Quantifying Sediment Budget Variability for the Fernan Lake Watershed

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Abstract: Our goal for this study is to assess the timing and magnitude of sediment delivery within the Fernan watershed. We use landscape erosion rates derived from ^{10}Be concentrations in detrital samples, and sediment core stratigraphy, to quantify a sediment budget for Fernan; the three components of a sediment budget consist of sediment production, yield, and storage. We compare variability in sediment yield and climate throughout the Holocene in order to determine their covariance and assess natural controls on sediment delivery. The long-term variability of the sediment budget is considered to be the "natural" range of behavior for the watershed. We then compare this to recent trends in sediment yield to identify the potential magnitude of human impact on the Fernan watershed.

Study Area

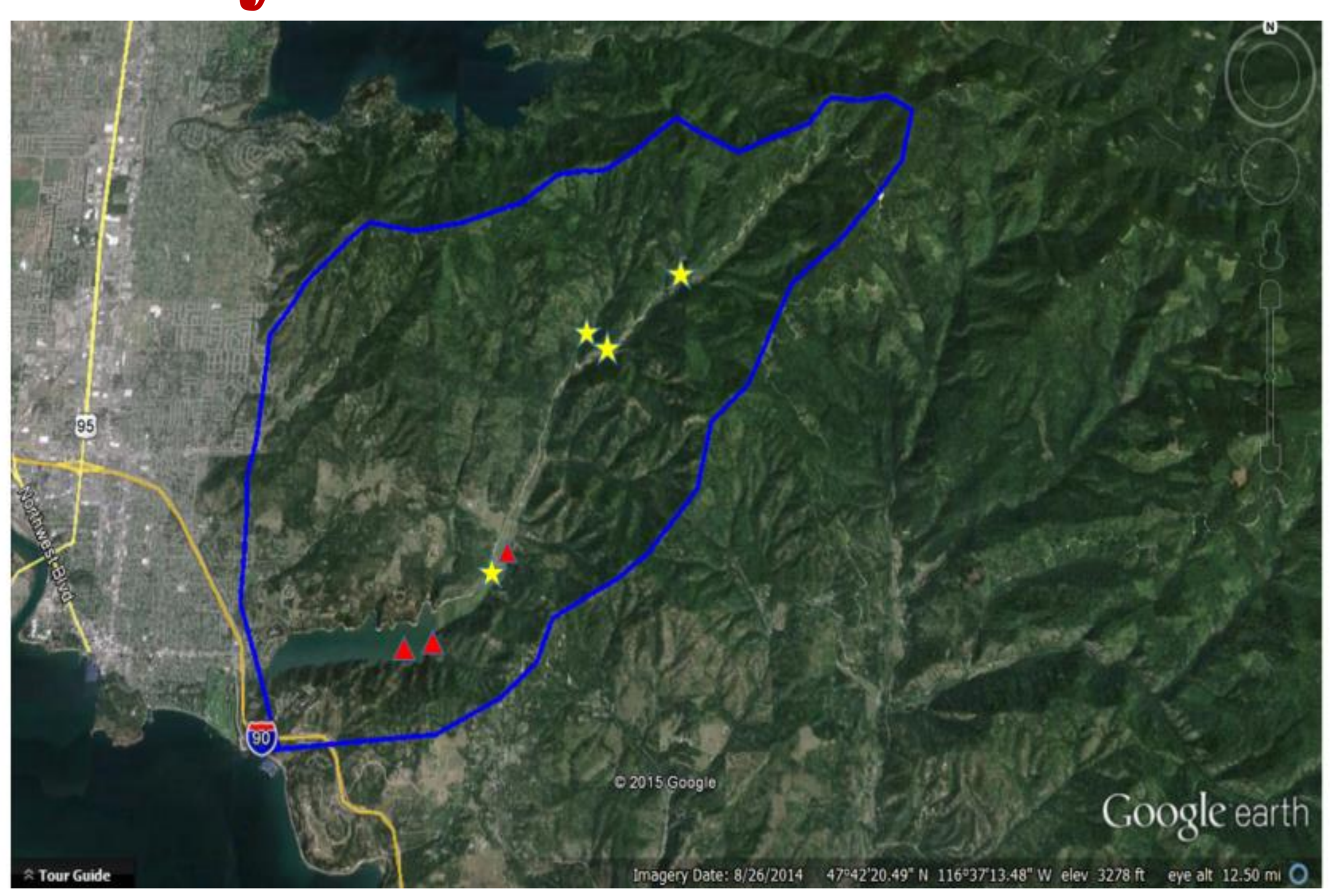


Figure 1 showing the Fernan Lake Watershed outlined in blue. The coring sites are indicated by triangles and the detrital sample locations with starts

