

Groundwater and Heat Transport Pilot Project:
Hoh River Watershed



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Why?

- Hoh Tribe was interested in knowing more about influence of forest practices on small, groundwater fed rearing streams
- Perched saturation in shallow soil horizons on hillslopes is an important subsurface flowpath that contributes water and energy to wetlands and small tributaries used for salmon rearing
- More research on flow dynamics in shallow subsurface flow in forested landscapes, but limited on heat transport to streams

Objectives

- This pilot study examines groundwater heat transport responses to forest management practices in the Hoh River basin
- Primary objectives:
 - Investigate the relationship between forest management practices and groundwater temperature
 - Evaluate the relationship between groundwater temperature and heat transport to streams

Questions

1. Does canopy removal change groundwater temperatures?
2. Do changes in soil and groundwater temperature affect stream temperature?
3. What is the relationship between stream, groundwater and soil temperatures and air temperature?
 1. What are the primary variables & mechanisms?

Hypotheses

1. H_0 1 (null hypothesis): Groundwater discharge temperatures are not significantly altered by canopy removal at depths equal or greater than 0.5 meters.
 1. H_a 1 (alternative hypothesis): Groundwater discharge temperatures at depths \Rightarrow 0.5 meters are significantly altered by canopy removal
2. H_0 1: Stream temperature is significantly related to air temperature
 1. H_a 2 (general alternative hypothesis): Stream temperature is significantly related to soil temperature
 2. H_a 3 (general alternative hypothesis): Stream temperature is significantly related to groundwater temperature


Criteria for Sites

- Similarity in
 - Soils with similar hydrologic characteristics
 - Slope aspect—south to southwest
 - Topography—streams or wetlands on terraces and hillslope
 - Three land covers: stand to be harvested, mature growth similar to site to be harvested, old growth



SITE 1

- Mature growth forest harvested in 2001

Site 1:
Pre-harvest installation—08/08/ 2001
Post-harvest installation—11/11/2001





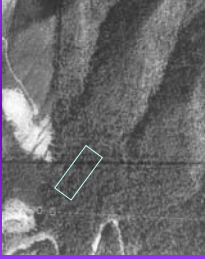


SITE 2: Control

- Mature second growth forest



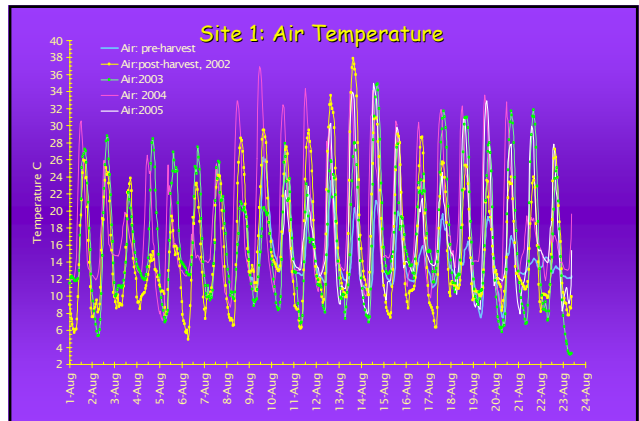


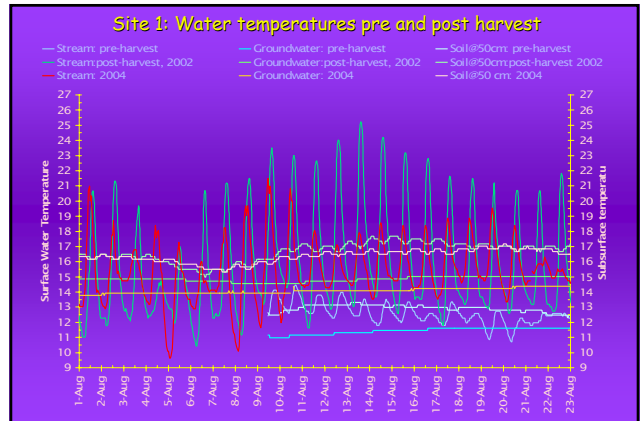
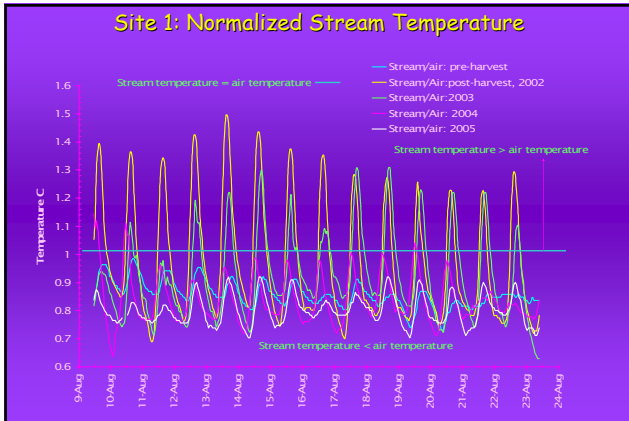
Site 3: Reference Old Growth Site

