Report as of FY2007 for 2006MT110B: "Student fellowship: Sources of groundwater and subsurface water aquisition and utilization by conifers invading riparian communities in western Montana"

Publications

Project 2006MT110B has resulted in no reported publications as of FY2007.

Report Follows

ROOTING DISTRIBUTION OF TWO TREE SPECIES IN UPLAND AND RIPARIAN AREAS IN WESTERN MONTANA

Final Report for
Water Research Fellowship

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Picture by Erin Thais Riley at Pony Canyon, January 26, 2007.

Project Synopsis

This current project is an effort to provide insight into a plant-soil interaction that may be fundamental to the understanding of landscape scale effects of global climate change, disrupted fire cycles, and stream flow. While it is believed larger trees are tapping into deeper groundwater sources and smaller sized trees are using water in the upper 1-2 m of the forest floor, it is possible that small Douglas-fir are capturing shallow ground water before it can enter the subsurface flow path that recharges streams. In contrast, small aspen may be sharing deeper water sources with conspecific larger trees (Arno 1986).

Identifying those variables that affect lateral runoff is key to understanding the water budget and ultimately the affect of fire suppression and climate change on stream flow. This research will help management agencies to adjust their management objectives for vegetation management under the constantly changing pressures of climate change, fire suppression, and grazing.

The Beaverhead-Deerlodge forest south of Boulder, MT is dominated by lodgepole pine and Douglas-fir in the uplands with Quaking aspen in the riparian systems. Following a century of aggressive wildfire suppression, local ranchers and government officials are seeing a decline in stream flow that wildlife and livestock use for water sources. The degree of interaction between climate change and disrupted fire cycles and stream flow has become a focal point for forest, range, and landscape ecological research. Among the management agencies interested in this work is Bureau of Land Management, Lewistown Field Office. A fire ecologist at this field station acknowledges immediate benefits from this research.

Vegetation management requires knowing which species and age class to manipulate to achieve landscape goals. The goal of this project is to determine if Douglas-fir, aspen, and herbaceous communities extract water from the same or different depths within the top 1-2 m of the soil column. To achieve this goal we will: 1) ascertain rooting zone within the upper soil column in Douglas-fir, Aspen and grass/forb communities; 2) confirm rooting depth stratification by using a DNA fingerprinting tool (AFLP's) to match roots from a specific depth to their counterpart; 3) compare the impact of the forb and grass community on soil water decline in non-forested areas. The hypotheses of this study are as follows: 1) smaller sized Douglas-fir and aspen use water within the upper profile where as larger sized Douglas-fir use deeper water sources and 2) grasses and forbs have less affect on soil water status than small-size classes of trees.

Douglas-fir size classes 1,2 vs. 3 are significantly different ($P=0.07$). Conversely, aspen was not showing significance among different size classes with $n=15$. The initial results are based on four sites, two were Douglas-fir and two were aspen out of the 24 total sites.

Research Approach:

This research project will aim to achieve the goal of determining if Douglas-fir, aspen, and herbaceous communities extract water from the same or different depths within the top 1-2 m of the soil column. Predawn water potentials ($\Psi_{predawn}$) coupled with soil water potentials (Ψ_{soil}) extrapolated from soil water content (θ) measured with a neutron moisture meter will give estimations about what depths Douglas-fir and Aspen are acquiring their water from. Measuring leaf conductance with a porometer will allow us to see if the trees are water stressed. AFLPs which is a DNA fingerprinting tool, will allow us to definitively say if those tree roots are found at that depth in the soil.

