Managing landscape response to climate-driven floodplain disturbances at Mount Rainier National Park, Washington State

Managing Climate Change at a Landscape Level,
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Overview of Presentation

- Climate change
  - Shrinking glaciers
  - River and landscape response

- Why we care:
  - Downstream impacts
  - Loss of park access

- Case study – White River
  - Role of old growth forests
  - Logistic and regulatory challenges
“I can see glaciers from my house.”
The study area is Mount Rainier...
More glacier ice than all the Cascade volcanos combined.

- 25 named glaciers
- 34 square miles of ice
- Ice volume ~1 cubic mile
- Most glaciated massif in the continental USA

Credit: Dee Molenaar
The Problem: Lots of melting glaciers....

Volume loss:
- **25%** — 1913-1994
- **18%** — 2003-2009
- Recent volume loss rate is 600% higher.

Sources: Nylen, Riedel
Since 1913, an area of 37.5 km² (14.5 mi²) has been exposed by retreating glaciers.

(1) Glacial sediment exposed on steep slopes

(2) Lateral moraine undercutting and failure
Instability of the exposed sediments contributes to aggradation and flooding.
Aggradation trends:

- Filling of rivers channels with sediment;
- Recent increases:
  - historic rate = < 4 inches/decade
  - current rate = ~ 3 feet/decade
  - almost 10X increase over historic
Limited sediment data

- Puyallup river system is heavily loaded with sediment

USGS: Czuba, Magirl
INCREASED STORMINESS:
Dramatic increase on Nisqually:
Previous 100 year flood, now every 14 years
With increased river flows, and decreased river transport capacity....
….the park has experienced significant, on-going flood problems, since 2003
Starting Nov. 6, 2006, 18 inches of rain fell in 36 hours, immediately flooding many roads.
Park rivers responded immediately, with record flows
The Usual Road Failures...
Park-wide Locations of Damage

Almost every stream and road and trail crossing damaged.

- Park closed for over 6 months;
- Over $36 million dollars damage;
- Park still not fully recovered…
Challenges to access from increased flooding...
Steady loss of roads and campgrounds….

- Reduced non-hiking access
-Unable to maintain cultural resources
-Conflicts with NPS mission

**White River Road; State Route 410**

- Carbon River road closed 2006 (forever?)
- Westside Road closed 1980s; 50,000 visitors/yr.
- Road to Paradise; Highest risk; Only year around road.
- Sunshine point CG; closed 2006; Only year around camping in park.
Constraints

• **Physical:**
  – Extreme perched channels
  – Road location
  – Riparian forest condition

• **Logistic and regulatory:**
  – **Regulatory**
    ▪ National Historic Preservation Act
    ▪ Wilderness Act
    ▪ Endangered Species Act
  – **Funding source**
    • Federal Highway Administration
    • Prevention or repair
White River — State Route 410

*physical constraints: road location*

Old Storbo Mine Road

– 1915 map

Source: WSDOT
Welcome to Mount Rainier National Park

- Example of river parallel road (capture)
- 2 year flow event can inundate highway;
- 2\textsuperscript{nd} most-traveled route Seattle-Yakima.
- Crystal Mountain Ski Area access lost
- SR 410 co-managed by park and WA Dept. of Transportation (WSDOT)

Photo: WSDOT
White River — SR 410

*physical constraints: aggradation*

Why not move road?

Bottom of river over 16 feet above road

Flow above road surface, even in summer.

Photo: WSDOT
Height above water map reveals 13 below-river floodplain areas, as much as 20 feet below the river channel.

No ‘safe’ location on valley bottom.
How can a river remain above floodplain?

Role of large trees in mediating avulsions

Physical constraints: role of wood

Sitka Spruce, lower Bogachiel River, Olympic NP, WA
Classic braided river with young vegetation
(Sunwapta River, Alberta)

Forest encroachment into valley bottom & channel confinement
Worst case: old-growth forest loss, extreme instability

- 1967 – present: multiple debris flows killed Tahoma creek forests
- Active channel widened over 500 feet, and the river has occupied 3 distinct channels in the last 10 years
- Took decades for the forest to die; but will take centuries to recover
In White river, multi-acre areas of valley-bottom old growth are being smothered by recent aggradation in the park, however the forest is still mostly intact.
Images of White river floodplain in disequilibrium
At avulsion path inlet, the standing forest “sieves” downed wood — ultimately plugging the hole.

This is 1 mechanism, of several, that helps prevent total main stem avulsions.
Despite massively perched channels and large lateral gradients, avulsion paths are small compared to mainstem.
Why not move the road?  
*regulatory constraints*

**FEDERAL LAND MANAGEMENT**

- **National Historic Preservation Act**
  - Roads provide excellent, public access
  - Highest level of cultural protection
  - Historic alignment contributes to significance

- **Wilderness Act**

- **Endangered Species Act**
Why not move the road?

regulatory constraints

FEDERAL LAND MANAGEMENT

• National Historic Preservation Act

• Wilderness Act
  • Roads not allowed
  • Comprises 97% of the park
  • Act of Congress to change

• Endangered Species Act
Why not move the road?

regulatory constraints

FEDERAL LAND MANAGEMENT

- National Historic Preservation Act
- Wilderness Act

Endangered Species Act
- **Valley bottom** (aquatic)
  - bull trout, and multiple salmon species listed
- **Hillslope** (terrestrial)
  - endangered spotted owl and marbled murrelet habitat (old-growth dependent)
  - high landslide potential, if move road to valley wall
Scale of Potential Side Channel Expansion at Floodplain M Associated with Medium Sized Avulsion

unvegetated active channel

floodplain forest

medium avulsion channel of similar scale to Floodplain A (220' width)

medium avulsion channel of similar scale to Floodplain L (110' width)

medium avulsion channel of similar scale to recent expansion of downstream end of Floodplain M (70' width)

current side channel (10-20' width)

SR 410

300

350
Avulsion channel headcut

- Headcut migrates upstream during high flows
- ~12 ft. from main stem
- Fear is side channel expansion or mainstem avulsion, and road capture
Prevention vs. Repair

**HEADCUT GRADE CONTROL**

- Stop headcut migration
- Wilderness Act (minimum tool requirement)
  - wood construction
  - fish passage
  - no mechanized tools
  - minimum aquatic impact if fail
- **$10,000s to fix beforehand**
Prevention vs. Repair

**HEADCUT GRADE CONTROL**
- $10,000s to fix beforehand

**ELEVATED HIGHWAY**
- Highest level of protection
- Maximum river–floodplain connectivity
- Millions of dollars to fix after flood
Funding Source: Federal Highways

- Traditionally, easier to do ‘emergency repairs’ versus prevention

- originally: “replace in kind” policy
  - locked into old-school practices
Funding Source: Federal Highways

- Traditionally, easier to do ‘emergency repairs’ versus preventative
- Originally: “replace in kind” policy
  - Locked into old-school practices
- Currently, moving to “betterments”
  - Preventive action for imminent threats
• To date: multiple funded, preventive projects have been stopped, due to *perceived* Wilderness concerns.
• Currently park working to explore wilderness flood protection options, before an emergency
• Exploring WSDOT partnership for short and longer-term solutions
Our best option?

Thank you.