TRANSPIRATION SOURCE WATER and GEOMORPHOLOGICAL POTENTIAL OF ROOT GROWTH in the BOULDER CREEK CRITICAL ZONE OBSERVATORY, COLORADO

LAWRENCE UNIVERSITY

RESEARCH EXPERIENCES IN SOLID EARTH SCIENCE FOR STUDENTS RESESS

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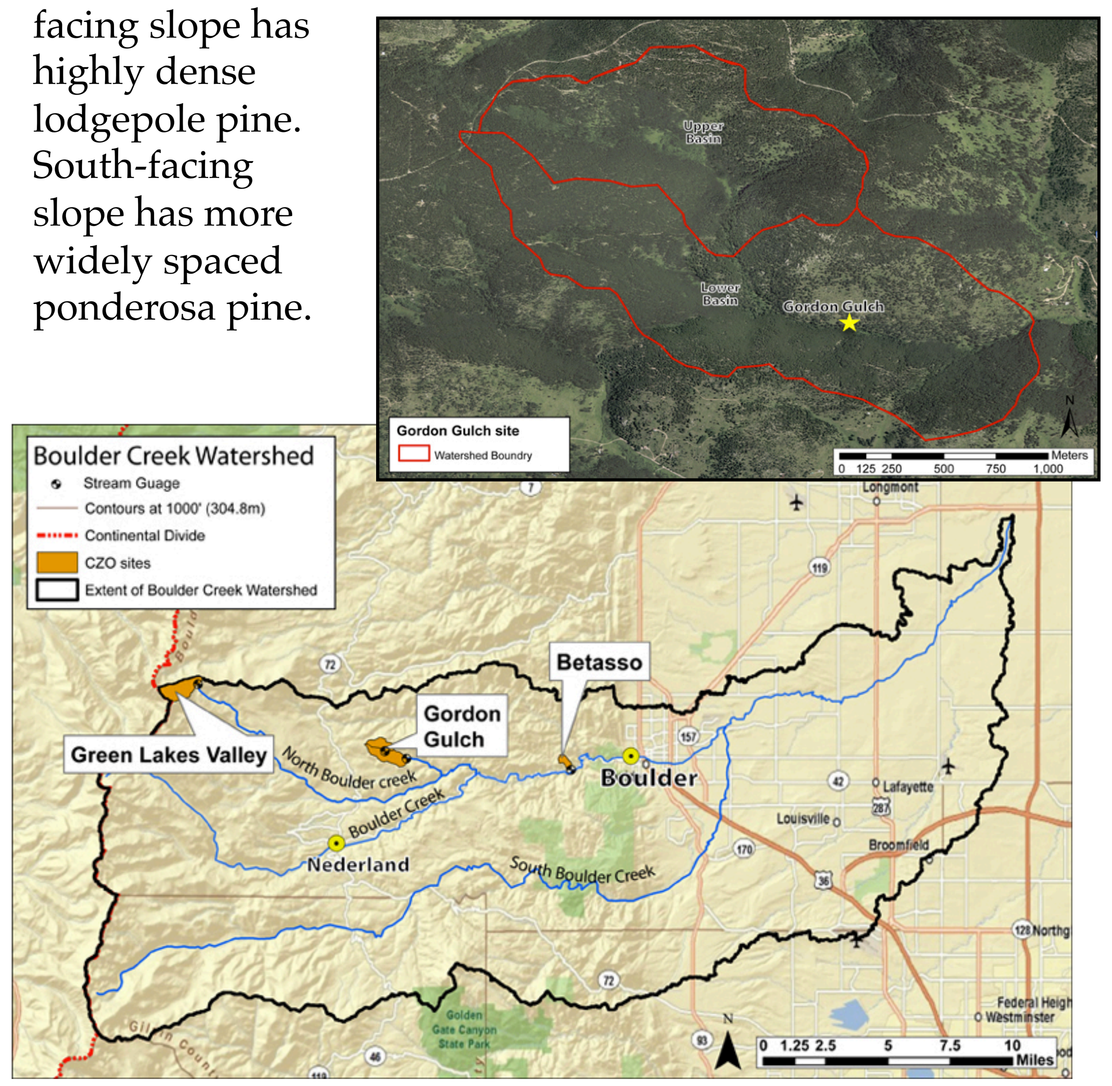
Introduction

The link between vegetation and the hydrologic cycle is poorly understood. Ecohydrological work is critical to understanding the role of vegetation within catchment processes. It has been shown that water sources trees use come from different pools than those generating streamflow, as determined by stable isotope data (Brooks et al., 2010). Additionally, the role of roots in changing the landscape has not been widely explored; especially in rock outcrops and possibly the underlying bedrock.

