

THE RELATIONSHIP OF CLIMATE TO SEDIMENTATION RATES  
IN LAKES AND PONDS IN YELLOWSTONE NATIONAL PARK

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Objectives

The problem posed concerns the relative importance of climate, fire, hillslope erosion induced by overgrazing, and nutrient enrichment as recorded in selected lakes in the Northern Range of Yellowstone National Park especially during the last 150 years, when populations of elk are known to have fluctuated greatly, and when slight climatic changes are suggested from other lines of research.

Lake sediments contain as their principal constituents inorganic matter washed in from the hillslopes, organic matter largely produced within the lake, and carbonates and certain other compounds that result mostly from biogenic processes in the lake. Among the microfossils in the sediments are pollen grains blown into the lake from the local and regional as well as local vegetation, as well as charcoal derived from local and more distant fires. The diatom assemblage should reflect such limnological variables as nutrient content of the water, transparency, and water chemistry. Pigment content is a measure of algal productivity and preservation, and certain pigment types are diagnostic of blue-green algae — usually a product of nutrient enrichment. If the sediments are fractionated in the laboratory by partial chemical digestion the biogenic silica (mostly diatoms) can be determined separately, as can other compounds of biological importance, with the residue representing mineral particles derived from soil erosion. Stratigraphic analysis of lake sediments, with dating by radioactive isotopes, can therefore reveal the history of the landscape as well as of the lake itself.

Methods

After study of topographic maps of the Lamar Valley and the Mammoth Area and consultation with Park biologists concerning the winter range for elk and other ungulates, five lakes with no discernible human impact were chosen for initial study. The vegetation of the surrounding catchments was examined and the morphometry of each lake determined by depth transects. Piston cores at least a meter long were extracted from the deepest portion of each lake and were sampled in the field at contiguous intervals of 0.5 cm for the top 10 cm, 1.0 cm for the next 30 cm, and 2.0 cm for the next 20 cm.

The proportions of organic matter and carbonates were determined by weight losses after combustion at 500°C and 1000°C respectively, with the residue

representing inorganic matter (Figure 1). The sediment-accumulation rate was determined by lead-210 analysis, which provides a chronology for about the last 150 years (Figure 2). Pollen analysis for the upper part of one of the cores (Foster Lake) has been completed. Preparation of the remaining samples is in progress for analysis of pollen, charcoal, diatoms, pigments, and chemical constituents.

### Results

Foster Lake, located 1.6 km SW of Soda Butte, has only a limited fringe of emergent aquatic plants in the littoral zone, so that little of the material derived from hillslope erosion is screened out. According to the first results the core from Foster Lake has the most distinctive stratigraphy. A pronounced maximum in the proportion of inorganic matter relative to carbonate occurs between about 1890 and 1950, perhaps the result of increased erosional inputs. A less pronounced maximum is dated 1815-1840. At about 1970 the proportion of organic matter increases greatly, rising steadily from 25 to 40% at the surface. Coincident with this rise is a color change from brown to black. These relations strongly suggest nutrient enrichment starting about 1970, perhaps as a result of increased animal manure in the shore area. Preliminary pollen analyses indicate a slight rise in spruce, Douglas-fir, and grass pollen from about 1915 and decline in willow pollen. The possible roles of fire suppression and climatic change as causes for the trends will be evaluated when further pollen analyses are completed for this site and for the other sites.

Buck Lake, located 4 km NE of Soda Butte, shows a relatively high proportion of inorganic matter between 1955 and 1965. The sediment-accumulation rate, which was similar to that for Foster Lake in the lower part of the core, doubled between 1910 and 1940 and remained high thereafter. The proportions of the three sediment components did not change at this time, however, i.e. all three increased simultaneously. Redistribution of sediment may be the explanation.

Trumpeter Lake, located 1.5 km E of Junction Butte, shows a gradual decrease in inorganic matter from 1850-1945. The concomitant increase in organic matter is greatly enhanced after 1975. The carbonate content of the core is 40% throughout the core, except in the top 5 cm, where it decreases to 20% as organic matter rises.

Buffalo Ford Lake, located 2 km N of Junction Butte, has remarkably uniform sediment composition below 48 cm and above 18 cm, with about 20% carbonate and equal portions of organic and inorganic matter. Between these depths the profiles show maxima of inorganic matter generally alternating with maxima of organic matter as the carbonate content is reduced to about 10%. The increase in organic matter at 1920-1930 is accompanied by a relatively high accumulation rate, implying an influx of silt. Other maxima occur at 1880-1890, and at one earlier time.

