Type N Experimental Buffer Treatment Studies

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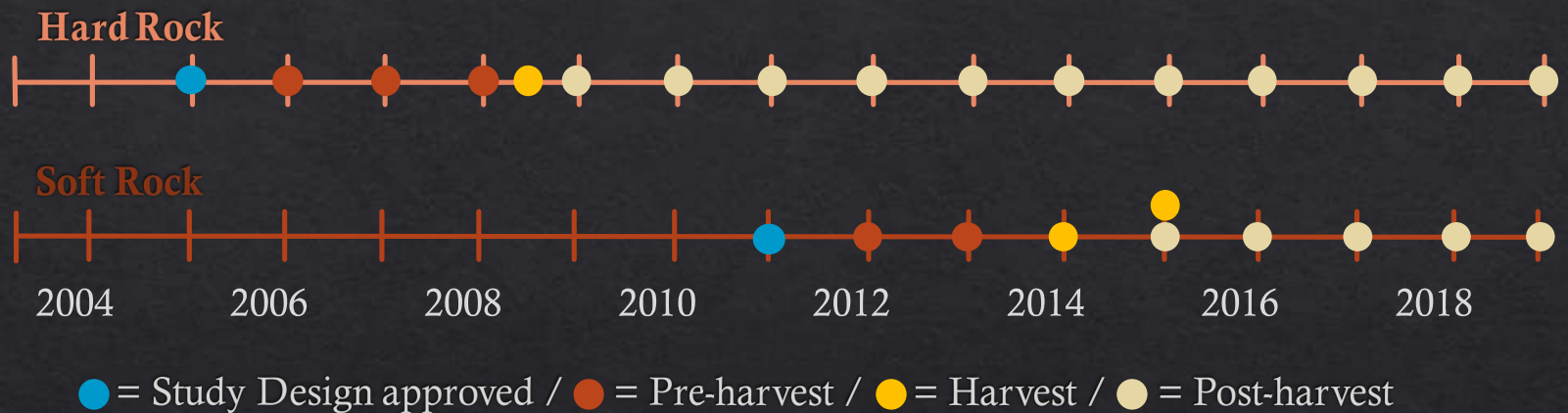
Type N Experimental Buffer Study Objectives

Evaluate the effectiveness of riparian buffer prescriptions for non-fish-bearing perennial streams

- Hard Rock Study: Competent lithologies, current FP prescriptions and alternative buffers
- Soft Rock Study: Incompetent lithologies, current FP prescriptions