Study Design:

Individual trees will be sampled for three seasons within 24 pre-selected sites represented by four drainages. Samples will be collected during the months of April, May, June, July, August, September and October. Each of the 24 sites have two Neutron Moisture Meter tubes inserted to a 154 cm depth and soil water volume at 20 cm intervals will be collected Monthly during the spring and fall and weekly during the summer months. One

of the Neutron Moisture Meter tubes is undisturbed and one has the entire vegetative understory removed to account for water uptake by grasses and forbs. At each site 12 trees will be selected, tagged, and classed into three size categories. Class size one is between 0 and 120 cm, class size two is between 120 and 240 cm and class three is any tree above 240 cm. Twelve trees at each site will be paired within 2 meters (Moore and Owens 2006) of one another and sampled using the predawn water potential and porometer on the sides as close to each other as possible to avoid environmental variability that can occur from atmospheric, edaphic, topographic, and vegetation variables (Wambolt 1973). To be sure roots are present at certain depths, DNA from aboveground plant tissue such as leaves will be isolated and digest the DNA using Amplified Fragment Length Polymorphism technique then matched to their roots. Soil cores will be taken with a two inch circumference soil core to 154 cm depth or bedrock, extracted and fine roots will be removed, their depth recorded in the soil, and matched to their above ground counterpart. Drs. Luther Talbert and Mike Giroux at Montana State University have offered the use of their labs to conduct this portion of the research project.

Neutron Moisture Access Tubes

24 forested sites were chosen to install two Neutron Moisture Meter access tubes. These sites were chosen by location within watersheds and tree community. 12 of the sites are dominated by aspen and 12 sites are dominated by Douglas-fir. These access tubes will be 15 meters apart and one will have all understory vegetation removed with roundup. 24 of these access tubes were inserted 154 cm or bedrock, whichever came first, and the remaining will be inserted at the same depth this coming summer. The access tubes were dug with a 5 cm hand auger and thin walled PVC pipe was installed for the access tubes. Rubber stoppers were inserted in the bottom of each tube to keep moisture from entering at the bottom of the tubes. About 31 cm were left above ground to set the Neutron Moisture Meter on top of.

Soil water potential

Soil water potential (Ψ_{soil}) will be calculated through soil retention curves developed for the study site. Samples from different horizons visible within soil pits dug will be collected. Soil water volume (θ) is measured at 20 cm intervals to the bottom of the neutron moisture access tubes. Soil water potential will be developed by Midwest Industries Corp. from the soil samples collected from the different soil horizons, and soil water potentials (Ψ_{soil}) will be extrapolated from soil retention curves by using soil water content collected with the Neutron Moisture Meter. This method of extrapolating soil water potentials from soil water content has shown to have a very high correlation (Fahey and Young 1984).

Xylem Water Potential

In this study, leaf petioles from Quaking aspen trees are used to get an estimate of xylem water potential and twigs are used to get xylem water potential for Douglas-fir. Pressure chamber determinations are estimates of the total water potential of the xylem sap (Ritchie and Hinckley 1975). The twig or leaf is removed from the tree and cut with a razor blade at an angle to allow for more surface area of the xylem. The instant water is seen at the end of the leaf petiole or twig, the pressure gauge is read and recorded. This value measured in bars is the xylem water potential for the twig and will be used to represent the xylem water potential for the tree.

