The Effects of Forest Management on Sediment, Turbidity, and Salmonid Population Health

Maryanne Reiter, Hydrologist, Weyerhaeuser Co.
Doug Martin, Fisheries Scientist, Martin Environmental
Western Forestry Conservation Association
September 8, 2016. Heathman Lodge, Vancouver WA.

Focus of This Talk

- Why do we care about sediment and turbidity?
- Landscape context of sediment
- Sediment and forest practices
- Management effectiveness/trends
- Biological effects

Sediment and Turbidity

Image from : Ministry of Forestry, Canada

Why is sediment a concern? High sediment can decrease the survival of salmonid eggs by reducing water flow through the streambed gravel. Excessive sediment can also affect fish habitat by reducing pool volume.

Images from: http://pubs.usgs.gov/fs/2004/3069/

Why is turbidity a concern? It is an important water quality parameter that can affect photosynthesis and sight–feeding organisms.

Landscape Control on Sediment Yield

Suspended Sediment Varies Across the Landscape

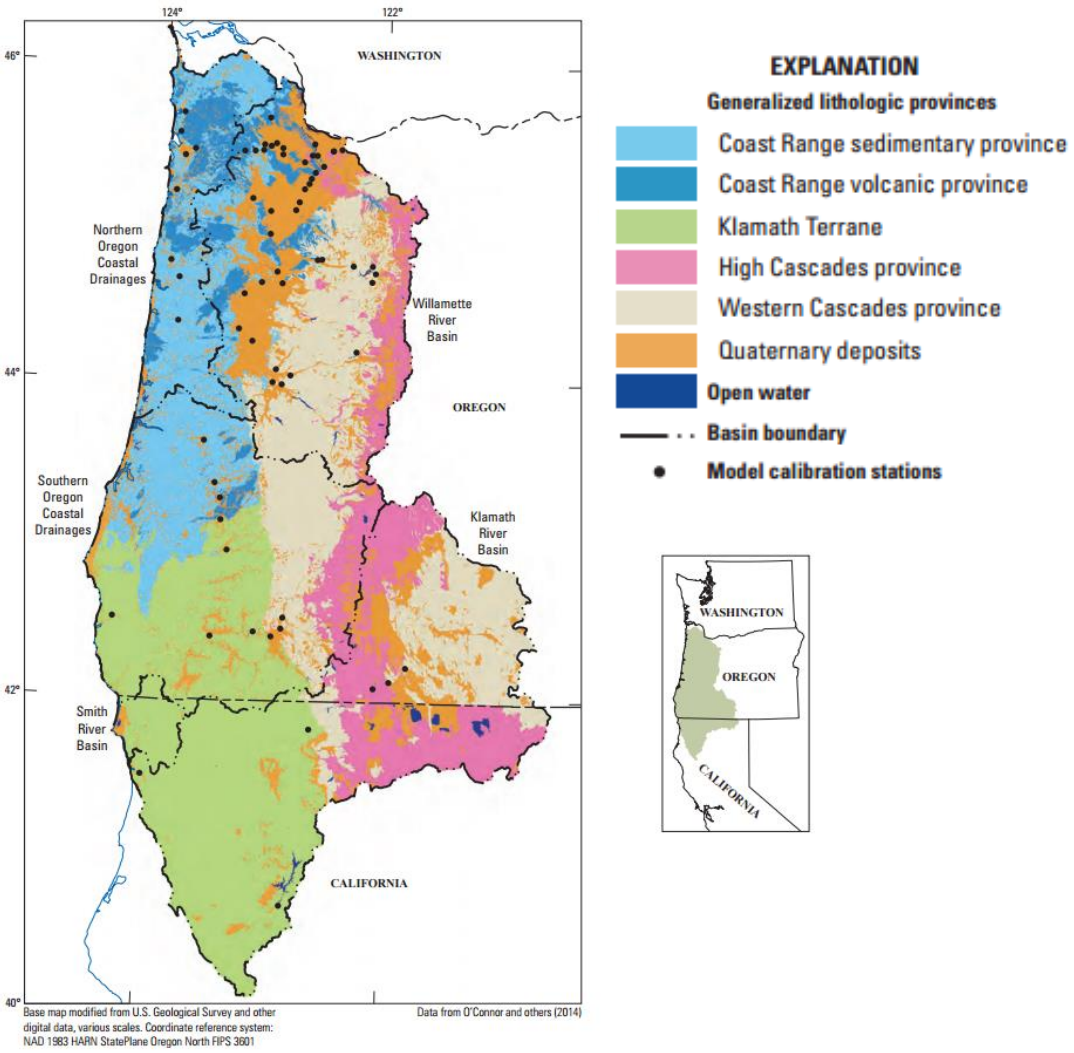


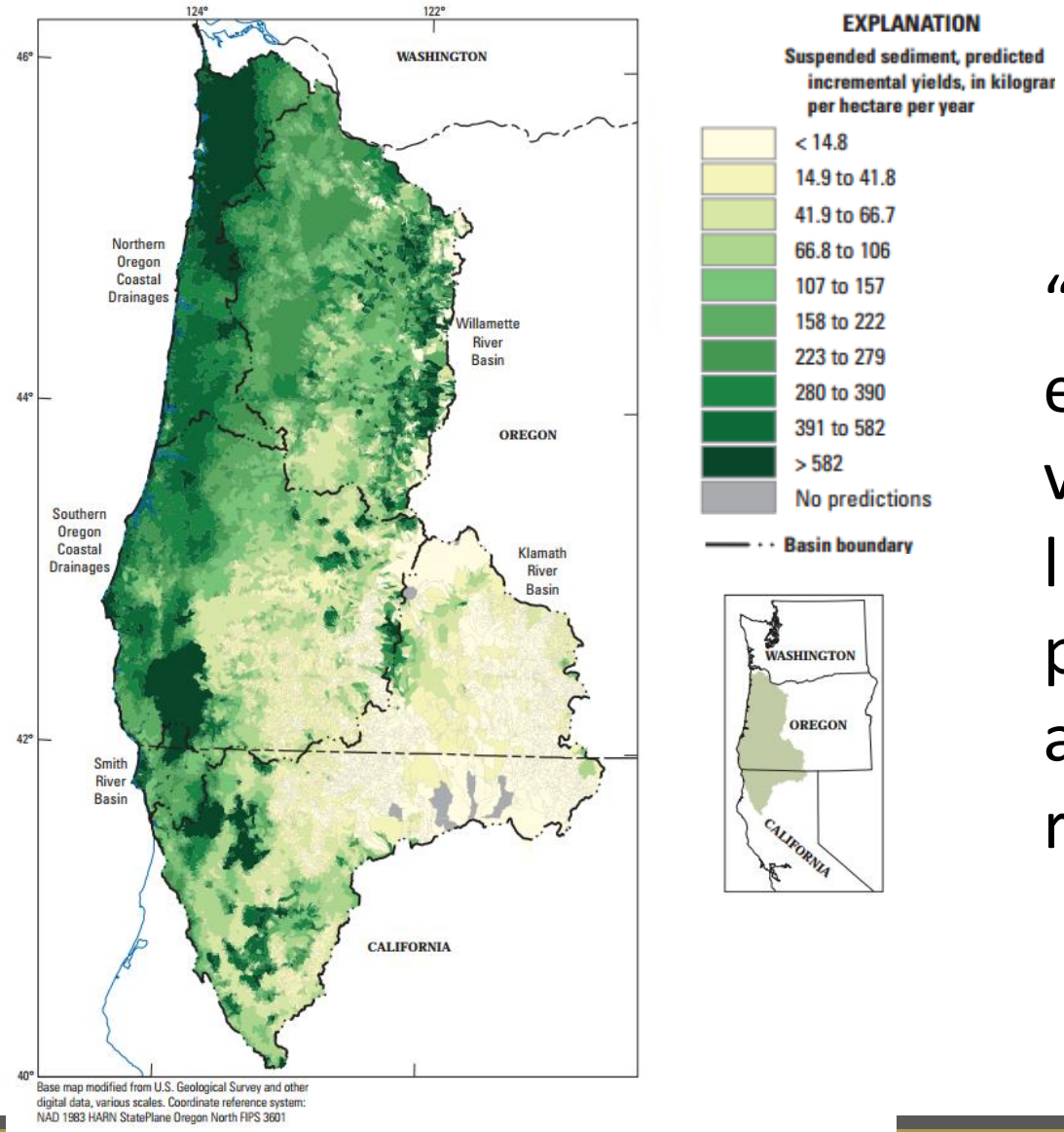
Figure 1. Modeling domain for the Western Oregon SPARROW model of suspended sediment.

2016 USGS Sediment Load Model for Western Oregon.

It examined sediment data from 68 stations and predicted sediment using several landscape variables including lithology, rainfall, wildfires, land cover, etc.

(Wise and O'Connor, 2016)

Suspended Sediment Varies Across the Landscape



Base map modified from U.S. Geological Survey and other digital data, various scales. Coordinate reference system: NAD 1983 HARN StatePlane Oregon North FIPS 3601

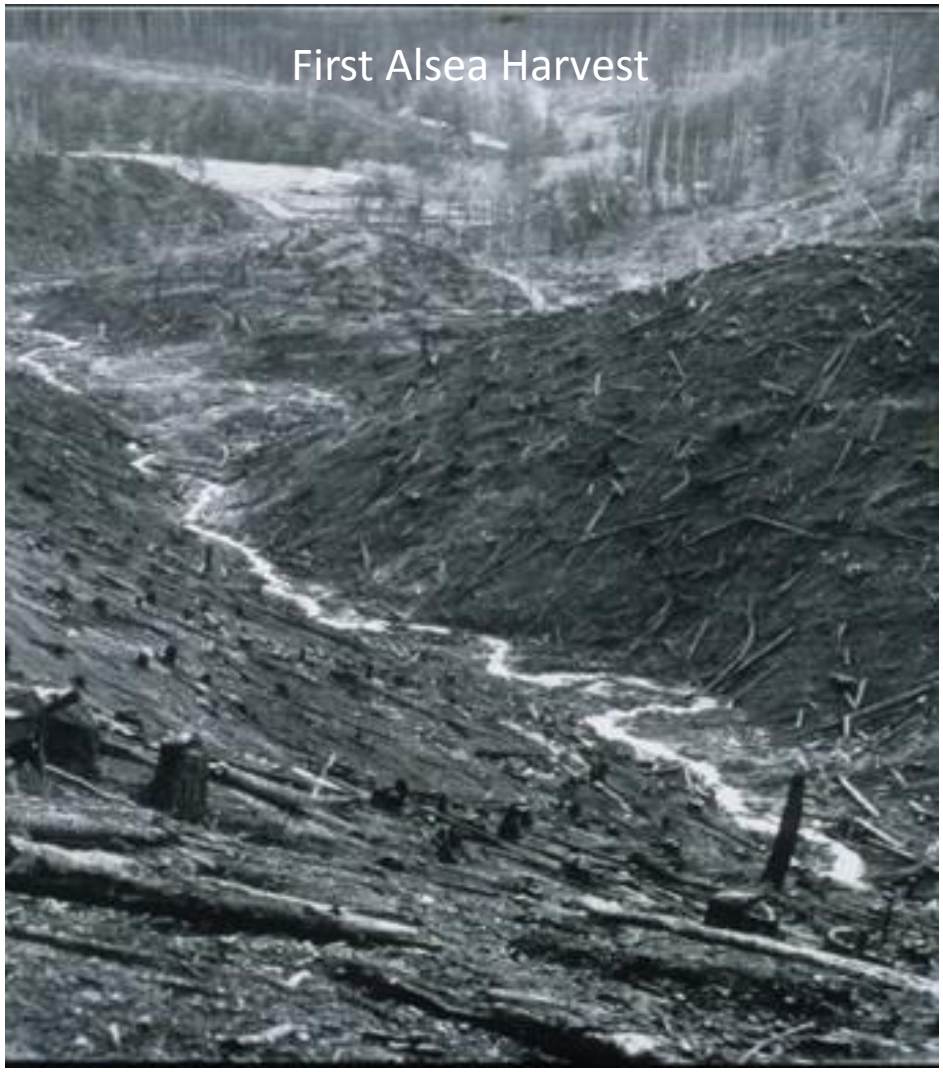
Figure 5. Incremental yields predicted by the Western Oregon SPARROW model of suspended sediment.

