CHANGES IN GEOMORPHIC PROCESSES IN THE SNAKE RIVER FOLLOWING IMPOUNDMENT OF JACKSON LAKE AND POTENTIAL CHANGES DUE TO 1988 FIRES IN THE WATERSHED

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Objectives

Rivers are dynamic features of the landscape whose characteristics vary over time and space with changes in environmental controls. The Snake River in Grand Teton and Yellowstone National Parks has responded to the impoundment of Jackson Lake and subsequent changes in the operation of Jackson Dam. The 1988 fires in the Snake River watershed may also affect channel morphology. Whether a new system equilibrium might be attained and the extent to which the effects of past events might persist in the fluvial landscape are two critical questions that need to be addressed for the Snake River. The stability of the Snake River, in turn, will affect the quantity and quality of riparian habitat critical to fish and wildlife in the park. Stream channel dynamics of the Snake River in Grand Teton National Park are also intimately tied to issues of floodplain delineation and management, the aesthetic value of the river, and the quality of recreational float trips.

This study is utilizing controlled field experiments, interpretation of aerial photography and topographic maps, field-based surveys of hillslopes and streams, a geographic information system, and time series analyses of gaging station data to describe, explain, and predict changes in channel morphology of the Snake River and related shifts in floodplain vegetation. Specific hypotheses to be tested are:

1) Ho: Jackson Lake Dam has had no significant affect on morphology of the Snake River and the development of related floodplain vegetation downstream from the dam.

2) Ho: The Snake River above Jackson Lake will not experience significant increases in sediment delivery (and related changes in channel and lake morphology) due to 1988 fires in the upper watershed.

3) Ho: The Snake River below Jackson Lake will not experience significant increases in sediment delivery (and related changes in channel morphology) due to the 1988 fires that burned major portions of the Pacific Creek drainage.

Methods

The basic approach of this study is to compile a sediment budget for the Snake River and to use these data to explain measured shifts in the channel and related floodplain vegetation. A sediment budget quantifies movement of sediment through the drainage basin. The principal sources of sediment to the Snake River and its tributaries are mass wasting, hillslope erosion from rainsplash and overland flow, and channel erosion from avulsion, channel widening and shifts in pattern. A geographic information system is being developed to display spatial trends in sediment budget components.

Runoff and soil loss from rainsplash and overland flow have been measured on replicate plots at each of 30 hillslope sites affected by the 1988 fires. Twenty-three of the 30 sites were located in severely burned watersheds of the Shoshone National Forest, as suggested by Dr. Henry Shovic, Soil Scientist with Yellowstone National Park/Gallatin National Forest. The remaining seven sites were located in the John D. Rockefeller Memorial Parkway. Two unburned sites in each study area were used as a control. The following characteristics were measured at each site: slope gradient, slope aspect, percent vegetation cover, percent litter cover, depth of soil charring, and depth of the wetting front (i.e., infiltration from the one-hour rainfall simulation).

The runoff/soil loss samples were taken at five points (12 minute intervals) during the one-hour simulation experiment. A total of 300 samples were transported to the Soils Laboratory in the UW Department of Geography where the volume of runoff and weight of sediment were be measured using standard analytical techniques. Soil samples collected adjacent to each experimental plot were analyzed for texture (using sieves and hydrometers), pH, percent organic matter, and water repellency.

A computer-based search for aerial photography and topographic maps covering the Snake River between Jackson and Moose Junction was pursued through the Soil Conservation Service in Salt Lake City. A manual search was also conducted through offices of Grand Teton National Park, the UW-NPS Research Center, UW Remote Sensing Center in the Department of Geology and Geophysics, and Wyoming Geological Survey. The following maps and imagery have been collected: 1899 topographic map (1:125,000) from the U.S. Geological Survey; 1921 base map (1:125,000) from the U.S. Forest Service; 1945 black-and-white aerial photos (1:23,000) from the National Archives; 1955 black-and-white aerial photos (1:20,000) from the Wyoming Geological Survey and UW Department of Geology and Geophysics; 1967/68 topographic map (1:24,000) from the U.S. Geological Survey; 1975 black-and-white orthophotos (1:24,000) from the U.S. Geological Survey; 1983 National Wetlands Inventory maps (1:24,000) from the U.S. Fish and Wildlife Service; 1987 color aerial photos (incomplete set, 1:15,780) from the National Park Service; and 1989 floodplain insurance rate maps (1:12,000) from the Federal Insurance Management Agency.

