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

Annual Report 2008

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

GRI Publication #5030

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USGS science for a changing world

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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 agreements 04HQAG0135 and 08HQAG0139. The MSU program was managed by the Geosystems Research Institute. The USGS BRD Invasive Species Program manager was Sharon Gross, the NBII Invasive Species Information Node manager was Annie Simpson, and Randy Westbrooks of USGS BRD worked with MSU on virtually every task.

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Introduction

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.

Figure 1. Early detection and rapid response in action! Joshua Cheshier, Ryan Wersal, and Wilfredo Robles (l to r) rig a boat to apply an herbicide to the pond in the background that has become infested with waterlettuce (*Pistia stratiotes*), an invasive plant from South America. The pond is located on the Thad Cochran Research, Technology, and Economic Development Park adjacent to the Mississippi State University.

This report presents progress on a program of planned research, extension, and regional coordination for implementation by the Geosystems Research 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), 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) was launched during January 2008 at 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.

Figure 2. Devil's tongue cactus (*Opuntia humifusa*) on one of the barrier islands in the Mississippi Sound. USDA APHIS PPQ, MS Department of Agriculture and Commerce, and MSU are working to survey for pricklypear cactus and the cactus moth along the coast of the Gulf of Mexico.

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.

Task 1. Aquatic Invasive Plants

MSU Faculty John Madsen surveys Eurasian watermilfoil and other invasive aquatic plants using a computer-based database program and GPS antenna in a Montana reservoir, for the Montana Lower Clark Fork Eurasian Watermilfoil Task Force.

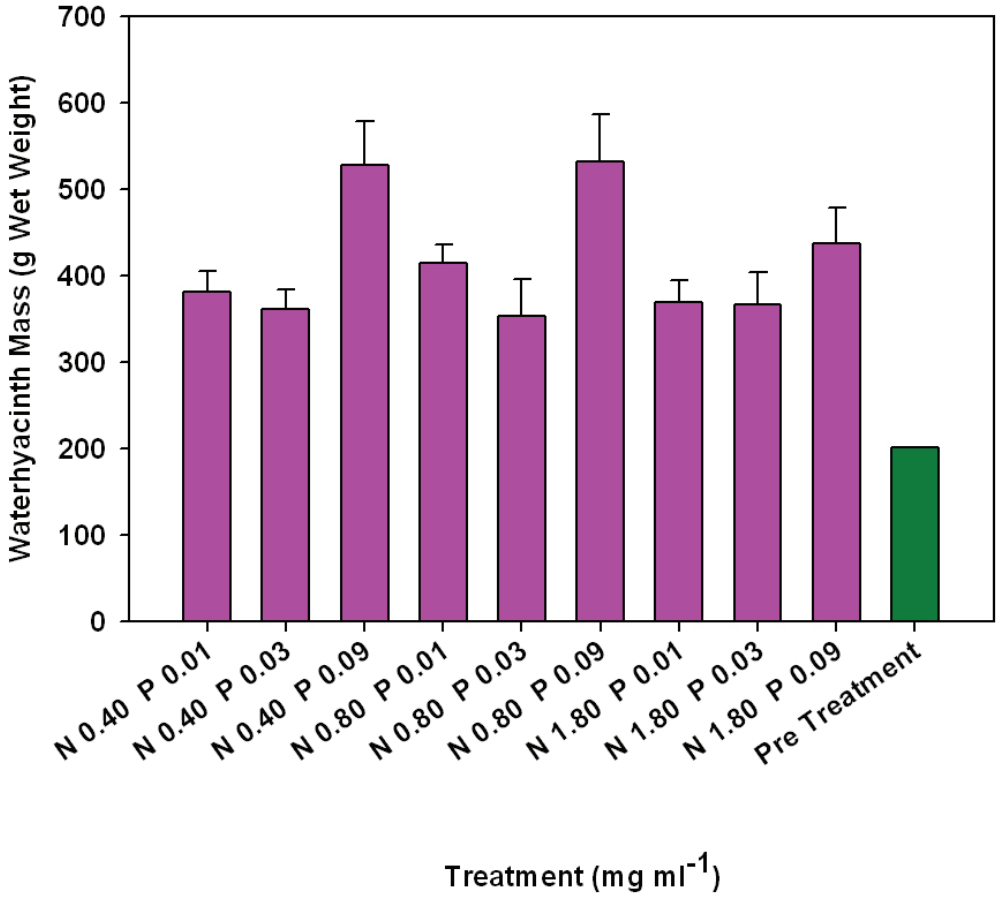
MSU Faculty Eric Dibble (foreground right) assist MSU Graduate students Krisan Webb and Wilfredo Robles (foreground left) measure water quality in a pond infested with the invasive waterlettuce (*Pistia stratiotes*) while graduate students Ryan Wersal and Joshua Cheshier (background) assemble gear for an EDRR treatment to control the waterlettuce.

Task 1.1. Growth of Waterhyacinth as Regulated by Loading Rates of Water Column Nitrogen and Phosphorus

PI: John Madsen
Collaborators: Randy Westbrooks, USGS NWRC

Waterhyacinth (*Eichornnia crassipes*) is the worst aquatic weed worldwide. It impedes navigation, hydropower generation, recreation, and can have negative impacts on animal communities through alterations in habitat quality. Waterhyacinth is thought to be adapted to flood cycles within a watershed. The flooding aids as a dispersal mechanism, more importantly, flood water is a source of nutrients to invading plants. Although management of waterhyacinth has been well documented there is still a need to further understand its ecology and the mechanisms that are involved in its growth and spread. Therefore, we conducted a replicated study to determine how differing rates of water column nutrient loading would affect the growth characteristics of waterhyacinth.

The study was conducted in a mesocosm facility located at the R.R. Foil Plant Science Research Center, Mississippi State University from June through August 2008. Water from the source pond was sent to the Environmental Water Quality Laboratory at Mississippi State University to determine initial concentrations of nitrogen and phosphorus. Waterhyacinth was collected from a local source and planted into 36, 378 liter tanks; fresh weight was determined and recorded. An inert dye was added to all tanks at a rate of 1 ml $tank^{-1}$ to suppress algae growth. After planting, the water in each tank was amended with 1 of 9 nitrogen (N) as (ammonium nitrate) and phosphorus (P) as (potassium phosphate) combinations. Combinations consisted of all possible pairings of N concentrations (low 0.40, medium 0.80, and high 1.80 mg L^{-1}) with P concentrations of (low 0.01, medium 0.03, and high 0.09 mg L^{-1}). Nitrogen and phosphorus concentrations were determined based upon mean concentrations found in eutrophic, mesotrophic, and oligotrophic waters. Nitrogen and phosphorus were added to each tank weekly for 4 weeks. At the conclusion of 4 weeks, all plant material was removed from each tank blotted dry and fresh weight recorded. The entire experiment was then repeated a second time. Four outliers were removed from the data set due to extremely low values. Data were analyzed using a Mixed Procedures Model in SAS at a $p = 0.05$ level of significance. There was no trial effect so data from both experiments were pooled and differences between treatments determined by conducting a pairwise comparison of all treatment combinations.



Initial water samples indicated that there was no P and only trace amounts of N in the source water. Pre-treatment mass was 201 ± 0.90 g for every tank, and there was no difference between nutrient combinations

Fig. 1. After 4 weeks, waterhyacinth mass increased from pre-treatment levels indicating that plants were healthy throughout the study.

($p = 0.15$) or trial ($p = 0.83$). After 4 weeks, waterhyacinth mass increased from pre-treatment levels indicating that plants were healthy throughout the study (Figure 1). There were no differences in waterhyacinth fresh weight among nutrient combinations except for the N 0.4 + P 0.09 and N 0.8 + P 0.09 combinations (Table 1). These two combinations resulted in greater fresh weight than all of the other combinations, but were not different from each other. However, the N 0.8 + P 0.09 combination was not different than the N 1.80 + P 0.09 combination. The increase in fresh weight under the N 0.4 + P 0.09 and N 0.8 + P 0.09 combinations and the fact that these 2 combinations were not different from each other suggests that P may influence waterhyacinth growth more so than the presence of N.

Treatment (mg L^{-1})	N 0.4 + P 0.01	N 0.4 + P 0.03	N 0.4 + P 0.09	N 0.8 + P 0.01	N 0.8 + P 0.03	N 0.8 + P 0.09	N 1.8 + P 0.01	N 1.8 + P 0.03	N 1.8 + P 0.09
N 0.4 + P 0.01	-	0.84	0.03	0.48	0.71	0.01	0.64	0.47	0.29
N 0.4 + P 0.03	0.84	-	0.002	0.38	0.86	0.01	0.80	0.61	0.23
N 0.4 + P 0.09	0.03	0.002	-	0.01	0.001	0.68	0.001	0.001	0.05
N 0.8 + P 0.01	0.48	0.38	0.01	-	0.30	0.05	0.26	0.17	0.69
N 0.8 + P 0.03	0.71	0.86	0.001	0.30	-	0.005	0.92	0.73	0.17
N 0.8 + P 0.09	0.01	0.01	0.68	0.05	0.005	-	0.004	0.002	0.12
N 1.8 + P 0.01	0.64	0.8	0.001	0.26	0.92	0.004	-	0.80	0.14
N 1.8 + P 0.03	0.47	0.61	0.001	0.17	0.73	0.002	0.80	-	0.09
N 1.8 + P 0.09	0.29	0.23	0.05	0.69	0.17	0.12	0.14	0.09	-

Table 1. Significance (p-values) matrix of the differences in pairwise comparisons of nitrogen and phosphorus combinations. Significance was determined at $p = 0.05$ level of significance.