"The significant explanatory variables were lithologic province, precipitation, and area disturbed by recent wildfire"

(Wise and O'Connor, 2016)

Effects of Forest Management on Sediment

Past Practices Had Pronounced Effect on Sediment



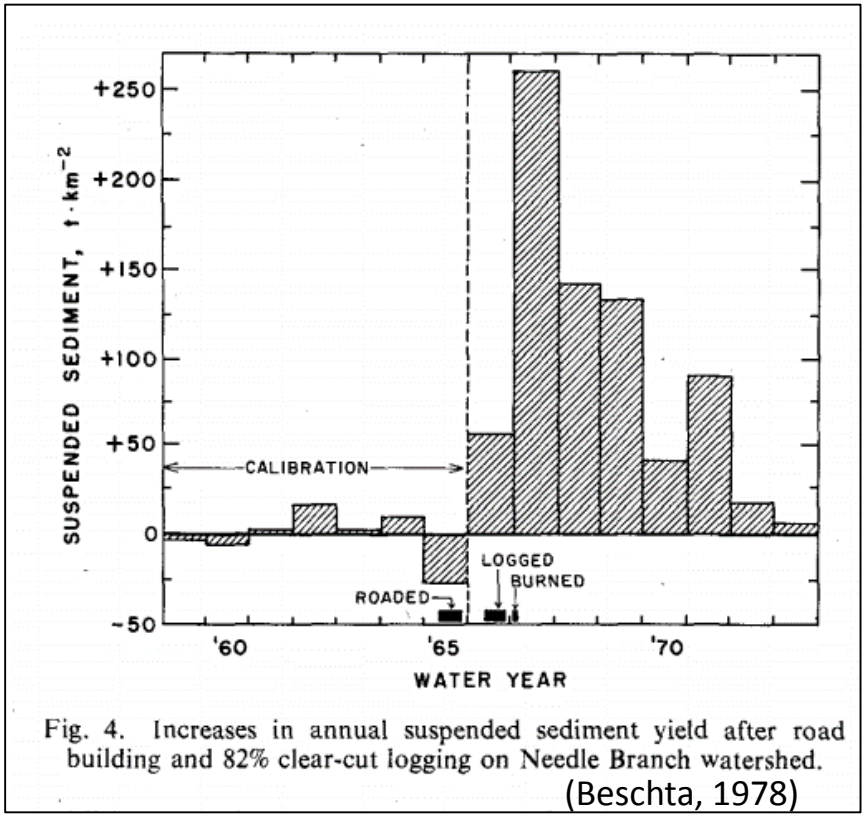


Fig. 4. Increases in annual suspended sediment yield after road building and 82% clear-cut logging on Needle Branch watershed.
(Beschta, 1978)

Forest practice rules have changed through time to address sediment delivery to streams

Forest Road Studies and Practice Changes

1978

WATER RESOURCES RESEARCH, VOL. 14, NO. 6, P. 1011, 1978
doi:10.1029/WR014i006p01011

Long-term patterns of sediment production following road construction and logging in the Oregon Coast Range

Robert L. Beschta
Department of Forest Engineering, Oregon State University, Corvallis, Oregon 97331

"..increases were caused primarily by mass soil erosion from roads."

1999

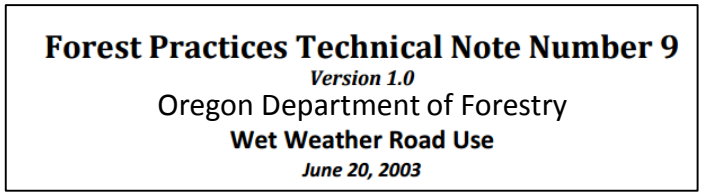
WATER RESOURCES RESEARCH, VOL. 35, NO. 8, PAGES 2561–2570, AUGUST 1999

Sediment production from forest roads in western Oregon

Charles H. Luce and Thomas A. Black
USDA Forest Service, Rocky Mountain Research Station, Boise, Idaho

"Road segments where vegetation was cleared from the cutslope and ditch produced about 7 times as much sediment …"

2003



Forest Practices Technical Note Number 9
Version 1.0
Oregon Department of Forestry
Wet Weather Road Use
June 20, 2003

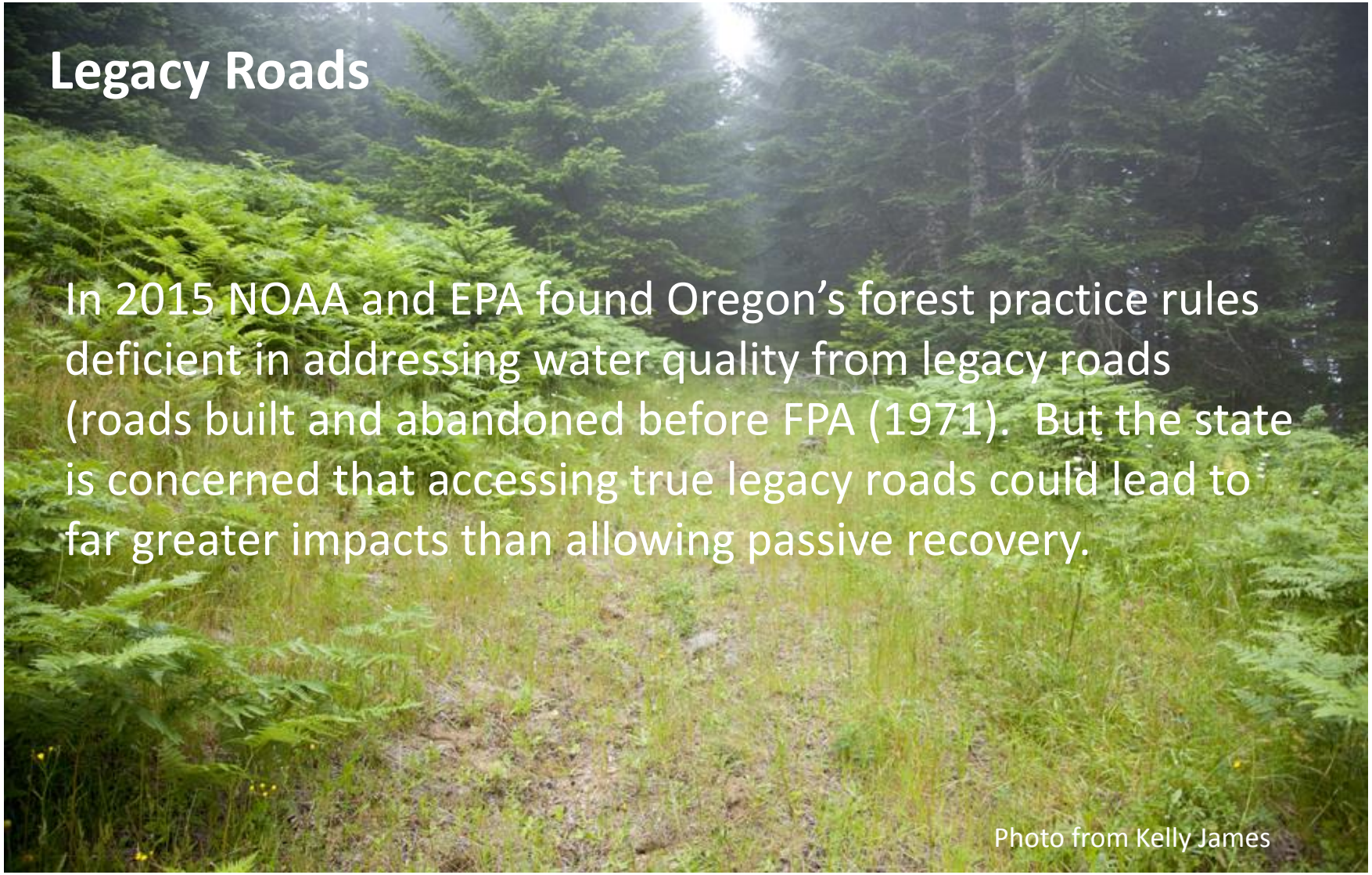
"Research and monitoring show that wet weather road use can influence water quality, especially turbidity."

Road Practices Have Evolved to Address Sediment

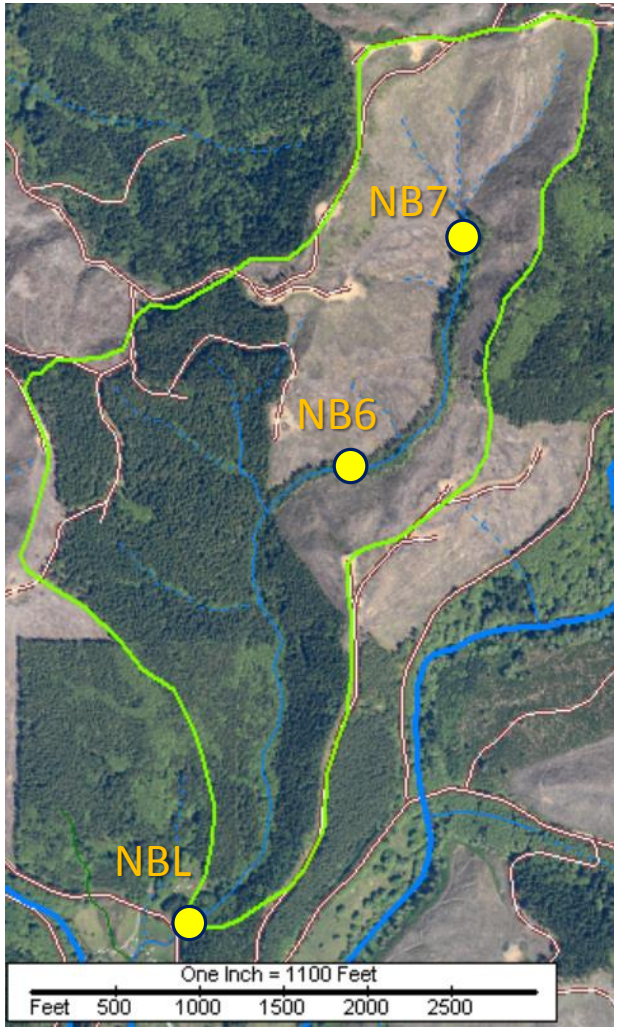
Road Design, Construction and Maintenance

