

Shifting Grounds: Soil pH Patterns across the Grassland-Aspen Forest Ecotone at Miquelon Lake Provincial Park

Nmazule King Nyenke-Wofuru¹

¹ Department of Science, Augustana Faculty, University of Alberta, Camrose, Canada.

*Correspondence: nyenkewo@ualberta.ca

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Abstract

Soil chemistry forms the foundation of ecosystem function by regulating nutrient availability, microbial activity, and plant community dynamics. Soil pH is especially influential because even small changes can shift which species dominate, alter decomposition rates, and affect long-term habitat resilience. In transitional zones (or ecotones), where one vegetation type gives way to another, soil pH often signals whether grasslands remain stable, wetlands persist, or forests expand. Understanding these shifts is essential for predicting ecological change and guiding management. To investigate this, I examined whether soil pH varied across the grassland-aspen forest ecotone in Miquelon Lake Provincial Park, Alberta. I hypothesized that soil pH would differ significantly among habitats and help explain aspen encroachment into grassland. Through on-site measurements of soil pH, I used non-parametric approaches to assess its effects along transects spanning grassland, ecotone, and forest, with soil moisture measured as a supplemental variable. Contrary to my hypothesis, soil pH did not differ significantly across either transect points or habitat types. Soil moisture also showed no significant differences, although ecotone sites displayed slightly higher median values. My findings suggest that soil pH may not be the primary driver of vegetation transitions at Miquelon Lake, but they contribute to a broader understanding of grassland–forest dynamics and provide relevant insights to biodiversity conservation and management in the Aspen Parkland.

Keywords: pH, Miquelon Lake Provincial Park, Design, Soil Chemistry, Grassland, Forest.

1. Introduction

The Soil forms the foundation of ecosystems, influencing everything from nutrient cycling and microbial activity to plant growth and community structure (Chen et al. 2024). Among soil properties, pH is one of the most critical because even small changes can shift nutrient availability, alter decomposition, and regulate which plant and microbial species can thrive (Du et al. 2025). Ecologists often look to pH not only as a measure of soil chemistry but also as a signal of long-term ecological resilience and habitat stability.

This matters especially in ecotones, transitional zones where one vegetation type gives way to another. In many systems, pH has been shown to change predictably across these transitions. For example, Danso Marfo et al. (2019) found that soil pH declined from agricultural land into adjacent forest, with the steepest shifts at the ecotone boundary. Similarly, Gupta et al. (2024) reported acidification across alpine tree lines linked to changes in organic matter inputs, while Sui et al. (2021) reported strong pH-driven restructuring of microbial communities in wetland-meadow transitions. Together, these studies suggest that pH is not merely background chemistry but a potential driver of ecological feedback in transitional landscapes.

In western Canada, the Aspen Parkland represents one of the largest ecotones on the continent, lying between the prairies and the boreal forest (Forests | Nature Conservancy of Canada 2025). This biome contains a mosaic of grasslands, wetlands, and trembling aspen (*Populus tremuloides*) stands, historically maintained by fire and grazing

(Roellig et al. 2018). Disturbance suppression, particularly fire exclusion and reduced grazing, has allowed aspen to expand into grasslands, raising concerns about biodiversity loss and shrinking prairie habitat (Alberta Parks 2025). At Miquelon Lake Provincial Park, mowing has been used in some areas to slow this process, but the role of soil chemistry in either mediating or reflecting vegetation transitions remains unclear.

The goal of this study was to determine if soil pH changes across the grassland-aspen forest ecotone at Miquelon Lake. Given evidence from other ecotones, I hypothesized that soil pH would differ significantly among habitats, with lower values expected in forest soils compared to grasslands, reflecting differences in litter inputs, organic matter accumulation, and microbial activity (Gupta et al. 2024; Sui et al. 2021). I also measured soil moisture as a supplemental factor, predicting that median values would be higher in the forestland due to canopy cover (Li et al. 2014).

If soil pH proved to be a key driver of vegetation transitions, I expected it could help explain mechanisms behind aspen encroachment and inform management strategies such as fire, grazing, or mowing. Conversely, if soil pH remained stable across habitats, this would suggest that other factors (such as moisture variability, disturbance history, or species interactions) play more significant roles. Overall, the findings of this study were expected to provide new insight into the ecological dynamics of the Aspen Parkland and to anticipate how climate change and land-use policies may influence the stability of grassland–forest transitions in Alberta and beyond.

