# Using Geospatial Techniques to Analyze Landscape Factors Controlling Ionic Composition of Arctic Lakes, Toolik Lake Region, Alaska

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## ABSTRACT

*The impacts of climate change on landscapes in arctic Alaska are evident in terms of permafrost melting, frequent thermokarst activity, and the occurrence of more broadleaf vegetation. These changes may alter natural biogeochemical cycles of ions along with major nutrients and affect ionic compositions of lakes, as they are connected with the landscapes. However, the nature of the connectivity between lakes and landscapes in this region is not yet explored. The authors propose that geospatial analysis of landscape properties along with observed lake ion concentrations will enable an understanding of the currently existing landscape controls over ion inputs into the lakes. For the watersheds of 41 lakes in the Arctic Foothills region of Alaska, spatial properties of natural vegetation communities expressed in terms of percentage, shape complexity, and patch density metrics were derived using satellite data. Regression analyses were performed for concentration of ions as well as conductivity in lake water where the spatial metrics along with lake physical properties, lake order, and glacial till age categories were used as predicting variables in the regression. Landscape metrics for major land covers i.e., Percentage of Moist Acidic Tundra (MAT) and Moist Non-acidic Tundra (MNT) were the major predicting variables for concentration of several ions.*

Keywords: *Arctic Lakes, Geospatial Analysis, Ionic Composition, Landscape Metrics, Percentage of Moist Acidic Tundra (MAT)*

## INTRODUCTION

The ionic composition of lakes plays a significant role in controlling their trophic structure. Anions and cations are important for many aquatic primary producers as they control various cellular processes. Further, they are crucial to maintain the pH of surface waters, creating favorable conditions for several prokaryotes and plants to grow (Smith, 1995).

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In closed drainage basins, the ionic composition is controlled by the evaporation rate and precipitation (Lesack & Melack, 1991). Specifically within low arctic watersheds, it has been observed that transport of $Na^+$ and $K^+$ was governed by precipitation whereas $Ca^{2+}$ and $Mg^{2+}$ concentrations in lakes were related to chemical weathering (Cornwell, 1992). For lakes in the coastal region, atmospheric inputs were considered to be important. However, weathering of parent material (i.e., soil and rock) is considered to be the major source of ions for lakes (Wetzel, 2001). Weathering processes are affected by several landscape factors, with land use and land cover being the most prominent (Drever, 1994).

Likens et al. (1977) and Drever (1994) emphasized that natural vegetation aids chemical weathering of parental material via natural biota in the root zone. In particular, the mineralization and immobilization processes carried out by these microorganisms are crucial for recycling ions (Frost et al., 2006; Xiao & Ji, 2007; Canham et al., 2004). It has been further explained that these processes along with soil moisture and hydrological events determine influx of ions into surface water bodies. Therefore, it is necessary to derive information about land covers to understand their influence on water bodies. With the advent of remote sensing technology, satellite datasets have been used to obtain such information at various scales (Jensen, 2005). Limnological studies, which have adopted remote sensing data, are considered to be constrained only to above ground information and not really inferred about root zone interactions (Gergel et al., 1999; Griffith et al., 2002).In contrast, King et al. (2005) argued that if remote sensing data is converted into spatial and structural information about land cover researchers will be able to understand indirectly root zone interactions and weathering processes. Such spatial and/or structural information, when expressed in terms of landscape metrics, allows quantitative analyses for lake-landscape interactions (O'Neill et al., 1997).

For example, Stewart et al. (2001) studied Proportion and Fragmentation metrics related to riparian vegetation. The authors considered riparian zones as regions of high water fluctuations and correlated landscape metrics for the riparian zones with the trophic structure of lakes. Similarly, Patch Density of a land cover is another such metric useful for investigating water quality (Johnson et al., 1997). Patch Shape Complexity metrics, mostly used in wildlife studies (Forman & Gordon, 1986), are also adopted in limnological studies to understand growth stages of land covers. For instance, prominent land covers within basins will occupy most of the area and exhibit simple shapes. On the other hand, emerging land covers will display more complex shapes. It is likely that the dominant land cover and the emerging land cover may exhibit different root zone properties and influence export of ions into water bodies accordingly. Using the same principle, Kearns et al. (2005) have demonstrated that shape complexity metrics can be applied to understand landscape controls over ionic composition of lakes.

The arctic lakes also should be studied carefully for their ionic composition and associated landscape controls, particularly when the climate change is altering the dynamic between landscapes and lakes. Arctic landscapes are highly sensitive to the contemporary air temperature increase and are therefore, experiencing severe alterations (ACIA, 2005). Permafrost is rapidly melting due to rising temperatures, which are also inducing more frequent thermokarst activity. Both of these processes could release stored ions within soils into streams and lakes. Hence, the ion concentrations of surface water may be altered in the near future due to terrestrial inputs (Keller et al., 2007).

Previous studies quantified ions within particular vegetation communities (Marion et al., 1989; Schimel et al., 1989; Giblin et al., 1991). These studies indicated that soil moisture influences the concentration of ions and vegetation communities having higher amount of moisture in the soil of their root zones exhibited higher leaf concentrations of common ions. For example, moist soils hosting broadleaf shrubs had higher potassium contents compared to

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