Treatment Implementation

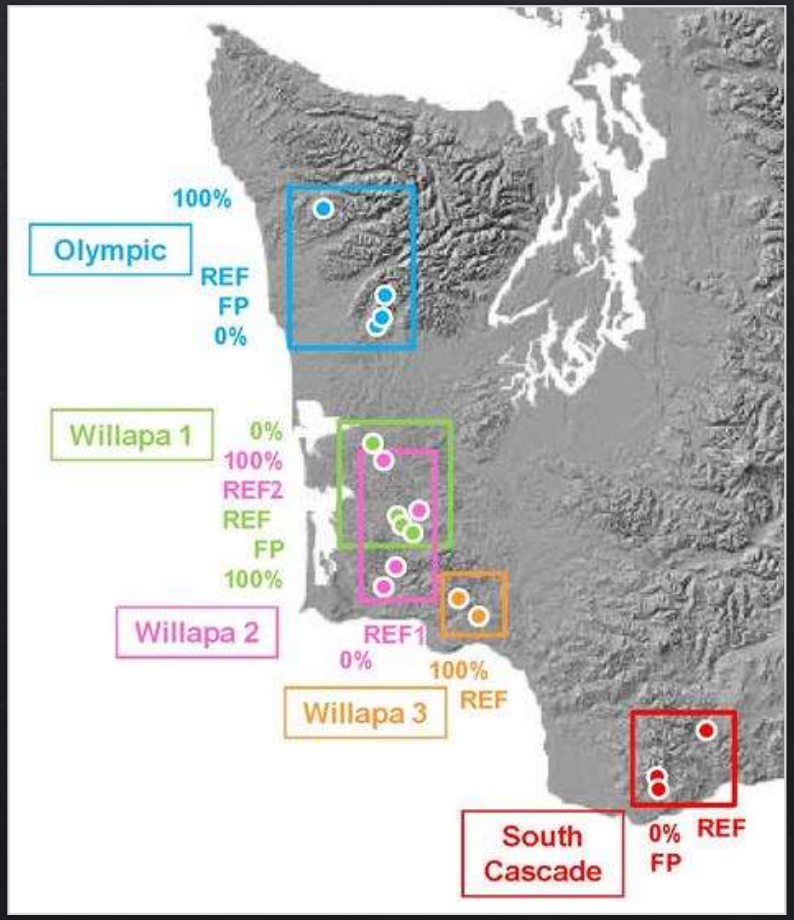


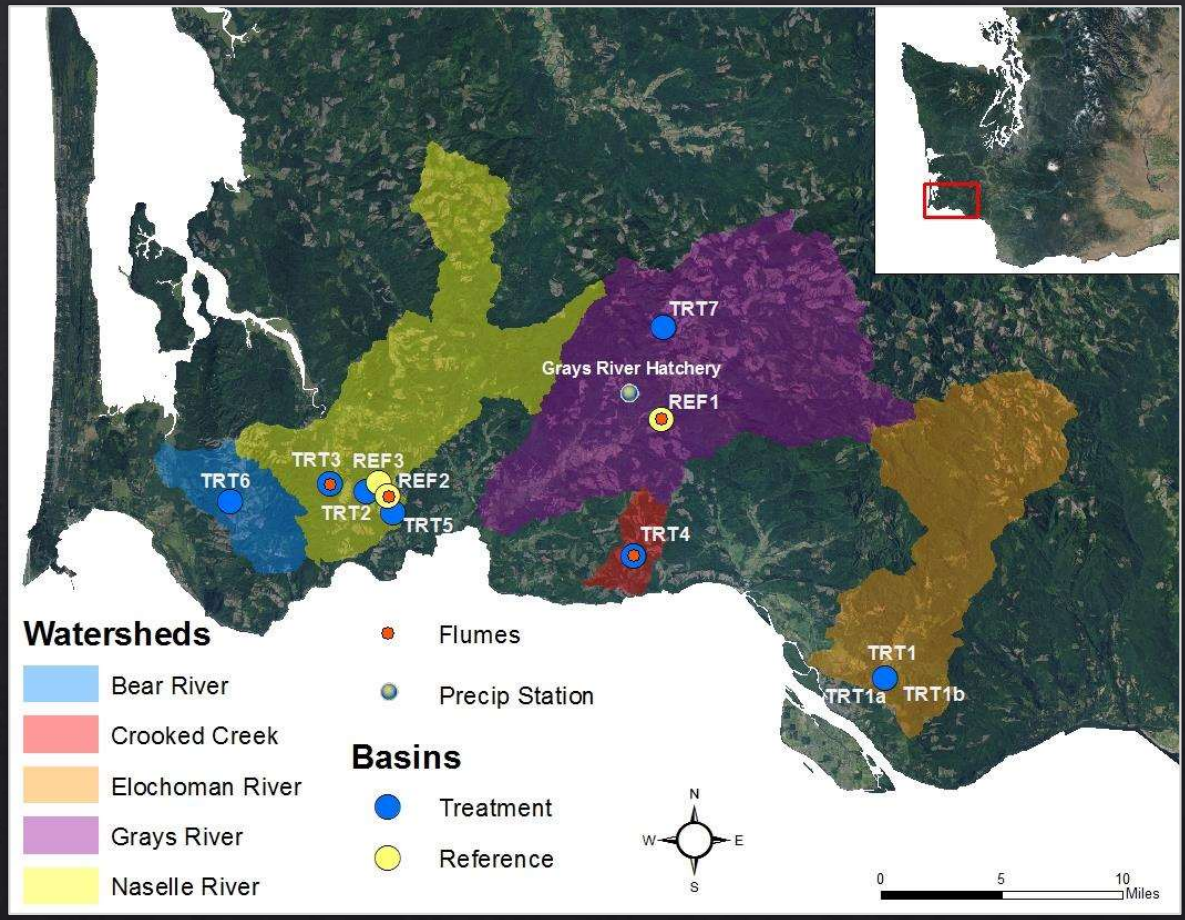
Response		Hard Rock	Soft Rock
Non-fish Waters	Stand structure & tree mortality	X	X
	Shade	X	X
	Water temperature	X	X
	Sediment	X	
	Wood input	X	X
	Organic input (litter)	X	
	Channel structure	X	
	Amphibians	X	
Exports to Fish Waters	Water temperature	X	X
	Suspended sediment	X	X
	Organic & nutrient exports	X	X
