Research to Support Integrated Management Systems of Aquatic and Terrestrial Invasive Species

Annual Report 2007

A Collaborative Effort between Mississippi State University’s GeoResources Institute and the U.S. Geological Survey and National Biological Information Infrastructure

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Preface

The research and outreach programs described in the following report are the result of an ongoing partnership between the U.S. Geological Survey Biological Resources Discipline, the National Biological Information Infrastructure, and Mississippi State University. Funding for these programs was provided by an award from USGS BRD to MSU under cooperative agreement 04HQAG0135. The MSU program was managed by the GeoResources Institute. The USGS BRD Invasive Species Program manager was Sharon Gross, the National Biological Information Infrastructure Invasive Species Information Node manager was Annie Simpson, and Randy Westbrook of USGS BRD worked with MSU on virtually every task.

This report should be cited as:


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Invasive species are an enormous problem for terrestrial and aquatic ecosystems in the United States, degrading their biodiversity and the ecosystem services they provide to our society. As a result, over the past decade federal and state agencies and nongovernmental organizations have begun to work more closely together to address it.

While awareness of the problem is becoming more widespread, efforts to address the threat are often piecemeal and fragmented, and new tools to deal with the problems are needed. In particular, the states in the Mid-South Region (AL, AR, LA, MS, and TN) need assistance in developing additional capacity, expertise, and resources for addressing the invasive species problem.

This report presents progress on a program of planned research, extension, and regional coordination for implementation by the GeoResources Institute (GRI) of Mississippi State University (MSU) in collaboration with the U.S. Geological Survey (USGS). We propose three areas of directed, peer-reviewed research to enhance the management of invasive species: aquatic invasive plants, terrestrial invasive plants, and the renegade biocontrol agent, cactus moth (*Cactoblastis cactorum*). For each area, a program of extension and outreach has been developed to deliver the information from our research to those who can best make use of the results, both through traditional printed information and web-based information solutions. Our current webpage effort, the Cactus Moth Detection and Monitoring Network ([www.gri.msstate.edu/cactus_moth](http://www.gri.msstate.edu/cactus_moth)), has been operating for two years and garnered significant attention as the one source for pricklypear cactus and cactus moth location information nationwide. We have been working through the past year to develop a new webpage, currently funded through USDA CSREES; the Invasive Plant Atlas of the Mid-South (IPAMS) will be launched during January 2008 at [www.gri.msstate.edu/ipams](http://www.gri.msstate.edu/ipams). While USDA CSREES is funding the initial program, we have listed USGS BRD and NBII as partners in the effort.

Specific results and deliverables are proposed for each of the main tasks described below. Specialists in USGS and other entities that are providing information, perspective, and/or oversight for the project are identified as collaborators. The research addresses invasive species issues that are often complex and require long-term cooperation.
MSU Investigators and Participants

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Dr. Gary Ervin, Department of Biological Sciences
Dr. Victor Maddox, GeoResources Institute
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David F. Spencer, U.S. Department of Agriculture – Agricultural Research Service
Thomas Stohlgren, U.S. Geological Survey, Fort Collins Science Center
Randy Westbrooks, U.S. Geological Survey, National Wetlands Research Center
Task 1. Aquatic Plants

Figure 1. MSU graduate student Ryan Wersal enters point location data during a plant survey in Ross Barnett Reservoir near Jackson, MS. Ross Barnett Reservoir is infested with many invasive aquatic plants, including alligatorweed, hydriella, and waterhyacinth (in background).

Figure 2. Giant salvinia (*Salvinia molesta*) infestation of a stream segment near Petal, MS. Giant salvinia is a federal noxious weed which could have significant impact on water resources throughout the southern United States. GRI has been mapping this species in MS through funding from USGS and from the MS Department of Agriculture and Commerce, Bureau of Plant Industries.
Task 1.1.1. Aquatic Plant Habitat Invasibility Models

PI: Gary Ervin
Co-PI: John Madsen

Habitat Suitability Modeling of Invasive Aquatic Plants
Gary N. Ervin and John D. Madsen

Based on readily available coverages of public land in Mississippi (included National Forests, National Wildlife Refuges, highway rights-of-way, John C. Stennis Space Center, and the Natchez Trace Parkway), ArcGIS was used to place random points on public lands across the state. We developed a set of 885 randomly located sample points on public lands in Mississippi, a subset of which were to be visited in the 2007 field season. Vegetation and habitat data were collected at an arbitrarily selected subset of these points for use in developing statistical models to estimate the likelihood of exotic plant invasion. We collected data on plant species present and microhabitat characteristics at the sampled points using a modification of the Beyond NAWMA guidelines (Stohlgren et al. 2003), with the addition of detailed soil sample analyses for each point. Those data ultimately will be augmented with geospatial information, such as land use/covet, soil characteristics, canopy cover, and proximity to such features as urban areas and transportation corridors. Data will be analyzed via one or more methods presently under evaluation to determine the best method(s) for developing habitat models within the study region.

During 2007, we sampled 250 of the 885 points, widely distributed across Mississippi (Figure 1). Of these 250 points, 44 were located in wetland land cover types, 42 of which were in the category of “woody wetlands.” These wetland points were less well distributed across the state, reflecting to some extent the localized nature of wetlands in the state. Noticeably absent, however, were points from within the Mississippi alluvial valley (the “Delta”).

Although the total number of wetland points in this dataset is likely too low to use in developing rigorous models of species invasion, their frequency among the total 319 points sampled is remarkably similar to the relative proportion of the region comprised by wetlands (10 to 15%). It is anticipated that work conducted under Task 1.4 (Invasive Aquatic Plant Survey for the Midsouth) will provide substantial data that may be used to augment these random point surveys in the development of habitat models for aquatic plants in the Mid-South region.

References
Development of a three-dimensional growth model for common reed (Phragmites australis)

Joshua C. Cheshier¹, John D. Madsen¹, and David Spencer²; ¹GeoResources Institute, Mississippi State University, Mississippi State, MS 39762-9652 and ²USDA ARS Exotic & Invasive Weeds Research Unit, Davis, CA 95616.

Common reed (Phragmites australis) is a non-native invasive perennial grass that creates a nuisance in aquatic and riparian environments across the United States. The ability of common reed to reproduce quickly combined with its ability to cycle nutrients has made it an aggressive invader of riparian and wetland ecosystems. Phragmites often forms monotypic stands that displace native vegetation more desirable as wildlife food and cover than Phragmites. Phragmites has been differentiated into 27 haplotypes, 11 haplotypes being native to North America, and 16 non-native haplotypes. The European haplotype M and South American/Asian haplotype I are of concern due to their ability to out compete native vegetation, alter hydrology, and change community structure of aquatic and riparian habitats.

A model of Phragmites (types I & M) growth can be used as a predictive tool in management regimes and wetland planning and restoration. Our goal was to develop a robust growth model based on empirical data from the plants at different growth stages rather than a mathematical model which is based on allometric relationships. Phragmites populations were grown from rhizome fragments in six tanks located at the R.R. Foil Experiment Station, Mississippi State University and at the USDA-ARS Aquatic Weed Laboratory, University of California-Davis consecutively (Photo 1). Two haplotypes, I and M, of Phragmites were grown in sterile builder and fertilized with 10 grams of Osmocote® slow release fertilizer. Air, soil moisture, water chemistry and temperature were monitored to optimize growth. Phragmites plants were digitized every month from emergence to senescence using a Polhemus Fastrak 3-dimensional digitizer system, utilizing Floradig software (Figure 1). In addition, the plant material was separated by above ground structure, measured, dried and weighed. Three leaves, the upper most, the bottom, and one in the middle, from each stem were separated, photographed, dried, and weighed. This is the second year in a two year study and a digital model will be based on both years of data. Data from year two can be found in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Comparison of growth metrics between Haplotypes I and M of common reed (Phragmites australis).</th>
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<td>Growth Metric</td>
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<td>Number of Leaves per Stem</td>
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<td>Average Above Ground Biomass (g)</td>
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Task 1.1.3. Growth of Common Salvinia and Waterhyacinth as Regulated by Loading Rates of Water Column Nitrogen and Phosphorus

PI: John Madsen
Collaborator: Randy Westbrooks, USGS NWRC

Growth of Common Salvinia and Waterhyacinth as Regulated by Loading Rates of Water Column Nitrogen and Phosphorus

Ryan M. Wersal and John D. Madsen

Introduction: Invading species have to overcome several barriers upon introduction before they become established and reproductively viable. An important barrier to surmount is the effect of the local environment, specifically the availability of nutrients. Species-specific growth models have yet to be developed for invasive species to identify interactions of species growth with environmental factors. These models can be developed based on water column nitrogen and phosphorus to estimate the probability of invasion success using available data on watershed water quality. This study will evaluate the effects of oligotrophic, mesotrophic, and eutrophic nitrogen and phosphorus water column concentrations, and loading rates, on the growth of waterhyacinth and common salvinia. The objectives are to 1) determine which nutrient is limiting to plant growth and at what concentration; and 2) model species-specific growth using known water quality parameters as a predictive tool for monitoring.

