To Jeff Yes (is this a Taylor Ranch piece of research?

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Changes in Wild Trout Habitat Following Forest Fire[1]

G. Wayne Minshall,[2] Douglas A. Andrews, James T. Brock, Christopher T. Robinson, and Deron E. Lawrence[3]

Abstract.--The responses of streams to the 1979 Mortar Creek Fire in Central Idaho provide valuable insights into the extended impact of wildfire on trout habitat. The fire dramatically increased runoff and fine sediment levels and reduced shading and cover from undercut banks and woody vegetation. Although habitat conditions for all life stages of cutthroat trout were adversely affected by the fire, these conditions gradually improved over the succeeding 8 years. Habitat for adults is expected to recover most rapidly and to reach optimal conditions about 15 years post-fire. Recovery of spawning and rearing habitat will be much slower with suboptimal conditions likely to persist well beyond the first 25 years.

INTRODUCTION

Although resource managers periodically recognize the need for information on the effects of fires on stream fish habitat, the amount of research on the topic is amazingly sparse. The reasons include the sporadic nature of fires, the tendency to treat fires as short-term crises rather than regularly recurring phenomena, and short-comings in the organization (including the frequent transfer of personnel) and funding of government agencies responsible for watershed management. In addition, most of the considerations to date suffer from the lack of a long-term temporal perspective.

In 1979, following the 26,000 ha Mortar Creek Fire in central Idaho, we began a study to document the changes induced by wildfire on streams of various sizes. The purpose of this report is to present results for the first ten years after the fire concerning mainly physical habitat conditions for native cutthroat trout (Oncorhynchus clarki) in tributary mountain streams of the Idaho batholith. Tributary streams, particularly those 2nd to 4th order in size, provide the main habitat for cutthroat trout in this area (Platts 1979) and were the most severely impacted by the Mortar Creek fire (Minshall et al. 1981). Streams larger than 5th order did not show any discernible effect from the fire (Minshall et al. 1981). The steep, erosive landscape of the Idaho Batholith is believed to be among the most sensitive to fire disturbance (Swanson 1979).

STUDY AREA

The Mortar Creek Fire occurred in the 41,440 km^2 Idaho Batholith, an area of granitic bedrock characterized by highly erodible soils, including large amounts of sand (Bjornn et al. 1977). The fire affected watersheds draining into the Middle Fork of the Salmon River. The Middle Fork is a major (7th order) tributary of the Salmon River. It drains a 7330 km^2 watershed, representative of much of the forested mountainous terrain found in central Idaho. Watershed elevations range from 2800 m at the headwaters to about 1550 m where they enter the Middle Fork. Most hillslope gradients range between 40 and 70%. The fire perimeter delineated an area representing about 4% of the Middle Fork basin, however, approximately 50 to 100% of the affected tributary watersheds burned.

The focus of this report is Little Loon Creek a 109-km^2 basin area mountain stream. Two sites were selected for analysis: one, a 5th order

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[2]Professor of Ecology and Zoology. Stream Ecology Center, Department of Biological Sciences, Idaho State University, Pocatello, Idaho.

[3]Research Associates. Stream Ecology Center, Department of Biological Sciences, Idaho State University, Pocatello, Idaho.

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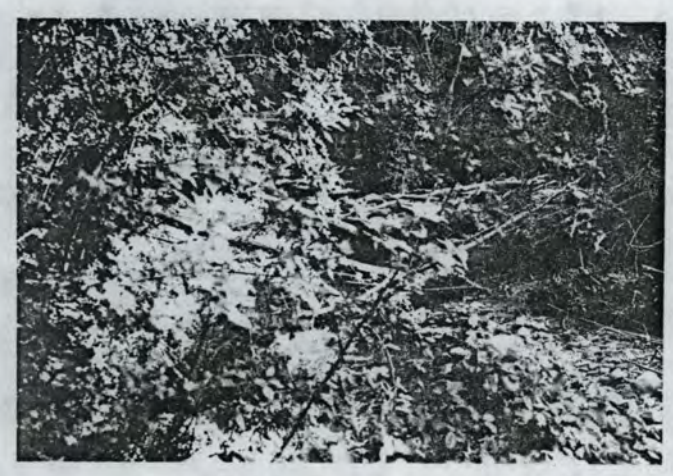
Main Stem of Little Loon Creek

