16,000 acres)
- Maintenance level for invasive plant control for roughly 1440 acres of Karner blue butterfly (Kbb) habitat.

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NPS Activities to Aid the Karner blue

- Goal was to burn Kbb habitat on a 3-4 year rotation
- US Fish and Wildlife Service mandated to:
  - Divide larger Karner occupied burn units into subunits
  - Not burn contiguous subunits in consecutive years
  - Retain “refugia” within burn units
  - Cease burning if # Kbb were < 65% of original

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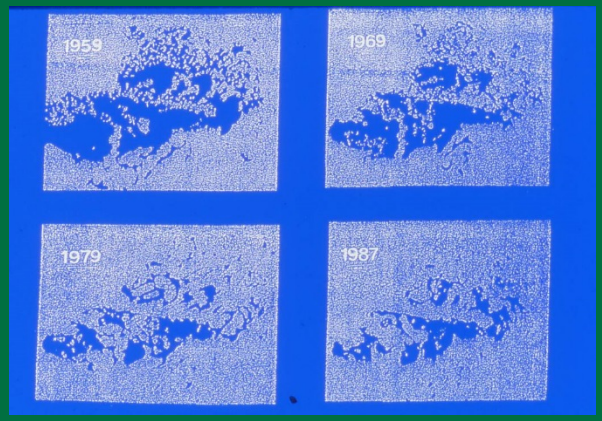
The irony of prescribed fire and the Karner blue butterfly

- The primary habitat occupied by the Karner blue is fire dependent and degrades with long term fire suppression
- Fire kills Karner blues



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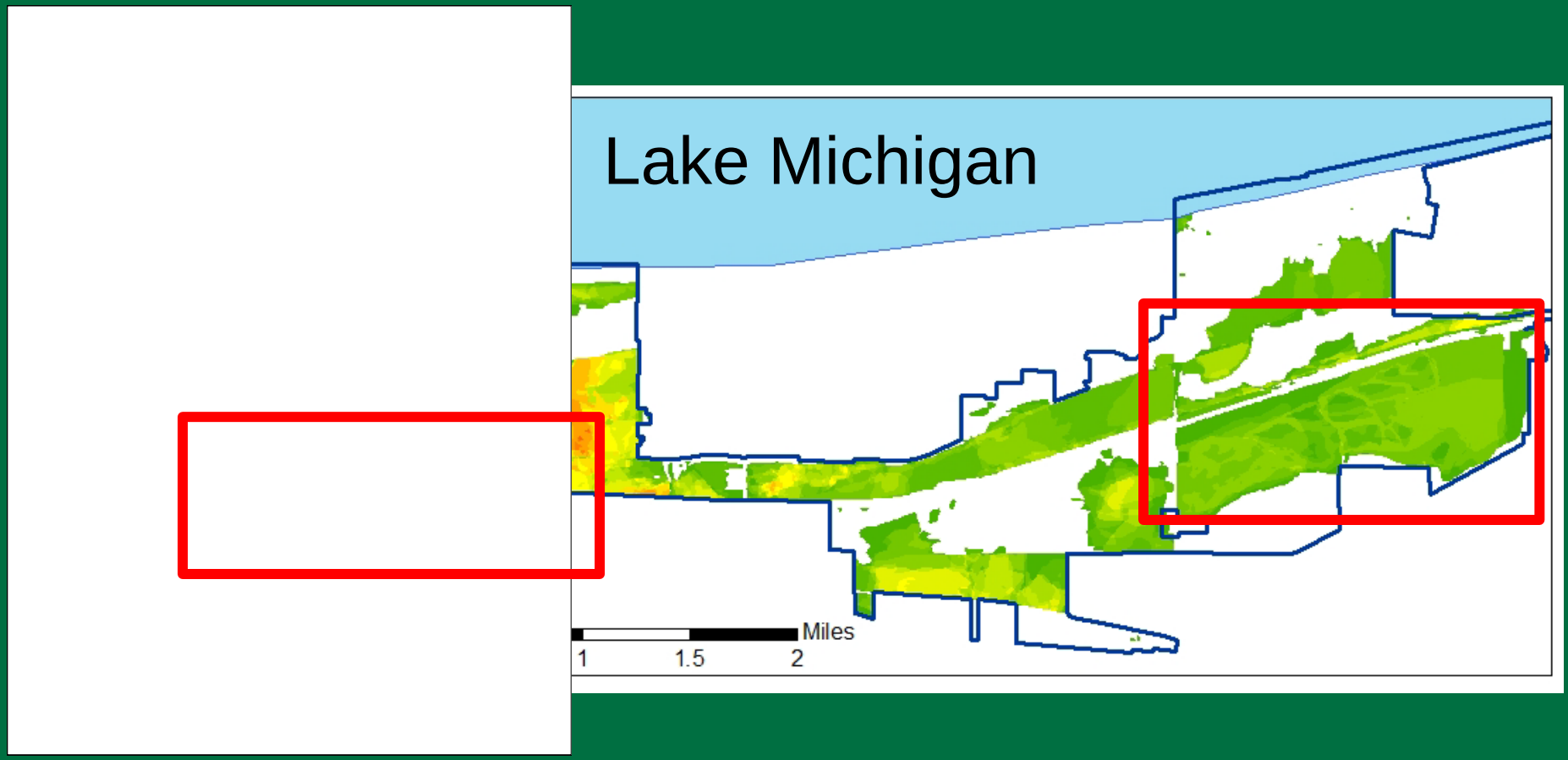
Indiana Dunes fire frequency 1979-2012
Up to 13 fires in 33 years



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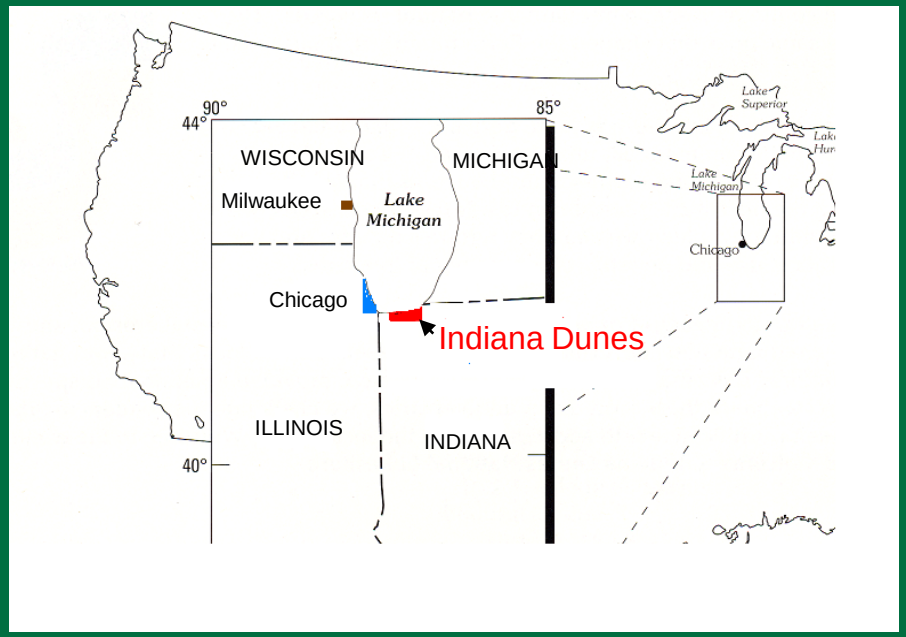
Indiana Dunes > 1100 native plant species



Prairies
Oak savannas
Woodlands
Scrublands
Forests

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Prairie-Forest Transition Zone

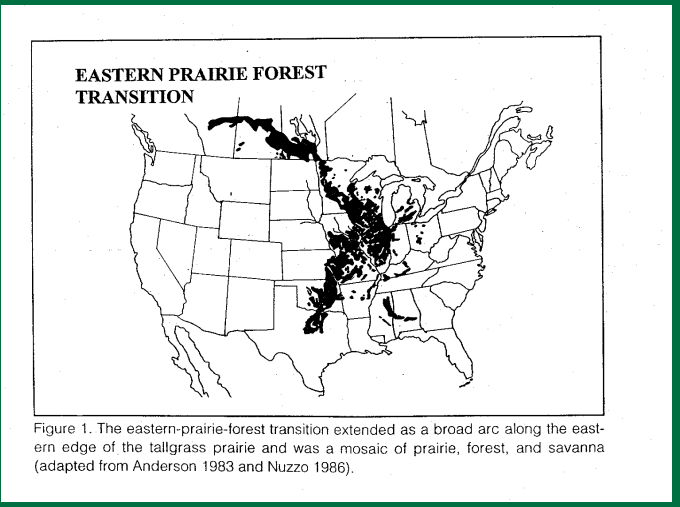
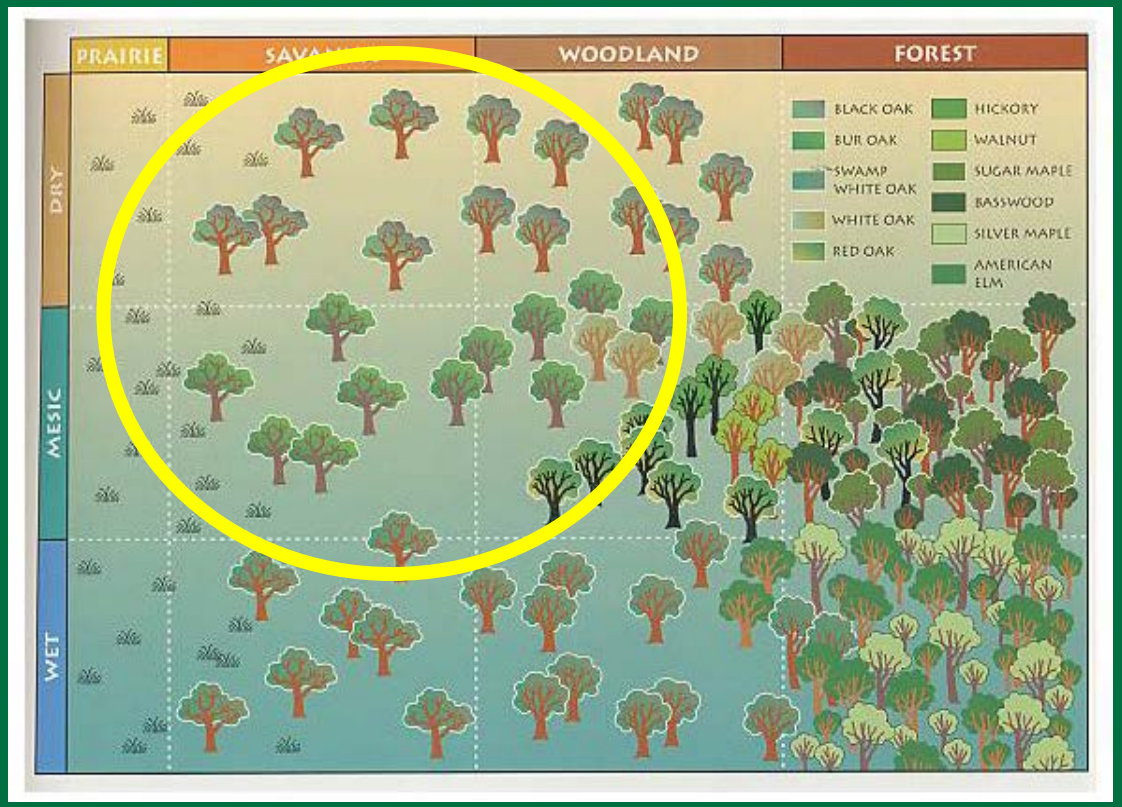


Figure 1. The eastern-prairie-forest transition extended as a broad arc along the eastern edge of the tallgrass prairie and was a mosaic of prairie, forest, and savanna (adapted from Anderson 1983 and Nuzzo 1986).



From: ***Chicago Wilderness: An Atlas of Biodiversity***

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Habitat Loss

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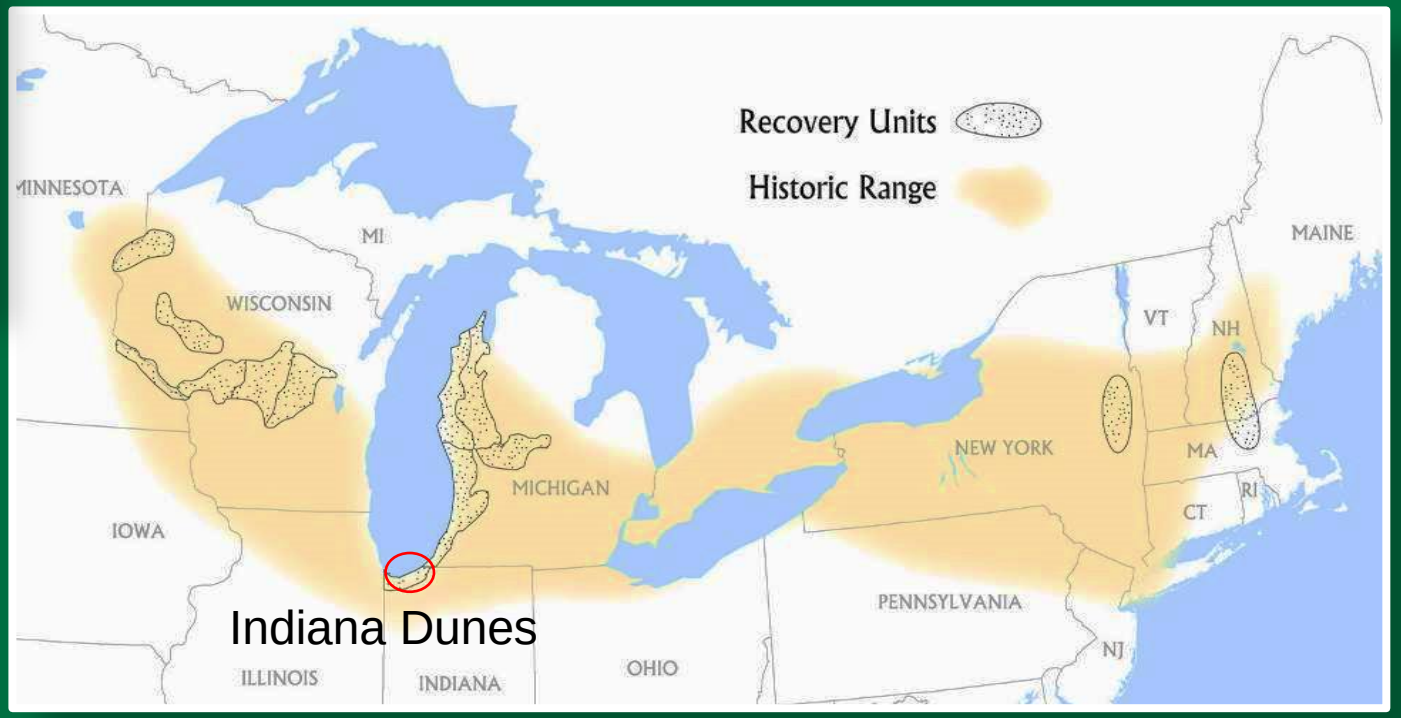
Karner blue butterfly
Lycaeides melissa samuelis

- Federally endangered
- Lupine specialist (*Lupinus perennis*)
- Historic range: NH/ME to MN
- Extirpated in IL, MA, NJ, PA, ME, Ontario, MN in 2012 ?, IN in 2014?



