Riparian Vegetation and Digitized Channel Variable Changes After Stream Impoundment:

The Provo River and Jordanelle Dam

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ABSTRACT

Following stream impoundment, rivers respond via changes in sediment dynamics, channel morphology, and vegetation distribution. Such changes have occurred along the Provo River, Utah, located within the Intermountain West of the U.S. Jordanelle Dam was built on the Provo River in 1992 after the majority of dam construction in the United States and therefore allows for a large-scale GIS analysis using aerial photographs, available before and after construction. To evaluate the effects of the dam, this study examines reach scale channel changes with respect to vegetation distribution and species richness. Post-impoundment, the authors find that channels downstream of the dam have become more stable, allowing for vegetation colonization, as exhibited in land cover changes from bare soil to grass. This results in greater species richness owing to colonization of a more stable riparian zone, ultimately changing habitat conditions. Identifying and understanding the impacts of the Jordanelle Dam on vegetation is necessary for protection of this valued ecosystem as rapid development continues.

KEYWORDS

Dam Impacts, Fluvial, Land Cover, Riparian, Vegetation

INTRODUCTION AND BACKGROUND

Dams have caused a host of changes in rivers everywhere. They have altered flow distributions and sediment transport, causing adjustments in sediment dynamics, channel morphology and vegetation distribution. The effects of stream impoundment are widely known though many long-term studies are still being conducted regarding the influence of dams on downstream vegetation characteristics (Williams and Wolman, 1984; Graf 1978). This study examines the Provo River, Utah, located in the intermountain west of the United States. Riverine changes are still occurring downstream of Jordanelle Reservoir along the Provo River because stream impoundment occurred in 1992 (UTI, 2013). Given the recent impoundment, this particular system gives us insight into understanding vegetation changes after impoundment as well as allows for high resolution imagery and observations

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prior to dam placement. In addition, examining this system allows us to begin a comprehensive, long term study that can elucidate the effects of impoundment on all aspects of a river system.

The objectives for this research are as follows: 1) Examine the hydrologic record to ascertain differences in river discharge before and after impoundment, 2) Measure vegetation richness above and below Jordanelle Reservoir to determine if changes in the hydrologic flow altered by the dam significantly changed channel processes such that vegetation habitat, and therefore distribution, changed, and 3) Measure changes in channel planform variables over time to determine the alteration of any channel characteristics as a result of impoundment. Each of these factors is quantified upstream and downstream of the dam so that the upstream portion serves as our control reach in which flow has not been altered. This work begins to address changes in the river after impoundment so that subsequent work as the river continues to change can be carried out with a baseline set of data.

The utilization of GIS and remote sensing methods for examining river changes over time gives researchers the opportunity to record channel features in the past and examine features over multiple time periods while limiting the expense of repeat, on-the-ground surveys (Luong, 1993; Jaiswal, Saxena & Mukherjee). Typically, this type of work can utilize multi spectral imagery to determine changes in land use and land cover (Zhang et al., 2015; Rahman, 2016) using pixel based supervised or unsupervised classification methods (Minaei & Kains 2016). However, when multi spectral imagery is not available for a specific site over multiple time periods, and the desired features to be captured are smaller than the typical 30m resolution size of such images, researchers can conduct a post-classification comparison after digitizing features on aerial photographs with the needed resolution (Jaiswal, Saxena & Mukherjee, 1999).

Hydrological Impacts

Each dam uniquely changes the flow characteristics of the impounded stream according to its main purpose and local geography. Although the purpose and effects of dams may differ greatly, studies have shown some consistent trends. Typically, peak discharges decrease after impoundment (Chin & Bowman, 2005; Chin, Harris, Trice, & Given, 2002; Graf, 1978; Singer, 2007; Williams & Wolman, 1984). In one example, Andrews (1986) found that discharges equal to or exceeding 5,000 ft^3/s typically occurring 10% of the time prior to impoundment on the Green River in Utah below Flaming Gorge Reservoir no longer occurred after impoundment. Elsewhere, the recurrence intervals of peak discharges along the Milk River, in Alberta and Montana, increased 2-3 times their pre-impoundment recurrence interval, meaning that large events became rarer (Bradley & Smith, 1984). In addition, the frequency of specific floods, especially high magnitude events, often decrease following impoundment (Bradley & Smith, 1984; Chin & Bowman, 2005; Graf, 1988; Higgs & Petts, 1988; Magilligan, Nislow, & Graber, 2003; Shields, Simon, & Steffen, 2000).

Sedimentological Effects

Decreased discharges from dams can result in decreased transport capacities along impounded rivers resulting in changes in overall sediment size and sediment size distribution. For sediment transport, stream power, not water quantity, is the important variable to consider (Knighton, 1987). For this reason, sediment load (or sediment transported below the dam) is often altered after stream impoundment owing to a reduction in stream power (Chien, 1985; Graf, 1988). For example, Allred (1999) recorded a decrease in the magnitude of discharge responsible for transporting the majority of suspended sediment along the Green River in Utah. Therefore, suspended sediment was less likely to be transported following impoundment. Also on the Green River, Graf (1980) found that 93% of the boulders stabilized after impoundment compared to 62% before dam closure because of decreased transport capacities. With regard to sediment size distribution, the Colorado River had a uniform sediment size distribution downstream of the impoundment before the closure of Hoover Dam. Six years after impoundment, sediment downstream of the dam became sorted, so that a greater portion of coarser particles were present immediately below the dam. Median particle size gradually decreased