Task 1.2. Phenology, Life History and Carbohydrate Allocation of Invasive Aquatic Plants

PI: John Madsen

Parrotfeather (*Myriophyllum aquaticum* (Vell.) Verdc) is a nonnative aquatic heterophyllous plant. Having both a submersed and emergent growth form may allow parrotfeather to invade and colonize highly disturbed or less than optimal environments through changes in growth habit. Currently, little is known regarding the seasonal growth or the ecological and biological responses of parrotfeather to perturbations in environmental factors. Knowing seasonal cycles in biomass and relationships with environmental factors may allow for the exploitation of low points in growth to maximize management efforts.

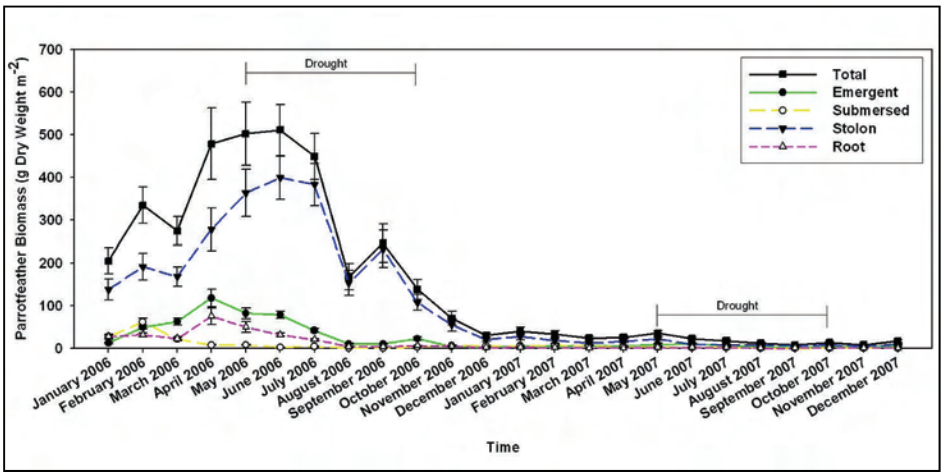


Fig. 1. Biomass sampling showed peak biomass of parrotfeather (*Myriophyllum aquaticum* (Vell.) Verdc.) occurred between April and July. Environmental factors tested had no relation to total biomass or emergent shoot biomass.

In an effort to quantify the seasonal dynamics of parrotfeather growth, 30 biomass samples were collected monthly from each of 4 natural populations in Mississippi for 2 consecutive years. Biomass was harvested using a 0.018 m^2 PVC coring device (Madsen et al. 2007). During plant harvests water depth was recorded during each core and water pH, conductivity, incident light, light transmittance through the water column, and water turbidity were recorded once at each site every month with a Eureka Environmental Multi-Probe. Additionally, one temperature probe was deployed at each site to record water temperature in 1 hr intervals over the 2 year study. After samples were collected, plants were transported to Mississippi State University where they were washed and sorted into emergent tissue, submersed tissue, stolon, and root tissue. These plant constituents were placed into a forced air oven and dried at 70 C for at least 48 hours. Dried plant material was weighed and biomass (g m^2) was determined for each month among the four sample sites.

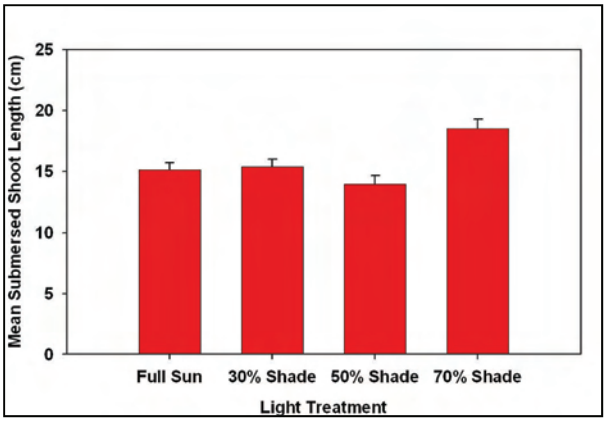


Fig. 2. Biomass sampling showed parrotfeather grown under 70% shade had longer submersed shoots than other plants.

Biomass data were analyzed using a Mixed Procedures Regression model in SAS to determine relationships between parrotfeather growth and environmental factors. This model accounted for repeated measures in the sampling design (i.e. sampling the same sites continuously for 2 years).

Peak biomass of parrotfeather appears to be obtained between the months of April and July with the greatest amount of biomass being stolons (Figure 1). Total biomass was not related to any of the environmental factors tested over the two years ($r^2 = 0.56$). Similarly, emergent shoot biomass was not related to the environmental factors tested ($r^2 = 0.55$). Submersed biomass appears to peak in February suggesting factors such as temperature or light availability influencing growth of parrotfeather during winter months. In fact, both temperature ($p = 0.01$) and water turbidity ($p = 0.05$) were inversely related to submersed tissue growth ($r^2 = 0.61$). Stolon growth was also related ($r^2 = 0.64$) to temperature ($p = 0.03$) and turbidity ($p = 0.02$). Root growth was related ($r^2 = 0.58$) to light transmittance through the water column ($p < 0.01$). The influence of light availability on parrotfeather growth was further investigated in a controlled mesocosm experiment where parrotfeather was grown under full sun, 30%, 50%, and 70% shade treatments. Parrotfeather grown under 70% shade resulted in greater elongation of submersed shoots than plants grown with greater light availability (Figure 2). Further more, water temperature generally decreased as the % shade increased; however no relationship could be determined in the controlled experiment because the treatment effect (shade) was driving the temperature effect and these to variable could not be separated.

Task 2. National Early Detection and Rapid Response Webpage Development

Graduate students Chris Doffitt (in green) and Steven Hughes (in lighter green) conducting random point sampling on Sandhill Crane NWR in south Mississippi.

Volunteers on Waites Island, a South Carolina barrier island, map prickly pear cactus and monitor for the cactus moth, as well as look for invasive plant species. Building a volunteer network will be critical for developing an effective national EDRR system. Photo by Randy Westbrooks, USGS.

Task 2.1. Early Detection and Rapid Response Information Development

PI: John Madsen
Co-PI: Victor Maddox
Cooperator: Randy Westbrooks, USGS NWRC, and Annie Simpson, USGS National Headquarters (NBII), and Les Mehrhoff, University of Connecticut (IPANE)

Early Detection and Rapid Response Information Development
John Madsen

As part of this task, we will be developing content for a National Early Detection and Rapid Response webpage. An outline of some of the components has been developed by Randy Westbrooks, and we will be working with him and other cooperators to develop information that is applicable at the federal, regional, state, and local level (Table 1). An explanation of these components follows:

Introduction to Invasive Species provides an overview of the problems caused by invasive species and how this issue might be addressed.

Development of Early Detection and Rapid Response provides a history of the development and implementation of the EDRR strategy.

Figure 1. Ryan Wersal treats the invasive waterlettuce (*Pistia stratiotes*) with an US EPA approved aquatic herbicide as part of our local early detection and rapid response. This pond is across the street from the offices of the Geosystems Research Institute.

National EDRR System for Invasive Plants outlines the components of an EDRR response that are organized by federal agencies and interests, and how these resources can be used to organize and build capacity for state EDRR elements.

State Interagency Coordination, Science, and Technical Support outlines how state agencies and federal entities located within the state may be organized into state invasive species councils, and work together to build a state EDRR program.

Early Detection and Reporting provides tools to develop a state early detection and reporting network, including volunteer training, field survey, data collection and reporting information, where data should be reported, and the outlines of a EDRN training workshop to train volunteers and collaborators.

Identification and Vouchering provides contacts for competent regional taxonomic expertise for invasive species.

Data Archival and Synthesis highlights existing invasive species reporting platforms, such as IPANE, IPAMS, EDDMaps (at the regional level) and national databases such as NAS, NIISS, and the NRCS Plants database.

Rapid Assessment provides some guidelines for determining if an exotic species has the potential to be invasive, or lists of species that have already been determined to be potentially invasive.

Rapid Response provides principles for invasive species eradication and management, success stories on eradication projects, contacts for cooperative weed management areas, and invasive species task forces.

Invasive Species Target List provides fact sheets on high profiles species as well as a listing of targeted EDRR species or watch list species.

We will be working to develop these materials in cooperation with IPANE, EDDMaps, and Randy Westbrooks over the course of the coming year.

Table 1. Components of a National Early Detection and Rapid Response webpage (revised from Randy Westbrooks).

