The impact of pine beetle-induced tree death on snowpack accumulation and melt in the headwaters of the Colorado River

Abstract

Nearly two million acres of lodgepole pine forest in Colorado have been infested by mountain pine beetles (MPB) since 1996. In this study we examine the impact of tree death on snowpack accumulation and ablation. Here, we show results after one year of beetle impact.

Snowpack and meteorological properties were measured at eight pairs of dead and living lodgepole pine stands in a subalpine region along the headwaters of the Colorado River during the winter of 2009. Results from this study indicate that snowpack accumulated equally beneath living and dead tree stands, but was depleted as much as one week sooner beneath dead stands. Snow under all tree stands became isothermal simultaneously regardless of mortality, but melted 15 – 20% more rapidly under dead trees.

Solar radiation measurements showed no consistent difference between living and dead tree stands regardless of mortality, but became isothermal simultaneously.

Our results differ from previous mountain pine beetle snow studies which found more snow accumulation and later snow depletion under dead tree stands. Earlier snowmelt caused by tree mortality accentuates established one to four week advances in snowmelt due to global warming.

Site and Methods

<table>
<thead>
<tr>
<th>Location</th>
<th>Measured Parameters</th>
<th>Research Season</th>
<th>Site Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado River</td>
<td>Snow depth, density</td>
<td>Feb to May 2009</td>
<td></td>
</tr>
<tr>
<td>Rocky Mountain National Park</td>
<td>Snow temperature</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8 site pairs
- Adjacent
- Similar slope
- Similar aspect
- Similar elevation
- Different Mortality

Tree Death Stage
- “Red Stage” where needles still remain on the dead trees
- “Dead Stage” where needles are removed

| Pine Mortality > 10cm DBH
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>65</td>
</tr>
<tr>
<td>90</td>
</tr>
</tbody>
</table>

1. No relationship with canopy transmission
2. The snowpack under living and dead stands became isothermal on the same date
   - The amount of sunlight making it through the canopy was not the primary driver for melt

What caused earlier melt under dead trees?

Conclusion

- Snow accumulated in similar amounts under living and dead trees
- The snowpack beneath living and dead tree stands became isothermal on the same date
- The snow under dead stands melted more rapidly than snow under living stands as a result of decreased albedo
- Snow cover was gone as much as a week earlier under dead tree stands

Future Impacts

- A drier winter with reduced snowpack
- More incoming radiation = Faster melt
- Less sublimation = More snowmelt = More water
- Will more snowmelt accumulation reverse the advance of snowmelt under dead trees even with faster melt rates?

Results

Snowpack Temperature

Snow Water Equivalent

Snow Cover

Explanation

Snow Surface Albedo

Future Impacts

- Dead trees without pine needles on their branches physically intercept less snow as it travels from the atmosphere to the ground. Snow that gets caught on branches is much more likely to sublimate directly into the atmosphere than snow that collects on the forest floor in the snowpack.

- Pine needles and branches collect in the snowpack beneath infested trees to create a substantial litter layer (>5 cm) during melt. The litter lowers the snowpack surface albedo and speeds up melt.

- After the third year of beetle infestation, a lodgepole pine is denuded of most of its pine needles allowing more direct sunlight to reach the snowpack on the forest floor.