	Macroinvertebrates	X	X
	Discharge	X	X

Site Selection

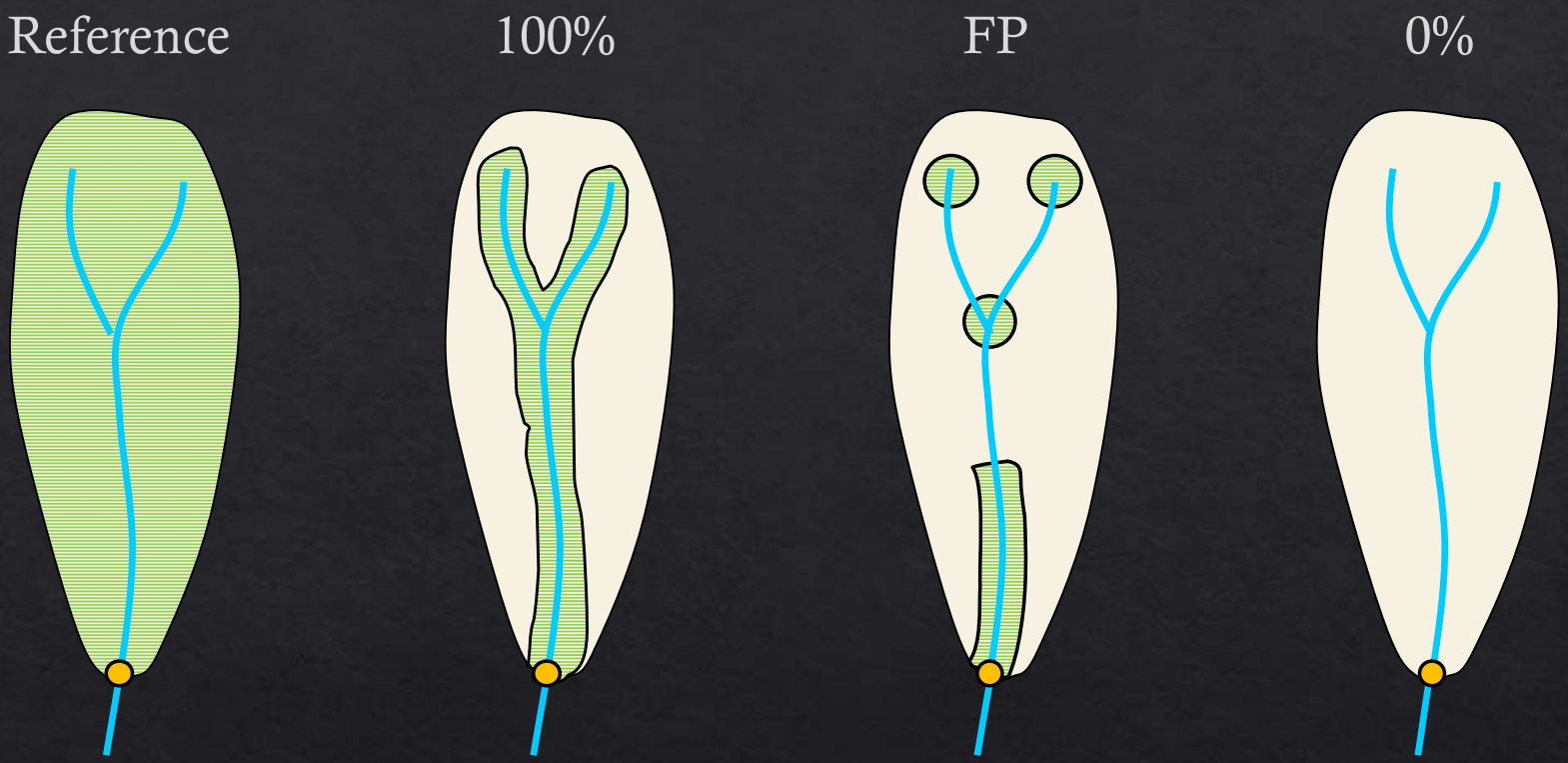
- GIS screening: geographic location, elevation, gradient, lithology, and basin area.
- Landowner information: ownership, stand age, harvest timing, and landowner commitment.
- Field verification: accessibility, stand age, stream flow, amphibian presence (Hard Rock only), and fish end point.
- Selection of sites and assignment of treatments.