Task Description: The study will be conducted in an outdoor mesocosm facility beginning July 2007. The 54 mesocosm tanks (1100 L) will be set in a randomized block design with 2 plant species (waterhyacinth and common salvinia), 3 phosphorus concentrations, 3 nitrogen concentrations, and replicated 3 times. The tanks will be numbered and assigned a treatment combination. Water will be pumped to each tank from a nearby irrigation reservoir. The water will be filtered via a basket strainer and a sand filter before it reaches each tank. A regenerative air blower will supply aeration for all tanks. Air will be circulated in each via 30.5 cm stone diffusers.

Common salvinia (Salvinia minima), an invasive species increasingly common to the Gulf Coast states but less well-known than giant salvinia, will be harvested from the Mobile River Delta and propagated at Mississippi State University. Approximately, 300 grams fresh weight of common salvinia will be placed into the appropriate tanks.

Fig. 1. Common salvinia (Salvinia minima), while not as well-known a weed as cogener giant salvinia, is a nonnative invader to swamps and marshes. Common salvinia is currently one of the largest problem aquatic plants in Louisiana.

Fig. 2. Waterhyacinth (Eichhornia crassipes) is the world’s number one aquatic weed, and a significant problem in Mississippi water bodies such as the Ross Barnett reservoir.
Waterhyacinth (Eichhornia crassipes) will be collected from the Tennessee-Tombigbee Waterway and propagated at Mississippi State University. Six rosettes of waterhyacinth will be placed into each of the appropriate tanks.

Plants will be exposed to combinations of differing water phosphorus and nitrogen concentrations. Phosphorus concentrations will be 0.01 mg P/L, 0.03 mg P/L, and 0.09 mg P/L. Similarly, the nitrogen concentrations will be 0.40 mg N/L, 0.80 mg N/L, and 1.80 mg N/L. The nutrient concentrations are meant to represent typical concentrations in oligotrophic, mesotrophic, and eutrophic waters and will be achieved using ammonium nitrate and potassium phosphate. Tanks will be amended weekly with nitrogen and phosphorus to simulate nutrient loading rates of oligotrophic, mesotrophic, and eutrophic waters, and to maintain water column nutrient concentrations.

Biomass will be harvested in three-week intervals for 12 weeks using a 0.01 m² PVC quadrat for common salvinia and a 0.05 m² quadrat for waterhyacinth. A total of two samples will be harvested from all tanks during each sampling period. Samples will be dried to a constant weight to assess the effects of phosphorus and nitrogen on plant biomass.

This study is currently underway in a greenhouse at the R. R. Foil Plant Science Center, Mississippi State University. Data from this study will be used to begin developing landscape models of habitat invisibility by freefloating invasive aquatic plants.
Task 1.2.1. Assessment of Aquatic Plant Populations
PI: John D. Madsen
Collaborator: Randy Westbrooks, USGS

The Use of Hand-held Computers in Point Intercept Surveys

Ryan M. Wersal and John D. Madsen

Aquatic macrophytes are an integral component in freshwater systems and understanding the dynamics of macrophyte populations has become increasingly important due to the spread of invasive macrophyte species. One cost effective and efficient method to collect large quantities of data on the distribution and abundance of aquatic macrophytes is the point intercept survey. The point intercept survey has been refined to include the use of hand held computers enabled with GPS (Global Positioning System) capabilities and coupled with software to collect and store site specific spatial data. The use of Farm Works SiteMate® mapping software was used to develop and construct database templates to collect and store spatially explicit data from the Ross Barnett Reservoir, MS, Lake Onondaga, NY, and Lake Gaston, NC. The use of these technologies has increased survey efficiency by decreasing survey time, data handling, and data entry errors. These data can be easily converted to map layers for use in GIS (Geographic Information System) systems and exported to data files for statistical analysis. Our technique is central to survey and assessment efforts ongoing in the Ross Barnett Reservoir, MS and several lakes in Idaho.

This method has been utilized and cited in a number of studies, a selection of citations includes:


We constructed a new core sampler of light-weight PVC pipe to sample above and below ground biomass of submersed macrophytes. The core sampler can be easily constructed, modified, or repaired in the field, as there are no valves or moving pieces. It can be constructed to sample in shallow or deep water. Comparisons were made between above-ground biomass samples collected from the core sampler and samples collected from a 0.10 m² quadrat from lakes in Minnesota and New York. There is a significant relationship between macrophyte biomass collected using both sampling methods, indicating that similar above ground biomass data can be collected using a core or a quadrat. The core sampler was more effective at sampling below-ground biomass and propagules, both beneath the sediment and those lying on the sediment surface.

The core sampler is currently being used to assess the life history and phenology of invasive aquatic plants such as hydrilla and parrotfeather, assess the success of management efforts in Mississippi, New York, and Idaho, and collect baseline information for the restoration of littoral plants in Onondaga Lake, New York.

This sampler is further described in a recent journal article:

Experimental Tests of the Effects on Invasive Plants on Aquatic Communities

Eric Dibble, John Madsen, and Todd Tietjen

We completed two trials of multilevel experiments conducted in ponds and aquaria. First the effect of invasive plant growth on littoral zone fish habitat was evaluated in pond level experiments. In the research ponds, differences in largemouth bass (*Micropterus salmoides*) growth and condition were compared between treatments of diverse native plants, invasive hydrilla (*Hydrilla verticillata*), and a vegetation-free habitat. The native vegetation assemblage yielded higher bass gains in length and weight than the others. The open-water environment resulted in moderate fish growth while the dense hydrilla beds produced poor gains in length and weight. The second experiment used aquaria and videography to assess the effects of different levels of hydrilla invasion on juvenile largemouth bass foraging ability. In a dense hydrilla habitat, bass experienced poorer capture rates, more attempts per capture, longer times required per capture and more attempts that never resulted in a capture. The open-water environment, and those possessing a combination of native vegetation and low hydrilla levels provided the best foraging conditions. Finally, in one large research pond, Eurasian watermilfoil (*Myriophyllum spicatum*) and a plant mix were used to compare effects on juvenile largemouth bass and bluegill (*Lepomis macrochirus*) growth using enclosures. Bluegills in the diverse plant beds experienced significantly larger gains in length and weight than those in the monoculture. Sub-sampled juvenile bass had higher length gains and growth rates in the monoculture than in the mixed treatment.

The second trial of experiments investigated how aquatic plants mediate ecological processes in aquatic habitats, specifically predator-prey (bluegill sunfish (*Lepomis macrochirus* Rafinesque)-macroinvertebrate) interactions. Macroinvertebrate colonization is directly and indirectly influenced by substrate heterogeneity, interstitial space, and surface complexity. Exotic invasive plant species, such as *Hydrilla verticillata* L.F. Royle, may alter the available structure in aquatic habitat by creating a shift to a homogeneous habitat thus affecting the macroinvertebrate community. Since macroinvertebrates provide a food base for many aquatic organisms, their abundance and diversity are crucial for the health of the ecosystem. Understanding the impacts of invasive plants on macroinvertebrate communities is essential for the management of aquatic ecosystems.
for young phytophilic fishes, changes in their density and abundance may alter food webs. We investigated the hypothesis that macroinvertebrate assemblage and community structure would differ between a heterogeneous native aquatic plant bed, homogenous hydrilla plant bed, and habitat with no plants. Studies were conducted in the field (pond) and the experimental treatments were: 1) no plants, 2) monotypic bed of hydrilla, and 3) diverse native plants. Aquatic plants, regardless of species, supported greater macroinvertebrate abundance, richness, and biomass. Macroinvertebrate abundance, richness, and biomass in a hydrilla-dominated habitat did not differ significantly from a diverse plant habitat, except for richness in October. Indicator taxa did differ significantly between respective treatments, suggesting a change in species composition. However no significant effect of fish predation on macroinvertebrate populations and/or community structure was documented, the data suggest that a shift of a natural mosaic in vegetated habitat to a highly complex monotypic one (e.g. exotic hydrilla) may reduce spatial heterogeneity important in structuring a macroinvertebrate assemblage.