Disconnecting Roads from Streams

But There Are Still Issues



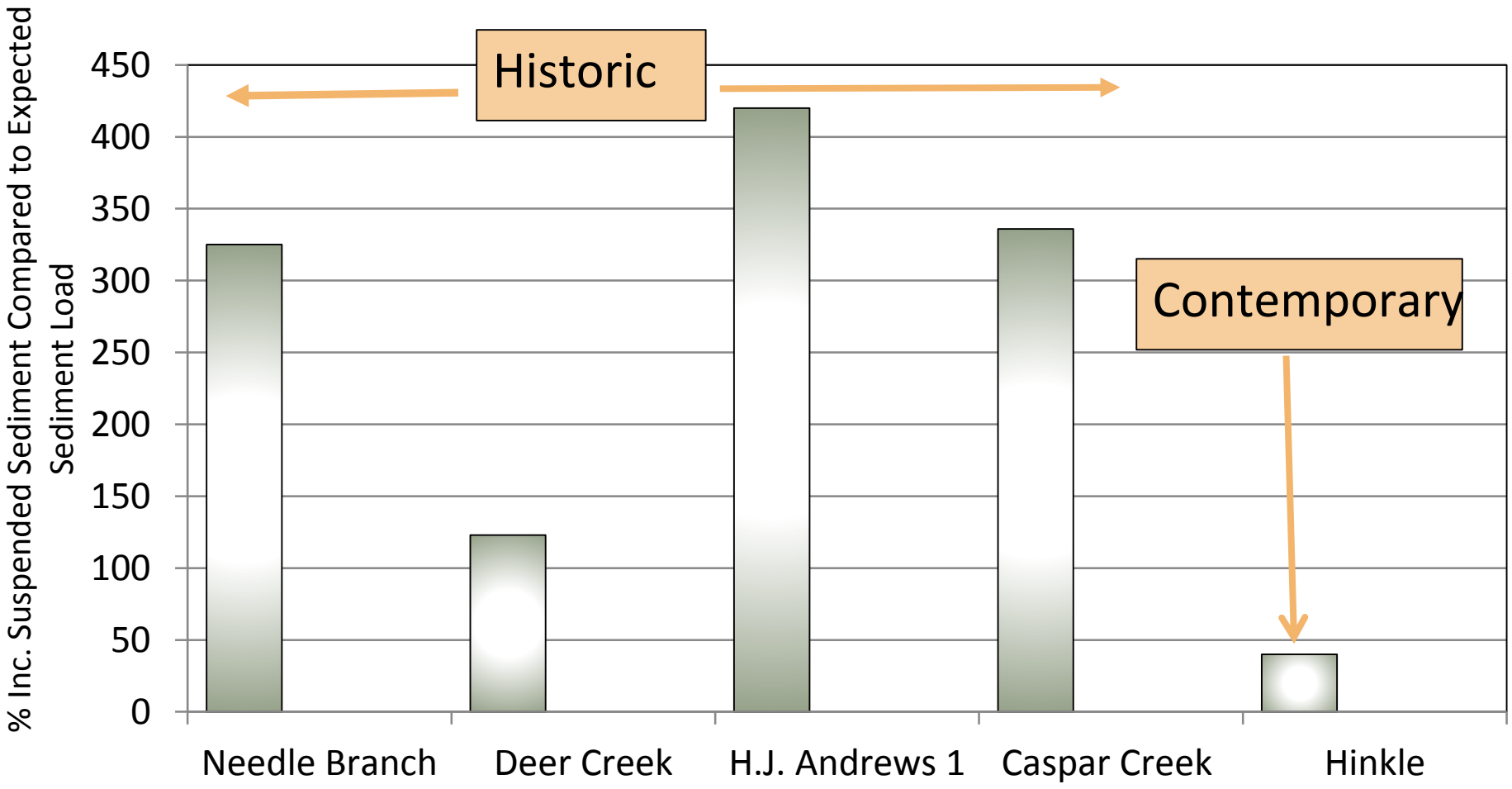
Other Practices That Have Helped Reduce Sediment



- Stream buffers
- Yarding systems (suspension)
- Discontinuing broadcast burning
- Limits on clearcut size and adjacent harvest timing

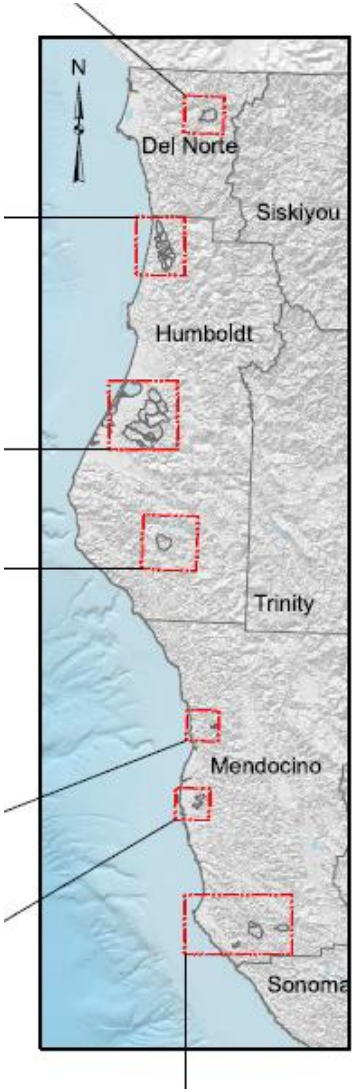
Alsea Watershed after 2009 harvest

Have These Changes Made a Difference?



Slide from G. Ice

Though Sediment Not Completely Eliminated



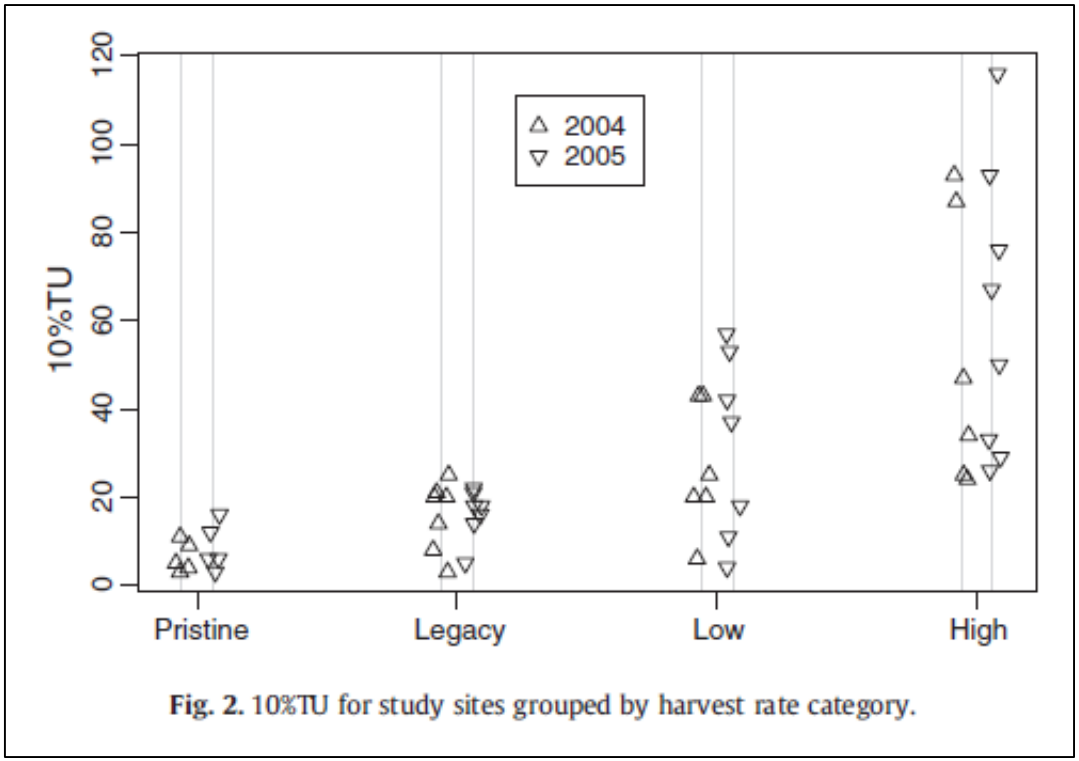
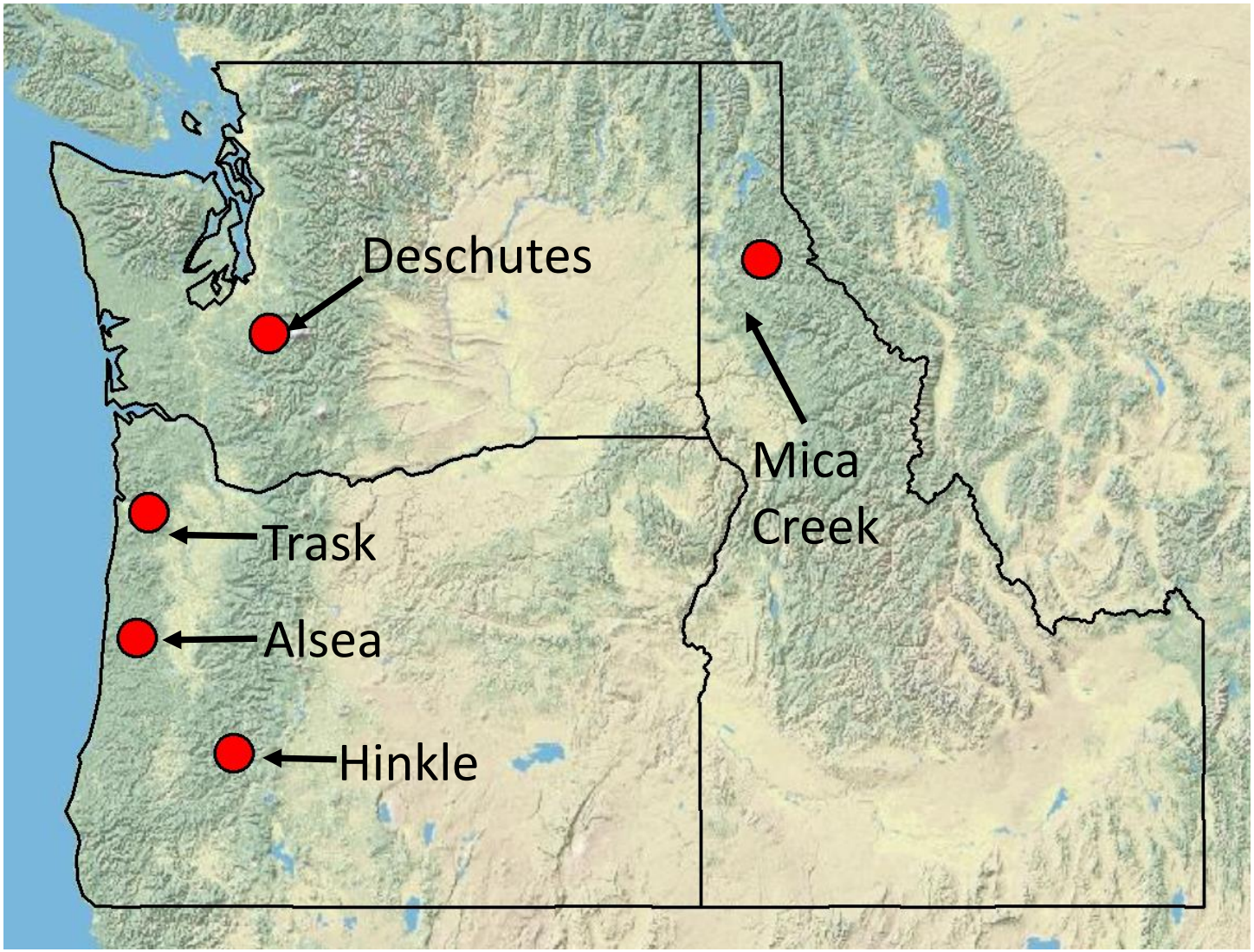


Fig. 2. 10%TU for study sites grouped by harvest rate category.

