Final Report
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Interaction between photosynthetic plasticity and nutrient levels as a factor driving wetland plant invasions

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Experimental progress

In the summers of 2002 and 2003, we measured morphological and physiological photosynthetic traits of several invasive (*Phalaris arundinacea*, *Phragmites australis*, *Lythrum salicaria*) and comparable non-invasive (*Calamagrostis canadensis*, *Carex lasiocarpa*, *Carex stricta*, *Carex* sp., *Typha angustifolia*, *Decodon verticillatus*) wetland species. Measured traits included light profiles, biomass profiles and photosynthetic light response curves through the canopy, leaf longevity, tissue nitrogen contents, plant-available soil nutrient ammonium, nitrate and phosphate. Samples are still undergoing laboratory analysis (drying, weighing and nutrient analysis) and we have begun statistical analysis of the preliminary data.

As expected, the invasive species had a higher proportion of leaf biomass concentrated near the top half of the canopy as a result of lower leaf loss and throughout the growing season (Figure 1). In contrast, the six non-invasive species retained leaves in the lower canopy and had more leaf biomass in lower light environments.

We found no inherent difference between invasive and native species in the maximum photosynthetic rates (A_{max}) of the light adapted leaves (i.e., those leaves in the top 50 cm of canopy; Figures 2, 3). Leaves in the lower canopy of native species, however, are shade-adapted (Figures 2, 3). In contrast, the lowest 50 cm of leaves of the invasive species have similar maximum photosynthetic rates as the top leaves of the canopy, indicating that these lower leaves are not shade-adapted. Lower leaves of the native species are located lower in the canopy than are the lower leaves of the invasive species (Figure 1). Thus, the invasive species have a different pattern of canopy development as aboveground biomass increases, and light availability decreases. The invasive species abscise lower canopy leaves as new leaves develop in the upper canopy, whereas the native species alter the physiology of their lower canopy leaves so that they are shade-adapted, with lower maximum photosynthetic rates (Figure 3). In addition, invasive species have higher total green leaf biomass in the canopy than do native species (e.g., *Phalaris* 0.80 g dry weight ± SE 0.29 vs. *Calamagrostis* 0.12 ± 0.01, $t = 2.30$, $df = 6$, $p = 0.06$; *Phragmites* 8.50 ± 0.41 vs. *Typha* 5.44 ± 0.76, $t = 3.55$, $df = 6$, $p = 0.01$; July). This indicates that the invasive species should have a higher rate of canopy photosynthesis, because they have more leaf tissue and light-adapted leaves higher in the canopy in higher light environments. Further analysis of data is ongoing.

Additionally, we performed a pilot study in which soil nutrient levels were manipulated by adding nutrients or carbon for one invasive and two non-invasive species. The resulting biomass, soil nutrient levels and photosynthetic rates were measured. Results will be used to determine appropriate nutrient levels for further experiments.