Figure 3. Mean macroinvertebrate (a) abundance, (b) richness by treatment (hydrilla, native diverse, and no plants) from July-October 2005 in experimental earthen ponds, National Warmwater Aquaculture Center, Mississippi State University. (N = 2 for each treatment and each month). Means with different letters within each sampling date differ statistically (P ≤ 0.05).

Figure 4. Relationships between plant biomass (g(dry weight)/m²) and macroinvertebrate biomass (g(dry weight)/m²) including the hydrilla and diverse treatment combined (N = 47) (a) and the hydrilla and diverse treatments individually (N = 24) (b) for July-October 2005 in experimental earthen ponds, National Warmwater Aquaculture Center, Mississippi State University. Each line represents a linear regression analysis.

Figure 5. Picture of plant treatment in the experimental aquaria that simulate an exotic aquatic plant (hydrilla) invasion.
Task 1.4. Invasive Aquatic Plant Survey for the Mid-South

PI: John Madsen
Co-PI: Victor Maddox
Collaborators: Thomas Stohlgren, USGS, Fort Collins Science Center; Pam Fuller, USGS, Florida Integrated Science Center; Randy Westbrooks, USGS NWRC

Mississippi Survey for Giant Salvinia (*Salvinia molesta*) and Hydrilla (*Hydrilla verticillata*)

Wilfredo Robles, Victor Maddox, and John Madsen

**Introduction:** Invasive aquatic plant species have been implicated in the degradation of water bodies worldwide. For instance, the introduction and growth of invasive aquatic plant species may limit the water body function when they displace native flora, as well as impede boat traffic. Two species in particular, hydriilla (*Hydrilla verticillata*) and giant salvinia (*Salvinia molesta*) are considered invasive aquatic plants and listed as a federal noxious weed. However, their current distribution on the Mid-South and number of water bodies impacted is not well known.

**Materials and Methods:** Extensive invasive aquatic plant species surveys were conducted throughout Mississippi and western Alabama to detect the presence of giant salvinia and hydrilla. Known locations of each species recorded in 2006 were revisited to document population persistence and establishment. A handheld computer with Global Position System (GPS) capabilities was used to obtain geographic coordinates of surveyed locations. Location maps were produced using ArcGIS-ArcMap, v. 9.1.

**Results and Discussion:** Giant salvinia still persists along Wedgeworth Creek, Forrest County, MS, but was not found in other locations (Figure 1). A more southern spread of giant salvinia at the mouth of this creek, which drains into the Leaf River, will ultimately result in the escape of giant salvinia into the Leaf River. Additional surveys of southern tributaries should be conducted. Hydrilla still persists and is well established in the following lakes of the Tennessee-Tombigbee Waterway: Columbus, Aberdeen, Aliceville, and Gainesville. Populations of hydrilla in the Ross Barnett Reservoir are located in the northern portion of the lake covering a total of 407 acres. Since 2005, hydrilla has been under management using herbicides, successfully limiting its establishment and slowing its spread. Although hydrilla still persists as individual plants, asexual propagules (e. g. tubers) have not been found.

Fig. 1. Survey point location and current status of giant salvinia and hydrilla in Mississippi and western Alabama.
Fig. 1. Fruit and foliage of tropical soda apple (*Solanum viarem*) from a pasture in southern Mississippi. Tropical soda apple is a federal noxious weed currently the target of a specific USDA APHIS eradication program. Cattle eat the fruits in one pasture and carry the seeds to other pastures, sometimes several states away. MS infestations were likely caused by cattle transported from Florida.

**Task 2. Terrestrial Plants**

Figure 2. Dr. Victor Maddox stands next to a specimen of hardy sugarcane (*Saccharum arundinaceum* Retz.) at an undisclosed location in Mississippi. Many nonnative ornamental grasses have been imported for the nursery trade, with little evaluation of their invasiveness.
As mentioned under Task 1.1.1, we sampled 250 random points during the 2007 field season, across the Mississippi (Figure 1.1.1-1). Data from the total set of 319 points is scheduled to be digitized during Spring 2008, and analyses will ensue shortly thereafter. Considerably insight has already been gained from those data, however, and that information was used to design another study targeted at the invasive grass *Imperata cylindrica* (L.) Beauv. (cogongrass). This study is described under subtask 2.1.3.

The following subtask descriptions give an overview of work conducted as part of the terrestrial invasive plant habitat modeling efforts. Two of these subtasks are related directly to habitat modeling, while the others describe supporting studies. A key participant in this work, Christopher Holly, is presently in his final year of Ph.D. studies and has made considerable progress towards understanding important ecological properties of cogongrass. Two of his graduate research projects have already been published, and a third will be submitted during early 2008. That study is described in subtask 2.1.2.
Task 2.1.1. Random Versus Targeted Surveys for Invasive Plant Habitat Modeling

Gary Ervin and Christopher Holly, MSU Biological Sciences

While we have surveyed more than 300 random points, we have encountered many key invasive plant species with a surprisingly low frequency. For example, cogongrass (*Imperata cylindrica*) has been encountered in no more than ten of our plots (ca. 3%), despite our having sampled 71 points in a part of the state that is heavily infested with this species (ca. 22% of all sampled points). In those points where cogongrass was present, it was noted that human disturbance of the physical habitat was almost always present. This information led us to design a stratified survey during Fall 2007 that targeted roads in the southern Mississippi counties to evaluate the distribution of cogongrass. Those surveys yielded data on 329 patches of cogongrass along the 267 km of roads that were surveyed. Sixteen of those patches (5%) lay more than 30m from the roadside, and only eight were located more than 60m from the road. Only one of the farthest eight patches was not associated with some form of disturbance, whereas only five of the sixteen found more than 30m from the road were in apparently undisturbed habitats. Of the types of disturbance encountered in these surveys, mowing (58% of patches) and soil disturbance (22% of patches) were the predominant forms, followed by fire (5%). Frequency of patches was highest along federal interstate highway I-10 (2.0 patches per km of road) than along other road types, with state highways (1.5 patches per km) and gravel roads (1.6 patches per km) having the next highest frequencies. Thus, there was no clear association with presumed intensity of traffic along the surveyed roadways; gravel roads were as heavily infested as state highways. However, these results do indicate a distinctly non-random distribution of this key invasive species within the study region – as was suggested by the low frequency of occurrence of cogongrass in our random point surveys. This work is described in more detail under subtask 2.1.3.

Revised from an abstract entitled "Assessing the (in)adequacy of random sampling for invasive plant species in the Mid-South," submitted as part of a symposium proposal for the 2008 Ecological Society of America conference to be held in Milwaukee, Wisconsin.
Task 2.1.2. Effect of an Invasive Grass on Microbial Community Structure and Function in US Gulf Coastal Plain Communities

Christopher Holly and Gary Ervin, MSU Biological Sciences

*In situ* decomposition of above and belowground plant biomass of the native grass species *Andropogon glomeratus* (Walt.) B.S.P. and exotic *Imperata cylindrica* (L.) Beauv. (cogongrass) was used to evaluate the effects of cogongrass on soil microbial communities. Decomposition was investigated using litter bags filled with above- or belowground tissues of both plant species over the course of a 12 month period. The microbial communities associated with cogongrass-invaded sites often differed from those found in soils under native vegetation. The microbial communities differed not only compositionally, as indicated by ordination analyses of molecular data collected for all fungi, basidiomycete fungi, and bacteria, but also functionally with respect to activity of enzymes involved in the decomposition process. As a functional counterpart to the molecular and enzymatic analyses, the above and belowground biomass of the invasive cogongrass always decomposed faster than that of the native *Andropogon*. Also, belowground biomass of both species decomposed at a consistently faster rate when placed in an area dominated by *Imperata*, as opposed to within a native plant assemblage. This study supports the growing consensus that invasive plant species alter ecological processes and highlights a possible mechanism (alteration of microbial assemblages) by which *Imperata* may alter an ecosystem process (decomposition).

