Ecological genetics of *Phragmites australis* invasion in southern Lake Michigan coastal habitats (Seed Project)

Final Report
Illlinois-Indiana Sea Grant
June 30, 2011

Investigators:
Dr. Daniel Larkin
Plant Science and Conservation
Chicago Botanic Garden
1000 Lake Cook Road
Glencoe, IL 60022
847-835-6931
dlarkin@chicagobotanic.org

Dr. Jeremie Fant
Plant Science and Conservation
Chicago Botanic Garden
1000 Lake Cook Road
Glencoe, IL 60022
847-835-6959
jfant@chicagobotanic.org

Project summary

Under this award, the project team investigated the genetics of populations of *Phragmites australis* (common reed) throughout the Lake Michigan coast of Illinois and Indiana. In a parallel study, the environmental correlates and plant-community consequences of *Phragmites* invasion in coastal and inland wetlands in northeast Illinois and northwest Indiana were observed.

A total of 71 patches of *Phragmites* distributed across 17 sites (Figure 1) were sampled, analyzing the genetics of 450 individual plants. The exotic subspecies, *P. australis* ssp. *Australis*, occurred with greater frequency than the native subspecies, *P. australis* ssp. *americanus* (Table 1, subspecies determined by RFLP fingerprinting). Exotic genotypes recurred less frequently among different sites than native genotypes, which is consistent with a more recent colonization. Despite *Phragmites* expansion being widely thought of as a function of its ability to spread clonally, the high genetic diversity within and between patches is consistent with colonization through seed rather than stem fragments (Figure 2, Figure 3). An analysis of microsatellite data using Structure v2.0 allowed for comparison of the genetic structure of populations sampled with reference populations analyzed in publications by Saltonstall. Native *Phragmites* were found to be a distinct, homogenous group, of the same genetic origins as reference populations (Figure 4). However, exotic *Phragmites* appeared to comprise two distinct genetic groups, one of which was not well-represented in reference collections. This suggests that the Illinois-Indiana region may be subject to invasion by a distinct exotic strain.

In parallel to the genetic work described above, an environmental and ecological sampling was performed to elucidate the behavior of native vs. exotic *Phragmites*. Attributes such as the amount of bare ground, water cover, water depth, soil moisture, and salinity were not important in explaining the occurrence of uninvaded patches versus native-*Phragmites* patches versus exotic-*Phragmites* patches. Inorganic nitrogen availability (nitrate + ammonium) significantly differed among patches of different invasion status, but not in a consistent manner and without indication that increasing nitrogen was associated with more aggressive *Phragmites* growth (Figure 5, Figure 6). In contrast, phosphorus availability was higher in invaded areas, and exotic *Phragmites* in particular showed a strong positive growth response to phosphorus availability (Figure 7, Figure 8). Exotic but not native *Phragmites* were associated with strong local losses of plant diversity (Figure 9).

Based on these seed results, the following conclusions were drawn for management of coastal habitats colonized by *Phragmites*:

- Exotic and native *Phragmites* are quite different genetically and ecologically despite being conspecifics.
- No evidence of the native subspecies behaving invasively was found in the study.
- Wetland managers should prioritize control efforts on the exotic subspecies.
- Other studies have found evidence of hybridization between *Phragmites* subspecies. Were hybridization to occur in Illinois-Indiana coastal habitats, *Phragmites* could pose an even greater ecological threat due to hybrid vigor.

Further investigation is needed on *Phragmites* dispersal dynamics and rate of spread, the effects of land-use on invasion risk, and the effectiveness of current efforts to control *Phragmites* and restore diverse native plant communities in degraded coastal systems.

Students supported and degrees conferred

Research conducted as part of this award contributed to research experiences for one graduate, one post-bachelors, and four undergraduate students:

- This award supported the master's thesis research of Amy Price, who will receive her M.S. in Plant Biology and Conservation from Northwestern University (defending July 2011).
- Research Assistant Joseph Boyer performed field and laboratory work under this award, helping him secure a position as a paid conservation intern with the Bureau of Land Management in Richland, Utah.
- Field work was conducted by undergraduate researcher Cat Collins (DePaul University).
- Lab work was conducted by undergraduate researchers Adewale Adeoba and David Ford (Loyola University Chicago) and Dara Wise (Benedictine University, accepted to medical school for fall 2011).