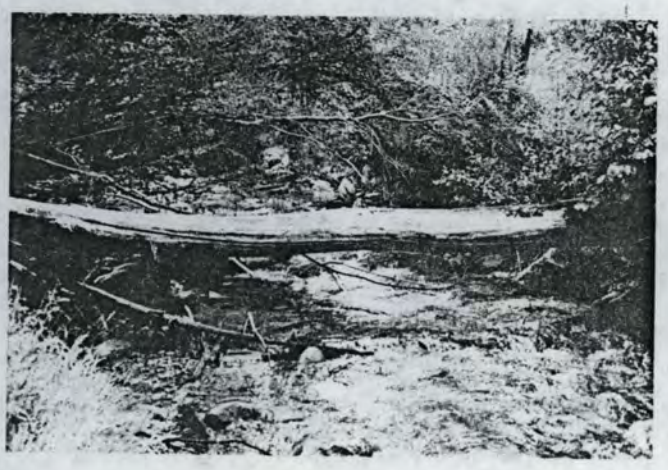
1980

1982

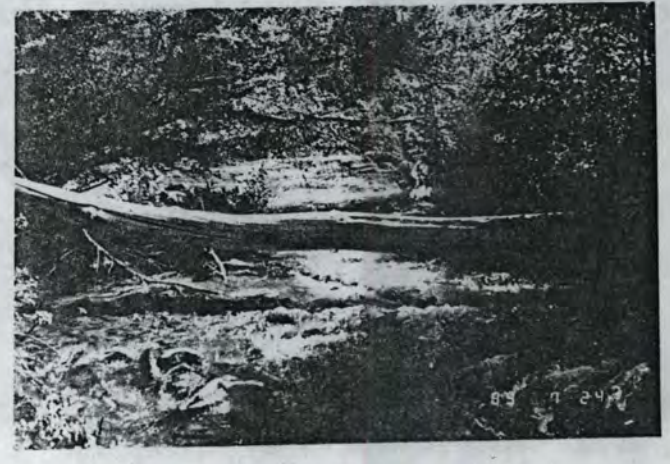


1983

1985



1987



1989

Figure 2. Mainstem of Little Loon Creek. Photographic record of stream and riparian conditions.

