DeVlieg Undergraduate Research Proposal

Exploring Climate Effects on Coniferous Seedling Regeneration in Burned Areas in Central Idaho

Pinus ponderosa seedling

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Abstract

Higher temperatures and the redistribution of precipitation have influenced the northern Rockies in recent years. These climatic changes could alter the distribution and abundance of important tree species. Frequently burned, or disturbed, landscapes offer the best chance to monitor and analyze the regeneration dynamics of tree seedlings through time. The Frank Church-River of No Return Wilderness (FC-RNRW) possess some of the most suitable and least anthropogenically tainted environments for observing changes in the distribution of conifer stands through time due to a rich history of frequent forest fires. Douglas-fir (*Pseudotsuga menziesii)*, ponderosa pine (*Pinus ponderosa),* and lodgepole pine (*Pinus contorta)* are the dominant tree species at low to mid-elevations in the wilderness. This project aims to compare the regeneration of coniferous seedlings following older fires to regeneration on more recently burned low elevation areas in FC-RNRW. Ultimately, this study will identify whether recently burned low to mid elevation conifer habitats are regenerating in similar time steps compared to older forests that established post-fire.

Introduction and Background

The current trend of increasing concentrations of greenhouse gases leads to higher atmospheric temperatures (IPCC 2007). Increasing annual temperatures are evident at Taylor Ranch from 1976-2006 (Figure 1). Warmer than average temperatures not only have direct heat related effects on vegetation, such as causing heat lesions, but also indirect effects by decreasing the amount and duration of the snowpack leading to low soil water availability in the growing season. This is especially true of the climate in Central Idaho, where precipitation is limited during the summer months. Emerging seedlings in which transpiration is limited by soil water have a reduced capacity for stem cooling, therefore increasing heat stress and mortality (Kolb and Robbrecht 1996). Thus, the compounding effects of drought, high temperatures, and evaporative demand can cause high rates of seedling mortality (Kolb and Robbrecht 1996). Much research is being performed to examine the possible effects of a warming climate on vegetation distributions along altitudinal and longitudinal scales (Miller and Urban 1999, Germino et al. 2002, Hessl and Baker 1997). However these studies focus on trees moving into alpine environments and devote little attention to possible changing regeneration patterns at low to mid-elevations, which historically have received less precipitation.

