Type N Experimental Buffer Treatment Studies

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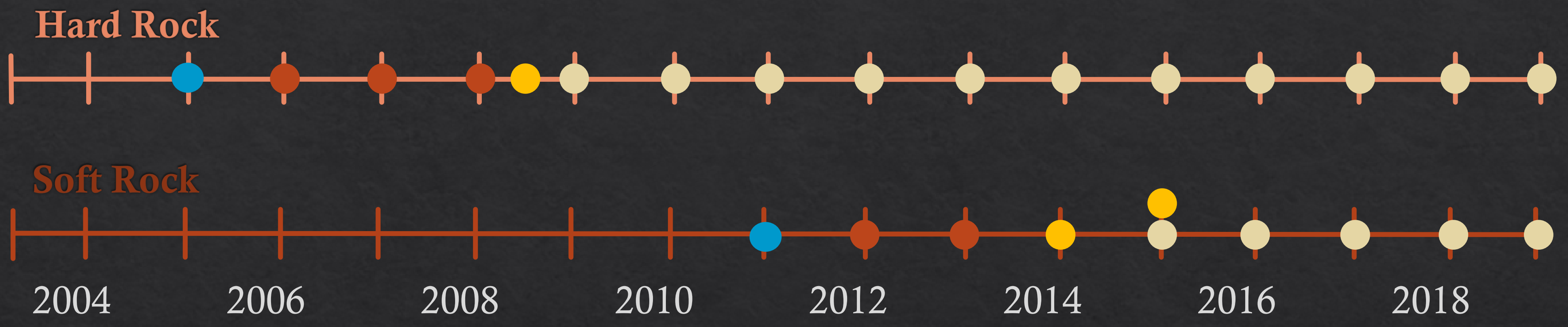
Type N Experimental Buffer Study Objectives

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



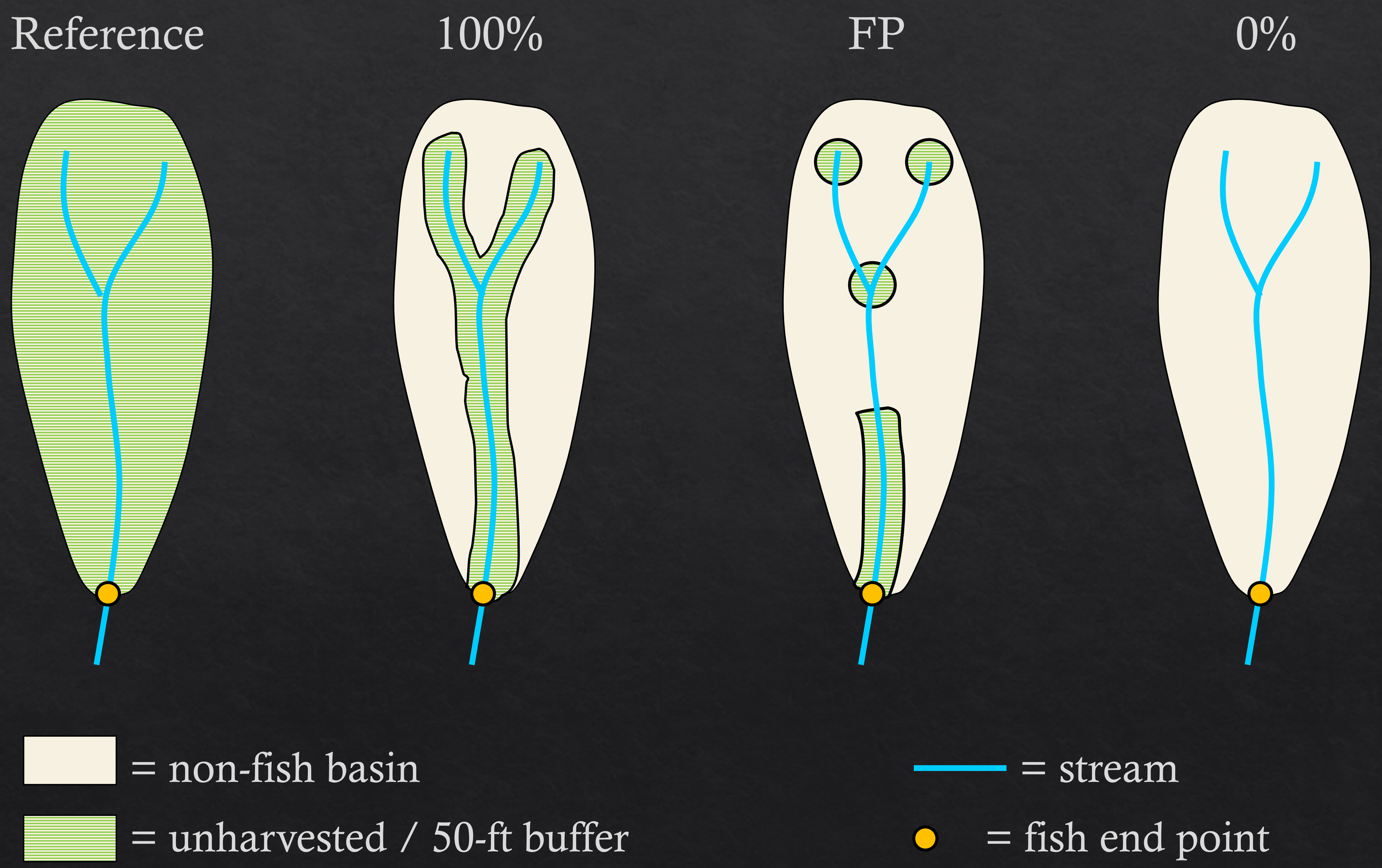
● = Study Design approved / ● = Pre-harvest / ● = Harvest / ● = Post-harvest

