Whitebark Pine Ecosystem Foundation, Annual Science Meeting
Kimberley, B.C., Canada, 14 September 2012

Mountain Pine Beetle and White Pine Blister Rust in Whitebark Pine Ecosystems: Cone Production Decline Impacts Seed Dispersal by Nutcrackers

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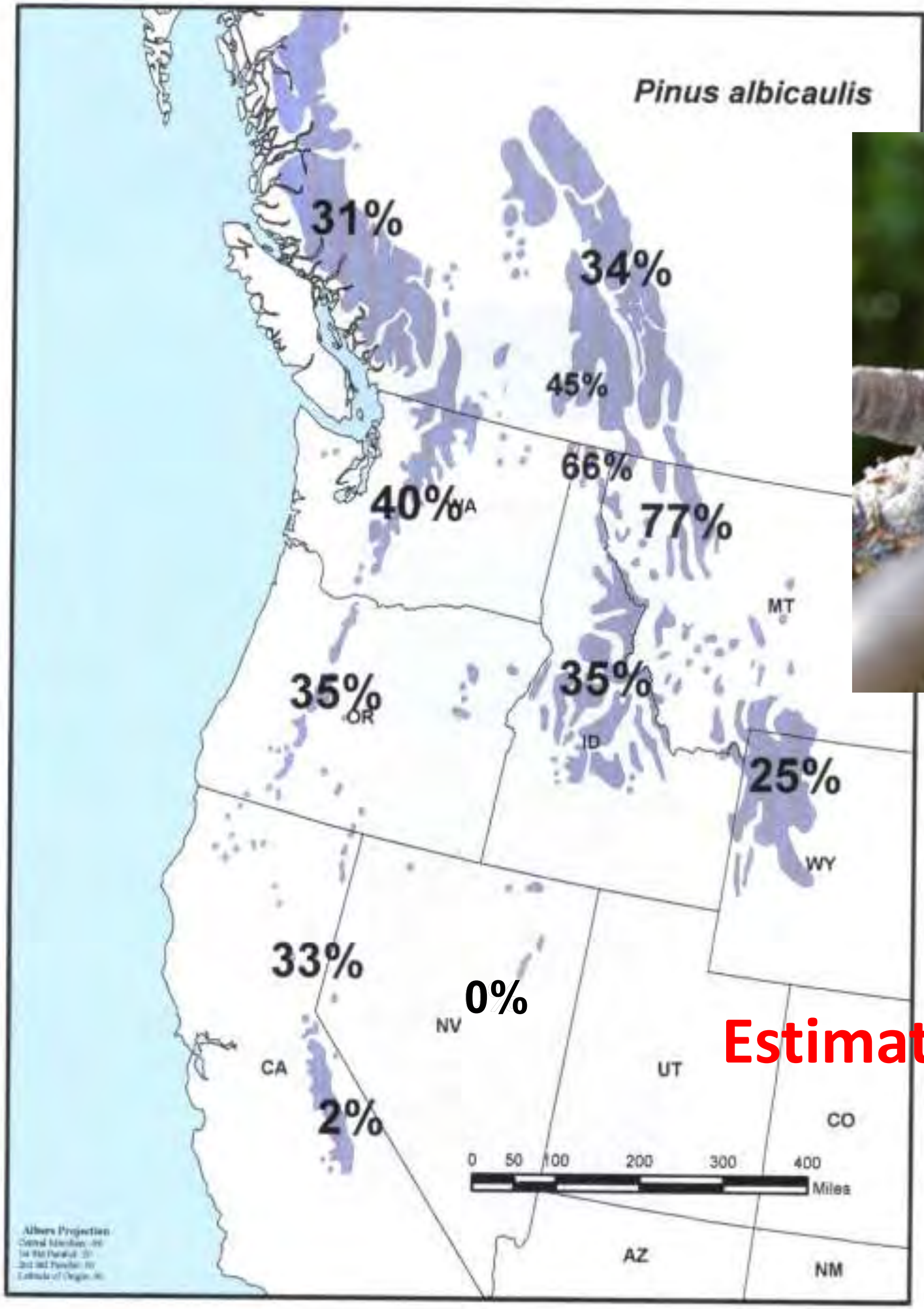
Whitebark pine depends on Clark's Nutcracker for seed dispersal: coevolved mutualism


Healthy whitebark pine communities

Cronartium ribicola
white pine blister rust

Blister rust

- **Cankers kill branches, reducing photosynthetic biomass.**
- **Trees are weakened.**
- **Cone production is reduced or eliminated.**
- **Cankers in stems kill trees.**