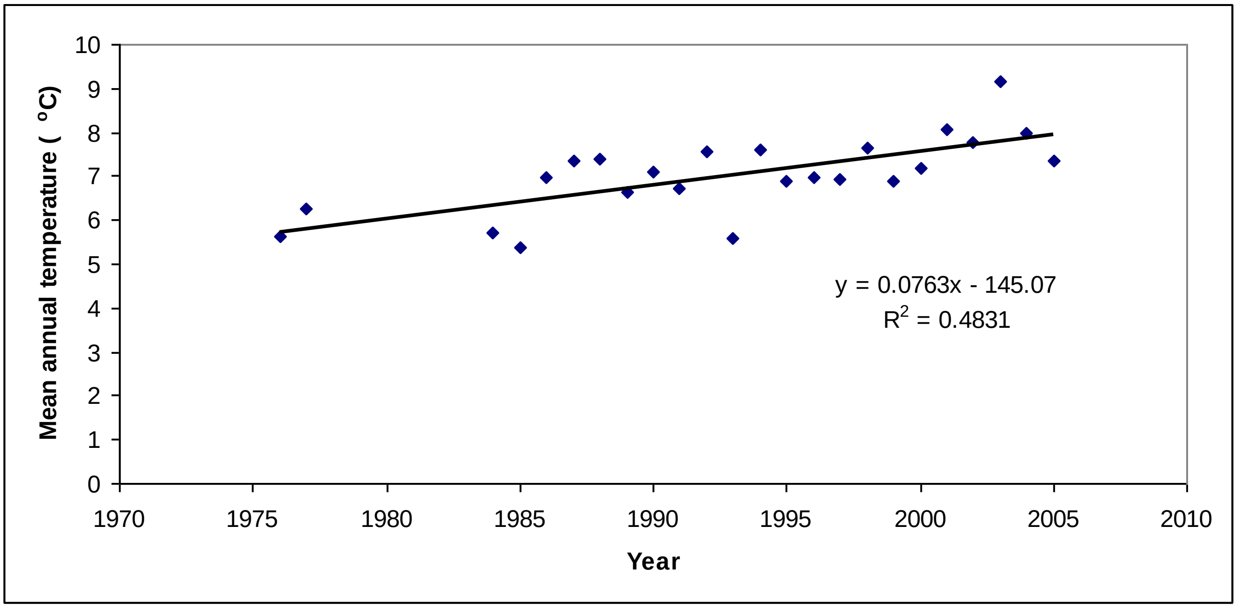

Figure 1. Average annual temperature at Taylor Ranch, Frank Church River of No Return Wilderness. In spite of high annual variability there is a trend of increasing annual temperature over this time 30 year time period.

Analyzing possible forest responses to climate change is a long term process. Mature trees must first die off, opening up the canopy, to create opportunities for species level changes during regeneration. Disturbances can provide an increased rate of forest response and allow new establishment opportunities for vegetation (Overpeck 1990). These opportunities come in the form of gap mosaics offering more available light and resources for regeneration (Reader et al. 1995). By examining regeneration patterns following disturbance it may be possible to detect changes due to climate that are not yet evident in older established forests.

Wildfires, both natural and human caused, are a common form of disturbance in the coniferous forests of Idaho. The accelerated arrival of spring (Cayan et al. 2001) has resulted in a 30% decline in the snowpack water content (Mote et al. 2005) and an increase in fire season length and increasing fire threat in central Idaho (Westerling et al. 2006). This combination of increased fire frequency coupled with a decline in soil moisture due to reduced snowpack duration may lead to more rapid changes in forest vegetation.

This project will concentrate on possible climatic effects on the young, developmental stages of tree establishment. Emergent seedlings are considered an ideal life stage to monitor because they are more sensitive indicators of climate change than mature trees due to their inability to cope with abiotic factors that lead to higher mortality in the first years of growth (Germino et.al. 2002). A lack of tree regeneration following a disturbance can be caused by three main factors; 1) no viable seed available 2) conditions are not favorable for germination or 3) seedlings are unable to survive once germination occurs. This study focuses on the third factor.

The research will be based out of the University of Idaho's Taylor Ranch Field Station in the Frank Church-River of No Return Wilderness (FC-RNRW) in rugged central Idaho. FC-RNRW encompasses over 2.3 million acres. With historic habitat suitable for conifer stands and a rich fire history, the landscapes around Taylor Ranch will provide ample opportunities for this research (Figure 2 and Table 1).

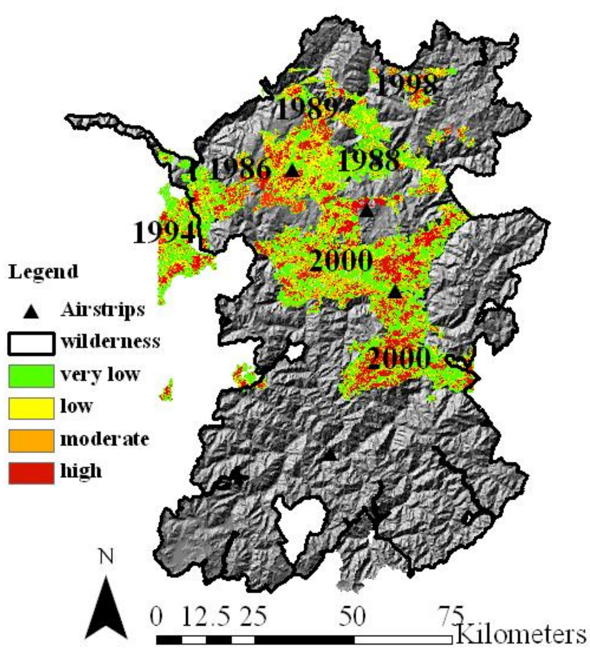

Figure 2. Burned area and severity within the northern half of the Frank Church Wilderness. Date represents year of the fire.