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

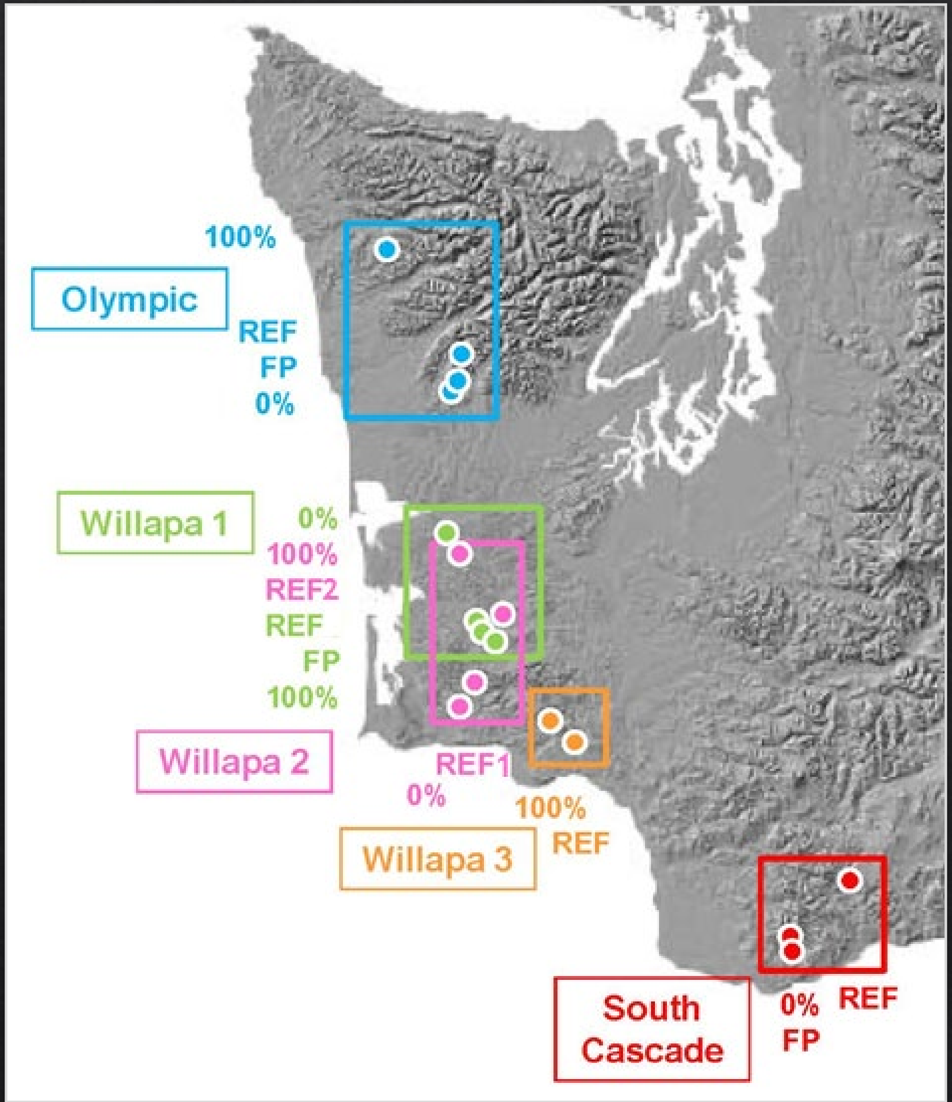
Site Selection

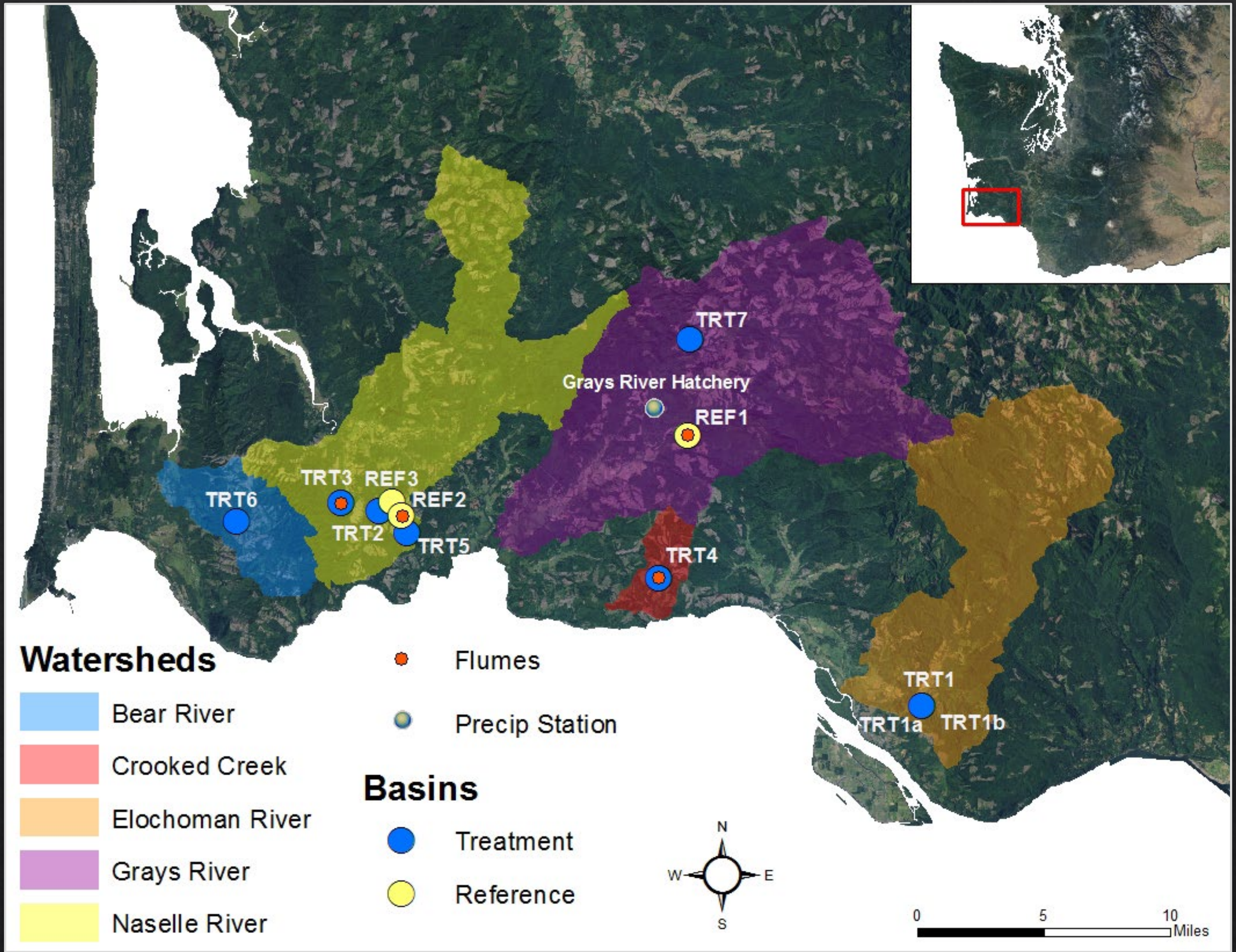
- GIS screening: geographic location, elevation, gradient, lithology, and basin area.
- Landowner information: ownership, stand age, harvest timing, and landowner commitment.
- Field verification: accessibility, stand age, stream flow, amphibian presence (Hard Rock only), and fish end point.
- Selection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