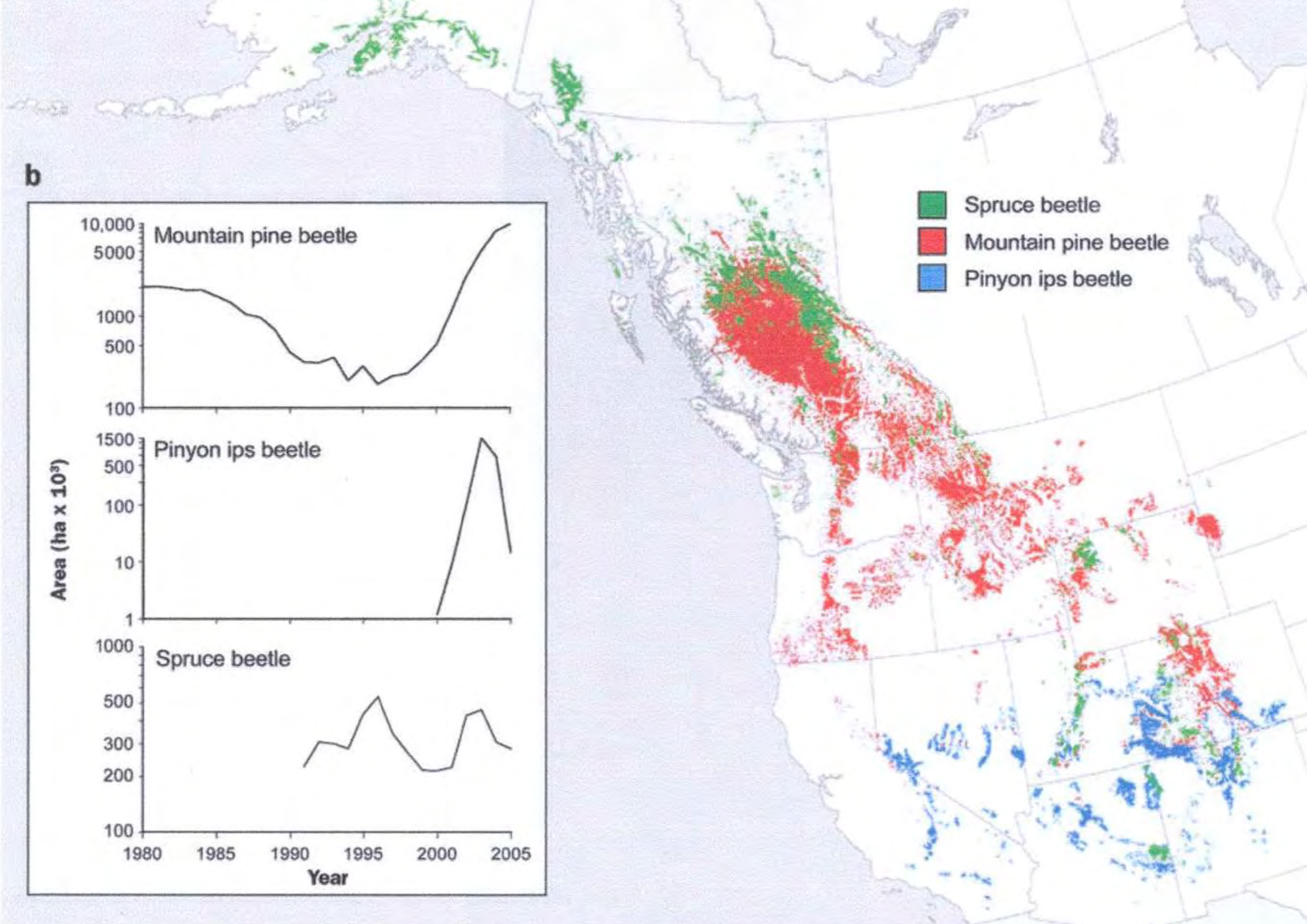


Estimates of blister rust prevalence


Unprecedented outbreaks of mountain pine beetle
are killing large numbers of whitebark pine

Mountain pine beetle

Raffa et al. 2008




Declining cone
production makes for
"Angry Nutcrackers"!

Rationale

- Reduction in cone production for whitebark pine.
- Fewer nutcrackers visiting whitebark pine communities.
- Reduced regeneration.

Began investigation in 2001, multiple studies.
Goals of study

- Determine the relationship between cone production, forest health measures, and the likelihood of nutcracker visitation to whitebark pine communities.
- Estimate how many cones must be produced per hectare to have reliable Clark’s nutcracker visitation.
- Estimate how much live basal area of whitebark pine this would represent.


American red squirrel
(*Tamiasciurus hudsonicus*)

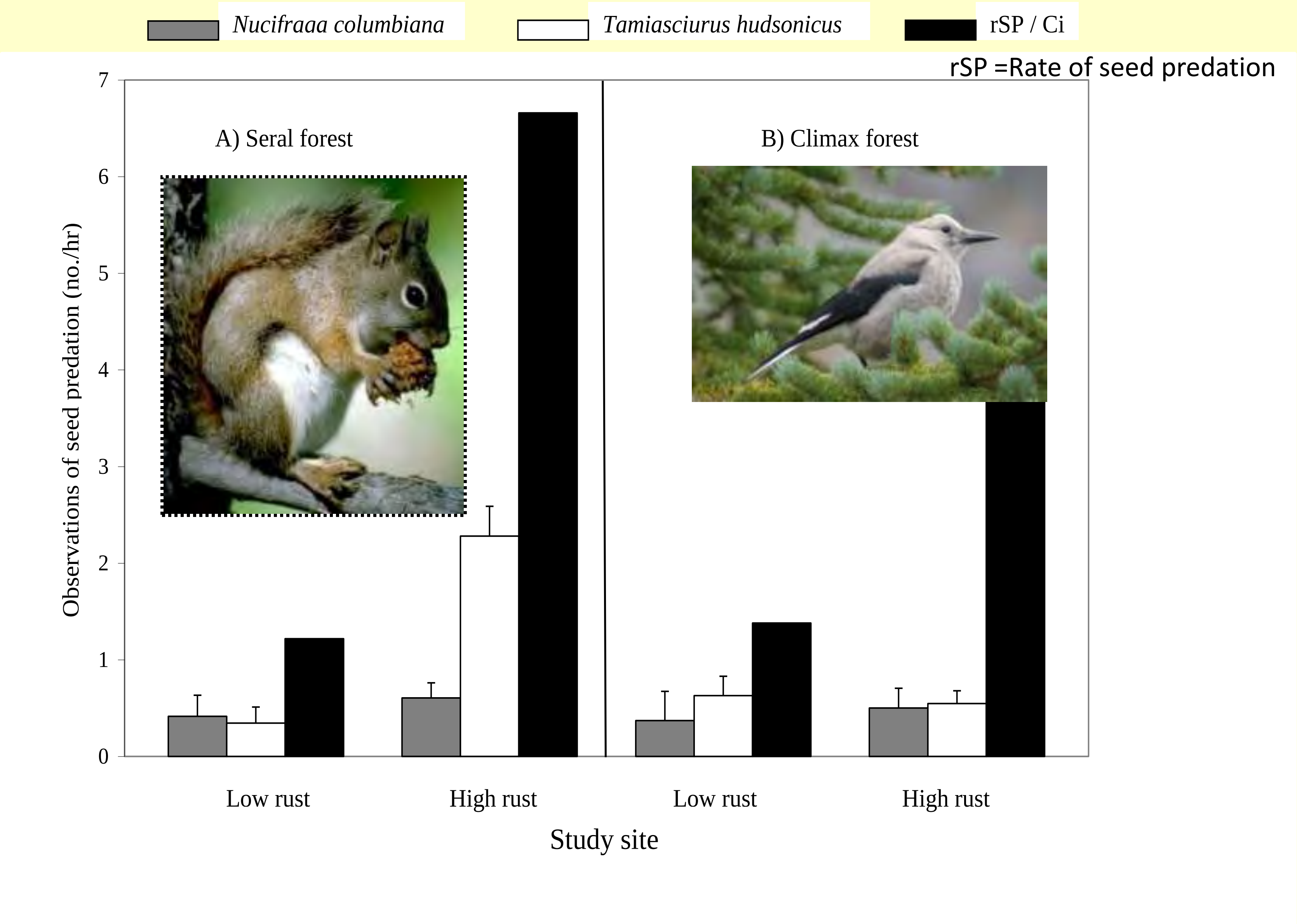
(McKinney and Tomback 2007, *CJFR*)

2001-2002 study	SeralBR	%CK*	ClimaxBR	%CK*
High rust				
Bitterroot NF, MT	97%	79%	96%	38%
Low rust				
Salmon NF, ID	24%	2%	54%	13%

*CK=canopy kill

Initial Research—predisperal seed predation

(McKinney and Tomback 2007, *CJFR*)



