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.
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*)

<table>
<thead>
<tr>
<th>2001-2002 study</th>
<th>SeralBR</th>
<th>%CK*</th>
<th>ClimaxBR</th>
<th>%CK*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High rust</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bitterroot NF, MT</td>
<td>97%</td>
<td>79%</td>
<td>96%</td>
<td>38%</td>
</tr>
<tr>
<td><strong>Low rust</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salmon NF, ID</td>
<td>24%</td>
<td>2%</td>
<td>54%</td>
<td>13%</td>
</tr>
</tbody>
</table>

*CK=canopy kill
Initial Research—predisperal seed predation

(McKinney and Tomback 2007, CJFR)

Observations of seed predation (no./hr)

A) Seral forest

B) Climax forest

Nucifraga columbiana
Tamiasciurus hudsonicus
rSP / Ci

rSP = Rate of seed predation

Study site

Low rust
High rust
Low rust
High rust
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*)

\[ y = \frac{e^{-6.02 + 0.16x}}{1 + e^{-6.02 + 0.16x}} \]

\( n = 34 \)

>70% \( P \) of seed dispersal if > 700 cones/ha

>83% \( P \) of seed dispersal if 1000 cones/ha

5.0 m²/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, Tombačk, 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 m² 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
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 underpredicted 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:

\[ \ln \left( \frac{p}{1-p} \right) = 0.03883x - 1.5165 \]

where \( p \) is the probability of observing nutcrackers and \( x \) is the cone density index (\( \ln(\text{cones/ha})^2 \)).

• 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.
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