Determining patterns of runoff in an ungaged, snow dominated basin

Abstract:

I plan on installing a stream gaging station at the Taylor Ranch research station on Big Creek in central Idaho. Taylor Ranch is a long-term research station that is the home of many biological research projects. Numerous biological systems are dependent on the timing and magnitude of flow in rivers, and adding a gaging station will provide necessary context for these studies. Due to proposed climate change, the timing and duration of snow dominated basins are expected to change, which will have a strong effect on biological systems and humans that depend on the large spring runoffs to fill reservoirs. It is important to understand the mechanisms of such basins in a natural setting so that future changes can be projected for highly impacted basins.

Objective:

The objective of this project is to reconstruct past hydrographs for Big Creek in order to provide context for the long-standing and on-going biological research at the Taylor Ranch field station and to understand the timing and relative magnitude of tributary contributions to flow in Big Creek.

Importance of Research:

Climate projections anticipate warmer temperatures in the Western United States (reference needed) and some research has found that these changes are already having effects on the timing of runoff in snowmelt dominated basins(Stewart et al, 2004). These changes are likely to have significant impacts on the availability of water for municipalities and agriculture (Barnett et al, 2004). There are also potential long-term changes in the total amount of water availability given changing precipitation patterns and evapotranspiration processes (Barnett et al 2005). All of these factors, coupled with continued population growth in western states, indicates a need for continued research and monitoring of rivers in order to predict, monitor and quantify changes to the system.

In addition to impacts on humans, changing the timing and magnitude of flood events that result from the spring thaw of the winter snowpack could have dramatic effects on biological systems and geomorphic forms. Native fish populations have adapted to given flow regimes, laying their eggs and timing stages of development to typical conditions for the river they inhabit and changes in these patterns of flow could have detrimental effects on native fish species which are already stressed by other environmental factors such as invasive species (Crozier et al, 2008). Plant communities have also adapted to certain hydrologic conditions, and alterations in those conditions could put additional stress on them and leave them susceptible to invasive plant species (Stromberg et al, 2007, Poff et al, 1997). The basic form of rivers, from the distribution of gravel bars to the width of the channel, is also dependent on the timing and magnitude of flow. Change in the shape of the river has a cascading effect on the plants and animals that depend on the river (reference needed).

My work will study in greater detail the effects of topography on a snow dominated basin. The aspect of a slope (the compass direction it faces) has a strong influence on the accumulation and melting/evaporation of snow. South facing aspects tend to accumulate less snow and melt earlier due to the higher amount of solar radiation. Elevation can determine the difference between rain and snow for a given precipitation event due to the lapse rate. As

temperatures increase, the snow line will rise up and due to the fact that a smaller percentage of the land lies at high elevations, a smaller amount of snow would accumulate (Erickson et al 2005). Also, the effects of rain shadow can be observed when one mountain range extracts the majority of moisture from a storm before it can reach another area (Barsted 2007). Although these effects are known, a precise quantification of their relative importance has not been done for my region of study.

Description of Procedures:

The Big Creek watershed, located in the Frank Church River of No Return Wilderness in central Idaho, is an ideal location to study snow-dominated watersheds in light of climate change and topographic effects because of the river's pristine nature. Due to a lack of human modified land use change, the landscape is in its natural form. And because there are no dams, irrigation, or large scale withdrawals of any kind along the river, an unaltered hydrograph is produced. This makes it possible to focus solely on the natural processes at work and not have to factor in human influences.

The Taylor Ranch field station is located alongside Big Creek and is the location of a number of long-term ecological research projects on a wide variety of topics including wolves, snakes, fish, forest fires, and sheep. Idaho State University researchers have an old and ongoing research program at Taylor Ranch. From the work of Dr. Wayne Minshall (and continued by Dr. Colden Baxter on invertebrate communities in the river to studies by Dr. Richard Peterson on reptile and amphibians in the area, ISU has a strong tie to the research facility. By knowing the hydrographs for times when these studies occurred, a richer and more complete understanding of the biological system would be achieved.