Study Site

Gordon Gulch, Boulder Creek CZO (N 40° 00' 48.14", W 105° 28' 10.08") in Roosevelt National Forest, CO. North-facing slope has highly dense lodgepole pine. South-facing slope has more widely spaced ponderosa pine.



Methods

- Sapflow (heat-dissipation) sensors were used to calculate xylem water flux rate using SPSS statistics software.
- Weekly isotopic sampling over three weeks on the north-facing slope, south-facing slope, and rock outcrops from ponderosa pine and lodgepole pine
- Soil sampling on both slopes at 5 cm, 10 cm, and 20 cm.
- Cryogenic vacuum distillation for 3 hours for all samples.
- Isotopic analysis using the Picarro Isotopic Water Analyzer, L2120-*i*.

Objectives

The objectives of this study are (1) to determine from isotopic analysis the depth at which the different trees in Gordon Gulch obtain their water and (2) because the bedrock outcrops of Gordon Gulch provide a unique growth environment that has not been well explored, to determine whether the tree roots contribute to long-term geomorphologic effects due to physical deterioration of the bedrock.

Objective 1 – Results

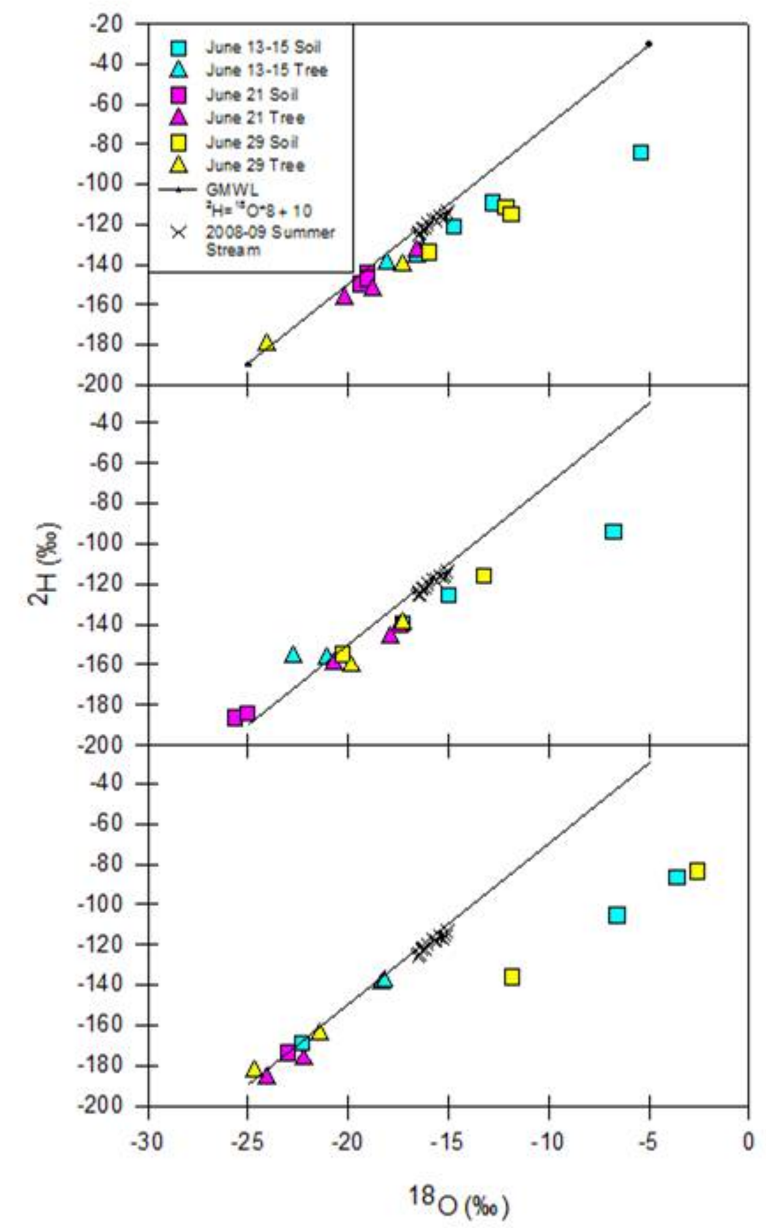


Figure 1: Isotopic samples from soils and trees plotted against the Global Meteoric Water Line (GMWL). Samples were collected during the 1st period of June 13 -15, the 2nd period of June 21, and the 3rd period of June 29th. **(A)** North-facing slope samples, with closely spaced *Pinus contorta*, demonstrate a strong isotopic signature of