The aerial photography and topographic maps have been used to produce morphological maps of the Snake River channel between Jackson Dam and Moose Junction. The channel was mapped according to the criteria outlined by Cowardin et al. (1979) for the U.S. Fish and Wildlife Service National Wetlands Inventory. A stereo zoom transferscope was used to reduce all maps to a common scale of 1:24,000.

Field surveys of hillslopes were conducted to quantify the magnitude and timing of mass wasting events. The choice of hillslopes to be sampled was based on a random sample stratified by geology, slope gradient, and land cover (including type of burn). In addition, special effort was be made to visit mass wasting scars identified from aerial photography and previously mapped by the Wyoming Geological Survey. Much of the headwaters of the upper Snake and its tributaries in Yellowstone and Grand Teton National Parks and the Teton Wilderness Area was surveyed in 1989. Data recorded for each scar include: location, type of mass wasting, volume of each scar, and estimated age (from tree cores and/or bracketed from aerial photos).

Stream surveys were conducted over a 41 km reach of the Snake River from Jackson Lake Dam to Moose Junction. One survey collected data on the following variables for 199 152.5m long reaches: reach type, water depth, bankfull depth, particle size distribution. A second survey collected data for 189 152.5m long reaches on channel stability indicators of the upper bank (slope, mass wasting, debris jams, bank vegetation), lower bank (channel capacity, bank rock content, channel obstructions, bank cutting, deposition), and channel bottom (particle angularity, brightness, packing, stability, scouring/deposition, aquatic vegetation).

The PC version of ArcInfo has been acquired by the UW Department of Geography for use in setting-up a geographic information system for the various spatial data sets utilized/developed in this project. The data sets compiled to date include maps of mass wasting (with notation of sediment delivery characteristics) and channel morphology maps. Maps to be developed later include riparian vegetation and estimated gross erosion rates from overland flow.

A computerized search of water and sediment data in the study area has been conducted through the Water Resources Data System at the Wyoming

Water Research Center. Time series analysis is being performed on the following data sets: 1) water and suspended sediment discharge of the Snake River above Jackson Lake, at Flagg Ranch (1983 to date), 2) water discharge of the Snake River near Moran (1903 to date), 3) water and suspended sediment discharge of Pacific Creek at Moran (1944-1975, 1979 to date), and 4) water discharge of Buffalo Fork above Lava Creek, near Moran (1944-1960, 1965 to date).

Results

Preliminary inspection of data from the controlled field experiments, Snake River geomorphic maps, mass wasting surveys, and analysis of streamflow-sediment data reveals several noteworthy trends related to the hypotheses proposed in this project. Rates of runoff and soil loss are generally higher in the study area than expected for most burned areas in the Greater Yellowstone Area (e.g., see Hydrology Assessment Team 1988). Regression analysis will reveal how much of the variance in runoff and soil loss can be explained by the site variables, including depth of charring. A dramatic contrast between plots is evident regarding the lag time between rainfall and the onset of runoff/soil loss and the rate of acceleration of runoff and soil loss. It appears that the depth of charring is a useful index of the water repellency of soils while the other variables control sediment delivery by affecting the development of microrills.

The degree of braiding in the Snake River channel has increased steadily since the impoundment of Jackson Lake (Figure 1). This shift can be attributed to the decline in magnitude and persistence of peak flows while the river continues to gain sediment from erosion of steep banks (especially above and below Deadman's Bar) and input from tributaries (especially from Pacific Creek, Buffalo Fork, Spread Creek). Channel bars have increased in number, enlarged in size, and become more stabilized by riparian vegetation. The 1910 washout of Jackson Dam was probably responsible for the oxbow cutoff two miles below the dam.

Sediment delivery from mass wasting was estimated in the Huck, Mink, and Emerald Creek burned areas as well as from unburned areas. In general, the larger pre-fire slope failures were little affected by fire-induced changes because: 1) they are large and deep-seated, 2) their common open terrain has few trees to burn, 3) low fuel-producing Populous tremuloides dominates rather than flammable conifers, 4) broken topography provides natural firebreaks, and 5) linear flow topography tends to train fires up along ridge lines and out of slope-failure zones.