Slide Lake, located 5 km N of Mammoth, averages about 80% inorganic matter throughout, except that after about 1950 it decreases slightly as organic matter

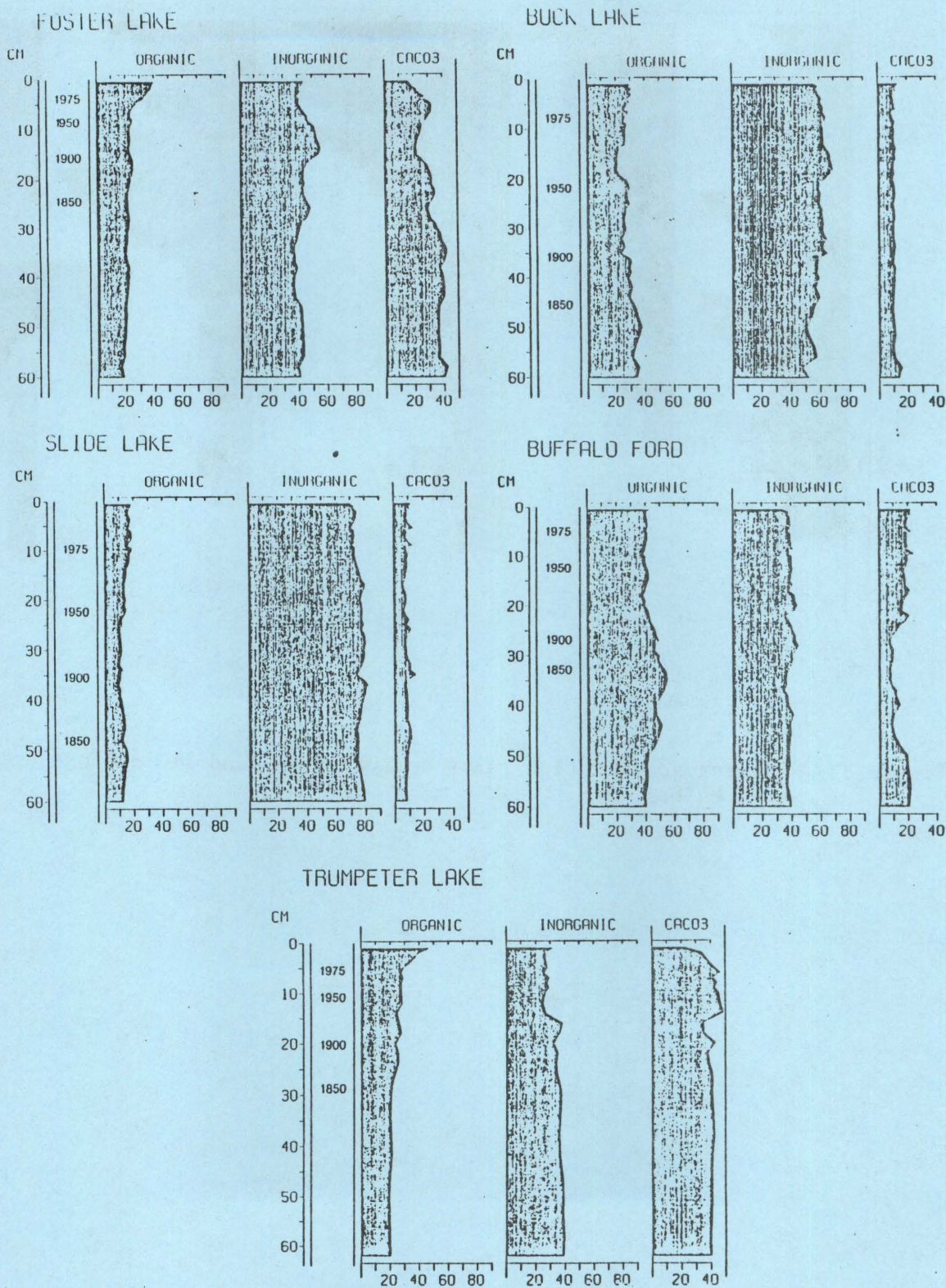


Figure 1. Percent composition of lake sediments from loss-on-ignition.