Conclusions

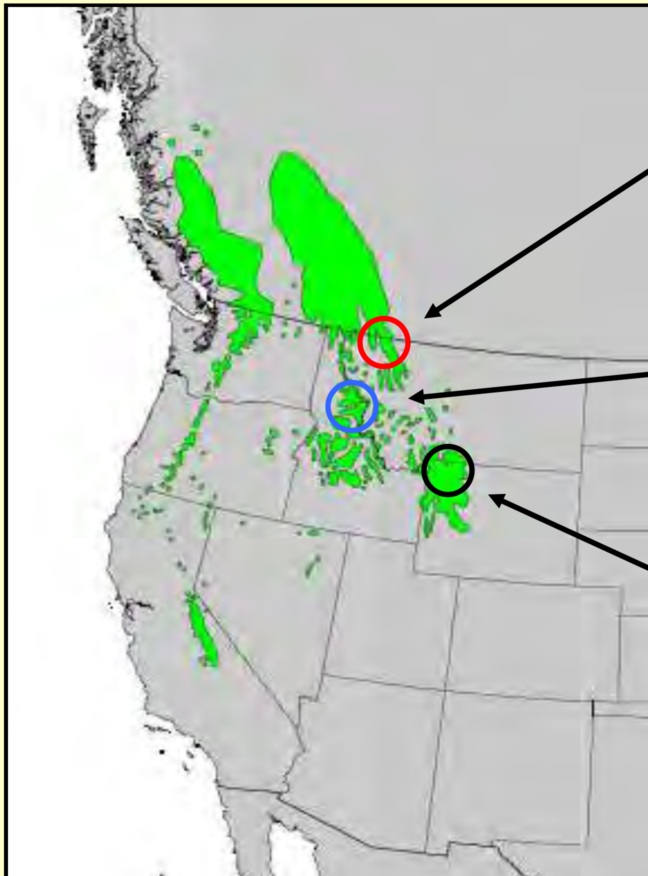
McKinney and Tomback 2007

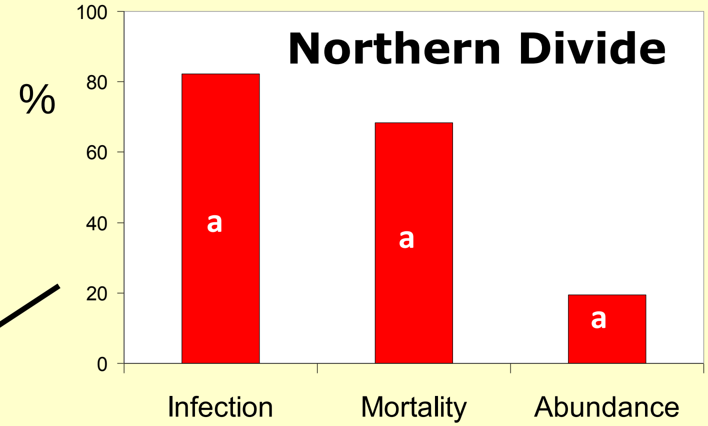
On study sites in Bitterroot Mountains with greater damage from blister rust:

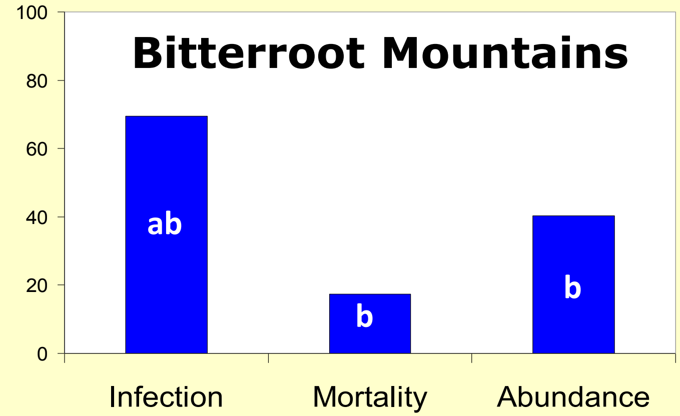
- Reduced cone production.
- Higher relative predation on seeds.
- Lower likelihood of cone survival to seed ripeness: faster rates of predispersal cone depletion.
- Reduced nutcracker visitation in 2001 and complete absence in 2002; few seed dispersal events.

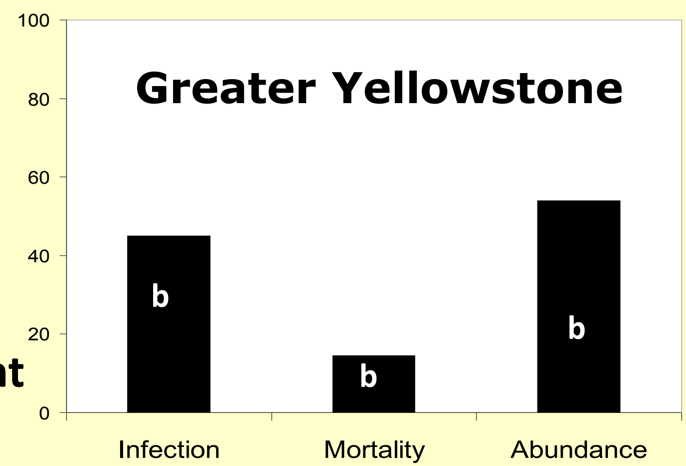
Forest conditions: ecosystem comparisons

McKinney, Fiedler, Tomback (2009)