2. Methodology

2.1. Study Area

This study was conducted in Miquelon Lake Provincial Park (MLPP), Alberta, within the Aspen Parkland natural subregion (Figure 1). Aspen Parkland is a broad ecotone between prairie grasslands and boreal forest, characterized by a mosaic of grasslands, wetlands, and trembling aspen stands (Alberta Parks 2025). Historically, the landscape was shaped by frequent fire and bison grazing, but suppression of these disturbances has allowed aspen to expand into grasslands, raising concerns for habitat loss and biodiversity decline (Roellig et al. 2018; Alberta Parks 2025).

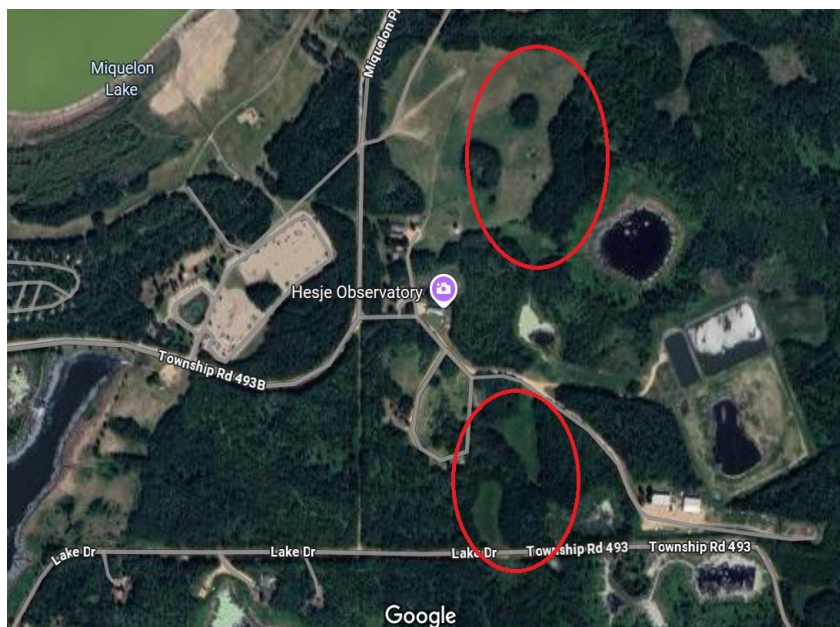


Figure 1. Satellite map showing aerial view of the study area at Miquelon Lake Provincial Park, Alberta, Canada, showing the two sampled grassland–aspen ecotone sites. Source: Google Earth.

Two field sites were selected within 5–10 minutes walking distance of the Augustana Miquelon Lake Research Station (AMLRs). Each site contained natural grassland–aspen transitions that had not been altered by mowing or other management practices. Sites subjected to mowing were excluded to ensure only natural ecotones were sampled.

2.2. Study Design

The study followed a comparative field design to test for differences in soil pH across the grassland–aspen forest ecotone. At each site, 5 transects were established, for a total of 10 transects. Transect placement was determined using a random number generator ([Wheel of names](#)) to reduce bias while ensuring representative coverage of each site. This technique was repeated at each site at the start of data collection, thereby providing consistent sampling across grassland, transition, and forest habitats at both study sites. This study was done under the Alberta Parks Research and Collection permit numbers 25-333 and 25-334 and University of Alberta Animal Ethics ID# AUP00001633, all held by Dr. Glen Hvenegaard.

2.3. Data Collection

Data collection occurred over a period of 4 days (from September 2nd to September 5th, 2025) with 2 days spent on each site. Seven standardized sampling points were established along each transect to represent the gradient from grassland into forest interior: F – 5 m before A (into grassland), A – first young aspen (3–6 ft tall) at the grassland edge, B – midpoint between A and C, C – transition zone (first line of aspens \geq 7 ft tall), D – midpoint between C and E, E – forest interior, G – 5 m beyond E (further into forestland).

Transects were laid in straight lines from the grassland into the forestland. At each point, I sampled the soil at 5-7 cm depth by creating a small hole with a screwdriver. Approximately 5 mL of distilled water was added to moisten the soil, allowed to absorb for 3 minutes, and then measured using a [Kelway soil tester](#). Soil pH was recorded after a 2-minute stabilization period, and soil moisture percentage was recorded after an additional 3 minutes. All values were recorded in my field notebook.

2.4. Data Analysis and Reporting

Sampling points were analysed in two ways to capture both fine-scale and broader-scale variation. First, each point along the transect (F - G) was tested individually to detect localized differences in soil pH and moisture. Second, points were grouped into grassland (F, A), ecotone (B, C, D), and forest (E, G) habitat categories to represent major vegetation zones and reduce noise from micro-scale variation.