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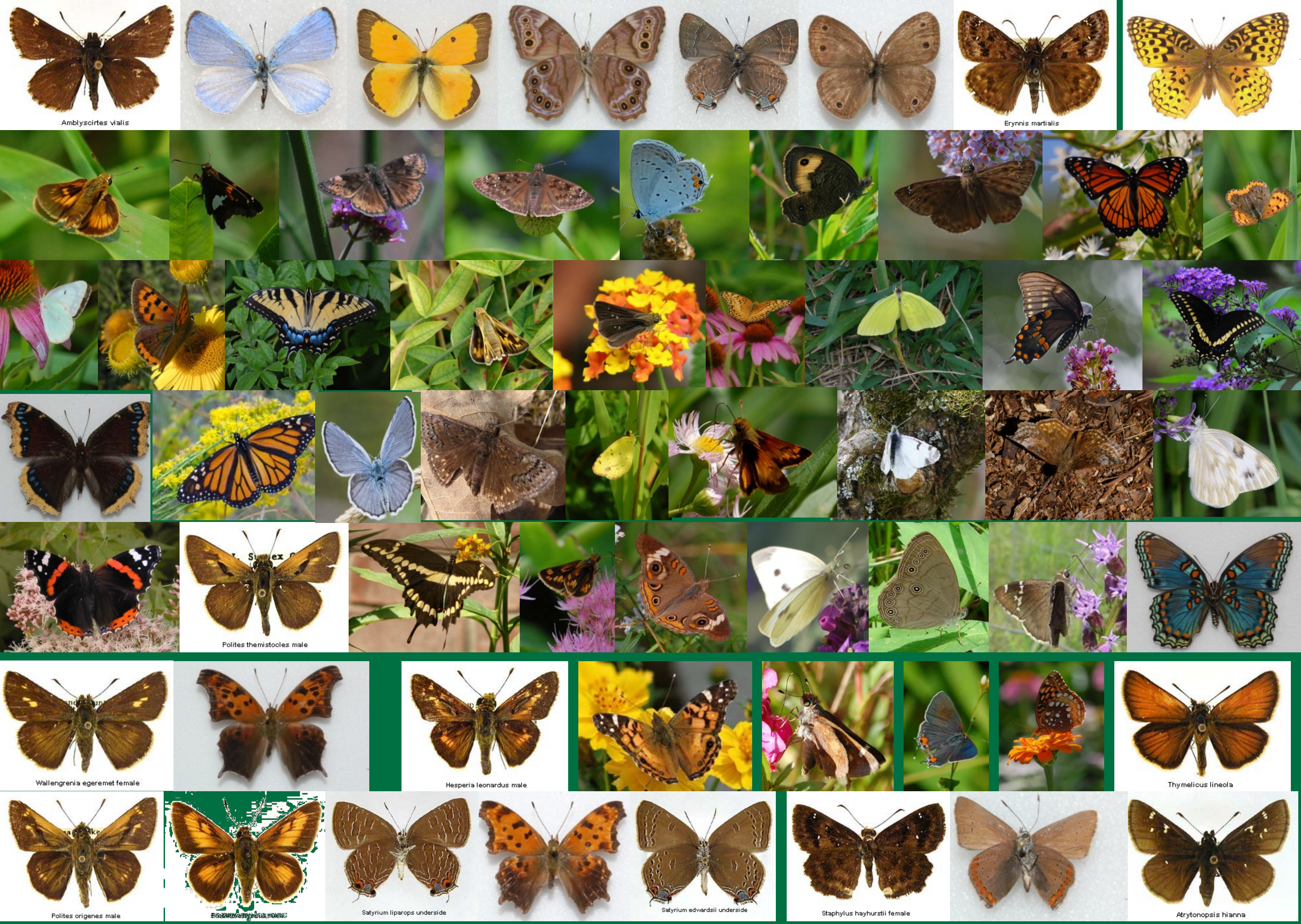
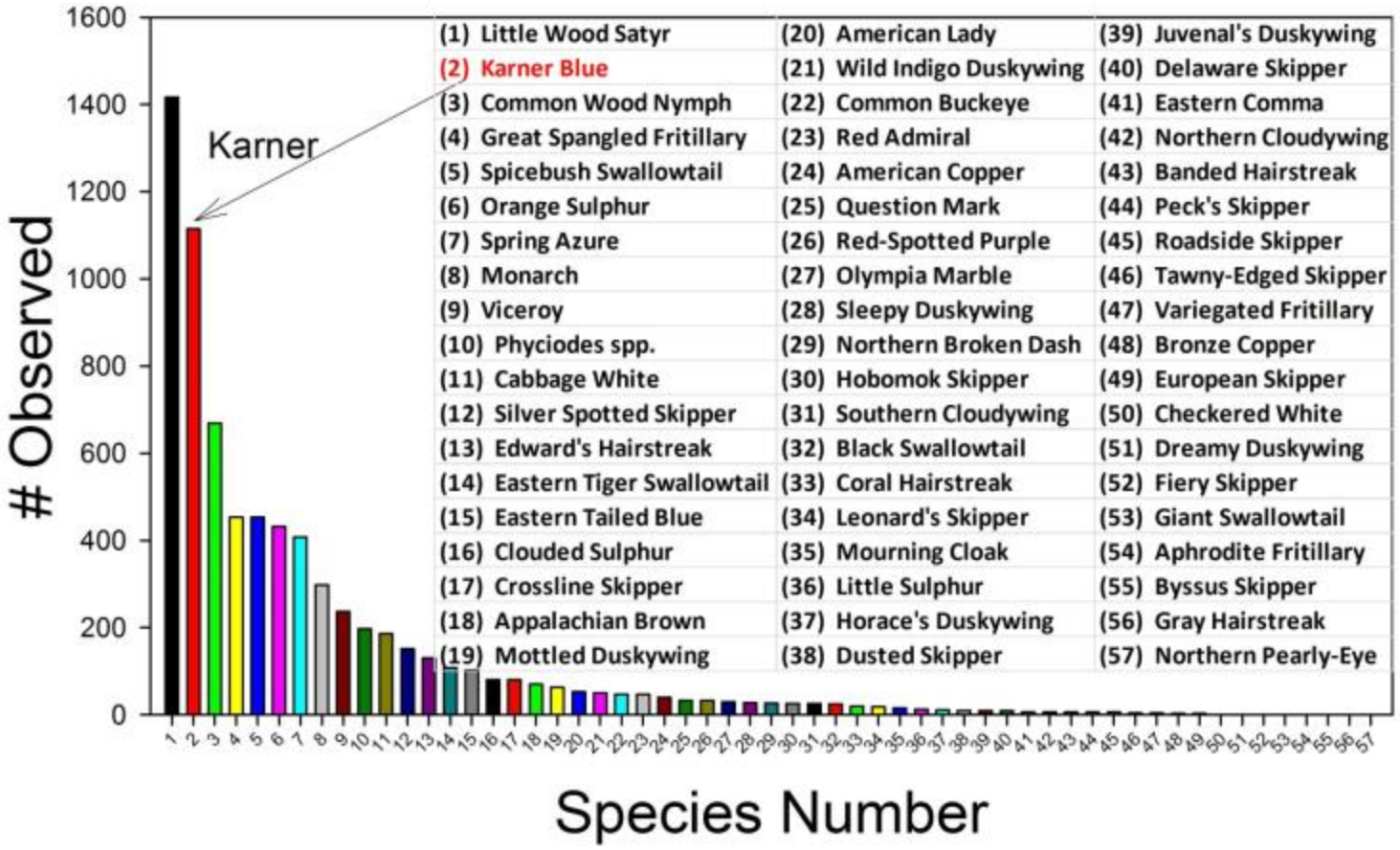

Amblyscirtes vialis
Erynnis martialis
Polites themistocles male
Wallengrenia egeremet female
Hesperia leonardus male
Thymelicus lineola
Polites origenes male
Satyrium liparops underside
Satyrium edwardsii underside
Staphylus hayhurstii female
Atrytonopsis hianna

Butterflies of INDU 1999



(1) Little Wood Satyr	(20) American Lady	(39) Juvenal's Duskywing
(2) Karner Blue	(21) Wild Indigo Duskywing	(40) Delaware Skipper
(3) Common Wood Nymph	(22) Common Buckeye	(41) Eastern Comma
(4) Great Spangled Fritillary	(23) Red Admiral	(42) Northern Cloudywing
(5) Spicebush Swallowtail	(24) American Copper	(43) Banded Hairstreak
(6) Orange Sulphur	(25) Question Mark	(44) Peck's Skipper
(7) Spring Azure	(26) Red-Spotted Purple	(45) Roadside Skipper
(8) Monarch	(27) Olympia Marble	(46) Tawny-Edged Skipper
(9) Viceroy	(28) Sleepy Duskywing	(47) Variegated Fritillary
(10) Phyciodes spp.	(29) Northern Broken Dash	(48) Bronze Copper
(11) Cabbage White	(30) Hobomok Skipper	(49) European Skipper
(12) Silver Spotted Skipper	(31) Southern Cloudywing	(50) Checkered White
(13) Edward's Hairstreak	(32) Black Swallowtail	(51) Dreamy Duskywing
(14) Eastern Tiger Swallowtail	(33) Coral Hairstreak	(52) Fiery Skipper
(15) Eastern Tailed Blue	(34) Leonard's Skipper	(53) Giant Swallowtail
(16) Clouded Sulphur	(35) Mourning Cloak	(54) Aphrodite Fritillary
(17) Crossline Skipper	(36) Little Sulphur	(55) Byssus Skipper
(18) Appalachian Brown	(37) Horace's Duskywing	(56) Gray Hairstreak
(19) Mottled Duskywing	(38) Dusted Skipper	(57) Northern Pearly-Eye

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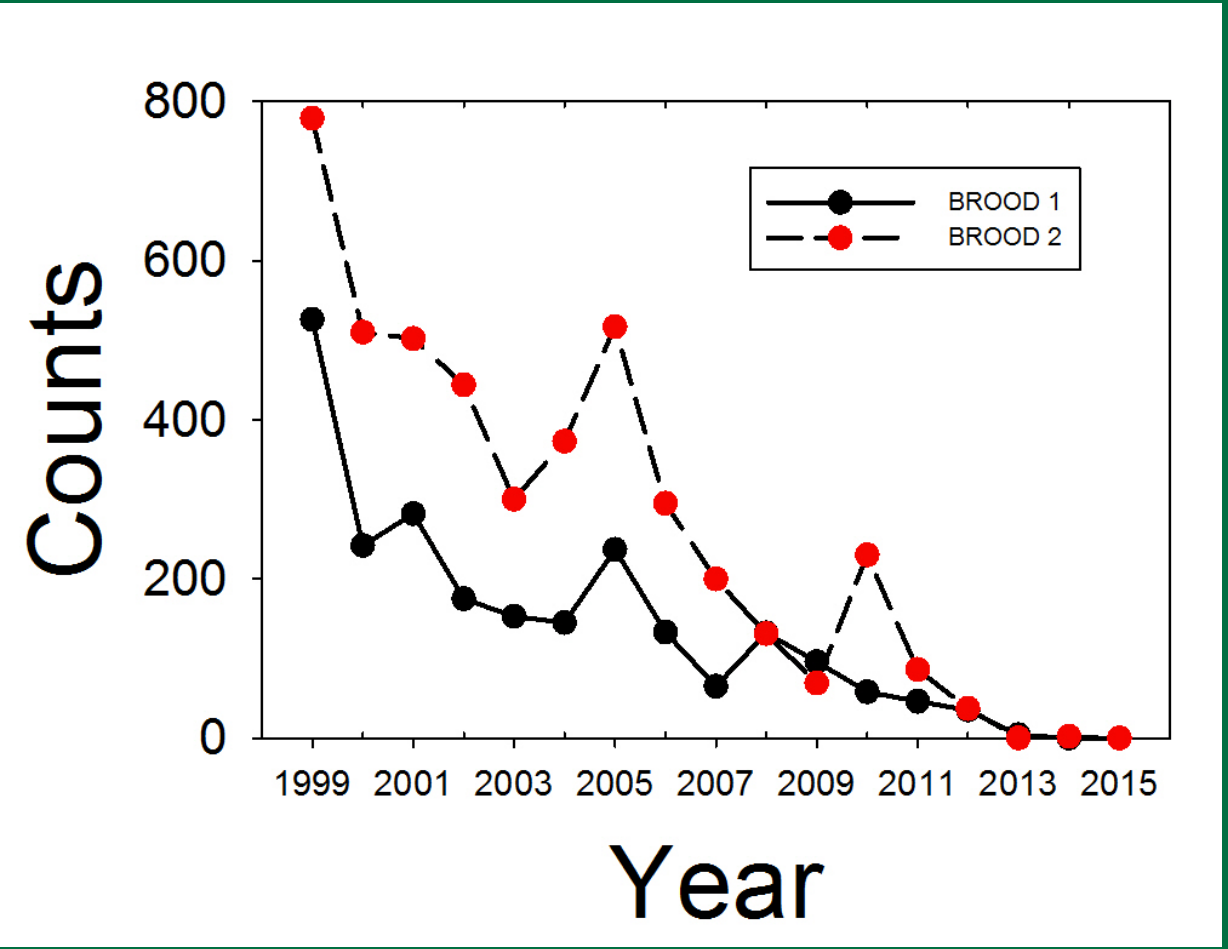
Karner blue counts by year and brood
From 2nd most abundant to extirpated



