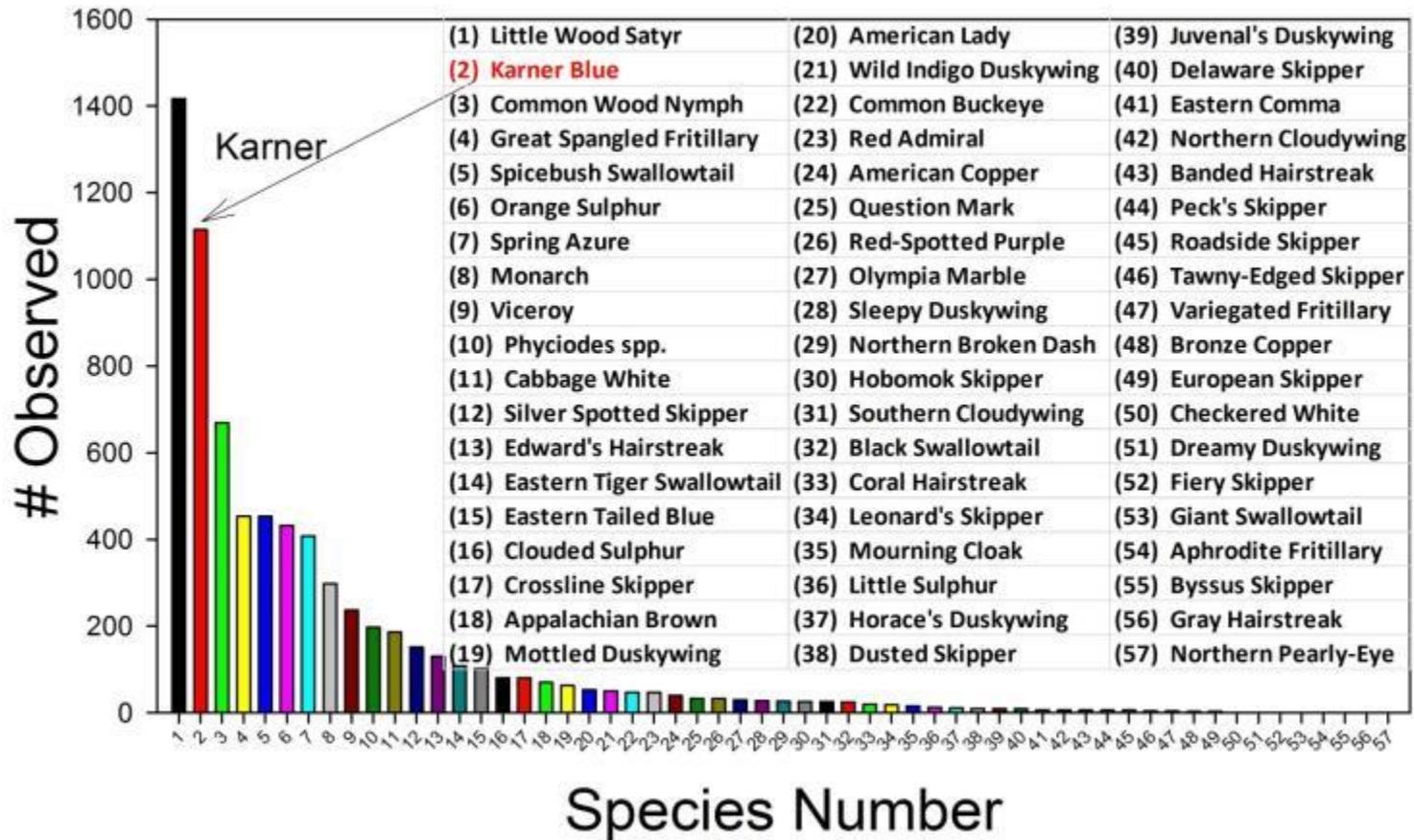


# How the weather and fragmentation might affect the Karner blue butterfly

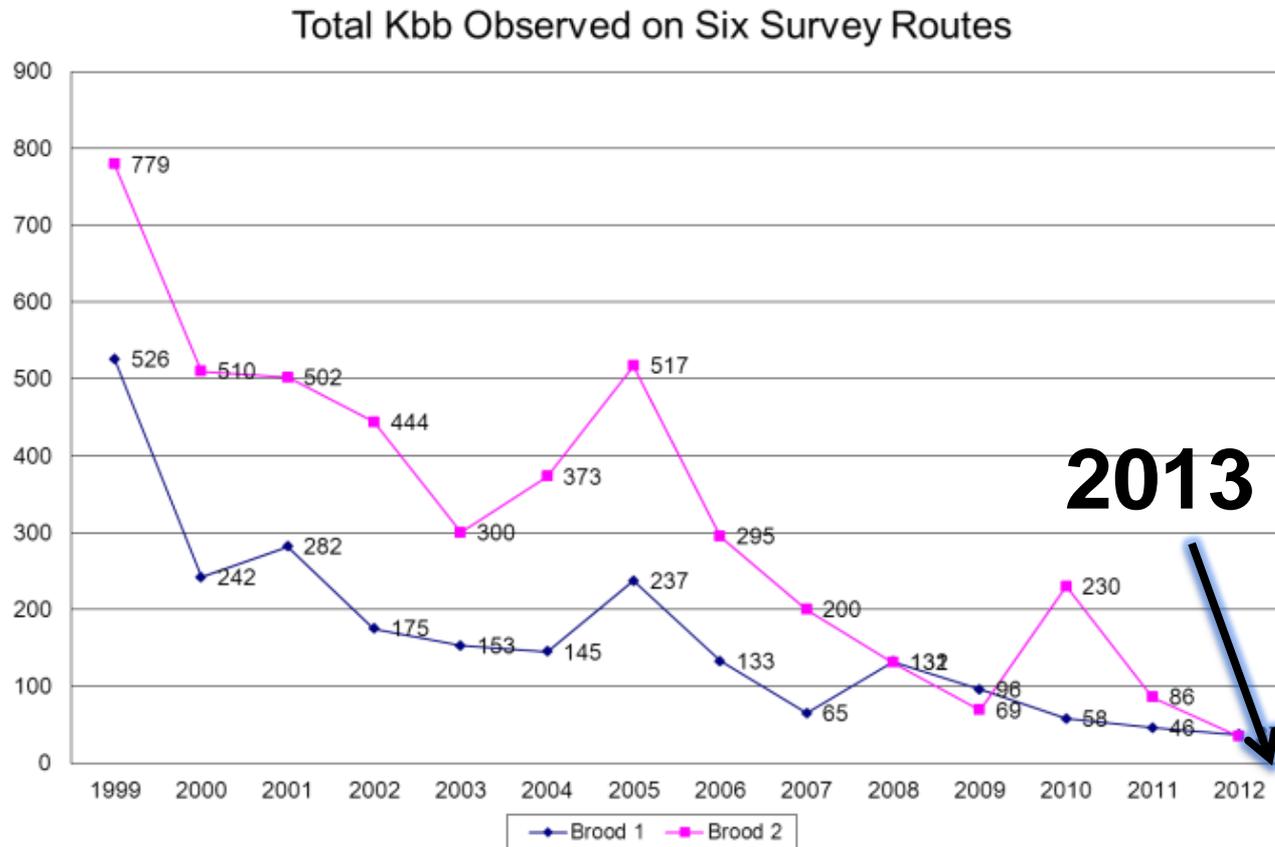


Ralph Grundel USGS Porter, Indiana

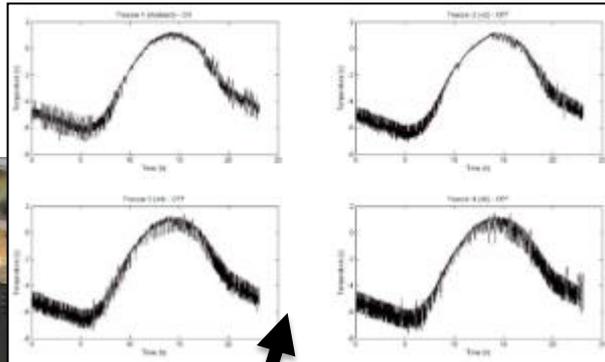
# Butterflies of INDU 1999



# Indiana Dunes KBB surveys – No Kbb seen in most locales in summer 2013



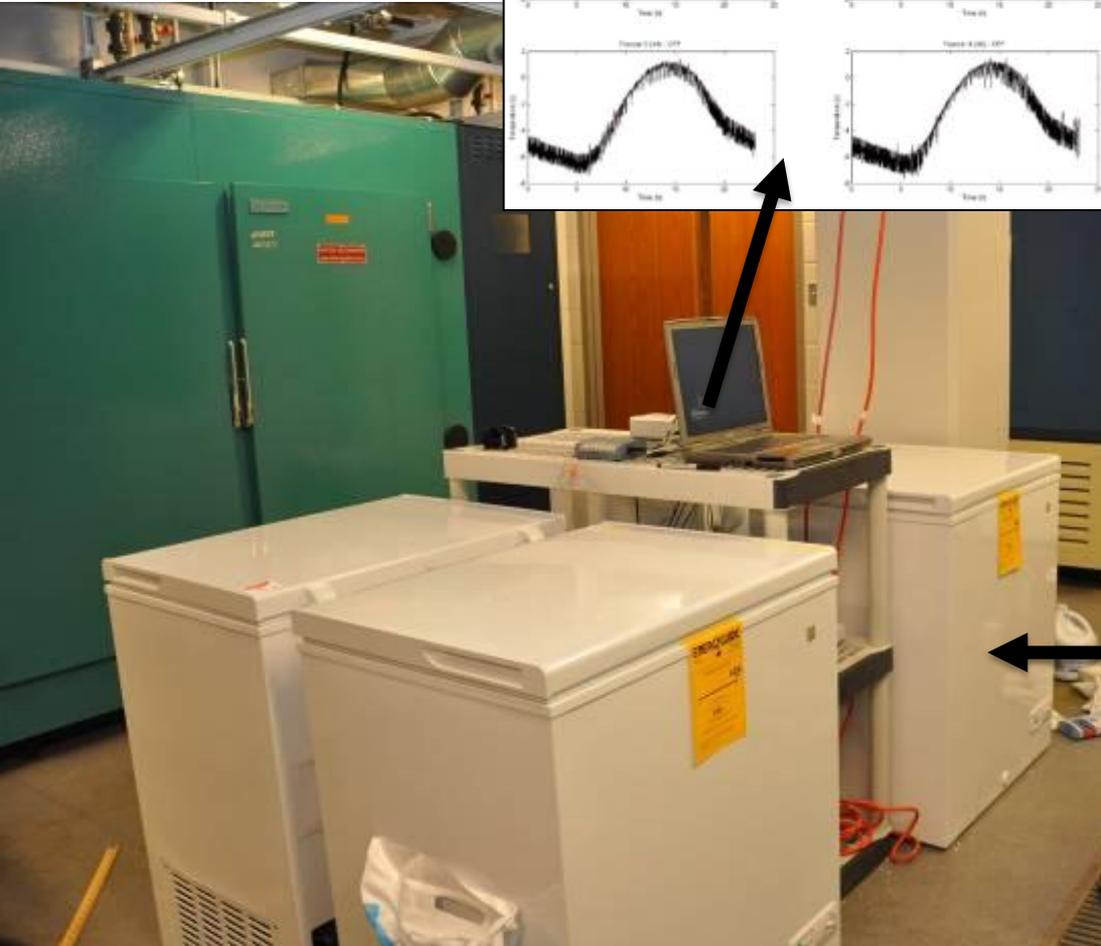
# THE EGGERATOR – USGS/Notre Dame Collaboration



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

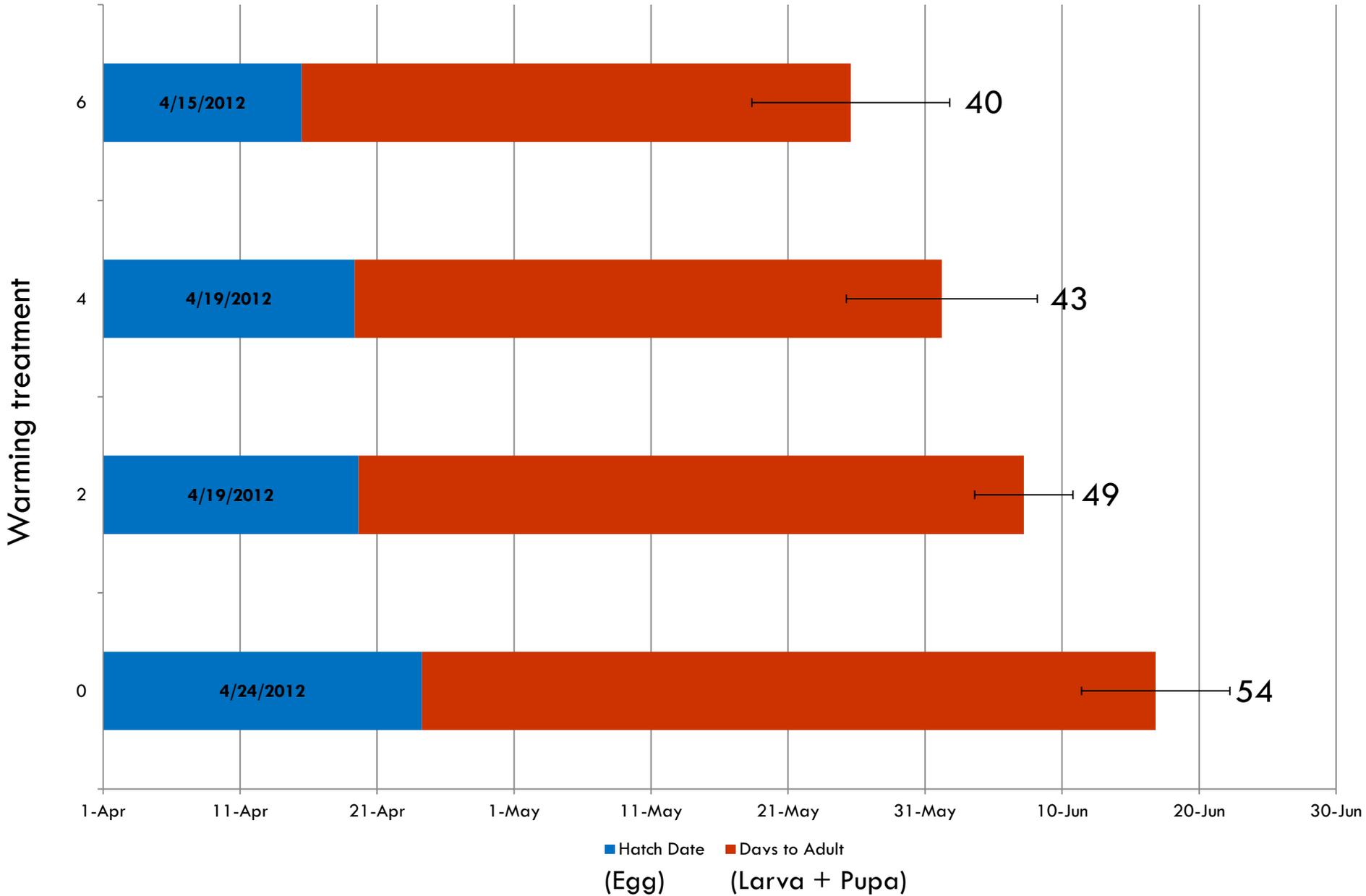
- Colony Established 2010
- Experiment 2011, 2012, 2013