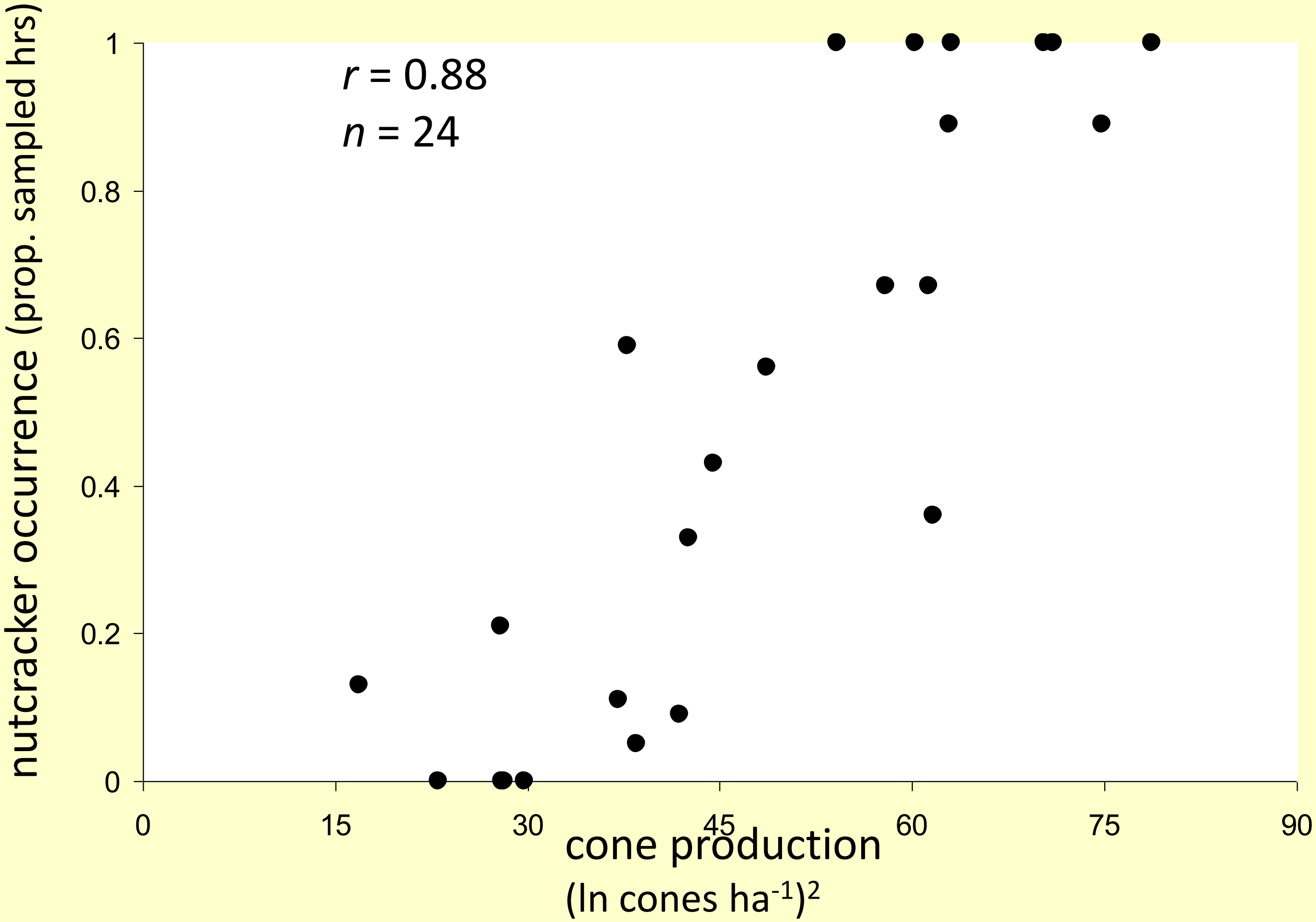




Ecosystems with the same letter are not different at $\alpha = 0.05$

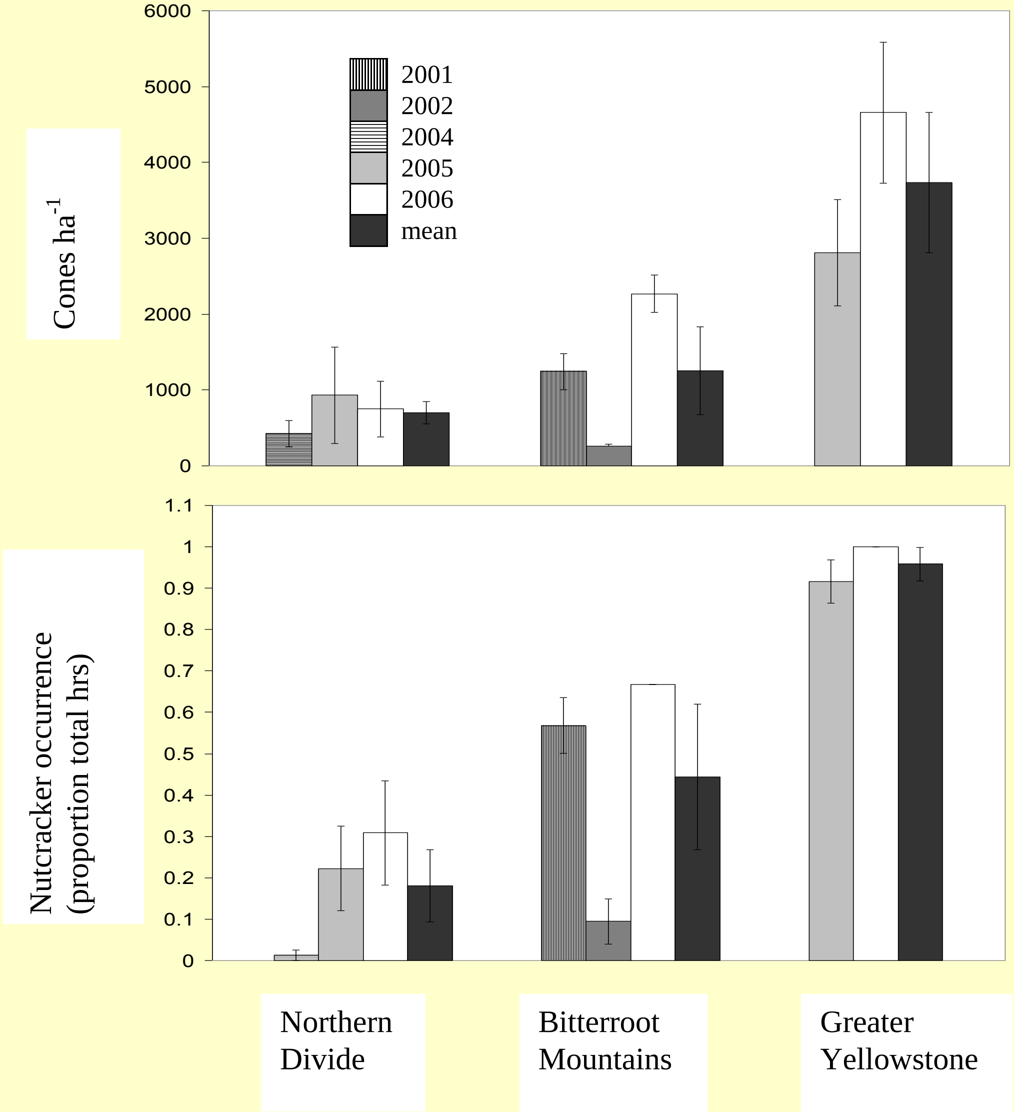
Clark’s nutcracker: site-level occurrence

(McKinney, Fiedler, Tomback 2009, *Ecological Applications*)



Below ~130 cones/ha, probability of seed dispersal falls to ~0.