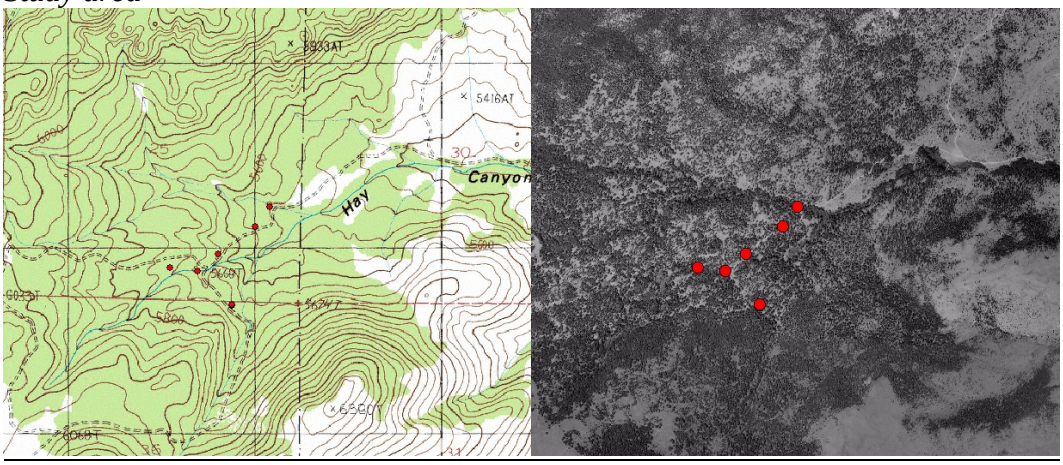
Leaf Conductance

A steady state leaf porometer (Decagon Devices) is used to measure stomatal conductance. This is a measures of the passage of carbon dioxide (CO2) or water vapor through the stomata of the leaf. The leaf porometer calculates the resistance between the inside and outside of the leaf with a measurement in mmol/m2 s1 (Millimoles per meter squared seconds). This measure how much conductance or exchange is taking place between the atmosphere and the leaf of the tree. If the tree is transpiring more, it has access to water, but when the tree does not have access to water, it will close its stomates. The same twelve trees that were measured for xylem water potential will be measured for leaf conductance.

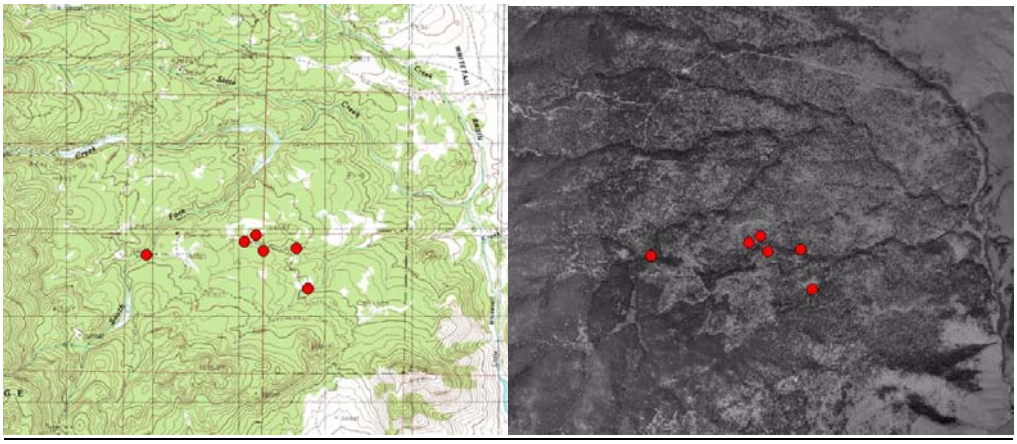
Amplified Fragment Length Polymorphisms

This DNA fingerprinting tool allows DNA polymorphisms to be determined between individual plants. We will use this technique to determine the identity of fine root tissue and match them to their aboveground counterpart at different depths. The use of AFLP kit from Invitrogen Life Technologies will be used to do the isolation and amplification following three major steps: restriction endonuclease digestion of the DNA and ligation of adapters, amplification of the restriction fragments, and gel analysis of the amplified fragments. This technique usually creates 50 to 100 restriction fragments in each AFLP, making it very powerful in detecting DNA polymorphisms and a good means to identify individuals. High quality DNA must be used with this technique which is why small roots will be used in fingerprinting (Jackson 2000). Douglas-fir plots will be sampled by individuals while fingerprinting aspen may be difficult since they are all one organism.

