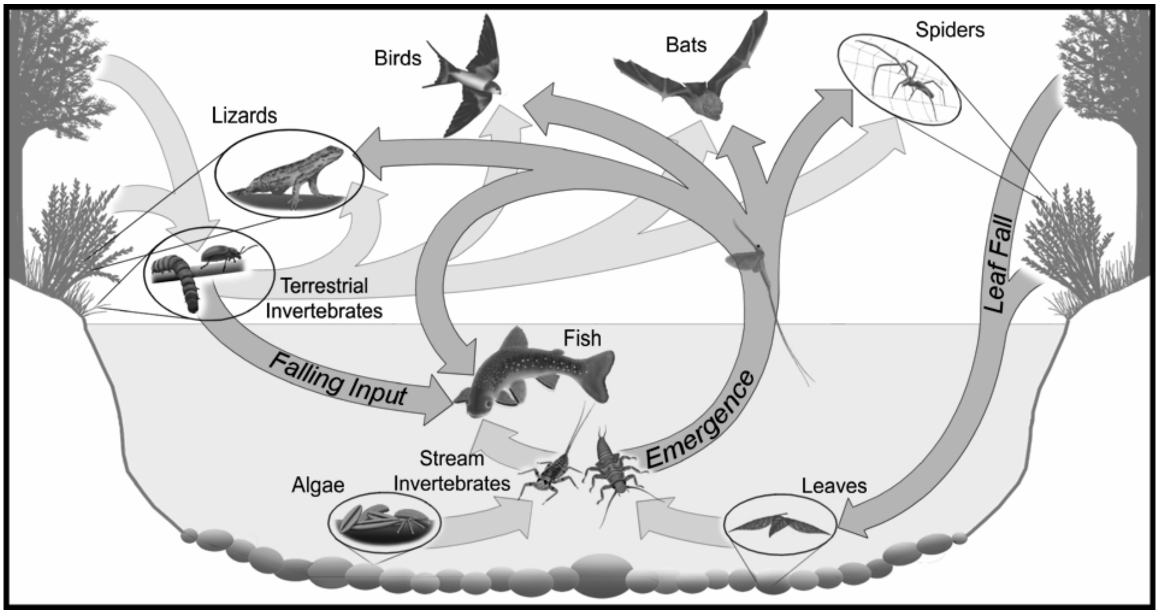
RIPARIA: INFLUENCE OF FIRE ON STREAMSIDE VEGETATION AND RIPARIAN-STREAM FOOD WEBS IN A WILDERNESS SETTING



Source: Baxter et al. 2005

A Research Proposal to the UI DeVlieg-Taylor Ranch
Graduate Research Fellowship Program

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Abstract

Riparian and stream ecology represent innovative fields of ecological research, yet few studies have explored the impacts of fire on riparian vegetation or the dynamic linkages between riparian-stream food webs in wilderness settings. This study is designed to take advantage of the fire-dominated landscapes of the Big Creek Basin (Frank Church-River of No Return Wilderness) and explore these research topics in relation to the continuum of environmental conditions associated with stream size, fire history and intensity. More specifically, this study will quantify: 1) spatial/temporal patterns of riparian plant succession along fire-impacted streams, 2) influence of species composition and structure in fire-impacted landscapes on the nature and timing of allochthonous (i.e. terrestrial) inputs to stream environments, and 3) riparian-stream food web linkages (see title page figure). Further, we propose to mesh our research on riparian environments with the long-term stream ecology studies of Dr. G.W. Minshall (1988-2004) and recent ecological studies proposed by Dr. C.V. Baxter (ISU-Dept. of Biological Sciences). Collectively, these UI/ISU research efforts will establish a framework for organizing long-term ecosystem studies within the Big Creek Basin.