Experimental Treatments

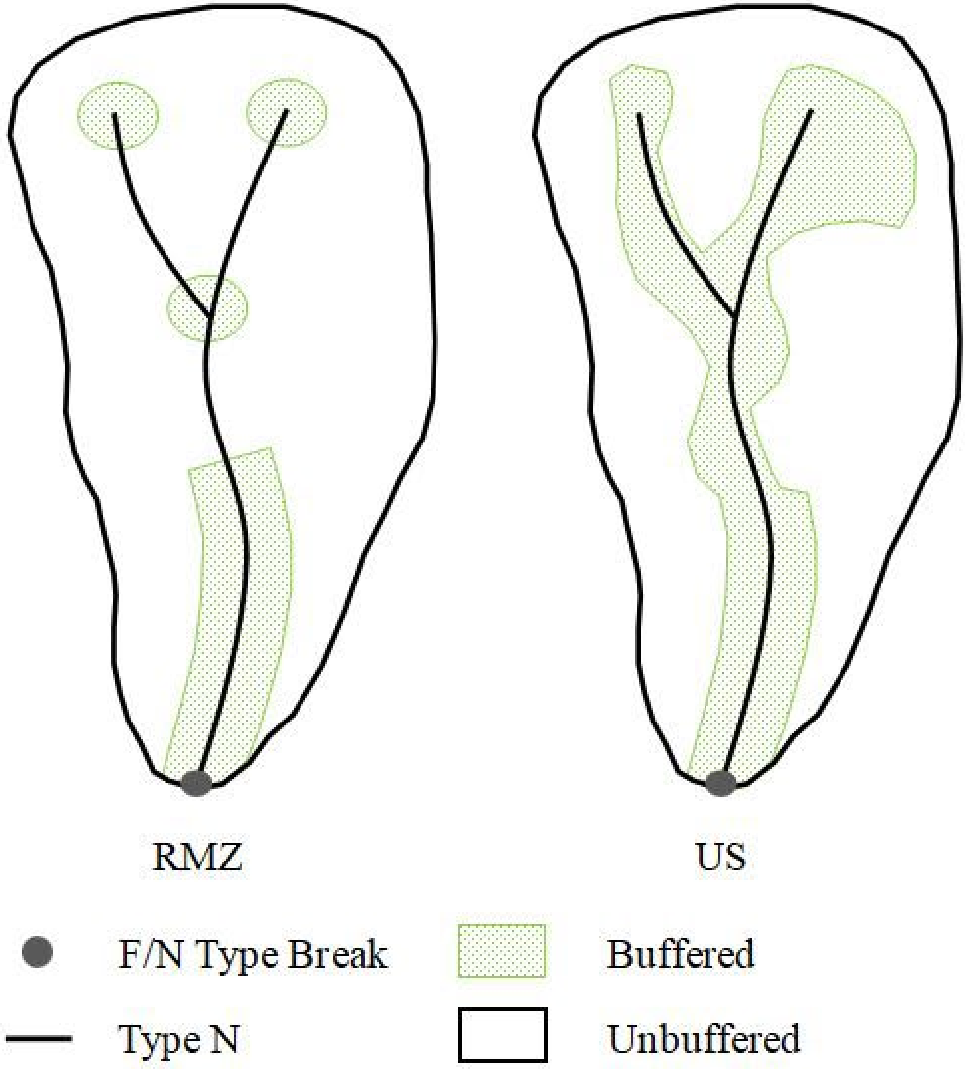


Study Site Distribution





Experimental Treatments



Unstable Slope (US) Buffers

Riparian Management Zone (RMZ) Buffers

Hard Rock: Riparian Stand, Wood and Channel Characteristics

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Dave Schuett-Hames & Greg Stewart
CMER Staff - Northwest Indian Fisheries Commission

Two Riparian Conditions: Buffered and Unbuffered

Unbuffered:

- Dominant disturbance was harvest (treatment)
- Large input of in-channel wood; decreasing Post 8
- No standing timber for future input

Buffered:

- Dominant disturbance from wind; variable
- Greatest tree mortality 2 years post-harvest; PIPs
- Large wood input variable (result of windthrow)
- Most large wood (80%) suspended over channel
- Small wood input intermediate; most provided in-channel function

