Competition and nitrogen availability affect nitrogen-use strategies in native and invasive wetland plants

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Introduction

Understanding how freshwater wetland native and invasive species use excess nitrogen has become important as the availability of inorganic nitrogen (N) increases. Invasive wetland grass, *Phalaris arundinacea*, is known to thrive in areas of high soil nitrogen by allocating N to photosynthetic processes (Green & Galatowitsch 2002; He et al., 2011).. Native sedge species, such as *Carex lacustris* and *Carex stricta*, tend to store excess N rather than use it immediately to increase photosynthetic processes (Holaday et al., 2015). What is unknown is how these species nitrogen-use strategies for carbon and nitrogen assimilation differ when in competition with each other under and between different soil nitrogen availabilities?

Methods

For 18 weeks from June to October 2014, individuals of *P. arundinacea, C. stricta*, and *C. lacustris* (n=4) were grown in Turface MVP clay mix (ROFILE Products LLC, Buffalo Grove, IL) and pea gravel to provide a nitrogen-free growth medium in a 70-L mesocosms (Fig 1). Each individual was treated with 1 L of either a high soil nitrogen (15mM) and low nitrogen (1.5 mM) nutrient solution twice weekly. Individuals were grown alone and, for the two *Carex* species, in competition with *P. arundinacea*. Data were collected on photosynthesis and leaf traits every four and a half week. Data analyzed using a mixed effects model in R (Pinheiro et al., 2015; R core team, 2015).

Figure 1: On the left, a photograph of how plants were divided in each mesocosm (*Carex stricta* under low nitrogen treatment pictured). On right a photograph of how the mesocosms were positioned in greenhouse.

2)

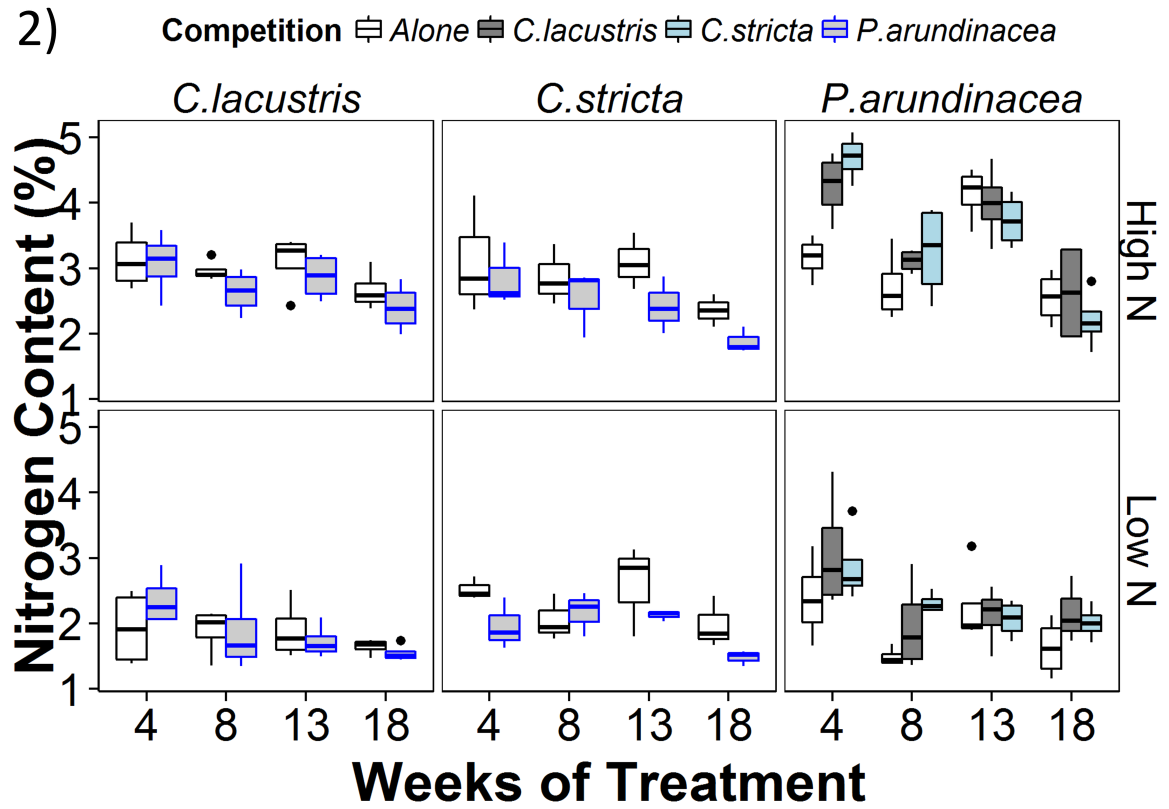

Figure 2: Changes in Leaf N over time between species grown alone and in competition. Species of interest are listed in the top x-axis. The competitor species differ by color as seen in the legend on top of the figure. The different nitrogen treatments are listed on the right y-axis.