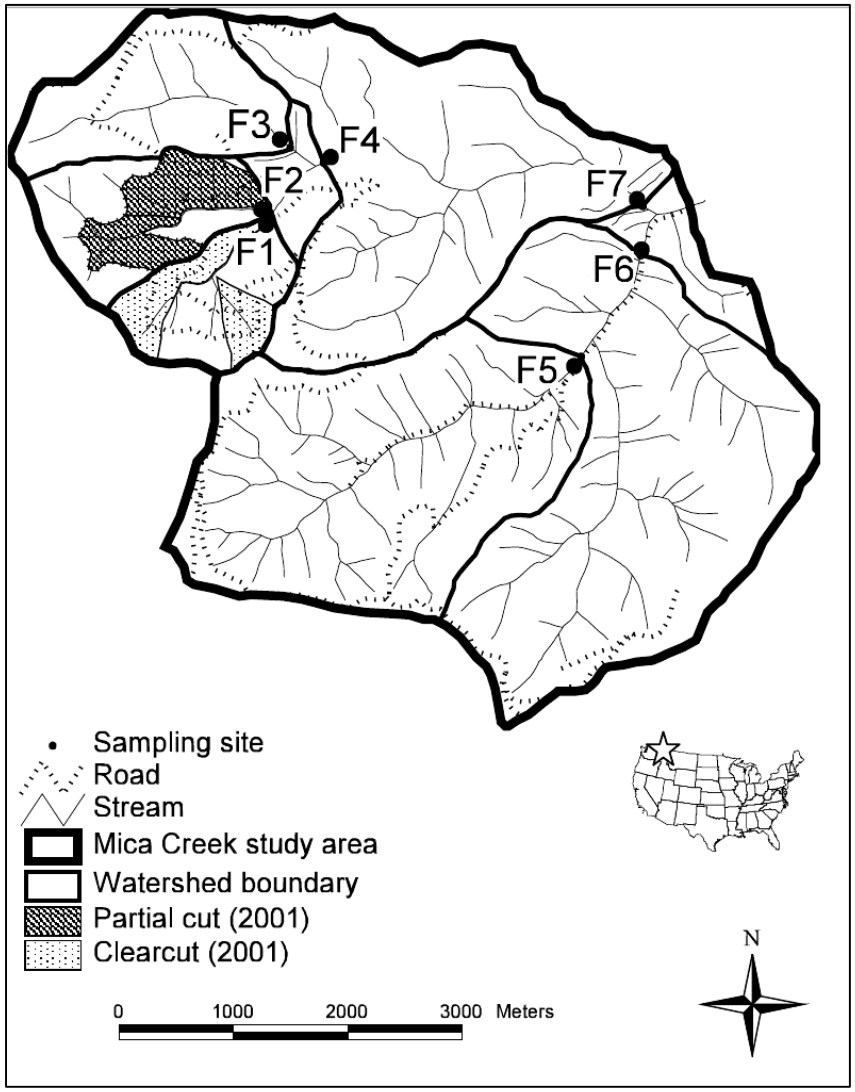
Rate of recent timber harvest "equivalence" explained the greatest amount of variability in turbidity. Drainage area was also significant but was a secondary variable.

(Klein et al., 2012)

Contemporary Studies of Sediment and Forest Practices: What Are We Learning?



Mica Creek Experimental Watershed



Paired and nested watershed study

Started in 1989 in north Idaho. 6,700 acre watershed on Potlach Corp. ownership.

Elevation: 3200 – 5240 ft

Vegetation: 70-80 yr old mixed conifer. Treatments are clearcuts and partial cuts.

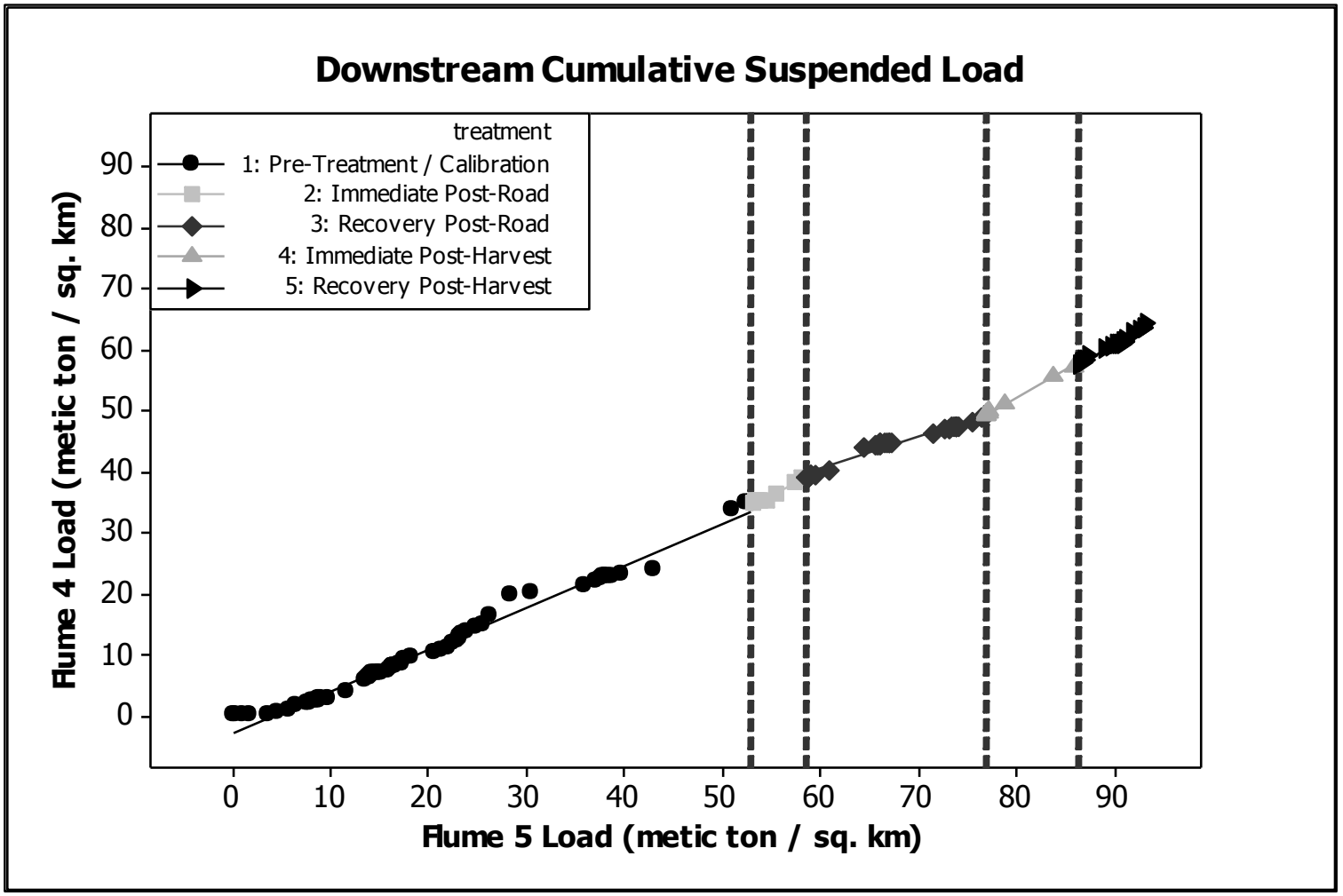
Slide modified from Terry Cundy, 2015

Mica Creek Sediment Load: Local

Road construction and upgrades did not produce a significant difference in monthly suspended sediment load compared to the control.

Clearcut harvesting produced a significantly higher suspended load immediately following the harvest. But within one year following harvest, it was gone. No increase in partial harvest. Karwan et al., 2007

Mica Creek Suspended Load: Downstream



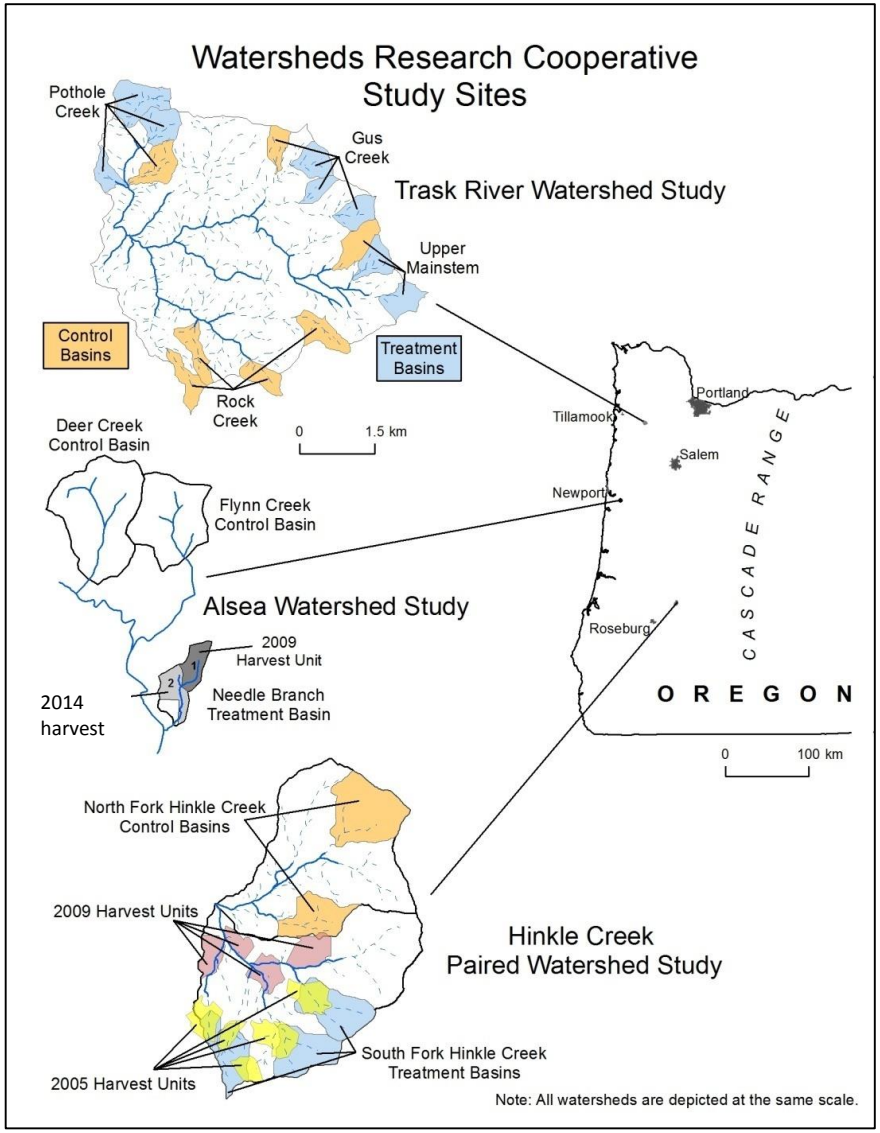
No increase in sediment load downstream of harvest

