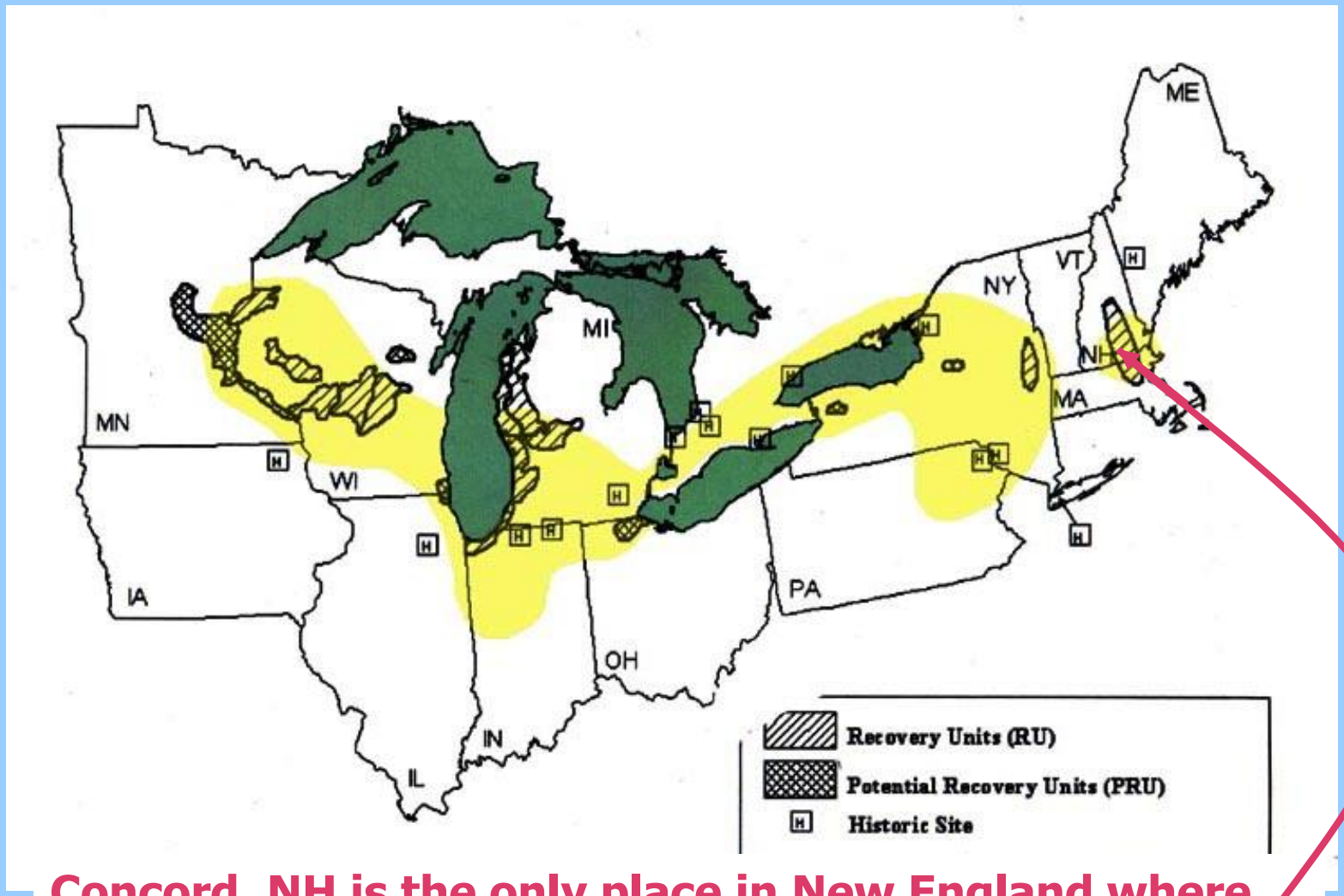
Karner Blue Butterfly Conservation in NH

Historic and potential recovery areas of the Karner blue butterfly

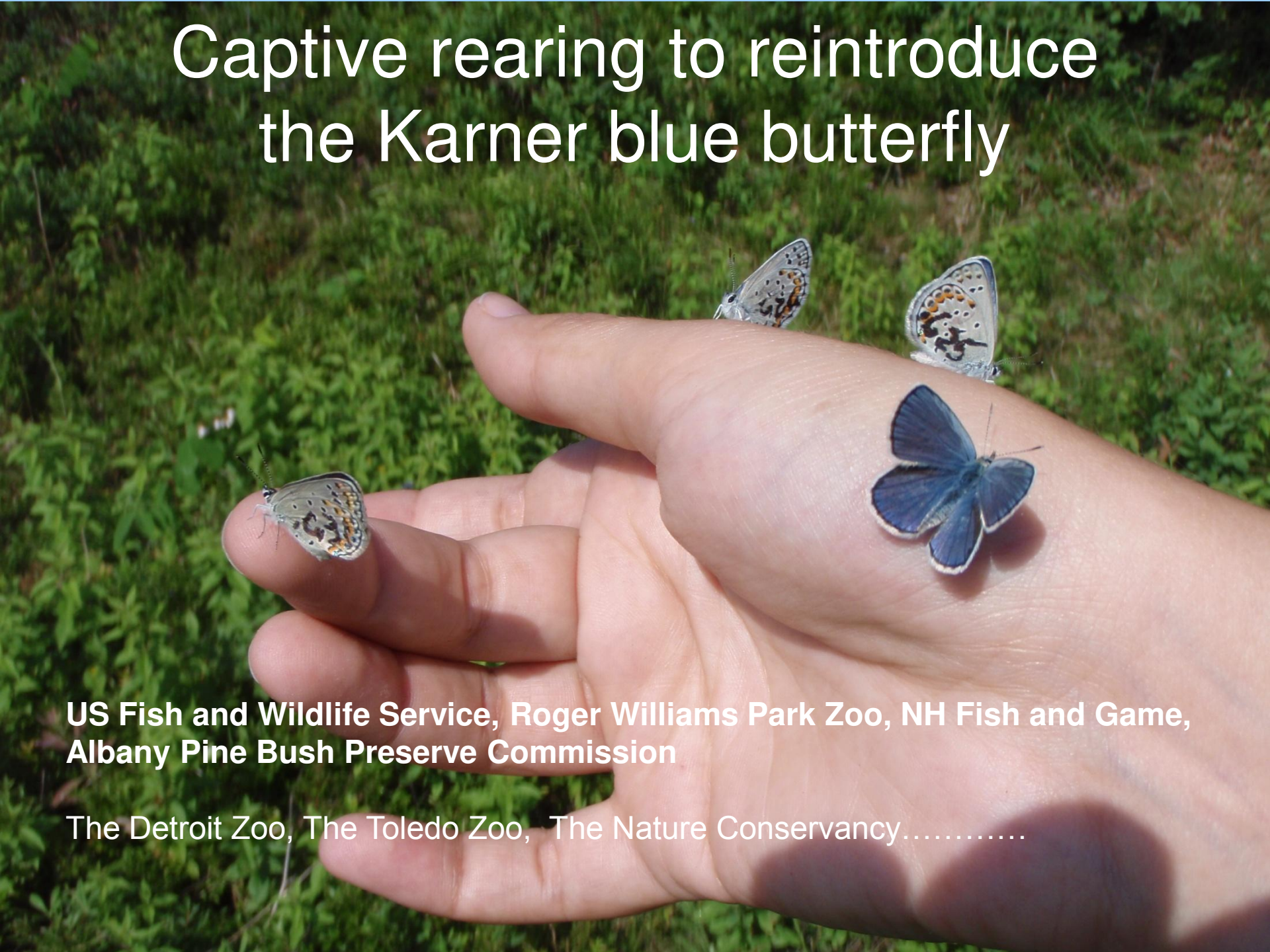


Concord, NH is the only place in New England where the Karner blue can be found.