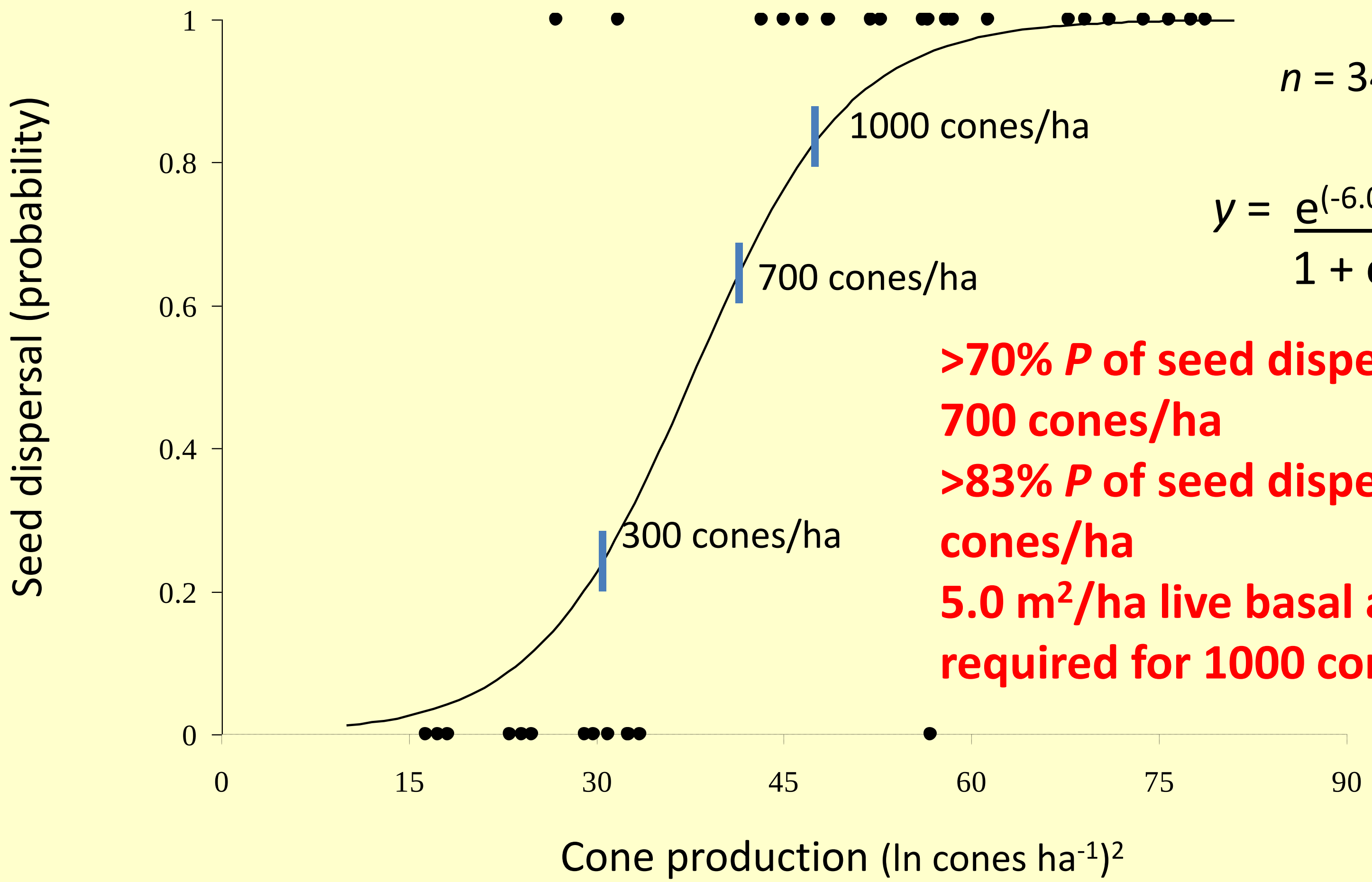
Clark's Nutcracker: ecosystem comparison
mean (±SE)



(McKinney, Fiedler, Tomback 2009, *Ecological Applications*)

Clark's Nutcracker: site-level seed dispersal

(McKinney, Fiedler, Tomback 2009, *Ecological Applications*)



$n = 34$

$$y = \frac{e^{(-6.02 + 0.16x)}}{1 + e^{(-6.02 + 0.16x)}}$$

>70% *P* of seed dispersal if > 700 cones/ha

>83% *P* of seed dispersal if 1000 cones/ha

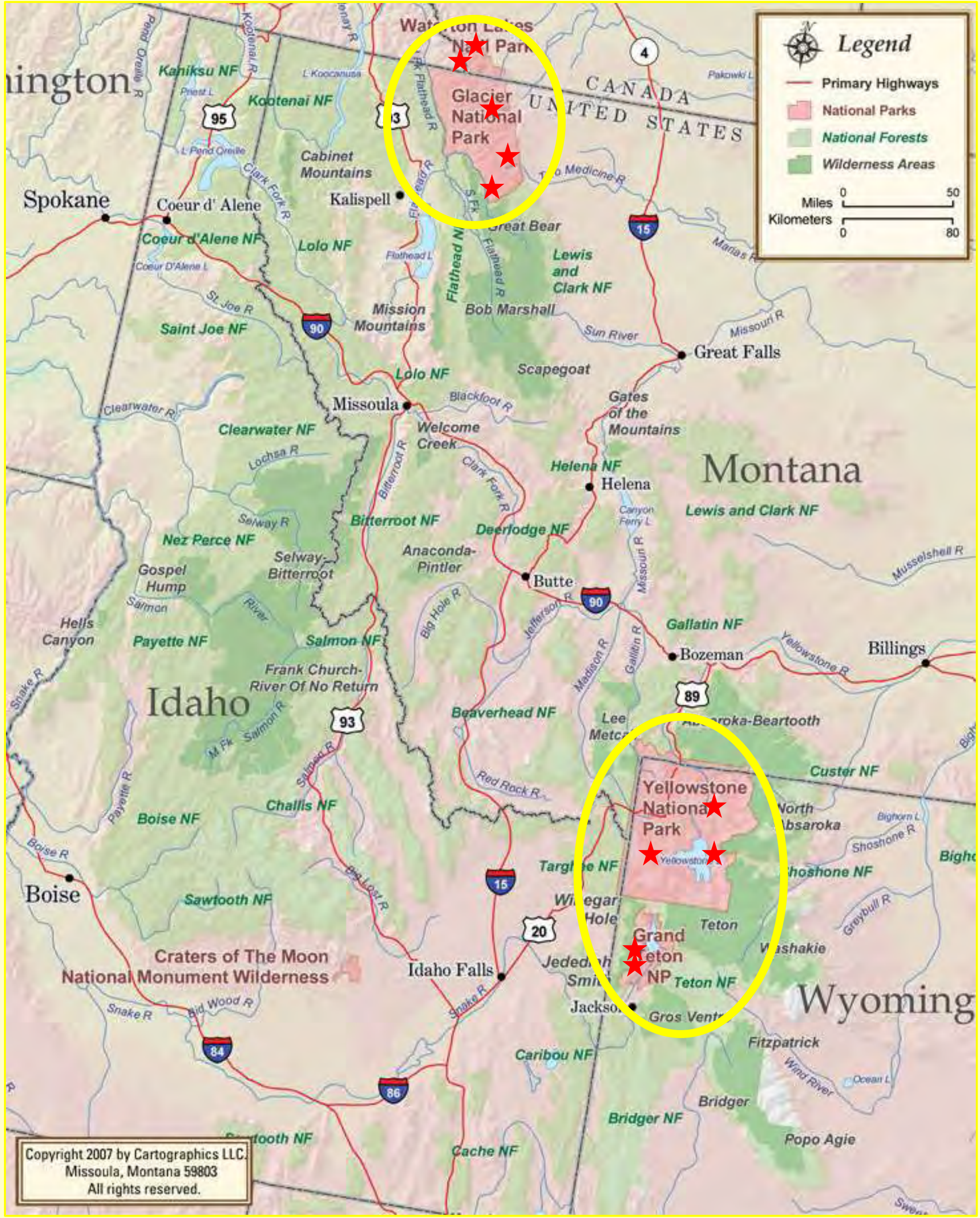
5.0 m^2/ha live basal area required for 1000 cones/ha