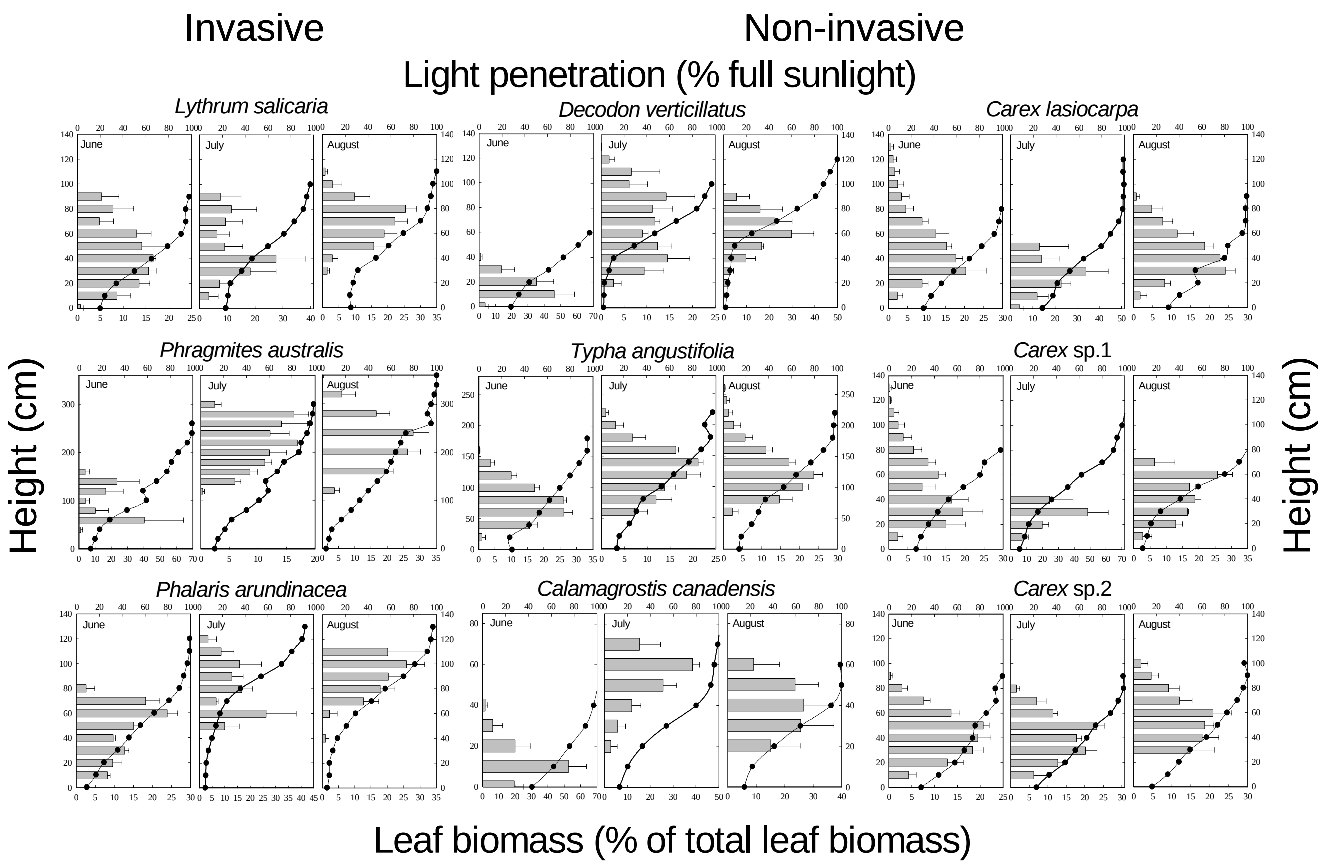

Figure 1: Leaf distribution and light levels within monoculture canopies based on four destructive samples for each harvest date of three invasive species and six non-invasive species. Bars represent biomass, curves represent light.

