Baby's Breath removal monitoring project

Sarah Emery (Rice University/University of Louisville)
In collaboration with TNC-MI and Sleeping Bear Dunes National Lakeshore
TNC contacts: John Legge and Patrick Doran

Title: Does removal of *Gypsophila paniculata* (baby's breath) from Lake Michigan sand dunes restore native community structure and ecosystem function?

Introduction

Great Lakes sand dunes represent the most extensive freshwater dunes in the world, and contain more endemic species than any other Great Lakes ecosystem (Albert 2000). These dunes also provide shelter for neighboring land and are a major focus of tourism in the region. Because of the dynamic nature of dunes systems, they can be particularly vulnerable to invasions by exotic species (Albert 2000). *Gypsophila paniculata* (baby's breath) is one such serious invader of the sand dune systems in the greater Sleeping Bear Dunes National Lakeshore region. In some areas, *G. paniculata* comprises 80% of all vegetation (Karamanski 2000). It is widely believed that *G. paniculata* creates problems for the dunes by over-stabilizing habitat, making it unsuitable for native species such as the federally-threatened *Cirsium pitcherii* (Pitcher's thistle) which thrive in active dunes, and may be capable of out-competing native matrix species (e.g., *Schizachyrium scoparium* and *Ammophila breviligulata*) for resources due to its incredibly deep root system (Karamanski 2000).

Because of the growing concern about the impacts *Gypsophila paniculata* may be having on native plant communities (and especially on populations of Pitcher's thistle), the Nature Conservancy (MI) and the National Park Service are actively managing their properties with the goal of *G. paniculata* eradication. This most often involves volunteer crews mechanically removing plants by cutting the plant below the root crown. While some data indicate that this method of removal is effective, there has been little long-term monitoring of the impact these removal efforts have on community and ecosystem properties due to limited time and financial resources. There is a great need for assessment, and not just development, of invasive species removal methods (Zavaleta et al. 2001). A collaboration between managers and scientists would provide an excellent opportunity to clearly demonstrate that *G. paniculata* is indeed negatively impacting the native dune systems, and that removal efforts are restoring these habitats. Further, such control/eradication programs provide a unique opportunity for large-scale ecosystem experiments (Zavaleta et al. 2001), allowing ecologists to better understand community assembly and dynamics on a more general level.

Proposed Research:

In collaboration with TNC-MI and Sleeping Bear Dunes National Lakeshore (SBDNL), I propose to quantify the effects of removing *G. paniculata* from sand dune systems. This will involve pre-removal assessment of the plant communities (species richness and abundance) in infested areas as well as in comparable un-infested areas. After removal of *G. paniculata*, sites will be monitored for several succeeding years to quantify the return of native species (especially target species such as Pitcher's thistle) and restoration of ecosystem function. Specifically, I propose to monitor primary productivity, insect communities, soil microbes, sand stabilization, and nutrient cycling. I predict the following:

1. ***Gypsophila paniculata* removal will increase native plant species richness** and cover by opening up niche space. In addition, Pitcher's thistle populations will increase due to restoration of active dune movement.
2. ***Gypsophila paniculata* removal will dramatically alter biodiversity in other trophic levels**. *Gypsophila paniculata* represents a functional group (forb/subshrub) that is rarely dominant in open dunes. The shift in community structure back to a community dominated by native grasses such as *Schizachyrium scoparium* (little bluestem) and *Ammophila breviligulata* (American beach grass) should provide vastly different habitat structure for insects, including a probable decrease in generalist pollinator abundance, and an increase in native insect specialists (e.g., Gratton and Denno 2006). Likewise, soil communities should show a big shift in structure due to belowground changes in root profiles (from taproots to fibrous roots), and a possible increase in decomposers/detritivores with the increase of dead taproot biomass and grass leaf litter.
3. ***Gypsophila paniculata* removal will increase sand movement** in open dunes, due to initial creation of largely un-vegetated areas. While it is believed that *G. paniculata* is better at stabilizing sand than native species such as *Ammophila breviligulata*, this has not been confirmed quantitatively, and would be something to measure in succeeding years.
4. ***Gypsophila paniculata* removal will initially decrease carbon storage and nutrient cycling in dunes,** due to initial loss of belowground biomass and carbon inputs from plants, and shifts in soil biota (Ehrenfeld 2003). With the return of native vegetation, and shifts to more extensive fibrous root systems of native grasses, carbon storage and nutrient cycling should slowly increase, though probably not to the levels found during high infestation.

Methods:

Summer 2007: In consultation with TNC and SBDNL staff, I will establish monitoring plots in sites dominated by *Gypsophila paniculata* and in companion sites without *G. paniculata.* Plots dominated by *G. paniculata* should be slated for control efforts in summer 2008. One possible plot design is the modified-Whittaker plot (fig. 1; Stohlgren et al. 1995), which allows for precise measurements of plant community diversity at small scales (1-10m^2) as well as large-scale plant species richness. In each of the ten 1-m^2 subplots, I will record the identity and relative cover of each species in the plot. The presence of additional plant species are recorded successively in the two 10-m^2 subplots, the 100-m^2 subplot, and the remaining unsampled area of the 1,000-m^2 plot.