0% Treatment

- Greatest input of small wood

  - 2.8 times increase vs. Reference in Post 1 & 2

- Channel characteristics had the most differences

  - 0.3 m decrease in bankfull and wetted width vs. Reference

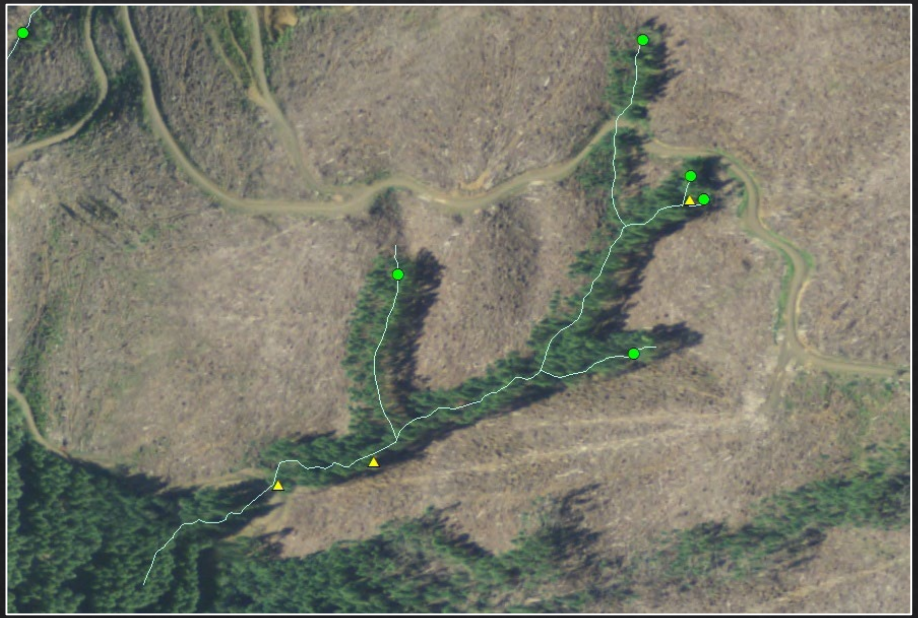
  - 2.5 increase in odds of substrate dominated by fines and sand vs. Reference

FP Treatment

- Basal area in buffers Post 8
  - RMZ decreased by 55%, little change in Reference
  - PIP decreased by 53%, slight increase in Reference
- Small and large wood loading increased
  - SW 64% increase vs. Reference, decreased
  - LW 44 % increase vs. Reference, persisted
- Future stand structure and wood recruitment potential depends on proportion of riparian harvest vs. buffer and mortality in buffers

100% Treatment

- Post 8 basal area decreased by 14% in RMZ
- Post 8 basal area decreased by 38% in PIP
- Small and large wood loading increased at lower levels
  - SW increased by 58%
  - LW increased by 66%
- Rates of mortality and wood input were intermediate between Reference and FP treatments



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

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Greg Stewart
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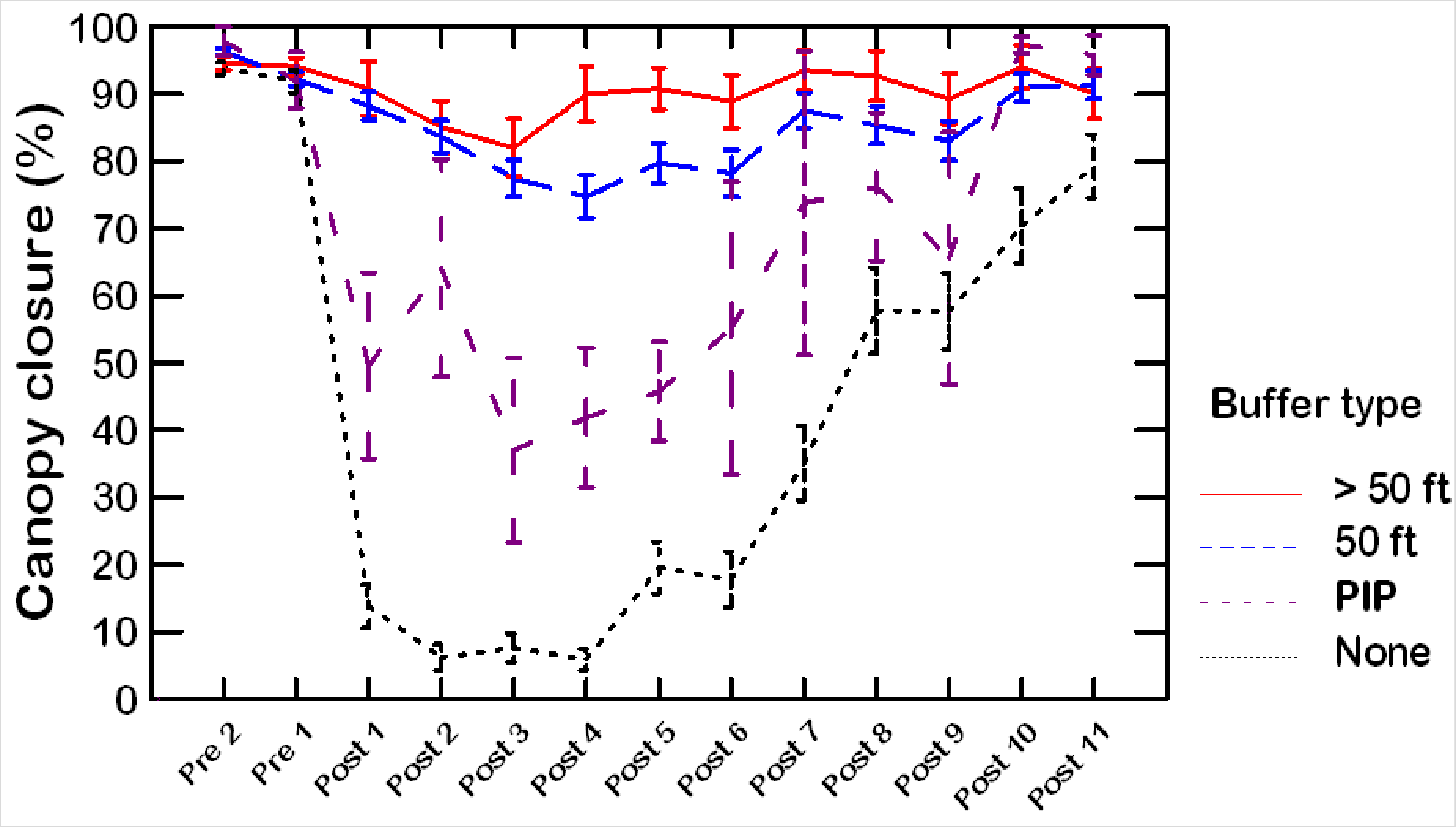
Shade–Post-harvest Change