Federal Recovery Goal

Restoring or mimicking ecosystem processes to increase habitat

Captive rearing to reintroduce the Karner blue butterfly



US Fish and Wildlife Service, Roger Williams Park Zoo, NH Fish and Game, Albany Pine Bush Preserve Commission

The Detroit Zoo, The Toledo Zoo, The Nature Conservancy……

Successful Reintroduction Requires

- Habitat Quality
- Overcoming Allee Effect
- Fitness

Problems with Captive Breeding for Species Recovery

- Self sufficiency of captive populations
- Poor success of reintroductions
- High Costs
- Preemption of Other Recovery Techniques
- Disease Outbreaks
- Maintain Admin. Continuity

Year	Lupine	Nectar	Planting Hours	Captive Rearing Hours	Kids Camp
2006	-	-	-	-	-
2007	364	-	86	68.75	-
2008	261	-	66	49	173.5
2009	530	20	157	300.5	192
2010	440	180	135	159.5	na
2011	285	89	136	72	
2012	186		50		
2013	160		50		
	2226	**289**	**680**	**649.75**	**365.5**

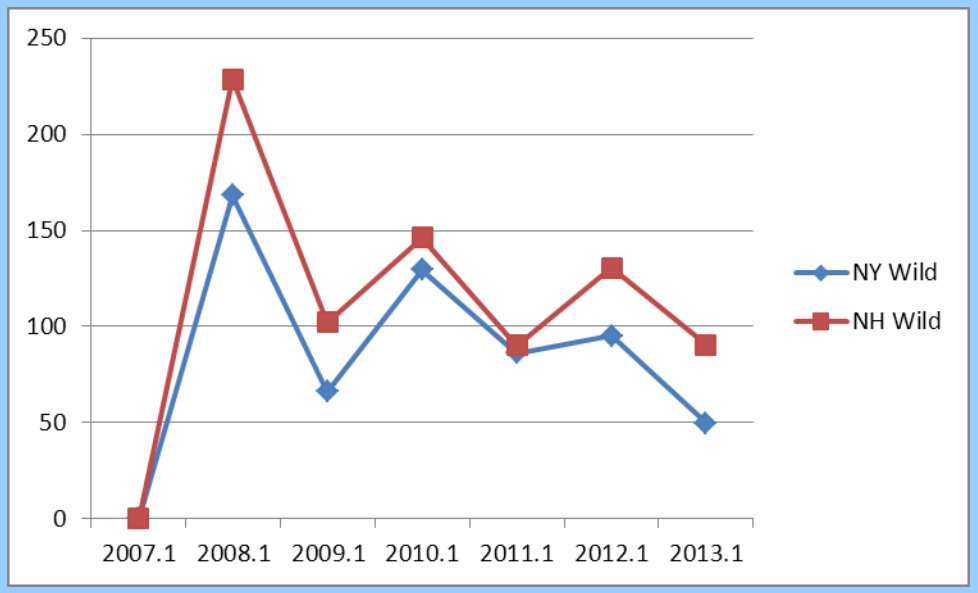
Numerous Partners are Necessary to Implement all Pieces to the Puzzle

Roger Williams Park Zoo and partners of the New England Conservation Collaborative

Kids For Karners

Over 4000 students and 2500 lupine plants from 2000-2014

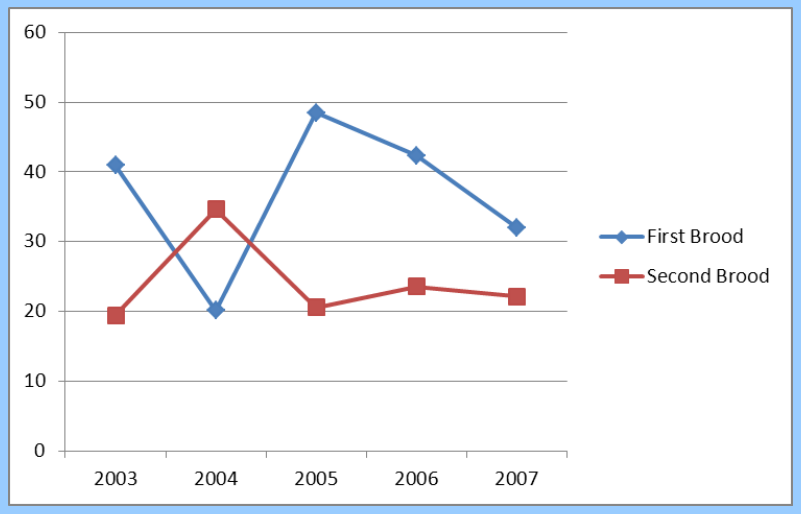
Assessing Traits relative to Founders

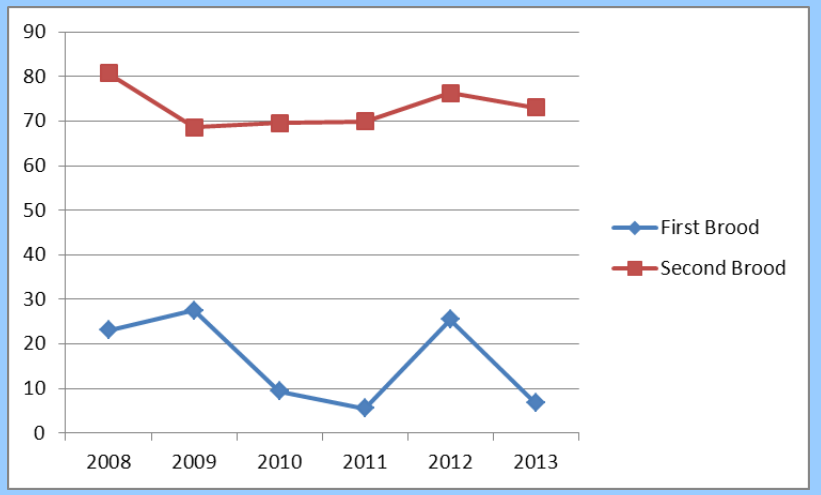


Instar	Average	NH 2011
First	1.9 - 3.5 mm	1.13 mm
Second	3.6 - 5.9 mm	4 mm
Third	6.0 - 9.9 mm	7.25 mm
Fourth	10 - 15 mm	11.2 mm