Diapausing KBB eggs:



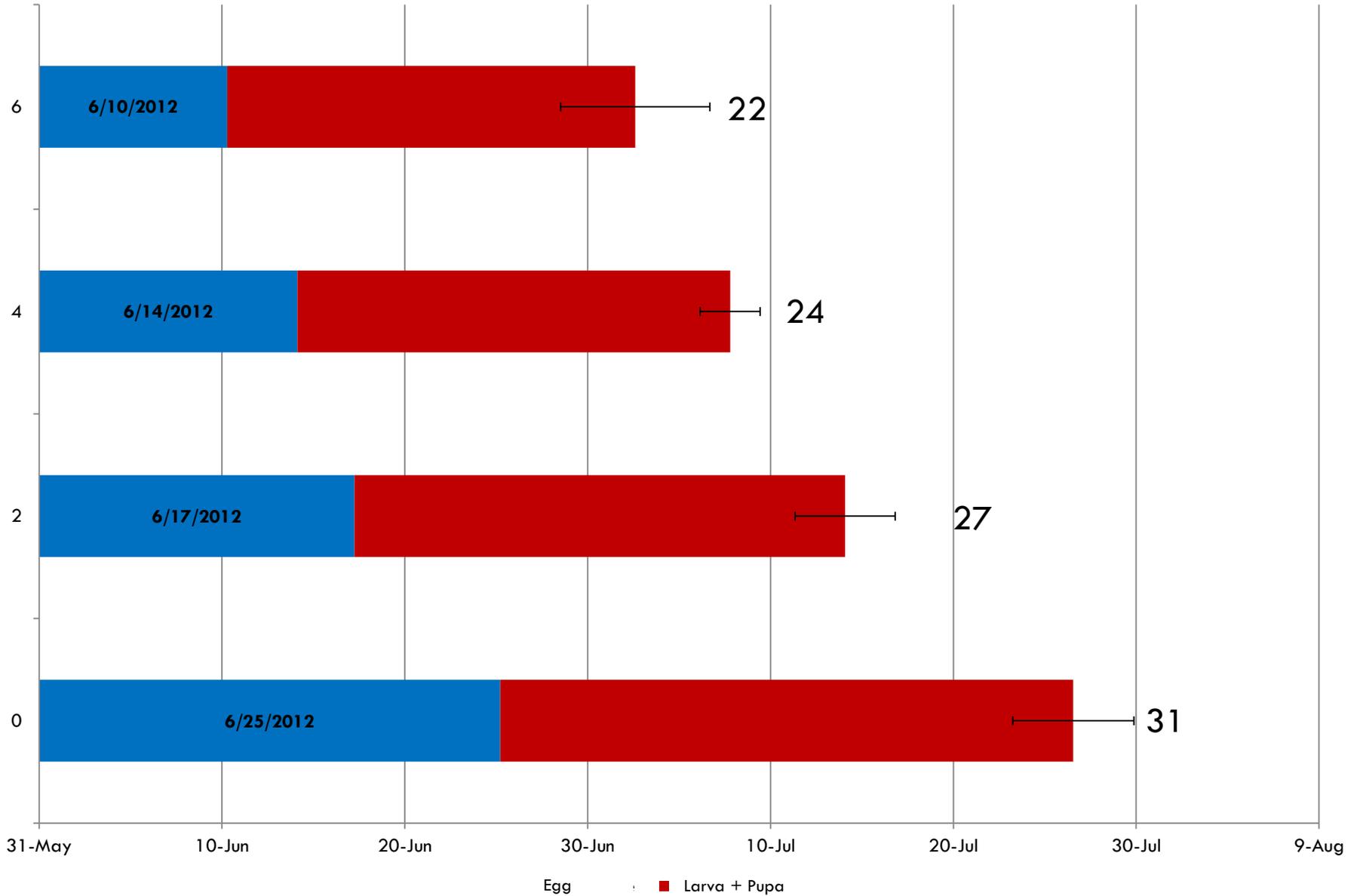
# 2012 First Flight

*Warming accelerates development*



# 2012 Second Flight

*Warming accelerates development*



# Additional Broods – Bad?

## 2011 Treatment Cohort Demography

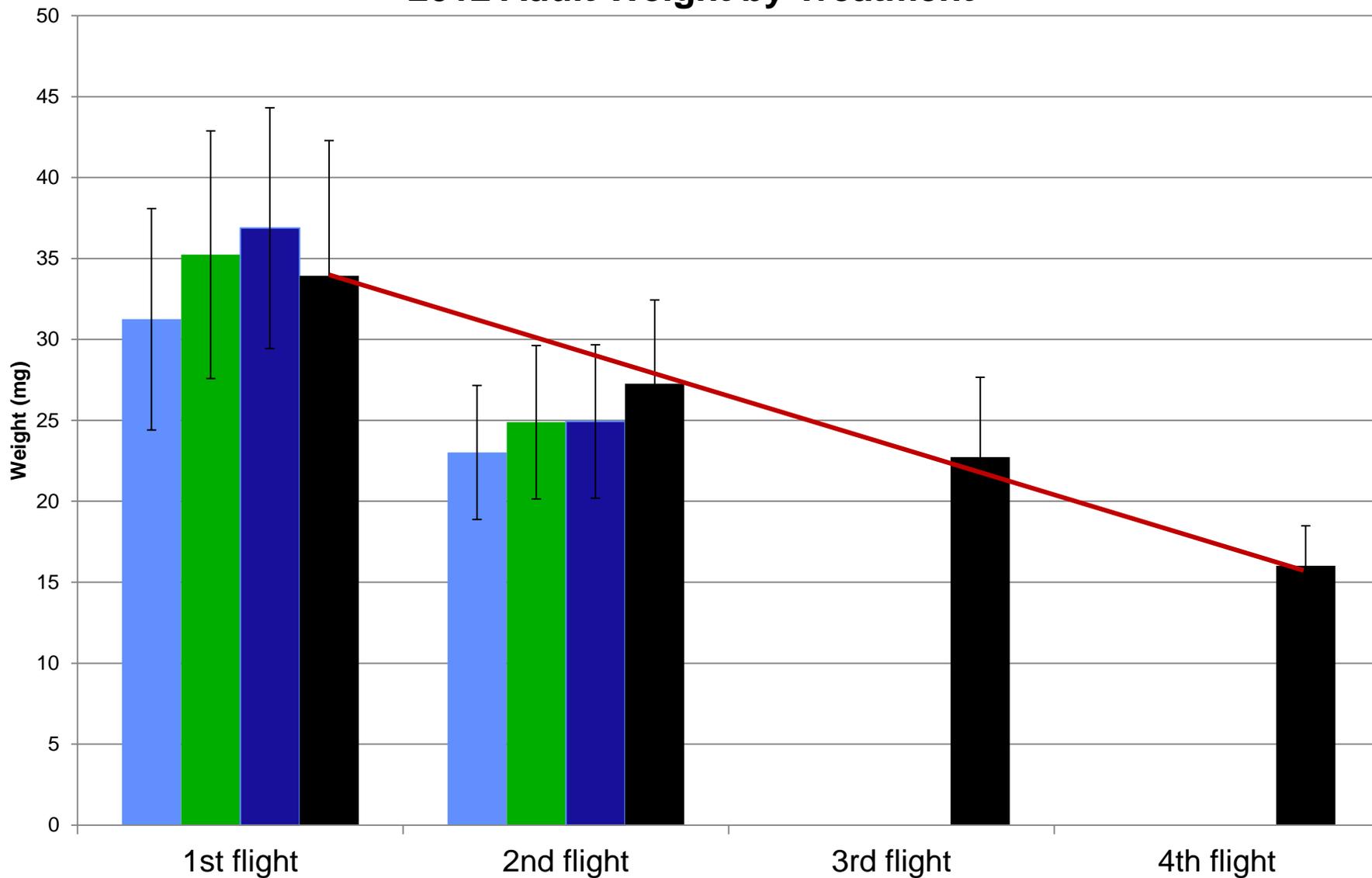
| Treatment | 1st Flight | 2nd Flight | 3rd Flight | 4th Flight |
|-----------|------------|------------|------------|------------|
| "+0"      | Y          | Y          | N          | N          |
| "+2"      | Y          | Y          | Y          | N          |
| "+4"      | Y          | Y        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