Motivation

A sediment budget is a quantitative means of addressing sediment production, transport, and storage over time. It is based on the equation:

Input - Output - change in storage

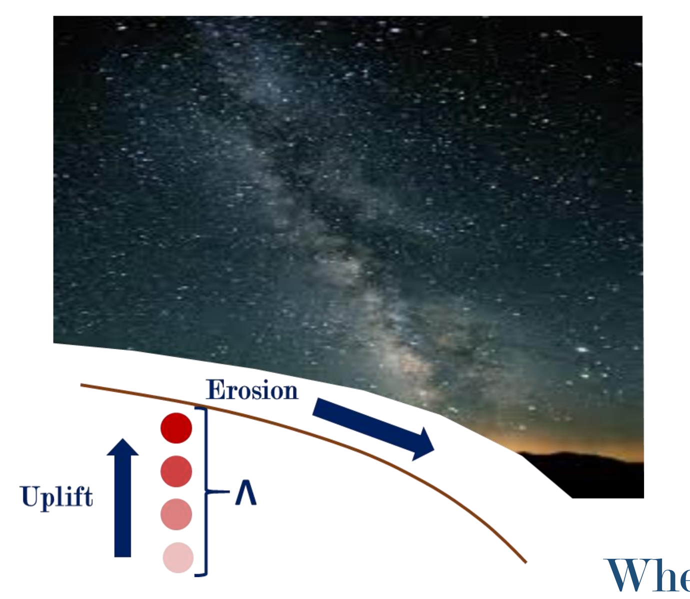
Quantifying the budget and its variability over time provides the context in which recent trends in sediment deposition can be interpreted. Previous studies have attributed disequilibrium in the sediment budget to human influence (Reusser et al., 2015) and the influence of low-frequency high-magnitude events (Kirchner et al., 2001)

Goal

To assess controls on sediment delivery within the Fernan Lake watershed

Methods

Rate Input



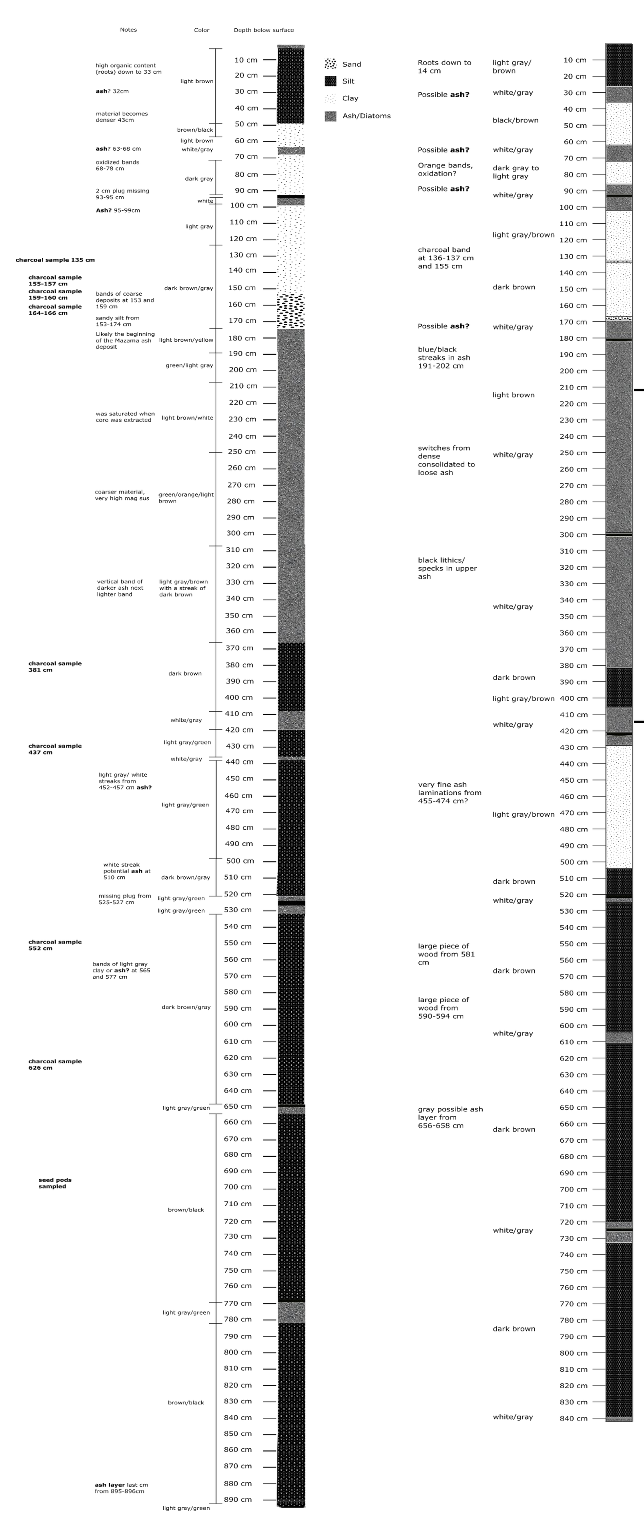
We have measured ^{10}Be concentrations from detrital samples from 4 sites in the watershed. We calculate landscape erosion rates from these concentrations according to the equation (Granger et al., 1996; Lal, 1991):