WHITEBARK PINE STAND CONDITION, TREE ABUNDANCE, AND CONE PRODUCTION AS PREDICTORS OF VISITATION BY CLARK'S NUTCRACKER

Barringer, Tomback, Wunder, McKinney 2012*, PLoS ONE*

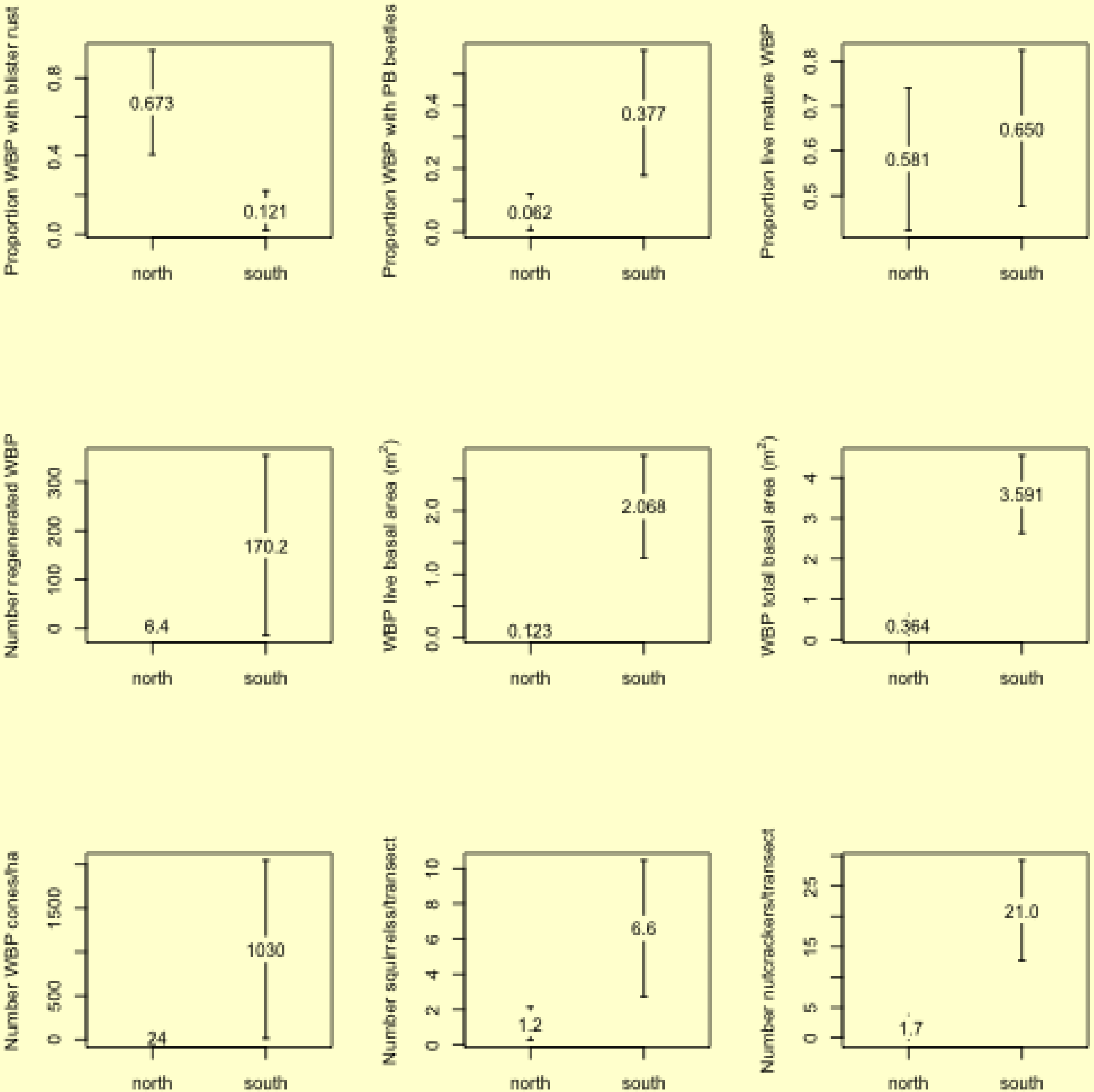
Relationship across four national parks: studied in 2008-2009

1) **Set up ten 1 km transects with 6 point count stations per transect to monitor nutcracker activity; counts twice a day, twice each summer.**
2) **Gather information on forest health and cone production on 2 plots--1000 m^2 per transect.**
3) **Determine if live basal area, cone production, and tree health predict nutcracker visitation.**
4) **Compare relationship with McKinney *et al.* (2009).**