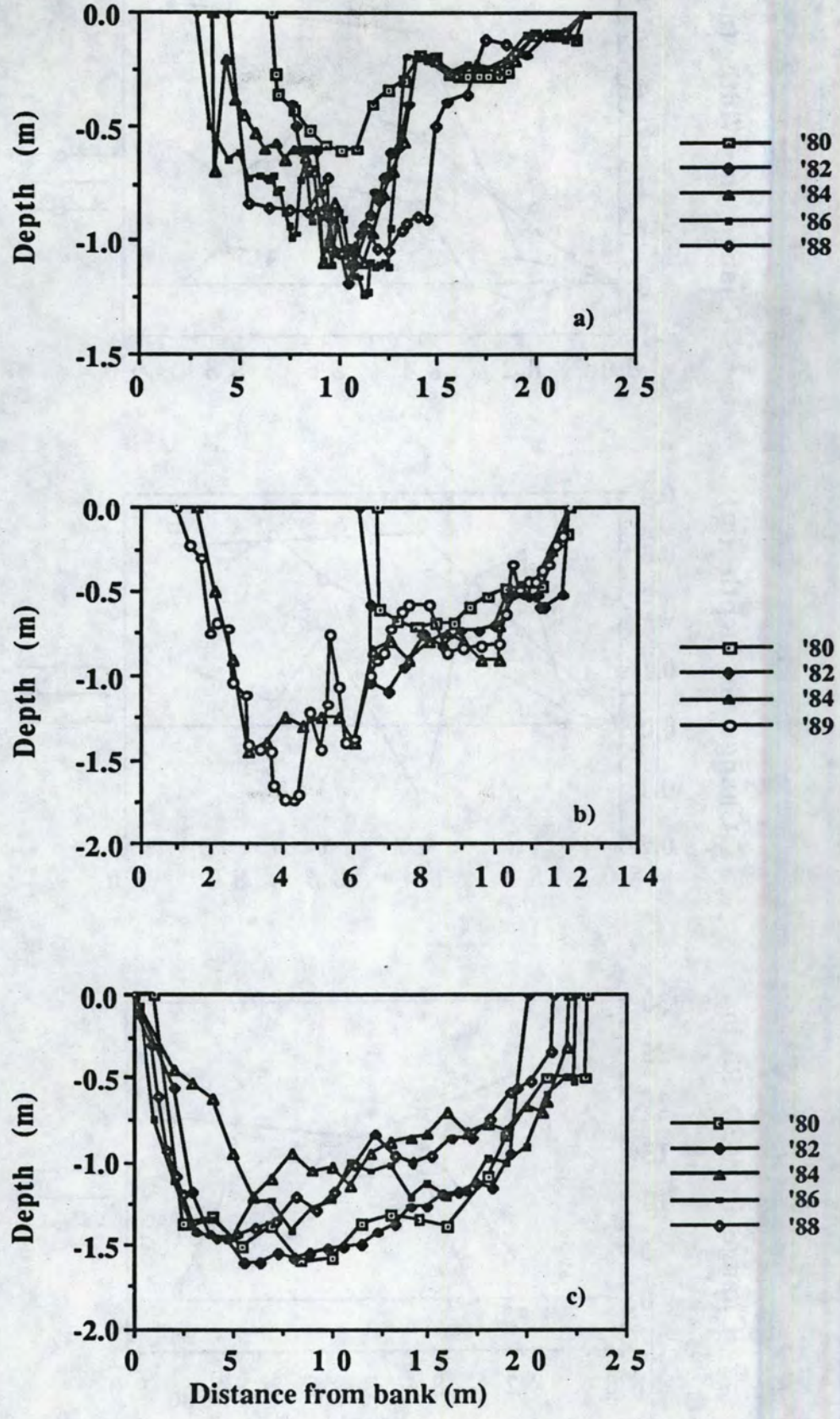


Figure 3. Channel cross-sections for (a) East Fork Little Loon Creek, (b) Mainstem Little Loon Creek, and (c) Indian Creek.

effect of fire and the trajectory of the recovery sequence are the result of a number of variables, including fire severity (intensity and extent), vegetation recovery pattern, geology, topography, and climate. Thus, this general model will need to be modified accordingly in order to be applicable to streams in other areas. Some suggestions as to the form these modifications might take are given elsewhere (Minshall and Brock 1989, Minshall et al. 1989).

As seen from Figure 1a, considerable movement and channel deposition of fine sediment occurred with the first spring/summer postfire runoff (Fig. 5). Most of this was removed during the following year, especially with spring 1981 runoff. Over the next few years, erosion and transport of sediments depleted near- and in-stream sediment storage sites and may have severely limited spawning and rearing substrata for several years. Optimum spawning substratum for cutthroat trout consists of gravel with small amounts of fines and rubble (Beschta and Platts 1986). Attenuation of peak discharges and resumption of normal geologic processes should result in the gradual reestablishment of suitable spawning substratum conditions after 12-15 years, under conditions found in Little Loon Creek. Megahan et al. (1980) found a more rapid recovery from watershed-induced sedimentation in the much larger South Fork of the Salmon River and we observed a similar response in the Middle Fork. In the South Fork, the spawning areas recovered more rapidly than the rearing areas.

