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Seasonal aluminum regimes and drivers thereof discovered in the acidified freshwaters of Nova Scotia, Canada

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Despite substantial reductions in sulphate and nitrate emissions in North America, ecosystem acidification and associated high concentrations of freshwater aluminum are an ongoing problem in Nova Scotia, Canada. Low pH and high aluminum levels in this freshwater acidification hotspot threaten aquatic organisms, including endangered subpopulations of the economically, biologically, and culturally significant Atlantic salmon (*Salamo salar*). Furthermore, the presence of aluminum in freshwater increases the cost of water treatment and has been implicated in the development of dementia in humans. Aluminum toxicity is dose dependant, where lethal doses vary by organism life stage; therefore, seasonal variation of freshwater aluminum levels can mitigate or exacerbate its toxic effects. Prior research has predominantly found yearly freshwater aluminum highs to occur in the spring, after snow melt, or during other high-flow episodes, but limited investigation of seasonal trends has been conducted. This research indicates that the spring aluminum high regime is only one of four aluminum seasonality regime types and occurs at the same frequency as fall aluminum high regimes. Each regime type is forced by different chemical drivers; pH drives the summer (direct) and winter (inverse) regimes, calcium drives the fall and winter regimes (both direct). Surprisingly, all seasonal aluminum high regimes are directly and strongly forced by total freshwater organic carbon levels. Additionally, the type of seasonal aluminum high regime exhibited in rivers and lakes has been correlated with various land cover and land use types. For example, freshwater calcium concentration in the fall aluminum high regime is moderately correlated with percent urban area (τ = 0.492, α = 0.05), while pH level in the summer aluminum high regime is strongly correlated with percent mature forest area (τ = -0.618, α = 0.05). By identifying when aluminum levels are the highest, conservation strategies for species at risk, including endangered Atlantic salmon subpopulations, can be tailored to increase positive impacts while reducing the risk of exacerbating poor water quality and decreasing ecosystem health. Additionally, by identifying the different aluminum regime types, associated aluminum concentrations, and water chemistry and land use/cover divers, this research enables more accurate modeling of a key component of freshwater health, allowing predictions to made of trends and changes in water chemistry as climate, weather patterns, and land use/cover continues to change due to human pressures.