Slide modified from Terry Cundy, 2015

Oregon Watersheds Research Cooperative

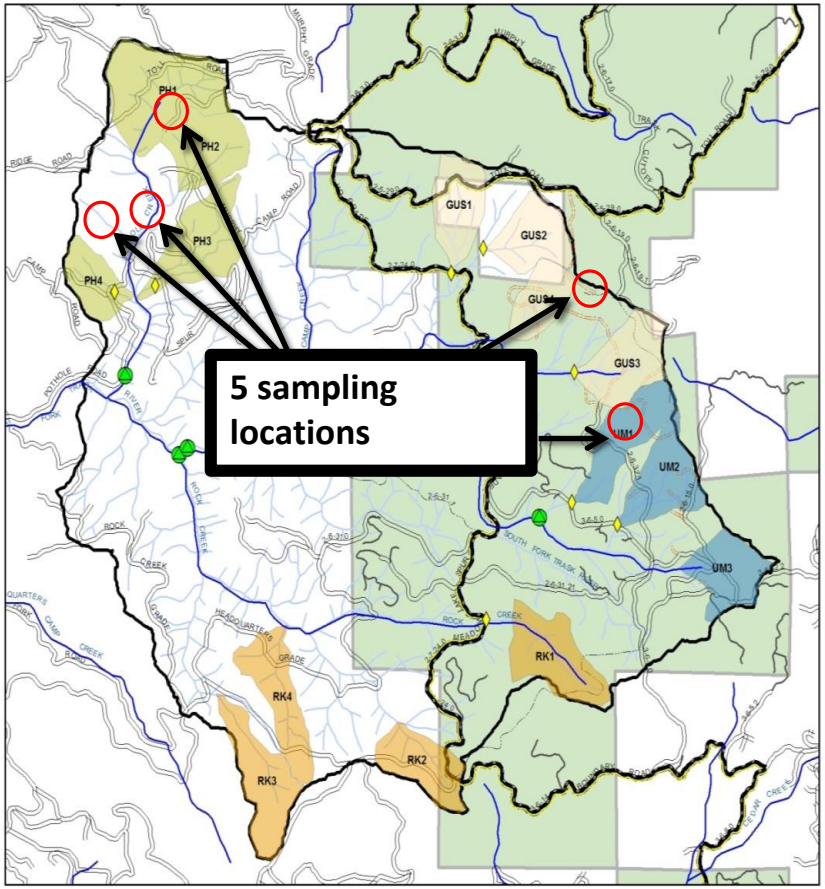
Goal: Quantify effects of contemporary forest practices on the physical, chemical and biological characteristics of streams

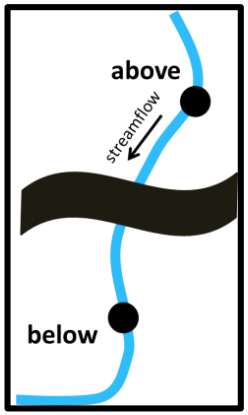
Approach: Cooperative, multi-disciplinary and long-term. Each watershed study has a slightly different in focus.



Trask Road Sediment Study

Field method: automatic samplers at road crossings before, during upgrade and during harvest and haul





Sediment/Turbidity Data Analysis: Statistical vs Biological Significance

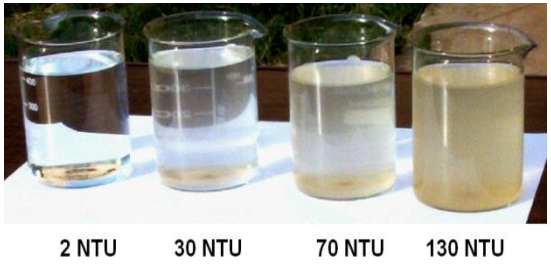
Data analysis method:

Is the median of [below – above] ≤ a certain threshold?

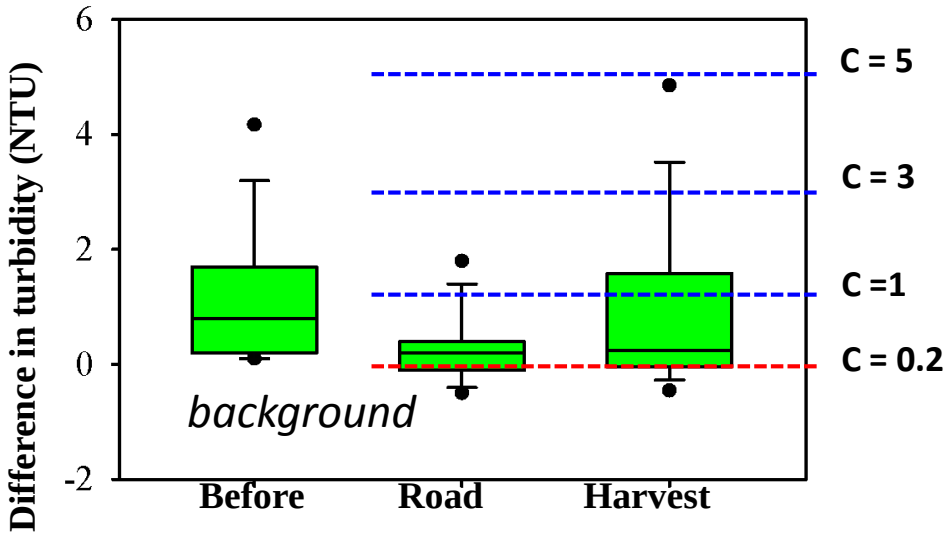
No

Yes

e.g.

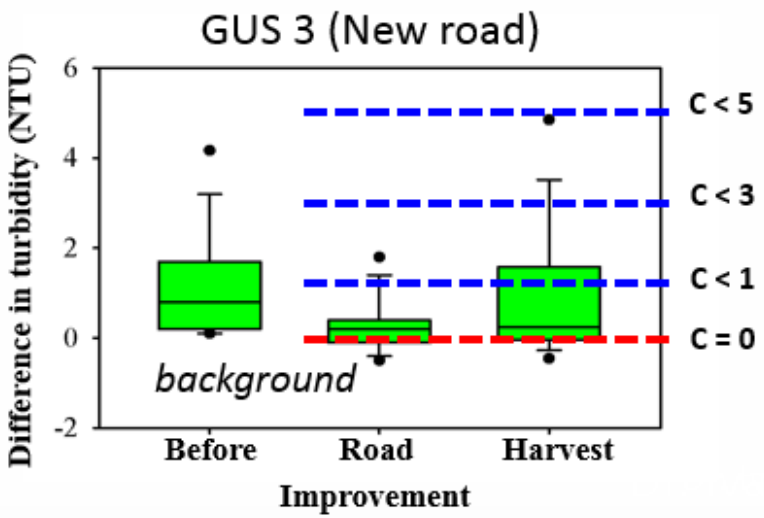


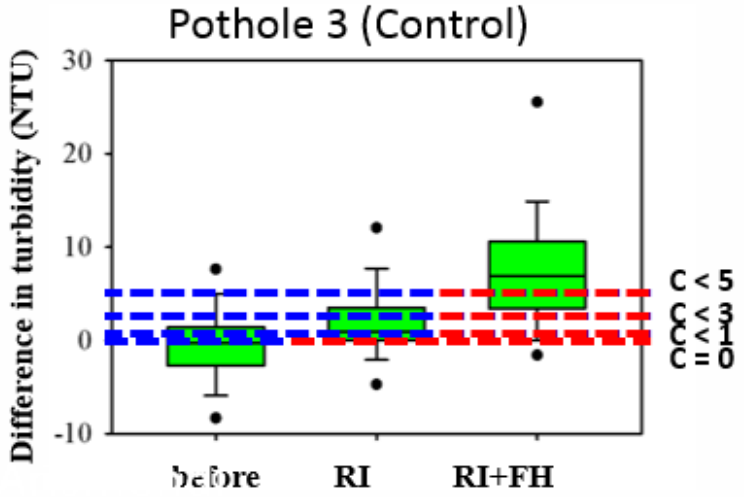
Example

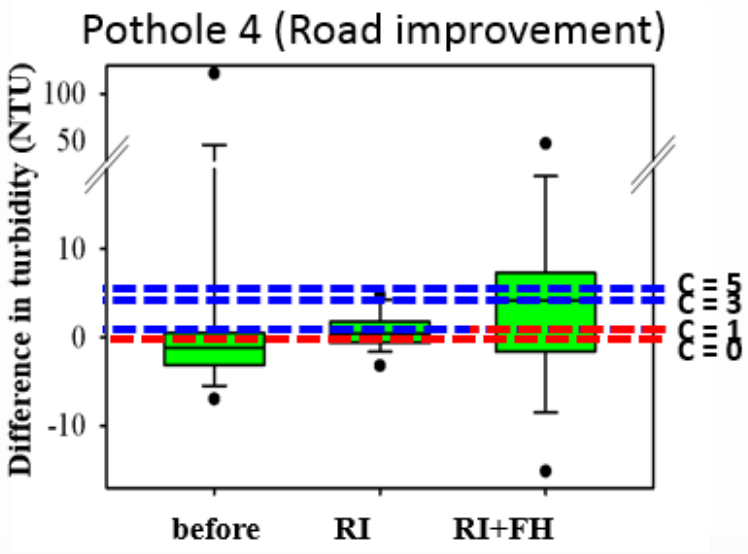


Why does this analysis method matter? Because statistical significance ≠ biological significance.

Trask Road Sediment Study Results



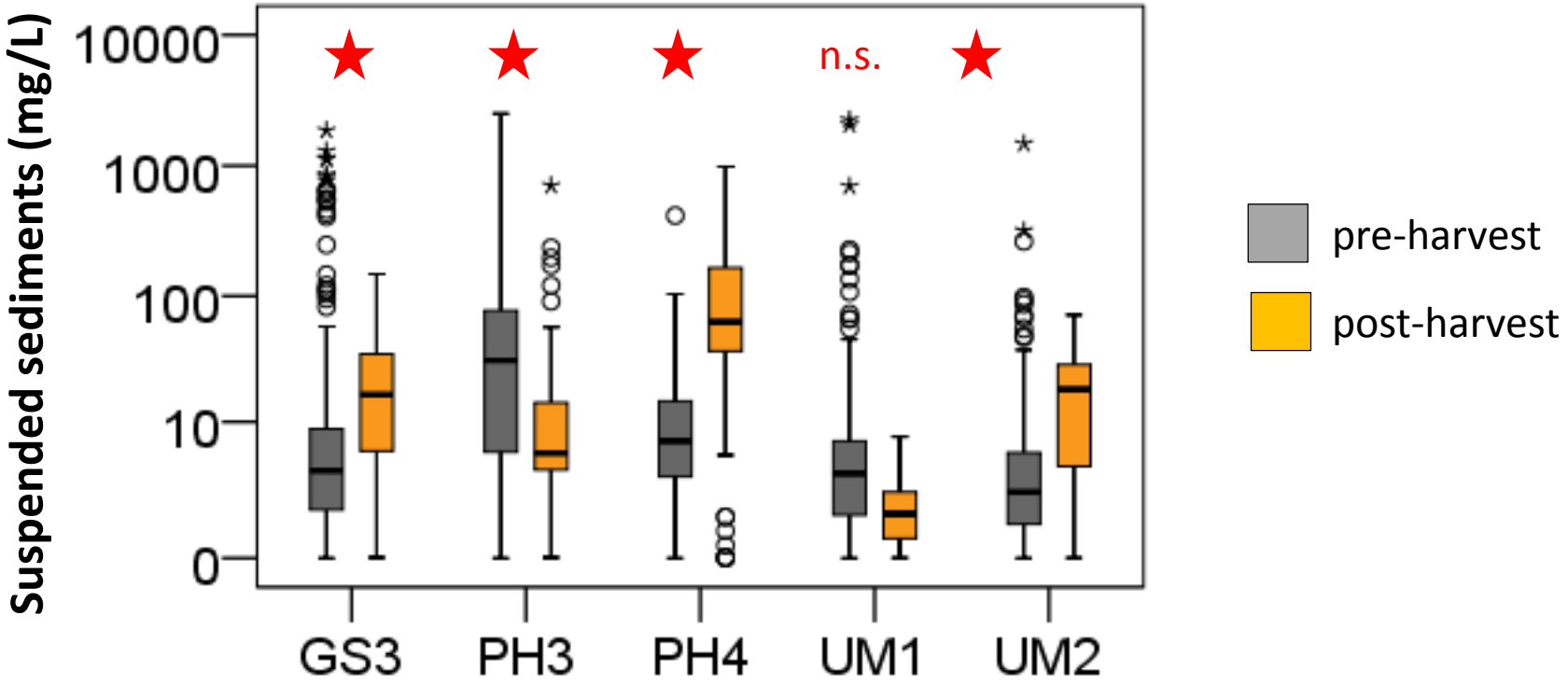




- Observed minimal increases in sediment & turbidity
- Local disturbances important in headwaters
- Natural variability within/between streams

