

**Title:** Arctic aquatic graminoid tundra responses to nutrient availability

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**MS No.:** bg-2020-351

**MS type:** Research article

### **General Comments**

Andresen and Lougheed present a well-written, interesting study on the natural responses of an aquatic plant nutrients along environmental nutrient gradient, as determined through biogeochemical methods and remote sensing-derived productivities proxies. A main strong point of this study is that it investigates the nutrient status along a terrestrial-aquatic interface, which is understudied. The main comments I have are around clarification around methodological reasoning as well as the framing of the discussion. Overall, I think this paper would be of interest to the Biogeosciences audience and adds some understanding to the role of nutrient availability in tundra plants and how these can be assessed using remote sensing (spectral signatures).

### **Specific Comments**

#### **Abstract**

Line 21-22: Add the  $r^2$  value to indicate strength of relationship

Line 25: I would suggest taking out energy balance, as that goes beyond the scope of this paper

#### **Introduction**

Line 37: Also López-Blanco et al. (2020), Multi-year data-model evaluation reveals the importance of nutrient availability over climate in arctic ecosystem C dynamics, ERL 15:094007.

Line 37-39: The first half of this sentence makes the previous sentence a bit redundant; I would add something about nutrient availability being the main driver of increased tundra productivity in this sentence and remove the previous one.

Line 43: I would suggest removing the reference to energy budgets and Swann et al. (2010), as that reference is largely referring to Arctic boreal shifts to deciduous cover. Here we are dealing with bare (tundra) surfaces.

Line 49-50: The latter half of this sentence (specifically “plant accumulated nutrients”) is unclear.

Line 57-68: This paragraph belongs later in the introduction and could be shortened and incorporated into the concluding paragraph of the introduction.

#### **Methods**

Line 118-119: The authors describe four categories of sites, however Figure 1 is labelled as though there are 5 categories of sites. Consider relabelling the detailed maps using letters rather than numbers.

Line 155: I would specific that this is Total nitrogen, as opposed to just nitrate from the soil samples.

Line 164-165: Consider including the analysis method used for macronutrients. Also, what is the reasoning for selecting nitrate specifically rather also investigating total N, ammonium, and/or the organic pool? And the rationale for selecting total P rather than phosphate (as you selected the anionic form of N)?

Line 169: Is the aboveground plant biomass harvested here separate from the 10-15 plants collected for nutrient analysis?

Line 170: Include a description of the sky/solar conditions and time of day around the time of measurements

Line 170-171: What were water table conditions like at locations of reflectance measurements? How were measurements taken to ensure that they were representative of the aquatic emergent tundra without inference of water reflectance?

Line 175-183: This section is almost identical to text of another manuscript published by the authors in Andresen et al. (2018) and needs to be rewritten

Line 176-179: What is the nature of the reflectance outputs from the spectrometer employed? Did you consider averaging reflectance values from the NIR and red ranges (i.e. 62-750 nm for red) rather than using a single wavelength value?

## Results

Line 202-204: Figure 3 does not directly back up this statement. I would move the sentence above the lack of significant relationships between plant leaf N and biomass to back this up.

Line 207: This is the first instance of root nutrient content being brought up in this paper, although it was not directly analyzed for (only collected and separate from plant leaves, according to the methods). Considering removing.

Line 240: I would put section 3.2 ahead of section 3.1, as all your figures and tables describe *C. aquatilis* before *A. fulva* (when reading left to right)

Figure 3: To help make the caption less cluttered to read, consider adding the relationships for both species with biomass and NDVI (and their respective  $r^2$ ) to the plots, as well as adding  $r_2$  values for the species relationships to the plots

Figure 5: It would be helpful for readers for ease of comparison to be consistent with symbols used for site categories. Include percent of explained variability in brackets on axes titles.

## Discussion

There is a lot of focus on leaf nutrient status, but it would be good to see some discussion around the role of the soil nutrients and framed as a bottom-up approach (i.e. discussion of soil nutrients, the role that plays in leaf nutrient and biomass, and how that is manifested in NDVI and GEI). The latter half of this study could also benefit from discussion of study limitations, like how point-in-time measurements at peak season would differ greatly from a time-series seasonal snapshot.

Line 296-314: Much of this first paragraph talks about existing research; I would suggest the authors try to tie in more of the work from this study into this discussion. Additionally, the comparisons on nutrient limitation made here are largely to moist and wet tundra systems, however those systems can vary substantially from tundra pond environments that were studied in this manuscript. Some more justification for this is needed.

Line 315-319: It would be useful for readers to see some of this data displayed as a figure (i.e. bar graph) to visualize the changes.

Line 339-341: References for this statement? Also the statement is very generalized, as other elements not studied here have been shown to be contributing factors (i.e. growing season length, water availability, etc).

## **Conclusion**

Line 377: A few sentences summarizing main findings and addressing the original research questions posed in the Introduction (line 97-99) would be helpful to tie things back together.

## **Technical Corrections**

Line 33: “nutrient availability” instead of “nutrients”

Line 112: should be “on” vs “in” the edge

Line 151: “randomly” would be more appropriate than “haphazardly”

Line 290: should be “non-experimental”