Preliminary Biogenic Silicon Analyses in Pre-treatment S1 Bog

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Introduction

•Silicon (Si) is the second most abundant element in the Earth's crust and is often overlooked in biogeochemical research as it is rarely limiting in terrestrial systems (Sommer et al., 2006).

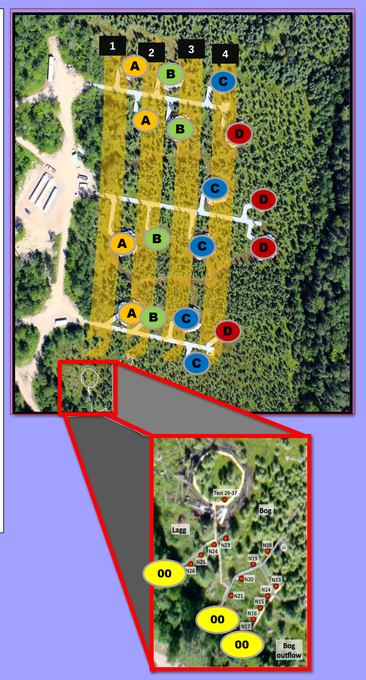
•Si is abundant in diatom and testate amoebae shells and has an important role in aquatic productivity. Si is tightly coupled to the carbon (C) cycle in oceans, rivers, and lakes, all of which depend on terrestrial sources for new inputs.

•On land, Si is vital for plant structure, rigidity and defense. Co-precipitating as opal silica, Si-Al and Si-Cd complexation helps to alleviate metal toxicity at the cellular level (Ma, 2015).

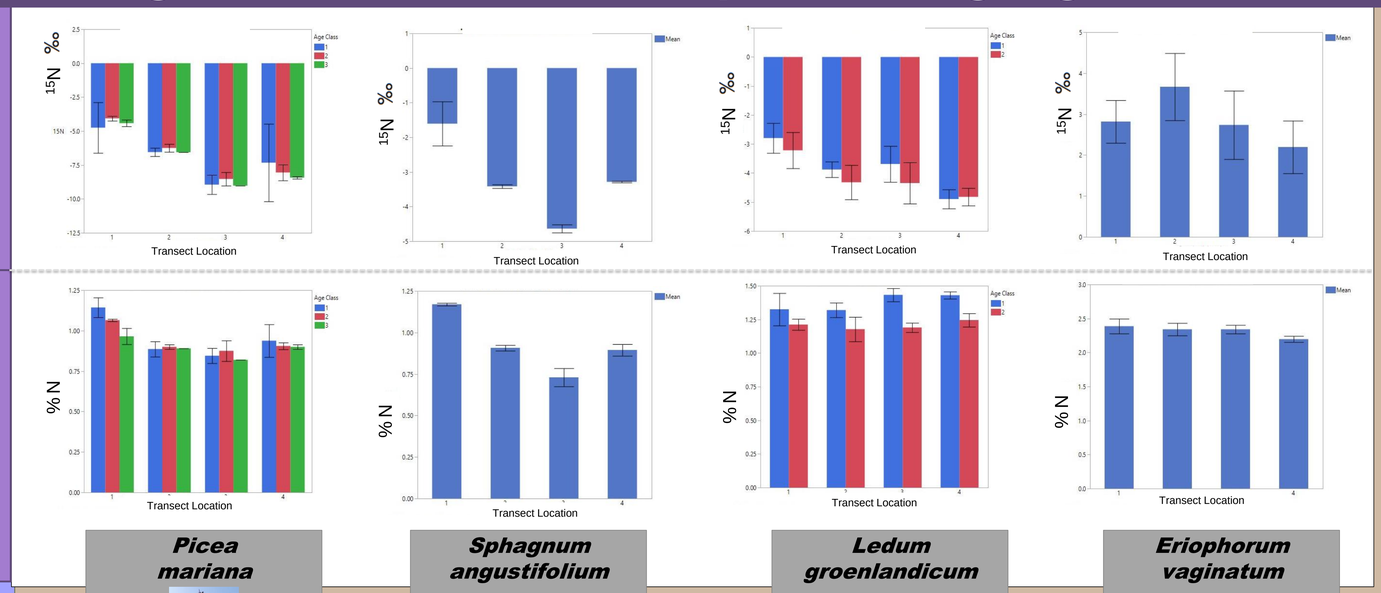
•Si is supplied to plants as silicic acid and absorbed into the plant through transpiration driven mass flow of water in passive accumulators and energetically imported in active accumulators (Jones and Handreck, 1967, 1969). Here we use Si as a means to explore nutrient acquisition strategies among diverse dominant bog plants.

Site / Plot Description

Figure 1. Plot locations within S1 Bog, USDA Forest Service, Marcell Experimental Forest, 40 km north of Grand Rapids, Minnesota. Map shows plot locations for SPRUCE environmental manipulation and bog-lagg transect at the southern end of S1 Bog near its outlet stream. Plant leaves were collected along transects 1-4, highlighted in yellow. Pore water samples were taken from pre-manipulation SPRUCE experimental plots and are labeled A, B, C, and D. Pore water samples taken at the boundary of upland and lagg zone are marked as 00.



Nitrogen Concentration and Isotopes in S1 Bog Vegetation



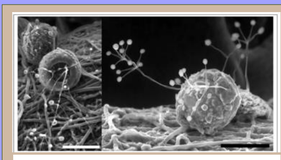


Figure 2. Scanning electron micrograph from Wilkinson (2008) showing ericoid fungi scavenging nutrients from testate amoebae shells.