Table 1. Fire year, number of fires that occurred each year, and area burned within the northern half of Frank Church Wilderness

Year	**# of Fires**	**Hectares Burned**
1986	2	7,684
1988	6	51,230
1989	2	1,280
1990	3	3,204
1991	2	3,800
1994	2	44,900
1998	3	65,610
1999	4	4,300
2000	5	161,600

Research Objectives and Hypotheses

There are three objectives for this research:

(1) Quantify the difference in post-fire seedling establishment rates between older forests and more recent burns. Determine if the newly emergent stand is regenerating over a significantly longer time period relative to stand it is replacing and adjacent unburned areas.

(2) Quantify the mortality of natural emergent seedlings and several year old seedlings over the course of a growing season.

(3) Monitor success of emergent seedlings that are given supplementary water over the course of a growing season.

I will be testing one encompassing hypothesis in this research. I hypothesize that these low to mid-elevation, recently burned sites will have lower rates of regeneration relative to similar sites in older fires. To test the hypothesis, I will gather information to reject the following null hypothesis:

H_o: Regeneration of coniferous seedlings in recent burns is not significantly different from older burns.

Research Methods

In order to focus on climate effects, sites with historically ecologically suitable habitat for conifer regeneration will be selected. Post-fire seedling density is greatest after moderate to low severity fires with significantly fewer seedlings present in high severity burns (Chappell et al. 1996). In order to eliminate seed source as a possible limiting factor, we will select sites that had low-moderate intensity fires to ensure that some seed-bearing trees are still available. Historical fire maps that include year of fire and fire severity layered onto geographic information systems software (Figure 2) will be used to choose regions to sample from. Actual transect locations will be randomly chosen once the site is visited. The initial sampling will be focused on areas that burned in the mid to late 1980's to comprise our older burns and sites that burned in the early 21st century to be our more recent burns. In addition, we will attempt to document the regeneration patterns of the forest stand that burned by coring snags and live trees that survived the fires.

Research sites will be located at elevations between 750 m (2460 ft) and 2000 m (6562 ft), considered low to mid elevations for a mountainous environment like FC-RNRW. Potential seedbed will also be taken into account. Rocky, thin soils will inhibit regeneration so plots will only be positioned on sites with adequate soil for seedling establishment. The locations sampled at each fire site will be Northeast to Northwest aspects in areas that historically had contiguous forests and where there is currently a seed source within 50 m of the transect. We have also arranged to overlap our study sites with Jim Peek's vegetation plots near Taylor Ranch. Dr. Peek has agreed to share his locations with us and provide us with data from his plots that had a forest canopy prior to the 2000 fires.

At each location, sampling will occur along 100 m transects parallel to the hill slope. 50 m^2 circular plots (4 m radius) will be taken every 20 m along each transect. In order to infer differences in post-fire seedling regeneration, species size and abundance of emergents, seedlings, and saplings will be recorded in each plot. Guidelines similar to those established by Germino et al. (2002) will be followed. Emergents are newly germinated shoots in their first year of growth; seedlings are older than one year, but less than 7 years and less than 5 cm in height while saplings are older and larger individuals. Mature trees that survived the fires will also be recorded. If newly emerging conifer germinants are present, a 1 m square plot will be used to monitor the seasonal mortality rate of the emerging germinants and seedlings within the plot. Each emerging germinant will be flagged in the spring and revisited several times over the summer to assess survival.

At sites with many germinants present, groups will be randomly chosen to receive supplementary water throughout the growing season. These seedlings will be flagged and condition and mortality will be monitored over the summer. If too few germinants are present, seed taken from a local seed source will be planted on a Taylor Ranch site and a subset will be watered throughout the summer. We have obtained some local seed from Breezy Jackson. Breezy set out litter traps in 2005 along three tributaries of Big Creek. We will use her data to estimate seed fall rates in low, moderate and severely burned areas as well as test the seed for viability.

To determine the past regeneration patterns at each site, increment cores will be taken on trees that survived the recent fire and sound snags where possible. Through core sample analysis of tree age the timing of regeneration of the previous stand will be quantified at each sample site. This data can then be used to compare relative time periods and patterns of the previous stand regeneration to the current regeneration regime.