Given the present rate of recovery, we do not expect the riparian vegetation or bank undercutting to develop sufficiently to provide measurable cover for trout until year 25 or later (Fig. 5). However, some shading by the riparian vegetation began around year 10 (Fig. 1) and can be expected to increase progressively as shrubs such as willow (Salix) and alder (Alnus) increase in stature and density. Maximum levels of shading are dependent on the development of a forest-stream overstory and may require 50 years or more. Heavy shading is expected to be detrimental to trout production due to decreased primary and secondary production. (Hawkins et al. 1983, Wilzbach et al. 1986, Thedinga et al. 1989). Hillman et al.'s (1987) findings suggest that undercut banks may be especially important for survival of overwintering juvenile salmonids.

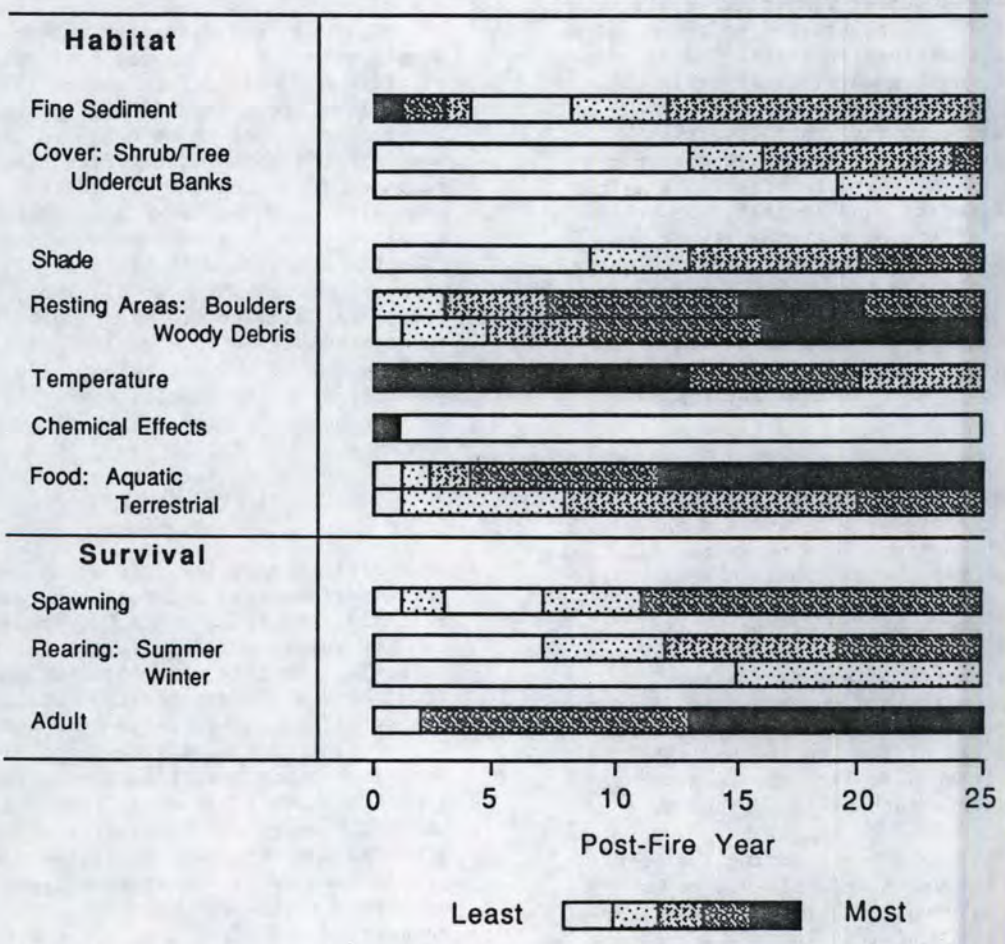


Figure 5. Effects of crown fire on trout habitat and survival in mid-size Rocky Mountain streams based on results for Little Loon Creek following the 1979 Mortar Creek Fire.

was conducted. Without the help and interest of numerous USFS field personnel, our work would have been much less productive and enjoyable. V.K. Moore and R.L. Vannote read an early draft of this article and contributed substantially to its improvement.