Introduction

Despite the importance of riparian areas to the ecology of western landscapes and the recognition of fire as a critical natural disturbance, few studies have investigated the influence of natural fire upon riparian and aquatic ecosystems (Bisson et al. 2003, Dwire and Kauffman 2003, Rieman et al. 2003). Riparian corridors are highly dynamic linkages between terrestrial and aquatic environments, and differ from these environments in a variety of ways: 1) composition and structure of plant and animal communities, 2) hydrology and soil moisture, 3) microclimate, 4) geomorphology, and 5) natural fluxes/transport of energy and materials (Dwire and Kauffman 2003). Collectively, these features result in unique fire environments (Multiple authors, Special 2003 Issue of Forest Ecology and Management), which mediate the influence of natural fires on aquatic ecosystems (Minshall 2003, Spencer et al. 2003). Riparian vegetation also determines the nature of allochthonous (i.e. terrestrial) inputs to their adjacent stream environments (Vannote et al. 1980), yet the spatial scale at which riparian vegetation influences this flux of plant material and terrestrial invertebrates remains unclear (Baxter et al. 2005, see title page figure). We can easily imagine that the species composition and structure of riparian plant communities is an important variable in regulating these fluxes, yet few studies of stream and riparian environments have undertaken this level of detailed inquiry. Further, the importance of riparian-stream food web linkages has received very little attention (Nakano et al. 1999, Baxter et al. 2005) and represent a unique opportunity to understand the functional linkages between riparian and stream ecosystems in a wilderness setting.

Overall, we intend to study the dynamic nature of riparian-stream interactions in the fire-dominated landscapes of the Big Creek Basin. We believe this proposal represents a critical realm of disturbance ecology whereby an innovative and highly integrated study design will yield novel ecological findings. This research will also help establish an interdisciplinary framework for organizing long-term ecosystem studies within the Big Creek Basin.

Research Objectives/Hypotheses/Methods

Objective 1: To quantify the species composition and structural complexity of riparian vegetation in burned and unburned tributaries of the Big Creek Basin.

Question for Objective 1
How does species composition and structure of riparian vegetation differ in relation to stream size, fire history and intensity?

H_0: Species composition and community structure will not significantly differ between burned and unburned tributaries, nor between stream order.
H_1: Species diversity will vary with stream order, fish history and intensity, with differences related to temporal/spatial components of environmental variation.
H_2: Total plant cover will decline with fire intensity.
H_3: Complexity in the structure of riparian plant communities will increase in relation to the diverse fire histories of a given stream corridor.

Methods: Riparian vegetation will be sampled at: 1) existing study sites (Cliff and Cave Creeks [Intense burn], Rush and Pioneer Creeks [Cooler-Wet Burn], Goat and Cougar Creeks [Unburned]) of Dr. Minshall within the Big Creek Basin (Figure 1) and 2) additional sites within the Big Creek Basin (i.e. Burnt, Doe [65 yr old fire] and Lewis Creeks) selected in consultation with Drs. Minshall/Baxter to achieve sufficient study replication (minimum of n = 3 per stream size and fire intensity, yielding a total of 18 different study sites), and which also captures the continuum of environmental conditions associated with stream size, fire history and intensity within the Big Creek Basin. Our goal will be to integrate riparian vegetation data collection with long-term stream ecology dataset of Dr. G.W. Minshall and ecological studies proposed by Dr. C.V. Baxter.

Riparian vegetation on both sides of the channel will be sampled at three locations per study site (i.e. upper, middle and lower sections of the stream study reach). Riparian plant species composition and community structure will be quantified by: 1) Point-line intercept methods - 30 m linear transects perpendicular and parallel to stream channel (n = 6/site), and 2) Tree plots (n = 3/site; rectangular plots of either 5x20m or 10x25m with long-axis parallel to the stream channel, plot size will depend upon overstory size class and valley width) with nested shrub and herb subplots (2 x 4m and 1x1m, respectively) located in tree plot corners (n = 24/site). Point intercepts of herbaceous species, litter type/class and substrate class will be recorded at one meter intervals along each transect line. The intercept of the transect line by tree and shrub species will be recorded to the nearest 5cm and 1 cm, respectively. In tree plots with their nested shrub and herb subplots, estimates of plant cover will be obtained for all plant species (grasses, forbs and woody plants). Stem counts, diameters at 0.25 m and age-class determinations (cores collected at 0.25 m) will be obtained for dominant overstory species. A permanent metal stake (i.e. rebar) will be placed at the end of each transect line and the location recorded using a Trimble GPS Pathfinder ProXRS (sub-meter resolution, Trimble Navigation Inc., USA). Tree plot corners will receive similar documentation. Collectively, these methods follow general sampling protocols of Mueller-Dubois and Ellenburg (1974), Goldsmith et al. (1986), Auble et al. (1994), Johnson et al. (1994, 2000) and Braatne et al. (2005a,b).