The climate data collected from Taylor Ranch Field Station from 1976 to present day will be used to parameterize an ecosystem process model, Biome BGC, to simulate 30 year changes in leaf area index (LAI), and net primary productivity associated with observed climate changes. This data will be compared to the field data to see if trends predicted by the model match the field observations. Data used will include daily maximum and minimum daily temperatures and precipitation.

Broader Impacts

The coniferous forests of Idaho are incredibly important, not only economically, but ecologically. In FC-RNRW conifer stands provide many valuable benefits to the ecosystem including habitat for animals, stabilization of hillsides, and precipitation interception and retention. Investigating old burns and the subsequent seedling establishment is important in judging the state of current seedling recruitment in more recent burns. This project is relevant because if current climate trends continue we may see a shift in coniferous tree regeneration success thus altering current plant communities. Secondly, we may see losses in overall forest biomass due to high seedling mortality in previously forested areas. Also these shifts may have immeasurable affects on natural ecosystem processes such as wildlife population dynamics and seral succession patterns. By examining old and new burn seedling recruitment at low to mid elevations, this project may draw critically important conclusions about vegetation redistributions that our changing climate is affecting across a dynamic spatial and temporal landscape.

<u>Timetable</u>

February – May 2008:	Continue thorough background research into project.
	Continue meeting with Dr. Kavanagh every week to discuss relevant literature, models, and sampling protocol.
	Assemble research equipment and tools.
	Create and organize data collection paperwork.
	Coordinate travel plans with Jim and Holly Akenson
May – August 2008:	Carry out field data collection. (Work will begin as soon as classes end in May to explore area for emergent seedling prior to the onset of hot spring/summer weather)
August – December 2008:	Enter data and carry out statistical analyses.
December – April 2009:	Organize and write report to be submitted.
April 2009:	Submit and present final results to C.N.R. as part of the ECB undergraduate Thesis Program.

Description of Faculty Support

Dr. Katy Kavanagh has agreed to be my faculty advisor for this research. Dr. Kavanagh's research emphasis includes both forest regeneration and fire ecology. She has studied the causes of seedling mortality and the physiological processes influencing tree establishement. In addition, she has worked on fire effects in central Idaho and is familiar with the model we will use to explore climate change impacts. Dr. Kavanagh will assist in field work including sampling design and logistics. She will also help by parameterizing Biome BGC, analyzing data and providing some field supplies. Dr. Zach Holden will also be assisting on this project. He has been instrumental in the identifying the areas burned and providing me with the expertise to do the GIS analysis for this project

Budget

Travel (Moscow to Taylor Ranch, Taylor Ranch to backcountry airfields, jet boat to sites)	$500
Food ($10/day * 9 weeks)	$450
Student Stipend ($7.50/hr. * 9 weeks)	$2700
Research Equipment (increment borers, GPS, grids, meter tape)	$700
TOTAL -	**$4350**

Literature Cited

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Image courtesy of www.bentler.us/.../plants/trosa.aspxees/ponder

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Westerling A.L., Hidalgo H.G., Cayan D.R., and Swetman T.W. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science 313: 940

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EDUCATION

University of Idaho – Moscow, ID

- Pursuing B.S. in Natural Resource Ecology – Conservation Biology
  Expected Date of Graduation: **May 2009**

Rogers High School – Rogers, AR

- Graduated with 3.8 GPA **May 2005**

PROJECTS

- **Palouse Soil Property Assessment** - Measured and calculated soil physical properties to determine differences in biological characteristics of two soils found in the Palouse region of Idaho/Washington.
- **Potlatch Creek Habitat Survey** - Classified stream type and performed a survey identifying quality and health of microhabitats available to fish and macroinvertebrates in several stream reaches.
- **Carbon Concentration Effects on Forest Productivity** – Analyzed global climate shifts effect on tree productivity using Biome-BGC modeling.
- **Upland Restoration Practices Evaluation** - Assessed effectiveness and feasibility of riparian and upland restoration applications on Asotin Creek, WA.