Study Site Distribution





Hard Rock Experimental Treatments



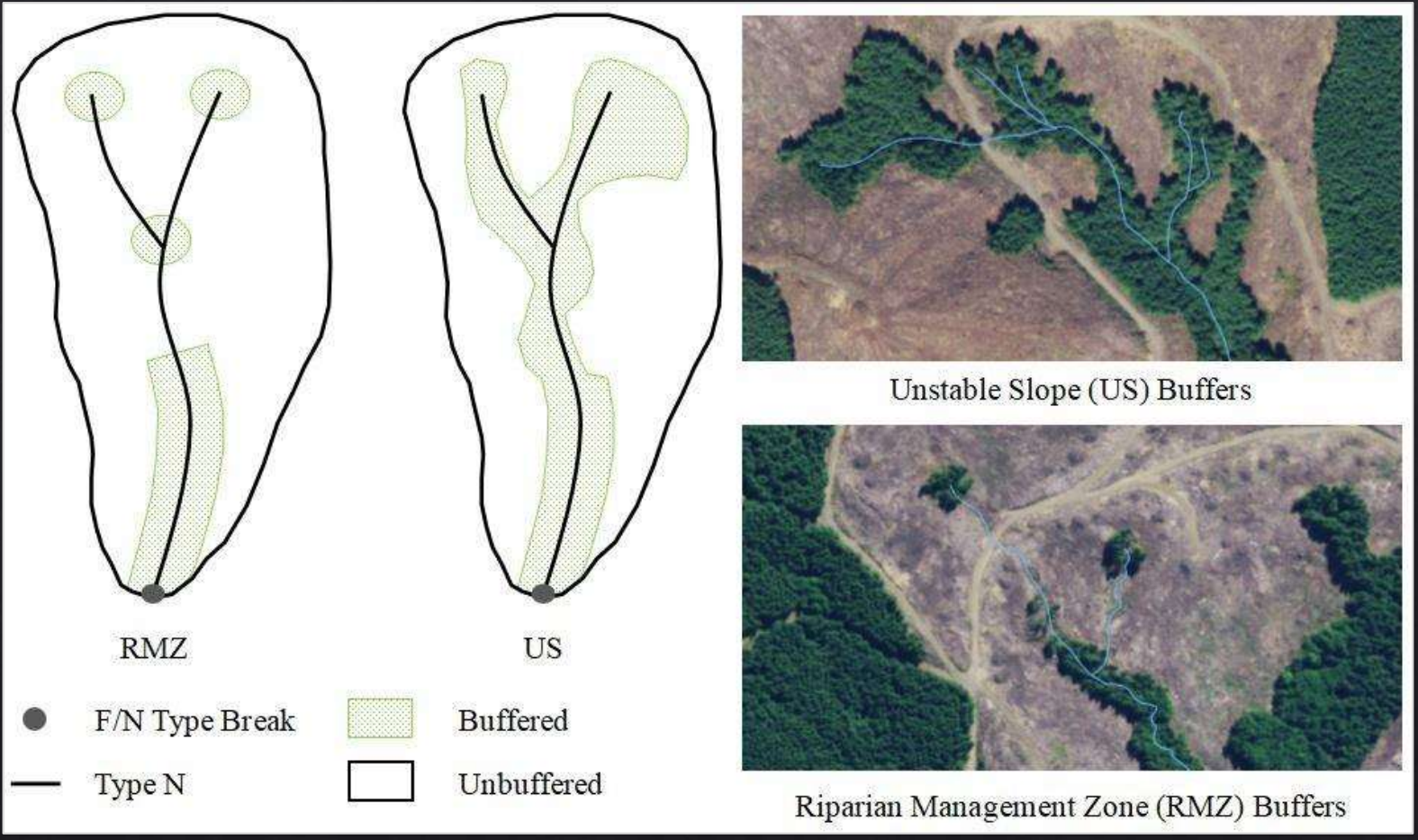
= non-fish basin

= unharvested / 50-ft buffer

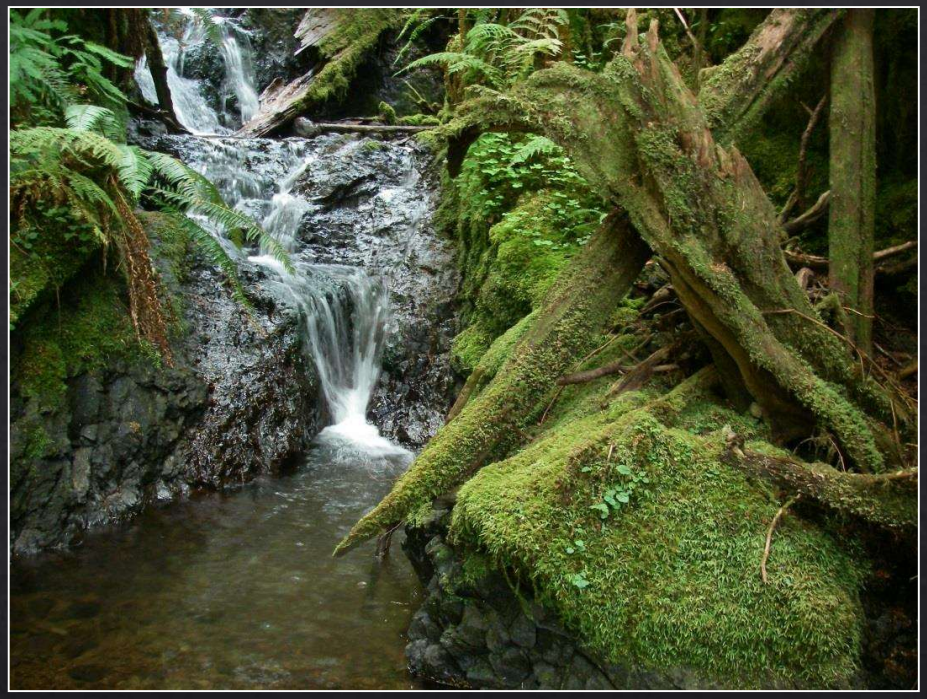
= stream

= fish end point

Experimental Treatments



Hard Rock: Shade & Stream Temperature, Discharge, and Sediment and Nutrient Export



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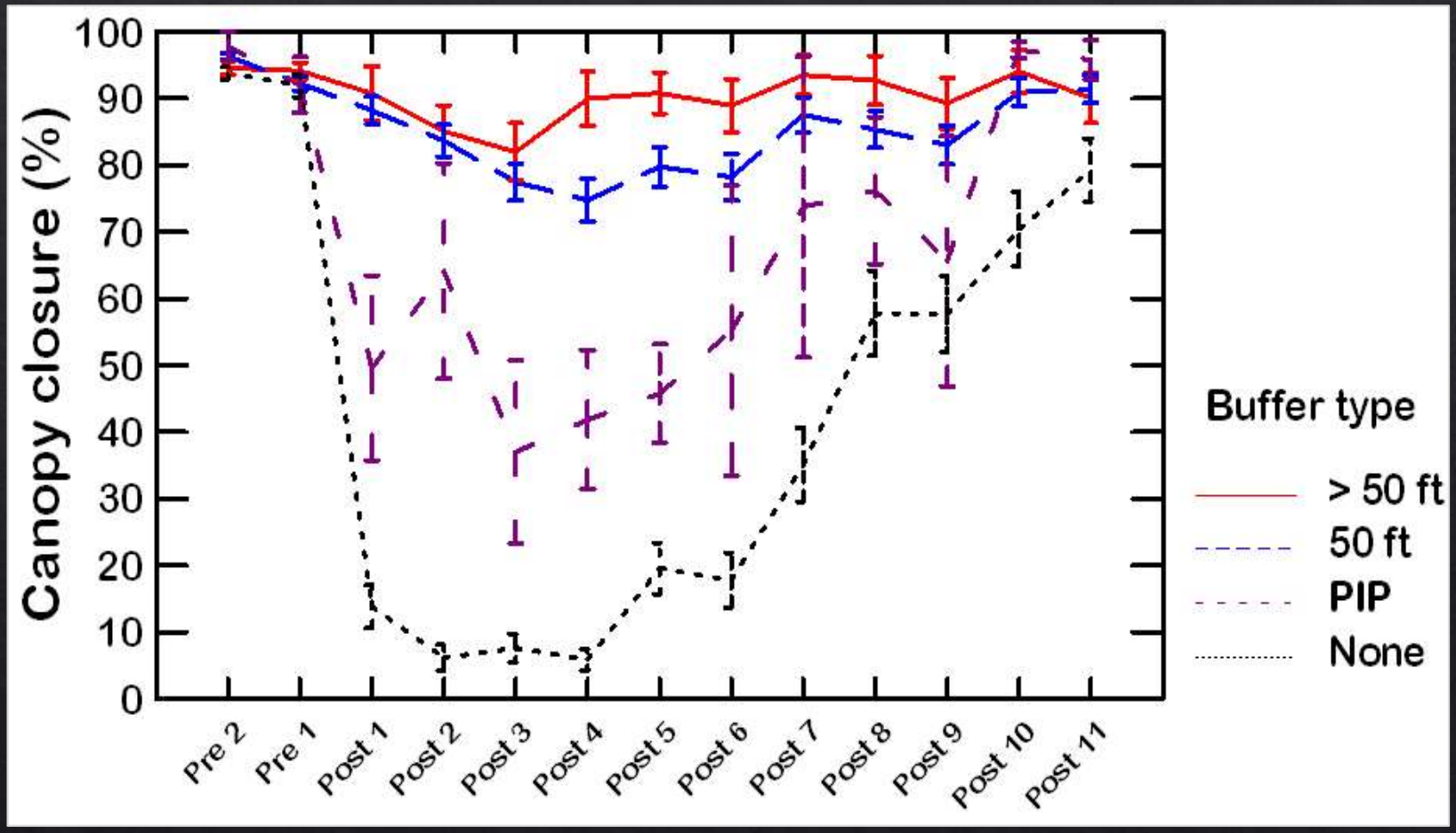
Shade–Post-harvest Change

- Canopy closure and effective shade decreased in all buffer treatments.
- Shade loss and years to recovery was least in the 100% treatment and greatest in the 0% treatment.
- Windthrow contributed to ongoing shade loss after harvest.