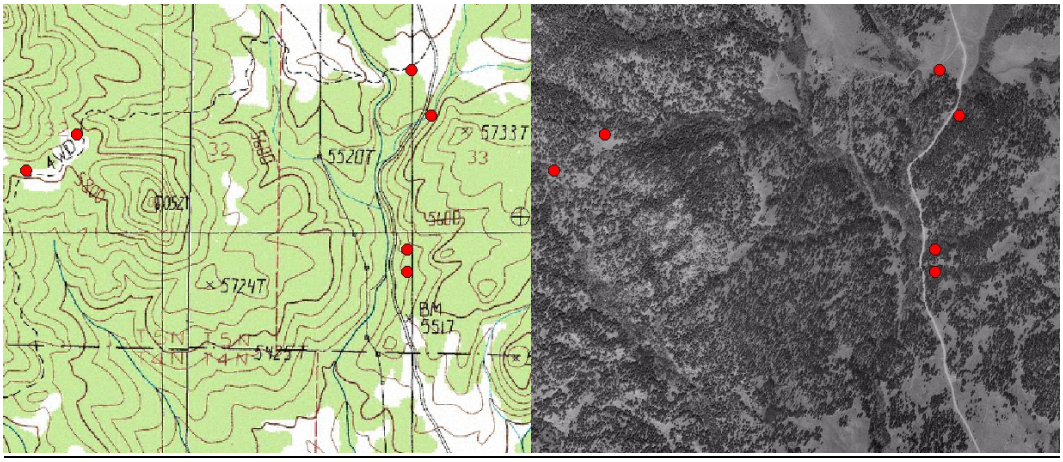
Study area



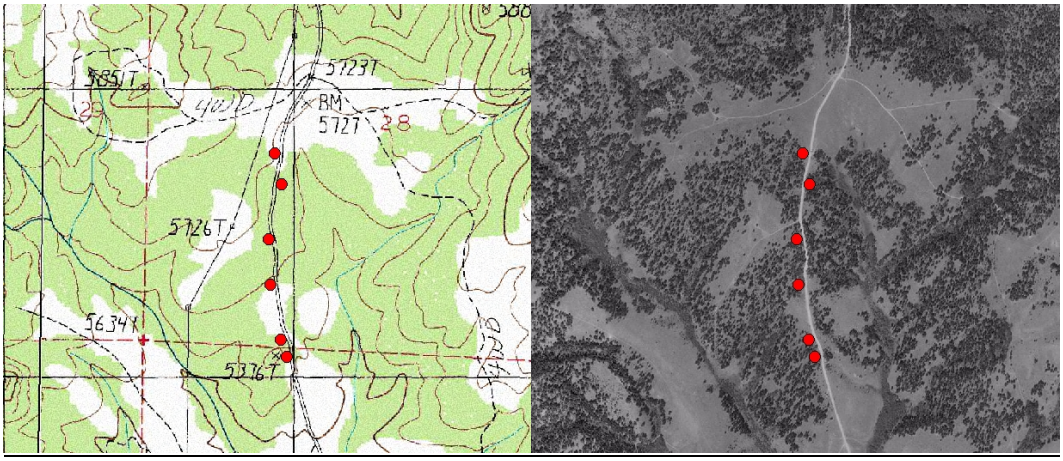
Hay Canyon with neutron access wells as the red points.



State Creek with neutron access wells as the red points.



Boulder Divide with neutron access wells as the red points.



Pony Reject with neutron access wells as the red points.

This study site is in Jefferson County, Montana north of Whitehall, Montana. It is located on Route 16 that goes from Whitehall, MT to Boulder, MT. The site is located on the west side of the road between long 45°00' and Lat 112°00, 46°00' and 112°15', 112°00' and 46°15', 112°15' and 46°15'. Land resources within the study are administered by the Bureau of Land Management, Butte Area Office and the Beaverhead-Deerlodge National Forest. The sub-watersheds under consideration lie within the northern portion of the Upper Jefferson TMDL Planning Unit.

The drainages empty to the east to south east and were chosen due to similarity in aspect. The upper portion of the larger watershed area is dominated by Lodgepole pine (*Pinus contorta*) forest which transitions into Douglas-fir (*Pseudotsuga menzesii*) forest and ends in a sagebrush/grassland type in the valley bottom. The watershed that contains the target sub-watersheds drains over 11,200 ha (28,800 acres) or about 36% of the Whitetail Basin.