3)

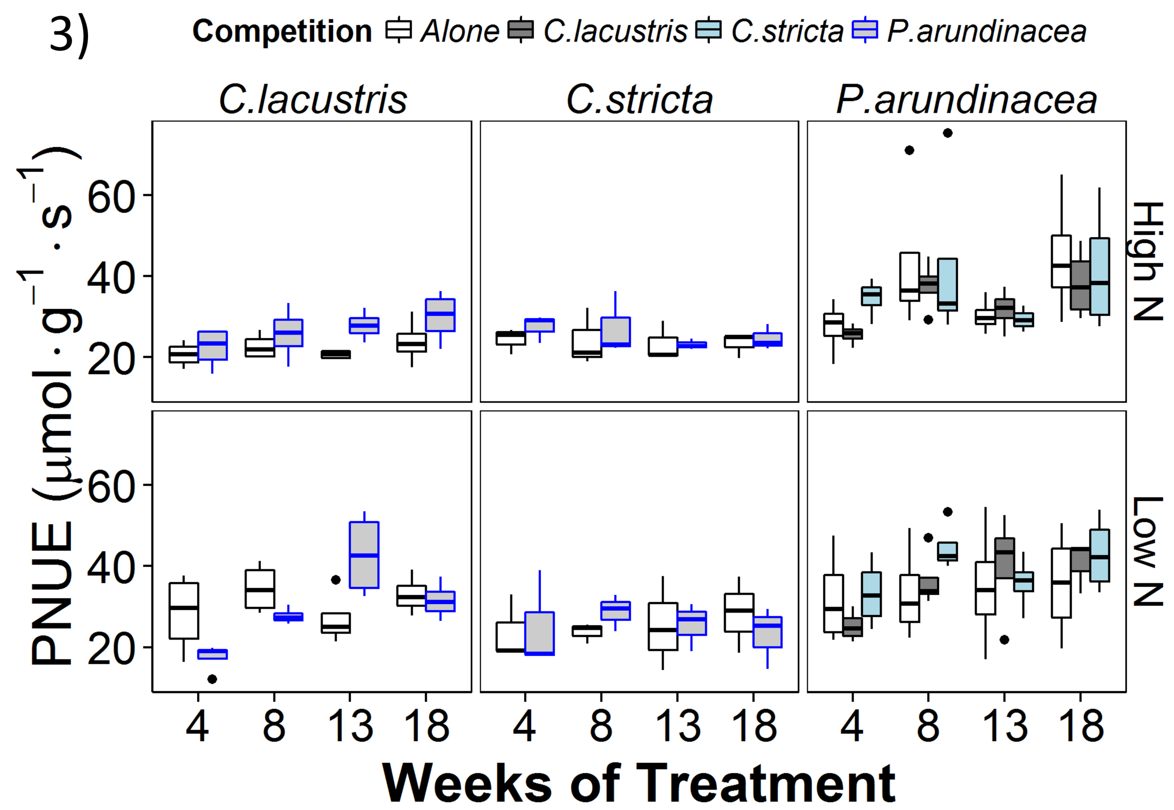

Figure 3: Changes in photosynthetic nitrogen-use efficiency (PNUE) over time between species alone and in competition. Species of interest are listed in the top x-axis. The competitor species differ by color as seen in the legend on top of the figure. The different nitrogen treatments are listed on the right y-axis.

4)