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Karner blue butterfly life cycle

April
Eggs hatch & larva feed on lupine

Mid-May
Caterpillars pupate, mature into butterflies, emerge & mate

Early June
Females lay eggs near lupine plants

June
Eggs hatch & larvae feed on lupine

July
Larvae pupate, mature into adults, emerge & mate

Late July- Early August
Females lay eggs near lupine plants

What we had learned about Karner blue habitat use

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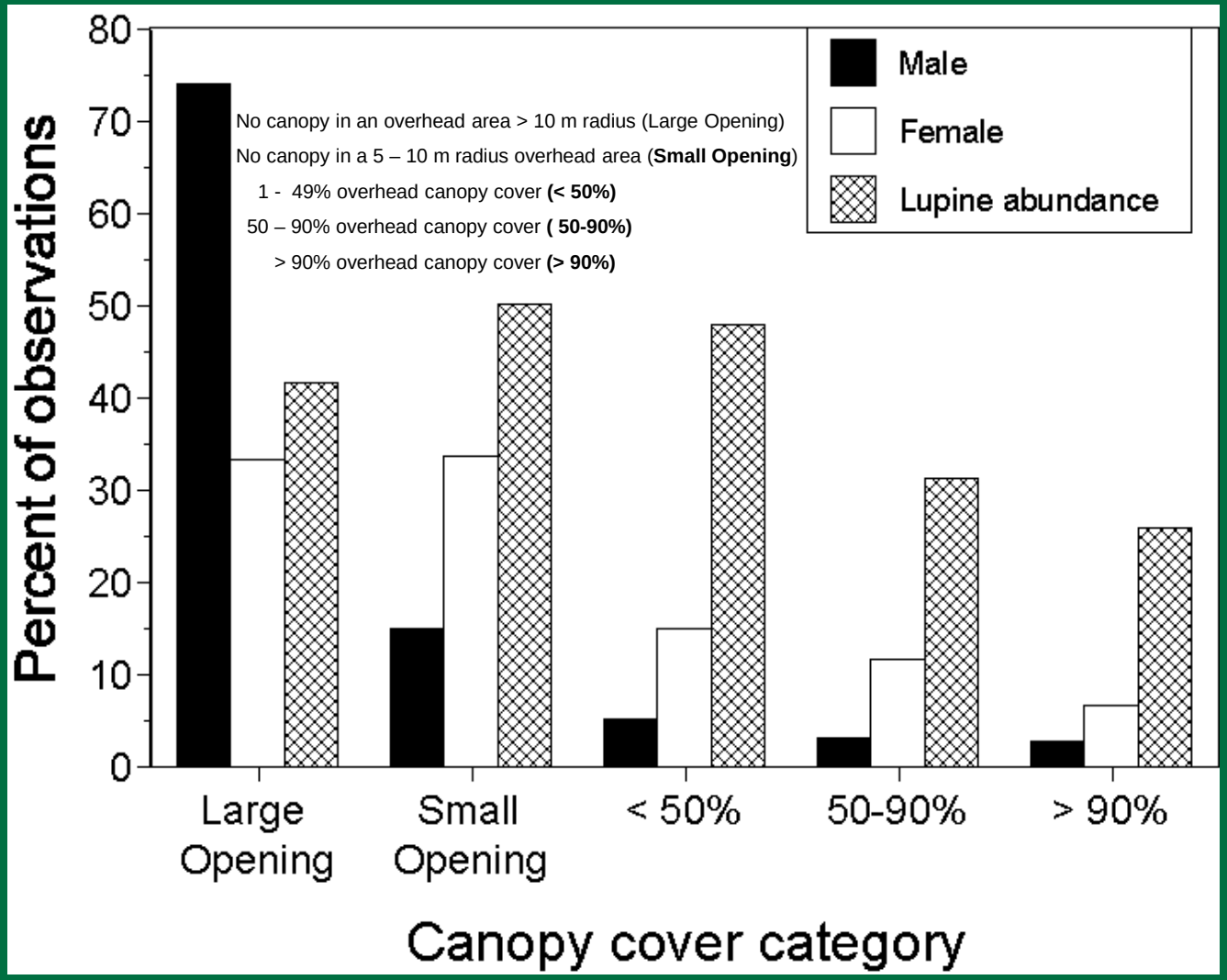
Adults do not necessarily reside where lupine is most abundant – Male habitat use not correlated with lupine abundance; female use is



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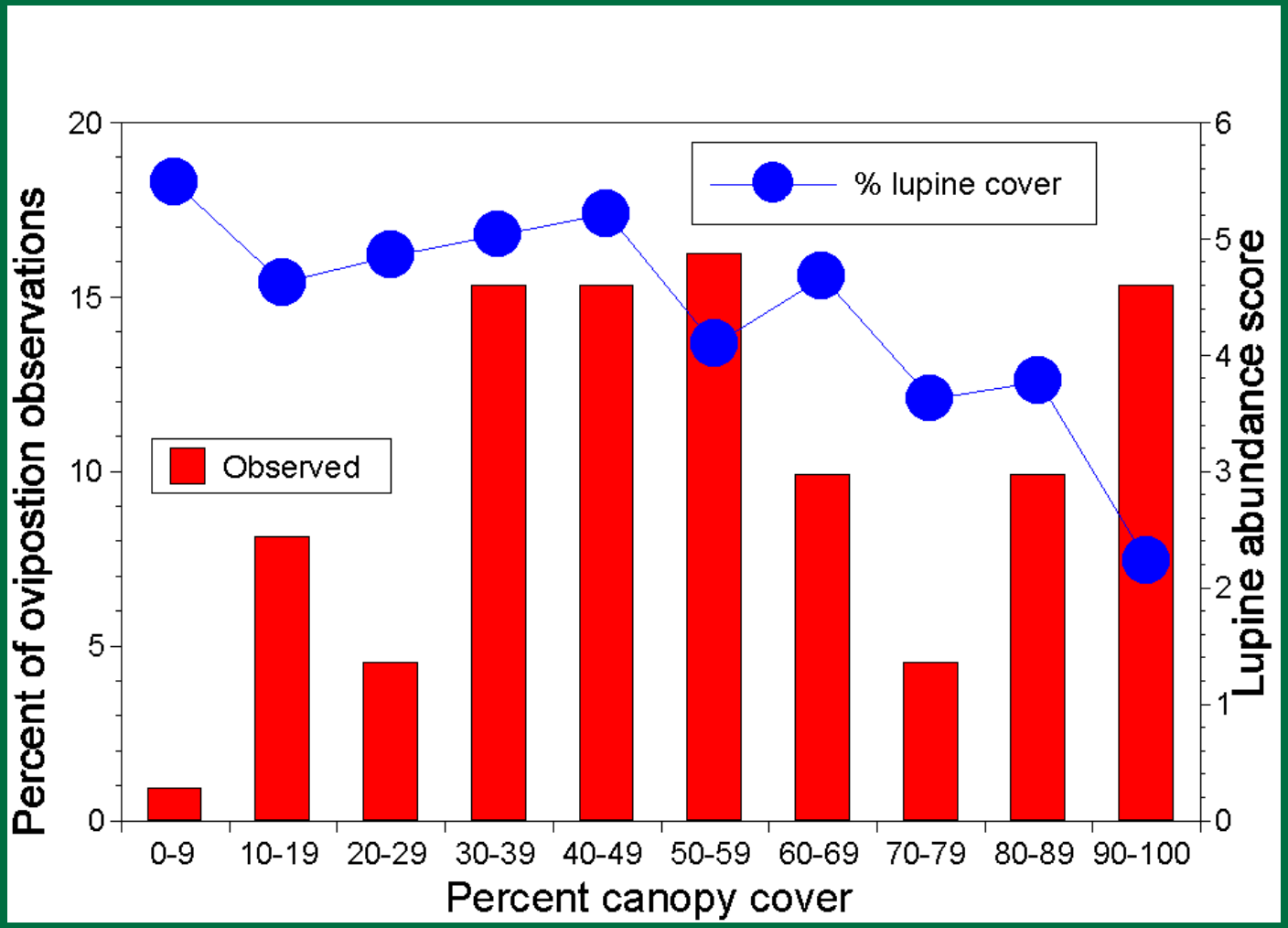
Shade heterogeneity is an important component of habitat quality



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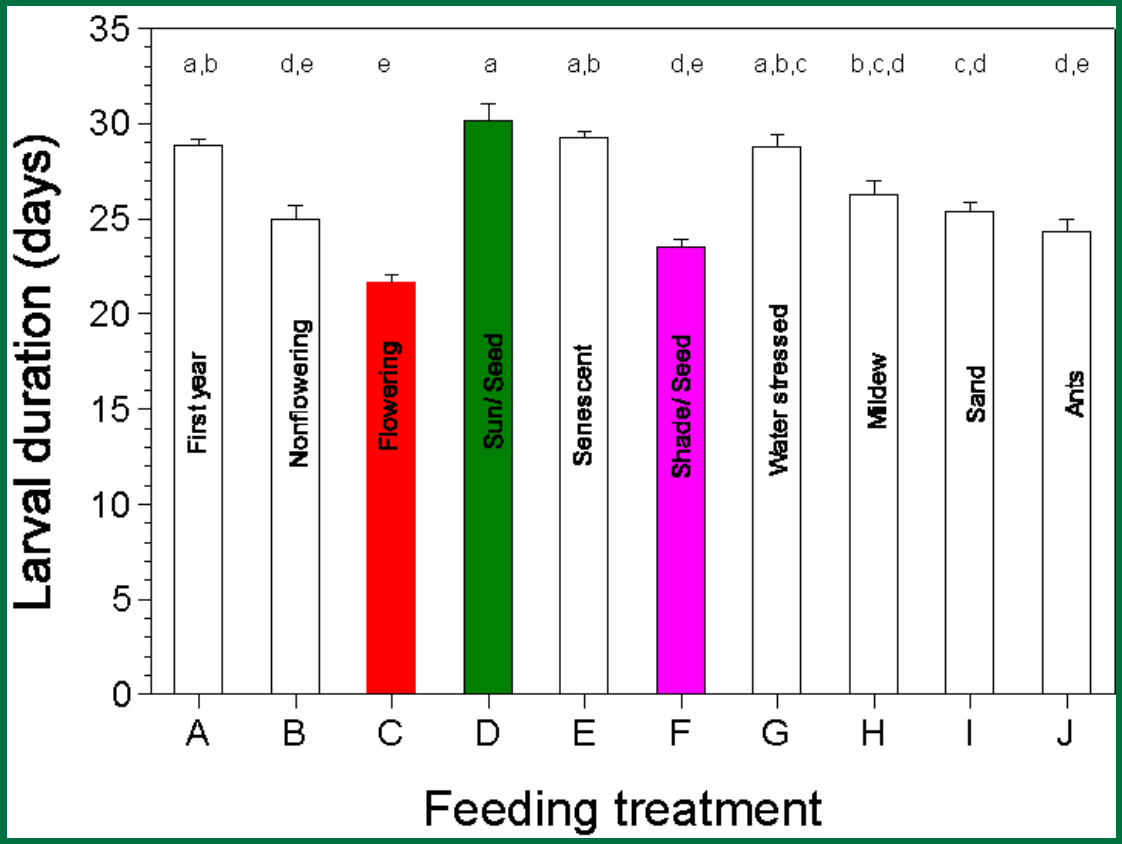
Larvae developed most rapidly when fed leaves from FLOWERING lupines and SHADE grown lupines and least rapidly when fed SUN grown lupine leaves