$$E = \frac{P_0 \Lambda}{N}$$

Where E - erosion rate, P_0 - production at the surface
Λ - attenuation length, N - concentration (measured)

Rate Output

We use cores from both the floodplain (paleo lake environment) and the lake to determine the rate of sediment deposition. We constrain timing of deposition of different layers in these cores using ^{14}C dating and ash layers from known volcanic events.



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Storage

We will use valley geometry to estimate the volume of sediment stored in valley fill deposits. Knowing the volume of stored sediment indicates the potential for sediment delivery to the lake given the appropriate climate and flow conditions to mobilize the sediment.

Results

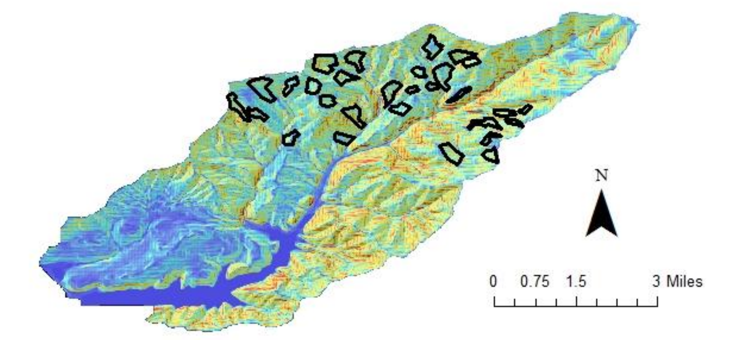


Figure 2: a map of slope distribution throughout the watershed. Outlined are recent logging sites.

We expect more sediment to be produced over time on steeper slopes. Additionally, changes in land use, such as logging, should increase the rate of sediment production in recent decades

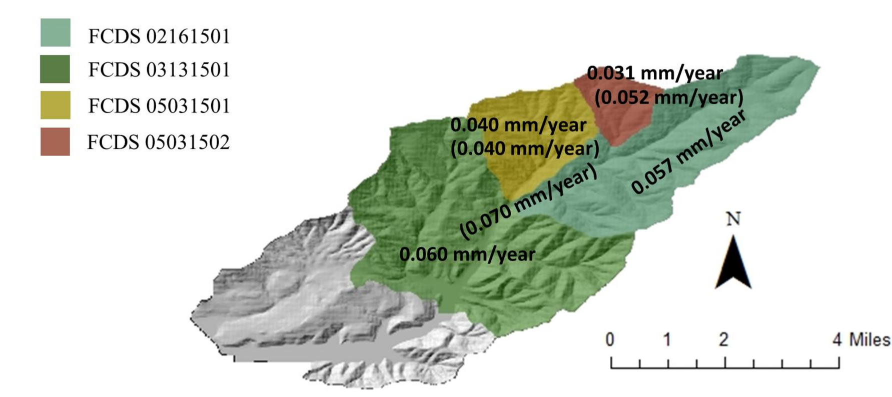


Figure 3: Rates of erosion calculated from ^{10}Be concentrations and mixing models. In parentheses are the rates derived from gravel sized samples which represent deep erosion events.