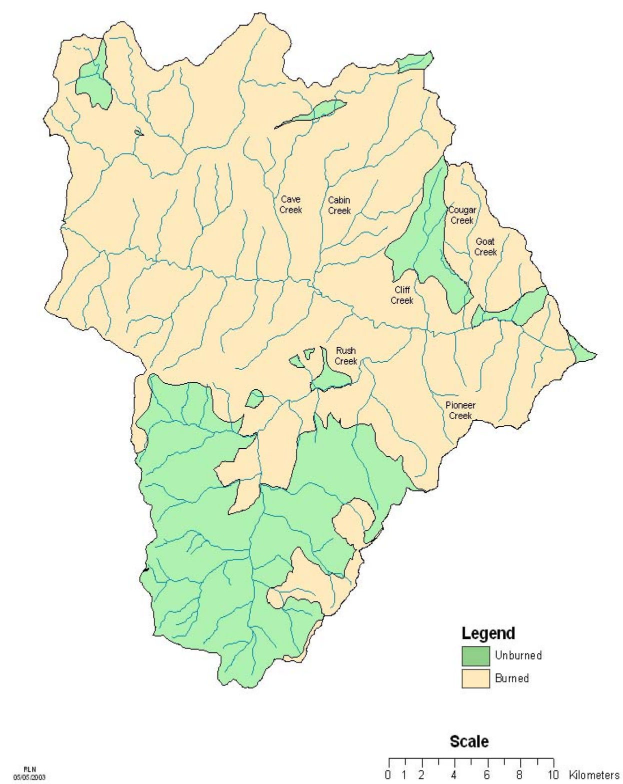

Figure 1. Location of Lower Big Creek Basin Study Sites (*Source: Minshall et al. 2003)*.

The percentage of stream channel area with tree canopy cover will be estimated with a spherical densiometer in the center of the stream channel adjacent to all study plots/transects. Structural attributes of the shrub-layer and overstory canopy will also be quantified following the protocols of Johnson et al. (1995) and Minshall and Rugenski (In Prep) to promote the integration of riparian vegetation data with future wildlife studies (bats, birds, native ungulates, etc) proposed by other research scientists.

Riparian vegetation parameters (species richness/nearest-neighbor analyses/etc) will be also assessed/verified using hyperspectral imagery (Summer 2002). This remote-sensing imagery of the Big Creek Basin was acquired by the PI in collaboration w/Drs. G.W. Minshall and C.R. Peterson to document riparian vegetation patterns following the extensive fires of the 2000 growing season. Preliminary analysis of riparian vegetation using this imagery was recently completed by Richardson & Minshall (2004). This imagery will also be used to analyze fire intensity in order to extend our studies to lower and higher order tributaries within the Big Creek Basin.

Objective 2: To compare allochthonous inputs of organic matter (plant materials and terrestrial invertebrates) between burned and unburned tributaries of the Big Creek Basin.

Questions for Objective 2
i) How do allochthonous inputs of organic matter (plant materials and terrestrial invertebrates) differ in relation to stream size, fire history and intensity?

H_0: Quality and quantity of allochthonous inputs do not differ significantly between burned and unburned tributaries, nor between stream order.
H_1: Quality and quantity of allochthonous inputs differ significantly between burned and unburned tributaries, regardless of intact riparian vegetation.
H_2: Biomass of allochthonous inputs are higher in unburned than burned tributaries, yet quality (i.e. nitrogen, C:N ratios) is lower**.**
H_3: Fire intensity and history (time interval between fire events) are the primary variables influencing the quality and quantity of allochthonous inputs.

ii) How does species composition and structure of riparian vegetation influence the composition and biomass of allochthonous inputs (plant and terrestrial invertebrate)?