evaporated water in soils. The 1st period, was dry with little rain shown by tree water uptake from the evaporative zone. Second period samples indicate that the trees consumed water from recent rainfall, as shown by similar isotopic signatures of the xylem and the soil samples. Water sources for the trees during the 3rd period are below 20 cm, as noted by a less evaporated isotopic signature. **(B)** Xylem water from more widely spaced *Pinus ponderosa* growing in soil on the south-facing slope show that the trees tapped into deeper water sources during the 1st period, which was dry. During the 2nd period, the soil isotopic signature was more negative in response to recent rain; however, the trees' isotopic signature was similar to that of the 1st period. Samples from the 3rd period show that the trees used shallow water near recorded soil depths. **(C)** Rock outcrop samples demonstrate that the trees used the water that's not in soil, but presumably from fractures. In the 1st period (dry), trees used deeper water sources, rather than surface soil water. During the 2nd (wetter) period, recent rainwater was the trees' source. It was determined during the last period that the trees were not using surface soil water, suggesting a deeper water source.

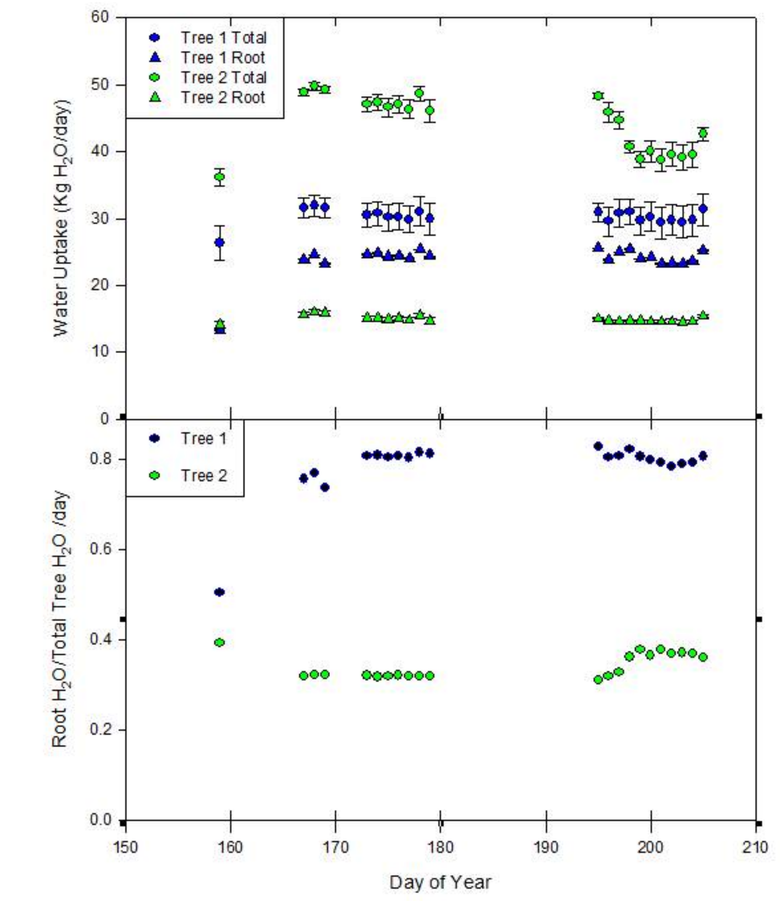
Objective 2 – Results

Total water use and the proportion of water use supplied by the instrumented root varied between Tree 1 and Tree 2, which may be a factor of the growth environment of each tree.