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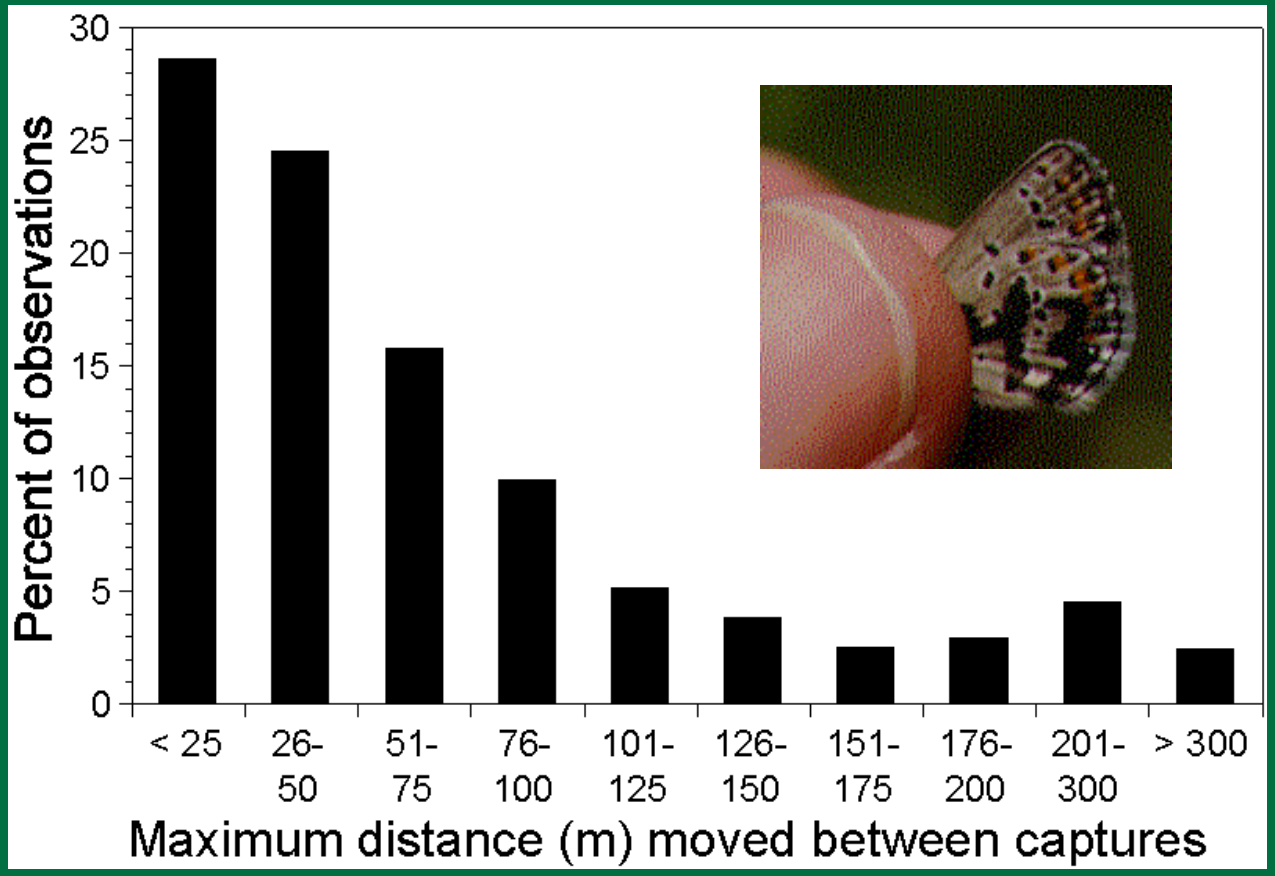
Distances moved by individuals were typically < 100 m



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By ovipositing across a gradient of shading, females “hedge their bets” exposing larvae to sunnier areas with higher lupine density and shadier areas with higher lupine quality.

These preferable variants may be more common in shaded areas in the second brood, when many plants growing in the sunnier areas are senescing.

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A prescription for Karner blue butterfly habitat at Indiana Dunes

- Many large canopy openings surrounded by areas providing a gradient of shading
- Units of shade-surrounded openings should be separated from each other by < 300 meters to facilitate Karner's metapopulation structure.

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So, if we know how to make good habitat for the Karner blue, what went wrong?

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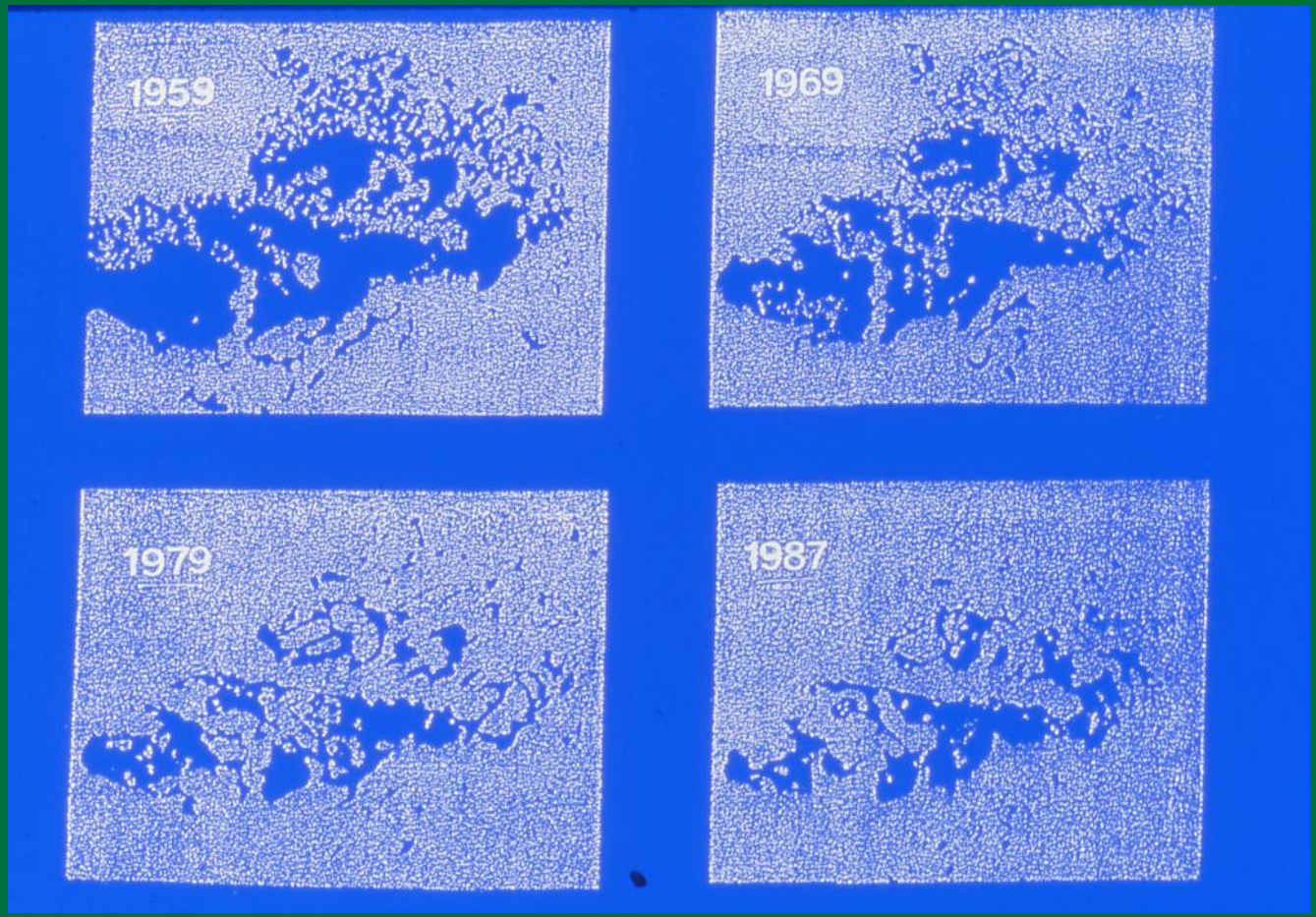
Fire – Too Little? Too Much?
Canopy closure with fire suppression (tree infiltration into a prairie area at Indiana Dunes)



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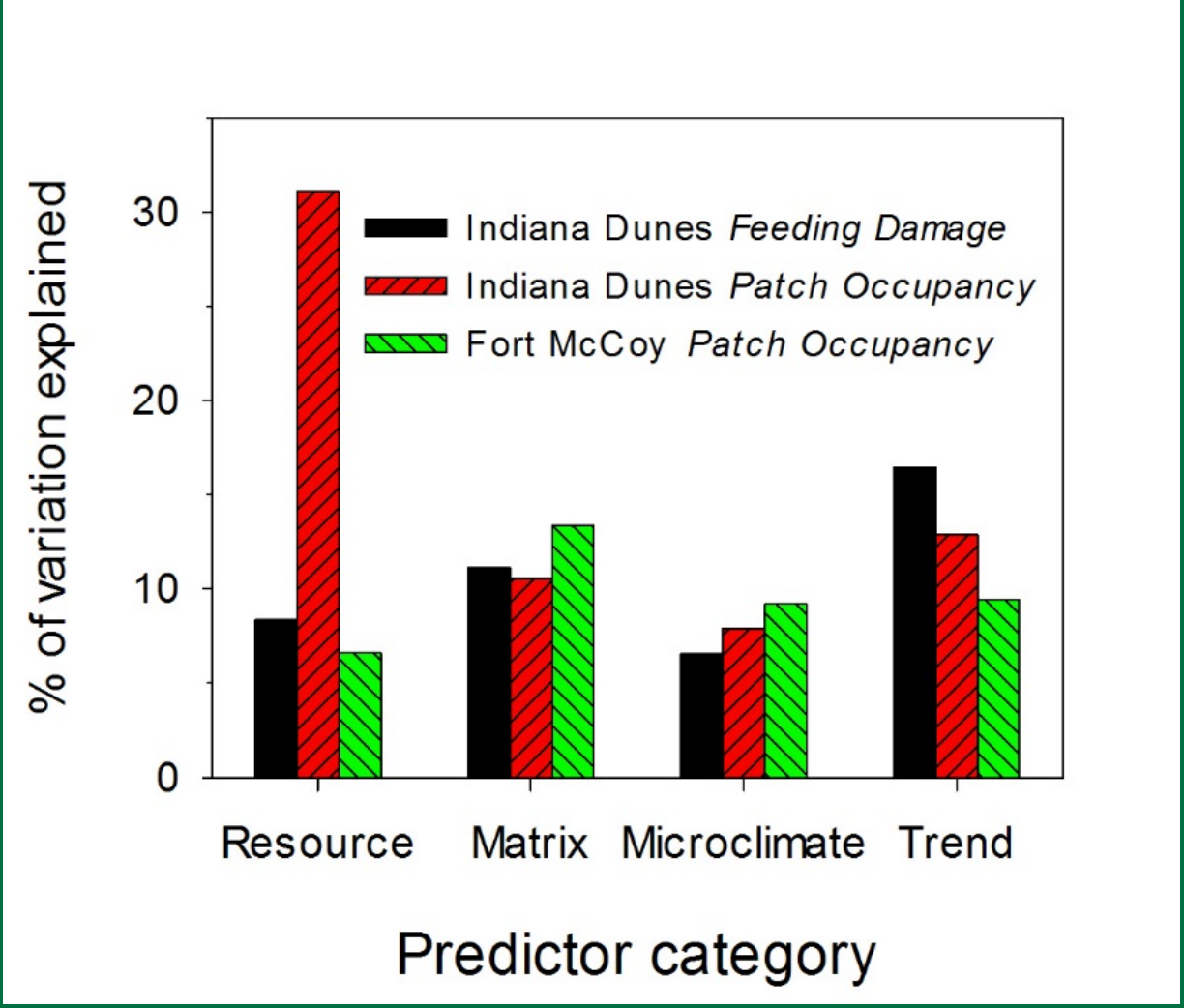
Importance of microclimate



