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CLIMATE CHANGE RESEARCH PROPOSAL

CLIMATIC IMPACTS AND TOPOGRAPHIC INFLUENCES ON WATERSHED HYDROLOGY AND FOREST PRODUCTIVITY

AUTHOR

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PROJECT DESCRIPTION

The redistribution of water as a function of elevation, lateral position and climate can lead to heterogeneity in how water accumulates in Forested Rocky Mountain Watersheds. Rocky Mountain catchments contain numerous variables that affect how water moves through both the shallow soil zone and deeper bedrock geology. Basement geology, topographic relationships and elevation gradients are some of the main controls dispersing water throughout complex terrain. This circulation of water in turn effects the production of photosynthate for biomass. Understanding and predicting the relationship of groundwater flow and how this affects biomass growth is crucial to understanding hydro-topographic effects on forest productivity. Climatic changes observed in the past, as well as projected into the future, (Deser et al., 2012) suggest an ever-changing global climate pattern where precipitation is directly influenced. The interplay of groundwater and topography may influence production of biomass and a better understanding of this relationship is required for assessing the sensitivity of forest productivity to climate change. I propose to explore this relationship at the Lubrecht Experimental Forest through analysis of historic precipitation records (NRCS SNOTEL sites), biologic inventories of tree ring growth rates, and hydrologic monitoring.

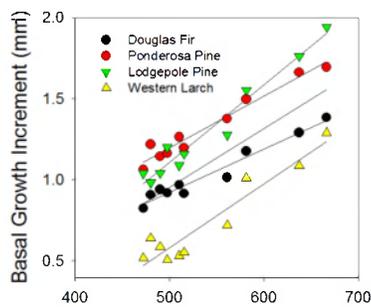
My project seeks to understand how watershed structure may impact water accumulation patterns and the resulting resilience of forests to changing precipitation regimes (climate). I hypothesize that watersheds with high topographic convergence may lead to more water accumulation and therefore less potential for water stress to plants during the growing season. Spatial patterns of vegetation growth may be predictable based on this relationship of terrain and water availability. Wetter landscapes characterized by regions of high convergence may create areas less sensitive to global climate change. Testing this hypothesis will help guide the development of mitigation techniques applicable to Rocky Mountain forests that are experiencing earlier snowmelt and decreased annual precipitation. By quantifying biomass growth with width and density of tree-ring core growth, we will develop on the ground records of past response to climate change. Coupling this data with field observations of groundwater flow and GIS analysis we can begin to determine the importance of water accumulation to annual growth rates as a function of topography.

JUSTIFICATION

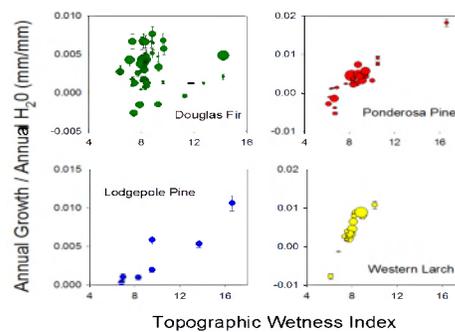
The purpose of this study is to fully understand this watershed behavior in the context of hydrology, climatic change and forestry. Forests in Montana supply essential timber products used throughout Montana and across the western United States. Countless jobs and substantial revenue come from Montana's national and state forests annually. The effects of climate change on water availability at a local level are not well understood, nor how these relationships translate to the Rocky Mountain watersheds as a whole. Analyzing and understanding these changing meteorological conditions is fundamental to supporting forest productivity and maintaining both a healthy ecological system, as well as economic stability.

METHODOLOGY

- Analyze preliminary tree-core/topographic index data from LEF (Jencso et al., in prep)
 - Continue to quantify the relationship between annual precipitation and basal tree ring growth rates (Figure 1)
 - Compare the basal growth rates to watershed metrics that represent water accumulation and redistribution patterns such as the Topographic Wetness Index (Figure 2)
- Use GIS to create maps and distributions of the Topographic Wetness Index in the LEF
 - Use this data to strategically choose relevant areas for further tree core sampling
 - Focus on the spectrum of TWI values (high to low) to ensure experimental heterogeneity
- Extract tree-cores from areas of topographically high convergence and low convergence to test the hypothesized relationship
 - Analyze the characteristics of tree ring annual growth (width and density)
 - Determine differences in growth rates based on high to low convergence setting
 - Compare growth rates to known annual precipitation values from nearby climate stations (SNOTEL)
- Place wells in areas predicted to have diverse and differing wetness conditions
 - Use wells to monitor and quantify shallow soil saturation (water tables)
 - Analyze soil moisture characteristics and compare to Topographic Wetness Index predictions
- Quantify hydrologic connectivity of hill-slopes with different TWI values:
 - Measure this relationship with well groundwater flow data following differing topographic convergence paths (where wells will be placed)
- Describe relations, study results and make conclusions