I. Introduction to Invasive Species – Nature and Scope of the Problem
II. Development of Early Detection and Rapid Response
III. National EDRR System for Invasive Plants – System Elements and Processes
IV. State Interagency Coordination, Science & Technical Support
V. Early Detection and Reporting
VI. Identification and Vouchering
VII. Data Archival and Synthesis
New England States – Invasive Plant Atlas of New England (Les Mehrhoff, UCONN, Storrs, CT) (CT, RI, MA, NH, VT, ME)
Southeastern States – SE-EPPC – EDDMaps (Chuck Bargeron, U-GA, Tifton, GA) (VA, NC, SC, GA, FL, AL)
Mid-South States – Invasive Plant Atlas of the MidSouth (John Madsen, MSU, Starkville, MS) (AL, MS, LA, TN, AR)
USDA Plants Database (Scott Peterson, USDA NRCS, Baton Rouge, LA)
VIII. Rapid Assessment
IX. Rapid Response
X. Invasive Plant Target List

Task 2.2. EDRR Tool Assessment

PI: Gary Ervin
Co-PI: John Madsen, Victor Maddox
Collaborators: Annie Simpson, NBII and USGS National Headquarters

The objective of this Task is to evaluate candidate EDRR approaches that may augment our ongoing habitat modeling efforts. There are numerous predictive tools available that can be evaluated under these objectives. Our plan is to conduct quantitative evaluation of a select subset of available EDRR (or habitat modeling) tools, using data in our own databases. These data include state and regional distribution of several native and non-native invasive plant species, in addition to the South American cactus moth. Results of these evaluations will be incorporated into the EDRR materials that will be developed for inclusion in the NBII internet pages on the "National Framework for Early Detection, Rapid Assessment, and Rapid Response to Invasive Species."

Focal species	Type of analysis	Factor(s) correlated with invasion
Baccharis halimifolia	Logistic regression with Information-Theoretic approach	Canopy density (GAP data) and soil organic matter, clay content, and pH
	Graphic and simple chi-square analyses	Canopy presence, anthropogenic disturbance, land use
Imperata cylindrica	Logistic regression – probabilistic approach	Anthropogenic disturbance, proximity to roads, soil sand content
	Logistic regression with Information-Theoretic approach	*same as above*
	ROC Curves	*same as above*
Mixed exotic plants (exotic species richness)	Mixed model probabilistic approach with spatial autocorrelation	Land use/cover

Table 1. Results of analyses of three independent invasive plant data sets.

As a precursor to these EDRR tool assessments, we have analyzed three of our own datasets using a host of statistical approaches (e.g., standard inferential statistics, information-theoretic approach, graphical methods. These analyses have included data on the native shrub *Baccharis halimifolia* in Mississippi and Tennessee, the exotic grass *Imperata cylindrica* in southern Mississippi, and general assemblages of exotic plant species across Mississippi. With these analyses completed, we now can use these datasets to test pre-packaged habitat modeling and species distribution modeling tools and make recommendations on their suitability for EDRR efforts.

Analyses of the *Baccharis* data have been submitted in two papers accepted for publication in *Southeastern Naturalist* and the USGS *GAP Bulletin* and have been presented at several meetings and invited lectures. The work on *Imperata* has been presented at multiple conferences, a manuscript is currently under revision, and the work contributed to part of a recent PhD dissertation in the Department of Biological Sciences. Analyses of the general exotic species data have just recently begun but are based on a set of more than 300 random points across Mississippi that have been visited for the collection of plant species and environmental data.

Results from all three data sets have supported published findings of a close association between human land use or anthropogenic disturbance and the distribution of invasive species. The work on *Imperata cylindrica* was used to develop a grant proposal aimed at conducting cost-benefit analyses of specific land management practices to minimize spread of invasive plants.

Accepted papers

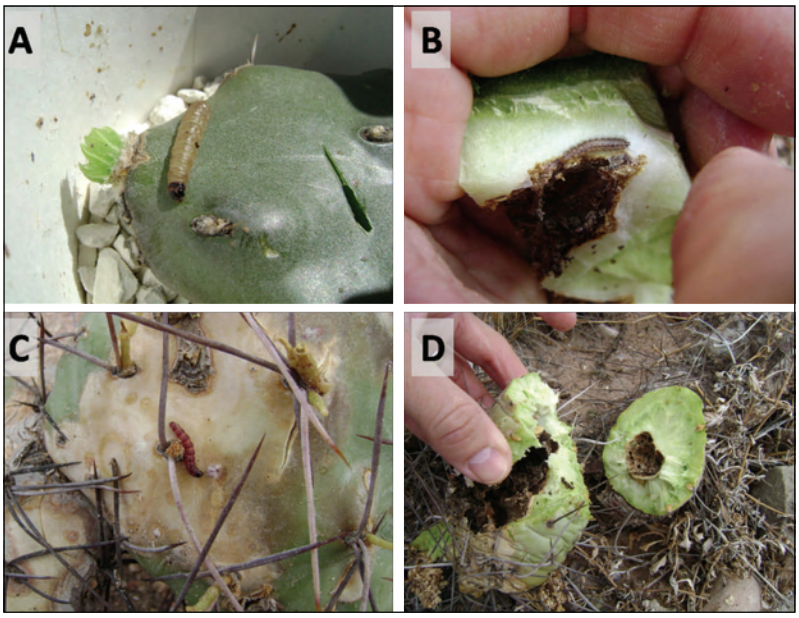
Ervin, G. N. 2009. Using GAP data in invasive plant ecology and management. US Geological Survey *Gap Analysis Bulletin* 16: *Accepted*.

Ervin, G. N. 2009. Distribution, habitat characteristics, and new county-level records of *Baccharis halimifolia* L. on a portion of its present US range boundary. *Southeastern Naturalist, In press*.

Manuscripts in progress

Holly, D. C. and G. N. Ervin. *In revision*. Predictive habitat modeling of cogongrass (*Imperata cylindrica*) populations in Desoto National Forest Mississippi, USA.

Task 3. Invasive Insects: Cactus Moth *Cactoblastis cactorum*



Assorted larvae encountered during December 2008 collection trip to Argentina. A) unidentified species of larva (possibly of genus *Tucumania*), on an *Opuntia* in northeastern Argentina; B) unidentified species of larva collected from *Opuntia ficus-indica* in western Argentina; C) likely *Cactoblastis doddi*, from northeastern Argentina; D) damage to *O. sulfurea* from *C. doddi*.

Dr. Guillermo Logarzo (left) and Laura Varone, of the USDA South American Biological Control Laboratory, collect *Cactoblastis cactorum* larvae for rearing.

Two Argentinean boys provided a song in Quechua-Castillano for Drs. Ervin, Brooks, and Logarzo during a stop at the botanical garden in Tilcara. Ervin is pictured here with the children.

Cactoblastis cactorum collected for lab rearing (center) and genetic analyses (vials in lower right).

Task 3.1. Early Detection and Reporting of Cactus Moth

PI: Richard Brown
Co-PI: John Madsen, Victor Maddox
Collaborators: Randy Westbrooks, USGS NWRC; Joel Floyd, USDA APHIS PPQ; John C. Stewart, USDA APHIS PPQ

Identification of Moths in Traps –
External Morphology of Scaleless Moths
Richard Brown

Pheromone traps are the primary survey tool for the cactus moth, *Cactoblastis cactorum*. During 2008, 915 traps from Alabama, Mississippi, Texas, Arizona, and California were screened for cactus moths. Cactus moth were trapped only on Petit Bois and Horn Islands off the coast of Mississippi. To facilitate field screening of moths, an identification guide (see following) was prepared that is based on superficial characteristics of moths, including color of scales covering wings and legs. However, these characters cannot be used to identify many specimens because specimens may be damaged or partially represented in trap samples. Knowledge of the external morphology of adult cactus moths is essential for identification of specimens as well as for studies of behavior and systematics that are morphologically based. Almost all studies on systematics of moths are based on morphology of scaled specimens (Fig. 1-15), rather than specimens denuded of scales. A new method for preparing slide mounts of whole bodies of moths (Lee and Brown, 2007) was used to compare male and female C. cactorum and the males of C. cactorum and M. prodenialis. One female and one male specimen of Cactoblastis and one male specimen of Melitara were examined. All scales were removed from the bodies, and disarticulated body parts were stained with eosin.

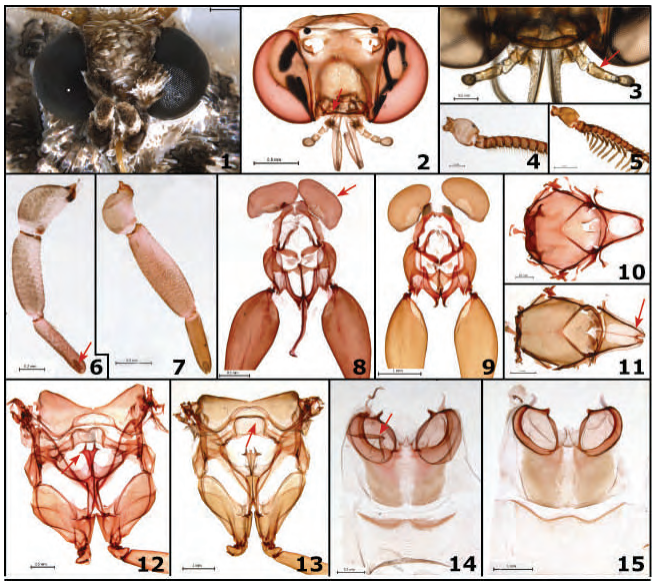


Figure 1-15. Figures 1-15. Cactoblastis cactorum and Melitara prodenialis, selected anatomical structure. 1-3, head of C. cactorum; 1, with scales, 2, with scales removed (arrow = clypeus), 3, maxillary palpus (arrow = second segment); 4-5, base of antenna, 4, C. cactorum, 5, M. prodenialis; 6-7, labial palpus, 6, C. cactorum (arrow = organ of vom Rath), 7, M. prodenialis; 8-9, prothorax, 8, C. cactorum (arrow = patagium), 9, M. prodenialis; 10-11, mesonotum, 10, C. cactorum, 11, M. prodenialis (arrow = cleft phragma); 12-13, metathorax, 12, C. cactorum (arrow = furcal arm), 13, M. prodenialis (arrow = opening of euphragma); 14-15, abdominal tympana, 14, C. cactorum (arrrow = tympanal cavity), 15, M. prodenialis.