H_0: Species composition of allochthonous inputs (plant and invertebrate) do not differ significantly between burned and unburned tributaries, nor between stream order.
H_1: Allochthonous inputs of coarse particulate organic matter are greater in unburned tributaries, regardless of intact riparian vegetation or stream order.
H_2: Species diversity and biomass of allochthonous inputs of terrestrial invertebrates is greater in unburned tributaries.
H_3: Species diversity and magnitude of allochthonous inputs of terrestrial invertebrates is positively correlated with the diversity and structural complexity of riparian plant communities.

Methods: All of these study parameters will be measured at the same study sites as outlined for Objective 1. Percentage of the wetted channel with cover (i.e. LWD, overhanging vegetation, large boulders) as well as the percentage of the stream bottom covered by leaves will be estimated visually to the nearest 5% (England and Rosemond 2004). Relative abundance of organic matter in relation to pool and riffle habitats within the study reach, in terms of total reach length, will also be recorded.

Terrestrial invertebrate fall into the stream at each site will be quantified using pan traps placed in the stream channel slightly above the water surface. Six pan traps located adjacent to sampled tree plots (each with surface area of approximately 0.1 m^2) will be placed in each study reach. Pan traps will be partially filled with soapy water and kept open for 24 hours. All terrestrial invertebrates will be preserved in 95% ethanol for transport to the laboratory. Following sorting, all invertebrates will be counted, identified to genus or species, and their length recorded to the nearest 1 mm. Biomass of terrestrial insects will be determined using published taxon-specific length-weight relationships (Wipfli 1997).

Leaf fall into streams will be captured by leaf litter traps within riparian plant communities and fine-mesh nets spread across the stream channel (Minshall and Rugenski In Prep). Benthic CPOM samples will be obtained from the Surber samples at each site after insects have been removed (by Drs. Baxter and Minshall study teams). CPOM will be separated from fine particulate organic matter (FPOM) using a 1-mm sieve, and then sorted into woody and non-woody fractions. Samples will then be dried and ashed to determine ash-free dry mass (AFDM). Leaf fall and benthic CPOM abundance per unit area will be expressed on a reached-based, habitat-weighted basis.

Nitrogen and C:N ratios of allochthanous inputs will be obtained during the course of carbon and nitrogen stable isotope ratio determinations (UI Stable Isotope Ecology Lab)

<u>UI/ISU Objective 3</u>: Use stable carbon and nitrogen isotope ratios to compare riparian-stream food webs between unburned and burned tributaries of the Big Creek Basin. (**Note:** This represents a broad, interdisciplinary effort combining the talents and research interests of Drs. Braatne, Baxter, Delahanty, Minshall and Peterson, among others.)

i) How do riparian-stream food webs (see title page figure) differ between burned and unburned tributaries, and how are these differences reflected in the stable isotope signatures of aquatic and riparian biota?

- **H_0**: Riparian-stream food webs do not differ significantly between burned and unburned tributaries, nor between stream order.
- **H_1**: Allochthonous carbon sources make a larger contribution to the diets of aquatic and riparian biota in unburned than burned tributaries.
- **H_2**: Dependence on allochthonous carbon sources does not differ significantly between unburned tributaries and burned tributaries with intact riparian vegetation.
- **H_3**: Average trophic position of aquatic and riparian biota will be greater in unburned than burned tributaries.

<u>Methods:</u> All of these study parameters will be measured at the same study sites as outlined for Objectives 1 & 2, with data collected in close collaboration with Drs. Baxter, Delahanty, Minshall and Peterson. Relative contributions of autochthonous (in-stream primary production) and allochthonous (terrestrial) carbon sources to the diets of aquatic and riparian biota will be estimated using carbon stable isotope ratios and the following two-source mixing model from Doucett et al. (1996):

$$\%\ \text{allochthonous} = \left(\frac{\delta^{13}C_{\text{fish}} - \delta^{13}C_{\text{autochthonous}} - fx}{\delta^{13}C_{\text{allochthonous}} - \delta^{13}C_{\text{autochthonous}}} \right) \times 100$$

with $fx = +.2‰$, the average trophic fractionation value reported for freshwater ecosystems by France and Peters (1997). Average $\delta^{13}C$ values for leaf litter, biofilm, and fish can be used as mixing model endpoints and consumer values, respectively. The Iso-Error spreadsheet developed by Phillips and Gregg (2001) will be used to obtain 95% confidence intervals for the mixing model estimates. Similar methods will be followed in the analysis of stable nitrogen isotope ratios, with the stable isotopic ratios of nitrogen serving as a surrogate measure of trophic position for different aquatic and riparian biota.