Steeper slopes are producing more sediment over time. Also, we find that there is an increase in erosion rate as we travel downstream toward the lake. Additionally, deep erosion events seem to be controlled by stochastic processes

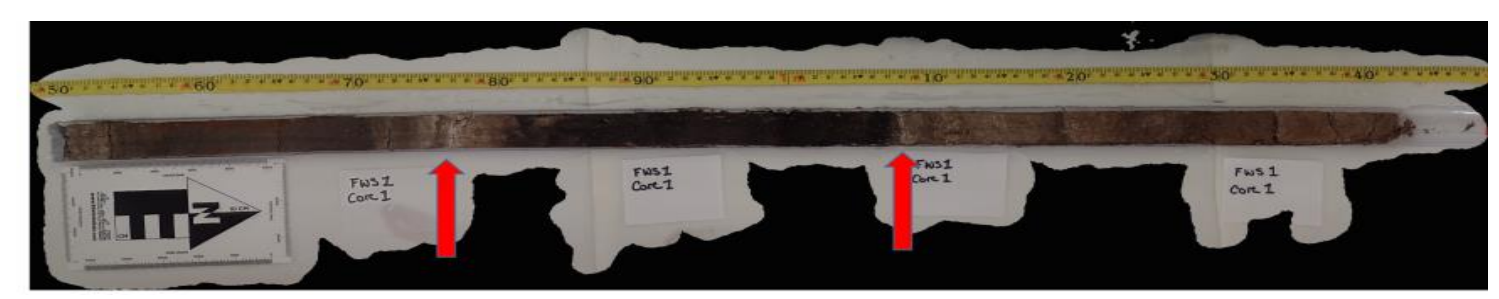
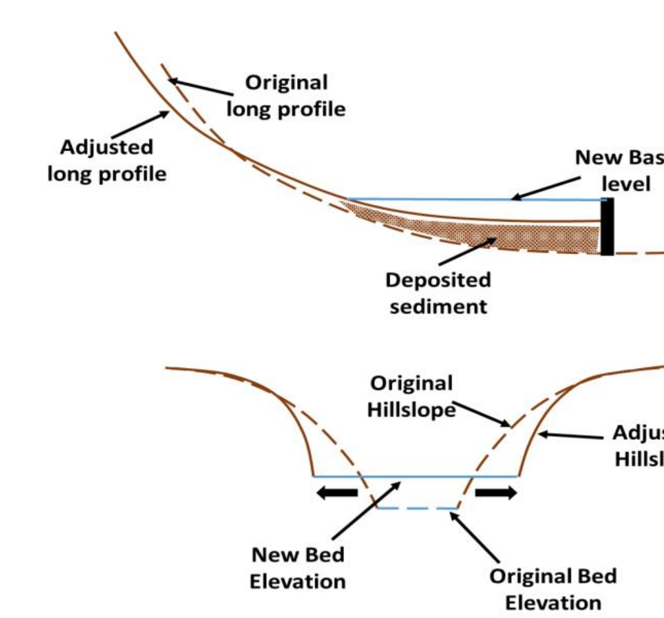


Figure 4: A length of sediment core from the floodplain. The bright white layers corresponding to 77 and 108 cm on the tape are diatoms blooms which may indicate an increased rate of sediment deposition to the lake.

Discussion

Base level rise due to the creation of the lake may be responsible for the fastest erosion rates furthest downstream. As the long profile of Fernan Creek adjusts upward by depositing sediment, the creek cuts into hillslopes. This causes an over-steeping of slopes which produce more sediment over time.



Implications

-Erosion rates are higher further downstream.

-As the influence of base-level rise propagates upstream over time, sediment yield of the watershed increases.

-Laminations of diatoms throughout the core length indicate changes in trophic status over time.

-More work is needed to assess the relation between increased erosion rates and deposition in Fernan Lake, including the characterization of stored sediment.

-Grain size dependence of erosion rates in some basins, suggests stochastic processes control deeper erosion events.

References

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