Observing for Morphological Change

Monitoring Infertility as a symptom for Inbreeding





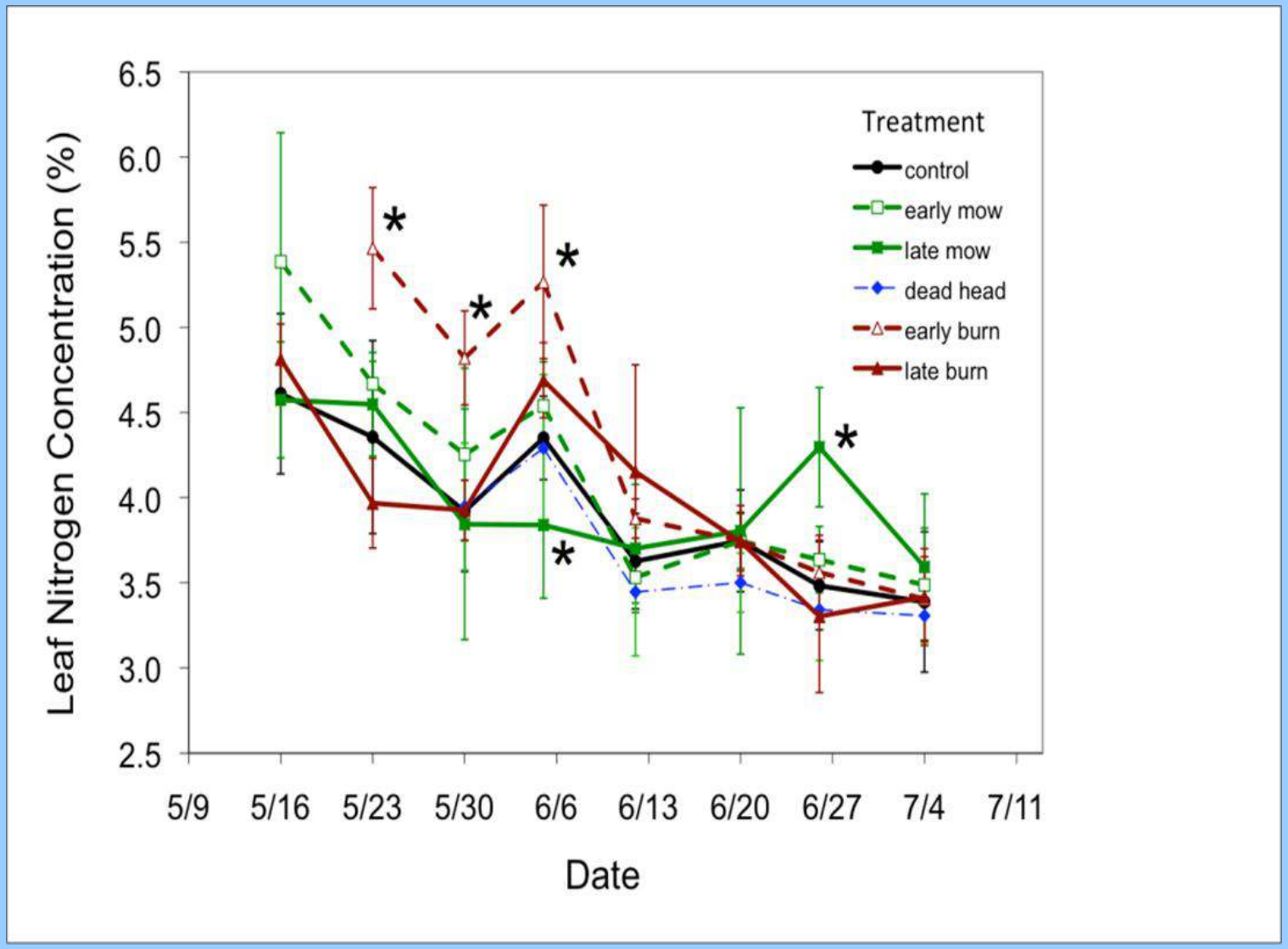
Evaluating Impact of Captive Breeding

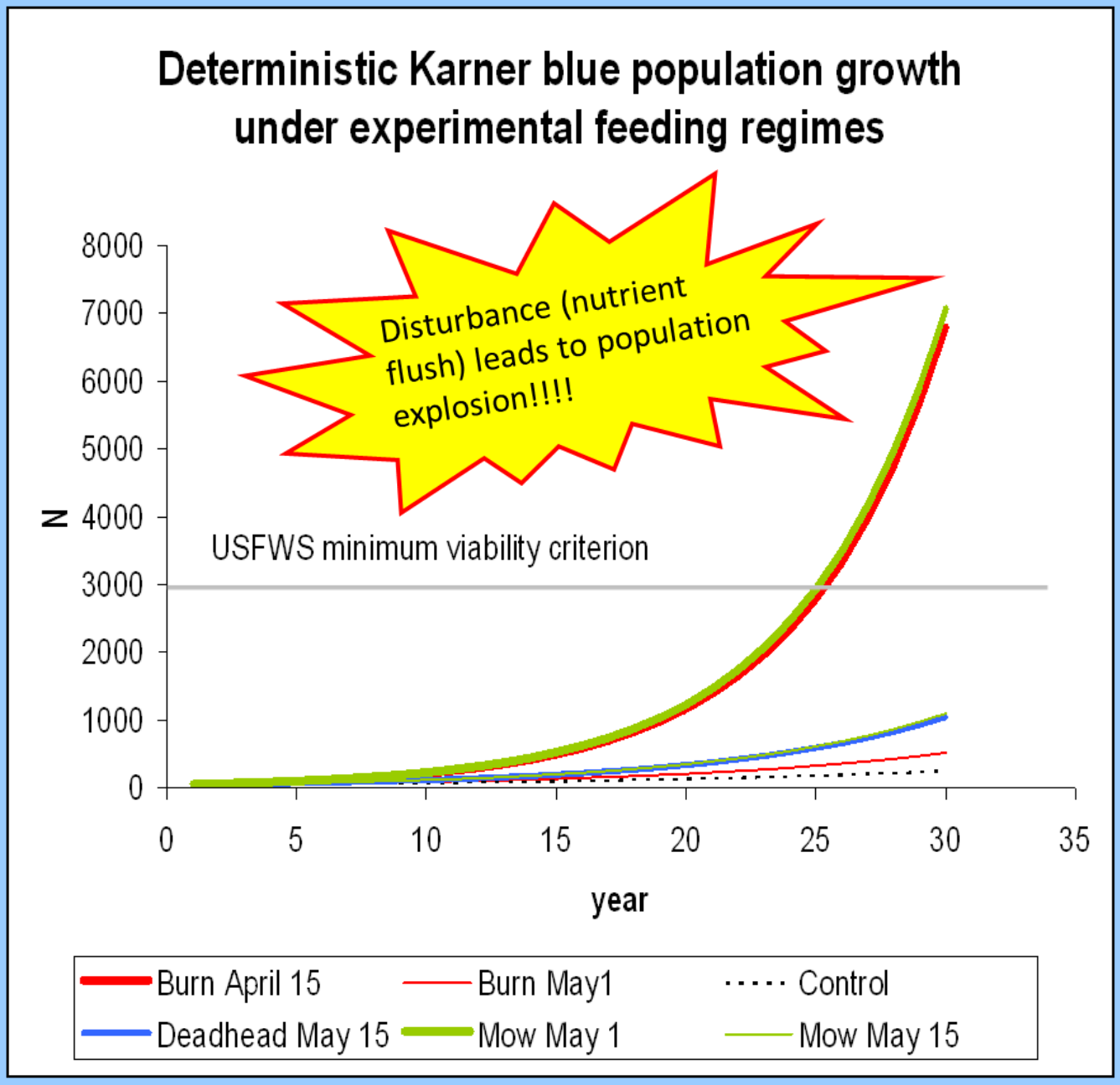
Life Stage	Fuller 2008	NH Lab
first brood hatch	0.12	0.35
first brood larval survival *	0.514	0.65
first brood female survival	0.207	-
first brood eggs per female+	40-64	131
second brood hatch	0.968	0.722
second brood larval survival	0.514	0.783
second brood female survival	0.207	-
second brood eggs per female	40-64	37.72