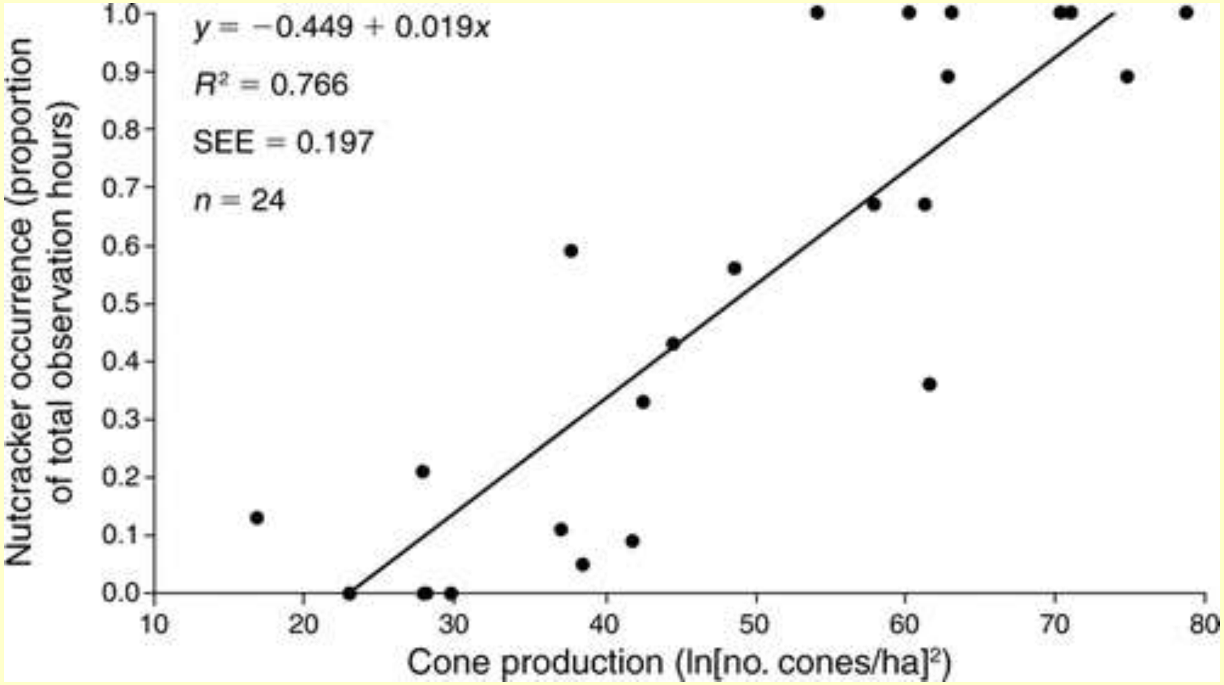


★ **Transects**

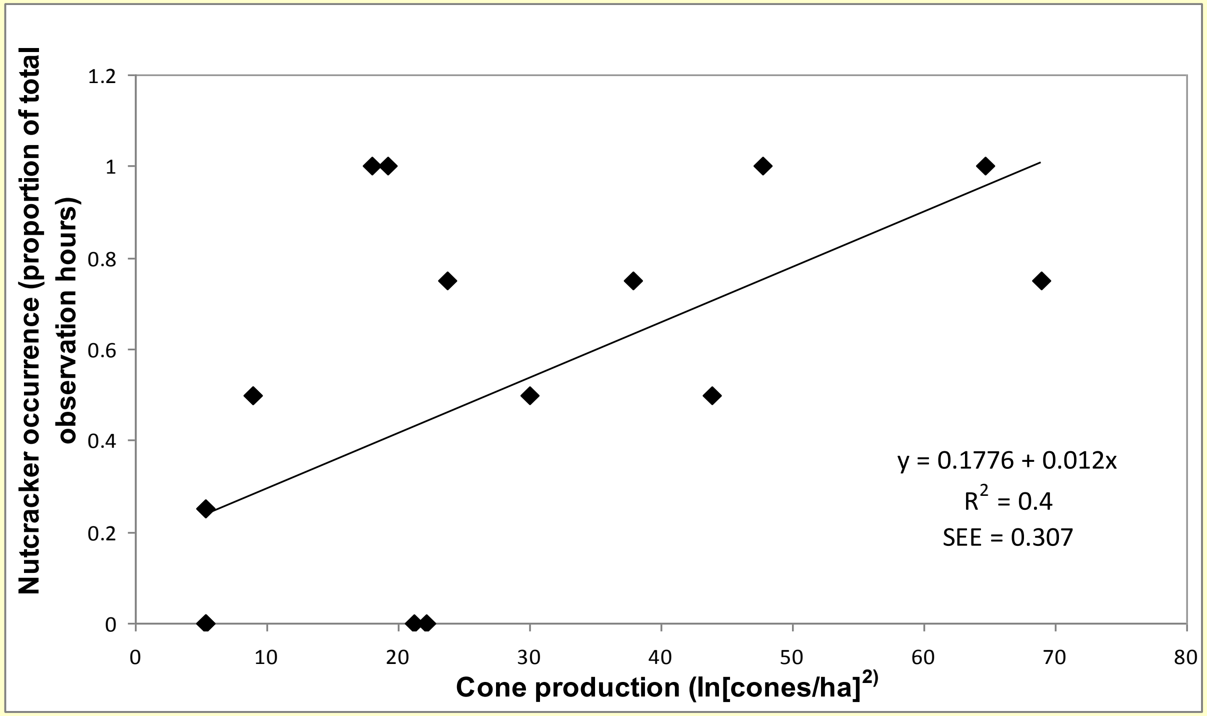
Study Areas



Proportion WBP with blister rust
0.673
0.121
Proportion WBP with PB beetles
0.062
0.377
Proportion live mature WBP
0.581
0.650
Number regenerated WBP
6.4
170.2
WBP live basal area (m^2)
0.123
2.068
WBP total basal area (m^2)
0.364
3.591
Number WBP cones/ha
24
1030
Number squirrels/transect
1.2
6.6
Number nutcrackers/transect
1.7
21.0
north
south