The gut contents of amphibians, birds and fish collected for stable isotope analysis will be analyzed using a dissecting microscope (assuming permission can be obtained for collecting these types of samples from rare/listed species). Although gut content analysis only reflects diet at the time of capture, it can be used to complement and verify stable isotope analysis results. This data may also offer insights on whether the diet of individuals of the same species inhabiting stream reaches with different riparian vegetation conditions change significantly.

Rationale/Significance: As previously noted, few studies have explored the impacts of fire on riparian vegetation or the dynamic linkages between riparian-stream food webs. The proposed research will thus provide novel insights into the dynamic nature of terrestrial-aquatic linkages in fire-dominated landscapes. Further, the significance of our findings will be heightened by conducting this research within a wilderness setting. There are other important venues of scientific inquiry whereby the proposed study findings can be analyzed in relation to recent experimental studies and theoretical models: 1) reciprocal linkages between stream and riparian food webs (Nakano et al. 1999, Baxter et al. 2005) and 2) non-random environmentally-mediated impacts on trophic structure with predictable effects upon species assemblages/extinctions (Raffaelii 2004, Solan et al. 2004, Zavaleta and Hulvey 2004). The significance of the proposed study also lies in its integration with the ongoing and future research activities of other scientists in the Big Creek Basin.

Research Integration: The proposed study is closely integrated with the long-term stream ecology studies of Dr. G.W. Minshall in the Big Creek Basin (1988-2004) and the recent ecological studies proposed by Dr. C.V. Baxter. This proposal complements Dr. Minshall's research by quantifying how the composition and structure of riparian vegetation in post-fire landscapes influences the nature and timing of allocthonous (i.e. terrestrial) inputs into stream ecosystems. The proposed study has also been designed to closely integrate with the data collection efforts of Dr. C.V. Baxter. Further, I will continue to confer closely with both Drs. Minshall and Baxter throughout the course of this study to ensure appropriate levels of data integration at the variable temporal and spatial scales associated with this type of interdisciplinary effort (see Proposed Study Timeline). Research efforts related to Objective 3 have been put forth with the explicit intent to capture the attention and talents of other researchers at the University of Idaho and Idaho State University, as well as other regional institutions. At this point both Drs. Delahanty and Peterson (ISU) appear interested and highly motivated to work closely with us. I anticipate that many others will follow suite.

In the end, one of our main goals is to help establish a solid multi-institutional framework for organizing long-term ecosystems studies within the Big Creek Basin.

Over the next several years, the findings of this research will serve to support competitive grant proposals to the U.S. Dept. of Agriculture (National Research Initiative), National Science Foundation and UNESCO Environmental Research Program.

Proposed Study Timeline (2005-2006)

March 2005: Additional discussions w/Drs. Baxter & Minshall to advance study design
April 2005: Fly into Taylor to select additional study sites w/Drs. Baxter & Minshall
June-July 2005: Prep for field sampling along Big Creek & its tributaries
July-Aug 2005: Collect riparian vegetation/food web data within Big Creek Basin
Fall-Winter 2005: Analyze riparian vegetation and stable isotope data

Spring 2006: Use prelim. data to write competitive grants to NSF/USDA/UNESCO
June-July 2006: Prep for field sampling along Big Creek & its tributaries
July-Aug 2006: Collect riparian vegetation/food web data within Big Creek Basin
Fall-Winter 2006: Analyze riparian vegetation and stable isotope data

Spring 2007: Complete data analysis, manuscript preparation & MSc thesis defense.
Summer 2007 (& Beyond): Continue interdisciplinary research within Big Creek Basin