* Larval survival was separated into predation and parasitism by Fuller

+Eggs per female was based on 5-8 eggs per day per female in Fuller

Kbb larval feeding study – Forage quality

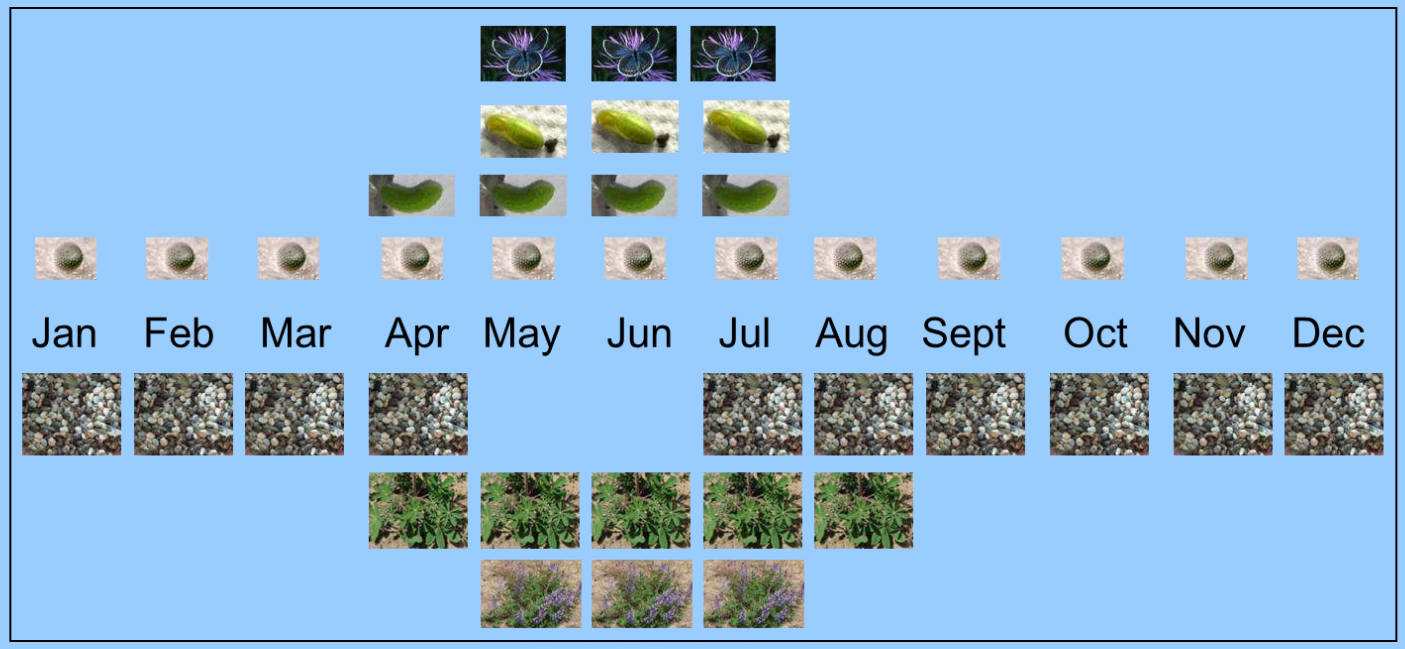



Deterministic Karner blue population growth under experimental feeding regimes
Disturbance (nutrient flush) leads to population explosion!!!!
USFWS minimum viability criterion
N
8000
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
35
year
Burn April 15
Burn May1
Control
Deadhead May 15
Mow May 1
Mow May 15

Year	Date Larvae	Larval Days	Avg. Temp*	Avg. Temp (Celsius)	Max. Temp	Min. Temp	Date Adults	Avg. Temp[1]	Avg. Temp (Celsius)	Max. Temp	Min. Temp	% Third Brood Hatch
2005	13-Jun	32	74.02	23.34	96.26	59.42	14-Jul	78.55	25.86	93.97	68.33	<1%
2006	15-Jun	23	75.37	24.09	85.83	62.17	7-Jul	77.64	25.36	100.98	61.48	<1%
2007	10-Jun	27	72.99	22.77	89.48	58.73	6-Jul	73.16	22.87	54.38	64.91	<1%
2008	8-Jun	26	72.51	22.5	89.48	65.59	3-Jul	76.42	24.68	91.71	76.42	4.30%
2009	5-Jun	32	67.97	19.98	82.95	58.73	6-Jul	70.4	21.33	82.95	59.42	6.70%
2010	21-May	29	na	na	na	na	19-Jun	na	na	na	na	11.00%
2011	12-Jun	28	68.85	20.47	75.22	62.17	9-Jul	70.669	21.48	78.71	65.59	0%
2012	26-May	26	73.12	22.85	93.21	67.65	20-Jun	79.04	26.13	93.97	69.02	8.05%
2013	15-Jun	24	68.84	20.47	87.28	58.73	6-Jul	72.27	22.37	80.82	66.96	<1%

*Temperatures Measured from first larvae hatched to first adult eclosed

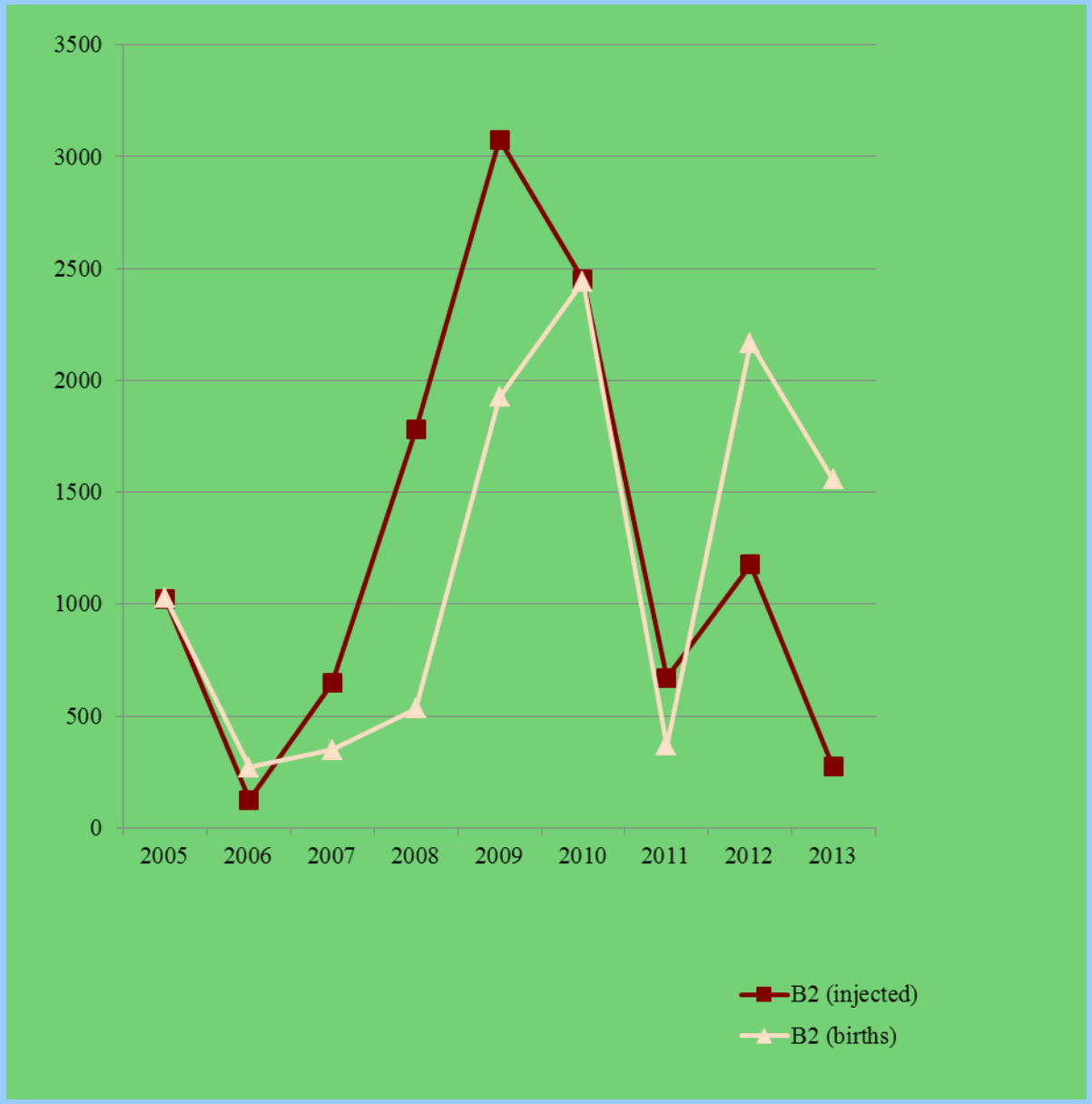
[1]Temperatures Measured from first adult eclose + 20days



UPPER MIDWEST TRENDS

- Michigan
  - Huron-Manistee National Forest
    - Karners down 73% from 2011 to 2012
    - Down another 28% from 2012 to 2013
    - Overall, populations dropped 81% from 2011 to 2013
  - Michigan State Forests
    - Declining populations from a raw count of 1117 in 2009 to 32 in 2013
    - Down by 97% from 2009
- Indiana Dunes
  - Declining population from a raw count of 779 in 1999 to 0 in 2013 - Extirpated
  - Other Indiana small sites are down from 2011 with a possible extirpation at one of the three sites
- Minnesota
  - Remnant populations. None seen since 2010
  - Extirpated
- Wisconsin
  - Down 24% from 2011 to 2012 (38650 to 29,400)
  - Down 40% from 2012 to 2013 (29,400 to 17650)
  - Down 54% from 2011 to 2013 (38,650 to 17,650)

Karner Blue Butterfly Population



New Hampshire population continues to show positive response to habitat management and augmentation

The agencies and organizations who assist on the Karner Blue Butterfly Restoration Project, in addition to the NH Fish and Game Department (NHFG) and the US Fish and Wildlife Service (USFWS), include NH Army National Guard (NHANG), Concord Municipal Airport, Natural Heritage Inventory (DRED), Forest and Lands (DRED), National Wildlife Federation (NWF), Wildlife Heritage Foundation, Praxair Foundation, Roger Williams Park Zoo, and Concord Schools Project SEE