Vegetation and soil sampling

The vegetation changes from site to site but the dominant vegetation are: Bearberry (*Arctosaphylos uva-ursi*), Baltic Rush (*Juncus balticus*), Big Sagebrush,(*Artemesia tridentata* ssp. *Veseyana*), Bluebunch Wheatgrass (*Psedorogenaria spicata*), Clover (*Trifolium repens*), Common Horsetail (*Equisetum arvense*), Idaho Fescue (*Festuca idahoensis*), Kentucky Bluegrass (*Poa pratensis*), Oatgrass (*Danthonia spp*.), Red Top (*Agrostis stolonifera*), Smooth Brome (*Bromus inermis*), Snowberry (*Symphoricarpos occidentalis*), Tailcup lupine (*Lupinus caudatus*), Wild Geranium (*Geranium viscosissimum*), and Woods Rose (*Rosa woodsii*)

The soils in this area are predominately sandy soils with some silt. This changes in the riparian systems where more clay is present. This is not expected considering the granite parent material of the boulder batholith area.

The parent material of the Whitehall site is intrusive igneous rock that probably originated 10-20 miles beneath the surface during the late Cretaceous and early Tertiary period.(78-69 million years ago) During the Eocene Epoch the overlaying rock was removed (1 mile above the surface) exposing the igneous rock below. The major exposure in the study site is the Boulder batholith with smaller satellite bodies connected to the primary extrusion but are similar in composition and texture. The dominant type of material is light gray coarse to medium grained quartz throughout the watershed. Large boulders can be found which are called tor piles, and were formed from weathering and erosion along joint planes. The material that is found in the stream beds in the Quaternary period is Alluvium composed of silt, sand and gravel in the stream valleys (Arno 1986).

Environmental Measurements

Relative humidity, temperature, and precipitation will be measured in each of the sub-watersheds by placing a probe at 2/3 ^{rds} canopy height. Vapor pressure deficit will be calculated using air relative humidity and temperature at a height corresponding to two thirds of the canopy height. This will give us a good indication of RH measures and effects on transpiration. Temperature and precipitation are recorded with digital recorders within one mile of the sample site. These are encased in fencing to keep wildlife from destroying them. Soil volumetric water content will be taken using a

Neutron Moisture Meter by wells throughout the sample units. Soils will be taken back to the lab, weighed, dried, and weighed again to get soil mass. Bulk density and volumetric water content will be calculated for the sites.

Supporting Hydrologic Data

This data will provide important information about vegetative effects on streamflow and at what depths different tree species are affecting the soil water moisture. In tangent of this study, fifteen monitoring wells have been placed in the riparian zone of 4 drainage. The wells are arranged in rows of three with the two outermost wells in the upland ecotone on the sides of the stream and one well adjacent to the stream channel. Since 2003, measurements of groundwater elevation have been taken from April to November. In 2004 pressure transducers were installed inside stilling wells on each stream above and below the prescribed burn sites to monitor surface flow. In the spring of 2006 Hay Canyon was burned with a prescription of 70% small Douglas-fir to be removed. We are currently looking how the groundwater wells and surface water runoff are affected by this burn.

Results to date:

Initial review of neutron and groundwater monitoring in 2006 indicated the following. Douglas-fir size classes 1,2 vs. 3 are significantly different (P=0.07). Conversely, aspen was not showing significance among different size classes with n=15. A sample adequacy test was used to get an idea of sample size using our initial results. This test indicated that we need close to n=45 samples to get a P=0.05 for the Douglas-fir size classes 1,2 vs.3. The sample adequacy for the aspen when comparing size class 1 vs. 3 is with a P=.1we need approximately n=91 and we currently have approximately 15(Kupper and Hafner 1989). The initial results are based on four sites, two were Douglas-fir and two were aspen out of the 24 total sites.