Water Flux Measurements	Tree 1	Tree 2
Average Total Water Flux Rate (kg/day)	29.07	42.51
Average Total Root Water Flux Rate (kg/day)	23.22	14.34
Average proportion of root contribution to total tree water	0.8	0.3
Root Cross-sections		
Rate of growth under stress	1 mm/yr	0.63 mm/yr
Rate of root growth under normal conditions	1.93 mm/yr	0.81mm/yr

Table 1: Different rates of water use of the trees located in rock outcrops. Trees were both ponderosa pine on the south-facing slope, and were growing in rock outcrops. Tree 1 was on the east side and Tree 2 was on the west side, both were approximately 20 – 25 m apart.

Figure 2: (A) The daily total water uptake of trees and their most dominant, visible root growing in rock fractures varies between the two instrumented trees. Initial data points at day of year (DOY) 159 (June 8th) is in a dry period with little rain fall and data points DOY 160 to 205 (July 24th) have experienced consistent seasonal rain. **(B)** Tree 1 has a high proportion of water supplied from root to tree. Tree 2 demonstrates a lower proportion suggesting that the tree's main water source is likely from other sources and not from the visible rock fracture.



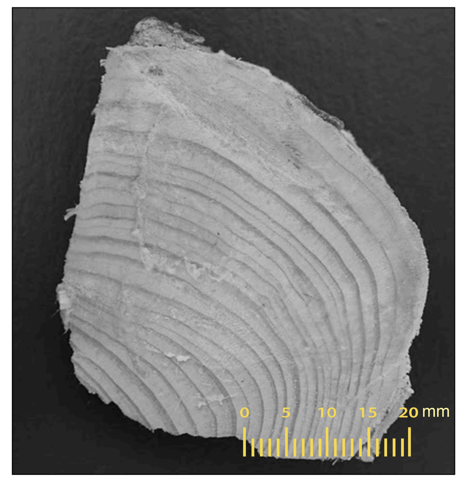


Figure 3: Tree 1 root growth rings

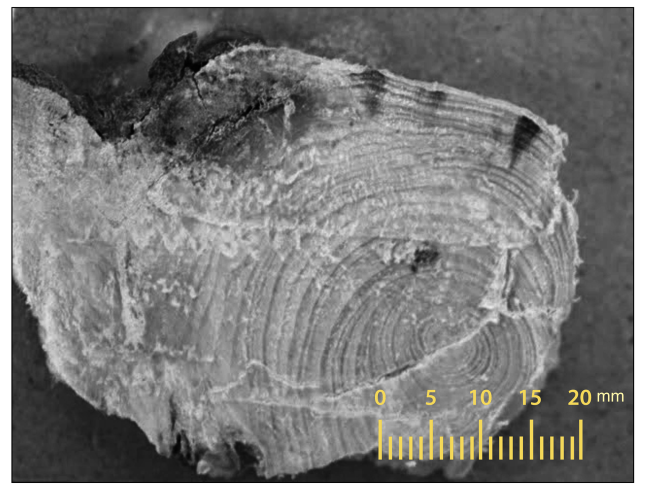


Figure 4: Tree 2 root growth rings

Figure 5: Tree 1 root in fracture

Figure 6: Tree 2 root in fracture

Conclusions

- Our results are consistent with those of Brooks et al. (2010), where the trees and the stream have distinctly different isotopic composition – suggesting a hydrologic disconnect between forest transpiration and streamflow generation processes.
- Trees in the Gordon Gulch ecosystem were highly responsive to rainfall events by changing the depth at which water was taken up and thus, demonstrating the highly dynamic behavior of roots.
- Our results from roots growing in outcrop fractures demonstrate the significant role roots play in both tree physiological processes and in bedrock deterioration.

References

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