EFFECTS OF THE 1988 WILDFIRES ON STREAMS OF YELLOWSTONE NATIONAL PARK

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♦ EXECUTIVE SUMMARY

We postulate (Minshall et al. 1989, Minshall and Brock 1991) that the effects of the 1988 fires on stream ecosystems in Yellowstone National Park can be partitioned into (1) immediate effects arising directly from the fire (e.g., increased temperatures, altered water chemistry, abrupt change in food quality) and (2) delayed impacts resulting from the removal and eventual successional replacement of the vegetative cover. Some of these delayed effects are primarily physical disturbances associated with increased runoff. These are likely to exert their maximum impact within the first few years after fire. In addition, longer-term alterations associated with the removal and recovery of riparian and upland terrestrial vegetative cover and consequent alteration of food resources and retention capacity in the stream may be expected (Likens and Bilby 1982, Molles 1982, Minshall et al. 1989).

In order to determine the immediate effects and to provide a basis for evaluating subsequent long-term changes, samples of the stream biota and measurements of environmental conditions were obtained before and after the initial, major runoff period. The measurements made during these two periods are repeated at annual intervals (each August) over the following four years (1989-1992) in order to document conditions during the anticipated early recovery phases in the streams (Bormann and Likens 1979; Arno 1980; Schimpf et al. 1980; Boerner 1982; Arno and Gruell 1983; Arno et al. 1985; Stickney 1985, 1986; Waring and Schlesinger 1985; Crane and Fischer 1986). This will provide a quantitative record of the first five years following the Yellowstone fires and permit an initial test of our hypotheses concerning the temporal responses of major stream ecosystem parameters to wildfire in Yellowstone (Minshall et al. 1989).

Based on the existing conceptual framework in stream ecology (Vannote et al. 1980, Cummins et al. 1984, Minshall et al. 1985, Minshall 1988, Resh et al. 1988) that major differences among streams in terms of intensity of the effect and rates of recovery from fire will occur as a result of stream size and watershed slope and aspect. Besides affecting the timing and rate of runoff, slope and aspect significantly influence the type and density of riparian and upland vegetation. We have concentrated our efforts on streams of 1st through 4th order because few, if any, streams above 4th order in Yellowstone National Park were directly affected by the fires. The sites selected for this study were chosen in September 1988, through aerial and ground reconnaissance of all of the major 1988 fires in Yellowstone, in collaboration with senior staff members of the U. S. Fish and Wildlife Service (Yellowstone Office). Each burned stream type chosen is replicated at least three times to provide generality to our findings and to avoid problems arising from pseudoreplication. However, the total number of burned-stream sites studied is arbitrarily

limited to 18 to meet time and budget constraints.

The thrust of this study is to examine hypotheses relating to stream ecosystem behavior in the early stages of recovery from fire. We have centered on changes in the structure of the biotic community and food resources, in chemical composition of the water (including potentially limiting nutrients), and in physical habitat conditions. Focus is on the measurement of producer (algae) and consumer (mainly invertebrate) standing crops and general chemical properties (alkalinity, hardness, specific conductance, pH) and major nutrient (PO_4, NH_4, NO_3) constituents of the water. These serve as indices of the responses of stream ecosystems to fire. However, general environmental features (temperature, discharge, current velocity, substratum composition) also are being characterized. In addition, five permanent channel cross-section transects and photopoints are resurveyed each year.

Most of our methods are routine in stream ecology and are described in detail in standard reference sources (Weber 1973, Greeson et al. 1977, Lind 1979, Merritt and Cummins 1984, APHA 1985). Methods for sampling invertebrates are described in detail by Platts et al. (1983). In addition to total standing crops, the algal and invertebrate communities were examined in terms of species richness, dominance, and diversity and the invertebrates evaluated in terms of principal functional feeding groups (Merritt and Cummins 1984, Cummins and Wilzbach 1985).

Although the effects of fire have been evident in the preceding years of this study, the streams could be characterized as being largely on a "fast recovery track" (sensu Minshall and Brock 1991). However, 1991 was marked by at least two major runoff events which caused major physical upheavel to all of the streams in burned watersheds located on moderate to steep gradients. These disturbances are expected to be reflected by declines in the biotic components and serve as important "resets" in the recovery process (Minshall et al. 1989, Minshall and Brock 1991).

Most high gradient burned streams displayed major changes (cutting or filling) in channel cross-section morphology in 1991 while low gradient burned streams and reference streams remained relatively constant. Data on the degree to which stones on the channel bed are buried by fine sediments (= embeddedness) suggest a pulse of fine sediments moving from the burned watersheds into the headwater streams and then gradually into the larger burn streams over time. Mean substrate size decreased in 1st through 3rd order streams following 1988 and remained low through 1991, also indicating the input of fine sediments within the study reaches. The coefficients of variation for current velocity dramatically decreased in most burn streams over time, while remaining unchanged in reference streams, suggesting the establishment of more homogeneous habitat conditions as a result of the fires. Maximum stream temperatures have either increased the first year following the wildfires then subsequently decreased in 1991 or have remained elevated above prefire values. Changes in major water chemistry are more variable among and largely restricted to smaller (1st-2nd order) than found in larger burned streams; a trend that continued in 1991. Ortho-phosphorus levels increased in the high gradient burned sites in 1989 and subsequently decreased through 1991. In contrast, nitrate values tended to increase in most burn sites by 1989 and remained high through 1991.

Periphyton chlorophyll a levels decreased in 1989 from rather high levels in 1988 in all burn and reference streams except for 4th order Soda Butte. The relatively high chlorophyll a values in 1988 simply may be due to the time of sampling (October vs. August). Chlorophyll a levels increased in 1st, 2nd, and 3rd order burn sites in 1990 from 1989 then decreased again in 1991, probably as a result of scouring by storm flows. Chlorophyll values remained low in 4th order burn sites from 1989-1991.

Periphyton AFDM values also were higher in 1988 than other years for most sites, reflecting the high chlorophyll a values. AFDM values essentially remained unchanged in 1991 in 2nd and 3rd order burn sites, and 2nd and 4th order reference sites.

The AFDM (biomass:B) to chlorophyll a (C) ratio indicates the degree of autotrophy at a site. The sites that experienced increased AFDM in 1991 also displayed high B/C ratio's suggesting a lower degree of autotrophy at these sites. The B/C ratio remained relative low in 2nd and 3rd order burn sites and 2nd and 4th order reference sites.

Transported organic matter was sampled and quantified in two size categories: Coarse (CPOM) and fine (FPOM) particulate organic matter. This material also was characterized qualitatively. CPOM levels increased in all burn sites in 1991 from previous years, and being most pronounced in 2nd order burn sites. CPOM levels also were higher in 1991 in reference sites, but not to the degree displayed in burn sites. As with CPOM values, FPOM values dramatically increased in burn streams in 1991. FPOM values increased only slightly for reference streams in 1991. These higher values in 1991 over previous years for both CPOM and FPOM may be attributed to higher overall flows and respective flow events. The higher CPOM and FPOM values for burn streams relative to reference streams reflect increased overland input in burn catchments from these flow events in 1991.

The percent charcoal of CPOM increased substantially in 1991 in the burn streams, also suggesting overland input of organics during high flow events. The percent charcoal of CPOM remained low in respective reference streams. The percent charcoal of FPOM also increased in 1991 in burn and reference streams. Results for macroinvertebrates are not completed for 1991, but will be presented in the 1992 Annual Report.

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