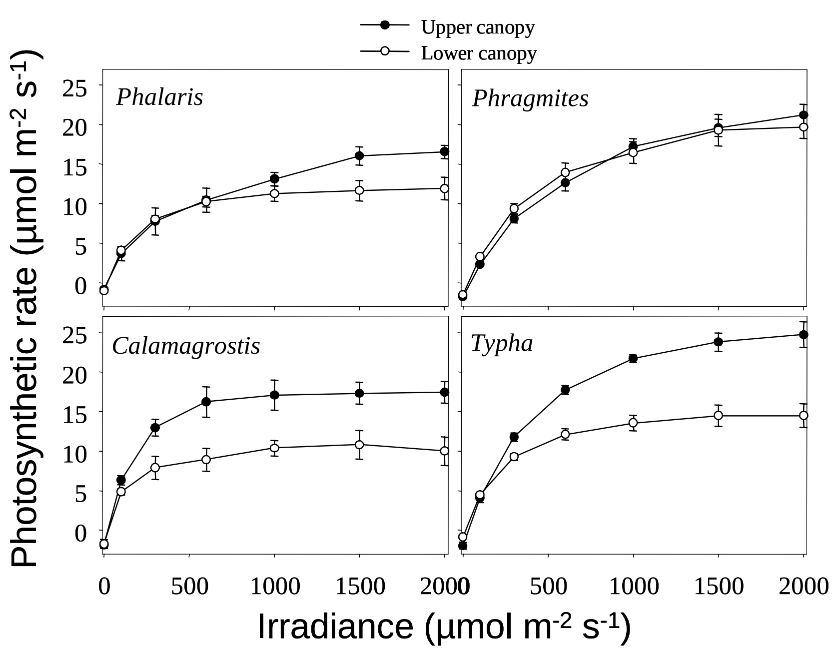

Figure 2: Photosynthesis as a function of irradiance in the upper and lower 50 cm of leaf canopy. Photosynthesis was measured in July 2002 and given as the mean rate ± SE for four leaf samples.

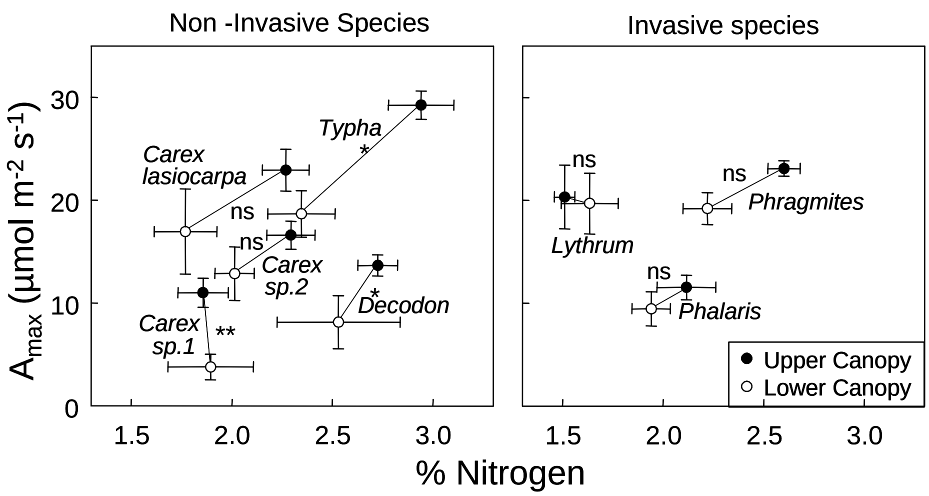

Figure 3: Leaf A_{max} versus leaf tissue nitrogen concentration of leaves in the upper and lower canopy measured in August 2002. Indicated significance levels are from analysis of covariance with A_{max} as dependent, leaf nitrogen concentration as a covariate and leaf position as the independent variable.

<u>Resulting projects, partnerships and ideas</u>

Personnel:
In addition to the principal investigator, Jean Knops, the project was managed by post-doctoral researcher, Heather Hager. Several undergraduate and other workers received training for, and were involved with various aspects of the field work, data collection and laboratory analysis: Sylvain Coq (Ecole Normale Supérieure, France), Leila Desotelle (Winona State U, MN), Linda Geisert (Teacher, Lincoln public high school), Bryant Reynolds (UNL) and Travis Smith (UNL). Students were encouraged to obtain further experience by developing and carrying out their own field projects related to aspects of the project presented here.

Field sites:
Cedar Creek Natural History Area NSF Long-term Ecological Research site, Minnesota
The Nature Conservancy, Platte/Rainwater Basin area, Nebraska
Platter River Whooping Crane Management Trust, Nebraska

Concurrent support for this work:
Layman Award 2002, University of Nebraska – Lincoln. Comparison of invasive and native plant photosynthetic characteristics.

Current grant applications resulting from this work:
NSF – Ecology. The interaction between photosynthetic plasticity and fertility as a factor driving wetland species invasions.
Nebraska Research Initiative, University of Nebraska – Lincoln. The interaction between photosynthetic plasticity and fertility as a factor driving wetland plant invasions.

Publications:
To be prepared for submission to ecological journals upon completion of analyses.