Publications and presentations

Publications

Price, A.L. *In prep* (Jul 2011 completion). Genetics and ecology of *Phragmites australis* invasion in the upper Midwest. Master's Thesis. Northwestern University, Evanston, IL.

Price, A.L., J.B. Fant, and D.J. Larkin. *In prep*. Comparative ecology of native vs. exotic *Phragmites australis* (common reed) in Chicago-area wetlands. For submission to *Wetlands*.

Fant, J.B., A.L. Price, and D.J. Larkin. *In prep*. Genetic structure and reproduction of native and exotic *Phragmites australis*. For submission to *Conservation Genetics*.

Presentations

Larkin, D.J., A.L. Price, and J.B. Fant. 2011. When the species concept and land management collide: *Phragmites australis* invasion in the Chicago region. The Chicago Plant Science Symposium. Chicago, IL. Apr 16, 2011.

Larkin, D.J., A.L. Price, and J.B. Fant. 2011. Ecology and genetics of *Phragmites australis* invasion in the Chicago region. Presentation to the Chicago Wilderness Natural Resources Management Team. Chicago, IL. Apr 25, 2011.

Tables and Figures

Table 1. Occurrence of unique native and exotic genotypes of *Phragmites* in sampled patches.

		Native	Exotic
Genotypes		38	89
Patches found in	1	74%	98%
	2	21%	2%
	3	5%	0%
	≥4	0%	0%
Sites found in	1	100%	100%
	≥2	0%	0%

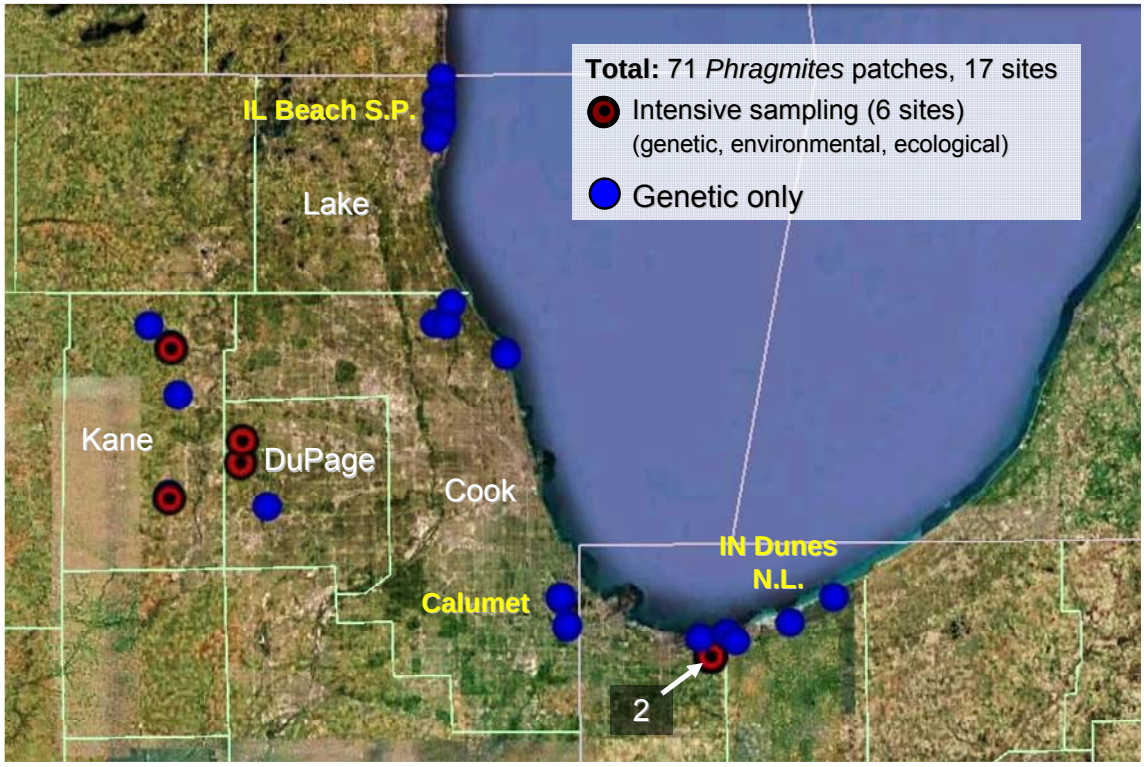

Figure 1. Locations of *Phragmites australis* populations sampled as part of this study.