- 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			Effective Shade		
Year	**100%**	**FP**	**0%**	**100%**	**FP**	**0%**
Post 1	-4	**-17**	**-83**	-8	**-27**	**-70**
Post 2	-5	**-22**	**-86**	**-9**	**-34**	**-65**
Post 3	-10	**-32**	**-87**	-7	**-35**	**-67**
Post 4	-6	**-28**	**-85**	**-11**	**-36**	**-62**
Post 5	-4	**-24**	**-70**	**-11**	**-32**	**-55**
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

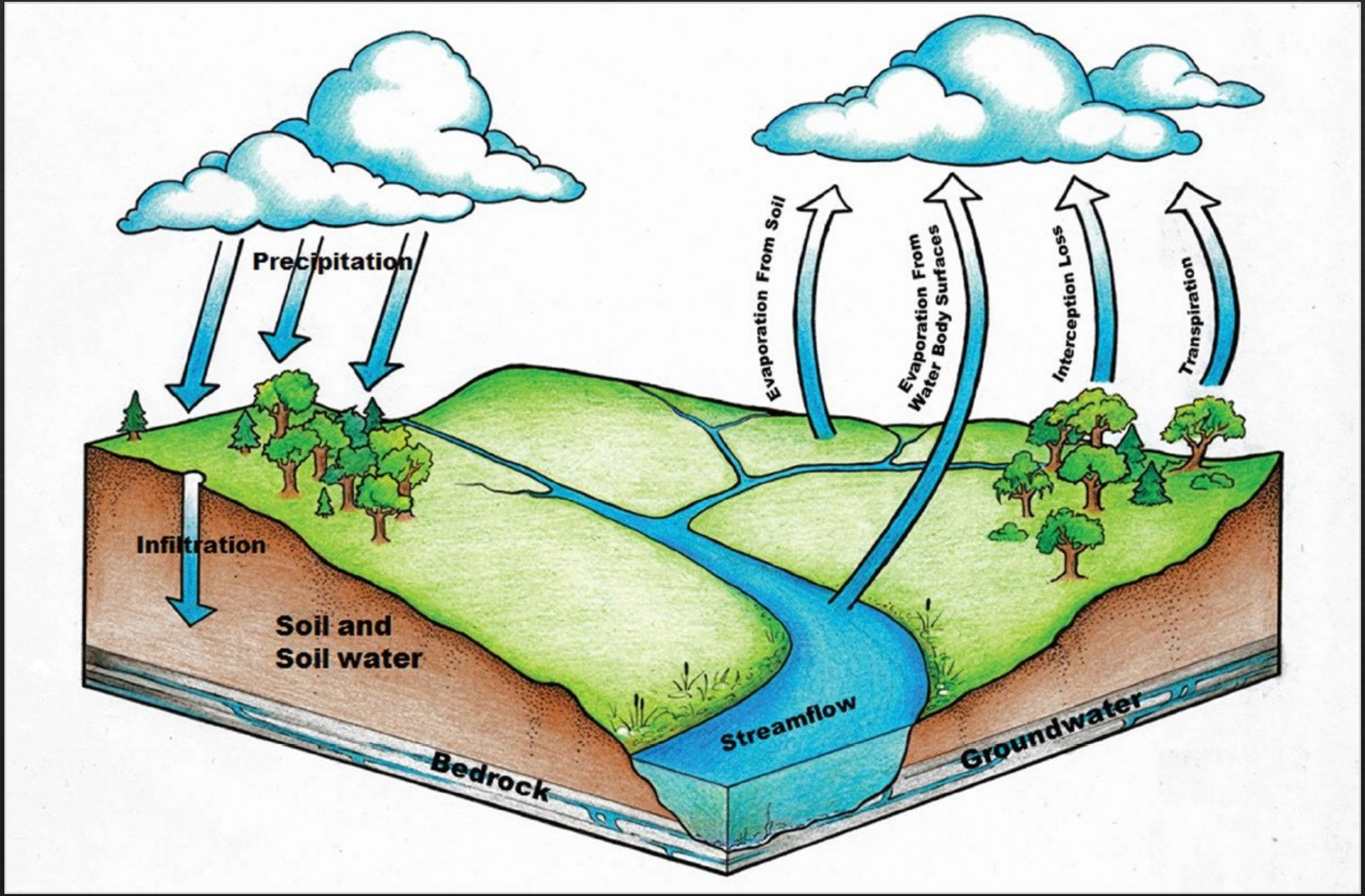


Stream Temperature–Post-harvest Change

- 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$_{FP}$	**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

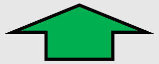
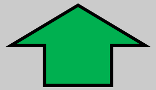
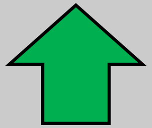
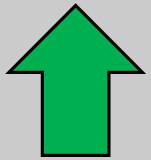


Type N Basin

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.