Revised from a paper to be submitted to the *Journal of Ecology* in Spring 2008.
Task 2.1.3. *Imperata cylindrica* (cogongrass) Distribution in Desoto National Forest, Mississippi, USA: Local Habitat Disturbance is More Important than Landscape Context

Christopher Holly and Gary Ervin, MSU Biological Sciences

The ability to predict the successful invasion of non-native plant species into new habitats has the potential to substantially increase the efficiency of early detection of nascent populations of key invaders. The integration of landscape ecology and predictive habitat modeling is a promising area of research that may permit the prediction of large scale patterns of invasion. These techniques enable researchers to use landscape-scale predictor variables to model, statistically and spatially, the habitat characteristics of invaded sites and then to estimate future sites of invasion by identifying suitable habitat across a landscape of interest. These habitat models then can be tested with independent field data and refined to the necessary degree of accuracy. The present study sought to predict future areas of invasion by *Imperata cylindrica* by first evaluating factors that best explained its present location in field survey data collected in Desoto National Forest during the Fall of 2007. The statistical modeling procedure analyzed anthropogenic disturbance factors (habitat disturbance type and proximity to roads) and biotic landscape-scale predictor variables (forest community type and forest cover change from 2004 to 2006). The results indicated that landscape-scale plant community patterns (forest cover change and forest type) were not statistically important in predicting the presence of *Imperata*. However, anthropogenic disturbance factors had a statistically significant influence upon cogongrass presence and provided a robust logistic regression model to predict the occurrence of *Imperata* (and consequently suitable habitat). This finding has management implications as it suggests that the resident forest community type is relatively unimportant in the invasion dynamics of this species, as compared to the influence of anthropogenic disturbance in creating habitat suitable for invasion by *Imperata cylindrica*. 
As part of the present research to develop integrated approaches for the management of invasive species, we are attempting to quantify the relationships of invasive species distribution and spread with landscape characteristics. The objective of these efforts is to use that information directly in developing and implementing Early Detection and Rapid Response (EDRR) systems to aid management activities. Two specific activities presently underway along these lines are the Cactus Moth Detection and Monitoring Network (discussed under main Task area 3: Invasive Insects) and the Invasive Plant Atlas of the Mid-South (IPAMS). Research associated with these programs includes systematic regional vegetation surveys and the development of habitat models for predicting the occurrence of target species based on geospatial data, such as soil, land use and cover, impervious surfaces, and canopy density data, the latter three representing data provided by the USGS GAP Program.

The present modeling effort used the State Soil Geographic Database (STATSGO; USDA NRCS 1994), along with the USGS GAP canopy cover data, to provide representative environmental predictor variables for distribution of *Baccharis halimifolia* within Mississippi. Despite being native to the southeastern US, *Baccharis* is widely recognized as a weedy invader of pastures in the region. Numerous characteristics of this species’ biology make it a useful representative invasive plant for conducting pilot studies on approaches for modeling and managing behavior of invasive plants. It is a wind-dispersed species that reaches sexual maturity in only two to three years and usually is associated with disturbed habitats, such as roadsides, fencerows, utility rights-of-way, and forest edges.

The statistical modeling approach used binary logistic regression models of soil factors and canopy cover as correlates with *Baccharis* presence-absence, followed by information-theoretic analyses to compare resulting models. Regressors on *Baccharis* presence-absence data included available soil water content, bulk density, CEC, clay content, organic matter content, permeability, and pH, each calculated as the minimum & maximum value for each soil mapping unit across MS. Information-theoretic analyses used the Akaike Information Criterion (AIC) to rank the resulting logistic regression models and indicate which provided the best fit to *Baccharis* occurrence across the northeastern portion of the state.
The resulting best-fit models were evaluated further by comparison with a training dataset, using assessment criteria such as sensitivity, selectivity, Cohen’s kappa, and the True Skill Statistic. The top statistical models were incorporated into an ArcMap GIS to generate layers indicating probabilities of occurrence of cogongrass, based on statewide soil characteristics (Figures 1, 2).

Although both “winning” habitat prediction layers incorporated soils data, the layer that appeared to provide the most information on potentially suitable habitat for *Baccharis* was that which included data on canopy cover, in addition to soils (Figure 2). This habitat model reflects the importance of the interaction between abiotic habitat features (soil) and biotic interactions (shading, for example) on determining areas where invasive species have the potential to successfully establish and reproduce. One notable concern with the environmental data used in this exercise is illustrated by the large, high-probability oval region in the southeastern corner of Figure 2. This is the result of the geographically large aggregations of soils data in the STATSGO database. This difficulty is ameliorated to some degree by use of SSURGO data, as described in Subtask 3.3.1 below.

**References**


![Figure 2. Predicted distribution of *Baccharis halimifolia* across north-eastern Mississippi. This predicted habitat distribution was one of two top models, and was based on the combined effects of soil organic matter, clay content, pH, and canopy cover on presence versus absence of *Baccharis*. Darker areas indicate higher probability of encountering suitable *Baccharis* habitat. Red dots indicate absence points, blue are presence points from Fall 2006 surveys.](image-url)
Task 2.2. Assessment of Terrestrial Plant Populations

PI: John Byrd
Co-PI: John Madsen, Victor Maddox
Collaborator: Randy Westbrooks, USGS NWRC

Seed Germination in Selected Varieties of Nonnative Ornamental Grasses

Victor Maddox, John Byrd, John Madsen, and Randy Westbrooks

Thousands of exotic species have been introduced to the United States. Many times the potential invisibility of these species is unknown. Determining risk associated with introduced species could be of great benefit in the prevention or early detection of invasions. Grasses are numerous in scope and continue to be introduced into the United States, mostly as forages or ornamentals. Multifaceted efforts on selected species are underway. Efforts conducted from 2005 to 2007 with four warm-season grass species are presented in this summary.

This study focuses on four species of grasses, Miscanthus floridulus (Labill.) Warb., M. sinensis Anderss. (cultivars and varieties), Saccharum arundinaceum Retz., and S. ravennae (L.) L. Aside from these four species, M. sinensis cultivars and varieties studied were ‘Arabesque’, gracillimus Hitchc., ‘Graziella’, ‘Kirk’s Dwarf’, ‘Little Kitten’, ‘Morning Light’, ‘Purpureascens’, ‘Sarabande’, ‘Strictus’, variegatus Beal, and zebrinus Beal. Miscanthus sinensis and S. ravennae are widely cultivated as ornamental. Though not common at present in the southeast, there are reports of both escaping cultivation. Little is known about S. arundinaceum, but its rapid growth, large size (Figure 1), and wind dispersed seed may pose problems if invasion where to occur. The purpose of this study was to determine which species and/or cultivars pose a risk of invasion, suitable temperatures for seed germination, and if M. sinensis cultivars and/or varieties pose a greater risk when outcrossing is possible.

Seed for the 2006 and 2007 germination studies were collected in the fall of 2005 and 2006, respectively, from field plants and retained in a refrigerator prior to plating. Multiple seedheads from multiple plants were collected for each grass. Two replications of 100 seeds per grass were placed on wet germination paper in petri plates. Petri plates were placed in a curtain germinator under continuous lighting and at constant temperatures of 12°C, 18°C, 24°C, 30°C, or 36°C. Separate runs were conducted at each temperature. Percent germination was recorded for each grass at each temperature (Figures 1, 2).

In 2006, M. sinensis ‘Purpureascens’, M. sinensis ‘Strictus’, M. sinensis variegatus, and S. ravennae all produced viable seed (Figure 1). All four grasses germinated at temperatures of 24°C, 30°C, and 36°C, except M. sinensis ‘Purpureascens’ which showed no germination at 36°C.

In 2007, germination was observed in *M. sinensis* ‘Arabescue’, *gracilimus*, ‘Graziella’, ‘Little Kitten’, ‘Morning Light’, ‘Purpureascens’, ‘Sarabande’, ‘Strictus’, *variegatus*, and *zebrinus* and *S. ravennae* (Figure 2). Only ‘Kirk’s Dwarf’ showed no germination at any temperature. ‘Little Kitten’ showed germination at 24°C and 30°C, but not at temperatures above or below. Germination was highest at 24°C for most grasses in the studies.