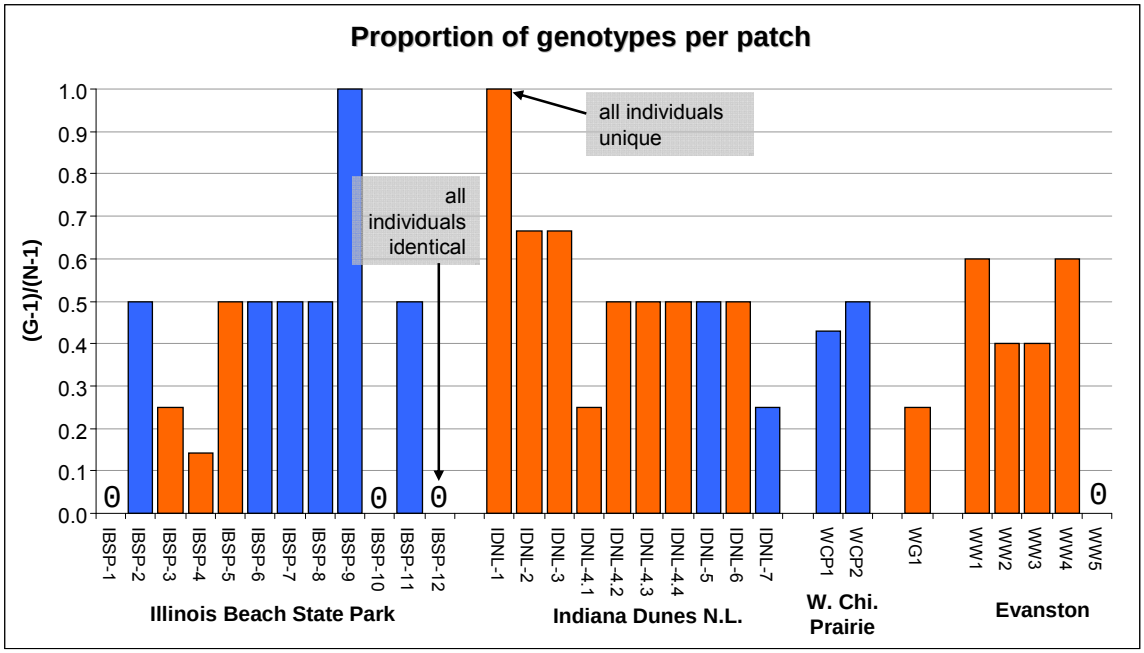

Figure 2. Patch-level genetic diversity for subset of sites sampled in this study. Blue and orange bars indicate representatives of the native and exotic subspecies, respectively. Results indicate that sexual reproduction is an important factor within patches, despite *Phragmites* being a clonal species.

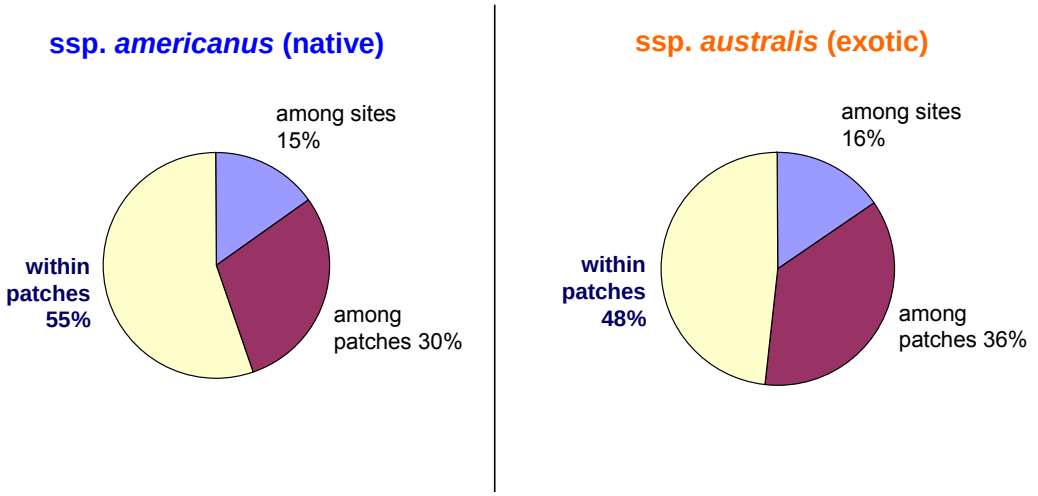

Figure 3. AMOVA analysis showing the distribution of genetic diversity among different population levels.