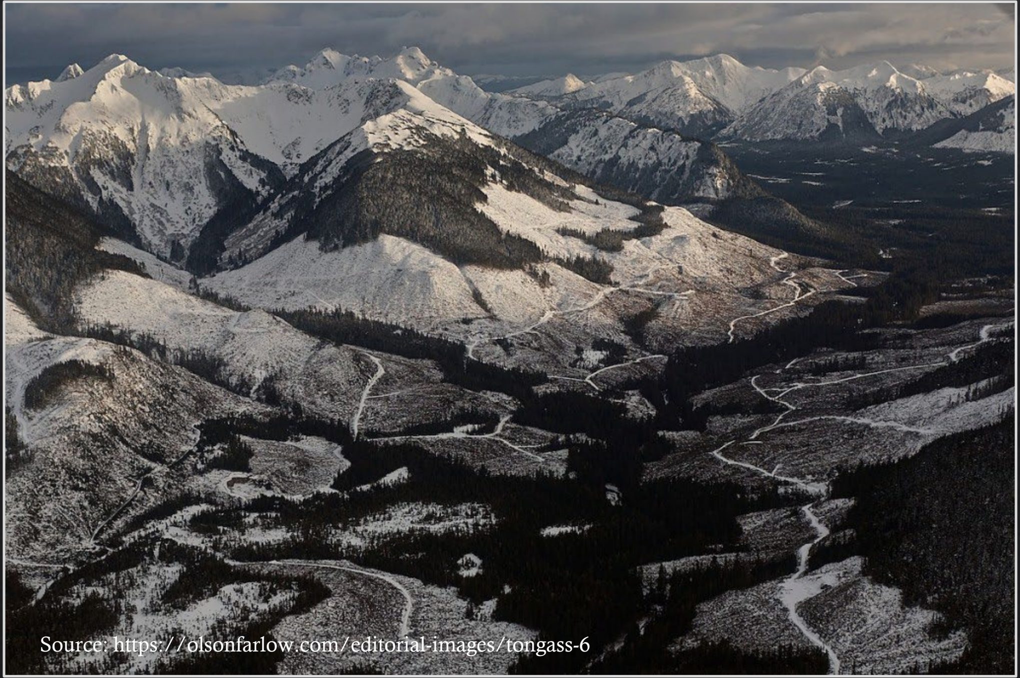
	Buffer Treatment		
	100%	FP	0%
Dry (summer)		—	
Rest of the year			

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.

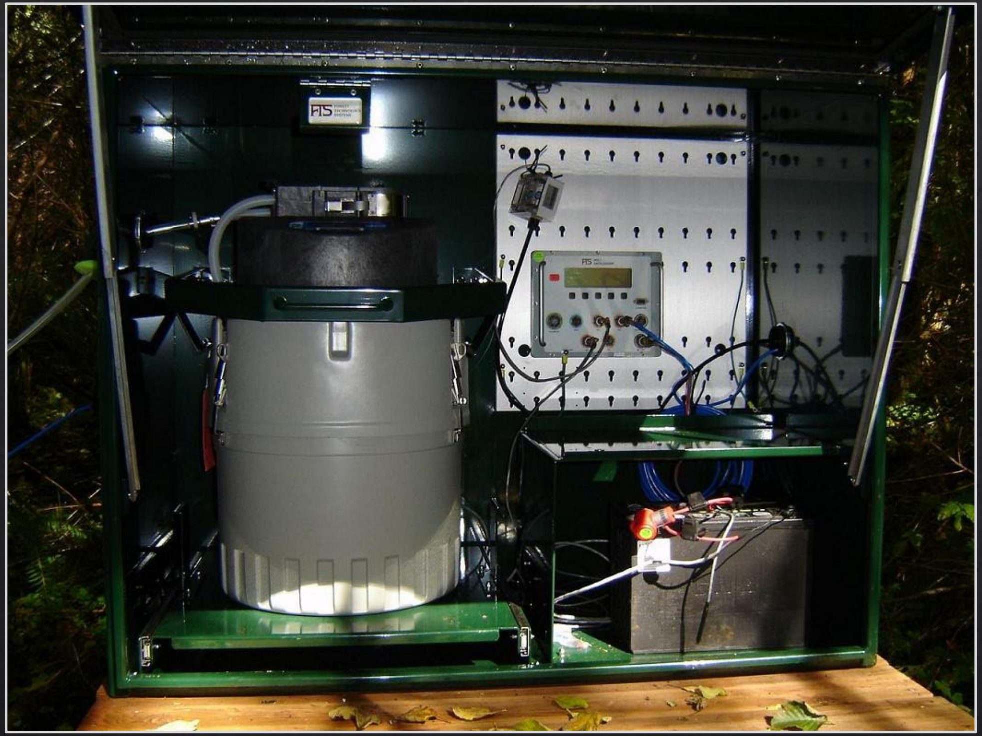


Source: https://olsonfarlow.com/editorial-images/tongass-6

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 seven and 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.