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Proposed Study Budget (2005-2006):

Funding is needed for MSc. graduate student (stipend/fees @ 2 yr), transportation, food and lodging, stable isotope analyses, misc. field supplies and equipment (2 field seasons). Additional funding support for this research project has already been obtained from the UI Governor's Initiative Fellowship ($18,000) with additional grants pending (see below, **note:** DeVlieg-Taylor Ranch Graduate Research Fellowship meets both IDF&G and ESPCoR requirements for matching funds/in-kind support). As noted above, our intent will be to use the data derived from these proposed UI/ISU interdisciplinary studies to obtain long-term ecological research funding from national and international competitive grant programs (NSF, USDA & UNESCO).

		Year 1	Year 2	Summary
Salaries				
	MSc. Student	14500	14500	29000
	Field Assistant	3000	3000	6000
Fringe		415	415	830
Sal & Fnge		17915	17915	35830
Fees/Tuition	Grad Student Fees	4500	4500	9000
Oper. Expenses				
	Field supplies	500	500	1000
	Stable Isotope Analysis	2000	2000	4000
	Travel (auto/plane)	1000	1000	2000
	Food & Lodging	1000	1000	2000
Total		26915	26915	53830

Funding request:
DeVlieg-Taylor Ranch Graduate Fellowship ($18,500/year @2 yrs) $37,000

Other funding support obtained:
UI Governors Initiative Fellowship $18,000

Total project funds: $55,000

Other related-grants pending:
Idaho Fish & Game: State Wildlife Grant $18,000
ESPCoR Funding to Enhance Graduate Student Recruitment $48,000
National Fish and Wildlife Federation Wildlife Grant $20,000

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Additional training (94-02): Applied Fluvial Geomorphology I & II and River Restoration (Wildland Hydrology Pagosa Springs, CO); Stable Isotope Ecology (BIO581, University of Utah, Salt Lake City, UT); Federal, State and Local Clean Water and Wetland Regulations I & II (Seattle Law Review Board).

BACKGROUND: Dr. Braatne is an ecologist with expertise in riparian and aquatic ecology, and the physiological ecology of riparian and wetland plants. Over the last ten years, he has been an active participant in the UW/WSU/UL Riparian Cottonwood Research Programs. Currently, his research and teaching interests focus on: a) physiological and morphological responses of willows and cottonwoods to drought and flooding, b) fluvial/ecological modeling of the riparian plant communities, c) impacts of stream-flow modifications on floodplain landscapes, d) influence of forest fragmentation (temperate & tropical) on aquatic insect and fish assemblages, and e) influence of exotic leaf litter on aquatic macroinvertebrate populations. Recent studies focused upon the ecology of riparian plant communities along the Yakima, Kootenai, Elk, Flathead, Oldman, Snake (Hells Canyon) and Salmon River Corridors. Dr. Braatne teaches undergraduate and graduate courses on Riparian Ecology, Wetland Ecology and Stream Ecology at the University of Idaho.

EMPLOYMENT HISTORY (90-05):
Assistant Professor: Depts. of Fish, Wildlife and Range Resources, University of Idaho, Moscow, ID, 2002-Present.
Affiliate Professor: Flathead Lake Biological Station, University of Montana, Yellow Bay, MT, 2000-Present.
Adjunct Research Professor: Biology Dept., University of Lethbridge, Alberta, Canada, 1997-2000.
Part-time Instructor, Affiliate Research Professor: College of Forest Resources, University of Washington, Seattle, WA. 1993-Present.
Postdoctoral Research Fellow: College of Forest Resources, University of Washington, Seattle, WA. 1990-93.

RELEVANT PUBLICATIONS (96-05):

Braatne, J.H., S.B. Rood and L. Gom. A tale of two rivers: the lower Salmon River Gorge and Hells Canyon Reach of the Snake River *(For submission to Ecology)*

Braatne, JH., S.B. Rood, L. Gom and R.K. Simons. Modeling the response of riparian vegetation to regulated flows along the Hells Canyon reach of the Snake River *(For submission to Geomorphology).*

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