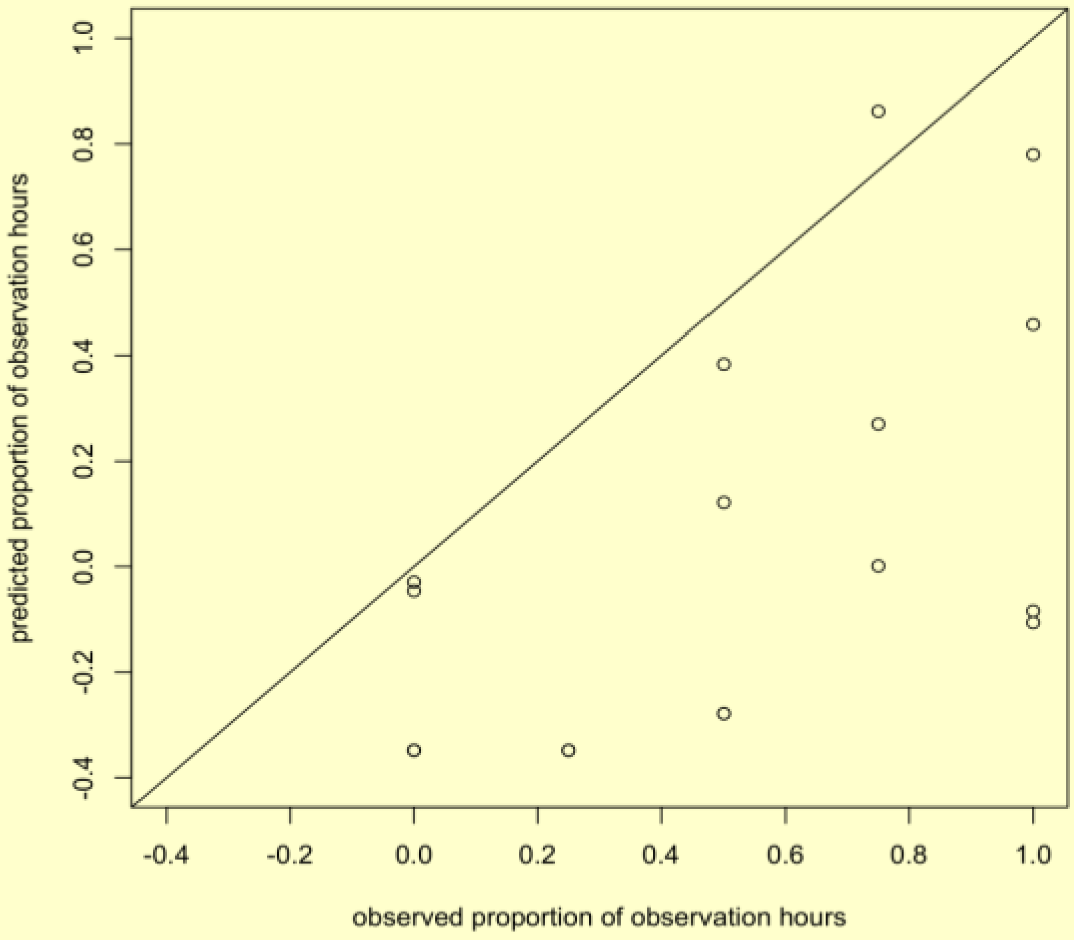


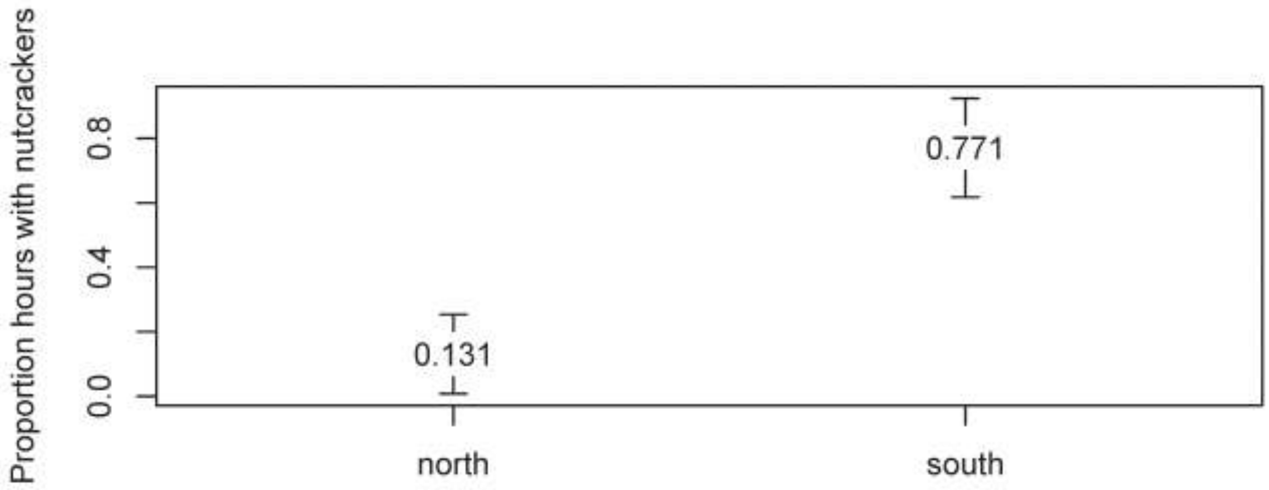
McKinney *et al.* 2009



Barringer et al. 2012

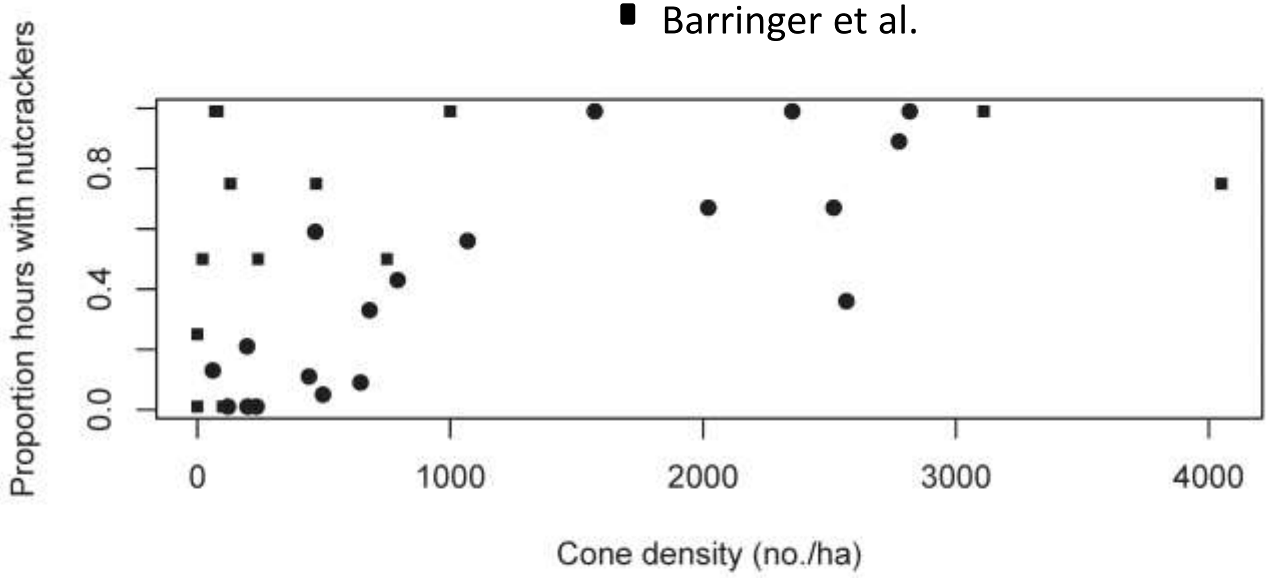
Comparing both data sets: **The diagonal represents a one-to-one comparison. McKinney et al. (2009) model generally under-predicted the probability of nutcracker occurrence for the cone production values observed in this study.**





Combined data: ● McKinney et al. 2009

■ Barringer et al.



Predictive model

- **The parameterized beta regression model for the pooled datasets is:**

  $$\ln (p/1-p)= 0.03883x -1.5165$$

  where *p* is the probability of observing nutcrackers and *x* is the cone density index (ln(cones/ha)^2 .
- **Example: What level of cone production is needed for a 50:50 chance of observing nutcrackers?**
- **Solving for *p* = 0.50 and converting the cone index results in 518 cones/ha.**

Management implications

- In Barringer et al. (2012), nutcrackers visited stands with 0-4,050 cones/ha. Thus, nutcrackers survey whitebark pine widely for cones but are more likely in stands with higher cone production.
- Monitoring for nutcracker occurrence may be best done at a landscape level rather than a stand level.
- Cone densities were positively correlated with live basal area
  ($r = 0.55$).
- The proportion of observation hours resulting in nutcracker observations was reliably above ~0.75 for cone densities of 1000 cones/ha, agreeing with McKinney et al. (2009).
- We found that 1000 cones/ha could be generated by a live basal area > 2.0 m^2/ha, whereas McKinney et al. found > 5.0 m^2/ha.
- Nutcrackers occurred in stands with a mean live basal area of 1.5 ±0.09 (SE) m^2/ha, and a range of 0.04 - 3.23 m^2/ha, n = 14.
- No nutcrackers occurred in stands with a mean live basal area of 0.1 ± 0.02 (SE) m^2/ha, and a range of 0.04 - 0.33 m^2/ha, n = 6.
- These correlates can be used to prioritize stands for restoration.

Acknowledgments:

Our gratitude to the following individuals and agencies for logistic or field support and funding for all three studies:

USFS, RMRS:
- Robert Keane
- Ward McCaughey

NPS:
- Kathy Tonnessen
- Tara Carolin
- Dan Reinhart

Field Assistants:
- Katie Chipman
- John Fothergill
- Sean Sweeney
- Brian Cook
- Brett Stauffer

Funding

USDA Forest Service, RMRS, Missoula Fire Sciences Lab, to DFT

USDA Forest Service, FHP, Whitebark Pine Restoration Fund to DFT

National Park Service, RMCESU Technical Support to DFT

Global Forest Science student tuition fund to DFT

Jerry O'Neal National Park Service Fellowship to LEB

USDI Cooperative Conservation Initiative to STM

USDA McIntire Stennis Research Grant to STM

USDA Rocky Mountain Research Station to STM

National Park Service Fellowship to STM