First Test

1. Does canopy removal change air, stream, soil and groundwater temperatures?





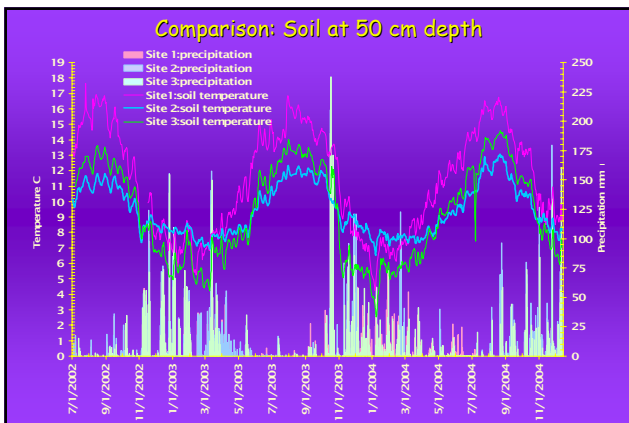
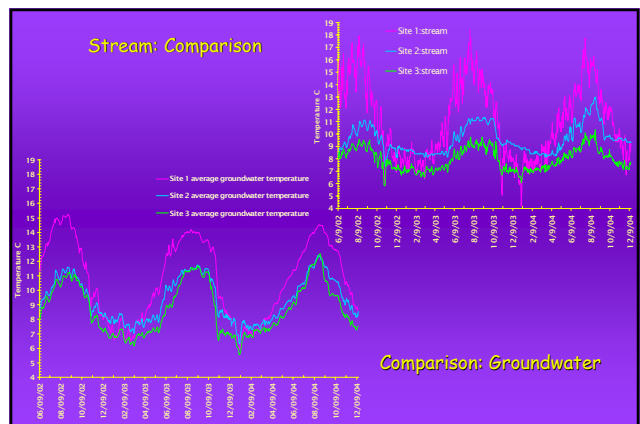
Temperature Comparison: Test Statistics

