**How do changes of habitat structure by multiple invasive woody species affect ant community in rare floating marshes?**

# I. STATEMENT OF WORK

## 1. Introduction

One of the oldest, but still not fully resolved, questions in ecology is what causes the changes of community across landscape. Although the underlying mechanisms are undoubtedly complex, one explanation is that *habitat structure*— defined as the amount, composition and three-dimensional arrangement of (a)biotic physical matter (McCoy and Bell 1991)— plays a significant role in determining the species diversity and composition in both local and regional scale. What seems like an intuitional and straightforward mechanism, however, is much more complex, and still causes disagreements among ecologists. In addition, the habitat structure is currently gaining more attention because human activities have modified and will continually alter the habitat configurations (Soulé and Orians 2001). One of the representative examples is biological invasion.

Biological invasion has been recognized as one of the major threats to the integrity and functionality of ecosystems worldwide (Vitousek 1990). However, it is still not fully understood how invasive species affect community. For example, instead of decreasing diversity, a few studies indicated that exotic species (especially plants) can increase heterogeneity of the ecosystem, leading to higher diversity and/or distinct species composition (e.g. Petillon et al. 2010). In addition, it is still unclear how *multiple invasions* affect the community structure and functions, especially in wetlands (Groshol 2002). Elucidating the correlation between habitat structure and invasive species will make an enormous contribution to conservation activities. In this proposal, I plan to study how changes of habitat structure by multiple invasive woody plant species affect ant community in *floating marshes*, which is an essential component of my Ph.D. project: ant metacommunity and co-occurrence patterns in coastal wetlands.

## 2. Background

Floating marshes (flotant) occur extensively only in a few locations in the world (Swarzenski et al. 1991). They are unique type of wetland in that the marsh surface is rarely, if ever, flooded (Sasser et al. 1996). The herbaceous species (such as *Panicum hemitomon*) are rooted in highly organic buoyant mats (Fig 1b, habitat 1). The mat rises and falls with changes in water level, keeping the surface of these marshes dry at all times (Swarzenski et al. 1991). Without flooding stress, floating marshes may support animal life which cannot survive in other types of wetlands. In addition, those marshes perform valuable ecological functions such as providing habitats for many species and protecting coastlines from storm and wave action (Battaglia et al. 2007). However, like other coastal wetlands, floating marshes are affected by anthropogenic and natural disturbances such as canal and levee building, hurricanes and associated storm surge, and invasive species (Turner 1997).

The invasive processes in floating marshes of Louisiana are quite interesting. First, since the surface of flotant is free from the inundation, the native less flood-tolerant shrub wax myrtle (*Morella cerifera*) invades the marsh and become the dominant species in some places with thick mats (Fig 1b, habitat 2). Then the establishment of wax myrtle has facilitative effects on the spread of another woody species— Chinese tallow (*Triadica sebifera*) which invaded the US in the late 1700s from Asia (Fig 1b, habitat 3). Last, these two woody species act together as

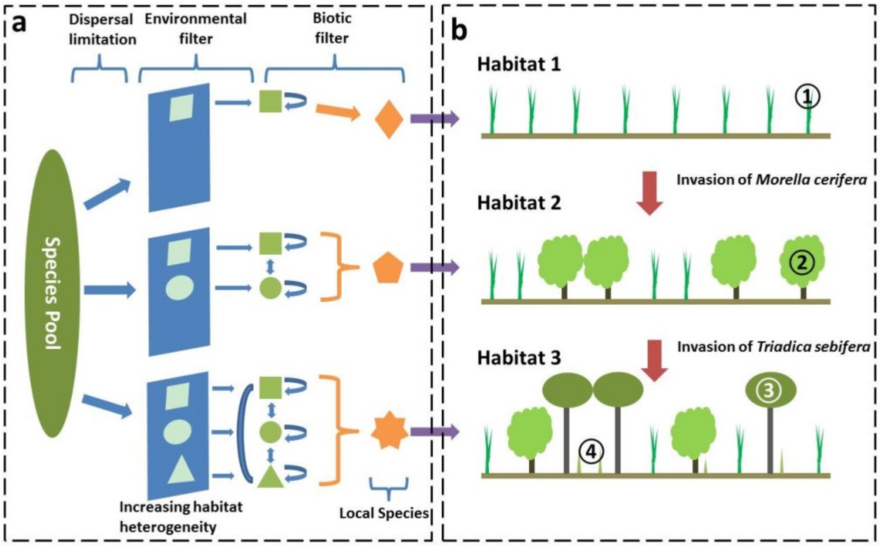


Figure 1. Schematic representation of **a)** assembly rule, **b)** three habitats (or three invasion stages) in floating marsh in Louisiana. ① *Panicum hemitomon*; ②*Morella cerifera*; ③*Triadica sebifera*; ④ invasive herb.

ecosystem engineers and change the understory micro-climate, which benefits the invasion of some exotic grasses (Battaglia et al. 2009). The multiple invasion changes floating marshes greatly: from herb dominant to herb-bush-tree system. These various habitats occur in a relatively small area, which enables us to focus on how changed habitat structure modifies the species assemblages while minimizing the confounding effects of climate, soil, and biogeographic history. Given this interesting multiple invasion processes, it is surprising that only two studies (Battaglia et al. 2007, 2009) mentioned the effects of invasion on vegetation, and to my knowledge, no research examined how this invasion process influences other trophic levels such as insects.