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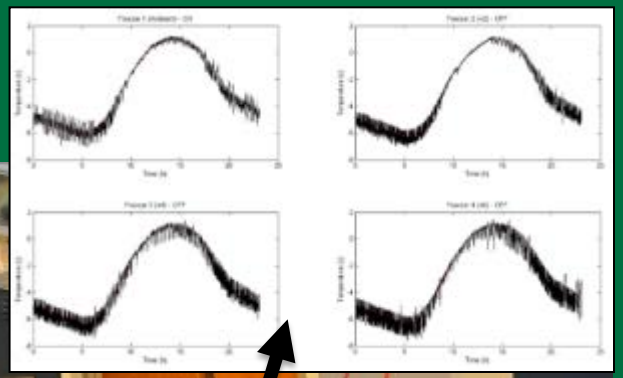
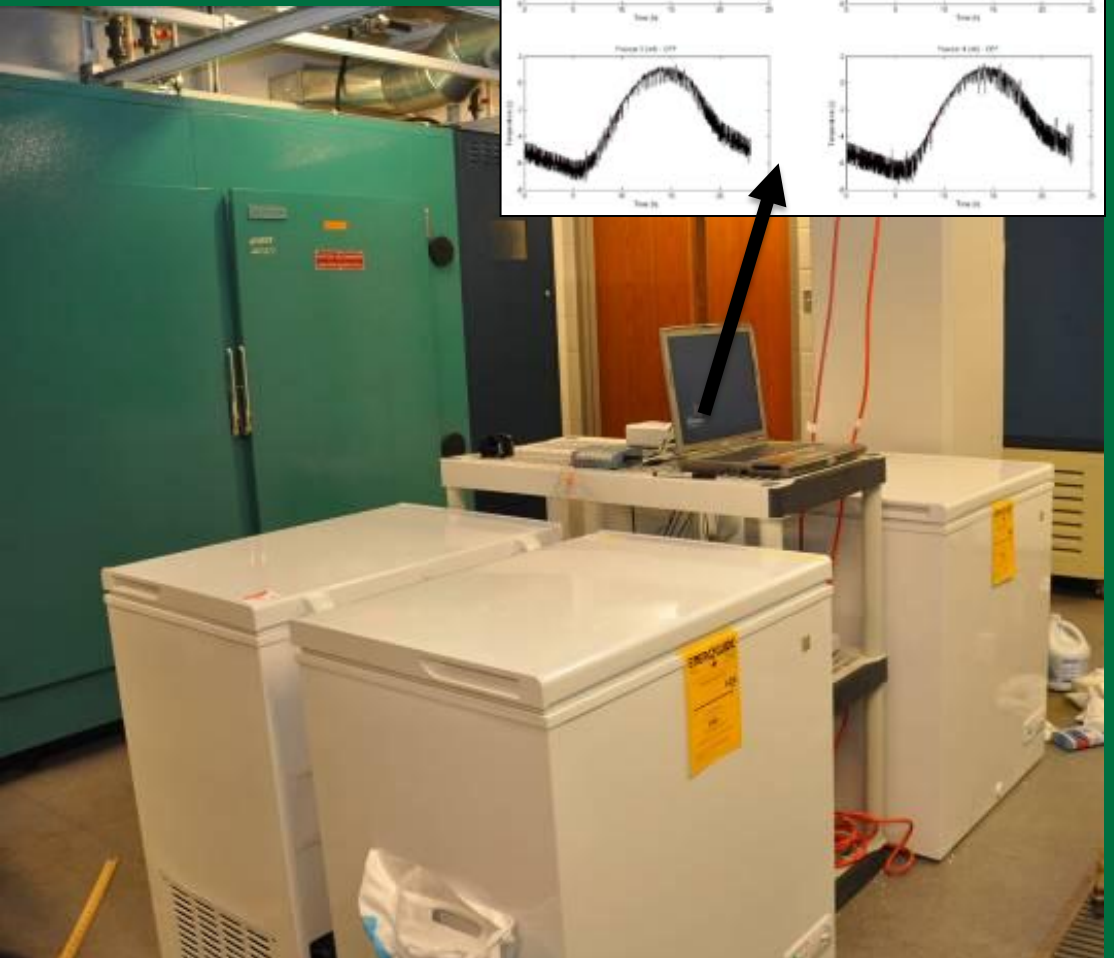
Grundel, R., and N. B. Pavlovic. Biological Conservation **135:135-144.**

What's doing in the Karner blue?
Climate +0.25 °C (0.46 °F) per decade





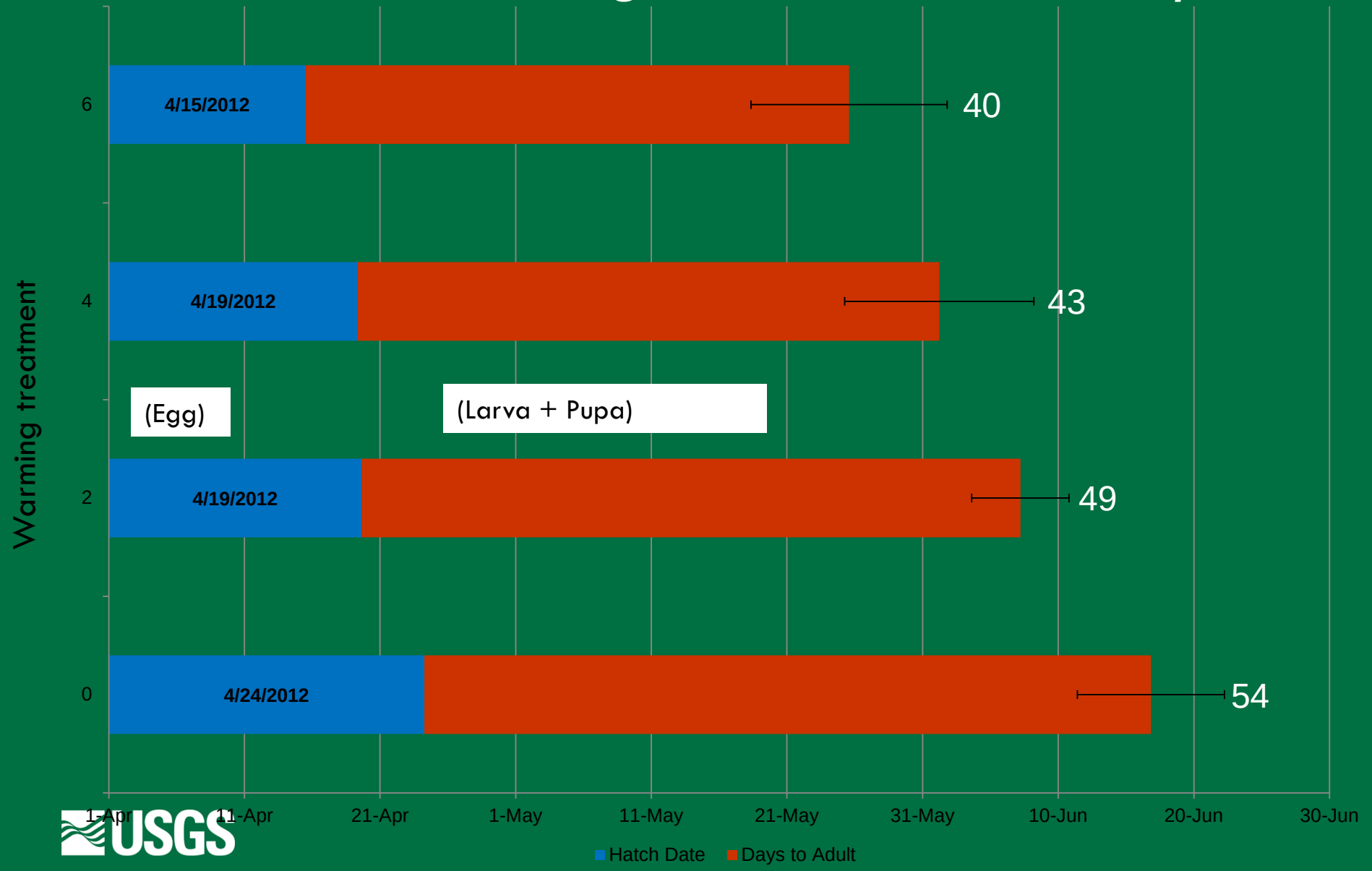
CLIMATE SIMULATION	TEMP (DEG C)
HISTORIC	INDU 1960-90 AVERAGE
~2040	+2
~2070	+4
~2100	+6

Temperature change Chicago region 1945 – 2007:

0.25 °C (0.46 °F) per decade

Hayhoe, K., J. VanDorn, T. Croley, N. Schlegal, and D. Wuebbles. 2010. Journal of Great Lakes Research 36:7-21.

2012 First Flight *Warming accelerates development*



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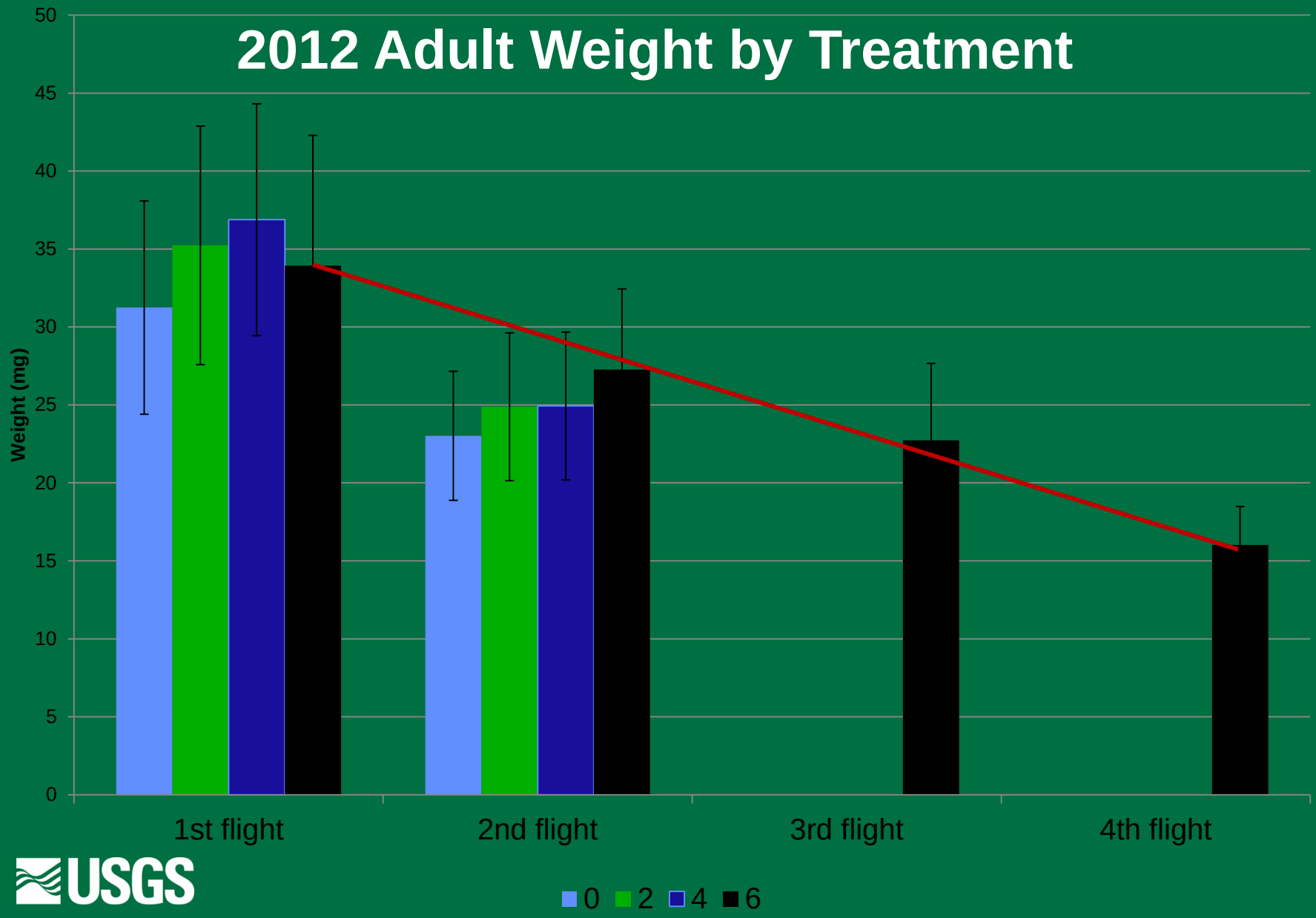
Additional Broods – Bad?
2011 Treatment Cohort Demography

Treatment	1st Flight	2nd Flight	3rd Flight	4th Flight
"+0"	Y	Y	N	N
"+2"	Y	Y	**Y**	N
"+4"	Y	Y	**Y**	N
"+6"	Y	Y	**Y**	**Y***

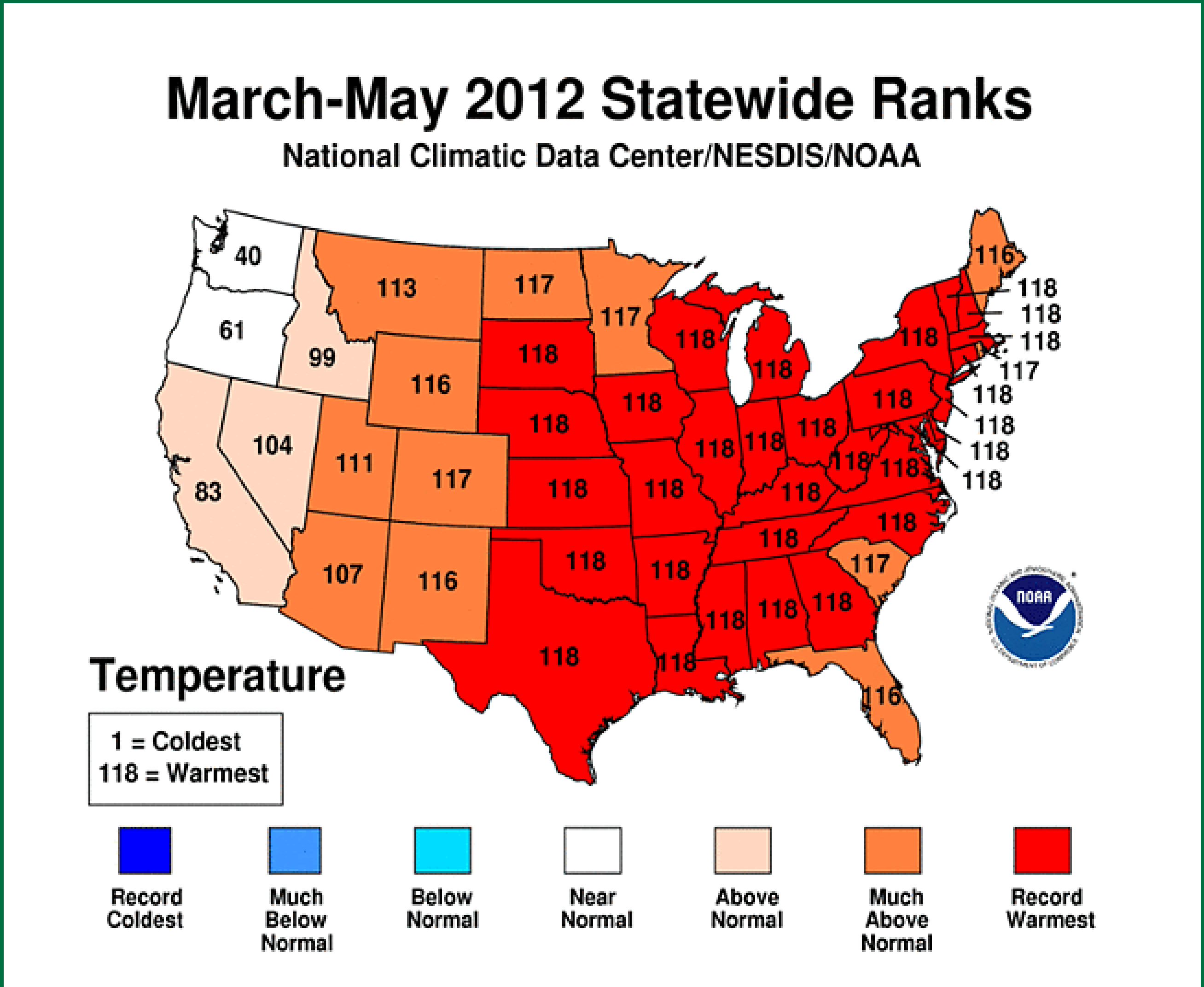
*Did not reach pupation

2012 Treatment Cohort Demography

Treatment	1st Flight	2nd Flight	3rd Flight	4th Flight
"+0"	Y	Y	N	N
"+2"	Y	Y	N	N
"+4"	Y	Y	N	N
"+6"	Y	Y	**Y**	**Y**


