Resiliency in masting systems: Do evolved seed escape strategies benefit an endangered pine?

Vern Peters[1], Matt Gelderman[1,2], Darcy Visscher[1]

[1]The King's University, Edmonton, AB

[2]Alberta Agriculture and Forestry, Peace River

Seed predator escape occurs when:

- Interannual variability in reproduction is high and unpredictable
- Time lags occur in numerical responses of seed predators

Untested Assumptions

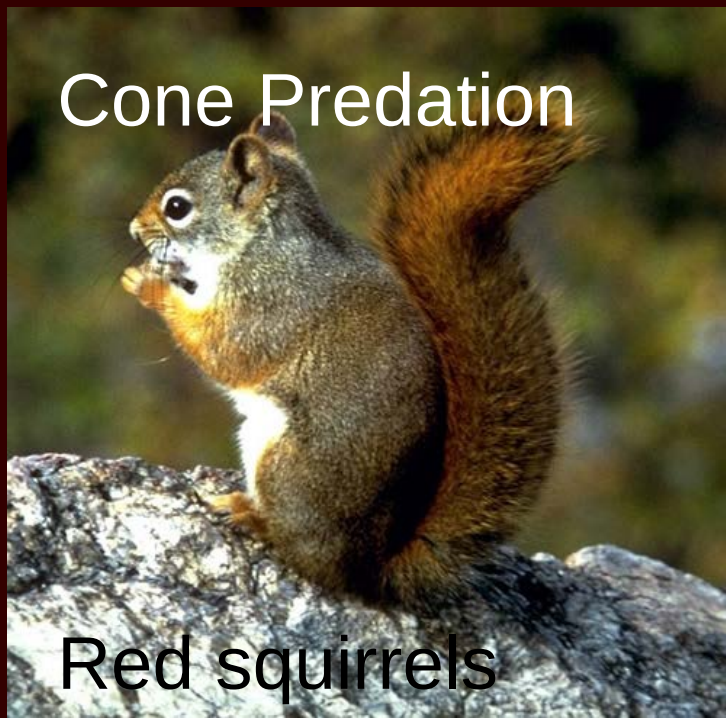
- Ecosystems are intact
- Populations are stable

Conservation Issue:

- Does masting benefit a declining species?

Limber Pine Seed Ecology

Clark's Nutcracker



Seed Predation Objectives:

To determine whether:

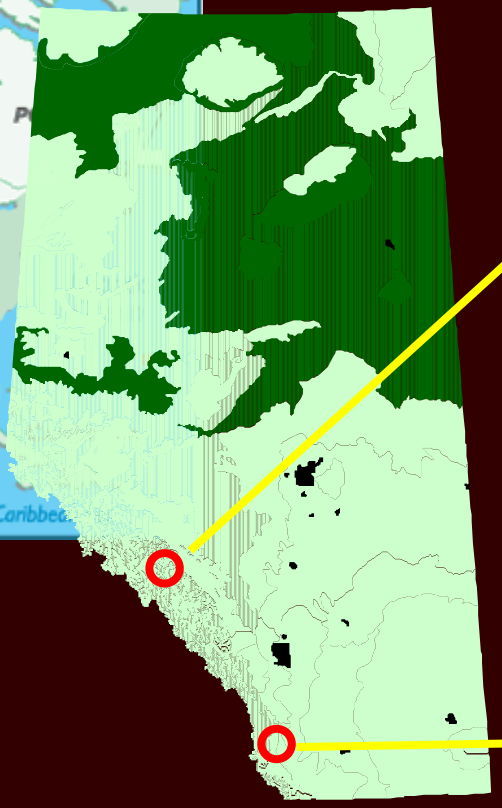
- Supra-annual variability in cone production assists in cone escape in an endangered species

Hypothesis

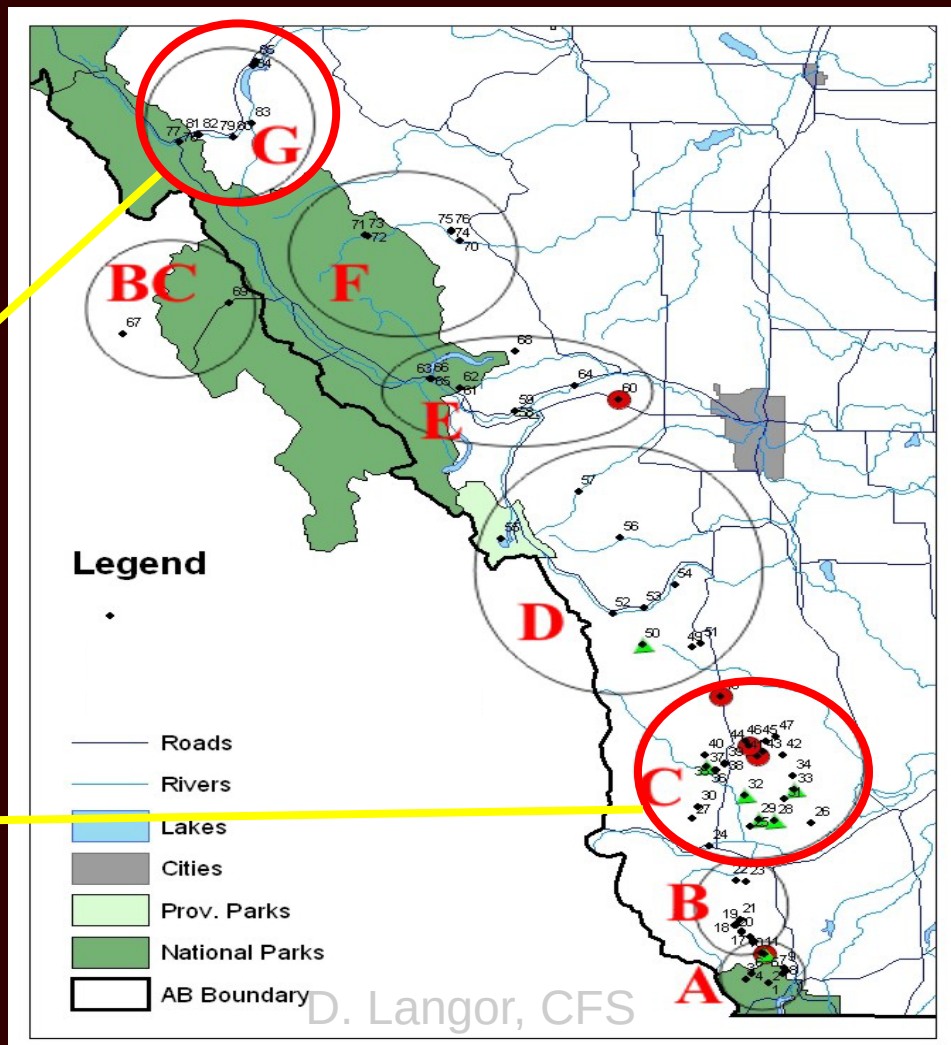
- Evolved seed escape strategies such as masting are resilient to a variety of ecological conditions including low seed output.