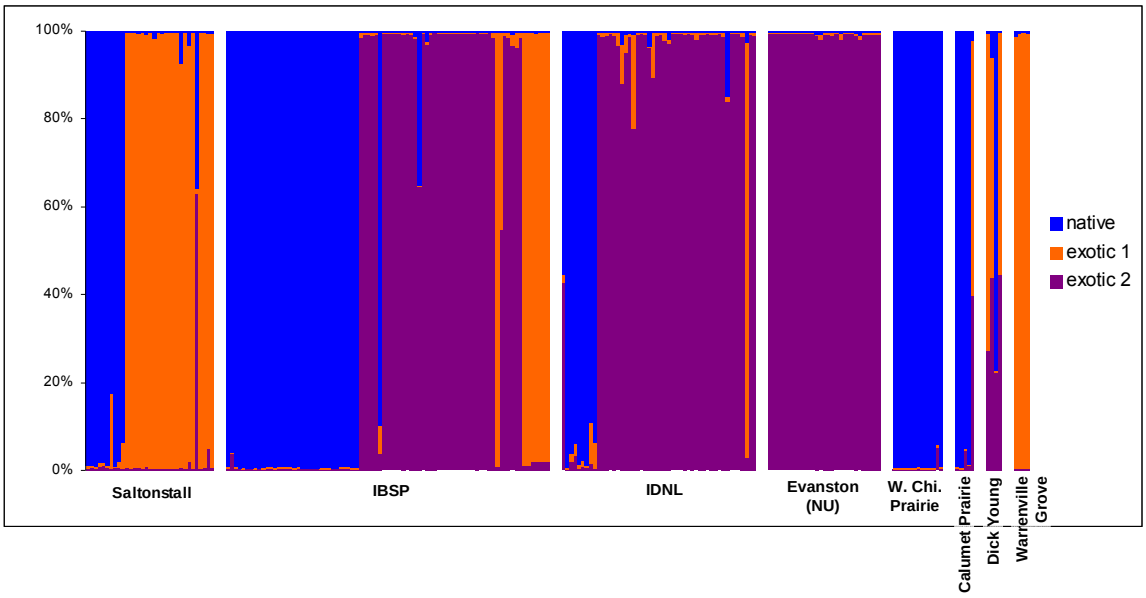

Figure 4. Results of a structure analysis of microsatellite data. Saltonstall data used for reference populations.

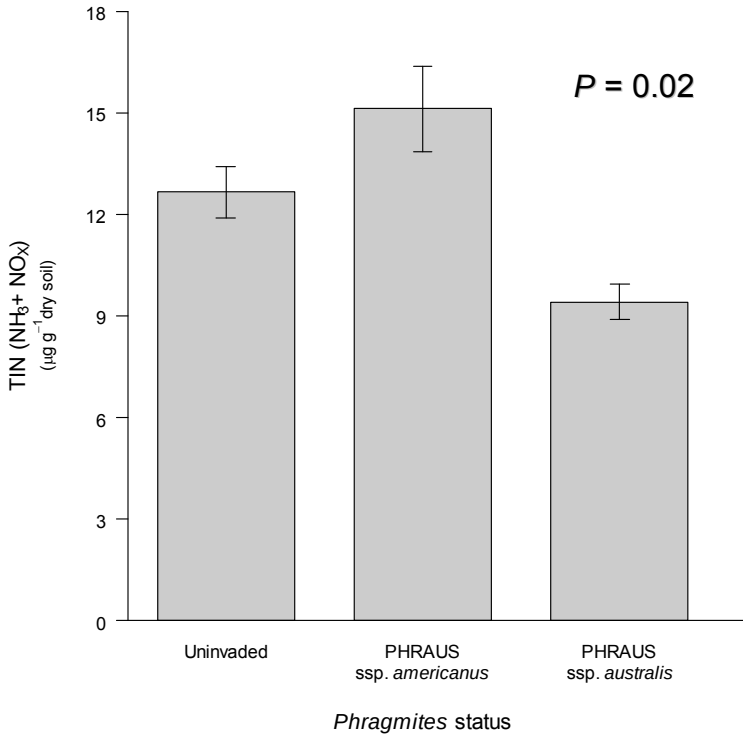

Figure 5. Differences in sediment inorganic nitrogen concentration in uninvaded, native-*Phragmites*, and exotic-*Phragmites* patches. Error bars are ± 1. s.e.