Percent germination was considered low since the highest germination in either year was only 36%. However, seed production on these grasses can be at least 1100 seed per inflorescence. No germination was observed at 12°C or 18°C in either year, but germination at higher temperatures may be expected since all are warm-season or C4 grasses. Regardless, germination appears to be inconsistent from year to year. Currently, seed germination studies are being conducted on 2007 seed to determine if outcrossing influences seed viability.
Cogongrass has become a major problem in many parts of the southern United States for several years. Hundreds of studies have been conducted upon this species with varying results. Management of cogongrass can be grouped into five major areas of control: preventive, cultural, mechanical, biological, and chemical. Each of these methods provides a certain level of control, but an integrated management strategy is the key to success. Three field studies were conducted from 2004 to 2006 in southern Mississippi to evaluate the most effective integrated management programs for cogongrass control. Results indicated that foliage removal either by fire or mowing increased the efficacy of both glyphosate and imazapyr. Tillage alone is an effective control system when multiple tillage events occur within one year or over several years. Also, tillage prior to chemical applications increases the efficacy of both glyphosate and imazapyr.

Task 2.4. Invasive Terrestrial Plant Survey for the Mid-South

PI: John Byrd
Co-PI: Victor Maddox, John Madsen
Collaborators: Randy Westbrooks, USGS NWRC

Invasive plant survey work was conducted in 2007 over a large geographic area of the central and southern United States (Figure 1). The greatest concentration of survey work was conducted within the five core mid-south states of Alabama, Arkansas, Louisiana, Mississippi and Tennessee. Survey work in states outside the mid-south region was limited to less than five trips per state. Numerous populations of both aquatic and terrestrial invasive species were mapped during active surveys.

Individual mapping trips ranged from just a few to over 8000 road miles. During this period, over 2500 invasive species data forms (NAWMA) were taken. Data on many invasive species were collected during these surveys. During 2007, new populations of callery pear, Chinese tallow tree (Figure 2), giant reed, itchgrass, kudzu, and many other species were identified and mapped in the Mid-South region and the central and southern United States.

Much of the survey work was conducted from highway rights-of-way. However, invasive species populations were mapped on federal, state, and private lands during this period. This data should assist respective stakeholders with monitoring and management efforts.

One of the major goals for 2008 is to complete the entry of this data into the IPAMS (Invasive Plant Atlas of the Mid-south) database. Active survey work is expected to continue in 2008, in addition to citizen scientist training workshops. Research has been initiated on three potentially invasive ornamental grasses identified within or adjacent to the region during survey work.

Fig. 1. United States map showing states where active invasive species mapping was conducted in 2007 (blue and red). More aggressive mapping was conducted in core states shown in red.

Fig. 2. Chinese tallow trees (*Triadica sebifera*), a state noxious species in MS, which were mapped in 2007 on a private lake shoreline in MS. Information was provided to the private landowner and entered into the Invasive Plant Atlas of the Mid-South (IPAMS) database.
Task 3. Invasive Insects: Cactus Moth (*Cactoblastis cactorum*)

Figure 1. USDA APHIS personnel set up a cactus moth trap on Petit Bois Island off the coast of Mississippi. All trap samples are processed by Dr. Richard Brown of MSU.

Figure 2. Pricklypear cactus pad from Dauphin Island, AL showing extensive cactus moth damage inside the dissected pad.
Task 3.1. Early Detection of Cactus Moth

PI: Richard Brown
Co-PI: John Madsen
Collaborator: Randy Westbrook

Cactus Moth Monitoring in the United States

Richard Brown

This project included the following objectives:
1) Maintain and refine techniques for detection and surveillance of cactus moth infestations,
2) expand the cactus moth detection network,
3) refine protocols for identifying cactus moths, and
4) determine pathways of introduction and dispersal of cactus moth by phylogeographic analysis using DNA.

Surveillance: The surveillance of cactus moth during 2007 was based on 415 pheromone traps in five states, establishment and monitoring of sentinel sites, and field surveys in seven states between Alabama (westernmost infestation) and California. Pheromone traps for cactus moths were screened from the following states (with number of traps in parentheses): Mississippi (72), Texas (45), New Mexico (5), Arizona (277), and California (16). Sentinel sites for detection of cactus moths were established in North Carolina, South Carolina, Mississippi, Texas (Fig. 1), and Arizona. Field surveys of *Opuntia* in Alabama, Arizona, Arkansas, Georgia, Louisiana, Mississippi, New Mexico, and Texas resulted in detection of cactus moth only on Dauphin Island and Fort Morgan, AL.

Identification: Based on collections of native larvae of *Melitara* infesting *Opuntia* in eastern U.S., Texas, New Mexico, and Arizona during 2006-2007, no native, cactus-feeding species have the distinctive red and black coloration characteristic of *Cactoblastis*. However, the first 2-3 instars of all species lack distinctive coloration, and examination of setal patterns or rearing is required for identification (Fig. 2). Adults of the cactus moth, *Cactoblastis*, and native species, *Melitara*, are superficially similar, but differ in that males of *Melitara* have pectinate antennae, whereas males of *Cactoblastis* have simple antennae. Females of these species require dissection of genitalia for confirmation of identity. Dissections of both male and female genitalia of the cactus moth were supplied to Mexican Agricultural Survey officials for identification references.

Introduction and Dispersal Rates of *Cactoblastis* in SE United States: Most authors have erroneously reported the first detection of the cactus moth in the U.S. as Big Pine Key, FL, rather than Bahia Honda Key on October 30, 1989 (Terry Dickel, personal comm.). Surveys for the cactus moth beginning in 1990 in the Florida Keys and expanded in 1991 to other areas of Florida documented that *Cactoblastis* was well established from the Keys to Terra Ceia, Manatee Co. on the west coast and to Brevard Co. on the east coast, rather than having dispersed there from the Keys. A phylogeographic study of *Cactoblastis* based on the COI gene showed that two different haplotypes are present in the SE U.S., with one occurring only on the Gulf Coast and the second occurring on the Atlantic Coast with a single occurrence of the Atlantic haplotype on the Gulf Coast at Pensacola (Simonsen Brown, and Sperling, submitted ms). The possibility of multiple introductions of *Cactoblastis* into SE U.S. is supported by numerous interceptions of this species in imports of cactus in Miami and other ports of entry, even though a small percentage of imported cactus were inspected. If *Cactoblastis* was present as far north as Terra Ceia, Manatee Co. in 1989, then its detection on St. George Island in 2002 indicates an annual dispersal rate of 33 km/year, or an average of 11 km/generation given three generations annually.
Task 3.2 Distribution of *Opuntia* in the Region

PL: John Madsen  
Co-PL: John Byrd, Richard Brown  
Collaborators: Randy Westbrooks

*Opuntia* Species Surveys for 2007

Victor Maddox, John Madsen, John Byrd, Richard Brown, and Randy Westbrooks

Pricklypear (*Opuntia* spp.) mapping and data collection was conducted over a large geographic area of the eastern and southern United States by Victor Maddox, GRI, in 2007, although other mapping and data collection was conducted by the GeoResources Institute and its partners during 2007. Most of that information has been entered into the Cactus Moth Detection and Monitoring Network (CMDMN)(Figure 1).

The greatest concentration of mapping and data collection work was conducted in Alabama and Mississippi, which are along the western leading edge of the cactus moth. However, there was an increase in mapping and data collection activity in Florida and the southwestern United States in 2007 (Figure 2). Individual mapping trips ranged from just a few miles to over 8000 road miles. During this period, many pricklypear dataforms were taken. Due to constraints with private land, much of the work was conducted from highway rights-of-way. However, pricklypear populations were mapped on federal, state, and privates lands during this period. During these trips, data from negative locations were also identified.

Currently, the distribution of *Opuntia* in the region continues to expand as new populations are identified. In 2007, surveys were conducted from Indiana to Georgia and Florida, west to California. Sentinel sites were also established during mapping trips (Figure 2), although some sentinel sites were established by volunteers via the CMDMN database. Most 2007 pricklypear dataforms have been entered into the CMDMN database. Entry completion of the remaining data is expected by early 2008.

Goals for 2008 related to this task will include continued mapping, data collection and entry, development of additional sentinel sites, monitoring of existing sentinel sites, collaboration with volunteers and agencies, and increased focus on *Opuntia* and cactus moth distribution in southeast Alabama and Florida. Mapping data from Alabama and Florida should assist USDA-APHIS with cactus moth eradication efforts in Florida. As of 11 December, only 206 reports from Florida were in the database compared to 753 reports from Mississippi. Although that number is up from 128 on 14 December 2006, it is expected to be much higher for Florida. In addition, most positive reports of cactus moth in Florida are from coastal areas. More *Opuntia* and cactus moth data are needed from Florida’s interior.