Hard Rock: Stream-associated Amphibians

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Jay E. Jones and Andrew J. Kroll
Weyerhaeuser

Stream-associated Amphibians

Overall Performance Goal:

- Support long-term viability of other covered species

CMER Work Plan Resource Objective:

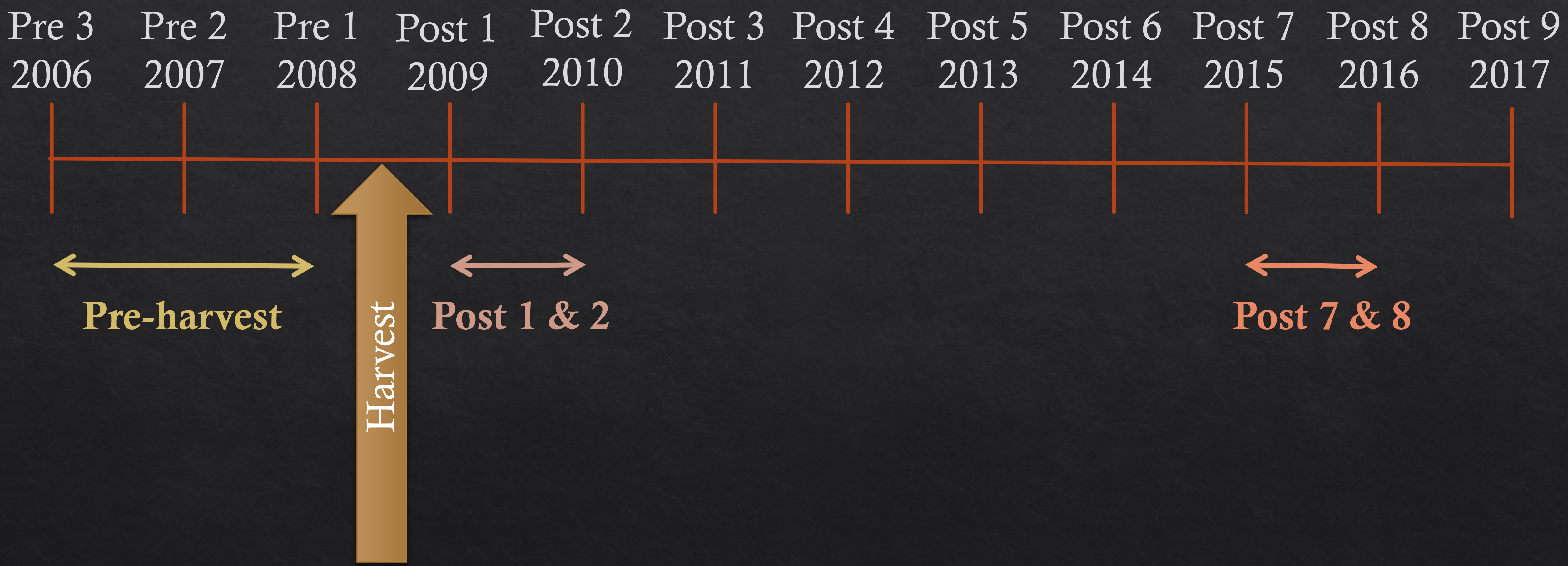
- Provide conditions that sustain stream-associated amphibian population viability within occupied sub-basins

Coastal Tailed Frog
(*Ascaphus truei*)

Torrent Salamanders
(3 *Rhyacotriton* species)

Giant Salamanders
(2 *Dicamptodon* species)

Timeline: Amphibian Demographics



Results

- ✓ 21,194 amphibian observations
- ✓ 98% were focal taxa

1,994

0 – 4.5 lar

0 – 2.5 post

12,989

0 – 110

5,727

0.3 – 59

Stream-associated Amphibians

Species	Post 1 & 2	Post 7 & 8
Coastal tailed frog (larval)	↑ FP	↓ 100%, FP, 0%
Coastal tailed frog (post-metamorph)	↓ 100%, ↑ 0%*	↓ 100%, FP
Torrent salamander	↑ 0%	↓ FP
Giant salamander	↓ FP	↓ FP**

* Large uncertainty in estimate; ** CI for comparison includes 1 (53% decline)

Stream-associated Amphibians in Wood Obstructed Reaches

- Post 1 & 2
  - All life stages for all taxa present
  - Large densities of torrent salamanders (up to 37/m)

- Post 7 & 8
  - Not all life stages present
  - Fewer individuals
  - No difference in salamander density between reaches

Stream-associated Amphibians

- Retention of a riparian buffer did not moderate effects of harvest.
- Amphibian response was related to harvest but not necessarily buffer length.
- Amphibians were found in wood obstructed reaches, especially in Post 1 & 2.
- We would not have observed the delayed response without study in Post 7 & 8.
- Additional sampling will provide the opportunity to evaluate potential for decline, stabilization, or recovery.




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

William Ehinger, Welles Bretherton, Stephanie Estrella, Stephen Nelson – Dept of Ecology

Greg Stewart, Dave Schuett-Hames – NWIFC

Soft Rock RMZ and PIP Buffers: Stand Structure

- Decrease in basal area in buffers.
  - RMZ Buffers: -26%
  - PIP Buffers: -46%
  - REF: -7%
- Wind dominant mortality agent in buffers.
  - RMZ Buffers: 75%
  - REF RMZs: <10%
- Extensive variability in mortality.
- Similar responses in Hard Rock Study.

Soft Rock RMZ and PIP Buffers: Wood Input

- Large Wood Input
  - RMZ Buffers 5 times > REF
  - ~90% suspended over channel
- Small Wood Loading
  - > Reference and < Unbuffered RMZs
- Similar pattern to Hard Rock Study.

