Effects of forest harvesting and riparian buffers on headwater stream temperatures

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Headwater Streams

• Small in size, but can be 80% of stream length
• High density on the landscape in steep terrain
• High Biodiversity - invertebrates, amphibians, fish
• Sensitive to Landscape Changes - e.g., harvesting
• Concern about headwater stream temperature and sediments that impact biota
• Impact Downstream Processes - Cumulative Effects
**Objectives**

1. To determine the effect of clearcut harvesting and riparian buffers on headwater stream summer temperatures (July and August) in lowland Douglas-fir forests in western Washington.

2. To determine how long stream temperatures in headwater streams take to recover after clearcut harvesting.

3. To determine management implications with respect to harvesting and stream temperatures.
What have others found about effects of harvesting and riparian buffers on headwater stream temperatures

Studies from California, Oregon, Washington, and BC

- Summer maximum stream temperatures in clearcuts can be cooler or as much as 11°C higher compared to uncut forests
- Summer minimum temperatures are less sensitive to harvesting
- Riparian buffers can reduce elevated temperatures by as much as half
- Recovery after harvesting can be as long as 15 years
Cold-water salmon are very sensitive to temperature changes.
Invertebrates and salamanders are also very sensitive to temperature changes.
Sensitivity of fish and amphibians to temperature

• WA DOE criteria – 7 day- average of maximum temperatures in excess of 16 °C.

• Critical thermal maxima for NW salamander species larvae and adults,
  - southern torrent salamander - 26.7 and 27.9 °C (Bury, 2008)
Many factors affect stream temperatures

air temperature
stream morphology
ground-water
riparian and basin vegetation condition
harvesting
shade
aspect
windthrow and sediment
stream wood
Factors controlling Stream Temperatures

Figure 1. Factors Controlling Stream Temperature. Energy fluxes associated with water exchanges are shown as black arrows.
Lateral changes in stream temperature in a clearcut in British Columbia – August 2001
Moore et al. (2005)
Type S   - Shoreline
Type F   - Fish
Type Np  - Non-fish perennial
Type Ns  - Non-fish seasonal
TYPE F STREAMS HAVE RIPARIAN PROTECTION

Graphic Representation of Riparian Zones

Jeff Grizzel, WA DNR
The WA Forest Practices requires leaving the riparian area in a condition today that will grow to replicate natural stands of older forest at age 140 years. A certain number of trees and canopy cover need to be left within the riparian zone to achieve this **Desired Future Condition (DFC)**.
Under Forest Practices, headwater streams discontinue protection 10 m equipment restriction zone Wide buffer strips make timber harvest difficult

Type Np waters

Sensitive Sites = seeps, springs, Np confluences, alluvial fans

Jeff Grizzel, WA DNR
- Most streams are non fish headwaters in lowland Douglas-fir forests in western Washington

- FP rules are the default for non-federal lands owners

- DNR lands in western WA exceeded FP rules, larger headwaters receive continuous protection -- added stream protection alternatives for smaller streams are being tested
Study site

Waddell Creek Watershed, Capitol Forest, Southwest of Olympia, Washington
Washington Department of Natural Resources

Retrospective analysis for harvest impacts to stream temperature
### Characteristics of study streams (<1.5 m wetted width)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Stream</th>
<th>Elev. (m)</th>
<th>Slope (°)</th>
<th>Aspect</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unharvested 89 yrs</td>
<td>Moonshine</td>
<td>387</td>
<td>32.9</td>
<td>W</td>
<td>7.4</td>
</tr>
<tr>
<td>Unharvested 60 yrs</td>
<td>Candy</td>
<td>369</td>
<td>37.3</td>
<td>SE</td>
<td>5.0</td>
</tr>
<tr>
<td>Unharvested 60 yrs</td>
<td>TNFC</td>
<td>257</td>
<td>48.6</td>
<td>NE</td>
<td>9.0</td>
</tr>
<tr>
<td>Clearcut 7 years</td>
<td>SAC</td>
<td>305</td>
<td>30.8</td>
<td>NE</td>
<td>19.8</td>
</tr>
<tr>
<td>Clearcut 7 years</td>
<td>Club</td>
<td>345</td>
<td>25.3</td>
<td>W</td>
<td>6.5</td>
</tr>
<tr>
<td>Clearcut 7 years</td>
<td>Flattire</td>
<td>279</td>
<td>34.4</td>
<td>NE</td>
<td>7.8</td>
</tr>
<tr>
<td>Clearcut 14 years</td>
<td>TNF-15</td>
<td>211</td>
<td>44.0</td>
<td>NE</td>
<td>8.2</td>
</tr>
<tr>
<td>Clearcut 17 years</td>
<td>West-N</td>
<td>240</td>
<td>29.0</td>
<td>W</td>
<td>3.6</td>
</tr>
<tr>
<td>Clearcut 17 years</td>
<td>West-S</td>
<td>180</td>
<td>27.8</td>
<td>W</td>
<td>3.7</td>
</tr>
<tr>
<td>Patch Buffered 6 yrs</td>
<td>Tums</td>
<td>250</td>
<td>31.3</td>
<td>S</td>
<td>5.0</td>
</tr>
<tr>
<td>Patch Buffered 5 yrs</td>
<td>Base</td>
<td>271</td>
<td>34.5</td>
<td>SE</td>
<td>4.7</td>
</tr>
<tr>
<td>Patch Buffered 1 yr</td>
<td>Donkey</td>
<td>373</td>
<td>48.6</td>
<td>SE</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>Waddell Creek (3rd order)</td>
<td>125</td>
<td>6.6</td>
<td>W</td>
<td>1962.8</td>
</tr>
</tbody>
</table>
WATER LEVEL SENSOR AND TEMPERATURE MEASUREMENTS AT WEIR