\*Did not reach pupation

## 2012 Treatment Cohort Demography

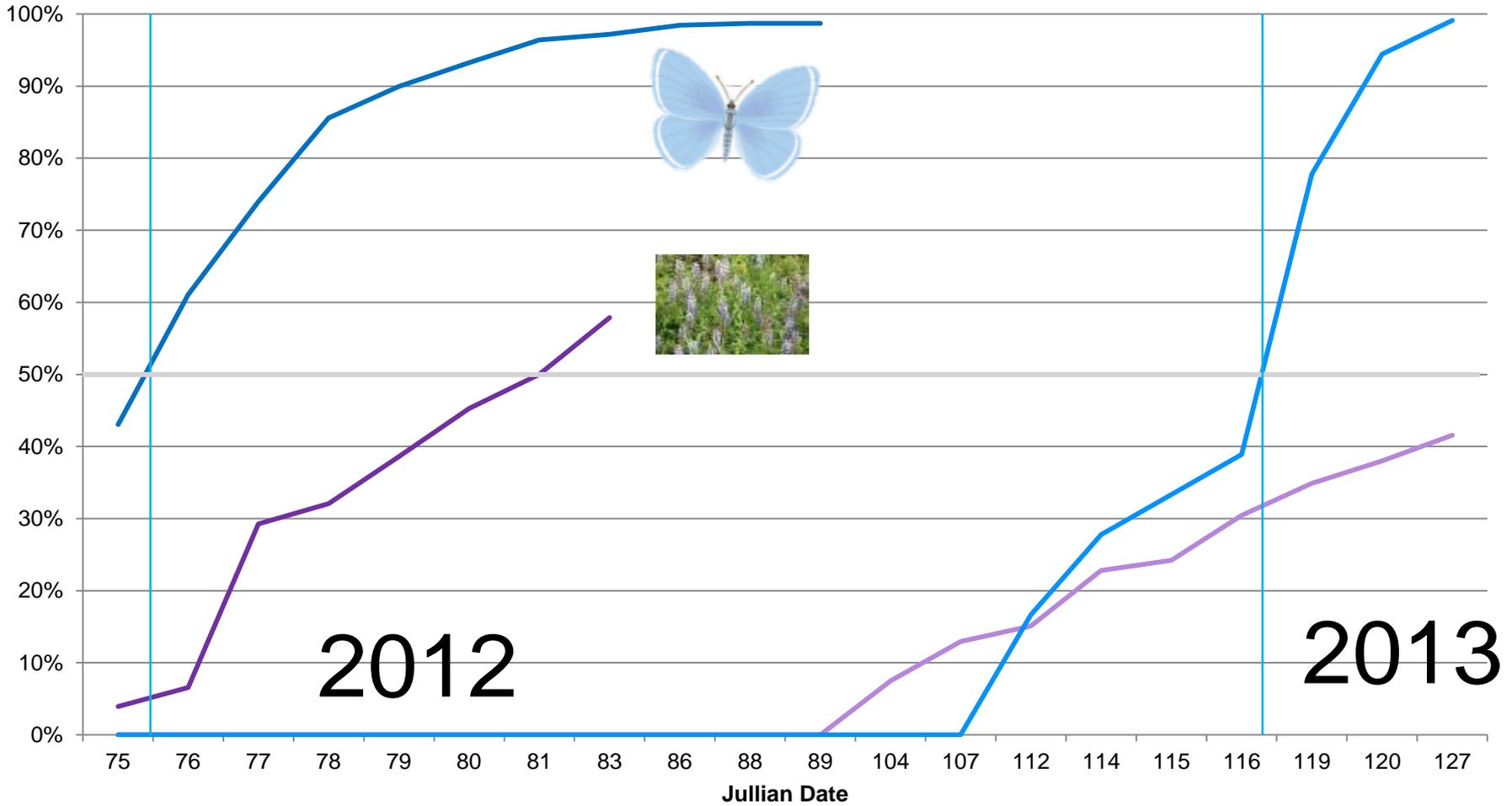
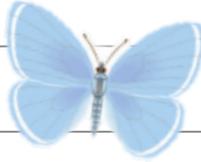
| Treatment | 1st Flight | 2nd Flight | 3rd Flight | 4th Flight |
|-----------|------------|------------|------------|------------|
| "+0"      | Y          | Y          | N          | N          |
| "+2"      | Y          | Y          | N          | N          |
| "+4"      | Y          | Y        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