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EFFECTS OF FIRE ON WILDERNESS STREAM ECOSYSTEMS

G. Wayne Minshall, Director
Stream Ecology Center
Idaho State University
Pocatello, ID 83209

SYNOPSIS

The purpose of this study is to examine the effects of wildfire on stream communities and their habitats in the Frank Church River of No Return Wilderness, for the purpose of obtaining information which will aid in resource management. Research in 1991 will focus on streams in the Big and Chamberlain Creek drainages in which 50% or more of the watersheds burned in the 1988 Golden and Sliver Fires. In particular, the ecological attributes of Cliff, Cougar, Goat, and Dunce Creeks will be resurveyed and compared with results obtained from Cliff Creek in 1988 (both before and after fire), 1989, and 1990. In addition, several new sites, which burned in the Sliver Fire, will be added to the study in 1991. These will focus on Crooked and Whimstick Creeks and their tributaries. Also, several unburned reference streams within the Big Creek and Chamberlain Creek drainages will be examined to provide comparisons with the burned sites. Special consideration will be given to Cave and McCall Creeks for this portion of the study. Finally, the ecological attributes of streams draining some older burns (≥25 yrs) will be examined to for evidence of recovery.

RESULTS AND CONCLUSIONS TO DATE

Big Creek Study - July 1990

One objective of the this investigation was to compare conditions in streams impacted by the Golden Fire of September 1988 to those in reference streams (i.e. streams within the same drainage basin, of comparable size and aspect, not impacted by this fire). Four streams were studied which flowed within the fire perimeter: Goat, Dunce, Cougar, and Cliff Creeks. Two reference sites were located on Cave Creek. One was located about 100 m upstream of the mouth and the other on West Fork Cave Creek about 100 m upstream of the confluence with East Fork Cave Creek. An additional study site was located on Doe Creek whose watershed burned in 1939.

Periphytic chlorophyll a and organic matter tended to be greater in reference sites than burn sites, whereas benthic organic matter was higher in burn sites than in reference sites. Charcoal comprised a substantial portion of the BOM in burn sites relative to reference sites. Benthic macroinvertebrates displayed greater abundance and biomass in reference sites compared to burn sites indicating an initial impact from wildfire to these stream systems. Macroinvertebrate species richness was reduced in burn streams, while the evenness among taxa was not different among burn and reference streams. The 50-year burn stream, Doe Creek, appeared more similar to reference sites than to burn sites for the parameters measured. Subtle differences in the ten most abundant taxa indicated a shift to more disturbance resistant species in the burn streams. For example, the highly mobile mayfly, Baetis, was relatively more abundant in burn streams than

reference streams. Doe Creek displayed greater similarities in taxa relative abundance to reference streams than to burn streams.

These data suggest that the Golden Fire has had an initial impact on streams by changing the food resource base and altering the species composition among streams. Greater abundances of Simulium suggest higher levels or enhanced quality of seston (transported organic matter) in burn streams and Doe Creek compared to reference streams. The reduction in macroinvertebrate abundance and biomass in burn streams is attributed to physical processes because evenness values (Simpson's Index) were similar and relatively low among sites. Low Simpson's values suggest minimal influence by density dependent factors in controlling community structure, i.e. all species were impacted similarly. This conclusion is substantiated even in respect to Baetis. Baetis relative abundances were higher in burn streams, but absolute abundances were substantially lower. Further, the impact by wildfire differed among streams. At this point it is not clear if this is due to the inherent heterogeneity among streams or to differences in such things as stream size, fire intensity, or fire extent. We intend to address these points in future work in the region. Our results for Goat Creek are particularly puzzling for, although the values for macroinvertebrate abundance, biomass, and richness were comparable to other burn streams, those for BOM and % charcoal and periphytic chlorophyll and AFDM were exceptionally high. We have been told that Goat Creek was "back burned" (H & J Akenson, personal communication) and we observed that, at least in the lower reaches, this resulted in the burning of the riparian vegetation but not that of the adjacent side slopes. From this, we expected that runoff from the watershed would be less rapid and disturbance of the stream channel less severe than in streams where the whole watershed burned. The high BOM and periphyton values are in keeping with this interpretation but it is not supported by the low macroinvertebrate values.