Descriptive statistics (median, IQR, range) were calculated for soil pH within each habitat grouping. A Kruskal-Wallis test was used to analyse differences in soil pH across habitats and points within the transect because the data was not normal. Soil moisture was also analysed using a one-way ANOVA. All statistical tests were conducted in [JASP 0.95.1](#) at an alpha level of 0.05.

Results were visualized using boxplots, with interpretation focused on whether soil pH differed significantly across the ecotone and what these patterns imply for aspen encroachment dynamics in the Aspen Parkland.

3. Results

3.1. Soil pH Distribution

Across all sampling points, a total of 70 soil pH measurements were collected. Soil pH values ranged from 4.40 to 6.90, with a median of 6.30 (IQR = 0.60). The distribution was slightly left-skewed, with most values clustering

between 6.0 and 6.9. A Shapiro-Wilk test confirmed that the data deviated significantly from normality ($W = 0.924$; $p < 0.001$).

3.2. Soil pH Differences Among Sampling Points

Since the data distribution was not normal, a Kruskal-Wallis test was conducted to test whether soil pH varied across the seven sampling points (F-G). The results showed no significant differences in soil pH across points ($H(6) = 7.31$; $p = 0.293$; Figure 2).

3.3. Soil pH Differences Among Habitat Types

When points were grouped into habitat types (Grassland = F and A; Ecotone = B, C, D; Forestland = E and G), soil pH showed similar patterns across categories. Grassland and forestland had slightly higher medians compared to the ecotone, but differences were not statistically significant ($H(2) = 6.37$; $p = 0.041$; Figure 3).

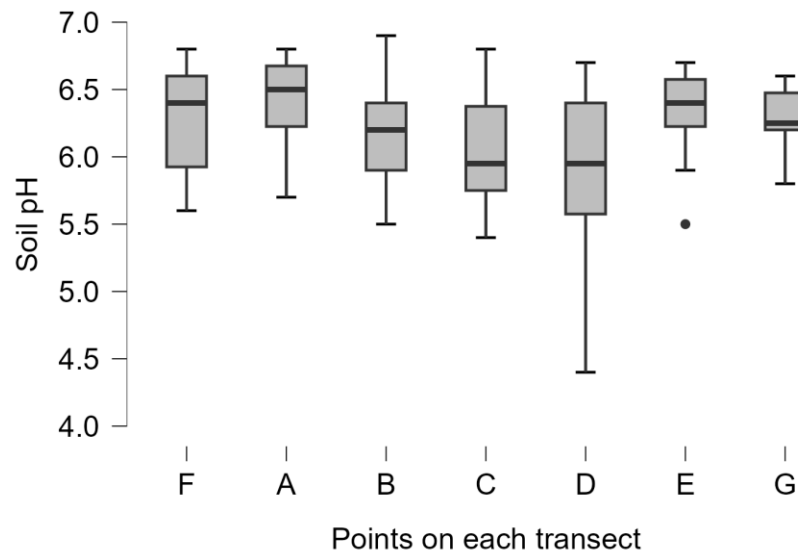


Figure 2. Boxplot showing soil pH across seven sampling points for along ten grassland–forest transects in Miquelon Lake Provincial Park, Alberta. Points represent a gradient from open grassland into forest interior: F = 5 m into grassland, A = grassland edge (first young aspen), B = midpoint between A and C, C = transition zone (first line of mature aspen), D = midpoint between C and E, E = forest interior, and G = 5 m beyond E into grassland. Boxplots show the median (thick horizontal line), interquartile range (box), and outliers (dots). Data was collected between September 2nd-5th, 2025 in Miquelon Lake Provincial Park.