	Canopy Closure-1m			
Year	**100%**	**FP**	**0%**	**1**
Post 1	-4	**-17**	**-83**	
Post 2	-5	**-22**	**-86**	
Post 3	-10	**-32**	**-87**	
Post 4	-6	**-28**	**-85**	
Post 5	-4	**-24**	**-70**	
Post 6	-3	**-20**	**-73**	
Post 7	-1	**-12**	**-62**	
Post 8	-5	**-15**	**-27**	
Post 9	-3	-11	**-25**	
Post 10	0	-3	**-20**	
Post 11	0	-2	-9	

Shade–Change vs. Buffer Width

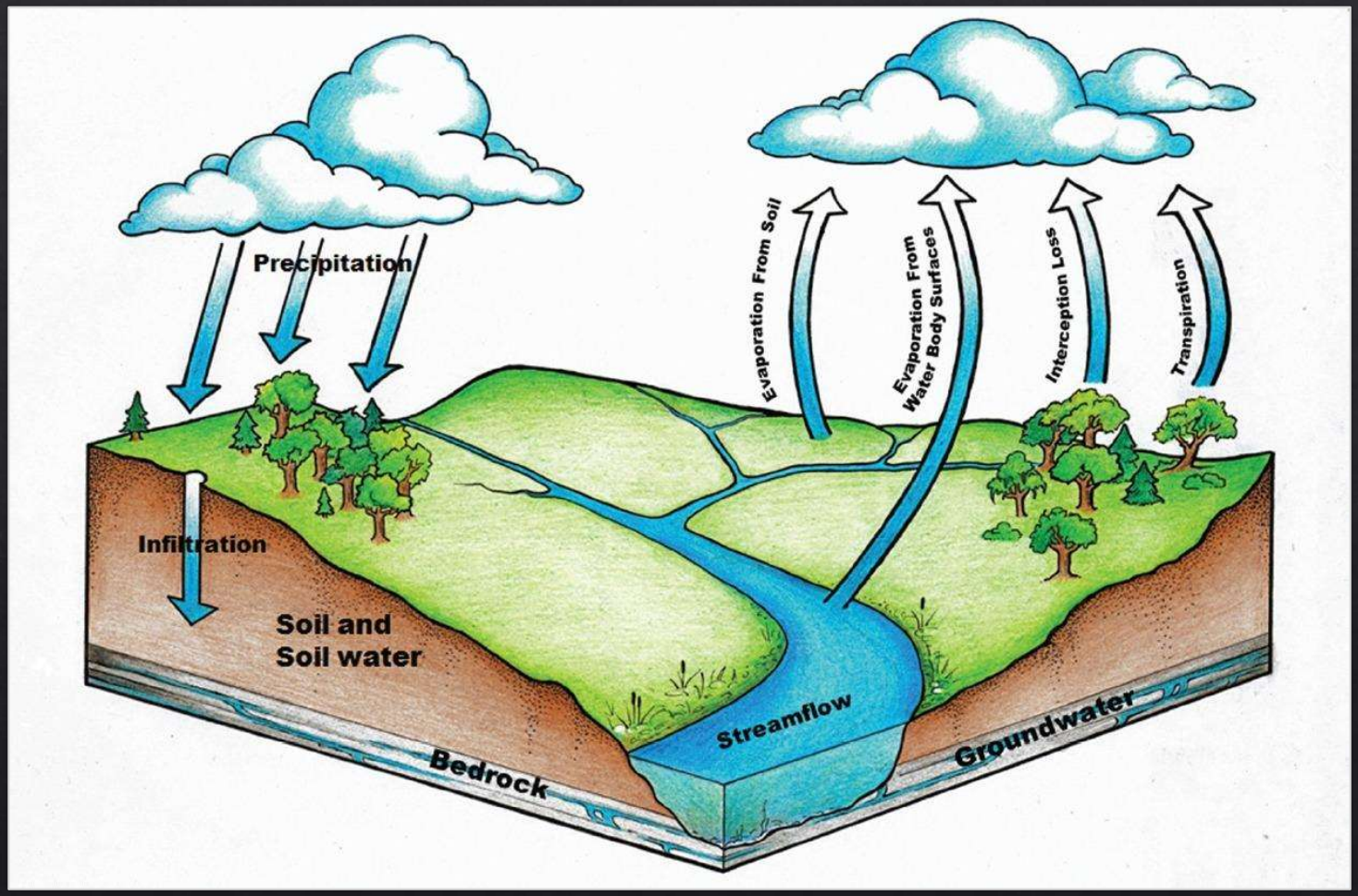


Stream Temperature–Post-harvest Change

- Seven-day average temperature response (7DTR) increased in all buffer treatments.
  - 100% treatment: Initial increase of ~1°C but returned to pre-harvest condition within three years.
  - FP treatment: Initial increase of ~1°C but remained elevated during most of the Post 1 through Post 9 period.
  - 0% treatment: Initial increase ≥3°C with a steady return to pre-harvest conditions at Post 10.
- Loss of riparian shade was the major factor in higher post-harvest summer temperatures.