2012 Adult Weight by Treatment
Weight (mg)
50
45
40
35
30
25
20
15
10
5
0
1st flight
2nd flight
3rd flight
4th flight
0
2
4
6

Spring 2012 – warmest on record



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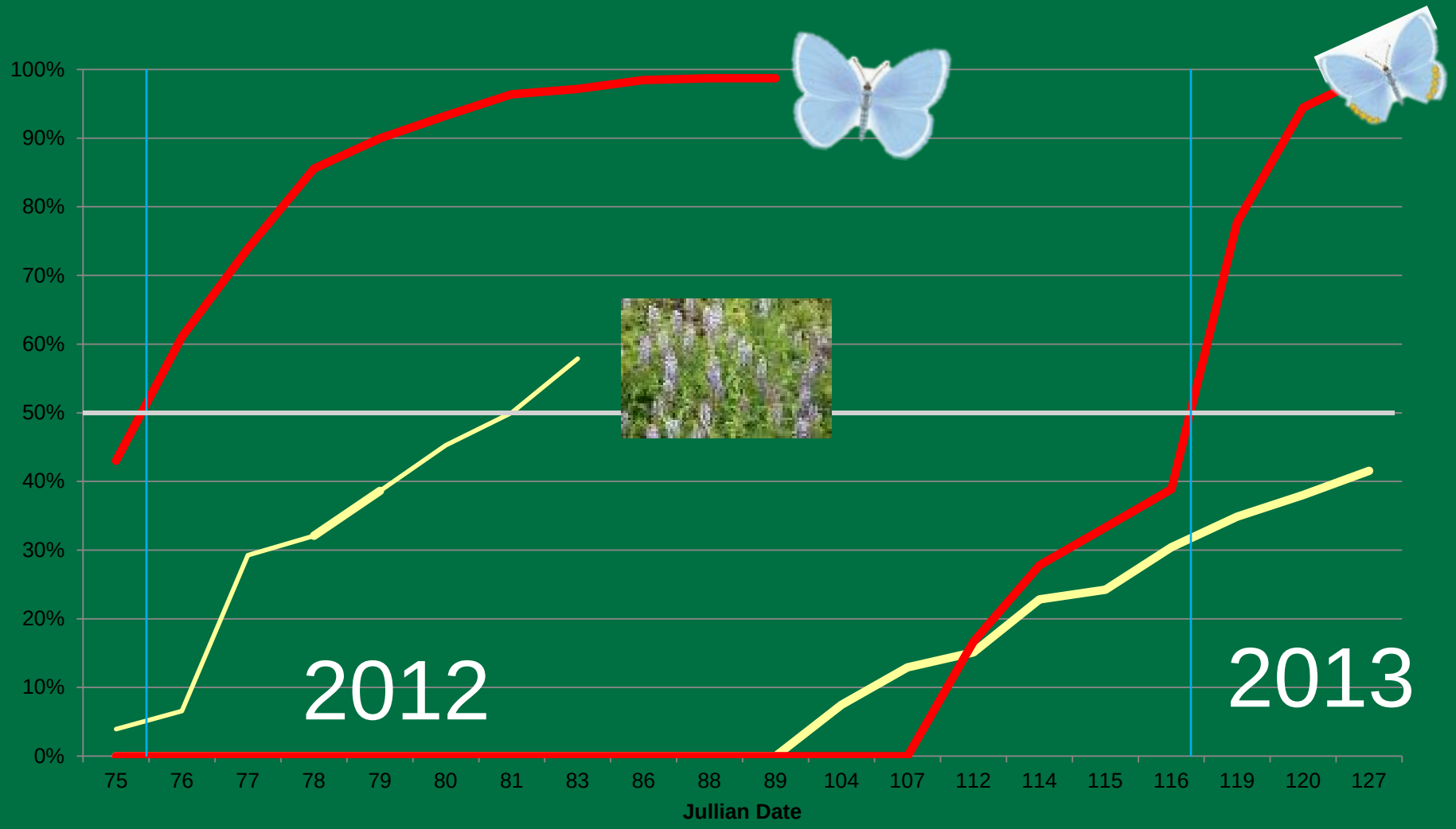
Karner blue butterfly

1 mm

Phenological Mismatch



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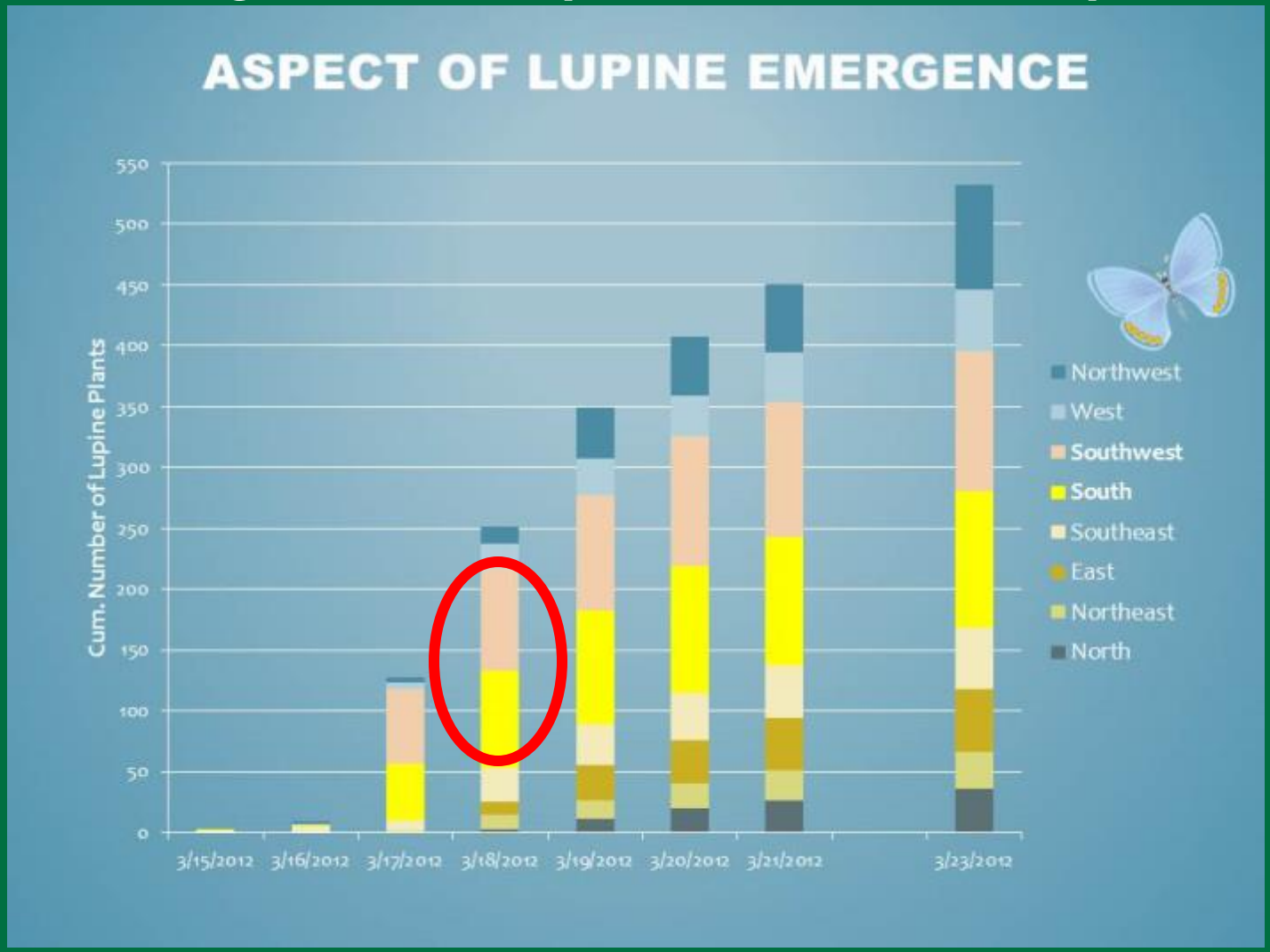
Lupine first comes up on Warm (South) Aspects
Survives longest on Cool Aspects
How do you assure right mix of lupine on different aspects?



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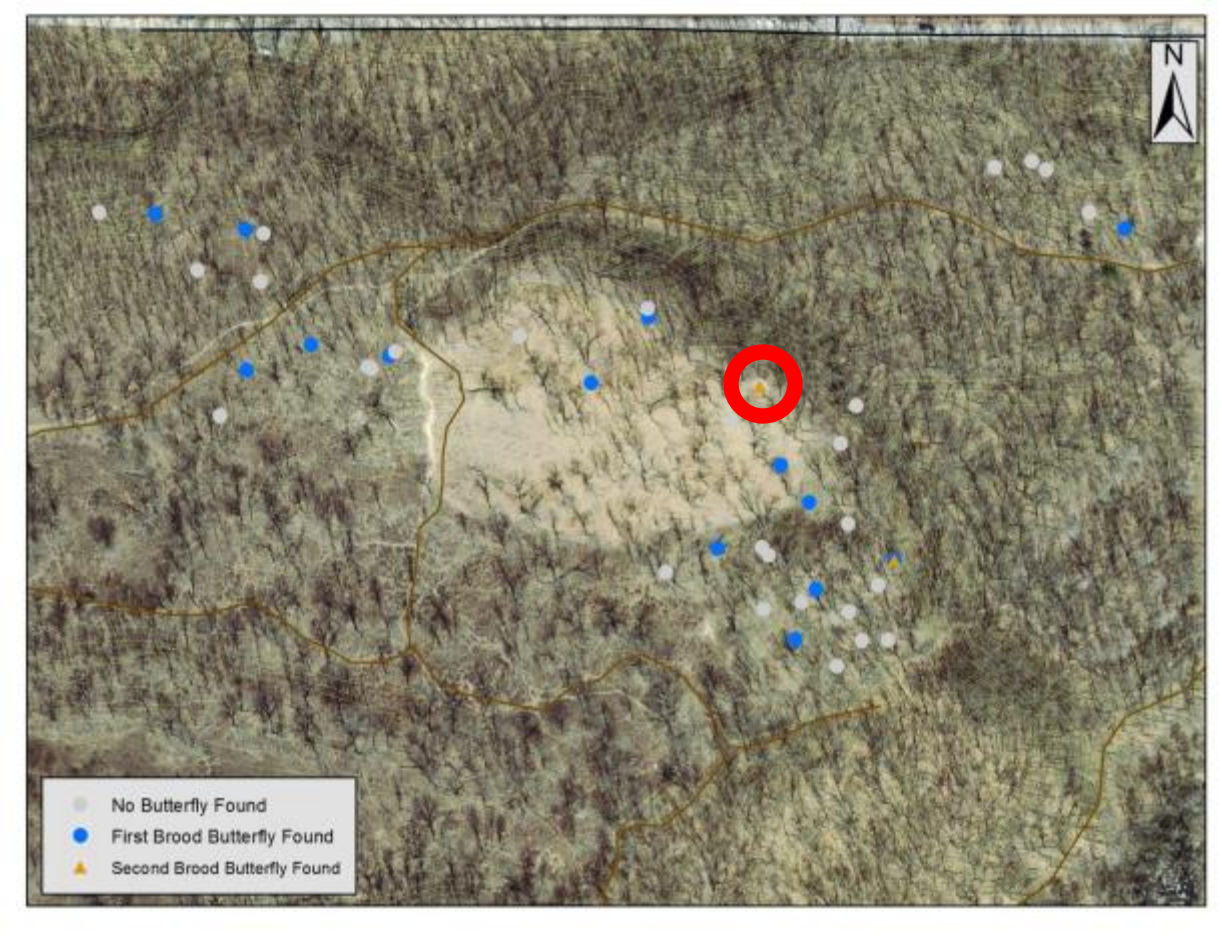
Poor second brood survival 2012
Only survived on Cool Aspects



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Did 2012, a year with exceptionally warm and early spring followed by a hot, very dry summer –> significant 2013 decline???