In addition to all of the past research that has gone on, environmental monitoring equipment has already been installed at Taylor Ranch. A NOAA cooperative weather station has been in operation at Taylor Ranch since 1974 and NOAA fisheries has a SOND which measures water properties such as temperature, turbidity, and dissolved oxygen, but not the actual amount of water flowing through the channel. The addition of a stream gaging station would provide an invaluable addition to this preexisting research infrastructure.

In order to complete my research plan, a downward looking sensor will be installed in the spring of 2008. This sensor would monitor the height of the water surface below a bridge that is at Taylor Ranch. This data will be digitally recorded and eventually tied into a preexisting telemetry station so that the data can be remotely accessed. During the summer, I will do an on the ground survey of the river to determine the stage discharge relationship (relating the height of the water surface to how much water is moving through).

Tributaries will be monitored using pressure data loggers, which will record the height of the water surface and store the data until retrieved. These will be distributed between different tributaries with different aspects and elevations to determine the timing and relative amount of water contributed to the main stem. Again, I will establish a stage-discharge relationship for these sites during the summer in the field.

Past flows will be reconstructed using two methods: a rainfall-runoff model and a regional statistical approach. The rainfall runoff model will use weather data from the Taylor Ranch Weather station and a digital elevation model to simulate the accumulation and melting of snow and its path from the hillslopes to the river channel. The statistical approach will use nearby gaging stations on the Middle Fork Salmon River and scale the observed flows there to the smaller drainage area of Big Creek.

Projected Research Completion Date:
Installation of the main sensor is to be completed by April 2008 with field measurements to be completed by summer 2008. Thesis work is to be completed by summer 2009.

Budget: see attached

Funding Sources for Proposed Research-

	GSRSC	**Other***	**Total**
Equipment			
Supplies	$990	5961.42	6951.42
Travel	$500	4800	5300
Personnel		20325.60	20325.60
Other		7140.00	7140
Fringe Benefits		1808.97	1808.97
	$1,490	40,000	41490

*Other Sources

Remainder of Funding
Tuition, stipend and remaining funds will be provided by a grant from the DeVleig Foundation.

Dissemination of results
Data from the gaging station will be remotely accessed by Dr. Ben Crosby and made available to researchers working in Big Creek. Results from the timing and historical analysis will be presented at the American Geophysical Union meeting in December 2008. Thesis work will be compiled and added to the Geoscience department's library of past work, and I will prepare a manuscript for submission to a journal.

References:
Barnett, T, Malone, R, Pennell, W, Stammer, D, Semtner, B, Washington, W (2004) The effects of climate change on water resources in the west: introduction and overview Climatic Change v. 62 pp. 1-11

Barnett, TP, Adam, JC, Lettenmaier, DP, 2005, Potential impacts of a warming climate on water availability in snow-dominated regions, Nature vol. 438, November 17

Barsted, I, Grabowski, WW, Piotr, KS, 2007, Characteristics of large-scale orographic precipitation: Evaluation of linear model in idealized problems, Journal of Hydrology, vol. 340 no. 1-2, pp 78-90

Crozier, LG, Zabel, RW, Hamlet, AF, 2008, Predicting differential effects of climate change at the population level with life-cycle models of spring Chinook salmon, Global Change Biology, vol. 14 no. 2 pp.236-249

Erickson, TA, Williams, MW, Winstral, A, 2005, Persistence of topographic controls on the spatial distribution of snow in rugged mountain terrain, Colorado, United States, Water Resources Research vol. 41

Poff, NL, Allan, JD, Bain, MB, Karr, JR, Prestegaard, KL, Richter, BD, Sparks, RE, Stromberg, JC, 1997, The Natural Flow Regime: A paradigm for river conservation and restoration, BioScience, vol. 47. no.11
Strombeg, JC, Lite, SJ, Marler, R, Paradzick, C, Shafroth, P, Shorrock, D, White, JM, and White, MS, 2007, Global Ecology and Biogeography, vol. 16, pp381-393