Resulting mounts of de-scaled moths displayed many anatomical structures that differentiate *C. cactorum* from *M. prodenialis*, of which only a few examples are given here. Cactoblastis has a straight clypeus and a maxillary palpus with the second segment being the smallest (Figs. 2, 3), whereas Melitara has a rounded clypeus and a maxillary palpus with the third segment being the smallest. Cactoblastis and Melitara greatly differ in the form of their antennae (Figs. 4, 5). Cactoblastis has a labial palpus with a third segment that is 0.73 the length of the second, whereas Melitara has the third segment only 0.54 the length of the second (Figs. 6, 7) (note the invaginated Organ of vom Rath at the apex of the third segment; the function of this structure is unknown). The proboscis of both male and female Cactoblastis have >40 styloconic sensilla, whereas <12 are present in Melitara; the presence of these gustatory sensilla suggest that Cactoblastis may feed as adults. The prothoracic patagia are more elongate in Cactoblastis than in Melitara (Figs. 8, 9). The mesothoracic phragma is rounded posteriorly in Cactoblastis, but cleft in Melitara (Figs. 10, 11). The metathorax has a euphragma with a small rounded opening in Cactoblastis, but a large quadrate opening in Melitara, and the furcal arms differ between the two genera (Figs. 12, 13). The abdomen has a tympanic cavity that is smaller in Cactoblastis than Melitara (Fig. 14); how sound reception may differ between the two genera is unknown.

This morphological study of de-scaled Cactoblastis moths indicates that all body segments have diagnostic characters for identification of specimens. In addition, this research has revealed structures of both systematic and behavioral importance.

References

Lee, S.M. and R.L. Brown. 2006. A new method for preparing slide mounts of whole bodies of microlepidoptera. J. Asia-Pacific Entomology 9: 249-253.

Task 3.2 Distribution of *Opuntia* in the Region

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

Surveys for Pricklypear Cactus
Victor Maddox, John Madsen, John Byrd, Richard Brown, and Randy Westbrooks

Pricklypear (*Opuntia* spp.) mapping and data collection were conducted over a large geographic area of the eastern and southern United States in 2008. However, compared to previous years more time was focused on assisting USDA-APHIS with eradication programs along the gulf coast, sentinel sites, and entry of negative host locations into the Cactus Moth Detection and Monitoring Network (CMDMN). The distribution of *Opuntia* in the Region continues to expand as new populations are identified, even on the Mississippi barrier islands.

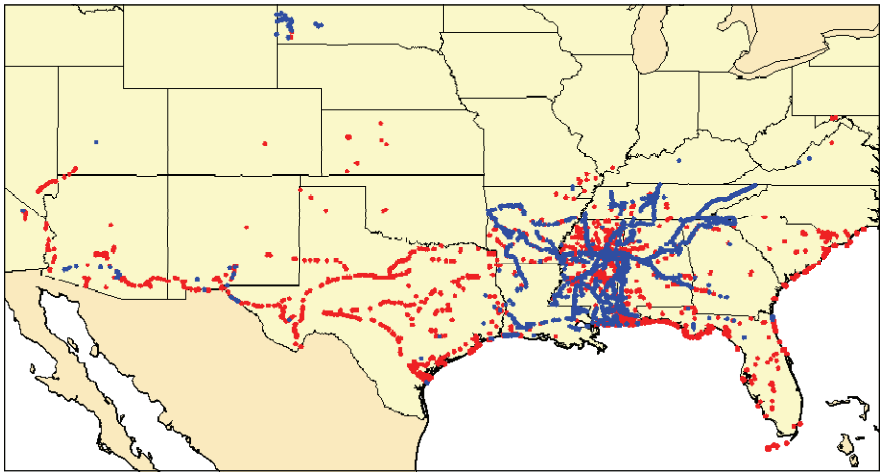


Fig. 1. Cactus Moth Detection and Monitoring Network map showing pricklypear populations and negative (absence) locations in the database as of 16 December 2007.

In 2008, surveys were conducted from Northern Illinois to Florida and Louisiana. The greatest concentration of mapping and data collection work in 2008 was conducted in Alabama, Mississippi, and Florida which are along the western leading edge of the cactus moth. Individual mapping trips ranged from just a few miles to a few hundred 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 private lands during this period. During these trips, data from negative locations were also recorded.

Fig. 2. Left to right: Maurice Duffel, USDA-APHIS, Craig Hinton, USDA-APHIS, Jay Standley, USDA-APHIS, Jeff Head, USDA-APHIS, and Victor Maddox, MSU-GRI, made up one of the two teams to visit Horn Island off the coast of Mississippi on 6 March 2008 to search for cactus moth, a serious threat to native pricklypear. Additional pricklypear populations were mapped during the visit, but cactus moth was not found by either team after checking thousands of plants. (Photo by Capt. Steve West, Charter Boat Captain).

As of 16 December, 4843 pricklypear reports were in the database (Figure 1). Recent emphasis on negative (absence) host data is evident, since 2294 reports were negative. Entry of negative *Opuntia* data is expected to continue into early 2009. Florida had 263 reports up from 206 in 2007 (only 128 in 2006) and Mississippi had 1614 reports up from 753 in 2007. Alabama was also up with 1035 reports. Still, more *Opuntia* and cactus moth data are needed from Florida's interior (Figure 1).

Sentinel site monitoring was continued in 2008 and one very important sentinel site was established in Texas at Aransas National Wildlife Refuge, which is being monitored by Jordan Harrison, Biological Science Technician (S.T.E.P.). In addition, increased collaboration with USDA-APHIS eradication efforts along the leading edge occurred in 2008 (Figure 2). This included mapping emphasis in Baldwin County, Alabama and extreme western Forida, and assistance with eradication efforts on Mississippi barrier islands. Collaboration with SAGARPA in Mexico to develop a Spanish version of the CMDMN database was also initiated in 2008.

Task 3.3. *Opuntia* and *Cactoblastis* Habitat Models and Population Genetics

PI: Gary Ervin
Co-PI: John Madsen, Richard Brown
Collaborators: Chris Brooks, Lisa Wallace, and Mark Welch; MSU Biological Sciences

The objectives of this Task are to A) further develop predictive modeling capabilities for the cactus-cactus moth system and B) to incorporate molecular genetics studies into the modeling approaches and into our knowledge of the moth's natural history. Work on habitat modeling slowed after initial efforts at accumulating a basic set of habitat modeling approaches; this was the result of a need for the extensive data sets required for carrying out such studies in a rigorous manner. We believe those data now are available, following a year of intensive data collection throughout Florida that will provide a set of cactus data that can be used to validate models derived from data previously available in the CMDMN database. These analyses will be enhanced by data on distribution and abundance of the cactus moth (*Cactoblastis cactorum*) in its native range in Argentina. These data have been collected on two sampling trips conducted during 2008 (February and December) that covered most of the northern half of Argentina (north of Buenos Aires).

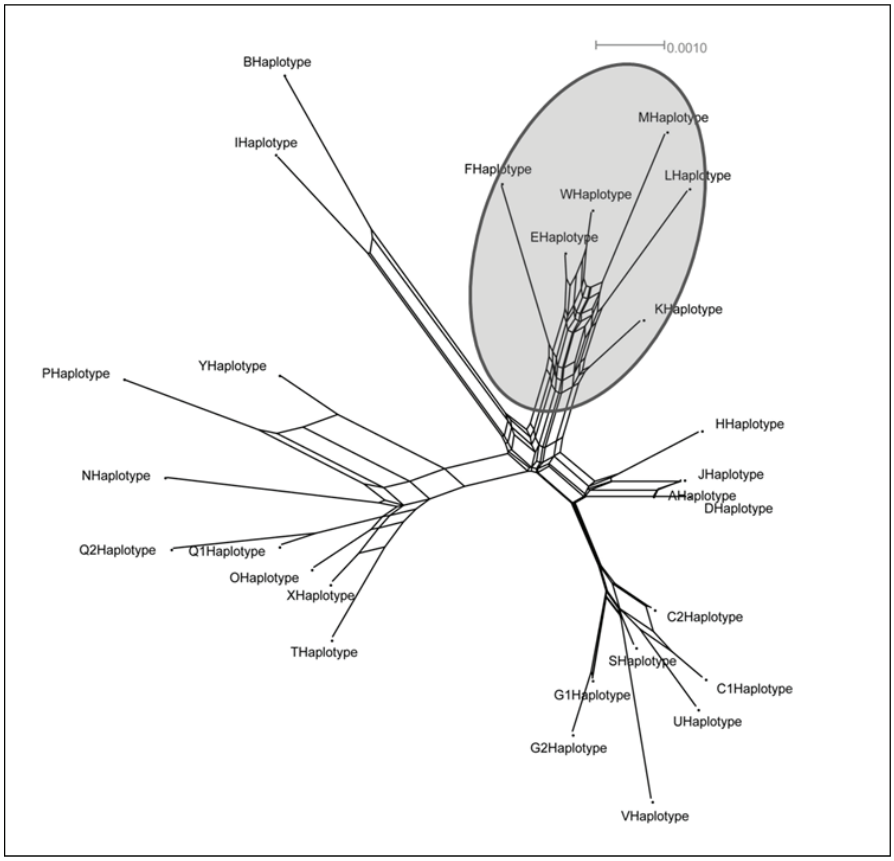


Fig. 1. Phylogenetic network for *Cactoblstis cactorum* haplotypes analyzed to date. The group shaded in gray represents haplotypes known from the non-native range of *C. cactorum*; all other haplotypes are known from Argentina only.