WORK EXPERIENCE

***Receiving*, Northwest River Supplies** **August 2005-Present**

- Responsibilities involve receiving and managing inventory
- Clean and refurbish returned rafts and kayaks

***Shipping and Receiving*, Ozark Rescue Suppliers** **February 2001-July 2005**

- Maintained the accurate and timely shipping of orders and ensured items were ordered, received and put into stock

SCHOLARSHIPS

- Eubanks Excellence Scholarship
- UI Achievement Scholarship
- Rogers Development Foundation – Waste Management Scholarship

VOLUNTEER ACTIVITIES

- Prescribed burning, invasive species surveys, and general maintenance at Hobbs State Park-Conservation Area, Rogers, Arkansas
- Trail building and maintenance with Moscow Area Mountain Bikers (MAMBA)
- Restoration and preservation of Moscow area streams with Palouse-Clearwater Environmental Institute (PCEI)
- University of Idaho Environmental Club
- Community recycling advocate

SPECIAL SKILLS

- Proficient in orienteering
- Backcountry travel and survival experience
- Wilderness first aid trained

COURSE HIGHLIGHTS

Soil Ecosystems, Forest Ecosystem Processes, Systematic Botany, Riparian Ecology, Fish Ecology, Watershed Science, GIS Primer, Population Dynamics, Wildland Restoration Ecology

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DeVlieg Foundation
Research Selection Committee
CNR

February 7th, 2008

Dear Committee Members,

I am writing this letter in support of Eric Clippinger's undergraduate research proposal "Exploring Climate Effects on Coniferous Seedling Regeneration in Burned Areas in Central Idaho". I met Eric in the Fall of 2007 when he was a student in my Forest Ecosystem Processes class. Eric was a good student in the course and showed an interest in continuing to explore the ecosystem concepts we covered in class. The semester project involved the students modeling the impact of various climate scenarios using Biome BGC. Several of the scenarios predicted a reduction in the amount and productivity of conifer forests. Eric and I discussed how to test the model outputs and I suggested he apply for a DeVelig Undergraduate Research Grant to explore post fire regeneration patterns in low-mid elevation forests. Eric never looked back. He began working on this as soon as the Fall semester ended and quickly demonstrated the ability to grasp complex concepts, read and comprehend primary literature, participate in preliminary modeling and GIS mapping and tie it all together in a proposal. The results of Eric's effort are presented in the attached proposal.

I am excited by this research for several reasons.
1) Recent papers have predicted that fire frequency and intensity will increase in central Idaho and that climate change will cause shifts in dominant species with parts of central Idaho shifting from conifer dominated to grasslands. The work being proposed by Eric will enable us to explore if species shifts are currently occurring and will establish a baseline for future long-term research.
2) The current and historic regeneration data created by this project will be used in my undergraduate and graduate courses to explore potential impact of climate change coupled with fire.
3) Almost 30 years of Taylor Ranch climate data are now in format that is readily available for use in Biome BGC and can be used in future student projects in several CNR courses and other research projects.
4) This project has the potential to be published in the scientific literature and to be presented at several national scientific meeting such as the Ecological Society of American Annual Meeting and American Geophysical Annual Meeting.
4) Eric's enthusiasm for this project is remarkable. He has met with me regularly to work through the process of proposal development and has never been overwhelmed by the scientific

concepts and logistical challenges. His strong interest and motivation will make it highly likely that this project will be completed in an accurate, timely and thorough manner.

My contributions to this project will bring added value. I am willing to spend time in the field with Eric to work out final logistics and experimental design. In my experience, even the best plans made in the comfort of our offices may not be realistic once one get to the field so it is important that the mentor be there at the initiation of the project and that they check in regularly during the summer. In addition, I am willing to provide some field equipment and other supplies required by Eric. This includes a second increment borer, field vest, temperature sensors, and 1m sample grid. Finally, I see this project as the beginning of a more comprehensive project exploring regeneration patterns and shifts in carbon uptake and forest productivity in the Frank Church wilderness. I am currently working with Zach Holden (UI) and Jenn Pierce (BSU) on a grant to expand this work in space and time.

Please let me know if you have any further questions. I look forward to spending time at Taylor Ranch and in the Frank Church.

Sincerely,

Katy Kavanagh
Forest Resources
College of Natural Resources
University of Idaho