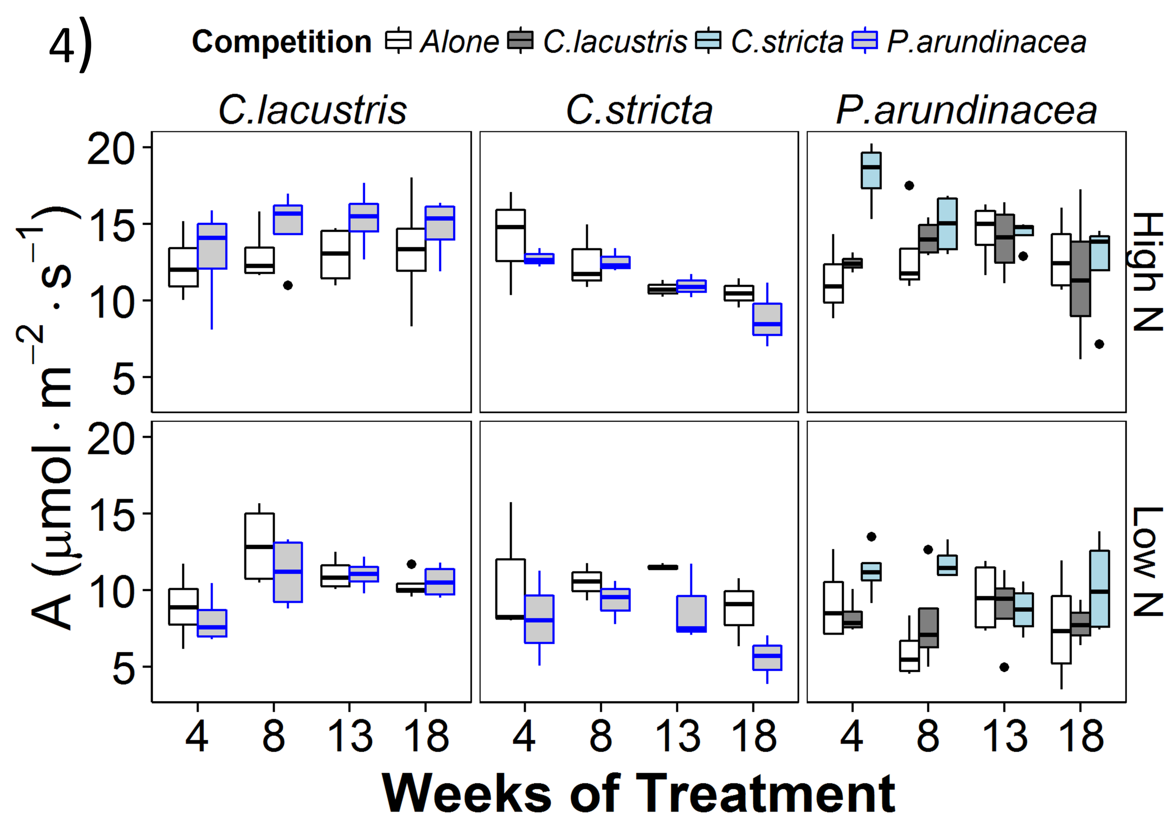

Figure 4: Changes in CO_2 assimilation (*A*) over time between species and treatment. Species of interest are listed in the top x-axis. The competitor species differ by color as seen in the legend on top of the figure. The different nitrogen treatments are listed on the right y-axis.

Results

Leaf N: *Phalaris arundinacea* had significantly higher leaf N content compared to either *Carex* species (Fig 2, p=0.0002). In both *Carex* species, leaf N decreased over time and while competing with *P. arundinacea* (p<0.0001 and p=0.0167, respectively). *Phalaris arundinacea* increased its leaf N content when it was competing with either *Carex* species. Leaf N was significantly higher under high nitrogen treatments for all species (p<0.0001).

PNUE: *Phalaris arundinacea* had significantly higher PNUE than either *Carex* species overall (Fig 3, p<0.0001). In *C. lacustris* and *P. arundinacea,* PNUE increased with significantly time (p=0.0010) while *C. stricta* did not. There was no effect of competition between species on PNUE (p=0.2775) nor nitrogen treatment (p=0.0573).

A: *A* differed significantly between species (Fig 4, p<0.0049) with *P. arundinacea* having the highest *A*, followed by *C. lacustris,* followed by *C. stricta*. For *C. lacustris* and *P. arundinacea*, growing in competition with one another significantly increased *A* (p=0.0043), while competition caused *A* to decrease in *C. stricta.* In all three species, *A* increased with nitrogen availability. *Carex stricta* ability to assimilation CO_2 appears to decrease over time, however, overall there was no significant effect of time on these species (p=0.0793).

SLA: *Phalaris arundinacea* had a significantly larger SLA than either *Carex* species (Fig 5, p<0.0001). There was no effect of treatment on SLA overall (p=0.9245). While competition did cause a significant increase in SLA in *P. arundinacea* and a decrease in *C. stricta* (p=0.0019). Both *Carex* species saw a significant decrease in SLA over time (p<0.0001).

5)