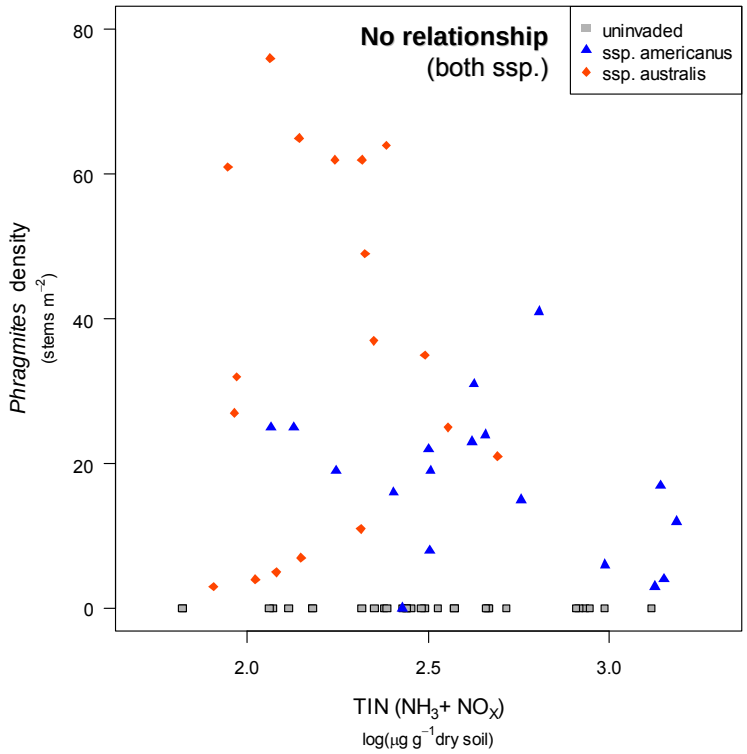

Figure 6. There was no increase in *Phragmites* stem density with increasing inorganic nitrogen availability.

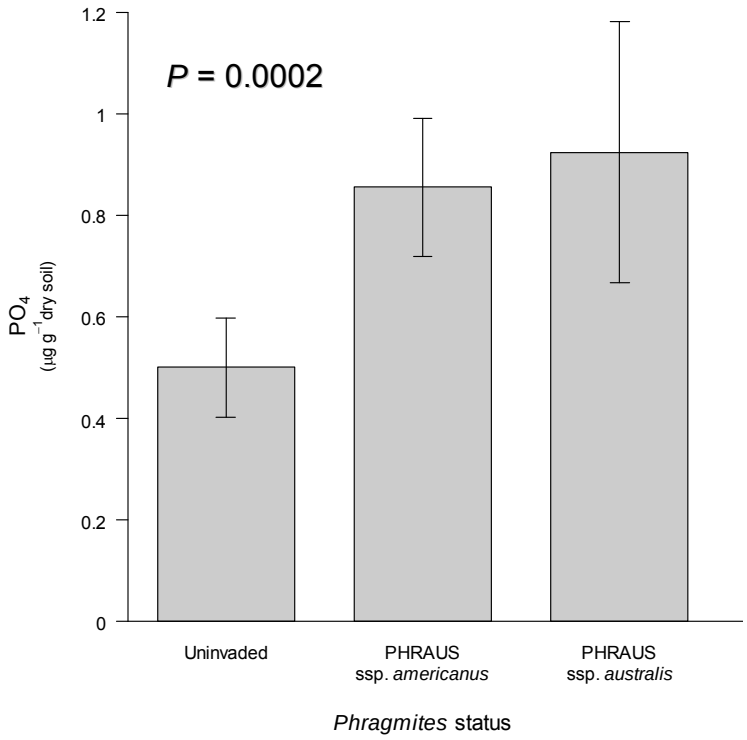

Figure 7. Differences in sediment orthophosphate concentration in uninvaded, native-*Phragmites*, and exotic-*Phragmites* patches. Error bars are ± 1. s.e.