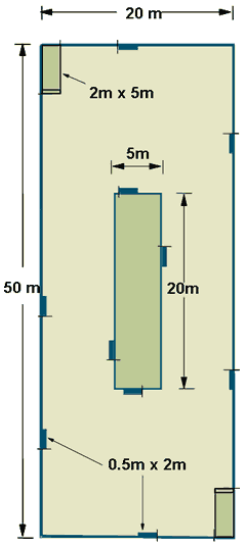

Figure 1. Modified-Whittaker plot design.

Cirsium pitcherii populations will be intensively monitored in three 10m^2 subplots in each site. The number of individuals in each subplot will be counted and classified as seedlings, rosettes, or flowering adults. Reproduction will be estimated as number of seeds produced per adult. By returning to the same subplots in following years, a life table can be constructed to calculate the effect of *G. paniculata* removal on *C. pitcherii* population growth rates (e.g., Thomson 2005). I have had previous experience with similar matrix population models of invasive species (Emery and Gross 2005).

To sample insect communities, I will take five 20m sweep-net samples per site, and take insects collected back to the lab for identification. In infested sites, I will conduct observations of the pollinators actively visiting *G. paniculata.*

To sample soil biota, I will take taking 10-20 soil cores (1.5cm x 10cm) per site, combining cores to create a composite sample for each site. From composite samples, mycorrhizal spore diversity, nematode abundance, and possibly bacterial functional diversity will be determined in the lab.

Carbon storage will be compared among sites through analysis of C:H:N concentrations in sub-samples of (1) total soil, (2) roots and (3) aboveground plant biomass in each site. I will also assess indirect effects on carbon storage via increases in primary productivity by determining above and belowground plant biomass in destructively harvested subplots (two 0.5m x 0.5m plots per site). In addition, I will monitor changes in sand movement using permanent graduated posts. Nutrient retention (nitrogen, phosphorus, potassium), will be assessed by sending composite soil samples to a soil-analysis lab at either University of Louisville or Michigan State University.

This design will be replicated across at least five infested sites and five un-infested sites. Ideally, multiple samples will be collected throughout the growing season to present a more complete picture of the effects of *G. paniculata* removal on the duens. Wind speed, distance from original source of contamination, slope, and distance from Lake Michigan will be estimated and used as covariates in any analyses.

Spring/Summer 2008: TNC/SBDNL crews will remove *G. paniculata* from infested sites.

Summer 2008: I will resample all large modified-Whittaker plots for the variables of interest discussed above. Ideally, this resampling will continue in successive years, dependent on securing additional funding for monitoring efforts.

Additional study:

In order to maximize native plant diversity after *G. paniculata* removal, it would be insightful to distinguish whether the extant native species are simply compensating by increasing their biomass and reproduction or whether new native species are actually colonizing these systems. Dunes systems are extremely seed-limited (Turnbull et al. 2000, Lichter 2000), and seed banks are rare (Emery, unpub. data). Once native species are lost from these systems, it may be difficult for them to re-colonize due to distance from source populations. Alternatively, it is possibility that *G. paniculata* fundamentally altered the habitat to make it unsuitable for native species colonization. There have been other cases where exotic species had unexpected indirect impacts on habitats, so that simple removal of the infestation was not enough to restore the native community (e.g., salt cedar *Tamarix* increased salinity of soils, making them unsuitable for natives to recolonize even after *Tamarix* was removed, Zavaleta et al. 2001). A propagule-addition experiment, where seeds or tillers of native species collected within SBDNL are added to subplots at each site, would allow me to separate out seed-limitation from any negative long-term residual effects of *G. paniculata* infestation.

Conservation/management questions addressed by this study:

1. Are current removal methods successful at reducing/eradicating *Gypsophila paniculata* populations in sites within and near the SBDNL?
2. Do sites infested with *G. paniculata* have lower native species diversity (including smaller Pitcher's thistle populations), or reduced ecosystem functioning compared with un-infested sites?
3. Does removal of *G. paniculata* increase native species diversity (including Pitcher's thistle population growth rates), and ecosystem functioning?
4. Will any additional management efforts (e.g., transplanting of natives) be needed to restore both *structure* and *function* of these dunes systems?

Basic ecological questions addressed by this study:

1. What are ecosystem consequences of removing an (exotic) dominant species from the landscape (ecosystem impacts of non-random extinctions?)?
2. Do direct or indirect effects of invasive species infestations play the more important role in altering plant diversity?
3. How quickly do other trophic levels (insects, soil biota) respond to drastic changes in plant community structure?

Potential sources of funding to support this project:

TNC has received funding for the *G. paniculata* removal efforts from Meijer stores. I have another project on-going in the Great Lakes dunes area that is funded through 2008 (National Parks Ecological Research fellowship), so will probably be able to cover most of the costs for pre-removal assessment and initial post-removal monitoring of this project. That said, I would very much like to apply for additional funding for this project in the next year (with pilot data from the pre-removal assessment this summer adding support to any proposal). Possible funding sources may include:

1. EPA Great Lakes National Program Office (usually fall call for proposals)
2. DEQ Michigan's Coastal Management Program (May 1 2008, small grants)
3. US Fish and Wildlife Service (for endangered species) usually requires 10-25% match
4. NSF Ecological Biology/Ecosystem Science (Jan 2008 due)

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