	F/N break		
Year	**100%**	**FP**	**0%**
Post 1	**$1.2_{0\%}$**	**$1.1_{0\%}$**	**3.3**
Post 2	$0.6_{0\%}$	**$0.9_{0\%}$**	**2.7**
Post 3	0.6	$0.8_{0\%}$	**2.0**
Post 4	$0.6_{0\%}$	$0.5_{0\%}$	**1.9**
Post 5	$0.4_{0\%}$	$0.5_{0\%}$	**1.7**
Post 6	$0.4_{0\%}$	**0.9**	**1.3**
Post 7	**1.1**	**1.2**	**1.5**
Post 8	$0.5_{\mathbf{FP}}$	**1.2**	**1.0**
Post 9	0.4	**0.8**	**0.9**
Post 10	0.1	0.2	0.6
Post 11	0.2	0.6	0.3

Discharge ~= Precipitation – Evapotranspiration – Storage

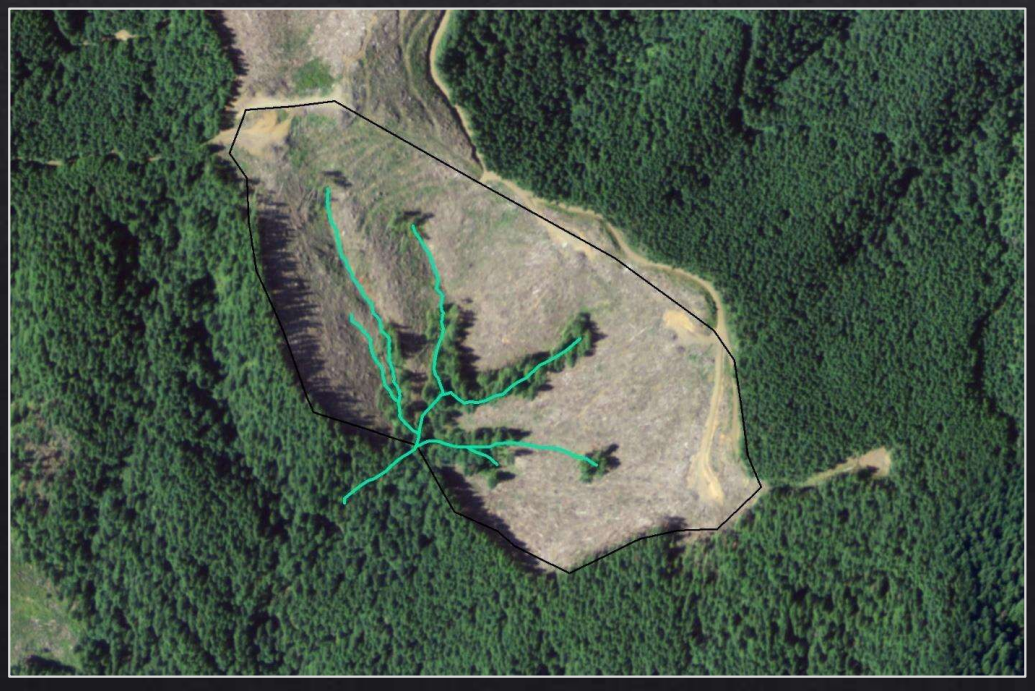


Type N Basin

Harvest

Discharge ~= ~~Precip~~ – ET – ~~Storage~~

- When you remove trees, ET is reduced and discharge generally goes up.
- Discharge is largely affected by the proportion of the watershed harvested.
- Buffers have only a small effect on discharge.



	Buffer Treatment		
	100%	FP	0%
Dry (summer)	↓	—	↑
Rest of the year	↑	↑	↑

Type N Basin Harvest

Discharge ~= Precip – ET – Storage

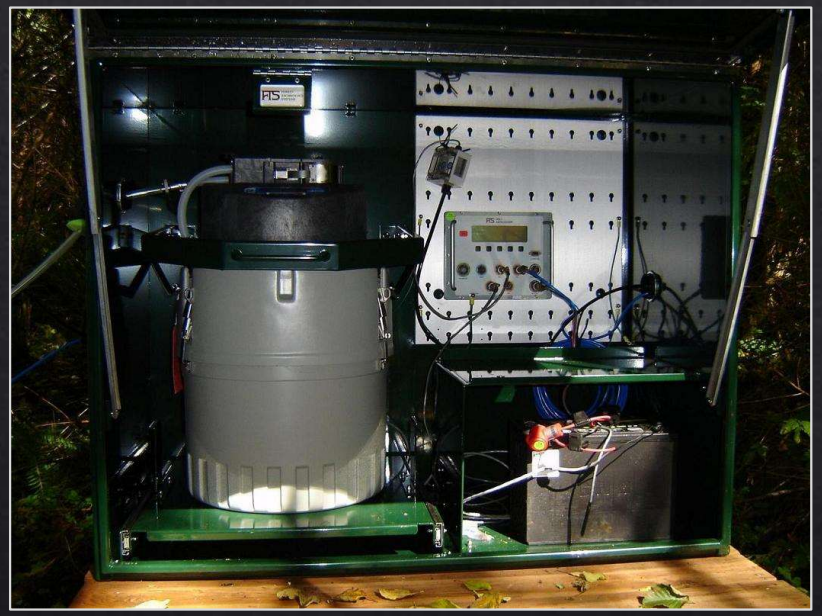
What about peak flows?

- In large storm events, ΔET is relatively small so the change in peak discharge is driven by changes in storage (i.e., snow and snow melt).
- Changes in peak flows only occurred in the highest two basins and only during some years.