![Fig. 1. Cactus Moth Detection and Monitoring Network map showing pricklypear populations (blue and red points) in the database as of 13 December 2007. Blue points also have the cactus moth (*Cactoblastis cactorum*) present.](image1)

![Figure 2. Populations of pricklypear have been mapped and sentinel sites established at Organ Pipe Cactus National Monument in southern Arizona near the Mexican border with the assistance of Charles Conner, a National Park Service employee.](image2)
Task 3.3. *Opuntia* Habitat Models

PI: Gary Ervin  
Co-PI: John Madsen, John Byrd  
Collaborator: James Grace, USGS, National Wetlands Research Center

*Opuntia* Habitat Models

Gary N. Ervin and Lucas Majure

Work during 2007 involved continued mapping of natural populations of *Opuntia* in the southeastern US, as well as completion of ecological, morphological, and ecophysiological studies of the southeastern *Opuntia* species. Most of that work was performed by Lucas Majure, a M.S. student in the Department of Biological Sciences. Data from that work has served as the basis for much of the habitat modeling to date, and as described in subtask 3.3.1 below. Majure completed his M.S. degree in Summer 2007, and now is continuing his studies of the southeastern *Opuntia* as a Ph.D. student at the University of Florida (Gainesville).

We anticipate at least three peer-reviewed papers to result from his thesis research, in addition to other papers that are in review or recently in print based on vegetation data collected during his mapping of prickly pear (see *Publications* section of this report). The most important information of practical use is Majure’s determination of *Opuntia* species presently in the state of Mississippi (Fig. 1). This chapter of his thesis has been reviewed by Dr. Donald Pinkava, author of the section on *Opuntia* for the Flora of North America project, and is presently under review by the journal *Haseltonia*. His thesis may be accessed at:  

We are in the process of expanding the focus of habitat modeling efforts to include a landscape genetics approach at better understanding the relationship between *Cactoblastis* and *Opuntia* species in the US. This has involved collection of geospatial data and tissue samples from both organisms during the latter half of 2007 (Fig. 2). These efforts also have resulted in increased cooperation with USDA personnel in order to coordinate ecological research with management and tracking efforts, such as pheromone trapping at Dauphin Island and Fort Morgan during 2008. We also plan to being developing habitat models that will be transferred to ARS and APHIS personnel during 2008 working in the area around Pensacola, Florida. The hope is that habitat modeling will aid in targeting areas for monitoring and/or management of the insect in that apparently high density region. This expanded research focus has involved three additional faculty in the Department of Biological Sciences:

- Dr. Christopher Brooks – Spatial Ecology and Ecological Modeling
- Dr. Lisa Wallace – Plant Molecular Systematics
- Dr. Mark Welch – Populations Genetics

**References**

Task 3.3.1. Pricklypear Cactus Modeling Efforts

PI: Gary Ervin

Using approaches outlined under Subtask 2.1.4, we are refining the methodology to be used in developing habitat models for plants such as the invasive cogongrass, as well as the native hosts of Cactoblastis cactorum. Species occurrence data for geospatial modeling of Opuntia habitat have come largely from mapping of natural populations conducted by MSU researchers associated with this invasive species program. The approach used thus far has focused on modeling using combined presence and absence datasets, as describe above. One marked improvement in the reliability of the models has been the inclusion of Soil Survey Geographic (SSURGO) Database data, rather than STATSGO soil data. The SSURGO data are mapped at a resolution about ten times more precise than the STATSGO data, and thus will be expected to provide more reliable predictive models. A comparison of this approach with the two soil datasets was conducted with Opuntia cespitosa (formerly considered as part of O. humifusa; Majure 2007). In this exercise, a limited region of Mississippi was used in order to restrict potential environmental variation that could decrease the signal-to-noise ratio in the small dataset presently available for this species. Absence points from the vicinity of the presence data were assembled from our invasive species survey points, using points that were believed to be devoid of Opuntia (Figures 1,2). Development and evaluation of logistic regression models was carried out as described above (subtask 2.1.4), using the closest possible match of STATSGO and SSURGO data variables within the modeled region of Mississippi. This comparison suggests the SSURGO data will provide a much finer spatial scale of habitat prediction, which should be more compatible with inclusion in EDRR efforts for these and other plant species targeted for management operations.

Plans for the coming months are to evaluate two presence-only modeling approaches in an effort to determine the best of the three methods for generating habitat maps to assist in management activities. The presence-only approaches to be tested are an approach that computes, within ArcView, a probability surface based on Mahalanobis Distance estimates for species occurrence locations dependent upon candidate environmental GIS layers. The other approach is a modification of classification tree methods, termed random trees.

Based on a presentation given at the Interagency Cactus Moth Detection and Monitoring Network Meeting, Mississippi State University, 04 December 2007.

Figure 1. Predicted distribution of O. cespitosa in northeastern Mississippi, based on models with STATSGO data. These models were based solely on the effects of soil parameters on presence versus absence of O. cespitosa. They were selected based on assessment criteria as compared to the original training data, thus they would be considered preliminary at best, but still are useful in assessing the information of the two soil databases. Darker areas indicate higher probability of encountering suitable O. cespitosa habitat; yellow dots show absence points, green are presence points.

References

Figure 2. Predicted distribution of *Opuntia cespitosa* in northeastern Mississippi based on models with SSURGO data. These models were based solely on the effects of soil parameters on presence versus absence of *O. cespitosa*. They were selected based on assessment criteria when compared with the original training data, thus they would be considered preliminary, but still are useful in assessing the information of the two soil databases. Darker areas indicate higher probability of encountering suitable *O. cespitosa* habitat; red dots are absence points, blue are presence points.
Task 4. Extension and Outreach

Figure 1. A major avenue of extension and outreach for cactus moth issues is the Cactus Moth Detection and Monitoring Network webpage at http://www.gri.msstate.edu/cactus_moth.

Figure 2. Dr. John Byrd of MSU speaks at numerous workshops each year concerning the management of invasive grasses. While web-based tools are valuable, they do not completely replace personal contacts such as this.
Task 4.1. Aquatic Plant Extension Information

PI: John Madsen
Collaborators: USACE (ERDC) Kurt Getsinger, Vicksburg, MS; Annie Simpson, USGS National Headquarters (Biological Informatics Program) and Randy Westbrooks, USGS NWRC

Aquatic Plant Management Information Products for 2007

John D. Madsen

During 2007 and early 2008, fact sheets for seven invasive aquatic plant species have been developed in the new shorter two-page format for use in the Invasive Plant Atlas of the Mid-South. These species include alligatorweed, hydrilla, Eurasian watermilfoil, giant salvinia, purple loosestrife, waterhyacinth, and waterprimrose (Table 4.1). For each fact sheet, a description of the plant, information on spread, dispersal, habitat, ecology, and management are included.

These are in addition to fact sheets on several invasive aquatic plants already available at the GeoResources Institute webpage.

Table 4.1. Invasive aquatic plant fact sheets available on the Invasive Plant Atlas of the Mid-South webpage (www.gri.msstate.edu/ipams).

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternanthera philoxeroides (Mart.) Griseb.</td>
<td>alligatorweed</td>
</tr>
<tr>
<td>Eichhornia crassipes (Mart.) Solms</td>
<td>common water hyacinth</td>
</tr>
<tr>
<td>Hydrilla verticillata L.f. Royle</td>
<td>waterthyme (hydrilla)</td>
</tr>
<tr>
<td>Ludwigia uruguayensis (Camb.) Hara</td>
<td>Uruguayan primrose-willow</td>
</tr>
<tr>
<td>Lythrum salicaria L.</td>
<td>purple loosestrife</td>
</tr>
<tr>
<td>Myriophyllum spicatum L.</td>
<td>spike watermilfoil (Eurasian watermilfoil)</td>
</tr>
<tr>
<td>Salvinia molesta Mitchell</td>
<td>kariba-weed (giant salvinia)</td>
</tr>
</tbody>
</table>
Grasses belong to a large family (Poaceae) consisting of 785 genera and approximately 10,000 species. Most are terrestrial and as a group are similar in appearance, which can make identification challenging. In Mississippi, 18% of introduced vascular plants are grasses. Approximately 30% of grasses in Mississippi are introduced. Roughly 11% of the grass species in the United States are introduced (~156 species). Not surprisingly, many grasses tend to be invasive. Cogongrass \( [\text{Imperata cylindrica} \ (\text{L.}) \ \text{Beauv.}] \) and itchgrass \( [\text{Roeckelidella cochinchinensis} \ (\text{Lour.}) \ \text{W.D. Clayton}] \) (Figure 1) are two examples of problematic grasses in the Mid-south. However, invasive grasses also include crabgrasses \( (\text{Digitaria spp.}) \), johnsongrass \( [\text{Sorghum halepense} \ (\text{L.}) \ \text{Pers.}] \) (Figure 1) and others. In addition to existing non-native grasses, species continue to be introduced into the United States and mid-south region making invasion by grasses an ongoing issue. Additionally, some invasive grasses, like cogongrass and itchgrass, are federal and/or state regulated while others are not. In either case, there is a need to assist federal, state, and public stakeholders with issues related to terrestrial grass recognition and control.