Riparian Stand Structure and Wood Recruitment: Implications

- Changes similar in direction and magnitude to the Hard Rock Study.
- Implications: HCP prescriptions increasing variability in riparian stands over time.
  - Low mortality buffers: older stands, stable wood input, increased large wood load
  - High mortality buffers: two cohort stands, episodic wood input, increased large wood load
  - Unbuffered RMZs: younger stands, episodic slash input, decreased large wood load

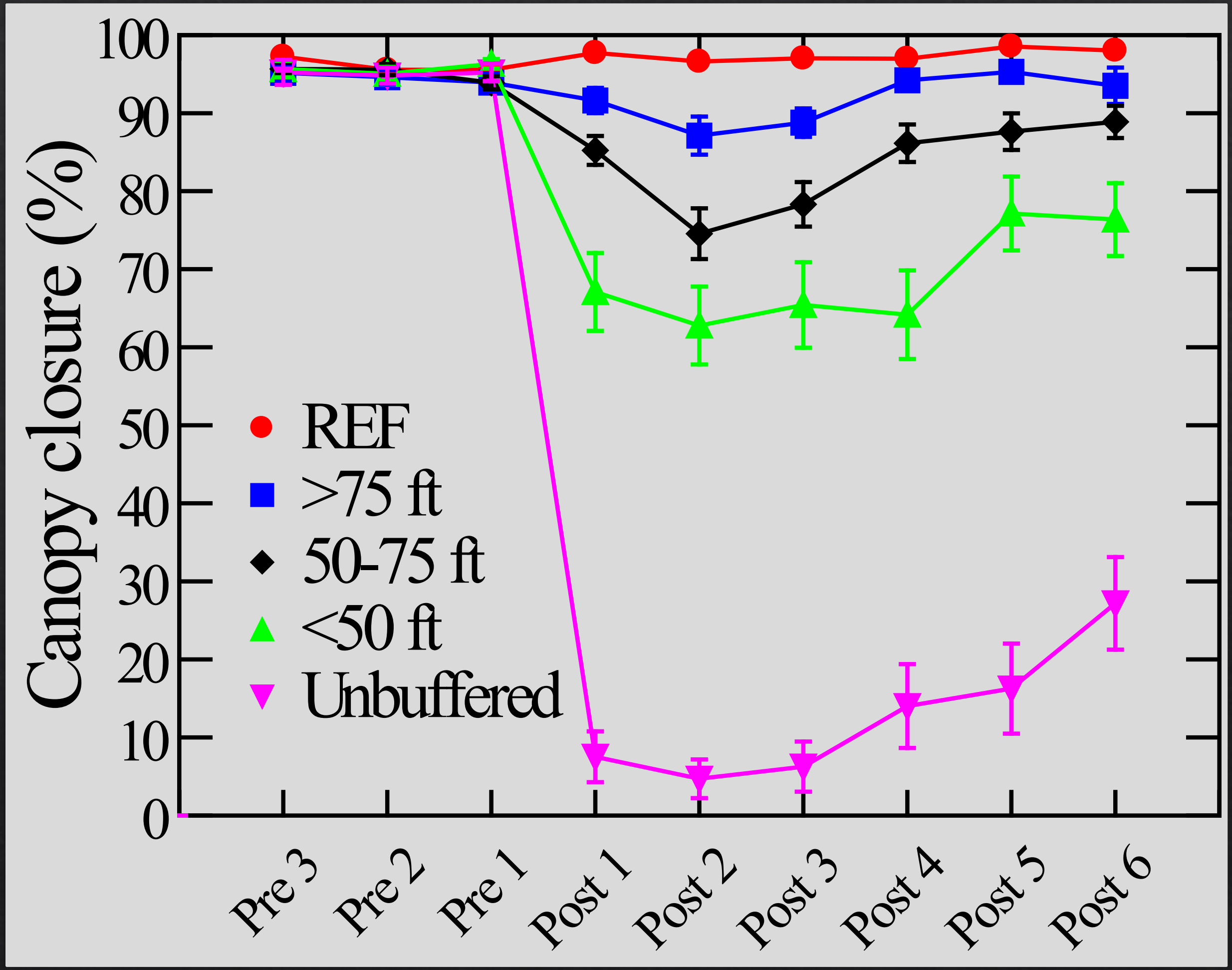
Canopy Cover

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

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

Year	Δ7DTR	P-value	95% C.I. 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.

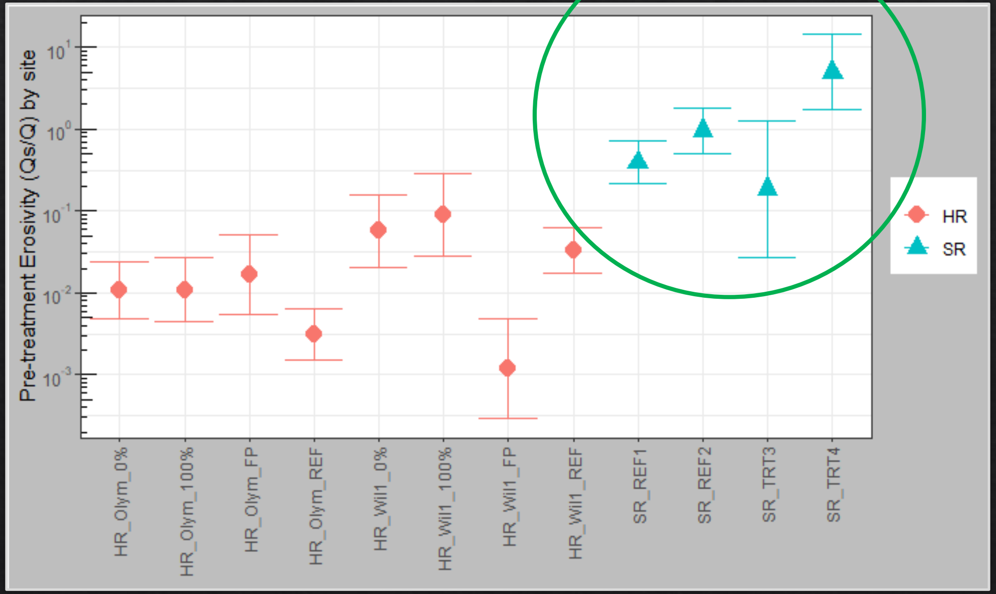
Stream Discharge

- 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

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- **Landowners:** Green Crow, Hancock Timber Resource Group, Rayonier, Weyerhaeuser
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