Suspended Sediment

- Suspended sediment export appears to be driven by random inputs (e.g., small landslides, bank sloughing).
- If there were treatment effects, they were masked by natural variability.

Nitrogen Export



- Timber harvest may increase nitrogen in soil and streams through changes in vegetative uptake, microbial nitrification, stream runoff, slash burning, and growth of nitrogen-fixing alder.
- Total-N and nitrate-N concentration and export increased in all treatments in the two-year post-harvest period with the greatest change in the 0% treatment and the smallest change in the 100% treatment.
- At eight years post-harvest, concentration and export declined in about half of the sites and increased slightly in the other sites with no consistent response to buffer treatment.

Acknowledgements

- **Landowners:** Fruit Growers Supply Company, Gifford Pinchot NF, Green Crow, Hancock Timber Resource Group, Longview Timber, Olympic NF, Rayonier, The Nature Conservancy, Washington Department of Natural Resources, Weyerhaeuser
- **WDNR Adaptive Management Program:** Charlene Andrade, Hans Berg, Lori Clark, Darin Cramer, Heather Gibbs, Howard Haemmerle, Emily Hernandez, Mark Hicks, Jim Hotvedt, Saboor Jawad, Amy Kurtenbach, Jeff McNaughton, Teresa Miskovic, Eszter Munes
- **Field and Lab Staff!**

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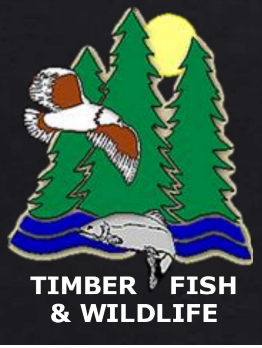
Field Staff!



Type N Experimental Buffer Study in Soft Rock Lithologies

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Greg Stewart, Dave Schuett-Hames – NWIFC

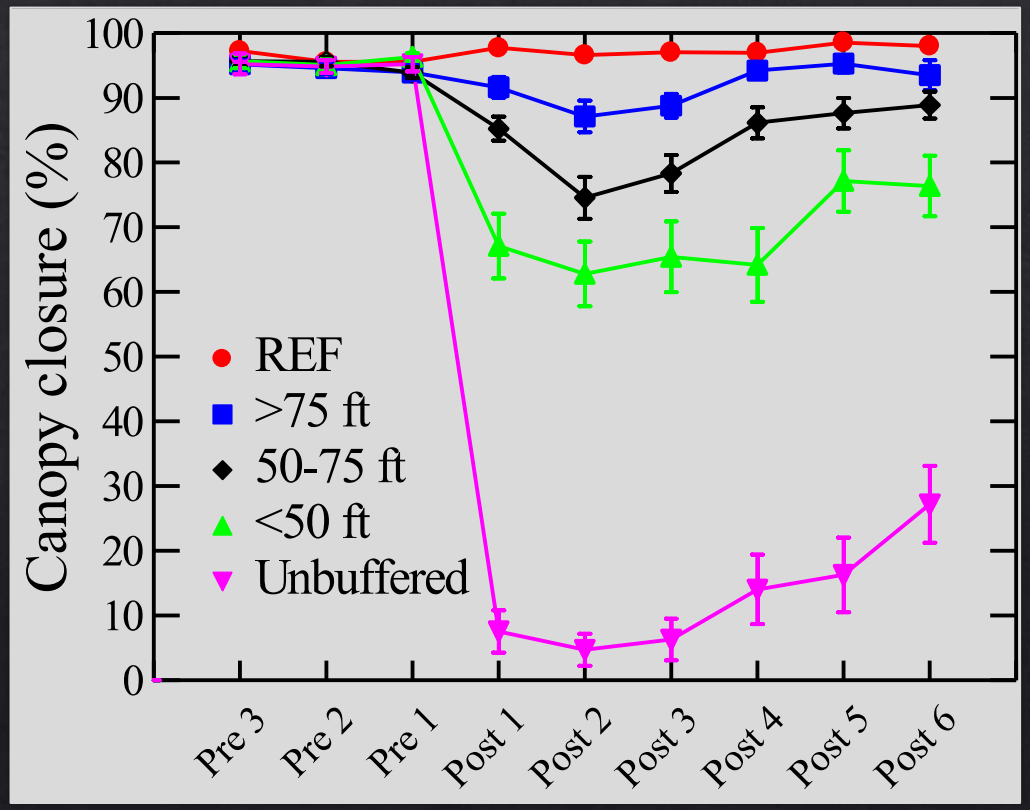
Canopy Cover

- Pre-harvest canopy closure was >90% in both Soft Rock and Hard Rock studies.
- Mean canopy closure at 1-m decreased in TRT sites relative to REF sites.
- Ongoing shade loss due to windthrow, similar to Hard Rock Study.
- Immediate post-harvest mean canopy closure comparable to Hard Rock Study FP treatment.

Year	REF	TRT
Pre	96	95
Post 1	98	73
Post 2	97	66
Post 3	97	67
Post 4	97	74
Post 5	99	78
Post 6	98	78

Canopy Cover

- Shade loss after Post 1 due to tree mortality.
- Mortality higher in buffers than in REF sites.
- Shade loss was greater and recovery slower in narrower buffers.
- Shade began increasing 3 to 5 years after harvest.
- Similar pattern in Hard Rock Study.



Stream Temperature

- 7DADM exceeded 16°C after harvest at only one site. This site had:
  - The highest pre-harvest 7DADM (15.4°C).
  - The lowest percent of stream channel with buffer.