Other Trask Sediment Results: Small Streams

Control sites: decrease or no significant changes in suspended sediment after harvest; treated sites increase after harvest

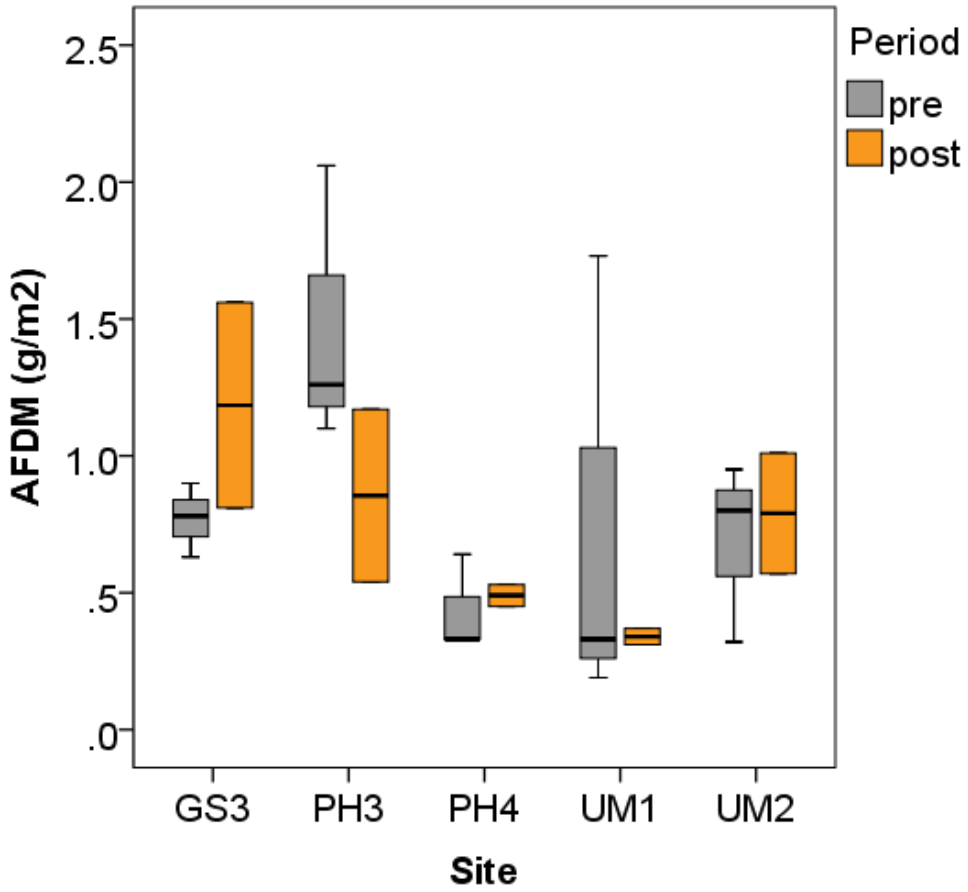


Slide from Alba Argerich et al., 2015 (AFS)

Wilcoxson Signed Ranks test, alpha=0.05

Can a Change in Sediment Change Fish Food?

While a change in sediment was indicated, it was not detected in the macroinvertebrate biomass

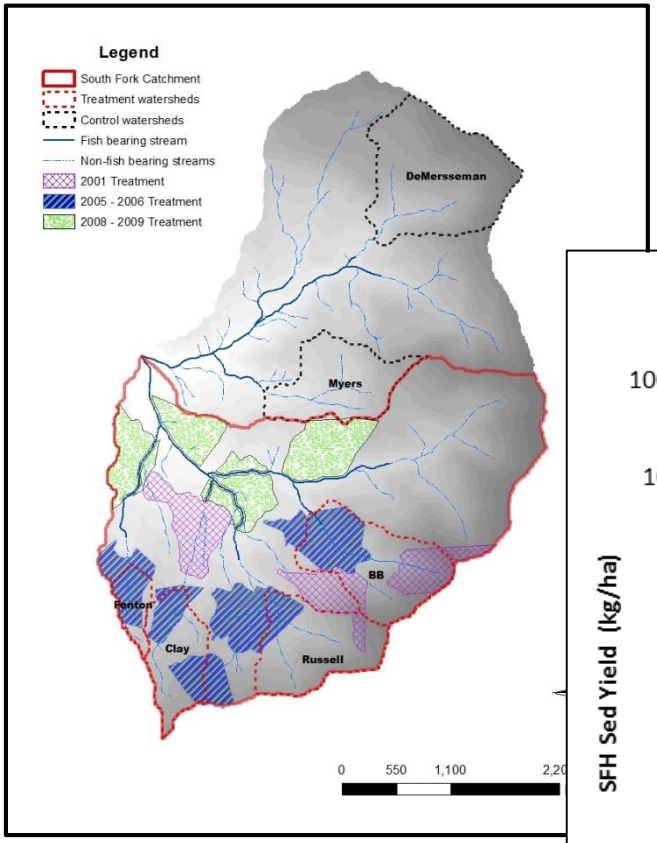


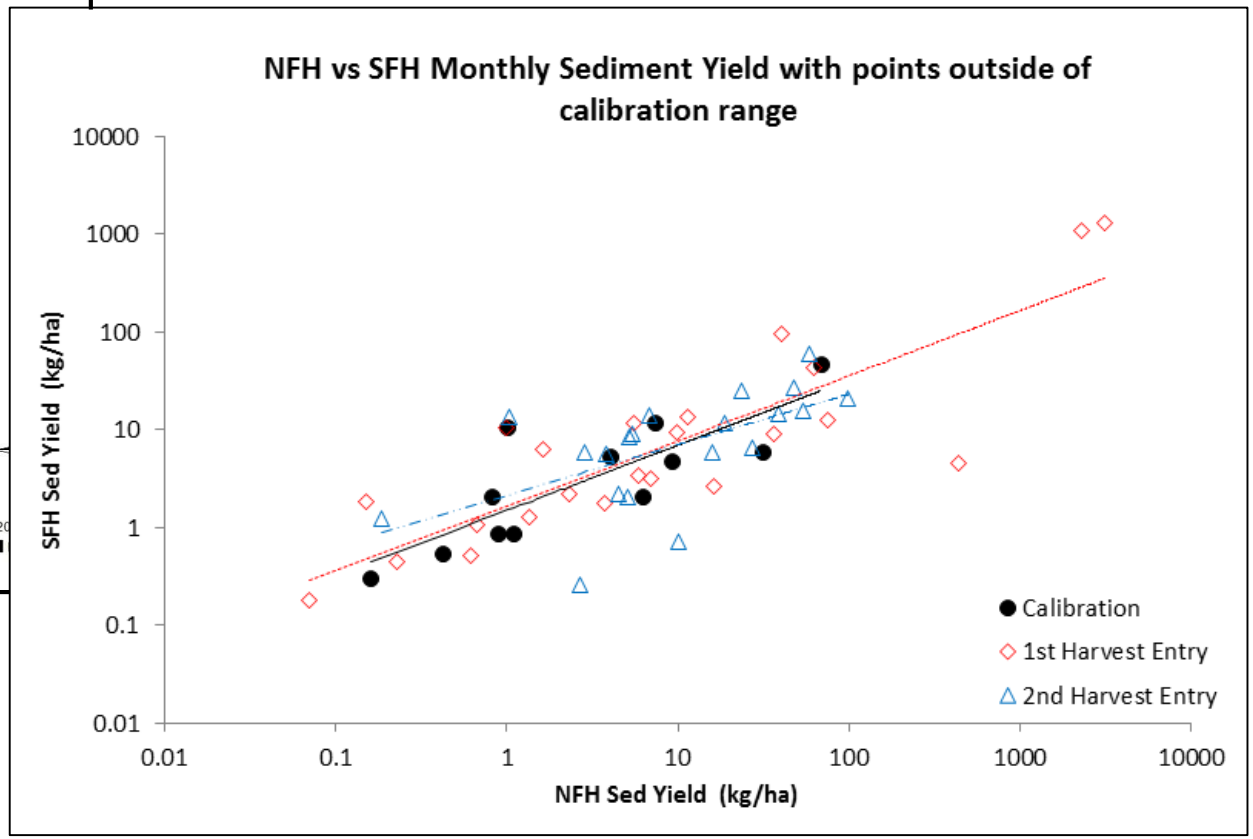
Control and treated sites: no significant changes in biomass after harvest

Slide from Alba Argerich et al., 2015 (AFS)

Mann-Whitney test, alpha=0.05

Hinkle Creek Sediment Response: Large Stream





Slide modified from Skaugset 2013

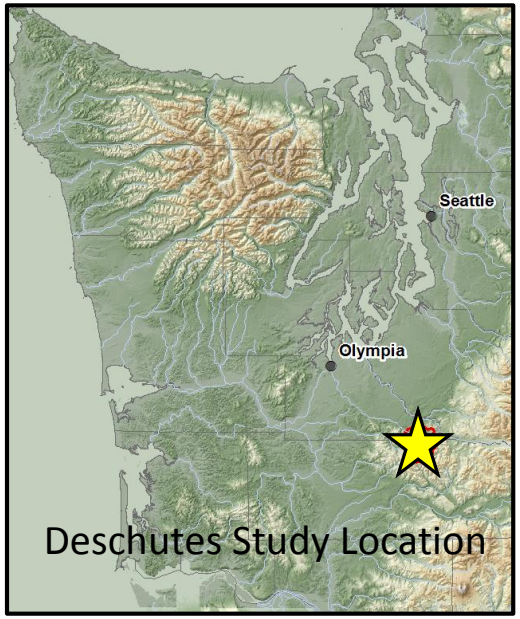
Hinkle Creek Sediment Response (cont.)

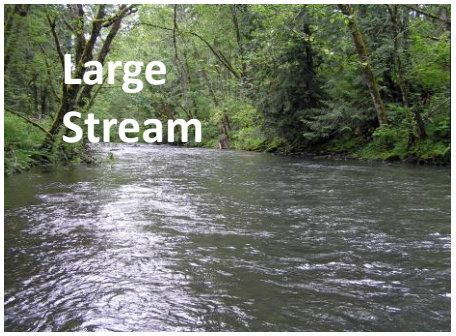
- Sediment yield much lower than previous literature.
- The results appear to be more muted, with increases in the 20% to 40% range.
- These results are in agreement with and correlate with the increases in water yield.