- **Hardly any food available for spring larvae and then mainly only on south slopes**
- **During the second brood only larvae on north slopes survived to adulthood**
- **60-90% declines across much of range**
- **Microclimate – key to survival?**

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- Microclimate – key to survival?
- Make landscapes with increased range of exposure to soil moisture
- Make landscapes with lupine growth on multiple aspects

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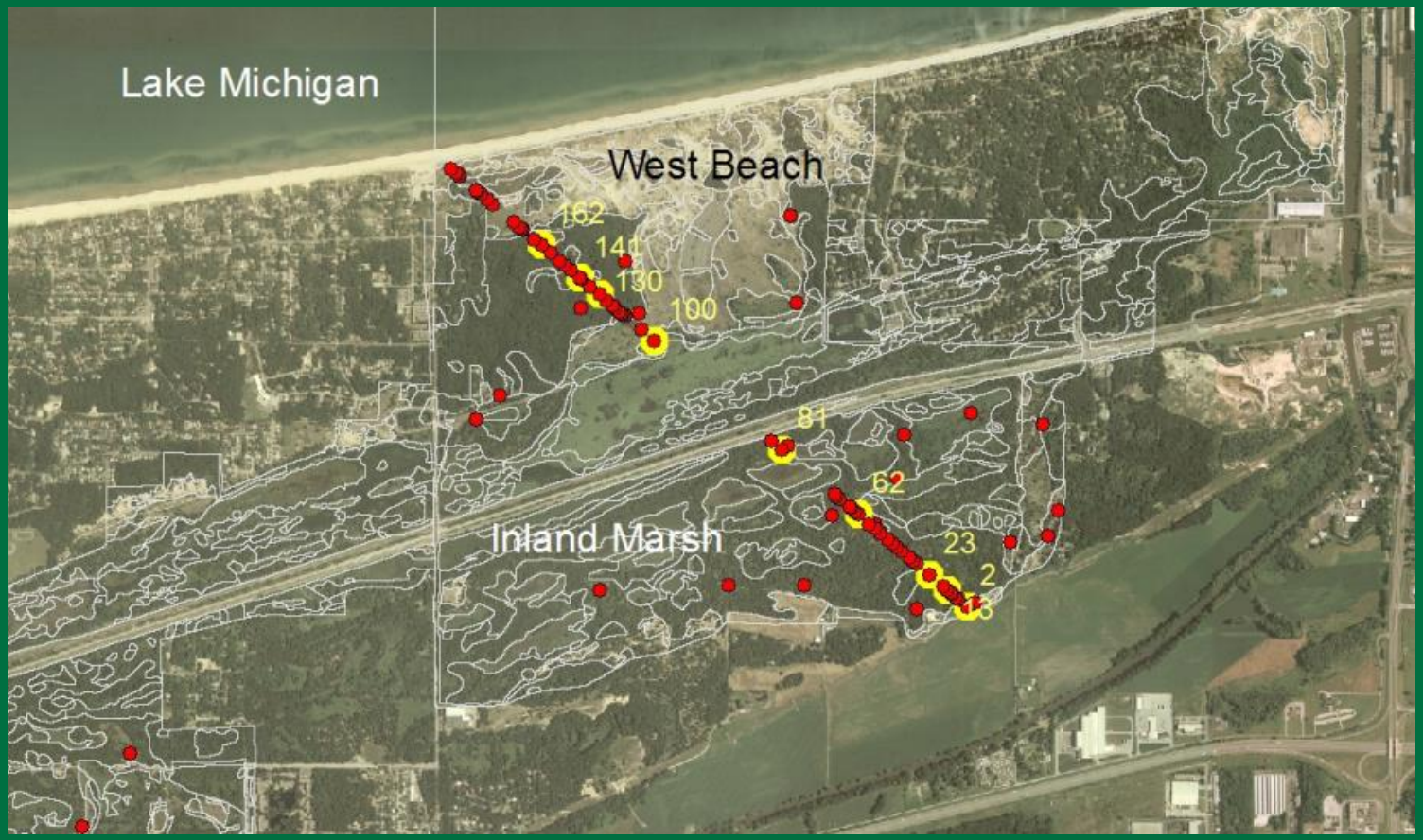
Microclimate study ca. 6° F difference between north and south aspects



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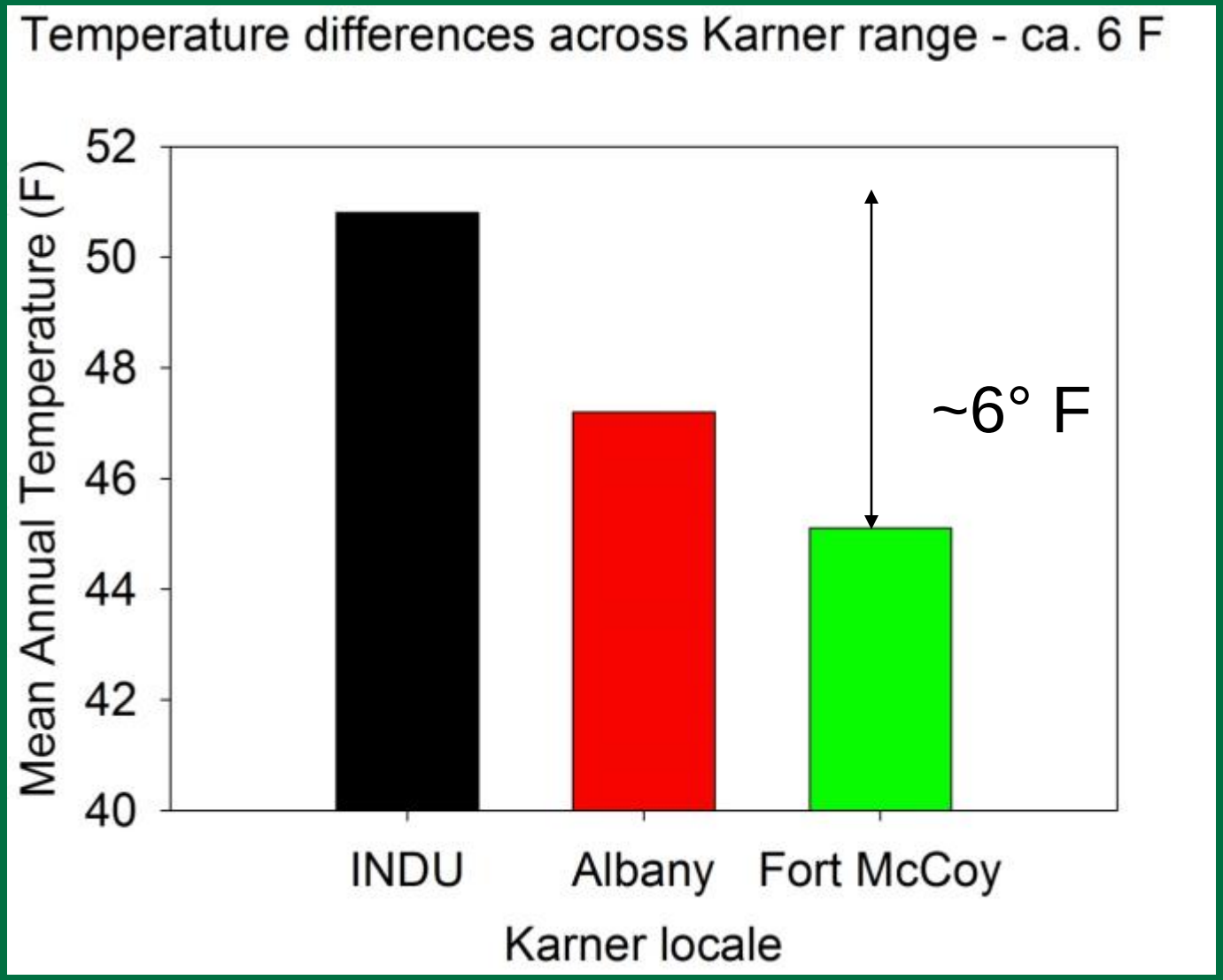
Temperature across range ~ temperature across aspects



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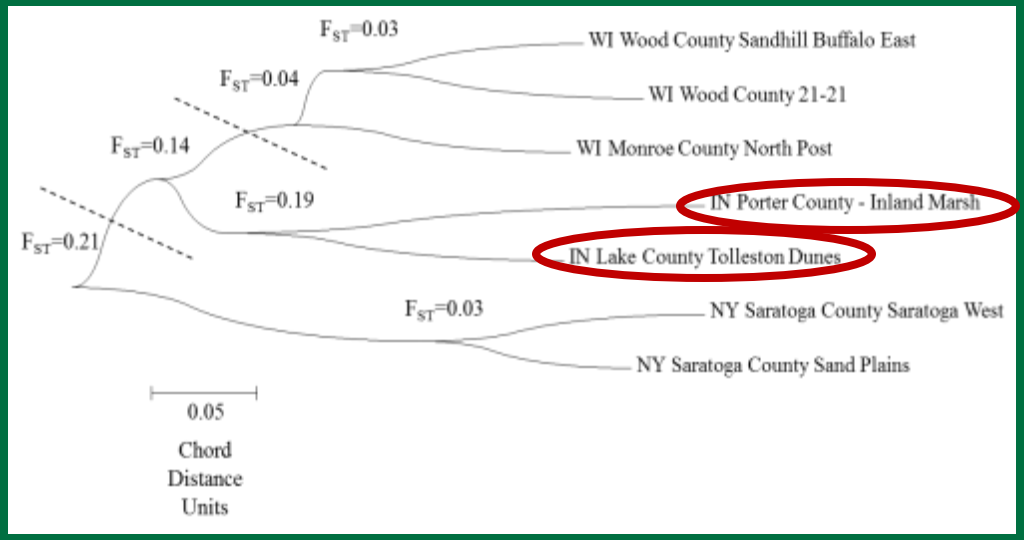
Fragmentation, barriers to dispersal

30 meters

Genetic effects of fragmentation, barriers to dispersal – Genomic analysis – Local Genetic Adaptation?

Neighbor-joining tree



- Sites within Indiana Dunes are about as different from each other as Wisconsin from NY
- Genetic bottlenecks due to fragmentation and population bottlenecks (Fire?)

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Assisted Migration

Local temp range = Rangewide temp range?

Increase connectivity?

Escape “in place”?

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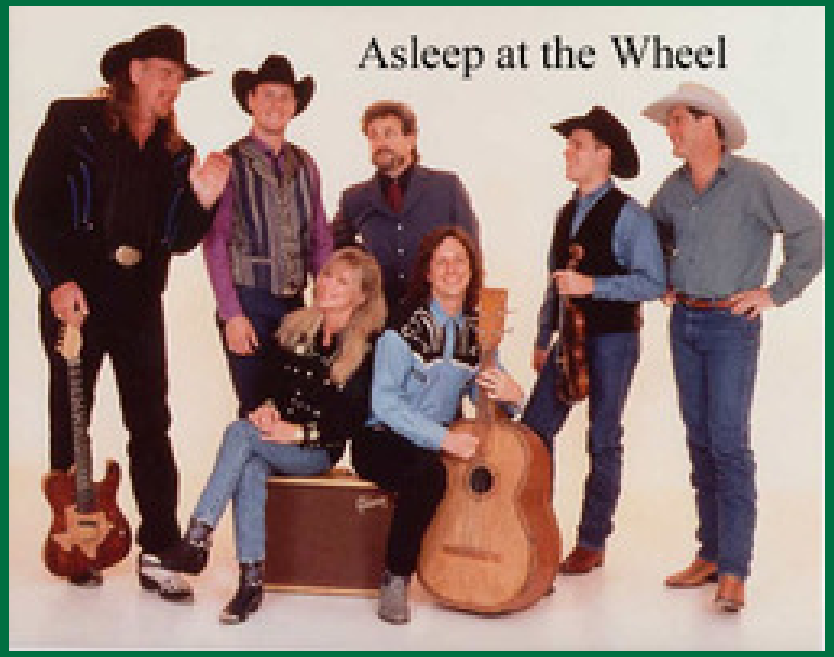
Why might we be failing to conserve the Karner blue at Indiana Dunes?

- Ignorance
- Asleep at the Wheel
- Overcome by Forces Beyond Our Control
- Too Expensive
- Inadequate Resilience
- Inadequate Connectivity



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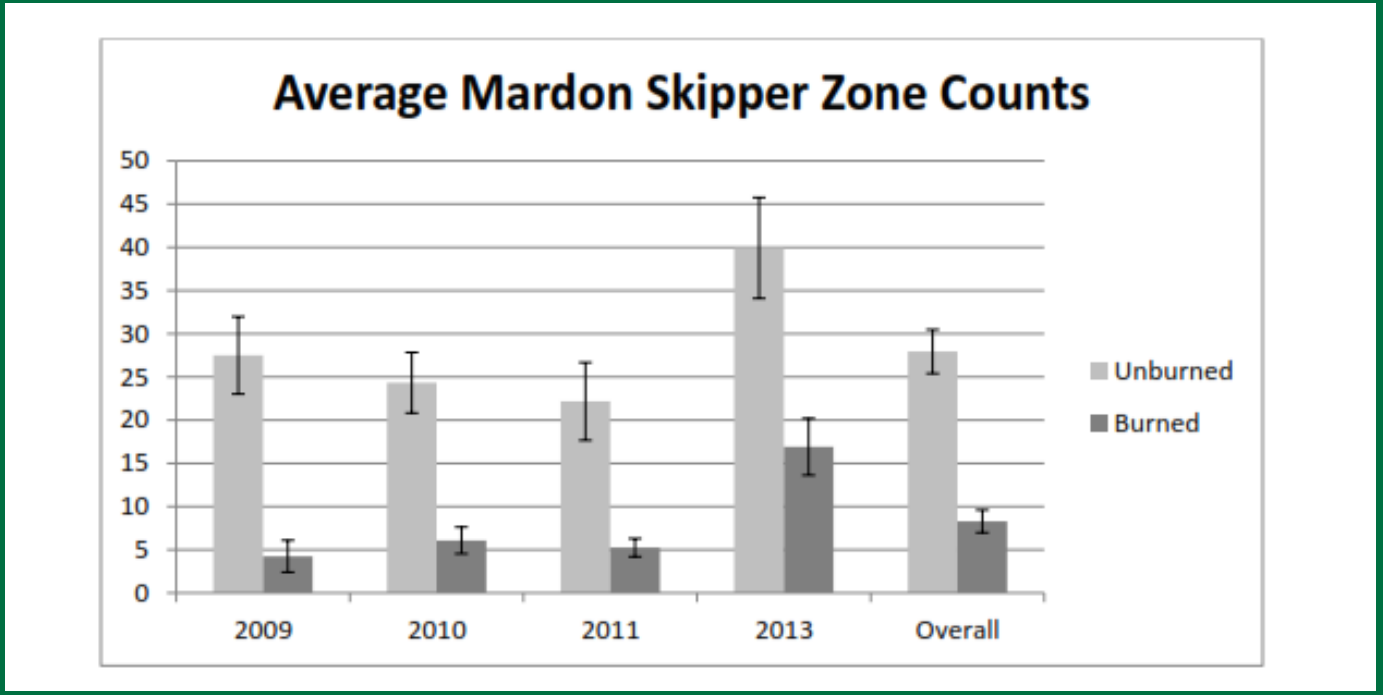
Oregon Forest Prescribed Burn for Imperiled Butterfly Burned in 2008; Not Fully Recovered in 5 years



Black, S. H., C. Fallon, R. Hatfield, and C. Mazzacano .Final report to the U.S. Forest Service, the Oregon Zoo, and the U.S. Fish & Wildlife Service. Summary of Mardon Skipper Coon Mountain Burn Site Occupancy Study 2009 - 2013, Xerces Society, December 2013.