(Figure 1) Annual Precipitation (mm)



(Figure 2)

By conducting this research we hope to describe the relationship of (a) topographic controls on hydrologic processes, (b) climate change effects on Rocky Mountain watershed systems and (c) biomass growth responses to these variables. The implications of this study can be extrapolated to similar Rocky Mountain watershed catchments and could be used to develop proper forestry mitigation techniques. With an ever-changing global climate this research is imperative to maintain forest productivity and sustain those who depend on it.

TIMELINE:

- JUNE 2013
 - Develop GIS Topographic Wetness Index Maps
 - Conduct well emplacement
 - Develop spatial distribution plan for tree-core sampling
 - Begin sampling
 - Begin sampling of tree-cores
 - Begin soil wetness measurements and correlate to GIS data
- JULY 2013
 - Continue sampling
 - Extract majority of tree-cores for later data processing
 - Continue soil wetness measurements
 - Begin water depletion tests
 - Quantify how topographic convergence relates to water availability
 - Explore hydraulic conductivity of soil across differing hill-slopes
- AUGUST 2013
 - Conclude sampling
 - Extract final tree-core samples
 - Finish soil wetness measurements
 - Describe hydrology within the soil
 - Describe relationship of conductivity, saturation and approximate flow directions
 - Begin data processing
 - Begin to extract volumetric and density data from tree-cores
 - Analyze temporal and physical data from tree-cores
 - Compare data to SNOTEL data
- SEPTEMBER – DECEMBER 2013
 - Conclude data processing
 - Analyze data and describe results in a technical report/manuscript
 - Create physical presentation material
 - Present results at the AGU (American Geophysical Union) in San Francisco, California (Fall meeting)

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EDUCATION

Bachelors of Science – International Field Geosciences 2013 (Anticipated)
University of Montana & University College Cork, Ireland

GIS Training 2012
Universität Potsdam, Deutschland (University of Potsdam, Germany)

FIELD AND RESEARCH SKILLS

- Extensive Field Geology
- Field Sampling
- Extensive Geologic Field Mapping
- Research in Hydrology
- Hydrologic Monitoring
 - Echo Sounder
 - Piezometer
 - Well Emplacement
- Project Completion and Awards (UMCUR 2011)
- GPS – (Global Positioning Systems)
- GIS – (Geographic Information System)
- Aerial Photo & DEM (Digital Elevation Model) Analysis
- Extensive Excel Experience
- Total Station Surveying
- Sediment Coring (Lake Mary-Ronan)
- Computer Science (Coding in C++)
- Presentation Experience

FIELDWORK/RESEARCH EXPERIENCE

Department of Geosciences – Watershed Hydrology 2013 - Present
- GEOMETRIC CORRECTION OF SHORTWAVE RADIATION MEASUREMENTS OVER COMPLEX TERRAIN FOR USE IN HYDROLOGIC MODELS (UNIVERSITY OF MONTANA) – DR. MANETA (ADVISOR)

Department of Geosciences – Metamorphic Petrology 2012
-METAMORPHIC ASSEMBLAGES, CONTROLS AND PROTOLITH IMPLICATIONS, MAFIC/FELSIC INTERACTIONS AND EVIDENCE FOR FAULT REACTIVATION IN THE NW BRITISH CRUST (UNIVERSITY COLLEGE CORK, IRELAND) – DR. REAVY (ADVISOR)

Department of Geosciences – Sedimentology 2011
- SOUTHWARD SEDIMENT TRANSPORT OF THE PANTHER TONGUE PALEODELTA AND ITS CAUSES (UNIVERSITY OF MONTANA) – DR. HENDRIX (ADVISOR)