GLOBAL WATER WL - 15/16 WATER LEVEL LOGGER
7 year Stand Conditions

~3 m
14-17 year Stand Conditions

~ 12 m
60-89 year Stand Conditions
5-6 year Buffered
Waddell Creek
<table>
<thead>
<tr>
<th></th>
<th>Unharvested</th>
<th>7 yr CC</th>
<th>14-17 yr CC</th>
<th>5-6 yr Buff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max.</strong></td>
<td>15.2±0.7a</td>
<td>14.0±1.0a</td>
<td>14.8±1.0a</td>
<td>16.0±0.8a</td>
</tr>
<tr>
<td><strong>Max-Min</strong></td>
<td>3.7±1.4a</td>
<td>4.3±0.6a</td>
<td>3.3±0.6a</td>
<td>4.4±0.8a</td>
</tr>
<tr>
<td><strong>Av daily Max</strong></td>
<td>13.2±0.5a</td>
<td>12.4±0.7a</td>
<td>13.3±0.8a</td>
<td>14.4±1.0a</td>
</tr>
</tbody>
</table>

Winter (Jan 2005-2007)

| **Min.**       | 4.9±0.3     | 4.8±0.7   | 5.6±0.7     | 4.6±1.0     |
## Temperature extremes (°C) 2004-2006

### Summer maximum temperatures

<table>
<thead>
<tr>
<th>Treatment</th>
<th>7 yr CC</th>
<th>14-17 yr CC</th>
<th>5-6 yr Buffered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unharvested</td>
<td>16.8</td>
<td>16.5</td>
<td>16.9</td>
</tr>
</tbody>
</table>

### Summer maximum temperatures above average of unharvested controls

<table>
<thead>
<tr>
<th>Treatment</th>
<th>7 yr CC</th>
<th>14-17 yr CC</th>
<th>5-6 yr Buffered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.9</td>
<td>1.6</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>14-17 yr CC</td>
<td>Waddell Creek</td>
</tr>
<tr>
<td>----------------</td>
<td>---------</td>
<td>-------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Max.</td>
<td>14.3</td>
<td>14.5</td>
<td>15.6</td>
</tr>
<tr>
<td>Av daily Max</td>
<td>12.7</td>
<td>12.7</td>
<td>14.6</td>
</tr>
</tbody>
</table>
24 hour stream temperatures (°C)
August 15, 2005
Wood volume in harvested streams in the Capitol Forest (Maxa, 2009)
Air temperature and stream temperature
Average maximum temp July and August
Variable buffer – Harvested May 2005
Influence of buffer at Donkey site

Maximum temperatures - (July-Aug)

Harvested May 2005
Other stream temperature and stream biology studies at Capitol Forest (DNR, WA DOE, USFS)

Photo courtesy - Pete Bisson, USFS
Blowdown in continuous buffer

Photo courtesy - Pete Bisson, USFS
CONCLUSIONS

• No statistical differences in maximum July-Aug stream temperatures in treatments (unharvested forest, clearcut, and buffered) from 2004-2006.

• The maximum stream temperature recorded was 18.1 C in first year after harvesting in a variably buffered stream. Not lethal for salamanders and fish, but could be disruptive to physiology. Maximum temperature in later years was 16.9 C in buffer treatment 5-6 years after harvesting. Harvesting did not greatly increase stream temperatures (max 3.3 C in first year in clearcut - WADOE)

• Stream temperatures were related to air temperatures, but not consistently among treatments which varied from year to year

• Stream temperatures in harvested streams seem to be responding to multiple factors; air temperature, shading, changing vegetation, wood in the channel, sediments and aspect, and are extremely variable from stream to stream
CONCLUSIONS

- Stream temperatures have recovered 6-7 years after clearcut harvesting. Clearcuts were slightly cooler than controls due to wood and shading.

- Stream buffers in headwater streams at this site don’t have a big influence on maximum stream temperatures. Headwater buffers are very vulnerable to blowdown. Could add sediment to streams increasing temperatures.

- Wood in clearcut streams reduces stream temperatures. Wood could be placed in streams.
Acknowledgements

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