# 2012 Adult Weight by Treatment



0 2 4 6

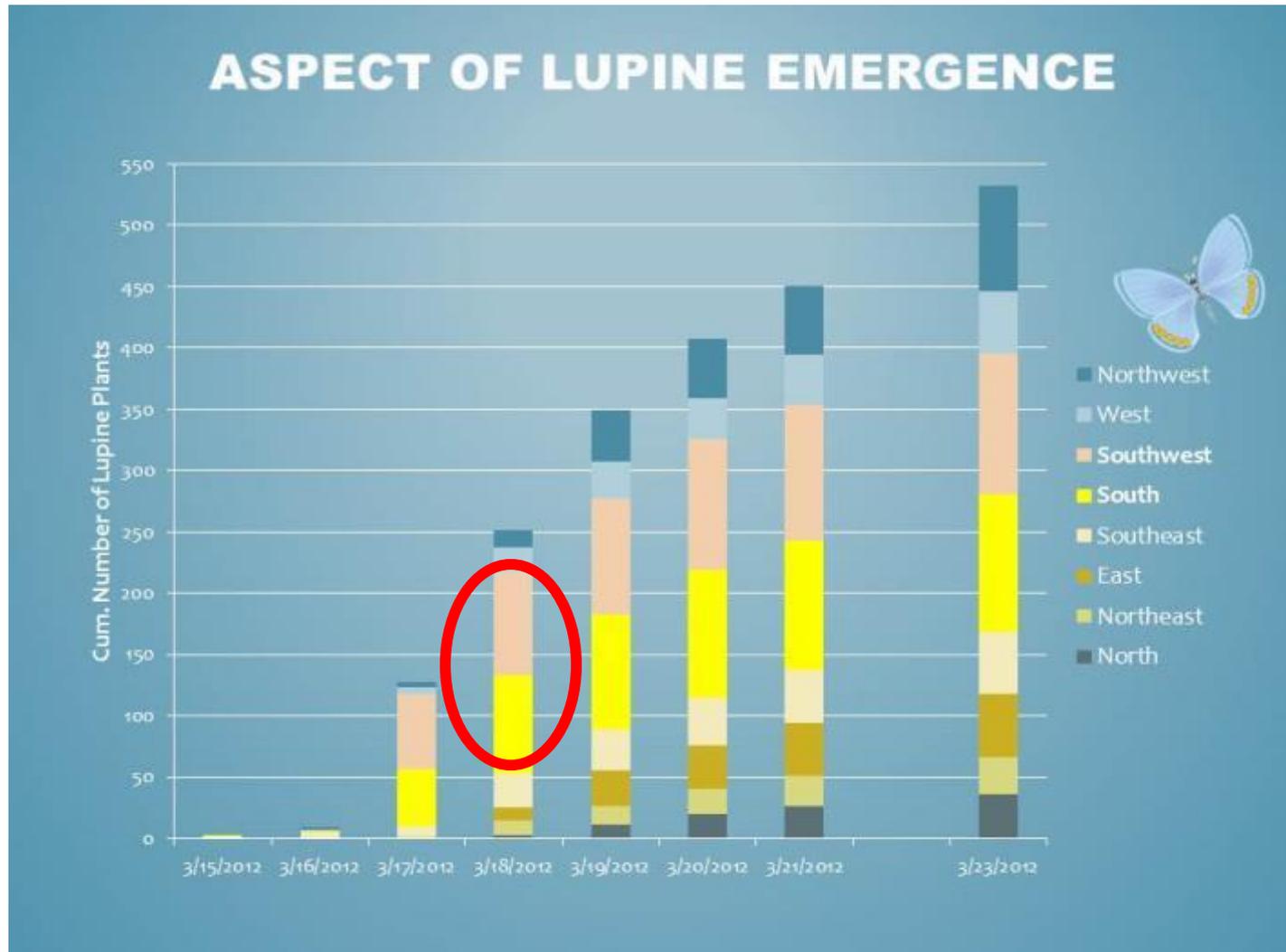
# PHENOLOGICAL MISMATCH



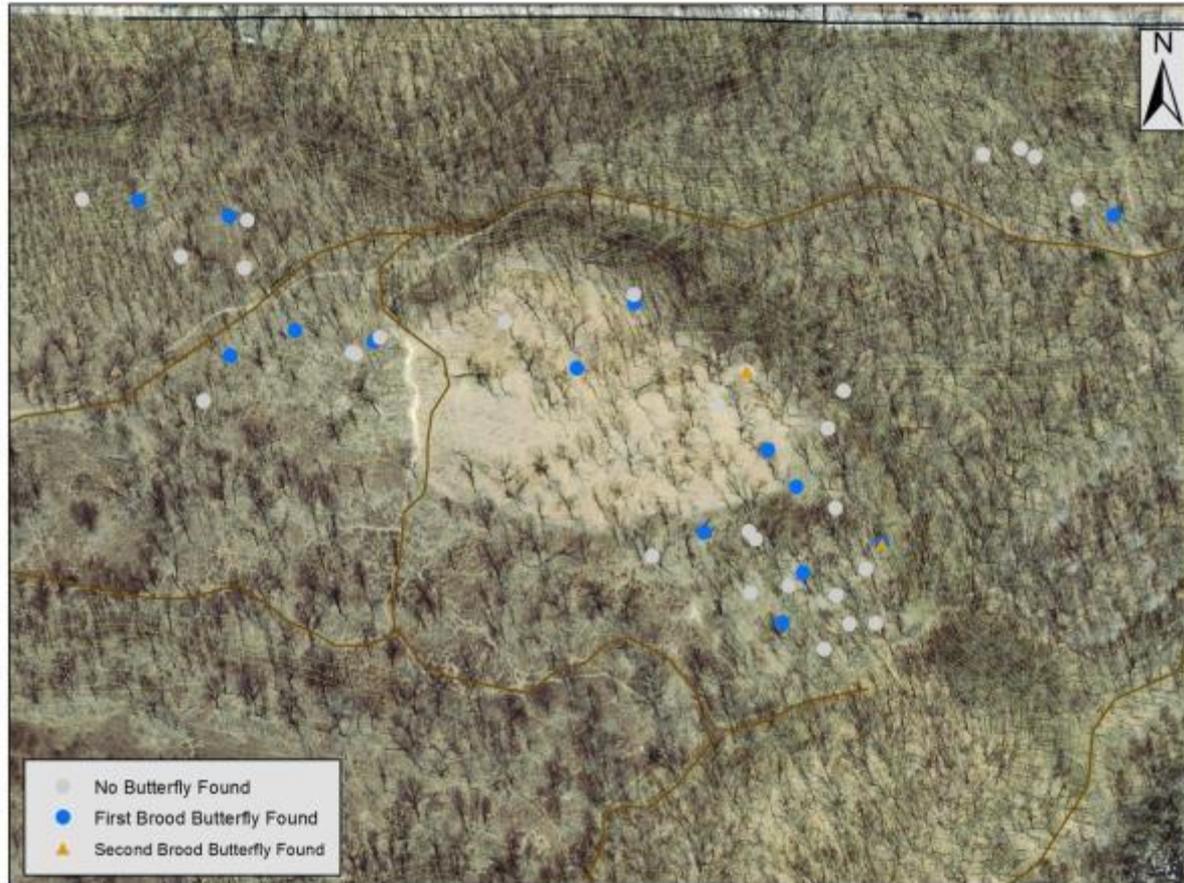
2012

2013

# Lupine first comes up South x Southwest



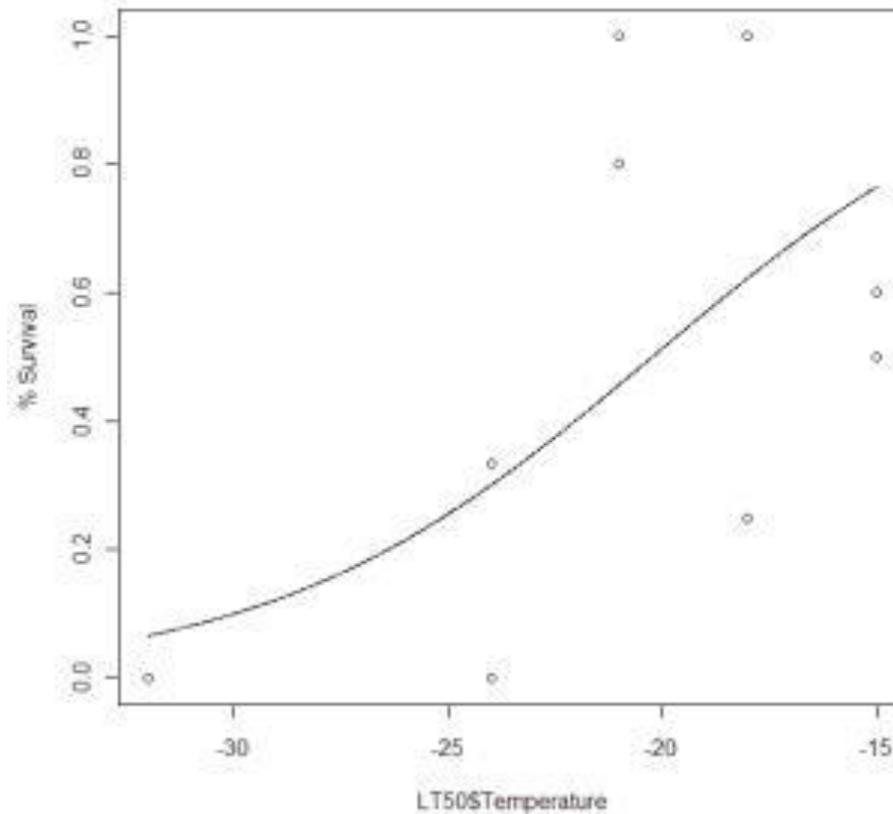
# Poor second brood survival 2012



**Did 2012, a year with exceptionally warm and early spring followed by a hot, very dry summer → 2013 Extinction???