In 2007, numerous federal, state, and local meetings were attended to present information on terrestrial grasses to stakeholders. Extension information ranged from formal presentations to fact sheets (Figure 2) handed out at garden and patio shows and other events. The scope of clientele ranged from federal land managers to public landowners. The majority of this activity occurred within the Mid-South, but was not confined to this region. Since clientele attending individual meetings ranged from a handful to just under 10,000 people, the number of people contacted verbally or through literature handed out in 2007 is estimated in the thousands.

Mapping and monitoring efforts were conducted to assist stakeholders, like the Department of Transportation (DOT) and Tennessee Valley Authority (TVA), by providing geographic locations of known invasions. For example, location information on itchgrass in Alabama and Florida, as well as Mississippi, was provided to stakeholders in 2007. In addition, numerous grass identifications and control recommendations were made during 2006 for a wide range of clientele.

A continuation of efforts similar to 2007 is planned for 2008, including numerous meeting presentations, additional fact sheets, and other activities designed to reach stakeholders. Additionally, we plan to assist with the training of public volunteers on how to identify invasive grasses and report information. We plan to continue active monitoring and mapping and provide this invasive terrestrial grass information to clientele via a new invasive species database (IPAMS) in 2008. Active monitoring and mapping efforts will assist with EDRR efforts, as well. Grasses continue to escape from cultivation, such as maidengrass \( (\text{Miscanthus sinensis} \ \text{Anders}) \) and others, and related research and extension information will be needed to support EDRR efforts with clientele.
Task 4.3. Cactus And Cactus Moth Extension Information

PI: John Madsen
Co-PI: Richard Brown, John Byrd
Collaborators: Randy Westbrooks, Annie Simpson

Extension Products for 2007

John D. Madsen

The cactus moth working group produced or revised a number of extension and outreach materials for 2007, as seen in the list below. All of these materials are available at the cactus moth webpage, www.gri.msstate.edu/cactus_moth, or at the GRI publication webpage. In addition to the webpage, survey manual, brochure, and four fact sheets, we produced eleven monthly reports (we take December off for the holiday). The monthly reports are available on the cactus moth webpage or by subscription to the e-mail list (send an e-mail to jmadsen@gri.msstate.edu and request to be added to the monthly cactus moth report e-mail list).

Extension Materials Produced or Revised in 2007


Floyd, J. P., J. D. Madsen. 2007. Survey Information for the National Cactus Moth (Cactoblastis cactorum) Detection and Monitoring Network. GeoResources Institute, Mississippi State University, Mississippi State, MS. GRI #5013.

Maddox, V. L., J. D. Byrd. 2007. Invasive Species Fact Sheet: Cactus Moth Host Plant, Cockspur Pricklypear [Opuntia pusilla (Haw.) Nutt.]. GeoResources Institute, Mississippi State University. GRI #5022.

Maddox, V. L., J. D. Byrd. 2007. Invasive Species Fact Sheet: Cactus Moth Host Plant, Devil’s Tongue Pricklypear [Opuntia humifusa (Raf.) Raf.]. GeoResources Institute, Mississippi State University. GRI #5024.

Maddox, V. L., J. D. Madsen. 2007. Invasive Species Fact Sheet: Cactus Moth Host Plant, Erect Pricklypear [Opuntia stricata (Haw.) Haw.]. GeoResources Institute, Mississippi State University. GRI #5023.

Maddox, V. L., J. D. Madsen. 2007. Invasive Species Fact Sheet: Cactus Moth Host Plant, Pricklypear Cactus (Opuntia P. Mill) in Mississippi. GeoResources Institute, Mississippi State University. GRI #5025.


Photo 1. Ornamental cactus (Opuntia ficus-indica) with fruit found in southern Mississippi.

Photo 2. Opuntia stricta pad infested by cactus moth larvae.
The cactus moth (Cactoblastis cactorum Berg.), a threat to natural biodiversity, horticulture, and forage in the southwestern United States and Mexico, has spread as far as South Carolina on the East Coast and Alabama on the Gulf Coast. Further spreading has been hindered by the control efforts and infestation removal in the leading areas. Monitoring from volunteers at sentinel site locations ahead of the leading edge are providing valuable information through the Cactus Moth Detection and Monitoring Network about the spread of the moth. Volunteers from public and private land management units, garden clubs and Master Gardeners report observations via a web-based system available from the network’s website at http://www.gri.msstate.edu/cactus_moth (Figure 1).

The Cactus Moth Detection and Monitoring Network, online since 2005, has 62 registered users reporting a total of 2,156 pricklypear reports. Of those reports, 2,031 are positive cactus locations leaving 125 negative locations. These reports come from 24 different collectors spanning 16 states and Mexico, and are reporting 33 different Opuntia species or varieties. The network has 98 positive reports for the invasive cactus moth, six of which are new for 2007 within the state of Florida. Of these six reports, only four have been verified. The reports that are submitted to the system are being used to model cactus locations in an effort to help predict where cacti are likely to be located. Using this information, collectors can identify areas that have high potential in containing cactus and possibly the cactus moth.

The network’s website, the one-stop-shop for information on the cactus moth, was viewed 22,051 times over 2007. A visitor can find the history of the moth, biology information, see what kind of threat it poses, and find information on it hosts, identification, and controls. There is a description on how to help as well as valuable resources for someone just interested in the subject or someone interested in being a volunteer. There are real-time maps embedded within the website to give a quick assessment of mapping efforts. A GIS map tracking tool (Figure 2) is also available and provides multiple maps for viewing cactus locations, moth locations, and sentinel site locations. The tracking map provides a visual representation of the detection and monitoring system, which may be used by collectors to identify areas in which there are gaps in the survey. Collectors are then able to plan survey trips into those areas that are lacking observations. The map is also being used to identify potential sentinel site locations on or around the leading edge of the moth’s progression.

The GIS map has become useful for other reasons as well. County boundaries, zip code boundaries, roads, and urban areas are displayed to help collectors find routes to certain areas, or to find their way to a certain cactus location. These data layers are also used for reports that have poor descriptions on their locations. Better, or more complete, location descriptions can be obtained. Areas can be zoomed into, maps can be made for printing or publication purposes, and reports can be queried to provide certain survey information on that location.
Despite the widespread occurrence of weedy plants, adequate assessment of coarse-scale landscape factors influencing their distribution is lacking for most species. Such information is potentially more useful to land managers and other concerned parties than are plot-scale factors on which most studies of invasive species are focused. The Invasive Plant Atlas of the Mid-South (IPAMS), in an effort to quantify relationships of weed distribution and spread with land use and educate people on potential human-induced opportunities for invasive species to spread, will provide a centralized invasive species database modeled after the Invasive Plant Atlas of New England (IPANE). IPAMS will provide information on the biology, ecology, distribution, and best management practices for an initial suite of forty of the most economically and ecologically significant invasive weeds in the mid-south. Development and implementation of this database will involve intensive outreach/extension and research activities, and will support the USDA NRRI’s stated goals of enhancing protection of US agriculture and protecting the nation’s natural and environmental resources.

An initial web presence for IPAMS is available at [http://www.gri.msstate.edu/ipams](http://www.gri.msstate.edu/ipams) providing an in-house interface for data submission. IPAMS is currently scheduled to be publicly launched in January 2008. IPAMS (Figure 1), when launched, will have an automated public registration process and will provide limited account management tools. Tools for survey submission and management will be available and a report generator will be available at a later date. IPAMS will also provide tools for survey verification and duplicate survey elimination. IPAMS will provide detailed species information from descriptions and distributions, to control methods. The species information will be limited to a small group of species at launch while more becomes available at a later date. Species without detailed information will be linked to the IPANE system for species information. The ability to sign up for “action alerts” on species within a certain region will be available at a later date. Also in the works is an extension to the system to allow multiple observations at the same location to track spread progress or control efforts. At launch time, map capabilities will be limited.