Stream Temperature

			95% C.I.	
Year	**Δ7DTR**	**P-value**	**Lower**	**Upper**
Post 1	0.6	0.000	0.30	0.90
Post 2	0.6	0.000	0.26	0.85
Post 3	0.3	0.042	0.01	0.60
Post 4	0.4	0.014	0.08	0.67
Post 5	0.0	0.845	-0.27	0.32
Post 6	0.0	0.999	-0.31	0.31

- Mean Δ7DTR was 0.3°C or more through Post 4.
- Mean Δ7DTR was 0.0°C by Post 5.
- Immediate temperature response lower in the Soft Rock sites than in the Hard Rock FP treatment sites (0.6°C vs. 1.1°C).
  - Likely due to longer and wider buffers in the Soft Rock sites.
- Temperature returned to pre-harvest conditions sooner in the Soft Rock than in the Hard Rock Study (4 years vs. 10 years).
  - Probably due to higher post-harvest windthrow in two of the three Hard Rock FP treatment sites.
- Shade was the main driver of the temperature response in both studies.

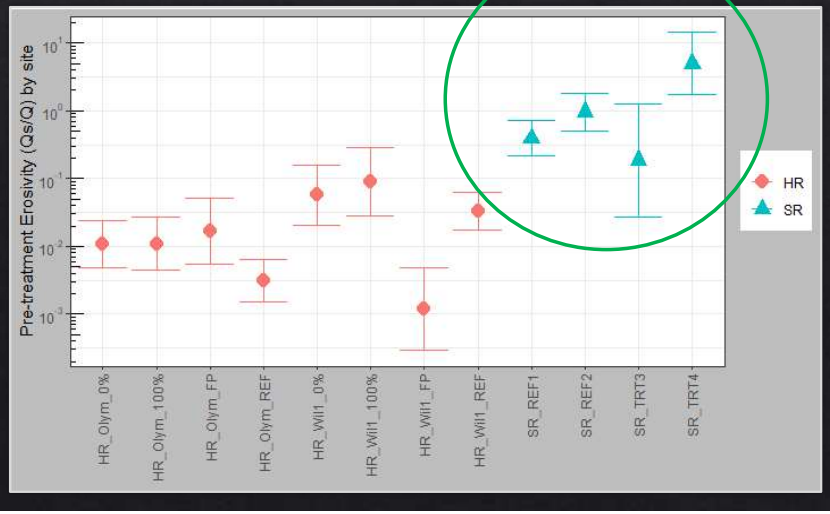
Stream Discharge

- Results inconclusive due to very low precipitation in the pre-harvest period.
- Hard Rock Study had more replication, normal precipitation, and well-matched sites.

	Hard Rock	Soft Rock
Pairs	4	2
Pre-treatment climate	Normal	Unusually dry
Pre-treatment period	2 years	< 2 years
Pairing	Good	Poor

Suspended Sediment Export

- Treatment and reference sites exported more sediment in post-harvest period.
- Windthrow-driven sediment delivery observed in treatment sites.
- Post-harvest sediment export greatest in reference site with streamside mass wasting.
- Soft Rock sites more erodible than Hard Rock sites.



Nitrogen Export

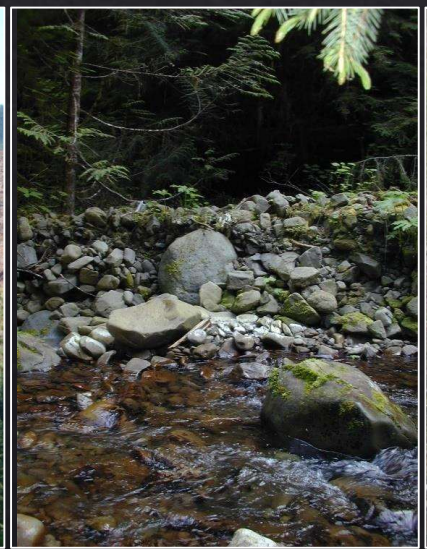
- Nitrogen concentration and export well within range measured in other Pacific Northwest studies.
- Change in total-N and nitrate-N concentration likely a result of reduced uptake.
- Estimated change in export related to proportion of stream buffered and to unusually dry weather and low stream discharge in the pre-harvest period.
- Hard Rock Study found an increase in total-N and nitrate-N concentration and export after harvest with the estimated change related to proportion of stream buffered.

Conclusions

- Similar responses between lithologies and studies:
  - Changes in riparian stand structure and wood input and loading were similar in the Soft Rock and Hard Rock studies.
  - Immediate post-harvest canopy closure comparable between Soft Rock and Hard Rock studies..
  - Changes in nitrogen concentration and export related to proportion of stream buffered in the Soft Rock and Hard Rock studies.
- Different responses between lithologies and studies:
  - Immediate temperature response lower in the Soft Rock and returned to pre-harvest conditions sooner in the Soft Rock. Likely a result of the SR's longer buffers, greater post-harvest shade, and lower windthrow.
  - Lithologies sampled in the Soft Rock Study were more erodible than those sampled in the Hard Rock Study.

Extended Study

- Monitoring over an extended period in both studies provided the opportunity to observe recovery for many response variables, and a delayed response for others

Acknowledgements

- **Field and Laboratory Staff:** Lara Boyd, Welles Bretherton, Jon Carr, Julie Englander, Jordan Erickson, Jackie Garrett, Matt Groce, Scott Groce, Daniel Hale, Erik Johnson, Jennifer Kienlen, Megan MacClellan, Caitlin McIntyre, Stephen Nelson, Suzie Saunders, Liz Schotman, Tyler Sorrell, Curtis Thompson, Molly Ware, Jacqueline Winter
- **Landowners:** Green Crow, Hancock Timber Resource Group, Rayonier, Weyerhaeuser
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