Insects, which play important ecological roles in wetlands, are largely unstudied (Adams in review). Insects constitute a substantial proportion of species richness and biomass, and play significant roles in controlling and maintaining processes which are essential for the function of ecosystems such as stabilizing food webs and nitrogen cycling (Weisser and Siemann 2004). However, complete inventories of all insects in one habitat present a challenge due to limitations in time, money, and taxonomic knowledge. A widely used alternative is to survey bio-indicators. *Ants* are one of the most widely used insect indicators because they are sensitive to habitat modifications and respond to the changes in ways similar to other taxa (Agosti et al. 2000). This makes ants a powerful environmental monitoring tool for future conservation programs.

3. Hypothesis and anticipated results

The overall hypothesis of this proposal is: the multiple invasions by woody species will change the diversity, community structure, and functional groups of ants in floating marshes. Before invasion, the floating marshes were dominated by one or two herbs whose leaf surface and hollow stems can only provide limited nesting and foraging sites for insects (ants only live in stems and at the bases of the plants in healthy flotant, not in the soil). The invasive woody plants may relieve this environmental filter by increasing the habitat complexity and heterogeneity (Fig 1a), which may lead to higher diversity and alternative species composition. We formulated this hypothesis, in part, based upon our preliminary data (see part II).

- Anticipated result 1: ant diversity in invaded places will be higher than un-invaded areas due to the increased habitat complexity.
- Anticipated result 2: ant community structure and functional groups are different among those three habitats. Ant community in herbaceous areas (habitat 1) is similar to that of salt and brackish marshes; ant composition in invaded areas (habitat 2 and 3) is similar to that of forest wetlands such as swamps and bottomland forest.

- <u>Alternative result:</u> both of the above predictions are based on the assumption that no invasive ants will live in these woody plants. If exotic ants (such as fire ants or crazy ant, see III: *How the study benefits coastal wetlands*) invade the floating marsh with Chinese tallow, the diversity and community structure will be un-predictable because of the changed biotic filter (Fig 1a) and overarching influence of a dominant invasive.

4. Methods

(1) Study sites and sampling methods: Three sites of each habitat (totally nine sites) will be chosen in Jean Lafitte National Park and Salvador Wildlife Management Area. Traps and hand collecting will be used in this study: sixty stems of *Panicum hemitomon* in each herb site and ten bushes or trees in each invasive site will be chosen randomly. All visible ants will be collected on the stem surface of *Panicum hemitomon* (1 min/stem), and on the trunk and canopy of wax myrtle and Chinese tallow (15 min/bush or tree, wax myrtle is low and Chinese tallow is stunted in floating marsh, ladder will be enough to collect ants in the canopy). Tree traps (Chen et al. 2012) will be set to the vegetation, and checked after 48 hours. After sampling, environmental factors that may influence ant presence will be measured. These include time of day, temperature, relative humidity, and plant structure (height of *Panicum hemitomon*, bush, and tree; circumference of trunks, and the height of the lowest live branch).

(2) Data analysis: Rarefaction curves and Renyi profiles will be generated to compare ant species richness among habitats using EstimateS (Colwell 2013). Ant species will be assigned to functional groups as described by Andersen (1997) and Chen et al. (2014). Non-metric multidimensional scaling (NMDS) will be plotted to assess the species composition and community structure among habitats, and then Analysis of Similarities (ANOSIM) will be performed to detect the similarity of composition among sites. Last, ant diversity and environmental factors will be analyzed using multiple linear regressions. All of the above analysis will be conducted using R (R core team).

5. Future study: the results of this proposed study will lay the groundwork for not only the conservation activities of floating marsh (see part III), but also future basic ecological research. For example: metacommunity, defined as a set of local communities organized into networks linked by dispersal, is one of the most exciting fields in modern ecology (Logue et al. 2011). The metacommunity concept makes a large contribution to understand how the regional ecological processes influence the local community structure, and how the characteristics of species distribution change along latent environmental gradients (Presley et al. 2010). In the last couple years, I have completed the sampling in salt and brackish marshes, swamps, and bottomland forests. After I finish the study in floating marshes, I can start to analyze the metacommunity structure of ants in all major coastal wetlands in Louisiana. Another hotly-debated topic gaining increasing attention is how niche and neutral processes regulate the assemblage composition. Most hypotheses presented in this proposal are based on niche theory (more specifically, the assembly rules, Fig 1a). However, the stochastic processes may also play important roles in structuring ant distribution. Once I finish sampling in floating marshes, I can explore how the relative importance of deterministic and stochastic processes changes from seashore to inland.