Existing Limber pine field sites with stand inventory, disease, and prior cone production data

www.worldatlas.com



Alberta



D. Langor, CFS

SAMPLING DESIGN – LANDSCAPE LEVEL CONE REMOVAL

- 2 study areas separated by 400 km with 8-9 limber pine populations in each

Southern Ecosystem - High WPBR

Northern Ecosystem - Low WPBR

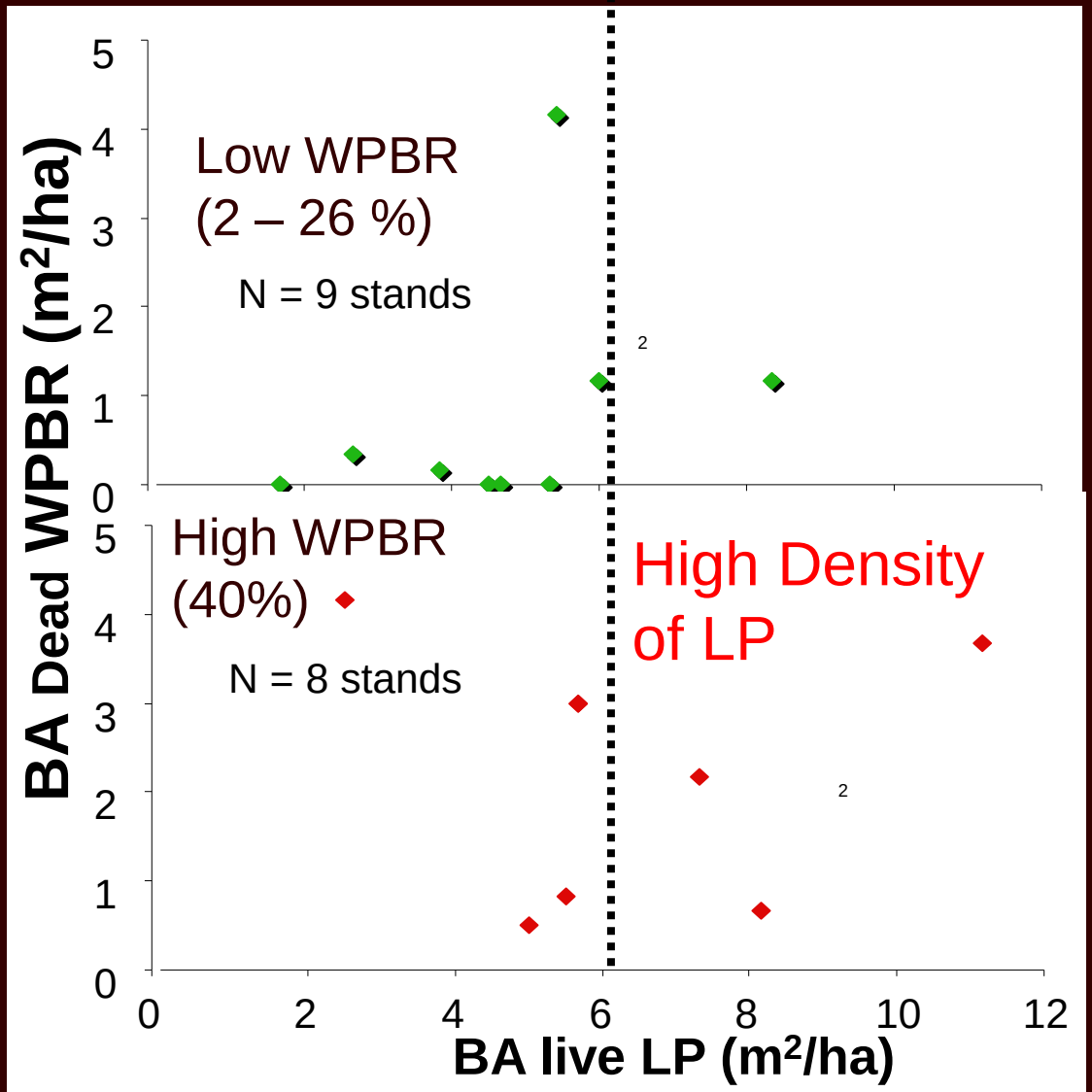
But, study ecosystems differ in other equally important aspects:

- Stand composition: L.P. and D.F L.P ., D.F. Lodge. P
- Spatial configuration, Seed production

Seed Limitation Hypothesis

- Spatial Escape
  - Cones escape in healthier landscapes

Disease Dynamics: Less effect than expected



Unexpected Result:

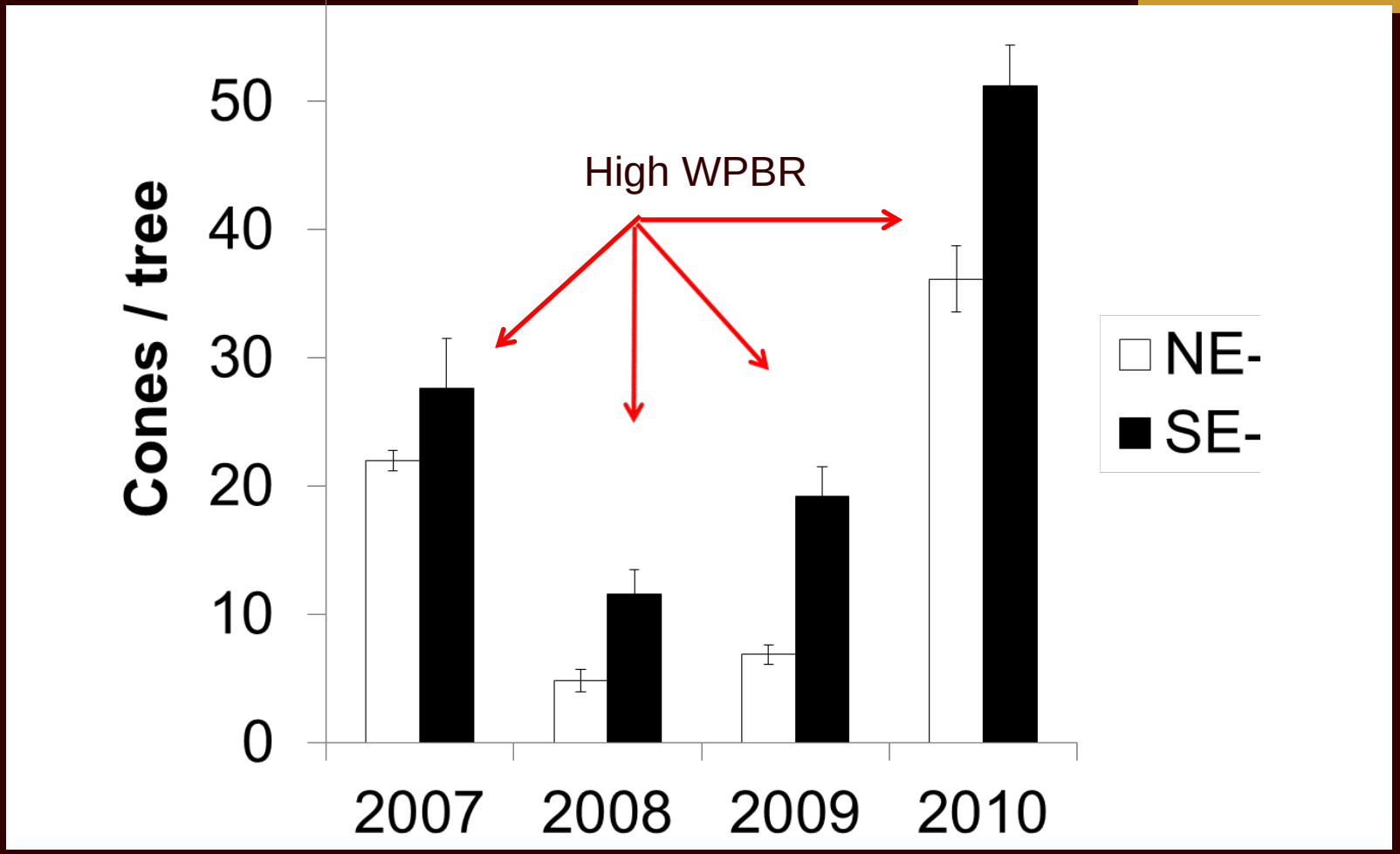
Live limber pine > on high WPBR sites

Best disease parameter:

Proportion dead Lp

Cone production in low versus high density limber pine study areas

(+/- std. error, n = 8-9 populations, 680 trees per annum)



Overall, 2.3 X more cones produced / ha in SE (high WPBR)

Study system is different than we thought

- White pine blister rust is having little effect on the density or cone availability in our study system
- Re – casting of Study System :
- **Northern Ecosystem vs. Southern Ecosystem**

Masting Escape Hypothesis

Temporal Escape:

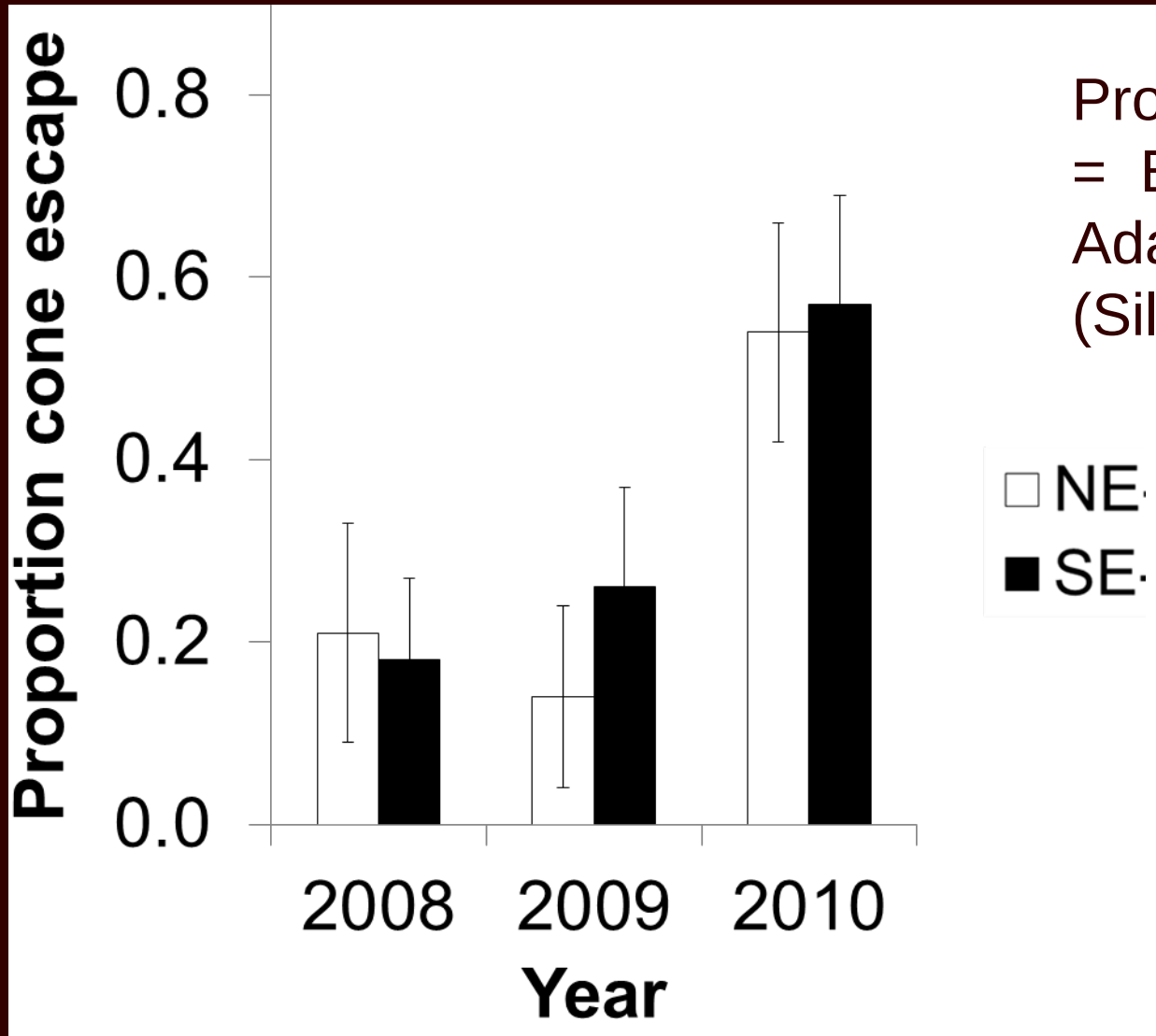
- Proportionately greater cone escape occurs in mast years