The high similarity between Doe Creek and the reference sites suggest recovery may be completed in less than 50 years for that size stream. The impact of fire on streams reflects the intensity and timing of the disturbance in relation to stream size and proximity to potential colonists. Severe impacts by fire in headwater regions of a watershed are likely to markedly reduce recolonization by downstream drift and thereby impede recovery (e.g. Wallace 1990).

Cliff Creek Temporal Study - 1988-1990

We conducted a temporal study on Cliff Creek, a tributary of Big Creek, with samples collected in July 1988 (prefire samples), and November 1988, July 1989, and July 1990 (postfire samples). All samples were collected from the same study reach along Cliff Creek. The study section was located just upstream of the (upper) Big Creek trail crossing and about 200 m upstream of the stream mouth. We felt it important that postfire samples be collected in the same proximity to prefire samples although this location was not within the actual fire perimeter.

The results indicate no difference in periphytic organic matter and benthic organic matter between prefire and postfire collection periods, probably because the extent of shading at the study site has not changed. However, the percent charcoal continued to increase from 1988 to 1990, suggesting that charcoal is being transported from upstream burned areas into

the study reach. These data indicate that downstream sites may experience a lag period in the effect of wildfire as indicated in the temporal increase in charcoal in Cliff Creek. Both macroinvertebrate abundance and biomass were reduced the year following the fire, although no difference was observed in species richness. No effect on macroinvertebrates was seen in 1990.

A common problem in studying the impact of fire on streams is collecting prefire data from the same stream to serve as a "control" against which to evaluate subsequent responses. The fortuitous collection of prefire data from Cliff Creek, as a part of another study, enabled us to avoid this problem. The before and after data from Cliff Creek support our findings on the impact of fire using reference streams to compare with burn streams. However, in Cliff Creek, the effects of fire may have been mitigated by the location of our sampling site outside of the fire perimeter. We intend to examine Cliff Creek within the fire perimeter and compare the results with data collected from the present study reach in the coming field season. This will add an important spatial dimension in the study of wildfire effects on stream systems.

Our future studies in the Frank Church Wilderness will be aimed at (1) documenting conditions over a wider range of stream sizes and watershed burn intensities, (2) further replicating (for increased statistical power and a better definition of mean response conditions) the number of streams of each type, and (3) examining additional streams in old burns of different age "classes" in the range 20 to $\geq$100 years.

Jeff, I changed this a bit to try not to portray us as brainless, inept tenderfeet (though some, including our wives might question that) because I'm leary that some might use it as an excuse to prevent us from working in close proximity to other fires.

MONITORING WILDERNESS STREAM RESPONSES TO WILDFIRES

Jeff Yeo, Scientist

University of Idaho Wilderness Field Station at Taylor Ranch

3-5

Wayne and I thought it would be an afternoon jaunt. after all it was only 2 miles to the crew's ties. Although we were required to have two firefighters accompany us, we weren't thinking ~~hazards~~ hardship, adventure, ~~danger~~. Just an afternoon jaunt up Rush Creek to obtain some pre-burn stream samples in the face of the oncoming Rush Creek Fire 1991. So we didn't take sleeping bags, we didn't take food except for a few snacks, we didn't take extra warm clothes (after all, it was early September). [Some would say (including my wife) we didn't take our brains either.] What we did take were several backpacks full of stream sampling equipment. And it took us until dark wading up Rush Creek to get to the sampling site. So we stayed out that night, huddled on the ground. It got cold for the first time all summer. Each of us did our best, half awake, to hug the fire without getting burned. The next day, we sampled the stream, left sampling equipment in place in hopes that the drainage would burn over, and proceeded to hike straight up several thousand feet, carrying packs full of water samples. [It's the first time that my body finally convinced my brain (which may have been left behind) that I wasn't going to make it.] So why this suffering? As part of my job, I want to promote wilderness research of other scientists and faculty. So I felt that I should help Wayne Minshall and his graduate Ph.D. student Chris Robinson lug the equipment into

trailless Rush Creek. Wayne vigorously supported my feelings.

