Watershed Function and Forest Management: For Today and in a Warming Climate

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Upland Hydrologic Processes Combine...

to Contribute to Upland Watershed Function:

- Store and transport ... water
- ... sediment
- ... nutrients
Watershed Function - Impacts

Upland watershed function:
- Store and transport water
- Store and transport sediment
- Store and transport nutrients

Impacts:
1. Climate Change
   - Less snow + early melt
   - More rain in winter
   - More evapotranspiration loss
Watershed Function - Impacts

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Impacts:

1. **Climate Change**
   - Less snow + early melt
   - More rain in winter
   - More evapotranspiration loss

2. **Timber Harvest + Fire + Roads**
   - Higher peak flows
   - Modify snow storage
   - More sediment transport
Watershed Function - Impacts

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Impacts:

1. Climate Change
   - Less snow + early melt
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2. Timber Harvest + Fire + Roads
   - Higher peak flows
   - Modify snow storage
   - More sediment transport

3. Riparian/In-channel wood removal
   - Channel incision
   - More sediment transport
Watershed Function

Upland watershed function:
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Management/Restoration Goals:
1. **Maximize** in-situ water storage and
2. **minimize** water export

1995 flood discharge (cfs) at Skagit River
2 locations

[Graph showing discharge data with labels: Upstream and Downstream]
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1995 flood discharge (cfs) at Skagit River
2 locations

Graph showing discharge (cfs) with peaks in November and December of 1995.
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Monthly Runoff (in) at South Fork Nooksack River at Wickersham - Historic and 2075s

Historical

Projected:
- Less Snow
- Earlier Melt

1995 flood discharge (cfs) at Skagit River 2 locations

Upstream

Downstream

Murphy, 2016; MS Thesis, WWU
Watershed Function

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“Hydrologic Maturity”?
Watershed Function

Upland Water Storage and Export:

- **Snowpack**
- **Surface water: Natural + Built**
- **Sub-surface water: Upland + Alluvial**
- **Routing and conveyance**
Motivation: Climate Change Effects on Streamflow

Current Climate

Snow stored in mountains to melt later

Rain runs off into streams

Snowfall

Rainfall

Slide courtesy of Karl Lapo, UW Mountain Hydrology Research Group
Photo: https://www.flickr.com/photos/reurinkjan/4462015331
Motivation: Climate Change Effects on Streamflow

Warmer Climate

Less Snow stored in mountains to melt later

More Rain runs off into streams

Snowfall

Snow-Rain Transition Rises

Rainfall

Photo: https://www.flickr.com/photos/reurinkjan/4462015331

Slide courtesy of Karl Lapo, UW Mountain Hydrology Research Group
Motivation: Changing Forests

Silviculture

Wildfire

Photos: Seattle Public Utilities, Brian Henn
Background: Forest-Snow Processes

Processes

Interception

Melting

Photos: Kael Martin
Background: Forest-Snow Processes

Processes

Interception

Melting

Effects

Local Scale

Stand Scale

Photos: Kael Martin, Google Earth
Background: Forest-Snow Processes

Processes
- Interception
- Melting

Effects
- Local Scale
- Stand Scale

Watershed Impacts
- Snow Storage
- Streamflow & Temperature

Photos: Kael Martin, Google Earth
Background: Forest-Snow Processes

Processes
- Interception
- Melting

Effects
- Local Scale
- Stand Scale

Watershed Impacts
- Snow Storage: Longer in Gaps
- Snow Storage: Longer in Forest

Photos: Kael Martin, Google Earth
Does Timber Preserve Snow?

Most of us have, without question, concluded that snow will last longer in the timber than in open parks and that the timber in the mountains is the great natural reservoir which retains the snow and consequently the water supply for the late summer. The following from the Gunnison News-Champion on the subject is worthy of consideration:

All forestry experts say it does. Experience and observation of hundreds of years in European mountains and the hills of eastern America proves that it does. Prof. Canton, in his book on forestry...
Application: Decision Tree

A framework to predict the net effect of forest on snow storage duration

Figure 3, Dickerson-Lange, et al. 2016 (in preparation)
Rain-On-Snow Events and Forest Cover

Warm, wet, and windy atmospheric river events: 
More contributing area (rain) + more melt (snow)

Less Snow stored in mountains to melt later

More snowmelt in open areas due to warm windy conditions

More Rain runs off into streams

Wayand et al 2015: Up to 29% of streamflow from snowmelt in Snoqualmie

Slide courtesy of Karl Lapo, UW Mountain Hydrology Research Group
Photo: https://www.flickr.com/photos/reurinkjan/4462015331
Soil Moisture

Perry and Jones (2016): HJ Andrews Exp. Forest, OR

- Summer streamflow 50% LOWER in re-generating Doug Fir stands (30-40 years old)
Example Silvicultural BMPs for Forest Hydrology

Group Selection System for:

- Snow retention
- Regeneration in gaps
- Regenerating mixed species
- Matrix thinning to reduce transpiration and interception
- Dispersed opening to reduce effects of Rain-on-Snow
Thanks!

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http://depts.washington.edu/mtnhydr/research/PNWsnowforestmap.shtml

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