In the area of genetic analyses, we have completed analysis of samples of *C. cactorum* from the area covered in the February trip to Argentina, as well as the Florida work from summer of 2008. These analyses also have included samples of *Melitara prodenialis* from much of Florida and data from an outgroup moth species for reference. The data thus far have demonstrated a high degree of variability in *C. cactorum* from its native range and also support the idea of a single source population from Argentina having been used in the original biocontrol work in Australia. That is, genetic data from samples of *C. cactorum* from all areas outside Argentina group very closely to larvae collected from a very small region of Argentina, near the reported source location for material transported to Australia. The region of the reported source location was visited in December, and those samples should be processed and analyzed early in 2009.

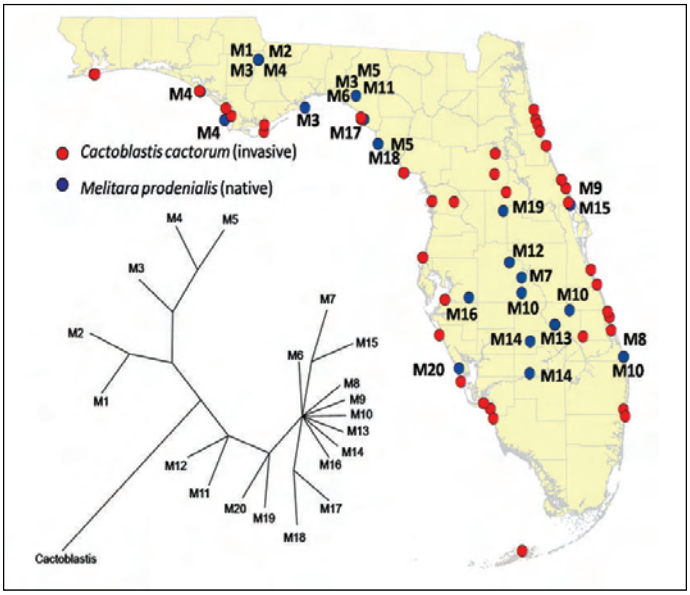


Fig. 2. *Melitara prodenialis* haplotypes and their distribution across Florida. Relationships among haplotypes are based on *C. cactorum* as the outgroup.

Another interesting finding from the molecular work thus far is the relatively high levels of genetic diversity represented by the *C. cactorum* samples collected in Argentina in February. Specifically, in the section of the genome used for these initial analyses, we found more than five times the genetic diversity in the native range relative to the non-native range (Fig. 1). The genetic haplotypes found in the non-native range belong

to a clearly defined group that includes haplotypes from near the original reported collection site in northeastern Argentina. The high levels of genetic diversity in the native range relative to the introduced range and the location of specimens from the *C. cactorum* adventive range within the group from the originally sampled regions of Argentina together support initial reports of a single source population used for biocontrol in Australia. Similarly, *M. prodenialis* exhibits a high degree of variability across the state of Florida. Here, using the same region of DNA as for the *C. cactorum* analyses, we recovered 20 genetic haplotypes from 40 specimens analyzed (Fig. 2).

We will be following up this initial molecular work with a grant proposal to NSF to conduct studies into the potential genetic control of host preference in *C. cactorum* and *M. prodenialis*. Work conducted thus far has been presented in talks given at two conferences. In addition to the grant proposal we are developing, we also have three papers underway and additional manuscripts planned to follow the December expedition to Argentina, which will complete our broad-scale data collection in that country. We further plan to initiate smaller-scale studies in Argentina to further tease apart factors that seem to be influencing the distribution and host selection of *C. cactorum* in its native range.

Accepted Papers

Majure, L.C. and G. N. Ervin. 2008. The *Opuntia* (Cactaceae) of the state of Mississippi, United States. *Haseltonia*, 14: 1-16.

Manuscripts in progress

Ervin, G. N. *In Review*. A brief history on the introduction of *Opuntia ficus-indica* (L.) Miller to South America. Submitted to *Journal of Vegetation Science*.

Majure, L.C. and G. N. Ervin. *In revision*. Habitat typifications for the *Opuntia* (Cactaceae) of Mississippi.

Majure, L.C. and G. N. Ervin. *In revision.* The morphological plasticity of *Opuntia pusilla* (Haw.) Haw. (Cactaceae) induced through microclimatic differentiations.

Task 3.4. Webpage: Cactus Moth Detection and Monitoring Network

PI: Clifton Abbott
Co-PI: Richard Brown, Victor Maddox, John Madsen
Collaborators: Randy Westbrooks, USGS NWRC, Joel Floyd, USGS APHIS PPQ, John C. Stewart, USDA APHIS PPQ, and Annie Simpson, USGS National Headquarters (NBII), John Byrd, MSU Plant and Soil Sciences

Cactus Moth Detection Network
John D. Madsen, Richard L. Brown, Gary N. Ervin, Victor L. Maddox, and Clifton F. Abbott

The US Geological Survey, National Biological Information Infrastructure, USDA-APHIS and the Mississippi State University entered into a partnership in 2004 to develop the Cactus Moth Detection Network. A team of scientists at Mississippi State University is collaborating on an overall project with six components. The Mississippi Entomological Museum has developed techniques for identification of cactus moth, as well as verifying the identification of field specimens. Surveys for native pricklypear cactus species have been conducted to map the locations of potential hosts. Volunteers are being solicited to establish an early detection network for cactus moth at georeferenced sentinel sites. A predictive model is under development to predict the locations of pricklypear cactus populations. A wide range of extension publications have been developed for the use of volunteers, resource managers, and other. Lastly, a web-based database and ArcIMS map have been developed (http://www.gri.msstate.edu/cactus_moth) to track cactus and cactus moth. Our group is active in coordinating our efforts with other groups working on cactus moth, as well as other invasive species efforts within USGS and NBII. Regular updates in the form of monthly reports are available either on the webpage, or through a subscription e-mail list.

Fig. 1. The Cactus Moth Detection and Monitoring Network webpage (http://www.gri.msstate.edu/cactus_moth) provides information on the distribution of pricklypear cactus and the invasive cactus moth across the U.S. and Mexico.