Wayne is Director of the Stream Ecology Center at Idaho State University. Since the 1970's, ~~Wayne,~~ he his colleagues, and graduate students have sampled streams in the Frank Church-River of No Return Wilderness. Initially, their research was directed at explaining the ecological patterns of biotic communities and organic matter storage and transport along stream gradients from headwaters to large rivers (The River Continuum Concept). Their early work coincided with the Mortar Creek Fire in 1979 so that Wayne had information prior to the fire and has been able to follow stream responses in the Mortar Creek drainage since.

The purpose of Wayne and his graduate students' current research is to examine the effects of wildfire on stream communities and their habitats to obtain information which will aid in resource management. A common problem in studying the impact of fire on streams is collecting prefire information from the same stream to serve as a "control" against which to evaluate subsequent responses. The fortuitous collection of prefire data from Cliff Creek (a tributary of Big Creek and whose headwaters were burned by the Golden Fire in September 1988), as part of another study, enabled Wayne to avoid this problem. Another approach that he's using is to compare conditions in streams impacted by the Golden Fires and Silver Creek to those in reference streams (i.e. streams within the same drainage basin, of comparable

For the Golden Fire,

size and aspect, not impacted by this fire). Four streams were studied which flowed within the fire perimeter: Goat, Dunce, Cougar, and Cliff Creeks (all tributaries of Big Creek). Two reference sites were located further up the Big Creek drainage on Cave Creek. An additional study site was located on Doe Creek (a tributary on the south side of Big Creek near Cabin Creek) whose watershed burned in 1939.

The before and after data from Cliff Creek supported Wayne's findings on the impact of fire using reference streams to compare with burn streams. Preliminary data suggest that the Golden Fire has had an initial impact on streams by changing the food resource base and altering species composition among streams. Apparently all species were impacted similarly. Information from the before and after study in Cliff Creek suggests that downstream sites may experience a lag period in the effect of wildfire as indicated in the temporal increase in charcoal. Both aquatic insect abundance and biomass were reduced the year following the fire, although no difference was observed in the number of species. No effect on aquatic insects was seen in 1990.

Further, the impact by wildfire differed among streams. At this point it is not clear if this is due to the inherent variation among streams or to differences in such things as stream size, fire intensity, or fire extent. Wayne intends to address these points in future work.

The high similarity between Doe Creek and the reference sites suggest that a great deal of stream recovery after fire may be completed in less than 50 years for that size stream. The impact of fire on streams reflects the intensity and timing of the disturbance in relation to stream size and proximity to potential colonists. Severe impacts by fire in headwater regions of a watershed are likely to markedly reduce recolonization by downstream drift and thereby impede recovery.

Wayne's future studies in the Frank Church Wilderness will be aimed at (1) documenting conditions over a wider range of stream sizes and watershed burn intensities, (2) adding new streams of each type to strengthen his ability to evaluate stream response, and (3) examining additional streams in old burns of different age "classes" in the range 20 to ≥100 years.

Other research supported by the Taylor Ranch Wilderness Field Station will complement Wayne Minshall's stream research. We currently are mapping from satellite imagery the distribution of past fires in the FCRNR. We have data to age some of these fires and will be ground-truthing additional burns to develop a complete fire history for the FCRNR. In addition, we began last year to implement monitoring of plant and animal communities to determine how wilderness communities recover after fire. Wayne Minshall's preliminary information suggests that some streams out the size of Doe Creek may recover within 50 years. Do communities away

(whereas others may take several hundred years. What is responsible for the difference?

See note on next page

We suspect not.

from streams recover as quickly? It'll take many years to answer ~~some of these questions~~ questions such as these. One question I can answer right now. When Wayne goes back up Rush Creek to recover his sampling equipment, my duties will necessitate that I be somewhere else.

Note: As originally written, there was only one question but the 1st full sentence above indicated there were several. Perhaps the suggested changes will take care of the problem.

Nice job overall.

Cheers,

Wayne