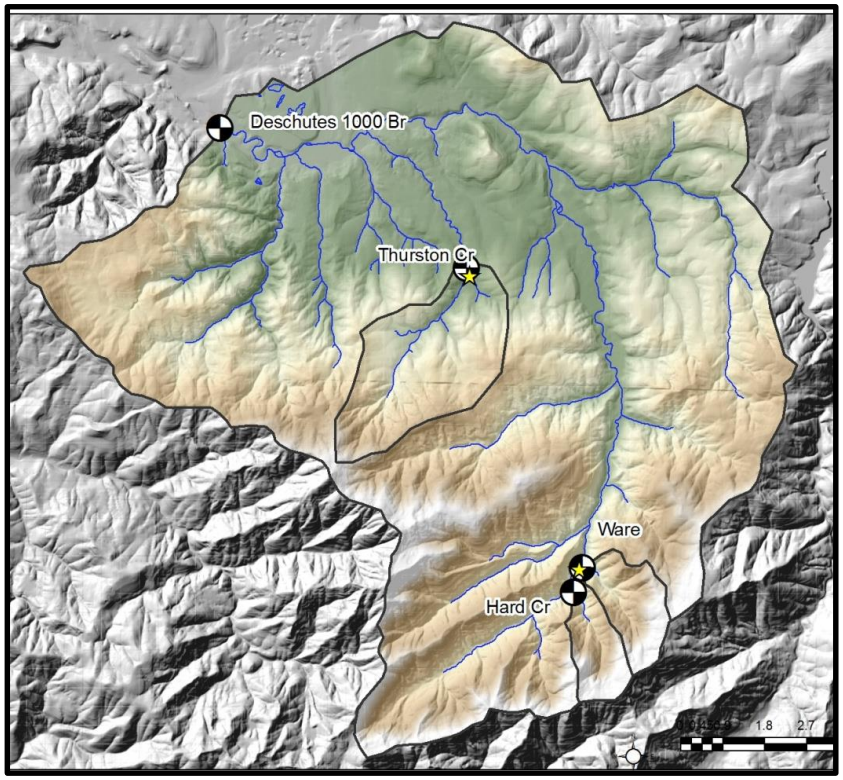
Slide modified from Skaugset 2013

Deschutes River, WA Long-Term Study

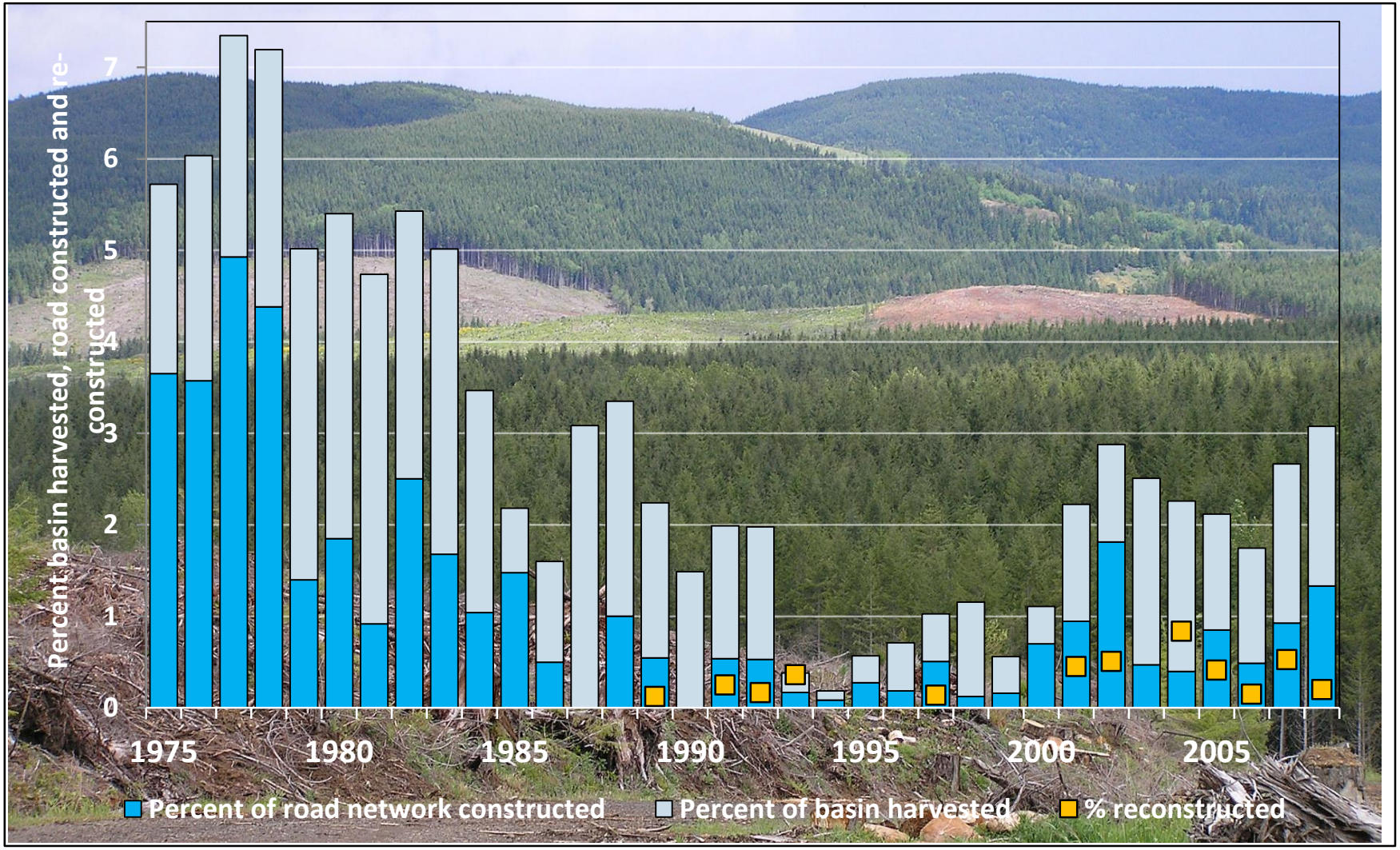
In 1975, Weyerhaeuser installed 4 permanent monitoring stations. Suspended sediment, turbidity, streamflow, air and water temperature was measured at the four stations.