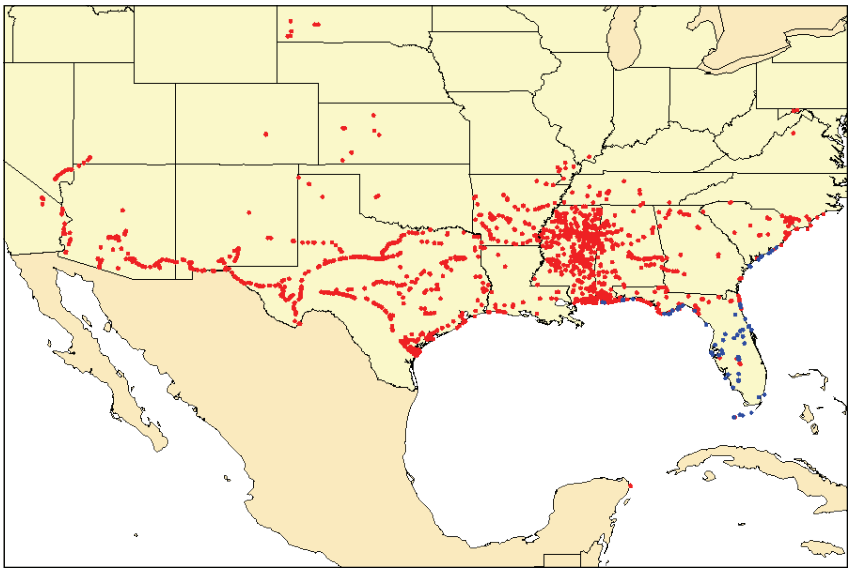
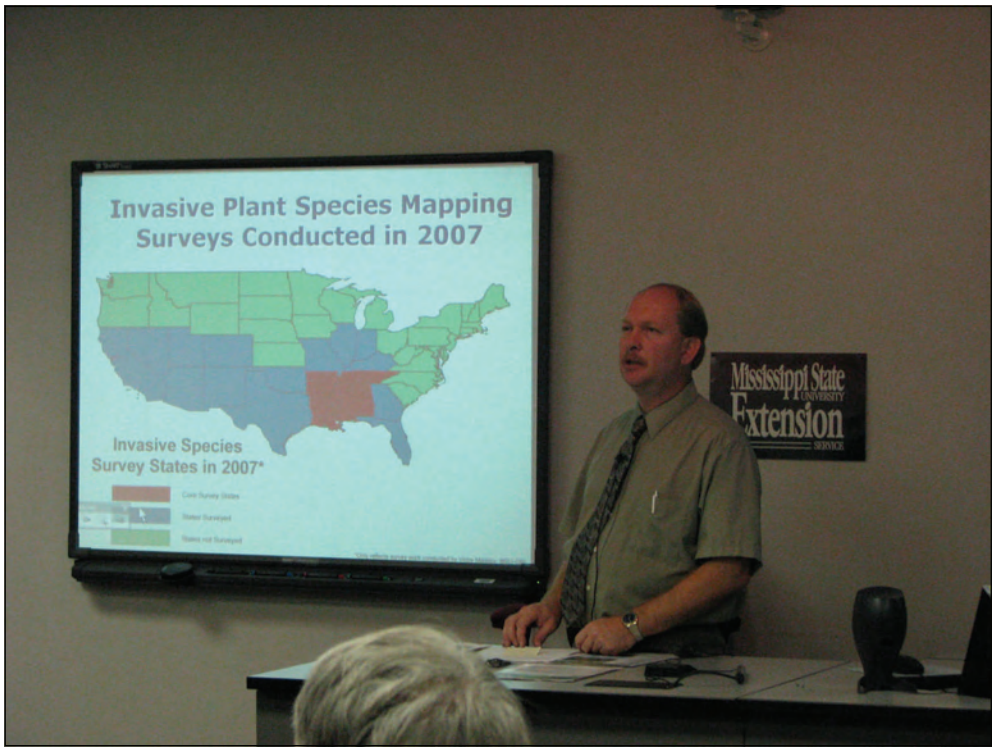


Fig. 2. The current distribution map of pricklypear cactus (red dots) and the cactus moth (blue dots) from the CMDMN webpage (http://www.gri.msstate.edu/cactus_moth). We currently have data from 24 states and Mexico.

Task 4. Invasive Plant Atlas of the Mid-South



MSU Botanist Victor Maddox teaches a Master Gardener's group about the IPAMS system.

MSU Botanist Victor Maddox hits the road over winter break 2007-2008 to map prickly pear cactus and invasive plants from North Mississippi to California. In this photo, Victor is near the Rio Grande River in Texas.

Task 4. Web-based Database of Invasive Plant Species Locations (IPAMS)

PI: John Madsen
Co-PI: Gary Ervin, Clifton Abbott, David Shaw, and John Byrd
Collaborators: Randy Westbrooks, USGS NWRC, Annie Simpson, USGS National Headquarters (NBII), and Les Mehrhoff, University of Connecticut (IPANE)

The Invasive Plant Atlas of the MidSouth
Clifton Abbott, Victor Maddox, John Madsen, and Gary Ervin

The Invasive Plant Atlas of the MidSouth, or IPAMS, is a web-based database system designed to allow users to access and record information on invasive plant species and their locations. Additional information provided by IPAMS includes distribution maps, identification assistance, management and control techniques, and reporting information. Emphasis will be placed upon, but not limited to, invasive species populations within the MidSouth region. Data will be shared amongst other organizations as well as through the National Biological Information Infrastructure (NBII). The database will include numerous invasive plant species, although initial training workshops for non-scientists will focus on 40 invasive plant species. These 40 species represent six primary habitats: aquatic, managed forests, pasture, rights-of-way, row crop, and wildland areas. IPAMS utilizes field data protocols established by the North American Weed Management Association (NAWMA) and includes general information, GPS location information, and invasive plant species information. The IPAMS system provides tools for users to manage their data within the database. An alert notification system is also provided to allow interested parties to be notified when certain species are located within certain areas. IPAMS provides up-to-date distribution maps through an ArcIMS system. IPAMS will provide a single stop for the region for invasive plant locations, management methods, and reporting information so that individuals can effectively perform early detection and rapid response for invasive plant species threatening the landscape.

Fig. 1. The Website of the Invasive Plant Atlas of the MidSouth.

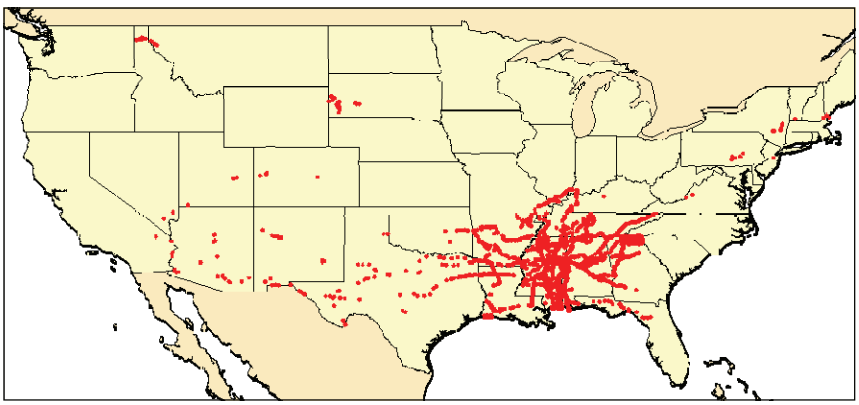


Fig. 2. A map on the Invasive Plant Atlas of the MidSouth shows the spread of an invasive species.

Task 5. Regional Coordination

Dr. Lester Spell, Commission of the Mississippi Department of Agriculture and Commerce, was the keynote speaker at the 2008 Annual Meeting of the Southeast Exotic Pest Plant Council. Dr. Spell also received an award from the Mississippi Exotic Pest Plant Council for leadership in fighting exotic plants through regulation and action. Federal, state, local governments and non-government agencies must all work together to manage invasive species. MSU Faculty John Madsen was the program chair for this event.

MSU's Wilfredo Robles (left), MS DAC's Kenneth Calcote (center), and USDA APHIS PPQ's John Corban confer during the 2008 annual conference of the Southeast Exotic Pest Plant Council. All three individuals and agencies have worked together on CAPS surveys for federal noxious weeds.

While presenting at a Eurasian watermilfoil task force meeting in Noxon, MT; MSU's John Madsen (who took this photo) and collaborator Kurt Getsinger of USAERDC were asked by a tribal college instructor to inspect the flowering rush (*Butomus umbellatus*) infestation on Flathead Lake, MT. One half of this lake is managed by the Salish tribe.

Task 5. Regional Coordination

PI: David Shaw
Co-PI: John Madsen

Coordination Tasks During 2008

- Project personnel participated in the NBII Invasive Species Working Group teleconference program, providing updates each month. The NBII ISWG meets each month, January through October.
- John Madsen presented invasive plant management information to the Minnesota Green Expo, a horticultural trade show, on January 10 2008.
- John Madsen met with Minnesota Department of Natural Resources invasive aquatic plant personnel and other scientists on January 11, 2008.
- Several project personnel attended the Southern Weed Science Society, January 28-31 2008.
- Several project personnel attended the Weed Science Society of America meeting, February 3-8 2008. A special GIS workshop and a symposium highlighted several MSU invasive plant projects, including the Invasive Plant Atlas of the MidSouth and USGS/NBII invasive plant and cactus moth surveys during the meeting.
- John Madsen participated in a teleconference with Jean Freeney and Terri Killeffer of NBII-SAIN on February 15, 2008.

Personnel with USDA APHIS PPQ offices in Mississippi and Alabama work to survey the Gulf Coast barrier islands for the presence of cactus moth and pricklypear cactus. Maurice Duffel, USDA-APHIS, Pensacola, FL; Craig Hinton, USDA-APHIS, Gulf Port, MS; Jay Standley, USDA-APHIS, Starkville, MS; Jeff Head, USDA-APHIS, Starkville, MS; and Victor Maddox, MSU-GRI, made up one of the two teams to visit Horn Island off the coast of MS on 6 March 2008 to search for cactus moth, a serious threat to native pricklypear. Additional pricklypear populations were mapped during the visit, but cactus moth was not found by either team after checking thousands of plants.