Sharpie

Inbreeding Symptoms

Percent infertile eggs increases
Adults will be smaller
Reluctant to pair
Death in final instars

After 6 generations you can expect problems, best way to maintain strong gene pool is to add wild stock throughout the year

From “The Commercial Butterfly Breeders Manual” (Venters, Rogers and Chesterfield 2001)

Pros

- Greater control over climate
- Protection from predators and parasites
- Observation and control of cause and effect
- Better control of selective breeding
- Ova laid in smaller area

Cons

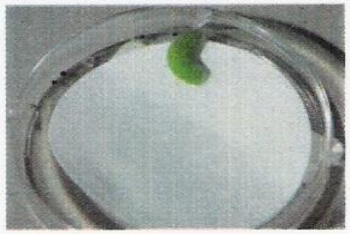
- Time consuming
- Increased risk of disease
- Increased work in providing and changing cut foodplant
- Less efficient use of foodplant
- Smaller less robust adults on cut foodplant
- Usually delays egg laying
- Larger percentage of ova laid in unnatural places causing them to dry out or be subject to fungal attack

Karner Blue Butterfly Life Cycle

Egg

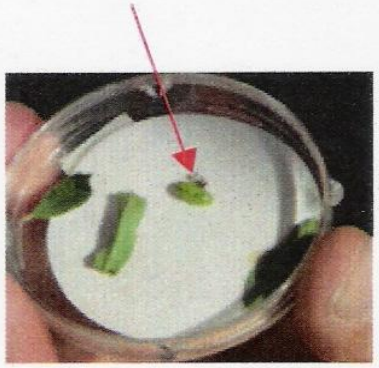
Adult

1 week
(flight is about 3 weeks)



Larvae

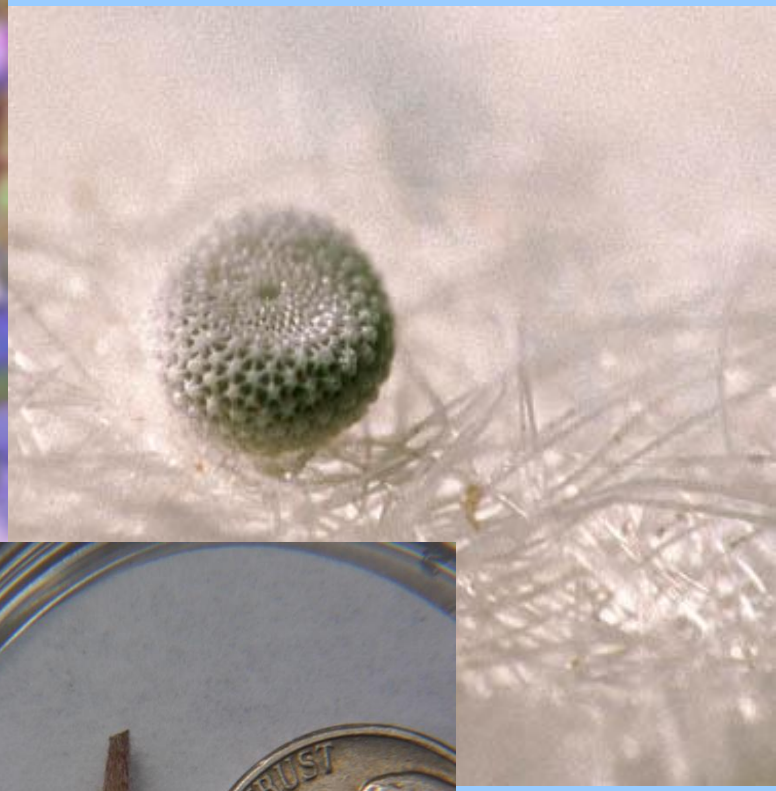
18-21 days
4 instars



Pupae

10 days

Adults lay eggs on or around wild lupine



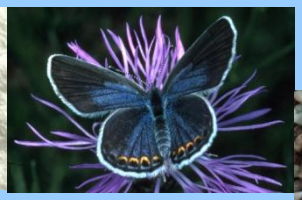
Karner Blue Butterfly Larvae

Note the hairs on the larvae and lupine leaf

Egg

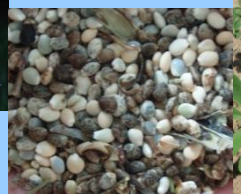
Larva

Pupa

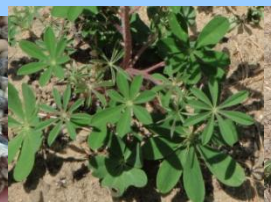


Adult

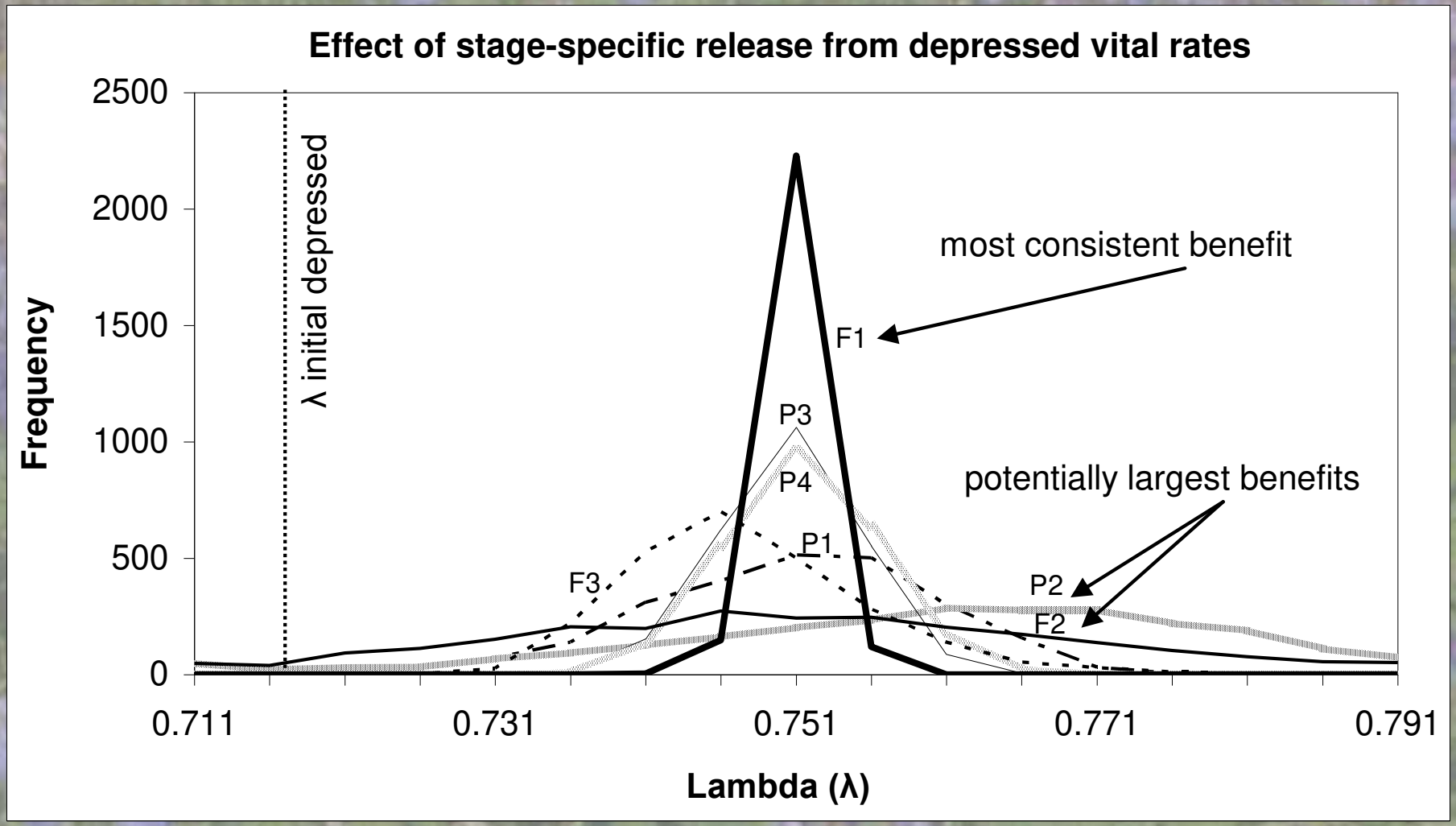
Seed



Plant



Flower


Effect of stage-specific release from depressed vital rates
Frequency
2500
2000
1500
1000
500
0
λ initial depressed
most consistent benefit
F1
P3
P4
potentially largest benefits
P1
F3
P2
F2
0.711
0.731
0.751
0.771
0.791
Lambda (λ)

