The Impact of Bark Beetle Outbreaks on Carbon Cycling in the Western US

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Outline

1. Background
2. Reduction of vegetative C bias in the western US
3. Insect forcing dataset
4. Results from paired simulations
5. Future work
Tree mortality is widespread throughout the West

Mountain pine beetle

Spruce beetle

Pinyon ips beetle

© Parks Canada/Ross MacDonald/KNP/2004

Photo by Craig Allen – USGS

Raffa et al., BioScience, 2008
Area affected by insects is similar to area affected by fires

Forest Disturbances in the Western US

Sources: USDA, Westerling et al. 2006

Western Bark Beetles

Mountain Pine Beetle

Wildfire in Forested Lands
Stages of Attack

Year following attack
Dead tree, needles on

“Red Attack”

After 3-5 years
Needles off

“Gray Attack”

After several decades
Snag fall/understory growth

“Recovery”
Modifications to CLM

- Stem C & N
- Coarse Root C & N
- Leaf C & N
- Fine Root C & N

- Snag (m^{th} year)
- Dead Foliage (n^{th} year)

- CWD C & N
- Litter C & N

- Green Attack
- Fading
- Red Attack
- Gray Attack
- Snagfall
- Recovery
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Vegetative C (kg C m\(^{-2}\))

Hicke et al., 2007, *Ecological Applications*
Point run in Colorado

Background Mortality = 0.5%

% reduction of CLM predicted area burned
100% Fire and 2% Mortality

\[ Y = 0.362071 + 0.295856 \times X \]

MBE (X-Y) = 5.78798
RMSE = 6.79536
R^2 = 0.226715
SEE = 2.21232
N = 594
50% fire and 0.5% Mortality

\[ Y = 0.336926 + 0.913223 \times x \]

MBE (x-Y) = 0.417304
RMSE = 6.75444
\[ R^2 = 0.231739 \]
SEE = 6.73237
\[ N = 594 \]
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USFS Aerial Detection Surveys (ADS)

- Conducted yearly to map insect, disease, and other disturbance
- Westwide (US) data available from 1997

Photos by W. Ciesla: http://www.fs.fed.us/r2/resources/fhm/aerialsurvey/
Aerial survey polygons on 2.4-m QuickBird satellite image
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Reduction in Vegetative Carbon
Example Outbreak in Montana

![Graph showing GPP, ER, NEP, and Cumulative NEP from 1994 to 2008 with a peak in Bark Beetle Mortality in 1998. The graph includes a red arrow indicating the outbreak and a label for the Control group.]
Vegetative Carbon Anomalies (Tg C)
### Regional Impacts to C cycle

<table>
<thead>
<tr>
<th></th>
<th>NEP (Tg C yr(^{-1}))</th>
<th>VEG C. (Tg C)</th>
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</thead>
<tbody>
<tr>
<td><strong>Lower Bound</strong></td>
<td>0.37</td>
<td>4.8</td>
</tr>
<tr>
<td><strong>Upper Bound</strong></td>
<td>8.64</td>
<td>103.0</td>
</tr>
<tr>
<td><strong>Kurz et al., 2008 BC</strong></td>
<td>12.85</td>
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</tr>
</tbody>
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Kurz et al., 2008
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Future Work

Historical Effects (Task 2)

- ADS #trees killed
- C in killed trees

Move carbon/nitrogen from live to dead pools; reset ages (Task 1)