- Attended NIWAW9 and briefed Office of Management and Budget personnel concerning the importance of cactus moth issues and the Cactus Moth Detection and Monitoring Network, as well as other USGS NBII projects.
- John Madsen represented the Aquatic Plant Management Society as a board member on the Council for Agricultural Science and Technology March 11-13.
- In mid-March, we had a teleconference with John Stewart and the APHIS folks from SC to talk about setting up about 20 new sentinel sites along the SC coast.
- John Madsen chaired the program committee for the annual conference of the Southeast Exotic Pest Plant Council. During this meeting, we had a database symposium and discussed data sharing and collaboration between IPAMS, CMDMN, EDDMaps (University of Georgia Bugwood Network and SEEPPC), and NBII SAIN
- MSU provided four talks on invasive aquatic plant management and activities to the Mississippi Water Resources Conference on April 16, 2008.
- In April, we updated cactus moth project progress to the ISWG.
- John Madsen and Victor Maddox attended the Mississippi Bureau of Plant Industry Cooperative Agricultural Pest Survey Program annual meeting, May 13, 2008, representing cactus moth project.
- John Madsen discussed invasive aquatic plant management and monitoring efforts of MSU to concerned citizens and state government personnel at a town meeting regarding Roebuck Lake in Itta Bena, MS on May 30, 2008.
- John Madsen was an invited instructor to an invasive aquatic plant tour and workshop on June 18-19 2008 in Twin Falls, Idaho.
- Participated in the USDA-sponsored Cactus Moth International Program Review, Pensacola, FL, June 23-27, 2008.
- Victor Maddox and Randy Westbrooks worked with USDA APHIS PPQ on surveys in the AL and MS Gulf Coast and coastal Carolinas, respectively.

- Gary Ervin presented on invasive plant research and IPAMS at the Ecological Society of America and CSREES NRI review, August 4-8 2008.
- Cactus moth survey trip to Petit Bois, and possibly Horn Islands, with USDA-APHIS planned for September.
- Collaborated with Jordan Harrison with the U.S. Fish & Wildlife Service at the Aransas National Wildlife Refuge regarding monitoring efforts in Texas.
- Victor Maddox assisted with cactus moth eradication trip to Petit Bois Island in MS with USDA-APHIS and USDA-ARS 9 September 2008.
- Victor Maddox worked with the Aransas National Wildlife Refuge in TX during September 2008.

Randy Westbrooks fires up the members of Southeast Exotic Pest Plant Council at their annual meeting in Biloxi, MS on May 20-22 2008. Randy was one of our keynote speakers, presenting on the importance of Early Detection and Rapid Response
and also on an environmentally-oriented ethic regarding invasive species.

- John Madsen met with Henry Sansing, refuge manager October 2, 2008 to discuss hydrilla and invasive plant control on the Noxubee NWR, MS.
- John Madsen attended the signing of the Mississippi Cooperative Weed Management Area agreement at the Forestry Museum, Jackson, MS.
- John Madsen, Cliff Abbott, and Victor Maddox represented MSU invasive plant projects and highlighted the IPAMS at the Natural Areas Conference, Knoxville, TN October 14-17 2008.
- John Madsen was the program chair for the 2008 annual meeting of the MidSouth Aquatic Plant Management Society.
- John Madsen represented the Aquatic Plant Management Society as a board member on the Council for Agricultural Science and Technology October 27-30.
- John Madsen and Ryan Wersal, along with other weeds scientists across the State of Mississippi, met for the Mississippi Weed Science Committee. This committee provides annually updated information on weed management, including invasive aquatic and terrestrial plants, through the Mississippi Weed Management Guidelines Manual that is produced each year through Mississippi State University Extension Service.
- Victor Maddox assisted with cactus moth eradication trip to Horn Island in MS with USDA-APHIS and USDA-ARS during November 2008.
- Clifton Abbott attended the USGS/NBII Developers Conference, December 1-5 2008, in Denver, CO.

Accomplishments

Peer-Reviewed Journals

Ervin, G. N. 2009. Using GAP data in invasive plant ecology and management. US Geological Survey *Gap Analysis Bulletin* 16: *Accepted*.

Ervin, G. N. 2009. Distribution, habitat characteristics, and new county-level records of *Baccharis halimifolia* L. on a portion of its present US range boundary. *Southeastern Naturalist, In press*.

Ervin, G. N. 2008. Applying the state-of-the-art to advance the state of our understanding in integrated hydrophyte ecology. *Verhandlungen Internationale Vereinigung für theoretische und angewandte Limnologie* (Proceedings of the International Society of Theoretical and Applied Limnology) 30: 128-132.

Holly, D. C., G. N. Ervin, C. R. Jackson, S. V. Diehl, G. T. Kirker. 2008. Effect of an invasive grass on ambient rates of decomposition and microbial community structure: A search for causality. *Biological Invasions*, Accepted – DOI: 10.1007/s10530-008-9364-5.

Madsen, J. D., R. M. Stewart, K. D. Getsinger, R. L. Johnson, R. M. Wersal. 2008. Aquatic plant communities in Waneta Lake and Lamoka Lake, New York. Northeastern Naturalist. Vol. 15. 97-110.

Madsen, J. D., R. M. Wersal. 2008. Growth regulation of *Salvinia molesta* by pH and available water column nutrients. Journal of Freshwater Ecology. Vol. 23. 305-313.

Madsen, J. D., R. M. Wersal, K. D. Getsinger, and L. S. Nelson. 2008. Sensitivity of wild rice (*Zizania palustris* L.) to the aquatic herbicide triclopyr. Journal of Aquatic Plant Management 46:150-154.

Majure, L.C. and G. N. Ervin. 2008. The *Opuntia* (Cactaceae) of the state of Mississippi, United States. *Haseltonia*, 14: 1-16.

Theel, H. J., E. D. Dibble, and J. D. Madsen. 2008. Differential influence of a monotypic and diverse native aquatic plant bed on a macroinvertebrate assemblage; an experimental implication of exotic plant induced habitat. Hydrobiologia 600:77-87.

Non-Refereed Conference Papers, Abstracts, or Posters

Cheshier, J. C., J. D. Madsen, R. M. Kaminski. 2008. Chemical Control of Swamp Smartweed (*Polygonum hydropiperoides* Michx.). Inaugural Southeastern Natural Resources Graduate Student Symposium, March 26-28, Starkville, MS.

Cheshier, J. C., J. D. Madsen, R. M. Wersal. 2008. Common Reed (*Phragmites australis* Cav. Trin. Ex. Steud): Life History in the Mobile River Delta, AL. Mid_West Aquatic Plant Management Society 28th Annual Meeting, March 1-3, Sandusky, OH.

Cheshier, J. C., J. D. Madsen, R. M. Wersal. 2008. Common Reed *Phragmites australis* Cav. Trin. Ex. Steud: Life History in the Mobile River Delta, AL. Western Society of Weed Science 61st Annual Meeting, Anaheim, CA.

Cheshier, J. C., J. D. Madsen. 2008. Digitial Growth of Common Reed *Phragmites australis* Cav. Trin. Ex. Steud. Southeast Exotic Pest Plant Council 10th Annual Meeting, May 20-22, Biloxi, MS.

Cheshier, J. C., J. D. Madsen, R. M. Wersal. 2008. Duckweed Control In Mississippi Waters. Mississippi Water Resources Research Institute 38th Annual Meeting, April 15-16, Jackson, MS.

Maddox, V. L., C. F. Abbott. 2008. The Invasive Plant Atlas of the Mid-South (IPAMS). 48th Weed Science Society of America Conference, 4-7 Feb 2008, Hilton Chicago, Chicago, IL.

Maddox, V. L., J. Byrd, J. Madsen, R. Westbrooks. 2008. Seed germination of selected maidengrass (*Miscanthus* spp.) cultivars and varieties. Southeast Exotic Pest Plant Council 10th Annual Symposium, 20-21 May 2008, Imperial Palace Casino, Biloxi, MS.

Madsen, J. D., K. D. Getsinger, R. M. Wersal. 2008. Combinations of Endothall with 2,4-D and Triclopyr for Control of Eurasian Watermilfoil. Western Aquatic Plant Management Society Annual Meeting, 3-5 March 2008, LakeTahoe, CA.

Madsen, J. D., R. L. Brown, G. N. Ervin, V. L. Maddox, and C. F. Abbott. 2008. Cactus moth detection and monitoring network. Southeastern Exotic Pest Plant Council Annual Symposium, May 20-21 2008, Biloxi, MS.

Madsen, J. D., R. M. Wersal, T. E. Woolf. 2008. Eurasian watermilfoil monitoring and eradication assessment in the Pend Oreille Lake and River System, Idaho. Western Aquatic Plant Management Society Annual Meeting, 3-5 March 2008, LakeTahoe, CA.

Madsen, J. D., R. M. Wersal, T. E. Woolf. 2008. Eurasian watermilfoil monitoring and eradication assessment in the Pend Oreille Lake and River System, Idaho. Fifth International Weed Science Congress, 23-27 June 2008, Vancouver, British Columbia, Canada.

Madsen, J. D., R. M. Wersal, T. E. Woolf. 2008. Eurasian watermilfoil monitoring and eradication assessment in the Pend Oreille Lake and River System, Idaho. Weed Science Society of America Annual Meeting, 4-8 February 2008, Chicago, IL.

Madsen, J. D., R. M. Wersal, T. E. Woolf. 2008. Eurasian watermilfoil monitoring and eradication assessment in the Pend Oreille Lake and River system, Idaho. Aquatic Plant Management Society Annual Meeting, July 13-16 2008, Charleston, SC.

Madsen, J. D. 2008. GIS for invasive aquatics management. Weed Science Society of America Annual Meeting, 4-8 February 2008, Chicago, IL.

Madsen, J. D., R. M. Wersal. 2008. Herbicide Formulations for Managing Free-floating Aquatic Plants. Southern Weed Science Society, Jan. 28-30, 2008, Jacksonville, FL. 61. 210.

