Quaking aspen and climate change

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Climate change

Direct Effects
• Altered temperature and precipitation regimes
• Droughts

Indirect Effects
• Increasing extent, magnitude and/or frequency of various forest disturbances

Effect on forest demography and ecology? Consequences for dominance and extent of aspen?
Changes in fire regimes

- Warm and dry conditions result in increased wildfires and bark beetle outbreaks, particularly in coniferous forests.
Regeneration of aspen

- Regeneration modes can vary even within a relatively restricted area
- But, generally favored by fire.
Regeneration of aspen

- Seed
- and
- Vegetative
Comparison of dominance in Grand Mesa area

Kulakowski et al. 2004
# Transition matrix of Grand Mesa

<table>
<thead>
<tr>
<th>Late 20\textsuperscript{th} century</th>
<th>Late 19\textsuperscript{th} century (ha and percent)</th>
<th>Burned</th>
<th>Unburned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lonan - Spruce - fir</td>
<td>Aspen</td>
<td>Spruce - fir</td>
</tr>
<tr>
<td>Aspen</td>
<td>9,792 ( (85% )</td>
<td>17,252 ( (62% )</td>
<td>33,238 ( (78% )</td>
</tr>
<tr>
<td>Spruce - fir</td>
<td>1,333 ( (12% )</td>
<td>7,626 ( (28% )</td>
<td>4,459 ( (10% )</td>
</tr>
<tr>
<td>Grass / shrubland</td>
<td>457 ( (4% )</td>
<td>2,761 ( (10% )</td>
<td>4,896 ( (11% )</td>
</tr>
</tbody>
</table>

Kulakowski et al. 2004
Successional replacement and mortality

- Severe fires during the late 19th century drought increased aspen cover.

- A larger portion of the landscape is presently dominated by aspen than in the 19th century.

- Long-lasting effect.
Amplitude of ecological patterns

Year

Aspen (ha)

Effec{}ts?
Aspen less flammable than conifers

- Fires increase relative amount of aspen, even without considering effects on regeneration
Compounded disturbances

• Extent, magnitude, and/or frequency of various forest disturbances are increasing.

• Two or more disturbances occurring in short succession.

• Can affect ecosystem development in ways that are not well understood.

• Critical to understand this complexity to better anticipate changes to aspen and other species.
1997 wind storm
• 1997 windstorm followed by 2002 Fire
• Effect of compounded disturbances on regeneration?
Total regeneration varies with pre-fire composition

Kulakowski et al. 2012.
Compounded disturbances favor initial dominance of aspen

Kulakowski et al. 2012.
Compounded disturbances and aspen regeneration

- Pre-fire forest composition and disturbance history affect post-fire regeneration.

- Effect of compounded disturbances on regeneration varies across species.

- Appear to favor aspen regeneration.

- Aspen also less susceptible to many climatically-driven disturbances.
Direct effects of climate change

• Aspen demography is contingent on climate

• What is the direct effect of the same climatic conditions that indirectly (via altered disturbance regimes) favor aspen?
Temperature

Correlation

Seasons

- SPR
- SUM
- FALL
- WINT
- Spring
- Summer

Not Significant

Significant

Hanna and Kulakowski 2012
Precipitation

Correlation

Seasons

SPR  SUM  FALL  WINT  Spring  Summer

Not Significant
Significant

Hanna and Kulakowski 2012
Recent growth of live vs. dead trees

GLM; Model selection used Akaike’s Information Criterion; Best model (AIC = 48.22) included variables log(3 year average BAI) [p value <0.001]; 20 year growth trends [p value < 0.001]
Aspen Death & Drought

Hanna and Kulakowski 2012
Climate and mortality

• Growth and mortality of quaking aspen away from transitional zones also strongly associated with climatic variation.

• Specifically:
  – the growth of aspen inhibited by warm temperatures, except at the highest elevations
  – mortality of aspen preceded by multiple years of reduced growth
  – frequency of mortality associated with multiple years of drought

Hanna and Kulakowski 2012
Climate

More fires
  - More aspen

More outbreaks
  - More aspen

More compounded disturbances
  - More aspen

More drought
  - Less aspen

?
Contingent on aspen’s ability to survive and regenerate under future climate
Feedbacks
More aspen

Less winds damage

Less outbreaks

Less compounded disturbances

Less fires

Less wind damage

Negative feedback

(Stabilizing factor for disturbance-driven ecological change?)
Less aspen

- Disturbances
- Climate

- Conifers?
- Conversion to non-forest
Consequences and future scenarios

• Increases in individual and compounded disturbances have potential to promote aspen dominance, *but only* if post-disturbance climate is suitable for aspen survival and regeneration.

• Continuing drought has potential to hinder aspen dominance.
The consequences of climate change for quaking aspen are likely to be complex and contingent on effects of post-disturbance climate as well as on feedbacks among climate, disturbances, and forest composition.