Conclusions

The data compiled to date, but not yet fully analyzed, appear to reject hypothesis 1, but support hypotheses 2-3. Jackson Dam has had a significant effect on the morphology of the Snake River, although the effect on development of related floodplain vegetation downstream from the dam remains to be documented. The fires in the upper Snake River watershed and in the Pacific Creek drainage will supply sediment of a caliper that will experience a short residence time in the channel and not affect channel morphology. However, it is likely that changes in channel morphology and riparian vegetation will continue to be induced by Jackson Dam and the direction and magnitude of these changes need to be predicted. Continuation of the project for the next two years, as outlined in the original proposal, will provide the data and interpretation needed to document these early conclusions.

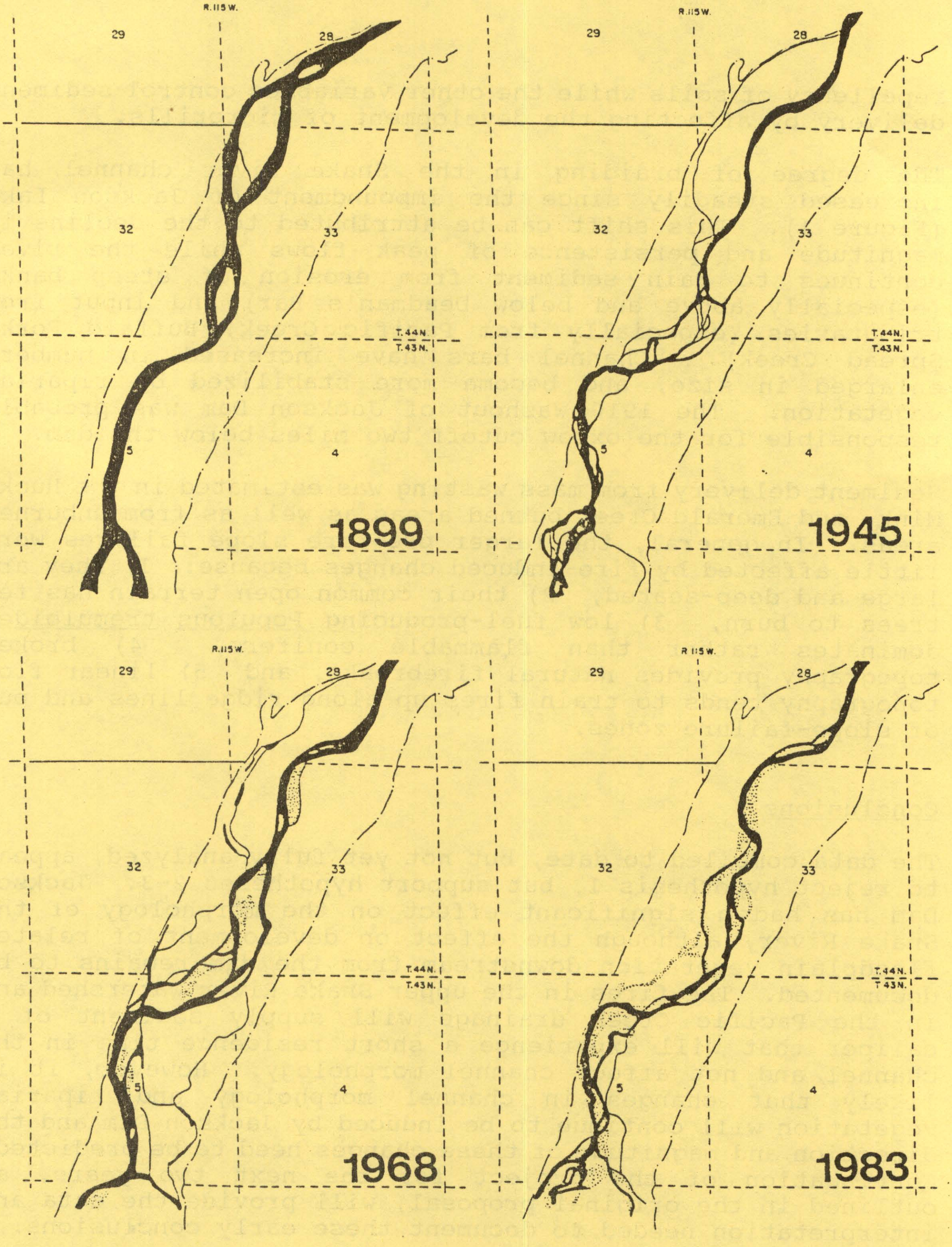

Figure 1. Morphological changes in the Snake River from river mile 17-20.5 below Jackson Dam. The public land survey sections shown are at the top of the Moose quad.

Literature Cited

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