Madsen, J. D., R. M. Wersal, W. Robles. 2008. Using GIS for management and assessment of invasive aquatic plants. Weed Science Society of America Annual Meeting, 4-8 February 2008, Chicago, IL.

Madsen, J. D., R. M. Wersal, and M. L. Tagert. 2008. Aquatic plant survey within the littoral zone of the Ross Barnett reservoir for 2007. Mississippi Water Resources Conference, 15-16 April 2008, Jackson, MS.

Prince, J. M., D. R. Shaw, J. D. Byrd, D. C. Holly, G. N. Ervin, S. C. Grado, and J. D. Madsen. 2008. Modeling spread of invasive weedy species following natural disasters. Proc. Southern Weed Science Soc., 28-30 Jan. 2008, Jacksonville, FL.

Robles, W., J. D. Madsen, V. L. Maddox, R. M. Wersal. 2008. Current distribution of giant salvinia and hydrilla in Mississippi: Three years Surveying. Southeast Exotic Pest Plant Council 10th Annual Symposium. Biloxi, MS.

Robles, W., J. D. Madsen, V. L. Maddox. 2008. Reservoir study for invasive and native aquatic plant species within the Pat Harrison Waterway District. Mississippi Water Resources 38th Annual Conference, Jackson, MS.

Robles, W., J. D. Madsen. 2008. Using Landsat 5 TM imagery to assess the efficacy of a broadcast herbicide application for control of waterhyacinth (*Eichhornia crassipes*). GIS for Invasive Weed Management Workshop. Weed Science Society of America Annual Meeting. Chicago, IL.

Robles, W. and J. D. Madsen. 2008. Seasonal biomass detection of waterhyacinth using normalized difference vegetation index derived from LandSat 5 TM simulated data. Midwest Aquatic Plant Management Society Annual Meeting, March 1-3 2008, Sandusky, OH.

Wersal, R. M., J. D. Madsen, M. L. Tagert. 2008. Assessing herbicide efficacy and aquatic plant community changes in the Ross Barnett Reservoir, MS. Southeastern Exotic Pest Plant Council 10th Annual Symposium, Biloxi, MS.

Wersal, R. M., J. D. Madsen. 2008. Comparison of Imazapyr and Imazamox Herbicides for Control of Parrotfeather (*Myriophyllum Aquaticum* (Vell.) Verdc.). Weed Science Society of America 48th Annual Meeting, Chicago, IL.

Wersal, R. M., J. D. Madsen. 2008. Comparison of Imazapyr and Imazamox for Control of Parrotfeather (*Myriophyllum aquaticum* (Vell.) Verdc.). Southeastern Exotic Pest Plant Council 10th Annual Symposium, Biloxi, MS.

Wersal, R. M., J. D. Madsen. 2008. Comparison of Subsurface and Foliar Herbicide Applications for Control of Parrotfeather (*Myriophyllum aquaticum* (Vell.) Verdc.). Southeastern Exotic Pest Plant Council 10th Annual Symposium, Biloxi, MS.

Wersal, R. M., J. D. Madsen. 2008. Comparison of Subsurface and Foliar Herbicide Applications for Control of Parrotfeather (*Myriophyllum aquaticum* Vell. Verdc.). 48th Annual Aquatic Plant Management Society Meeting, Charleston, SC.

Wersal, R. M., J. D. Madsen. 2008. Influences of Water Column Nutrient Loading on the Growth of Parrotfeather (*Myriophyllum aquaticum* Vell. Verdc.). 48th Annual Aquatic Plant Management Society Meeting, Charleston, SC.

Wersal, R. M., J. D. Madsen. 2008. Influences of light intensity variations on growth characteristics of parrotfeather (*Myriphyllum aquaticum*). 38th Annual Mississippi Water Resources Conference.

Wersal, R. M., J. D. Madsen, M. L. Tagert. 2008. Monitoring non-native plant populations in the Ross Barnett Reservoir, MS. Southeastern Exotic Pest Plant Council 10th Annual Symposium, Biloxi, MS.

Wersal, R. M., J. D. Madsen, K. D. Getsinger, L. S. Nelson. 2008. Sensitivity of Wild Rice (*Zizania palustris*) to the Aquatic Herbicide Triclopyr. Midwest Aquatic Plant Management Society 28th Annual Meeting, March 1-3 Sanduskey, OH.

Popular Articles

Madsen, J. D. 2008. Mississippi: Invasive Aquatic Plant Management Activities. Aquatics 29 (4):20-21.

Madsen, J. D. 2008. Aquatic weeds of the Mississippi Delta. Delta Wildlife 16(2) 22-28, Summer 2008.

In-House

Cheshier, J. C., R. M. Wersal, J. D. Madsen. 2008. Duckweed Control Using Fluridone in Sequential Treatments. Geosystems Research Institute, Mississippi State University. GRI #4005.

Cheshier, J. C., J. D. Madsen, R. M. Wersal. 2008. Restoring Native Aquatic Vegetation in Little Bear Creek Reservoir for 2007. Geosystems Research Institute Report. GRI #4004.

Madsen, J. D., R. M. Wersal. 2008. Assessment of Eurasian watermilfoil (*Myriophyllum spicatum* L.) Populations in Lake Pend Oreille, Idaho for 2007. Geosystems Research Institute, Mississippi State University. GRI #5028.

Madsen, J. D., R. L. Brown, J. D. Byrd, Jr., E. D. Dibble, G. N. Ervin, D. R. Shaw, T. E. Tietjen, C. F. Abbott, V. L. Maddox, J. C. Cheshier, W. Robles, R. M. Wersal, D. W. McBride, N. G. Madsen. 2008. Research to Support Integrated Management. Geosystems Research Institute, Mississippi State University. GRI #5029.

Robles, W., J. D. Madsen, V. L. Maddox, R. M. Wersal. 2008. 2007 Statewide Survey of the Status of Giant Salvinia and Hydrilla in Mississippi. Geosystems Research Institute Report. GRI #5019.

Robles, W., J. D. Madsen, V. L. Maddox. 2008. Reservoir Survey for Invasive and Native Aquatic Plants Species within the Pat Harrison Waterway District. Geosystems Research Institute. GRI #5018.

Wersal, R. M., J. D. Madsen, M. L. Tagert. 2008. Littoral Zone Aquatic Plant Community Assessment of the Ross Barnett Reservoir, MS for 2007. Geosystems Research Institute. GRI #5027.

Professional Presentations

Abbott, C. F., V. Maddox, G. Ervin, J. Madsen. 2008. The Invasive Plant Atlas of the MidSouth. Southeast Exotic Pest Plant Council 10th Annual Symposium, Biloxi, MS, 20-21 May 2008.

Bried, J. T. and G. N. Ervin. 2008. Making invasiveness count in floristic quality assessments. Society of Wetland Scientists, Washington, DC, 26-30 May 2008.

Brooks, C. P. and G. N. Ervin. 2008. Mechanisms controlling the spread of *Cactoblastis cactorum* (Berg) . Lepidopterists' Society 59th Annual Meeting, Mississippi State University, MS, 24-27 June 2008.

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Madsen, J. D. 2008. Aquatic Herbicides and Algaecides. Minnesota Green Expo 2008, Minneapolis, MS. 10 January 2008.

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Madsen, J. D., G. N. Ervin. 2008. Integrating effects of land use change on invasive plant species distribution into an invasive plant atlas for the mid-south (IPAMS). NBII Invasive Species Working Group, 28 April 2008.

Madsen, J. D. 2008. Understanding Eurasian watermilfoil. Eurasian Watermilfoil Training Seminar, Idaho State Department of Agriculture, 18-19 June 2008, Twins Falls, ID.

Robles, W., J. D. Madsen. 2008. Detection of herbicide injury on waterhyacinth (*Eichhornia crassipes*) using Landsat 5 TM simulated data. Weed Science Society of America 48th Annual Meeting. Chicago, IL.

Tietjen, T.E., G. Ervin. 2008. Comparing Index of Biotic Integrity Scores to Traditional Measures of Water Quality: Exploring the Causes of Impairment in Streams of the Mississippi Delta. Mississippi Water Resources Conference. Jackson, MS, 15-16 April 2008.

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Welch, M.E., C. Brooks, R. Brown, G. Ervin, J. McClure, T. Marsico, and L. Wallace. 2008. The phylogeography of the invasive cactus moth *Cactoblastis cactorum* in its native range. Southeastern Population Ecology and Evolutionary Genetics Conference. Eatonton, GA, 24-26 Oct. 2008.

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Awards

Cannon, Jeffery. 2008. Invitee to University of Georgia Graduate School Future Scholars Program invitee.

Cannon, Jeffery. 2008. Award of Department of Biological Sciences Plant Sciences Scholarship.

Cannon, Jeffery. 2008. Inductee to MSU Society of Scholars inductee.

Holly, D. Christopher. 2008. MSU Graduate Student Association Ph.D. Research Associate of the Year.

Madsen, J. D. 2008. Faculty Research Award by the Centers and Institutes, Office for Research and Economic Development, Mississippi State University. Presented 29 April 2008.

Wersal, Ryan. 2008. Research Associate of the Year. Geosystems Research Institute. Mississippi State University.

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