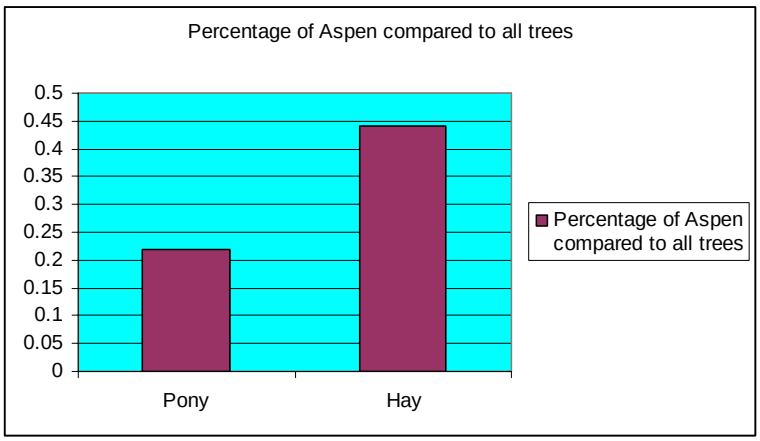


Figure 3

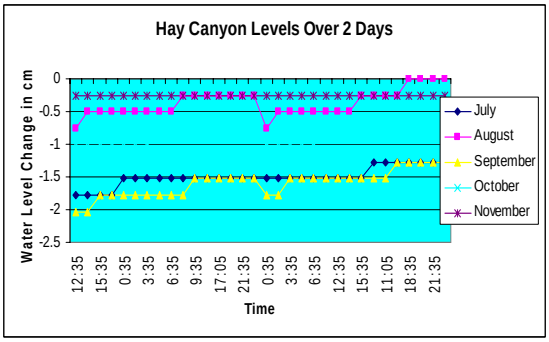


Figure 4

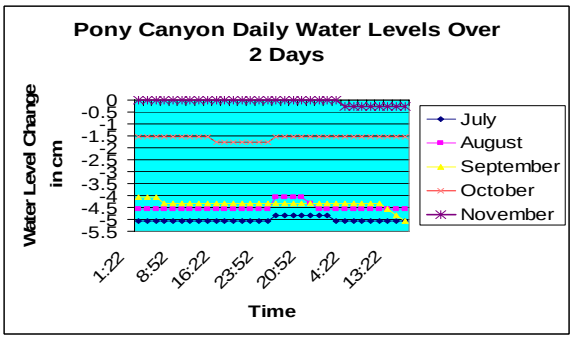


Figure 5

The two canyons sampled are Hay and Pony Canyon. Pony Canyon has considerably less aspen than Hay Canyon (fig. 3) which could explain the greater amount of oscillation in Hay Canyon than we see in Pony Canyon. If we look at the difference of surface water levels between Hay (fig. 4) and Pony (fig. 5) Canyon every hour and a half over two days, we see there is a much greater amount of fluctuation in the Hay drainage than in the Pony drainage. The more negative the number, the lower the water level. This relationship needs to be investigated in more detail to confirm or reject the hypothesis that tree encroachment can affect stream flow.

Research Products:

The expected products of this research are two journal articles, two posters presented at professional meetings, three departmental presentations and a paper for the Society of Range Management.

Outreach Activities:

As a Ph.D. student Erin Thais Riley has the opportunity to help design and implement a curriculum for a class given at Little Big Horn College on the Crow Reservation. This class was implemented this past summer and was a five day field school. A portion of the class was riparian ecology and management that Ms. Riley developed a course curriculum for. This course will continue for the next two summers with Ms. Riley's help. The Crow, as well as other Native Americans, are concerned about the affects of off-reservation land uses on water resources within the reservation. Riparian tree species, like aspen, have cultural significance to native peoples so the Crow are concerned about management options that involve tree removal. Consequently, the information generated

from this study will be incorporated into the LBHC natural resource field school curriculum in 2007 and 2008. The results of this research will be used by the Forest Service and BLM in land management prescriptions to help regenerate water in systems that are lacking.

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