**

- **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**
- **Microclimate – key to survival?**

# LOWER LETHAL EXPERIMENTS

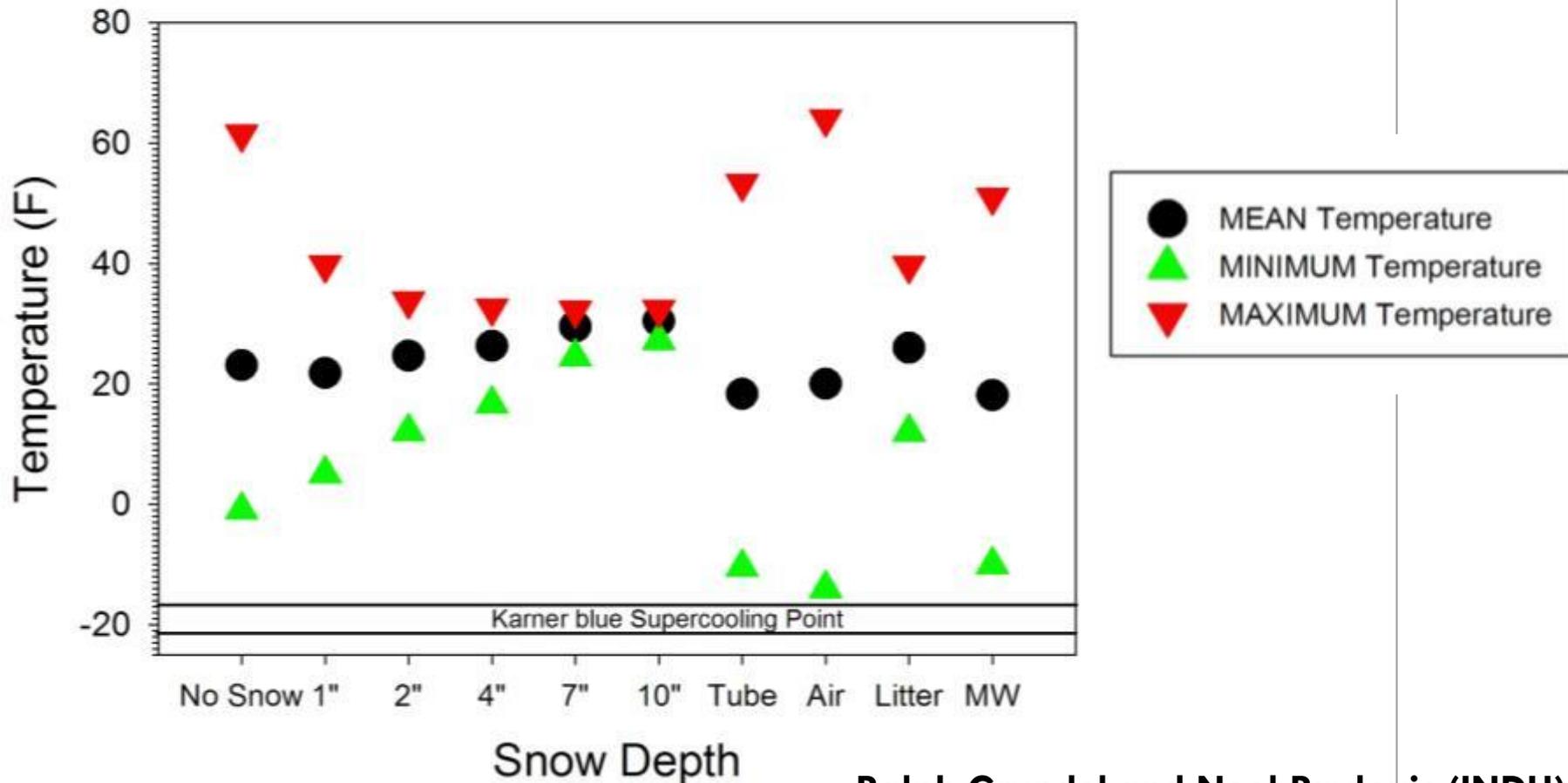


# SNOW DEPTH MANIPULATIONS



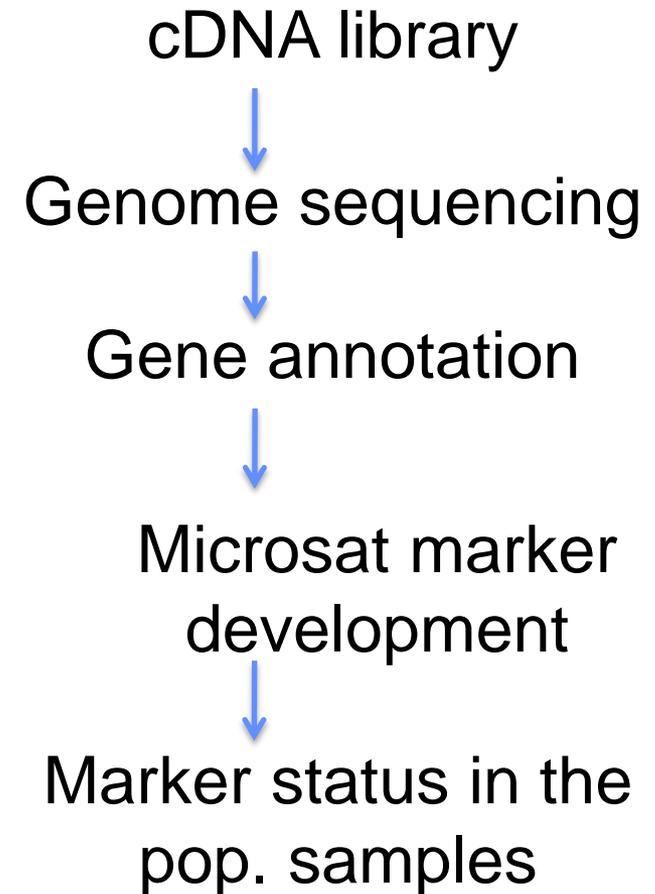
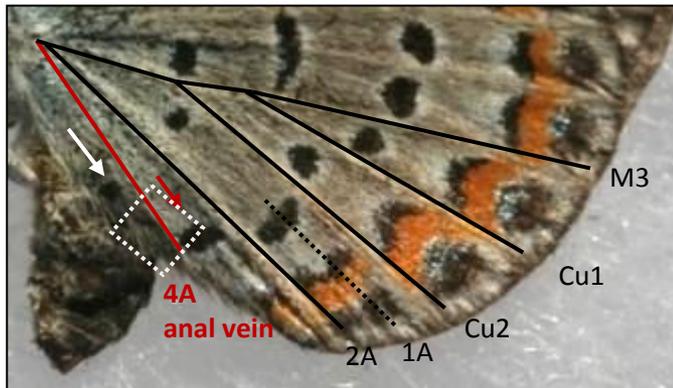
# SNOW DEPTH MANIPULATIONS