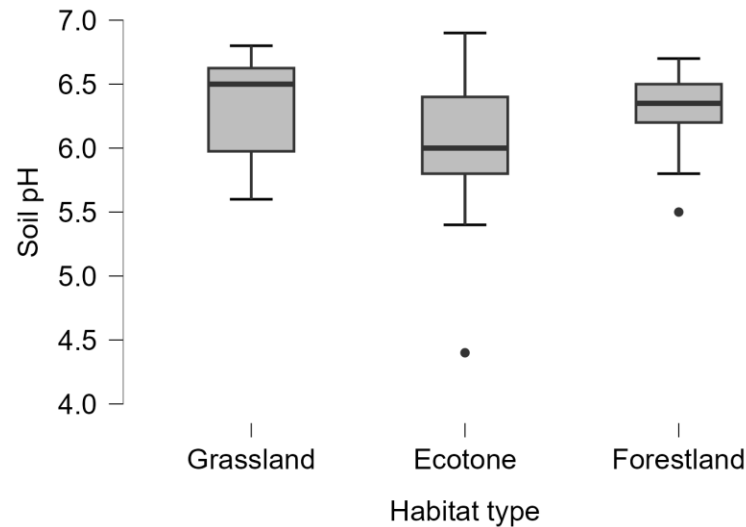


Figure 3. Boxplot showing soil pH across three habitat types in Miquelon Lake Provincial Park, Alberta. Habitats were defined from transect sampling points ($n=70$) as grassland (F, A), ecotone (B, C, D), and forestland (E, G). Boxplots show the median (horizontal line), interquartile range (box), and outliers (dots). Data was collected between September 2nd-5th, 2025 in Miquelon Lake Provincial Park.

3.4. Soil Moisture Distribution

Soil moisture was measured at 70 points across the transects, with values ranging from 29.0% to 92.0%. Median soil moisture across all points was 58.5% (IQR= 14.5). Shapiro–Wilk tests indicated that soil moisture values were normally distributed for all sampling points ($W= 0.969$; $p = 0.077$).

3.5. Soil Moisture Differences Among Sampling Points

A one-way ANOVA was conducted to test for differences in soil moisture among the seven sampling points (F–G). The analysis showed no significant effect of the point on the transect on soil moisture, $F(6, 63) = 0.520$; $p = 0.791$; $\omega^2 = 0.00$ (Figure 4).

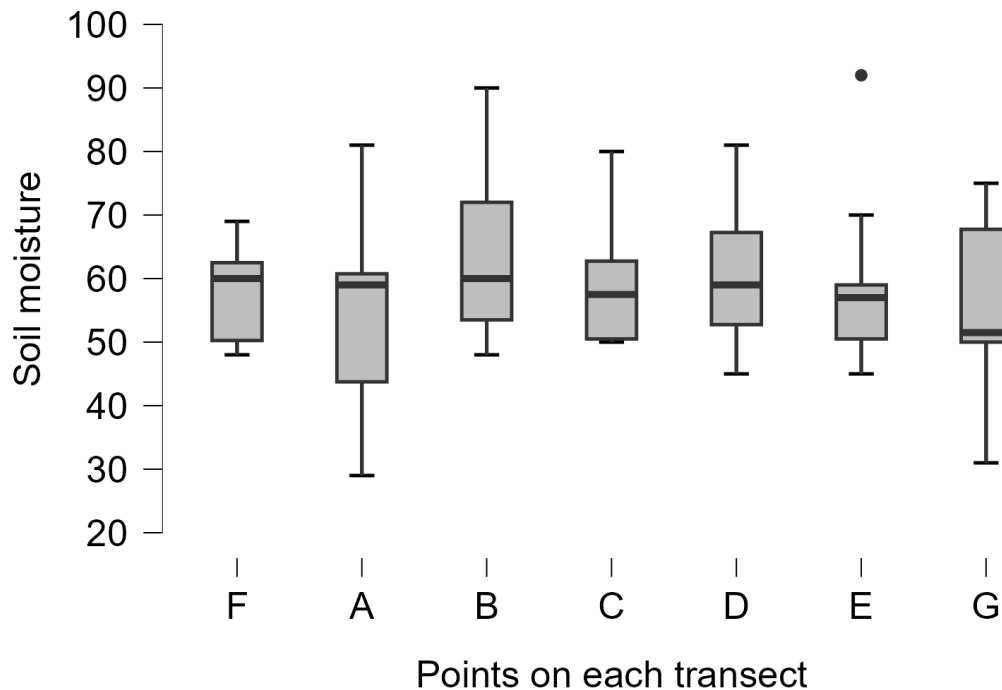


Figure 4. Boxplots showing soil moisture (%) across seven sampling points along ten grassland–forest transects in Miquelon Lake Provincial Park, Alberta. Points represent a gradient from open grassland into forest interior: F = 5 m into grassland, A = grassland edge (first young aspen), B = midpoint between A and C, C = transition zone (first line of mature aspen), D = midpoint between C and E, E = forest interior, and G = 5 m beyond E into grassland. Boxplots display the median (horizontal line), interquartile range (box), and outliers (dots). Data was collected between September 2nd–5th, 2025 in Miquelon Lake Provincial Park.