SEDIMENT ACCUMULATION RATE (MG/CM<sup>2</sup>/YR)

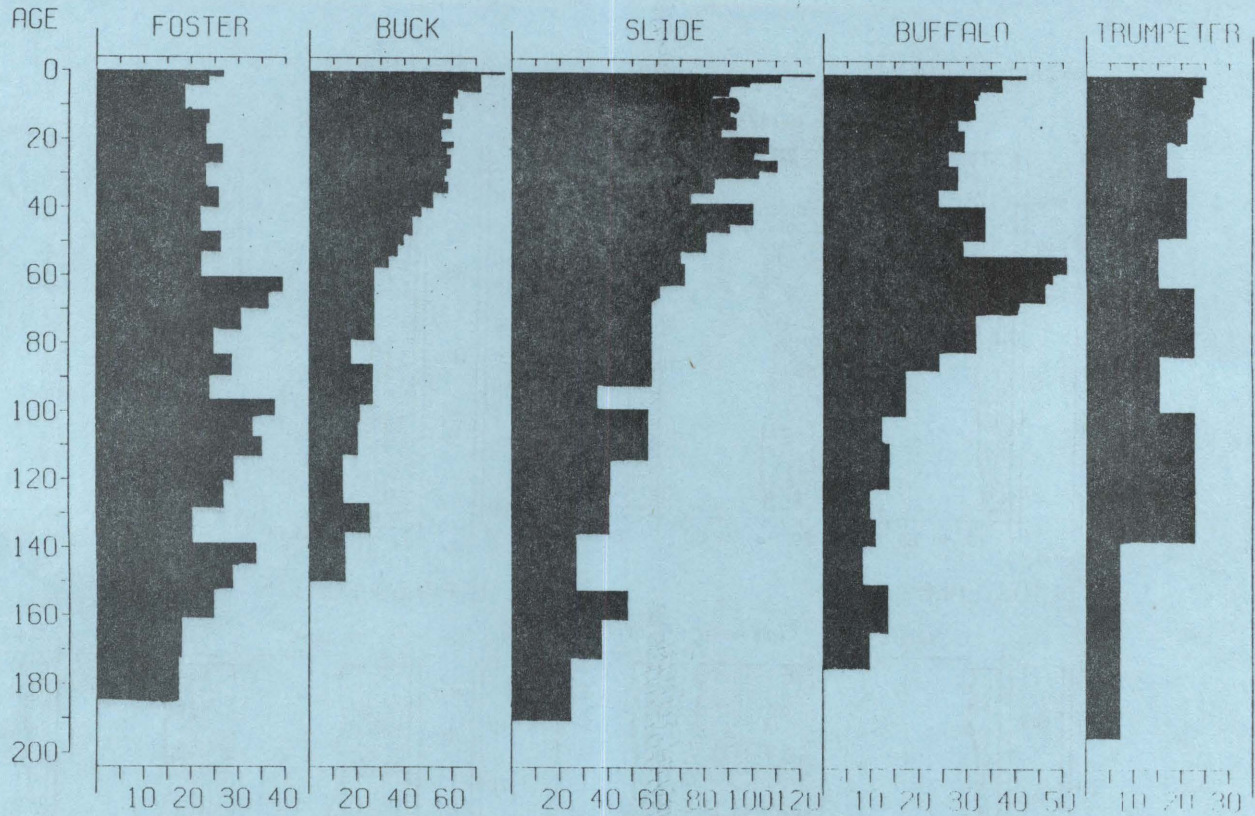


Figure 2. Sediment accumulation rates derived from lead-210 dating; age in years before 1986.

increases. Sediment-accumulation rate, which is at least twice that at the other sites, rises gradually between 1900 and 1950 and remains high to the surface.

### Conclusions

All five lakes investigated show stratigraphic changes in sediment-accumulation rates and in the proportions of the three components analyzed by weight loss on ignition (organic matter, carbonate, and inorganic matter). Preliminary pollen analysis for the Foster Lake core implies an increase in spruce, Douglas-fir, and grasses and decrease in willow since about 1915. Several of the cores show more stratigraphic changes in the last 150 years than previously. Although it is premature to interpret the results before completion of the planned pollen, diatom, and chemical analyses, there seems to be enough changes in the profiles so far to imply that the lake sedimentation has been affected by environmental changes, especially in recent time.