Range of temperature values under snow



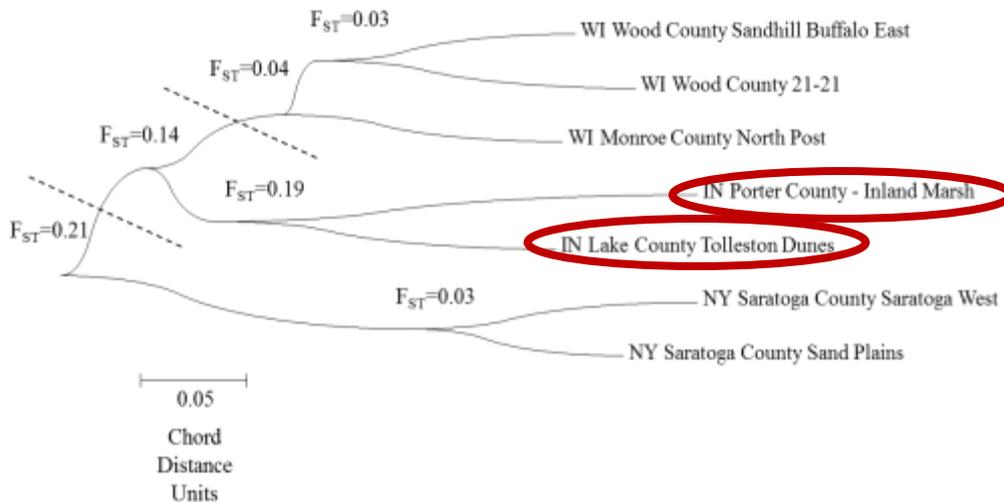
# POPULATION GENETICS

- 646 wing tissue samples collected in 2010-2011
  - IN, WI, NY, MI
- 72,769,476 reads
- 8,000+ markers



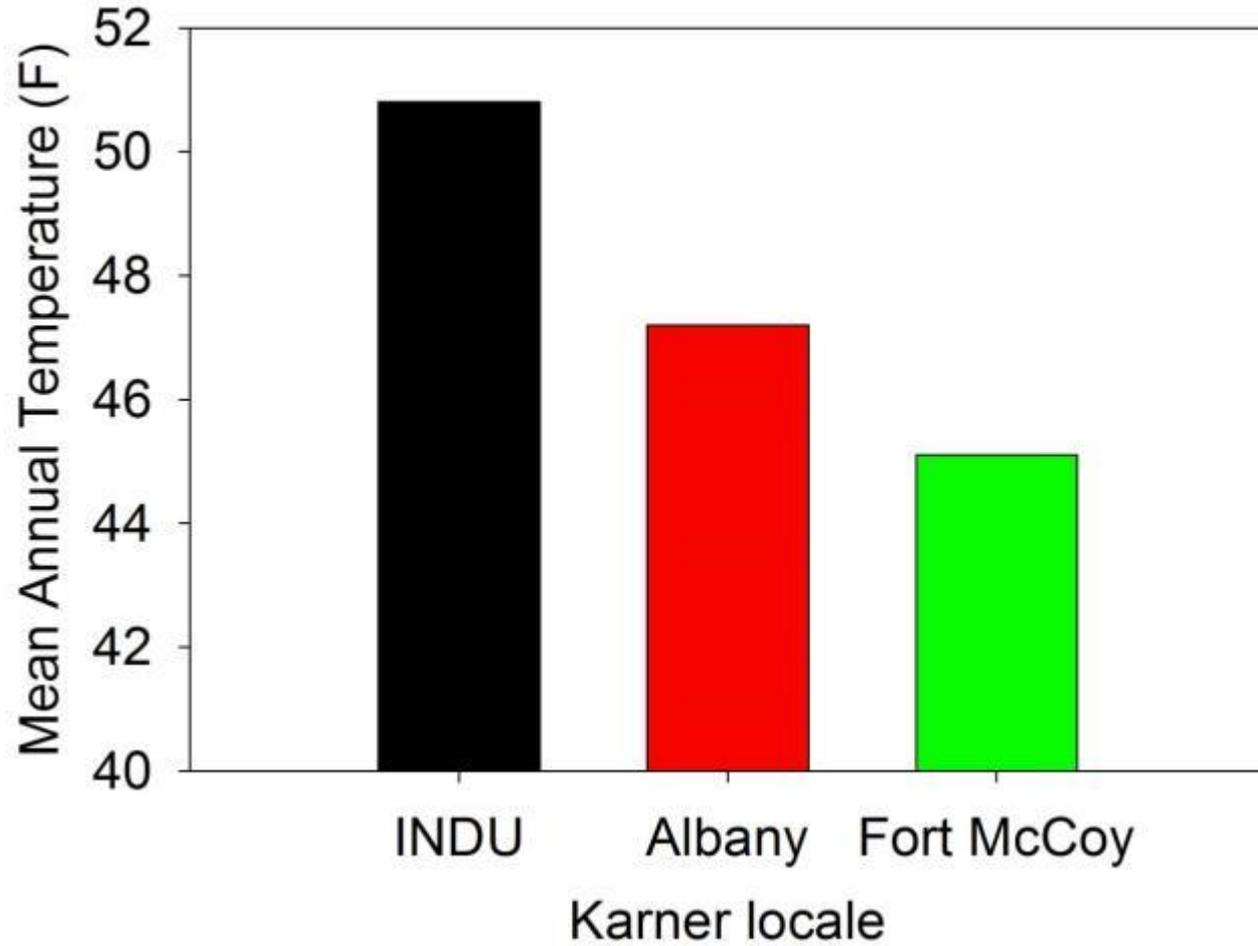
# Genetic effects of fragmentation, barriers to dispersal – Genomic analysis – **Local Genetic Adaptation?**