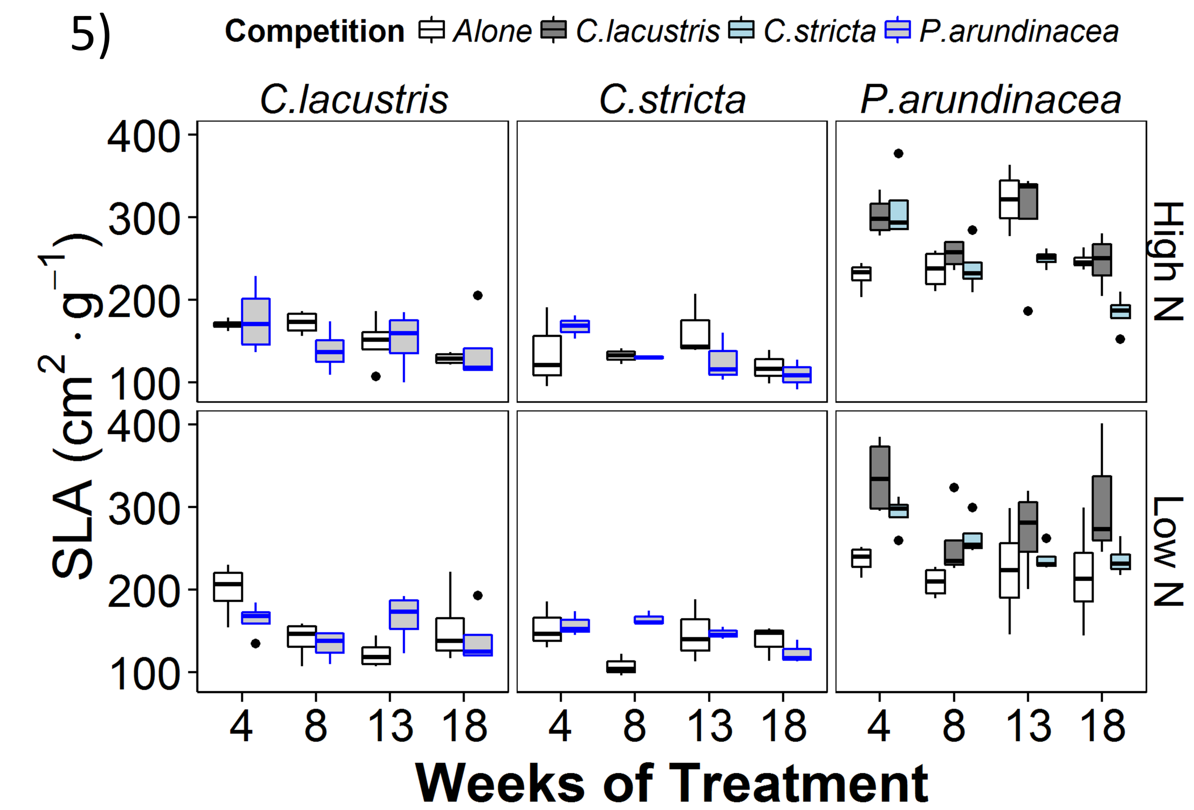

Figure 5: Changes in specific leaf area (SLA) over time between species and treatment. Species of interest are listed in the top x-axis. The competitor species differ by color as seen in the legend on top of the figure. The different nitrogen treatments are listed on the right y-axis.

Discussion

For *C. lacustris,* changes in soil N availability had little to no effect on *A* and SLA (Figs 4&5). However, a decrease in soil N caused a decrease in leaf N (Fig 2) and increase in PNUE (Fig 3) which indicates that *C. lacustris* can acclimate its nitrogen-use strategy under different conditions. *Carex lacustris* also increased its PNUE and *A* under high N while competing with *P. arundinacea* (Figs 3&4) which indicates it recognized its competitor and compensated for that competition. *Carex lacustris* might be better at slowing down an invasion by *P. arundinacea* compared to *C. stricta*.

For *C. stricta*, changes in soil N had little to no effect on PNUE, *A*, or SLA (Figs 3,4,5). Nor did competition with *P. arundinacea* effect those parameters. Although the effects of competition on *C. stricta* on *A* and leaf N are greater at low soil N compared to high soil N (Figs 2&3). Regardless of competitor or soil N, *C. stricta* decreases its *A* and SLA over time (Figs 4&5). Competition did decrease the overall leaf N content in *C. stricta* (Fig 2), which likely is because of the increased N consumption by *P. arundinacea*. The phenology of senescence appears to be hardwired in *C. stricta* and it is unable to take advantage of extra N or compete with *P. arundinacea.*

In *P. arundinacea*, there was an increase in leaf N and *A* with soil N (Figs 2& 4). *Phalaris arundinacea* is able to take advantage of excess soil N and use it in photosynthetic processes as seen in Holaday et al. (2015). The competition with *C. lacustris* and *C. stricta* caused *P. arundinacea* to increase its photosynthetic processes and leaf N content (Figs 2,3,4). Competition made *P. arundinacea* more aggressive in its nitrogen-use strategy of funneling excess N to photosynthetic processes. The opposite behavior was seen in competition with *C. stricta* (Figs 2-5). Because *C. stricta* does not appear to use the excess N under the high N condition, *P. arundinacea* was able to use the soil N to behave similarly to how it does when grown without competition.

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PDF of poster available on GitHub: http://git.io/vYtdD or right here

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Citations

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