Prior to predation

Post-predation: Tough

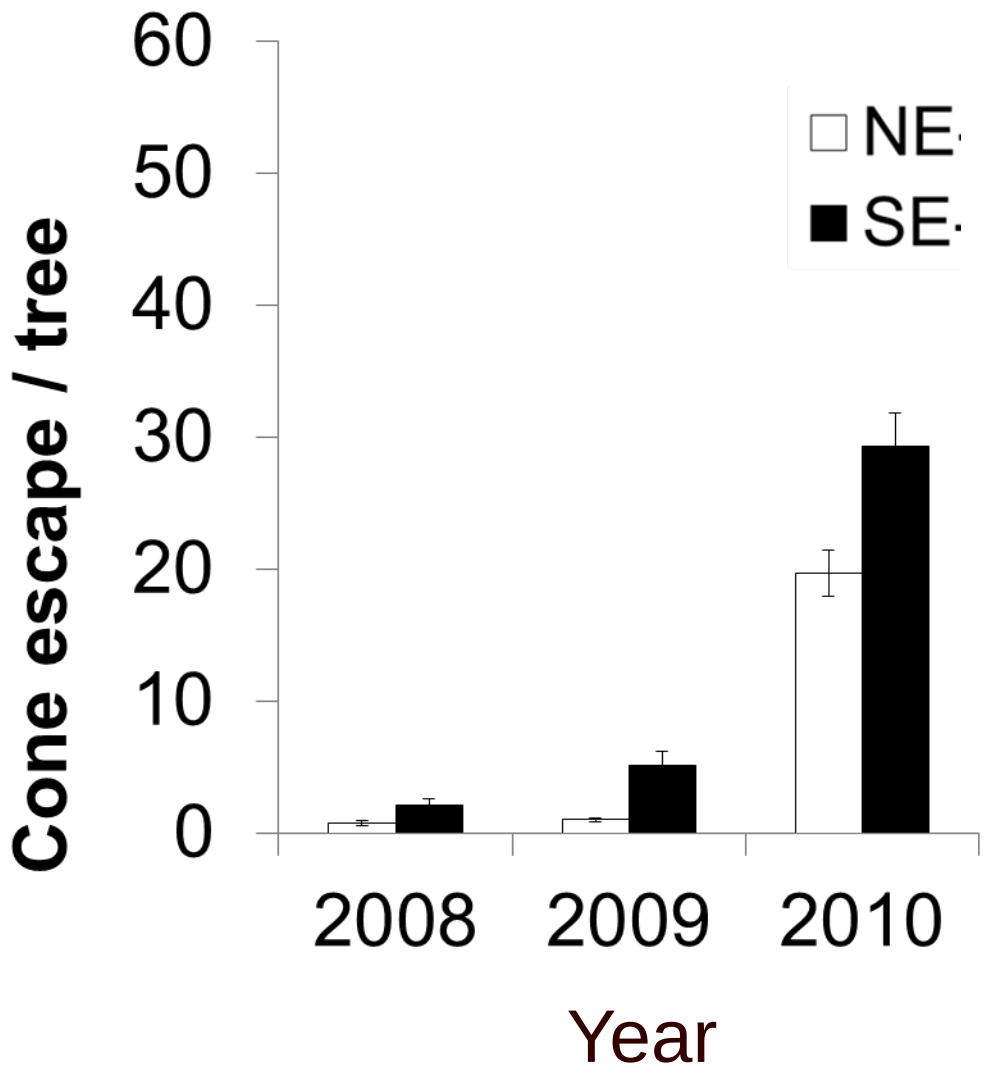
Masting Satiates Predators

(+/- 1 s.e.; n = 8-9 stands, 680 trees)



Proportionately >> = Evolutionary Adaptiveness (Silverton 1980)

Tension:
Do Evolutionary Benefits ≠ Conservation Benefits?



- Dispersal Benefits:
  More cones are available in mast years, even in diseased landscapes
- Little support for “Seed Limitation” Hypothesis

Masting Hypothesis:

Temporal Dynamics

- Populations are depressed in nonmast years

Habitat Quality Hypothesis

Spatial Dynamics

- WPBR lowers the basal area and quality of habitats

Sampling Design - Population Level

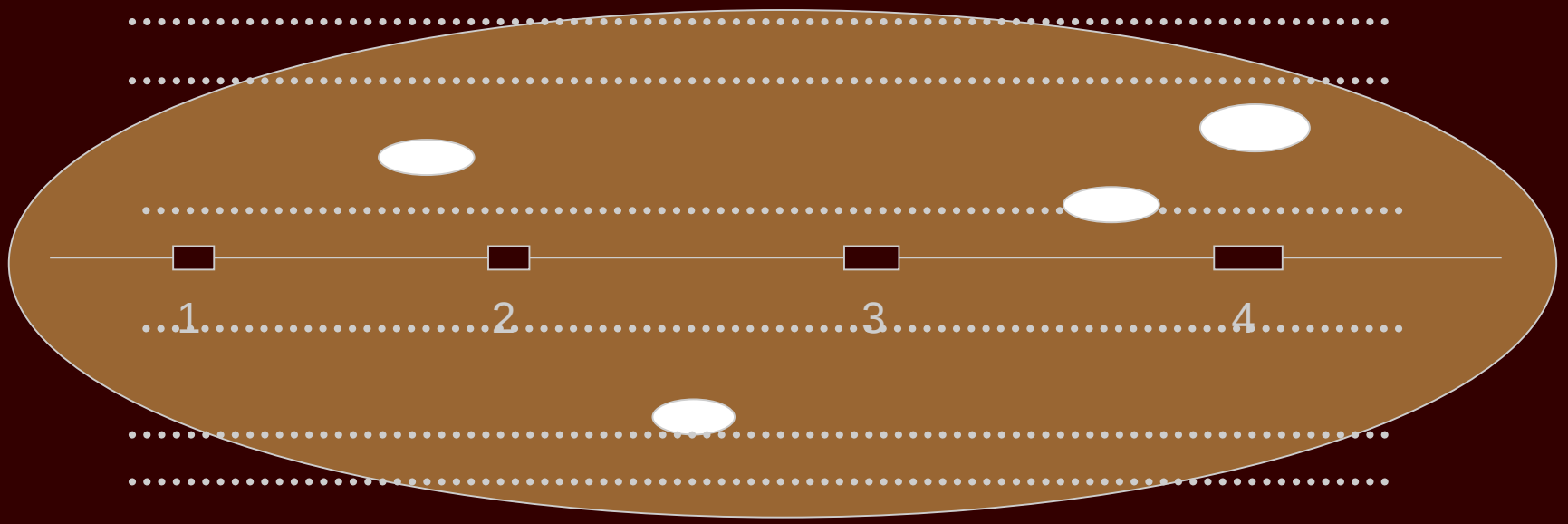
- 17 Populations Sampled, 40 trees/stand

Forest Composition

- 4 plots, 12 basal area counts by species
- Live vs. dead trees

Squirrel Abundance (overwinter survivorship)