## Neighbor-joining tree

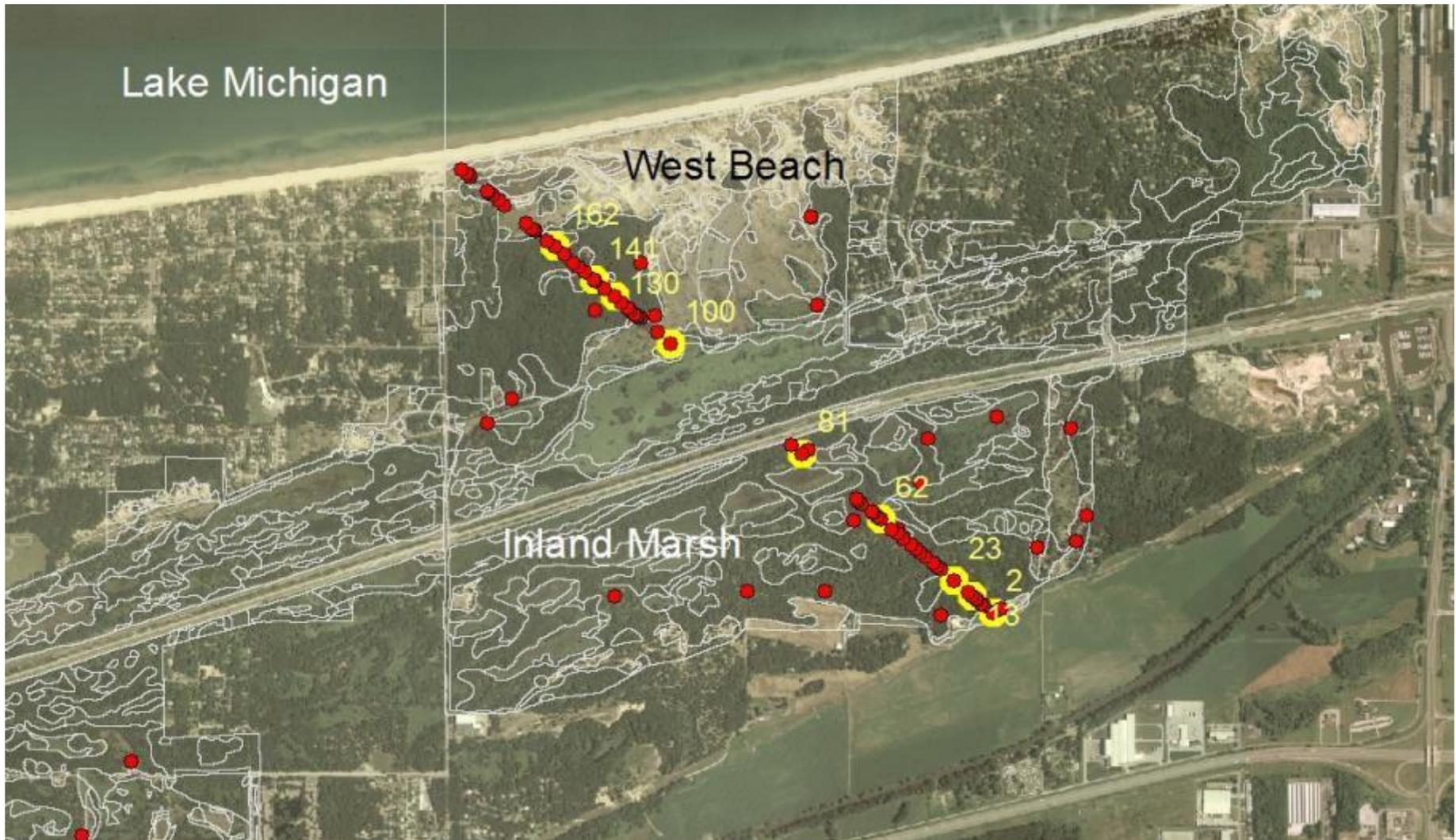


- Sites within Indiana Dunes are about as different from each other as Wisconsin from NY
- Genetic bottlenecks due to fragmentation and population bottlenecks (Fire?)

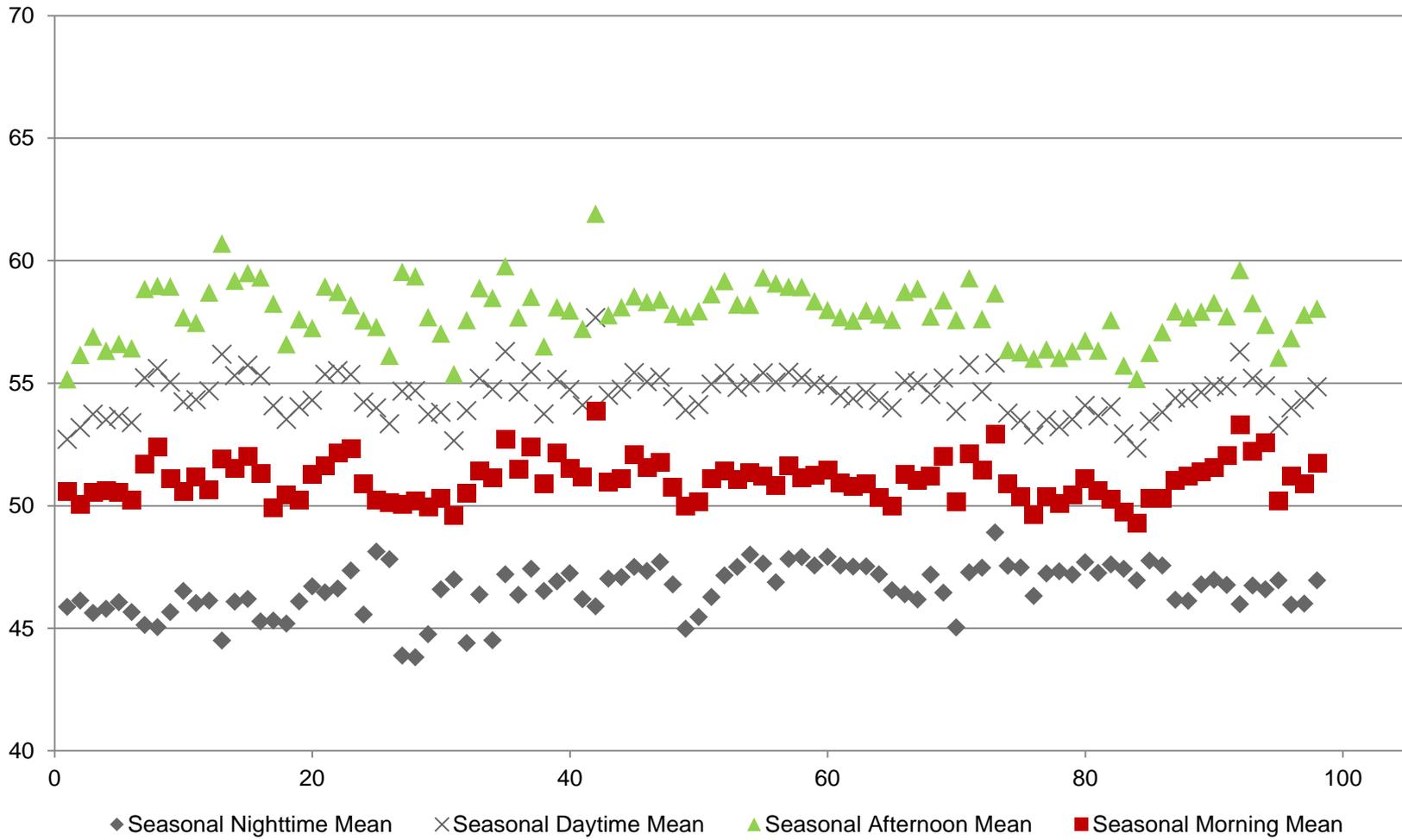
Temperature differences across Karner range - ca. 6 F



# MICROCLIMATE STUDY



# Autumn 2011 (3 month) Temperature for ambient (in tube) sensors – 6F afternoon



# Assisted Migration

Local temp range = Rangewide temp range?  
Escape “in place”?



Too hot here.