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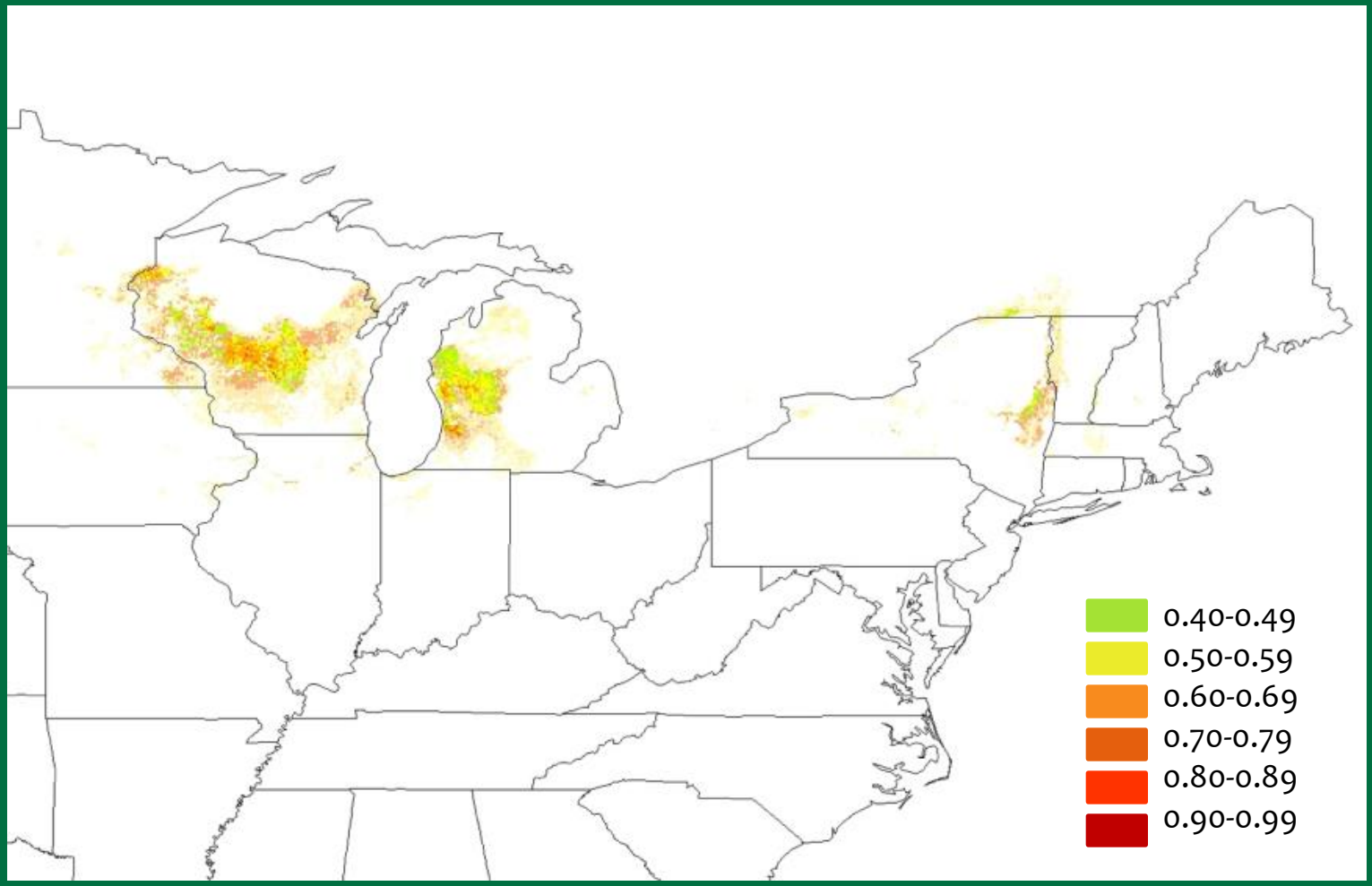
Karner 2014



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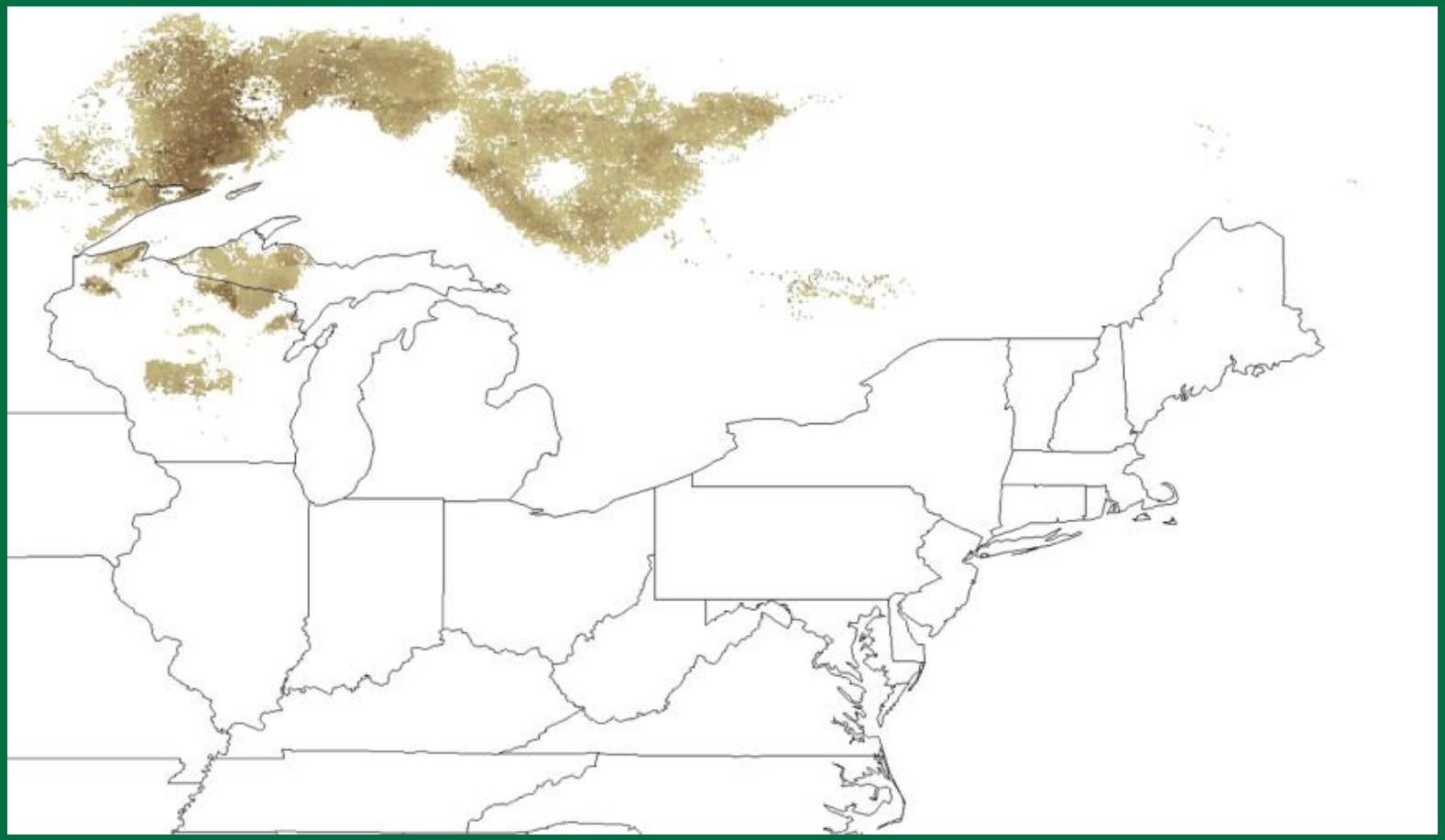
Karner 2080 – Overcome by Climate Change



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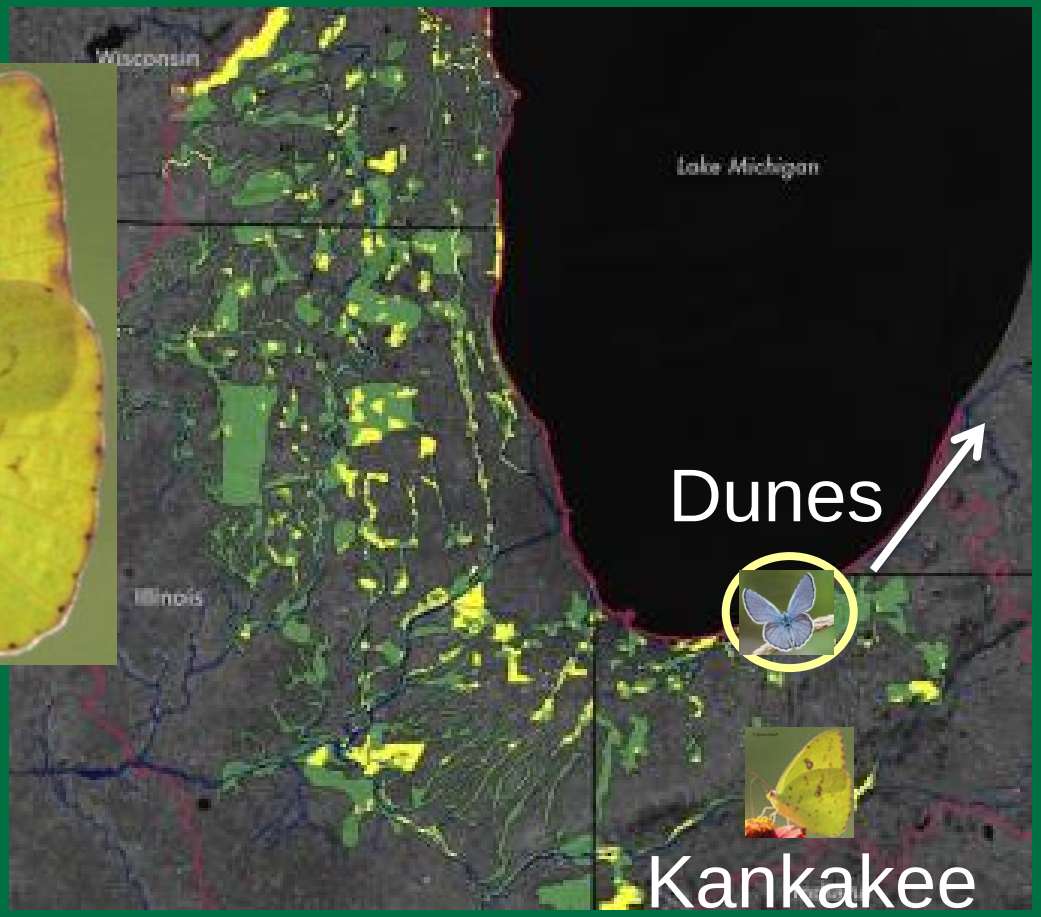
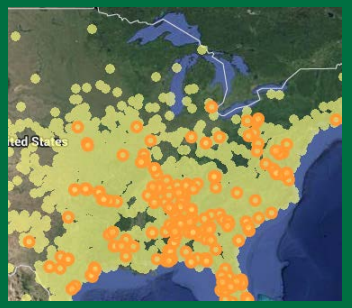
Connection to the future?
Chicago Wilderness Green Infrastructure Vision

Cloudless Sulphur





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Chicago Wilderness Green Infrastructure Vision:
http://www.chicagowilderness.org/what-we-do/protecting-green-infrastructure/

What have we learned?

- Do we have our fingers on INDU's pulse?
  - Know what's changing?
- Do we understand resilience?
  - Protect by incorporating microclimatic variation
- Do we manage fire conservatively?
  - Too frequent fire? Bitter feelings.
- Do we understand INDU's biogeography?
  - Species replacements.
- Do we know our cost limits?

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A long time ago there were so many Karners that they were described as clouds of blue.

..he [Audubon] rode under a sky darkened from horizon to horizon by a cloud of passenger pigeons.

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