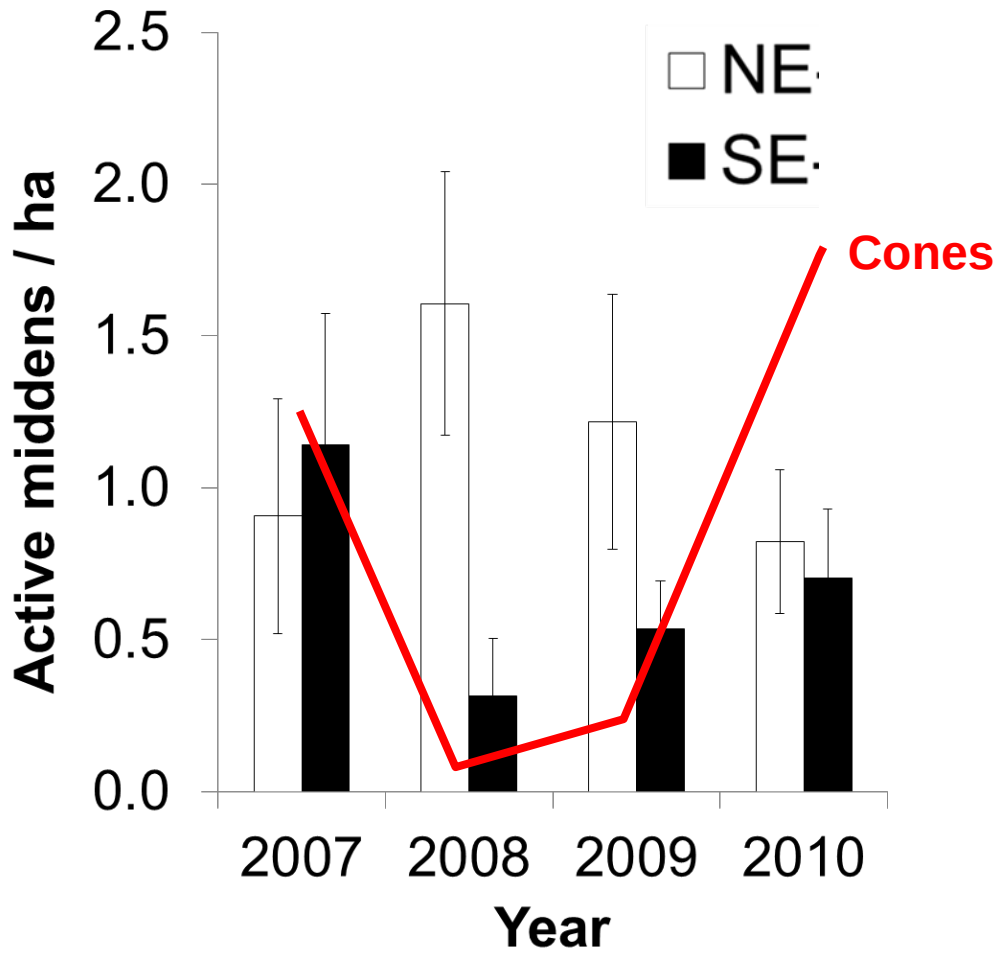
- 6 Midden transects – 3 km (6 ha)/population



Identifying Active Middens

Undergrads at ~~work~~? PLAY?

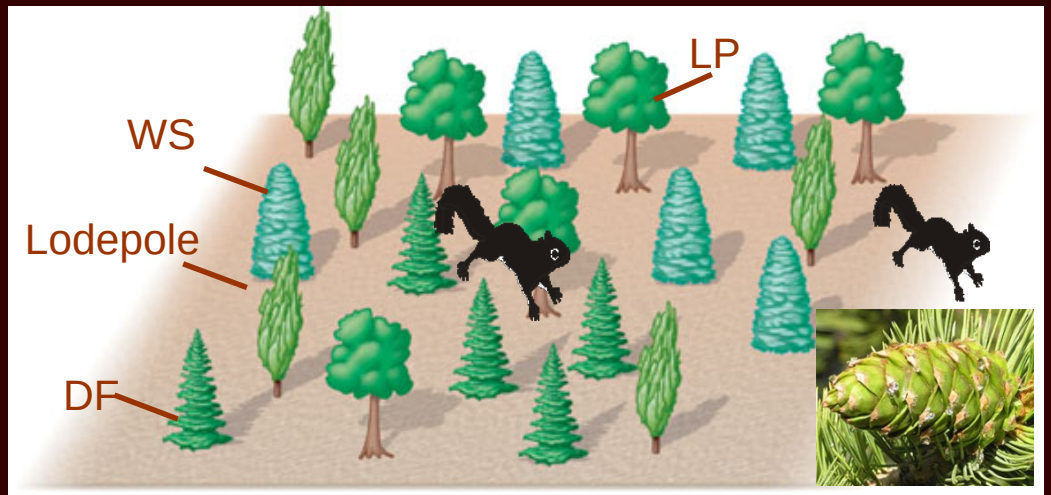
Seed predators differed temporally between ecosystems



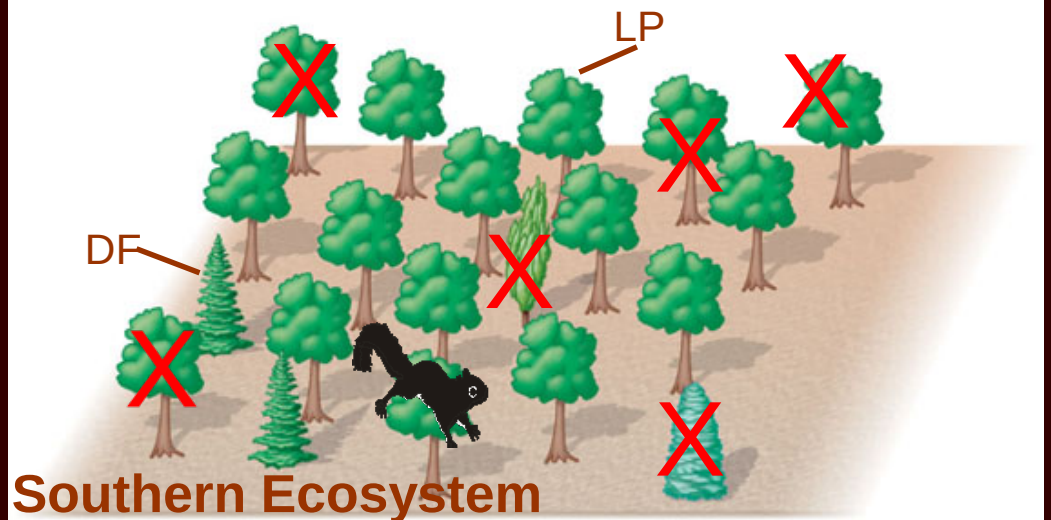
- In NE, squirrel populations were not dependent on limber pine
- Other conifer species reduce threat to limber pine