## II. Work has already been completed

I previously visited the sites and was only able to conduct quick hand collecting in 2013 due to the lack of funding. Based on this previous result, ants in woody areas seem different from that in herb sites which led to my hypotheses. Some species, such as *Dolichoderus pustulatus* and *Pheidole dentate*, normally occur in swamps, and immigrated into floating marshes with the invasion of wax myrtle. However, without the comprehensive sampling, it will be difficult to form any comprehensive conclusion.

## III. How the study benefits coastal wetlands

One main interest of conservation biology is to monitor the responses of biota to human disturbance such as pollution, habitat fragmentation, and invasive species. Given that insect indicators, such as ants, have been extensively used in terrestrial ecosystems, it is surprising that few studies mention the response of insects (besides some benthic species) to disturbances in wetlands. The study proposed here, to our knowledge, is among the first to test if ants can be used as ecological indicators in floating marshes and in wetlands in general. My previous research indicates they are good indicators in saltwater marshes, this study will add another ecosystem to the puzzle I am assembling.

Although habitat restoration is an intensively- studied field in wetland conservation, most of restoration programs focus on modifying hydrology, sediments building, and re-planting vegetation, with the assumption that other biota will then recover automatically. My previous study indicated that insects might not follow the plant restoration. This study will provide the basic information for monitoring recovery procedures of future restoration programs in the endangered floating marshes.

Insects themselves are important components of wetland ecosystems, and perform critical functions. However, to date they have received considerably less attention than plants, birds, fish and benthic invertebrates. It is surprising that no basic species list exists for most wetlands including those in Louisiana (Adams in review). Acquisition of a more complete knowledge set of species richness, rarity, community structure, spatial distribution and species' relationship with environmental variables is necessary as benchmark data. This is the prerequisite for assessing maintenance and recovery of ecosystem health particularly if using a BACI (Before-after, Control-impact) model for disturbance or restoration.

This research will provide benchmark data for the trajectory of the ecosystem concerning the invasive plants. In Louisiana, there are three destructive invasive ant species that are likely to impact the floating marsh in the near future. The red imported fire ant is present in some areas of the floating marsh in low numbers. Argentine ants and tawny crazy ants form supercolonies and have the potential to radically change the floating marsh ecosystem, which may cause invasional meltdown. The floating marsh that has been pre-invaded by the two woody plants may be preconditioned for the invasion of one or both these ants. Given that these two ants are poised to invade this sensitive wetland, my benchmark data will document the existing ecosystem dynamics, allowing us to examine the trajectory of the ecosystem and notice changes before alternative states are realized.

## IV. How funds would be used

**Travel ($4,000):** Support for travel to and sampling of research sites in the Salvadore Wildlife Management Area and the Jean Lafitte National Historical Park and Preserve is requested. Travel throughout the research areas will require the charter of an airboat at a cost of $1,000 per day, which includes boat gas. This is a state contract rate. The total cost will be $4,000. **Materials and Supplies ($1,000):** $300 is requested to offset the cost of fuel associated with driving to and from field sites. $600 is requested to purchase a ladder, vials, aspirators, ethanol, field books, hygrothermograph, batteries, wading boots, PVC (for constructing quadrats and marking sampling sites), etc. Additionally, $100 is requested to purchase field sampling supplies for personnel such as water, electrolyte replacement beverages, sunscreen, and bug spray.

## V. Plans or opportunities for sharing research results with a larger audience

Our research group has an active Facebook page in which we keep ~450 followers up to date on research. We publicize the results of our work through the media and web presence. In addition, I plan to present this work in Jean Lafitte National Park for park interpretive staff and volunteers this fall. Specimens stored in the museums can be checked or loaned by other researchers for future study. All data collected through this project will be archived in a public database for use by other researchers after the results are published (data will be in the form of electronic appendices of respective journals and my dissertation). Collecting information will also be submitted to the database of the national parks where the ants are collected for long term monitoring programs. Moreover, aesthetic photos of ants and natural views will be submitted to the websites of those parks for public education. All efforts will be made to publish in publically accessible journals. I assist my mentor LM Hooper-Bui in teaching Conservation Biology and Applied Ecology two large enrollment courses in which examples of my research will be used when appropriate.

Citation


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