INCUBATOR FEATURES

Chamber Performance

Temperature Range:	18°C to 32°C
Temperature Control:	±0.2°C
Temperature Sensor:	Type T Thermocouple
Cooling System:	Solid State
Humidity System:	Ultrasonic (optional)
Lighting:	Programmable LED (optional)

Controls

- Microprocessor PID controls
- Audible/visible alarms
- Remote alarm contacts

Cabinet Construction

- High density urethane insulation
- Double-pane thermal glass door
- Non-chip vinyl laminated steel exterior
- White NSF-approved aluminum interior
- 300 series stainless steel floor
- Low wall plenum
- 4" casters

A variety of factors determine impact on a particular species.

Table 1 Characteristics of insects likely to be high *vs*. low risk from global change, including land-use change, climate change and invasive species.

High risk	*Lower risk*
Small population size	Large population size
Narrow geographic range	Large geographic range
Widely fluctuating population size (exogenous population dynamics)	Regulated or stable population size (endogenous population dynamics)
Resource/habitat specialisation	Resource/habitat generalist
Narrow environmental tolerances (*e.g.* thermal tolerance)	Broad environmental tolerances and adaptive strategies for avoiding harsh conditions
High trophic position (*e.g.* parasitoid)	Basal tropic position (*e.g.* scavenger or plant-feeder)
Limited dispersal ability (*e.g.* wingless or small body size with limited flight distance)	High dispersal ability (*e.g.* winged with large flight muscles)
Involved in mutualism	Not dependent on mutualistic association with other organisms
Example: a small-bodied, specialised parasitoid with a small geographic distribution	Example: strong-flying butterfly that feeds on a number of abundant host plants and inhabits an entire continent

Cupido minimus (Fuessly, 1775) – Small Blue

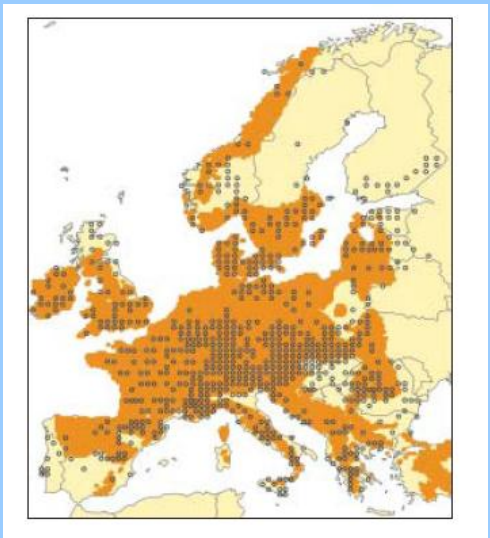
© Albert Vliegenthart

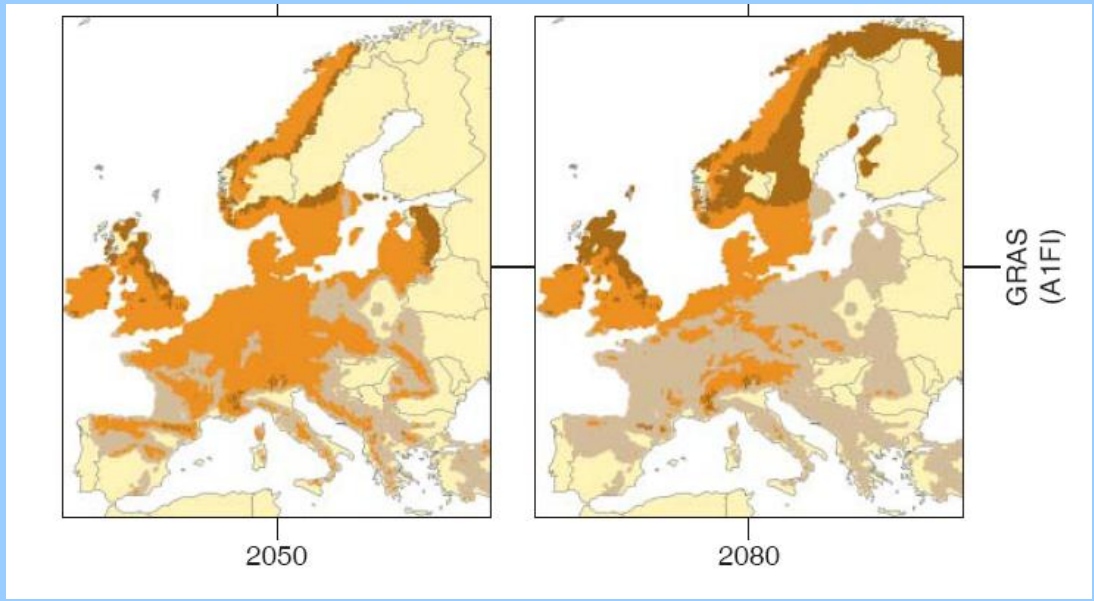
		Full dispersal	No dispersal
2050	SEDG	-2124 (-15.81%)	-3032 (-22.56%)
	BAMBU	-2256 (-16.79%)	-3275 (-24.37%)
	GRAS	-3245 (-24.15%)	-4134 (-30.77%)
2080	SEDG	-4157 (-30.94%)	-5451 (-40.57%)
	BAMBU	-4491 (-33.42%)	-6672 (-49.65%)
	GRAS	-6299 (-46.88%)	-8702 (-64.76%)

Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 13437)

- Large population size
- Large geographic range
- 1-2 generations per year
- Single host plant on specific soils
- Less environmental tolerance