F-Test Two-Sample for Variances

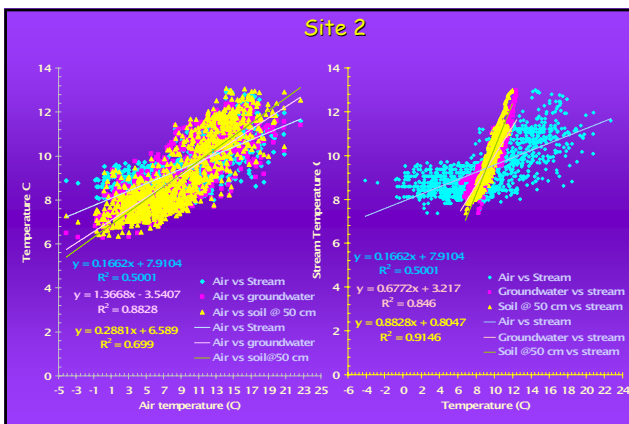
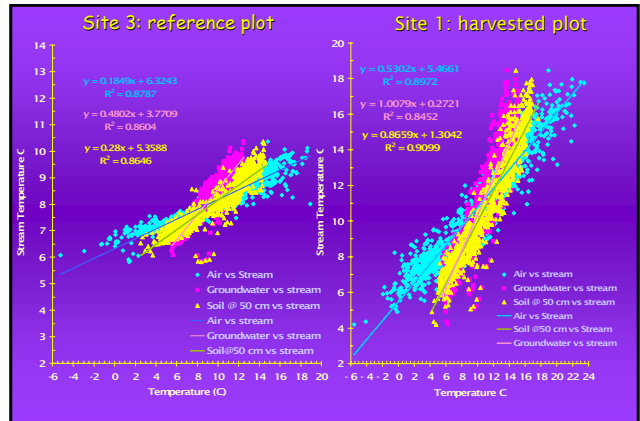
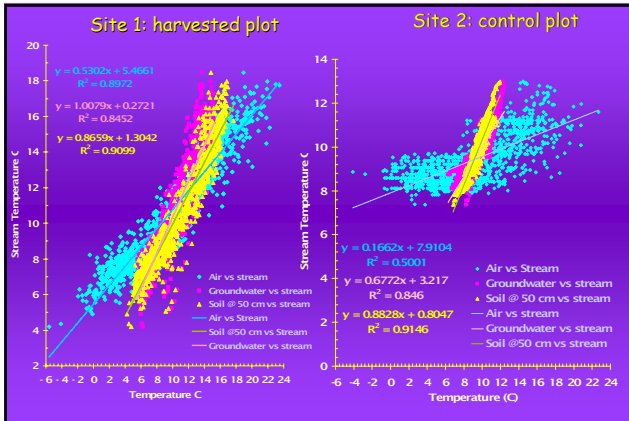
| | Air 1 | Air 2 | Air 1 | Air 3 | Air 2 | Air 3 | Soil 2 | Groundwater 2 |
|---------------------------|----------|-------|----------|-------|--------|-------|--------|---------------|
| Mean | 9.60 | 8.87 | 9.60 | 9.36 | 8.87 | 9.36 | 9.14 | 9.11 |
| Variance | 30.24 | 22.43 | 30.24 | 21.23 | 22.43 | 21.23 | 2.66 | 2.28 |
| Observations | 1133 | 1129 | 1133 | 793 | 1129 | 793 | 1129 | 1129 |
| P(R=F) one-tail, CI, 0,05 | <<<.0001 | | <<<.0001 | | 0.2037 | | 0.0049 | |

T-Test: Two-Sample for Means

| | unequal variances | | equal variances | | unequal variances | | | |
|---------------------------|-------------------|-------|-----------------|-------|-------------------|-------|--------|---------------|
| | Air 1 | Air 2 | Air 1 | Air 3 | Air 2 | Air 3 | Soil 2 | Groundwater 2 |
| Mean | 9.60 | 8.87 | 9.60 | 9.36 | 8.87 | 9.36 | 9.14 | 9.11 |
| Variance | 30.24 | 22.43 | 30.24 | 21.23 | 22.43 | 21.23 | 2.66 | 2.28 |
| Observations | 1133 | 1129 | 1133 | 793 | 1129 | 793 | 1129 | 1129 |
| P(T=t) two-tail, CI, 0,05 | 0.0007 | | 0.2961 | | 0.0237 | | 0.5710 | |



- ### Hypotheses-exploratory analysis
- $H_0 2$ (general alternative hypothesis): Stream temperatures are significantly related to air temperature
 - $H_0 2$ (general alternative hypothesis): Stream temperatures are significantly related to soil temperatures at 0.5 m depth
 - $H_0 3$ (general alternative hypothesis): Stream temperatures are significantly related to groundwater temperatures



Subsurface to surface water interactions

- Saturation from above - Infiltration
- Saturation from below - Decreasing K_{sat} at depth

Local slope break or area of thin soil or change in bedrock

- ### Next Steps
- Compare with data from other sites
 - Use subsurface heat transport models to examine:
 - What are the primary variables affecting the relationship between canopy removal and groundwater temperature (e.g. soil depth, organic matter)?
 - Do changes in groundwater quantity and temperature affect stream temperature? What are the primary variables and mechanisms
 - Test sensitivity of variables
 - Identify potential mechanisms