Currently, IPAMS houses 1689 surveys (Figure 2) and that number is growing daily. These surveys are locating 83 different invasive plants covering 7 states. Thousands of additional surveys have been collected from our in-house personnel and will be entered in 2008.
Task 5. Regional Coordination

Figure 1. GRI hosted a meeting in December 2007 of personnel from USGS, NBII, USDA APHIS, and MSU concerning the ongoing cooperative cactus moth effort.

Figure 2. MSU researchers including Cliff Abbott, Richard Brown, Gary Ervin, Victor Maddox, and John Madsen presented at the International Cactoblastis cactorum Conference May 2007 in Phoenix, AZ. The conference was hosted and organized by USDA APHIS, with speakers by invitation. This photo is of the conference attendees.
We were involved in two major ongoing statewide initiatives: the Cogongrass Task Force and the Mississippi Aquatic Invasive Species Task Force.

Dr. John Byrd continued to play a significant role in the statewide Cogongrass Task Force. During 2007, the Mississippi Cogongrass Task Force influenced the formation of task forces in Georgia and South Carolina.

Dr. John Madsen has been a representative to the Mississippi Aquatic Invasive Species Task Force. The MS AIS has a draft plan under preparation that should be near completion. Drs. Eric Dibble, Gary Ervin, and Victor Maddox also contributed to this plan.

Dr. Victor Maddox attended the Fiscal Year 2007 Mississippi CAPS Committee Meeting, 1 May 2007. Bureau of Plant Industry Conference Room, Mississippi State. Hosted by BPI, Mississippi State, MS.

Dr. Gary Ervin has volunteered to lead an effort in forming a statewide invasive plant list for the Mississippi Exotic Pest Plant Council. This list will be formed in cooperation with specialist representing the nursery industry, consumer horticulture, the turf industry, and home lawns statewide. The Mississippi Exotic Pest Plant Council is a forum for federal, state, and local agencies and nongovernment organizations to discuss invasive plant issues.

Through collaborative efforts with the Mississippi Department of Agriculture and Commerce, an invasive species question has been added to Part 1 of the Landscape Gardening Exam. This portion of the exam will be graded by Victor Maddox. Landscapers must pass this exam to be certified.

Invasive plant species will be presented for the first time in 2008 as part of the Master Gardener basic training. Victor Maddox will be the presenter for this segment of the program. The Master Gardener program is coordinated by the Mississippi State University Extension Service.

Victor Maddox provided invasive species information at three state events hosted by the Mississippi Nursery and Landscape Association at which over 25,000 were in attendance.
Task 5.2. Regional Coordinating Efforts

PI: David Shaw
Co-PI: John Byrd, John Madsen

Invasive Species Coordinating Efforts for the Mid-South Region and Beyond

John D. Madsen

Our group was very active in invasive species coordinating efforts both regionally and nationally through the USGS project.

The MSU team was a regular contributor to the NBII Invasive Species Working Group, a teleconference of the Invasive Species Information Node.

John Madsen and David Shaw attended the National Invasive Weed Awareness Week, 25 February to 3 March 2007, to present a display on the USGS project during the reception. The display was available to the public for the entire week at the US Botanical Garden. The project display will be up again for NIWAW 9 in 2008.

The MSU project was well represented at the International Cactoblastis cactorum Conference in Phoenix, AZ on 7-10 May 2007; organized by USDA APHIS. Presentations included:

- Victor Maddox, Distribution of *Opuntia* spp. in the Southeastern United States
- Richard Brown, Taxonomy and Morphology of *C. cactorum* and Other *Opuntia*-Feeding Lepidoptera in the United States
- Gary Ervin and Lucas Majure, Habitat Modeling for *Opuntia* spp. in the Southeastern United States
- Majure, L. C. and G. N. Ervin. Microstructural morphology of *Opuntia* species (Cactaceae) based on scanning electron microscopy.


Richard Brown participated in the Horticultural Inspection Society Southern Chapter Annual Meeting in Greenville, MS, September 17, 2007, to call attention to threat of the cactus moth and seek cooperation from state nursery inspectors for monitoring cactus nursery stock.

Victor Maddox participated in the USDA-APHIS Cactus Moth Budget and Planning Meeting, 16-17 Oct 2007, held at the Florida Dept. of Agriculture and Consumer Services-Division of Plant Industry, Gainesville, FL.

MSU hosted a Cactus Moth Detection and Monitoring Network meeting on 4 December 2007 with MSU, USGS, NBII, and USDA-APHIS personnel in attendance. An agenda is attached as table 5.2.1.
Publications and Accomplishments

Peer-Reviewed Journals


Majure, L.C. 2008. New records of Geranium molle and Erodium cicutarium (Geraniaceae), from Mississippi and other important collections from the state. The Southeastern Naturalist, In Press.


Peer-Reviewed Conference Papers


Non-Refereed Conference Papers, Abstracts, or Posters


In-House


Floyd, J. P., J. D. Madsen. 2007. Survey Information for the National Cactus Moth (Cactoblastis cactorum) Detection and Monitoring Network. GeoResources Institute, Mississippi State University, Mississippi State, MS. GRI #5013.

Maddox, V. L., J. D. Byrd, R. Westbrooks, B. Brabson. 2007. Invasive Species Fact Sheet: Beach Vitex (Vitex rotundifolia L.f.). GeoResources Institute, Mississippi State University. GRI #5020.

Maddox, V. L., R. G. Westbrooks, J. D. Byrd. 2007. Invasive Species Fact Sheet: Itchgrass [Rottboellia cochinchinensis (Lour.) W.D. Clayton]. GeoResources Institute, Mississippi State University. GRI #5017.

Maddox, V. L., J. D. Byrd. 2007. Invasive Species Fact Sheet: Cactus Moth Host Plant, Cockspur Pricklypear [Opuntia pusilla (Haw.) Nutt.]. GeoResources Institute, Mississippi State University. GRI #5022.

Maddox, V. L., J. D. Byrd. 2007. Invasive Species Fact Sheet: Cactus Moth Host Plant, Devil’s Tongue Pricklypear [Opuntia humifusa (Raf.) Raf.]. GeoResources Institute, Mississippi State University. GRI #5024.

Maddox, V. L., J. D. Byrd. 2007. Invasive Species Fact Sheet: Cactus Moth Host Plant, Erect Pricklypear [Opuntia stricta (Haw.) Haw.]. GeoResources Institute, Mississippi State University. GRI #5023.

Maddox, V. L., J. D. Madsen. 2007. Invasive Species Fact Sheet: Cactus Moth Host Plant, Pricklypear Cactus (Opuntia P. Mill) in Mississippi. GeoResources Institute, Mississippi State University. GRI #5025.

Maddox, V. L., R. G. Westbrooks, J. D. Byrd. 2007. Invasive Species Fact Sheet: Multiflora Rose (Rosa multiflora Thunb. ex Murr.). GeoResources Institute, Mississippi State University. GRI #5026.


Madsen, J. D. 2007. Assessment of Lake Gaston Hydrilla Management Efforts in 2006. GeoResources Institute, Mississippi State University, Mississippi State, MS. GRI #5010.

Madsen, J. D. 2007. Invasive Species Fact Sheet: Curleyleaf Pondweed (Potamogeton crispus L.). GeoResources Institute, Mississippi State University. GRI #5021.


Web Publications


Professional Presentations


Ervin, G. N. 2007. Habitat models as tools for invasive plant monitoring and management. Department of Biological Sciences, University of Southern Mississippi, 12 October 2007.


Holly, D. C., G. N. Ervin. 2007. Relative importance of propagule pressure, light availability, and nutrient concentration upon the establishment and physiology of a model invasive species, Imperata cylindrica. Graduate Student Research Symposium, Mississippi State University, Starkville MS, March 30, 2007.

Maddox, V. L., K. Johnson, T. Needham. 2007. Identification of 30 plant families important in horticulture. 16 May 2007, 135 Dorman Hall, Mississippi State University, Mississippi State, MS.


Items of Pride


Ervin, G. N. 2007. GeoResources Institute Academic Professor of the Year.


Madsen, J. D. 2007. Research Professor of the Year. GeoResources Institute, Mississippi State University.


Majure, L. C. (M.S. student in MSU Biological Sciences) was selected as the 2007 M.S. level Graduate Student Association Graduate Research Assistant of the Year.


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