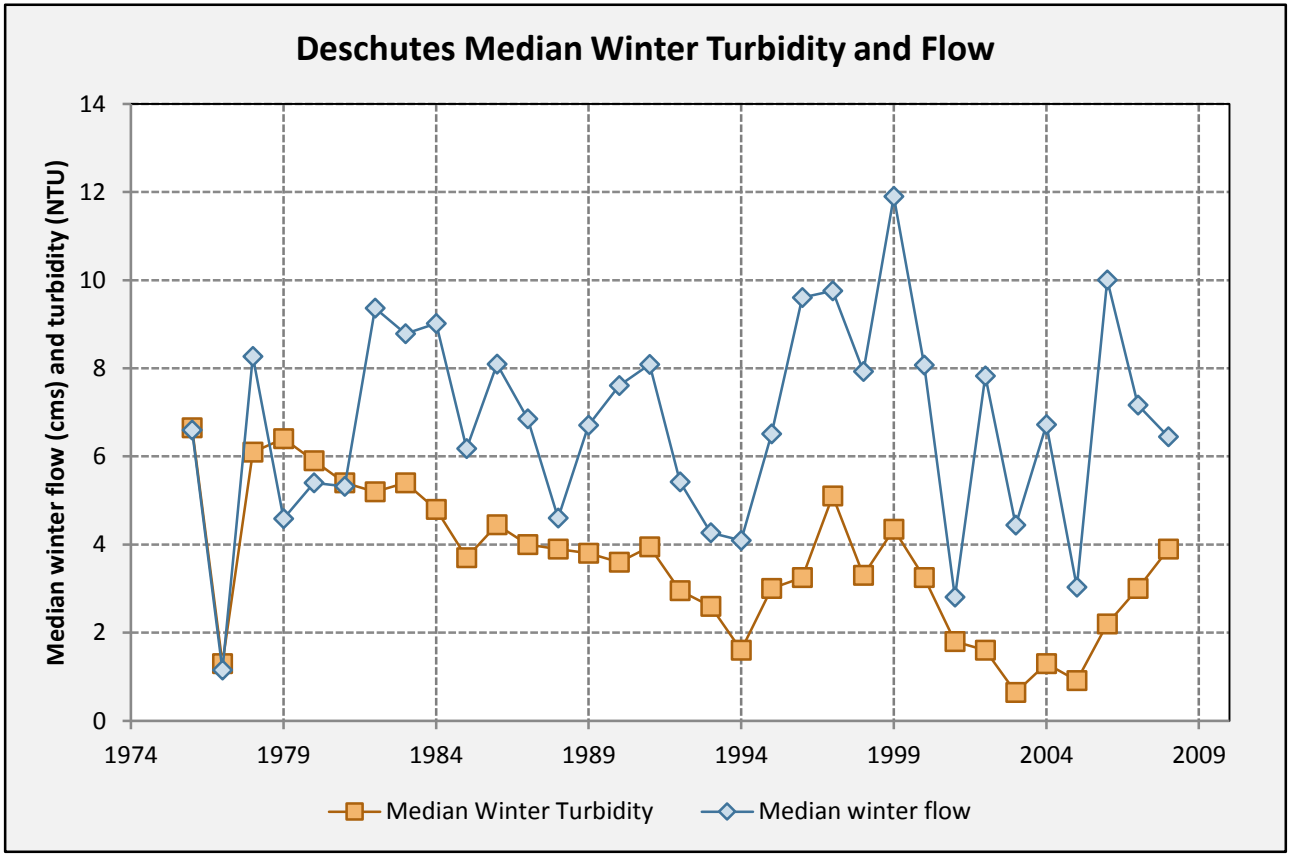




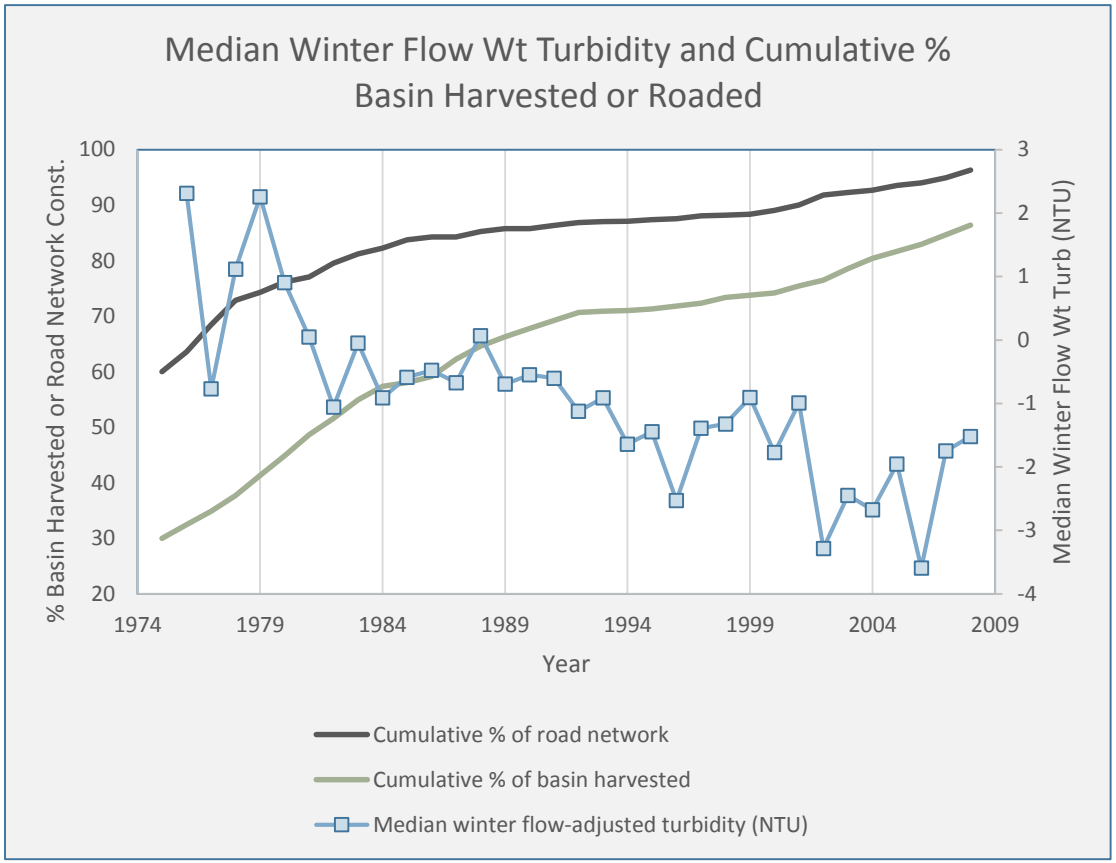
Deschutes Management Through Time



Turbidity and Flow Trends Through Time

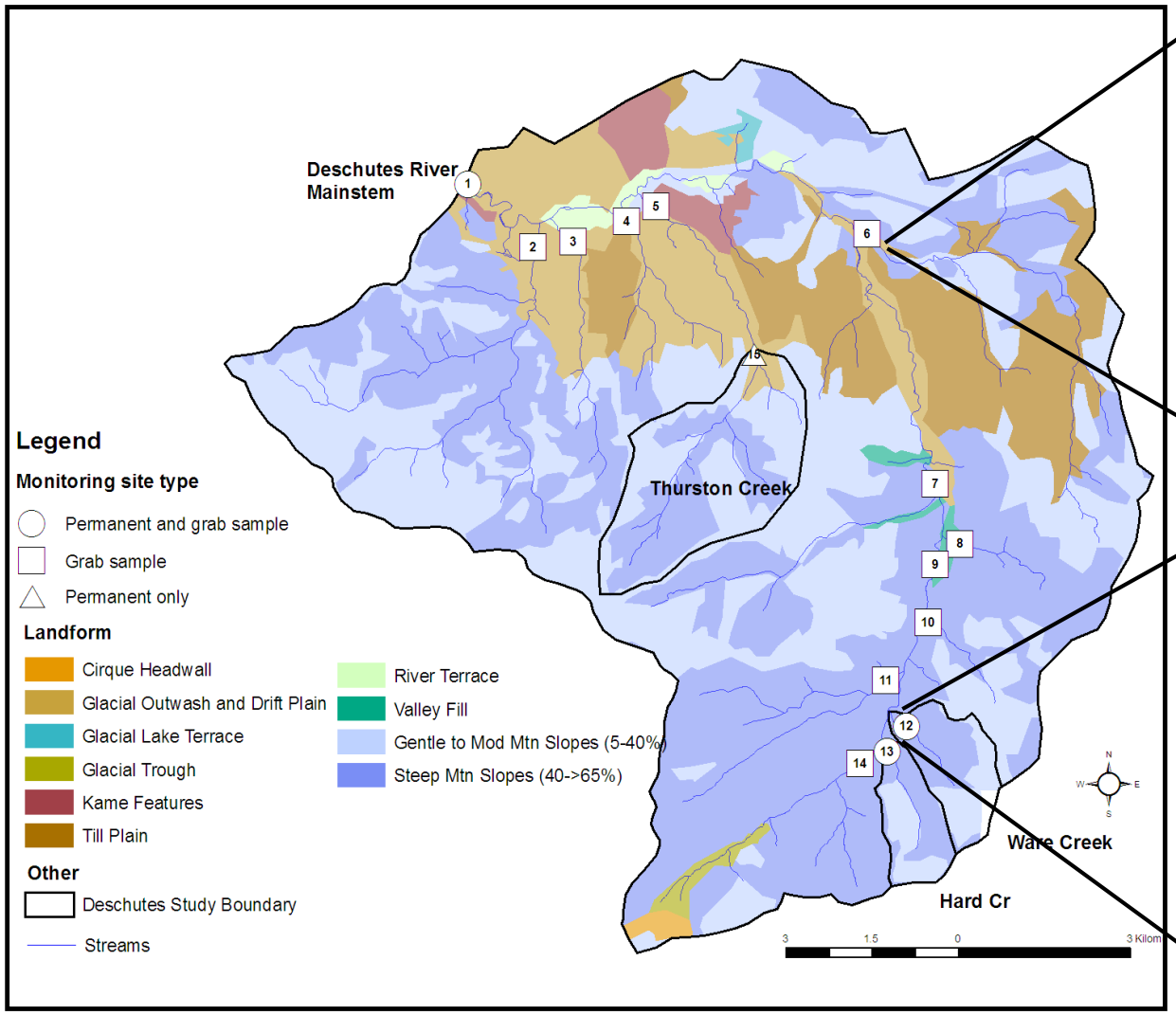


Flow Weighted Turbidity and Management

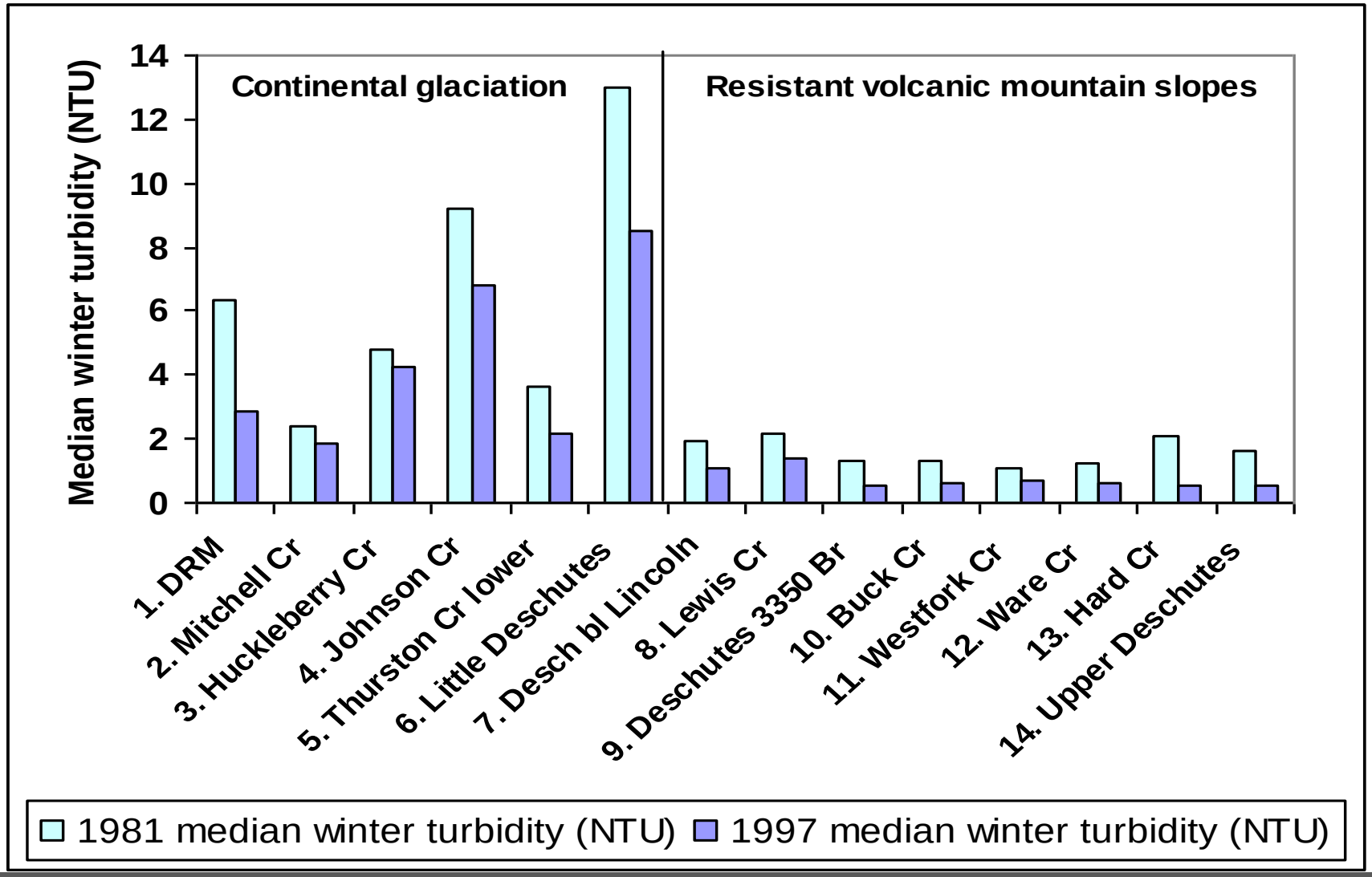


We saw a decline in median winter flow adjusted turbidity even as we continued to harvest and construct roads.

Forestry Effects in a Landscape Context



Forestry Effects in a Landscape Context



Sediment Summary

- Early practices had a pronounced effect on sediment
- There have been many changes in forest practices through time to address sediment delivery
- The changes have minimized, though not eliminated sediment delivery to streams
- The question is whether the amount of sediment generated and delivered to stream channels is impacting the biota

Literature Cited

Arismendi I, Groom JD, Reiter M, Johnson SL, Dent L, Meleason M, Argerich A, Skaugset AE (***in review***) Suspended sediment and turbidity after road construction/improvement and forest harvest in streams of the Trask Watershed Study, Oregon. *Forest Ecology and Management*

Beschta, R.L., 1978. Long-term patterns of sediment production following road construction and logging in the Oregon Coast Range. *Water Resources Research*, *14*(6), pp.1011-1016.

Karwan, D.L., Gravelle, J.A. and Hubbart, J.A., 2007. Effects of timber harvest on suspended sediment loads in Mica Creek, Idaho. *Forest Science*,*53*(2), pp.181-188.

Klein, R.D., Lewis, J. and Buffleben, M.S., 2012. Logging and turbidity in the coastal watersheds of northern California. *Geomorphology*, *139*, pp.136-144.

Reiter, M., Heffner, J.T., Beech, S., Turner, T. and Bilby, R.E., 2009. Temporal and spatial turbidiy patterns over 30 years in a managed forest of western Washington . *Journal of the American Water Resources Association*, *45*(3), p.793.

Wemple, B.C., Jones, J.A. and Grant, G.E., 1996. Channel network extension by logging roads in two basins, Western Cascades, Oregon1.

Wise, D.R., and O'Connor, J.E., 2016, A spatially explicit suspended-sediment load model for western Oregon: U.S. Geological Survey Scientific Investigations Report 2016–5079, 25 p., http://dx.doi.org/10.3133/sir20165079.