Species #2 - Estimated Range Shift



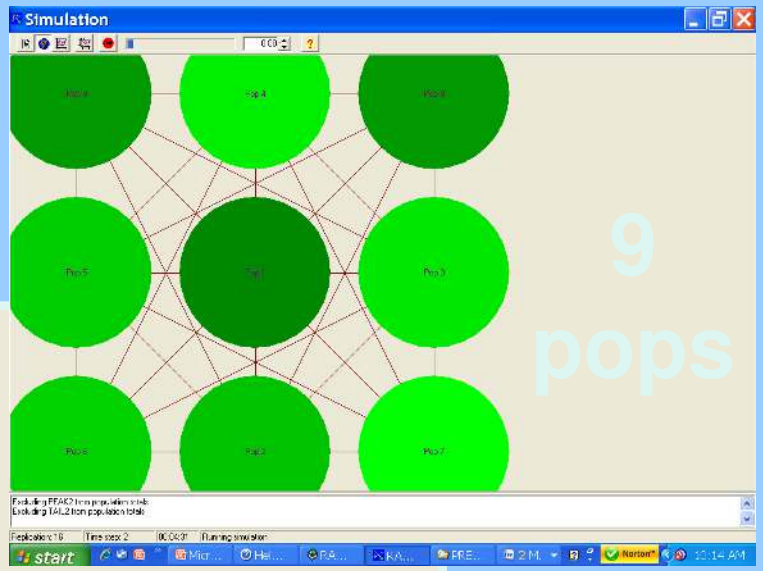


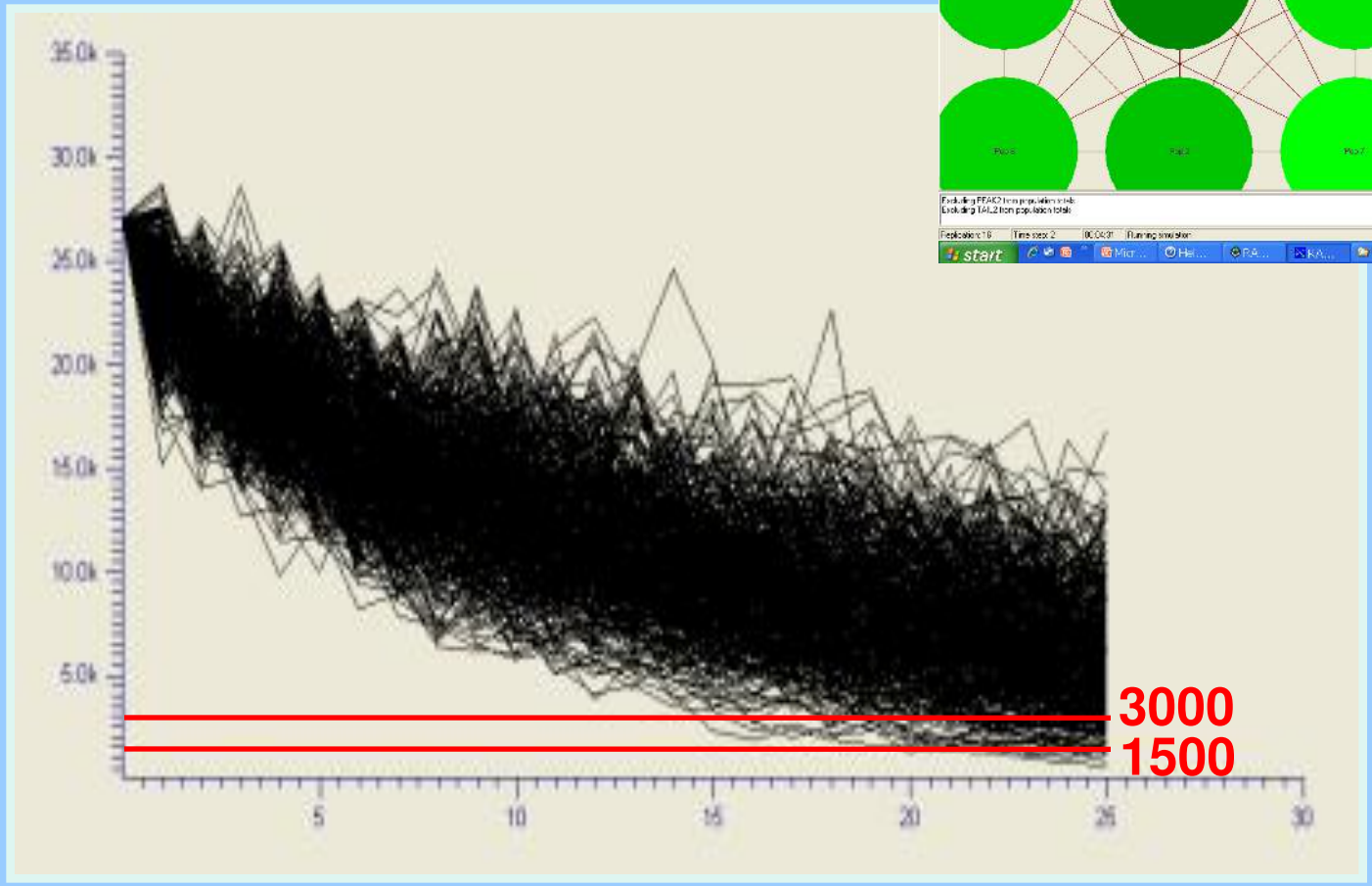
Orange = Stable

Grey = Lost

Dark brown = Gained

A good snow cover is essential to Karner blue egg survival


Simulation
9
pops


35.0k
30.0k
25.0k
20.0k
15.0k
10.0k
5.0k
5
10
15
20
25
30
3000
1500

Fuller 2008

Birds and Reptiles

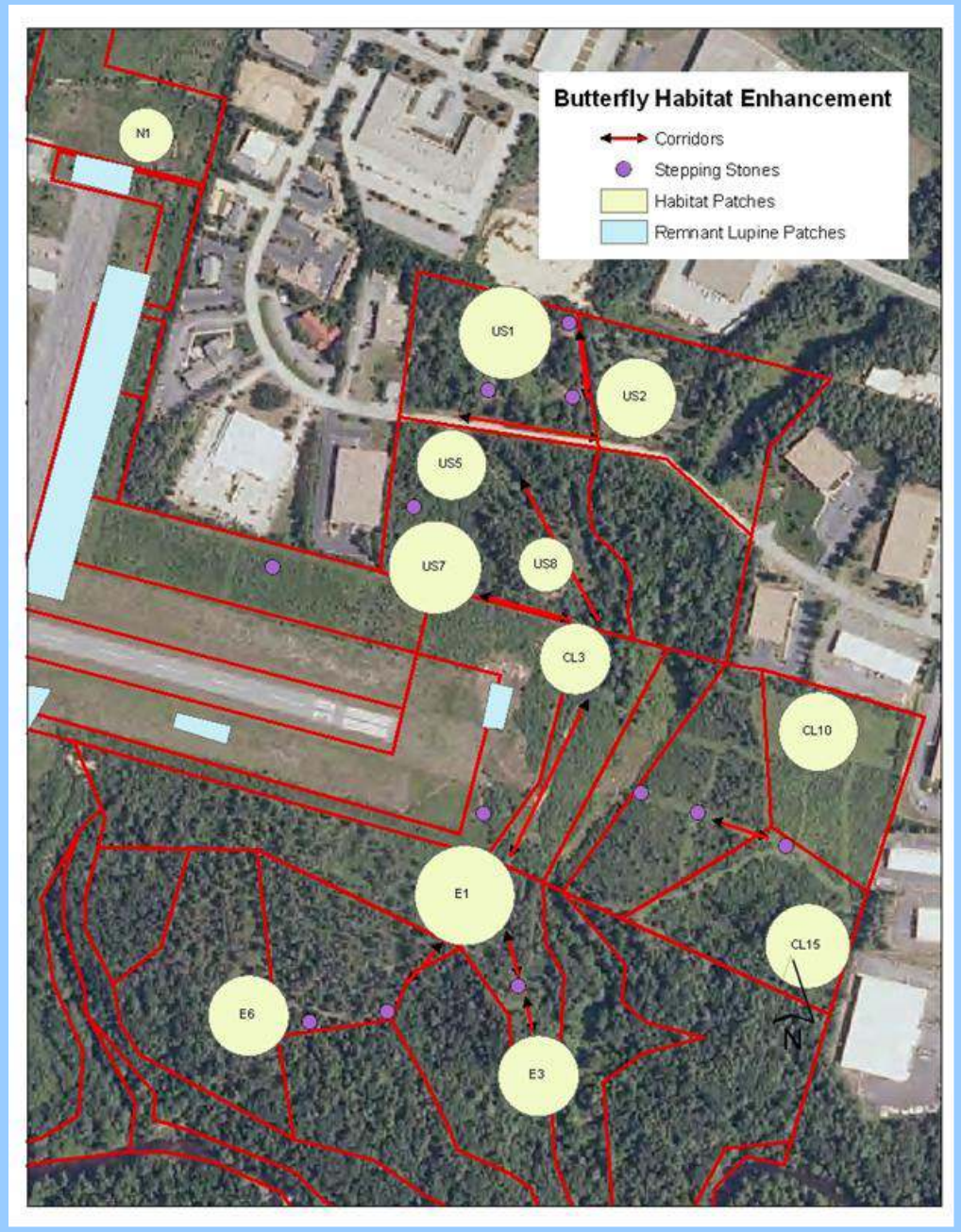
Whip-poor-will

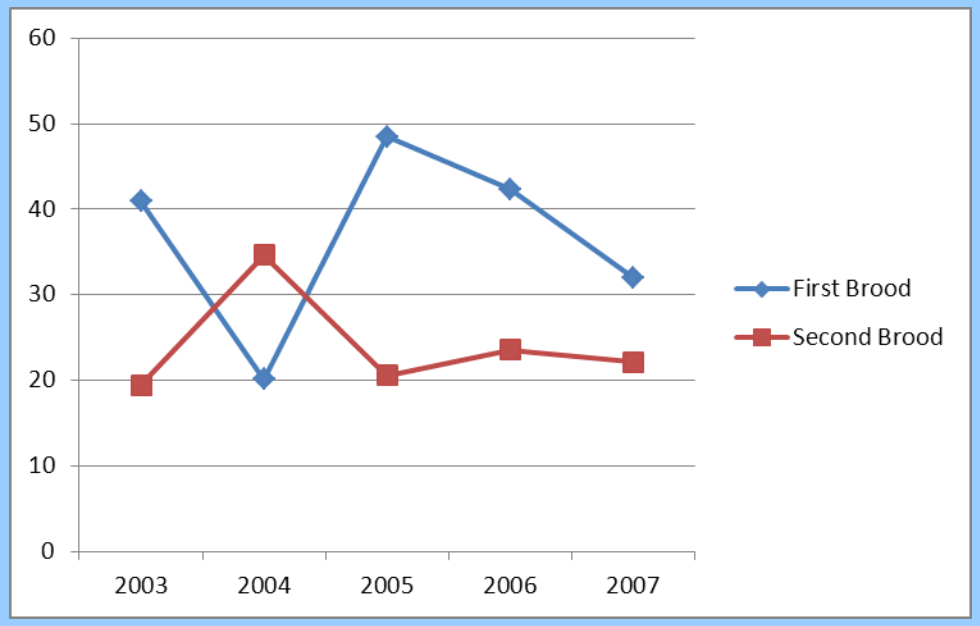
Common night hawk

Prairie Warbler

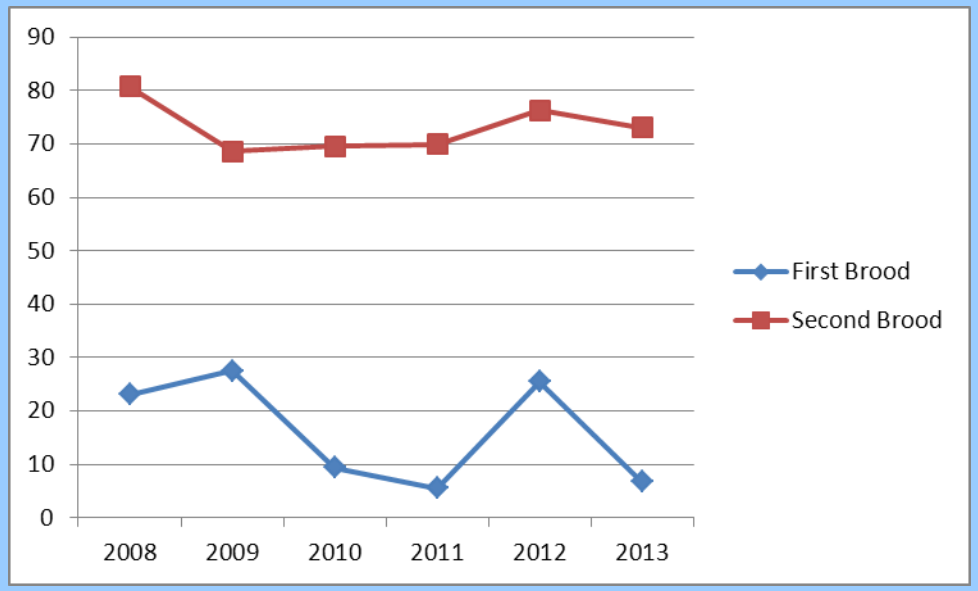
Grasshopper Sparrow

Eastern Hognose


Butterfly Habitat Enhancement
Corridors
Stepping Stones
Habitat Patches
Remnant Lupine Patches
N1
US1
US2
US5
US7
US8
CL3
CL10
E1
CL15
E6
E3
N

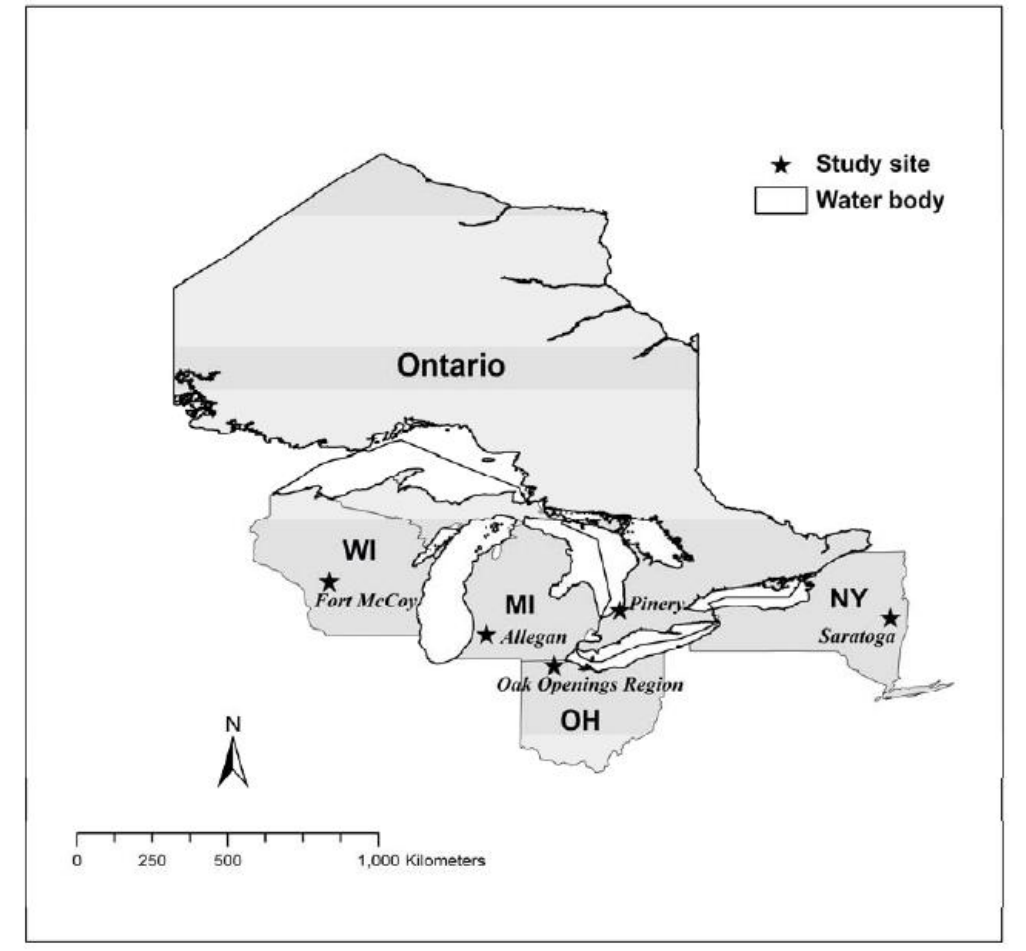


Hatch Success



Environmental change in former and present Karner blue butterfly habitats.

(Liu 2008)



Variables Analyzed

Table 3. Time periods used in the analyses of the climatic indices.

Climatic Indices	Description	Time 1	Time 2
SDII	Simple daily intensity index	1961-1983	1984-2005
RR10	Number of heavy precipitation days	1962-1983	1984-2005
RR20	Number of very heavy precipitation days	1962-1983	1984-2005
SnC	number of days with snow cover	1955-1983*	1984-2005*
ETR	Intra-annual extreme temperature range	1968-1983	1984-2005
T×10	Number of cold days	1968-1983	1984-2005
T×90	Number of warm days	1968-1983	1984-2005
Tn10	Number of cold nights	1968-1983	1984-2005
Tn90	Number of warm nights	1968-1983	1984-2005
FD	Number of frost days	1968-1983	1984-2005
T×35GE	Number of extremely hot days	1968-1983	1984-2005
Tn-10LT	Number of severe cold days	1968-1983	1984-2005

*Snow data are not available for Pinery, nor for Oak Openings Region for the period 1996-2005.

Results

- Identified thermal tolerances
- Identified precipitation limits
- Large population size has advantage
- Duration of snow cover possible effect, more data is needed

The damage may have already begun……

- “Extreme high temperatures and low rainfall may have had an impact in causing extinctions of the Karner blue butterfly at two locations in 1988”.
(Liu 2008)

Captive rearing is restoring the Karner blue butterfly population