3.6. Soil Moisture Differences Among Habitat Types

When points were grouped into habitat types (Grassland = F and A; Ecotone = B, C, D; Forestland = E and G), soil moisture medians appeared slightly higher in ecotone habitats compared to grassland and forestland. However, these differences were not statistically significant, $F(2, 67) = 0.972$, $p = 0.384$ (Figure 5).

4. Conclusion

4.1. Soil pH patterns across the grassland–aspen ecotone

Soil pH did not differ significantly across transect points or when grouped into habitat types (Figures 2–3) which does not support my hypothesis that soil pH would differ significantly across habitats. This result contrasts with previous studies that found consistent pH shifts across vegetation transitions, such as forest–agriculture boundaries (Danso Marfo et al. 2019) and alpine tree line ecotones (Gupta et al. 2024). In those systems, pH decline into forest soils was linked to organic matter accumulation and increased microbial activity. Based on my results at Miquelon Lake, however, pH values clustered between 6.0 and 6.9 across all habitats, suggesting that soil pH may not be the primary driver of vegetation transitions in the Aspen Parkland. Although median values were slightly lower in ecotone soils (median 6.0) compared to grassland or forest (both ~6.3–6.5), this difference was not statistically meaningful. This weak pattern may reflect the mosaic nature of Aspen Parkland soils, which are shaped by a history of fire, grazing,

and fine-scale heterogeneity (Roellig et al. 2018). It may also reflect that trembling aspen encroachment into grassland is influenced more by disturbance suppression than by soil chemistry alone.

4.2. Soil moisture as a supplemental variable

Soil moisture did not differ significantly across either transect points or habitat types (Figures 4-5). Ecotone habitats displayed slightly higher medians (~60%) compared to grassland or forest (~55%), but this variation was small and not statistically significant. These results did not support my hypothesis that soil moisture would be higher in forestlands but suggest that short-term soil water availability was relatively uniform across the sampled sites. However, studies in other ecotones have demonstrated that moisture gradients strongly influence vegetation dynamics, particularly where aspen competes with grasses and shrubs (Li et al. 2014).

4.3. Vegetation context along transects

The vegetation observed along transects reflected characteristic Aspen Parkland structure. Grassland zones were dominated by creeping thistle (*Cirsium arvense*) and mixed grasses, while ecotone areas contained goldenrod (*Solidago spp.*), prickly wild rose (*Rosa acicularis*), and occasional willow (*Salix spp.*). Forest interiors were dominated by trembling aspen and balsam poplars (*P. balsamifera*) with few white spruce (*Picea glauca*) saplings. These vegetation patterns correspond to known encroachment dynamics in the Parkland, where aspen gradually colonizes open habitats in the absence of disturbance (Roellig et al. 2018). Importantly, our soil pH findings did not correspond with these vegetation shifts, suggesting that soil pH may reflect rather than drive vegetation composition at Miquelon Lake.

4.4. Implications for management and conservation

The absence of strong soil pH or moisture gradients across the grassland–forest ecotone suggests that aspen encroachment at Miquelon Lake may not be chemically mediated. Instead, disturbance history (e.g., fire exclusion, reduced grazing) and plant-plant interactions may be the dominant forces maintaining or shifting boundaries. This finding supports the management strategies currently used in the park, such as mowing. From a broader perspective, my results contribute to global discussions on soil–vegetation feedback, showing that soil pH is not always a universal predictor of ecotone dynamics (Sui et al. 2021).

4.5. Limitations and future research

Soil Several limitations should be noted. First, the Kelway soil tester, while convenient for field use, requires pre-wetting of the soil, meaning that recorded values may not fully represent the actual in situ soil moisture conditions. Second, my study relied on relatively short transect lengths with only seven points per transect. While this scale was appropriate for the limited area sampled, results may differ in larger or more complex ecotones where wider spacing could capture greater variation in soil pH and moisture. Third, the study was constrained by limited field days and a single researcher conducting all sampling, which reduced the amount of replications possible and may have increased susceptibility to measurement error. These limitations suggest caution when extrapolating the results across the broader Aspen Parkland landscape.

Future research should therefore expand transect lengths and sampling density to better capture variation across larger ecotones and habitat mosaics. Longer-term monitoring across multiple seasons would also help address temporal fluctuations in soil moisture and pH. Finally, supplementing field-based testers with laboratory analyses would provide greater precision and reliability. Together, these improvements would strengthen inferences about whether soil pH contributes to vegetation transitions or primarily reflects disturbance and plant community dynamics. By centering these findings in the broader context of Aspen Parkland management, my study contributes baseline soil data for future monitoring.

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