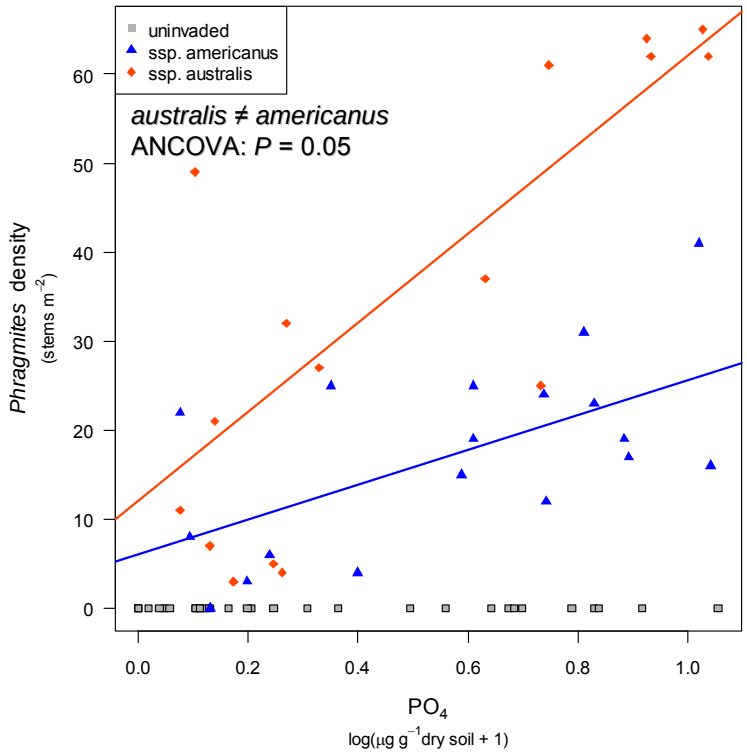

Figure 8. *Phragmites* stem density increased with orthophosphate availability, particularly for the exotic subspecies.

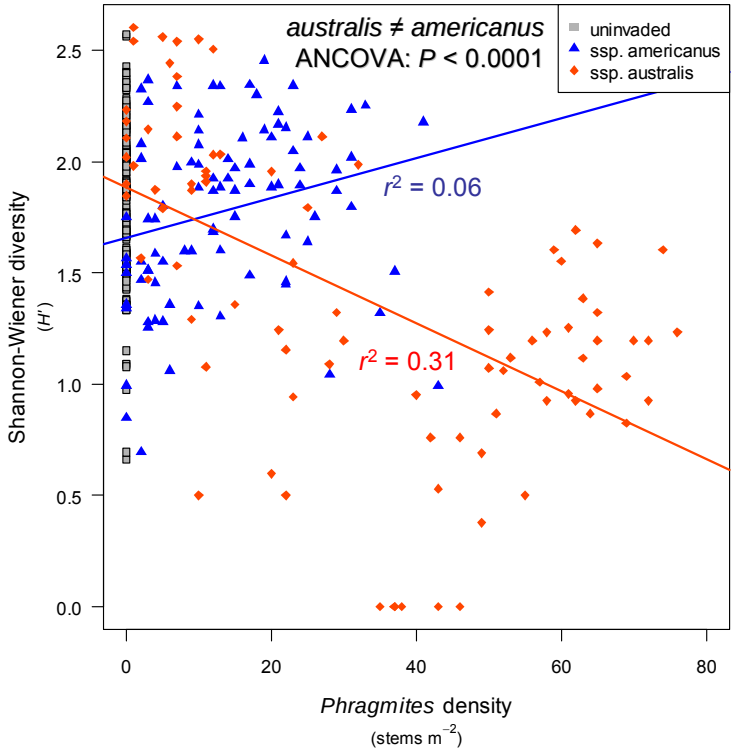

Figure 9. Non-*Phragmites* plant diversity was weakly positively correlated with stem density of native *Phragmites* but strongly, negatively correlated with increasing density of exotic *Phragmites*.