Evidence of an "Ecosystem effect" on predation"

Masting over-rides Habitat Quality



Northern Ecosystem



Southern Ecosystem

When Only LP Masts: escape occurs (2010)

- High predators due to basal area and persistent cones on lodgepole pine.
- Suggests squirrels use LP opportunistically

Pulling together the pieces . . .

Statistical Analyses

- We compared a series of a priori models based on our hypotheses on the role of disease, predators, and ecosystems on both:
  - Cone escape – Zero inflation negative binomial ($AIC_w = 0.74$)
  - Proportion cone escape – binomial model

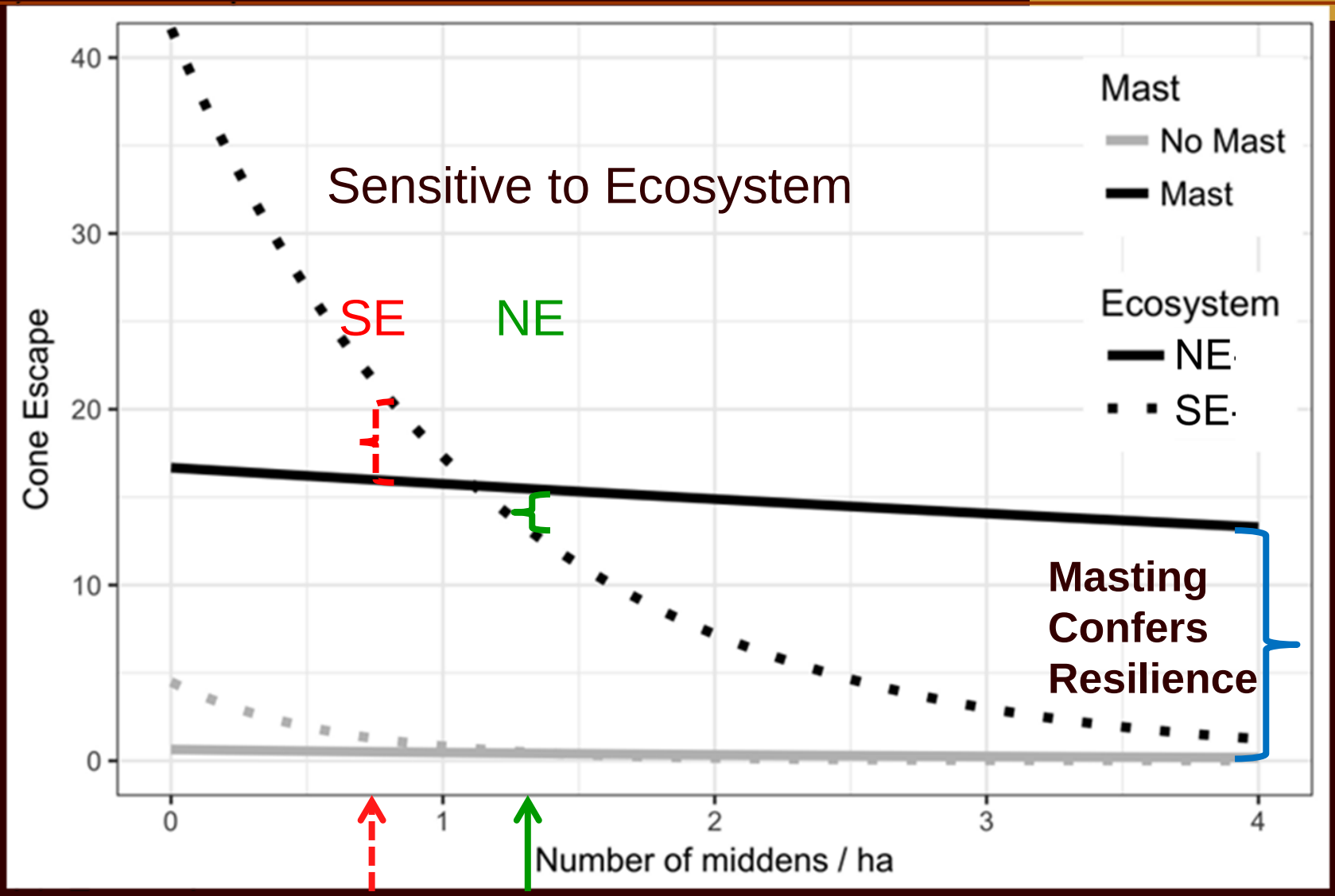
Model comparisons of hypotheses tested

2-way & 3-way Intxns

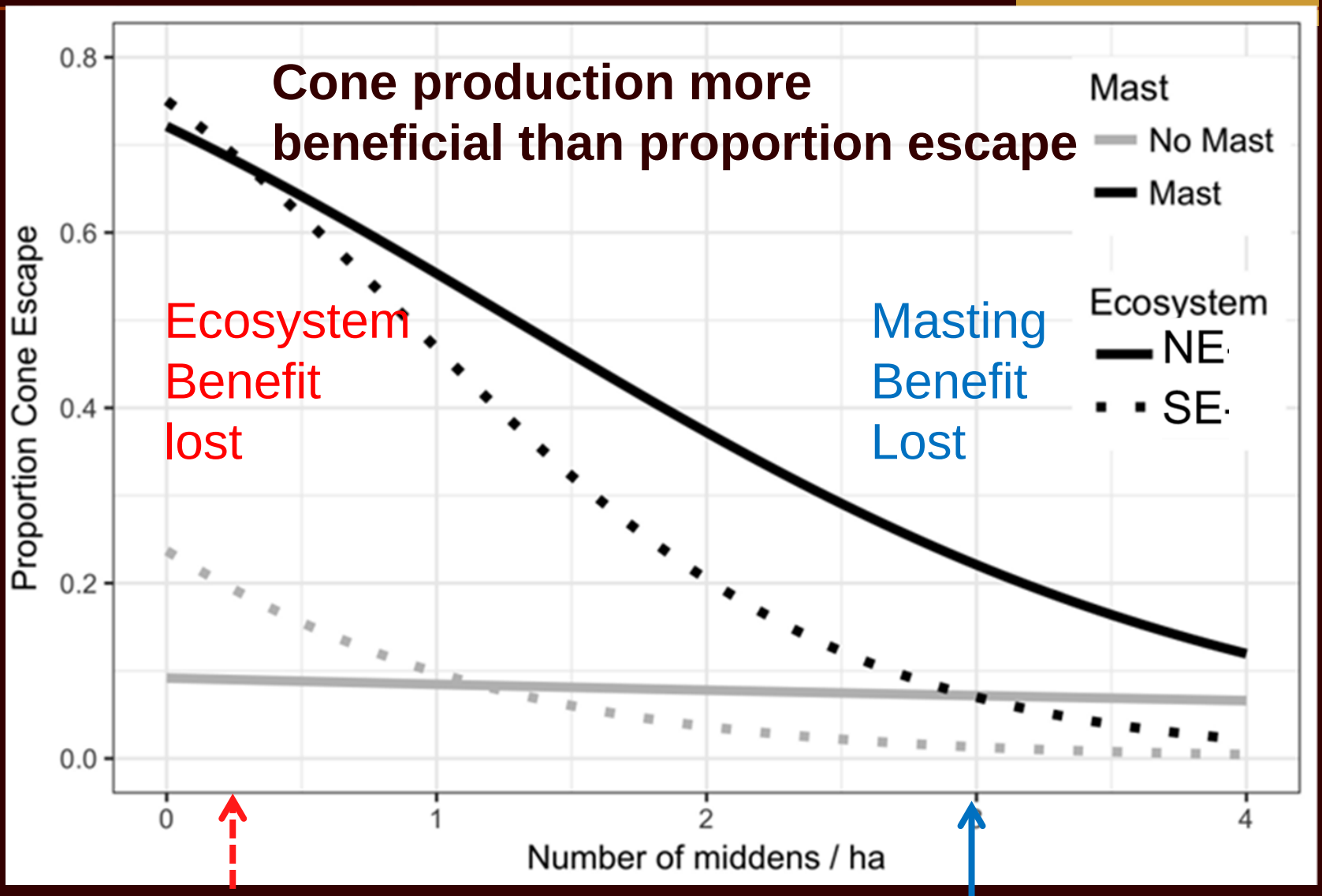
2-way Intxn

Model Name	k_i	Cone escape AIC	Cone escape ΔAIC	Cone escape AIC_w	df	Proportion cone escape AIC	Proportion cone escape ΔAIC	Proportion cone escape AIC_w
Ecosystem	5	8791.7	740.6	0	3	1629.5	292.6	0
Disease	5	8791.6	740.5	0	3	1628.0	291.2	0
Habitat quality	5	8773.9	722.8	0	3	1661.1	279.2	0
Predator	5	8740.1	689.0	0	3	1610.1	273.2	0
Masting	5	8112.5	61.5	0	3	1359.5	22.6	0
Cones					3	1593.2	256.3	0
Global	9	8074.0	23	0	8	1341.0	4.1	0.039
Interaction	10	8065.7	13.7	0.001	9	1341.1	4.2	0.038
Interaction	11	8066.1	15.1	0	10	1337.7	0.88	0.198
Interaction	12	8058.1	7.1	0.020	11	1337.5	0.66	0.221
Interaction	13	8052.9	1.9	0.271	12	1337.8	0.92	0.195
Top	**14**	**8051.0**	**0**	**0.708**	**13**	**1336.8**	**0**	**0.308**

Model Predictions for cone escape



Model Predictions for cone escape



Seed Predation Hypotheses:

Temporal Dynamics

- Proportionately greater cone escape occurs in mast years

Spatial Dynamics

- Seed predator behavior varies with ecosystem
- Seed predators exert less influence in dense conifer stands that are more diverse

Temporal escape is more important than spatial escape

Conclusions

- Masting confers temporal resiliency in seed escape in declining limber pine ecosystems, even under varying disease and seed predator threats, and varying reproductive capacity.

- Cone escape in time, more than cone escape in space, appears to facilitate the seed dispersal mutualism with Clark's nutcracker.

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Questions?