Figure 3. Nitrogen content of bog vegetation along a lagg-bog transect. Bars are means ± standard deviation for total %N and per mil ^{15}N stable isotopes of washed, dried, homogenized leaves from dominant bog vegetation (N=2). Transect locations 1-4 represent distance to bog edges where transect 1 is nearest the upland interface and transect location 3 is bog center, with location 4 roughly equivalent to location 2. Transect location 1 varied significantly from location 3 (Tukey's HSD, $p < 0.05$) for *Sphagnum angustifolium* and *Picea mariana* δ15N and %N.

S1 Bog Pore Water Elemental Silicon

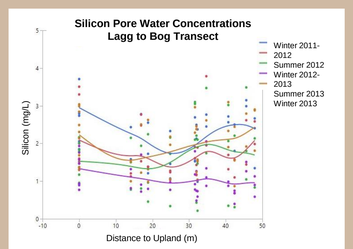


Figure 4. Sample points represent single collection dates along a transect running from the interface between uplands and the lagg into the bog. Distance to lagg did not differ significantly in Si content (p=0.4064) while sample collection date was a significant factor (p=0.0001)

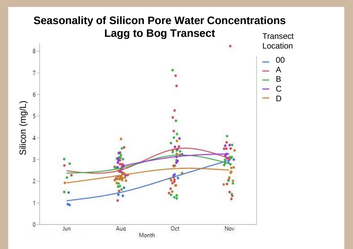


Figure 5. Pore water silicon concentrations along a transect within SPRUCE plots. between the bog transect locations A,B, and C when compared pairwise against. the upland interface (00) in August but not in Oct (Tukey's HSD $p<0.05$). Transect D did not vary significantly from either the upland interface (00) nor bog transects A,-C

S1 Bog Pore Water Biogenic Silicon

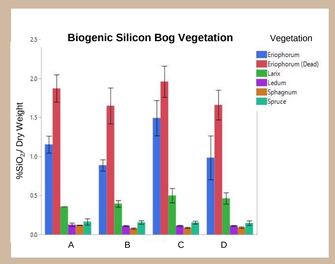


Figure 6. Bars represent mean values ± standard deviations of biogenic Silicon by dry weight of five different dominant bog plant species. Tukey's HSD statistical test showed ($p< 0.05$) significant difference between *Sphagnum angustifolium* in the A transect compared to B, C, or D.

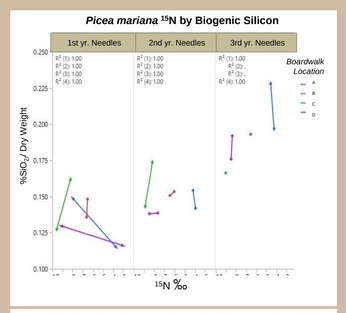


Figure 7. Correlation between biogenic Silicon and ^{15}N of *Picea mariana* leaves of three different needle ages at four different boardwalk locations. 3rd. yr needles show enrichment in ^{15}N and biogenic Silicon in the areas adjacent to the upland boardwalk plot.

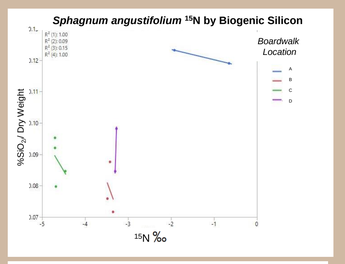


Figure 8. Correlation between biogenic Silicon and ^{15}N of *Sphagnum angustifolium* at four different boardwalk locations. The boardwalk location A showed enrichment in^{15}N and biogenic Silicon in the areas adjacent to the upland boardwalk plot.

Methods

Samples for biogenic Si and stable carbon and nitrogen (N) isotope analyses were collected before environmental manipulation at S1 bog in August 2015 along transects on boardwalks 2 and 3 (Figure 1) as a function of distance from the upland. Plant samples (leaves) were washed and dried before homogenization in shaker grinder. Isotopic analyses were performed on a DeltaPlus XP mass spectrometer interfaced to a Costech ECS4010 Elemental Analyzer via a Conflo III at the University of New Hampshire. Biogenic Si content was analyzed at Marine Biological Laboratory.

Conclusions

Stable isotope and elemental analyses indicate variability in pools or in access to mineralized nutrients across the bog transect for the dominant bog vegetation at the S1 bog. *Picea mariana* and *Sphagnum angustifolium* follow similar trends and appear to access the same variable nutrient pools along the transect. *Eriophorum vaginatum* showed a different pattern and did not vary along the transect, perhaps the result of distinct (e.g. depth, chemical, enzymatic) foraging strategies. Because biogenic Si values and ^{15}N isotopes correlate along the bog transect, it is possible that this response is due to enhanced access to Si and N from upland sources at the bog edge, which is then imported toward the center as it cycles through the biota. This conclusion is supported by higher % N and higher ^{15}N contents in vegetation at the bog margin. On the other hand, this pattern could indicate a higher degree of dependence on mycorrhizal fungi in plants near the bog center. In this scenario mycorrhizas access N from organic sources that are also high in biogenic Si content. A lack of variability in elemental Si concentrations in pore waters among bog transect locations may suggest that biogenic Si content in plants is more dependent upon this mycorrhizal mineralization than upon Si concentrations in pore waters. Future research should focus on Si sourcing, which can be clarified by comparing the germanium: Si ratio (Ge/Si) of lagg vs. bog plots to determine the pedogenic or biogenic origin of Si at S1.

Acknowledgements

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