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Effects of Hurricane Katrina on an Incipient Population of Giant Salvinia *Salvinia molesta* in the Lower Pascagoula River, Mississippi

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**SHORT COMMUNICATION****EFFECTS OF HURRICANE KATRINA ON AN INCIPIENT POPULATION OF GIANT SALVINIA *SALVINIA MOLESTA* IN THE LOWER PASCAGOULA RIVER, MISSISSIPPI**Pam L. Fuller<sup>1</sup>\*, Mike G. Pursley<sup>2</sup>, Dale Diaz<sup>2</sup>, and Wesley Devers<sup>2</sup><sup>1</sup>U.S. Geological Survey, 7920 NW 71<sup>st</sup> Street, Gainesville, FL 32653 USA, <sup>2</sup>Mississippi Department of Marine Resources, 1141 Bayview Avenue, Biloxi, MS 39530 USA \*Corresponding author, email: pfuller@usgs.gov**INTRODUCTION**

Giant salvinia (*Salvinia molesta*) is among the worst invasive aquatic weeds in the world (Holm et al. 1977) and has invaded aquatic habitats in numerous countries (Julien et al. 2002). Under ideal conditions giant salvinia can double its biomass within 2 (Cary and Weerts 1983) to 4 d (Gaudet 1973, Mitchell and Tur 1975, Sale et al. 1985), clogging waterways with dense mats of vegetation. A single plant is capable of starting a population that may cover 103.6 km<sup>2</sup> (40 mi<sup>2</sup>) in 3 mo (Creagh 1991/1992 in Jacono and Pitman 2001). Giant salvinia can out-compete native vegetation and if control measures are not implemented, will completely cover the water surface and form mats up to 1 m thick (Creagh 1991/1992 in Oliver 1993). These mats deplete dissolved oxygen, make waterways uninhabitable by most fish species, impede boat traffic, reduce habitat for waterfowl, limit access for fishing and swimming and can interfere with water use for electrical generation, irrigation and municipal water supplies (Julien et al. 2002).

Giant salvinia has been listed as a Federal Noxious Weed since 1984 (McFarland et al. 2004), and as such, it is illegal to import into, or transport this plant within the United States. Giant salvinia also appears on many state noxious weed lists, including Mississippi's (U.S. Department of Agriculture 2009). However, if giant salvinia is not declared by a state as a noxious weed, it can still be cultivated and sold within that state. Despite regulations, this species continues to be moved through the water garden trade as an ornamental plant for backyard ponds. Escapes or releases from such areas may have resulted in its establishment in numerous southern states such as Florida, Louisiana, and Texas and in major waterways like the Colorado River (U.S. Geological Survey 2009).

A population of giant salvinia was discovered in June 2005 in the lower west Pascagoula River distributary and a major tributary, Bluff Creek, in Jackson County, Mississippi. At the first report of infestation, the Mississippi Department of Marine Resources (MDMR) conducted an initial survey of the watershed and determined that giant salvinia was restricted to areas on the western side of the river both north and south of Interstate 10 and was densest in backwater sloughs

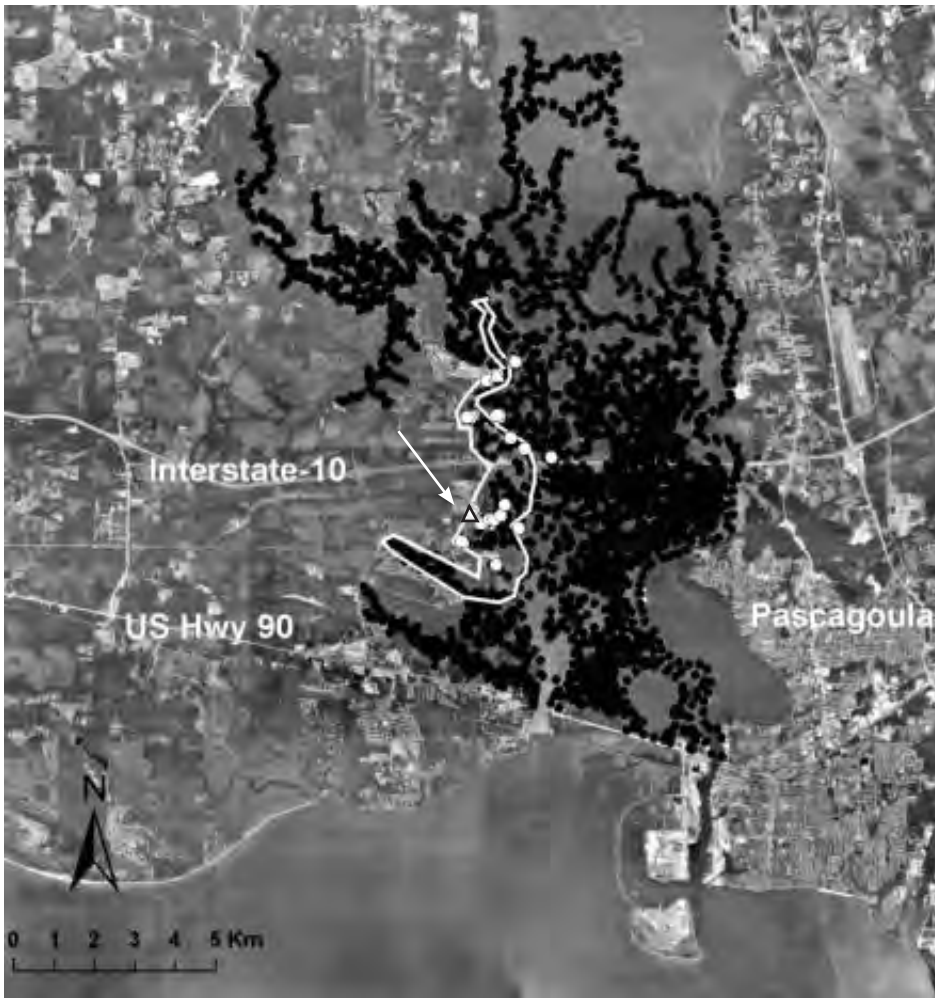
(Figure 1). Biologists from MDMR also concluded that the infestation had become too extensive (about 789 ha) to eradicate with herbicides or mechanical control methods, so Australian salvinia weevils (*Cyrtobagous salviniae*) were chosen as a bio-control agent. The weevils were seeded in 3 locations on 18 August 2005 in an effort to establish a population that would ultimately hinder the spread. An outreach campaign, in the form of signs at boat ramps and other high-visibility areas, was also initiated to increase public awareness of giant salvinia and on measures to prevent its spread. Interviews of local residents by MDMR indicate that the source of the infestation was likely a direct release of the plant during a clean-out of a water garden pond. The densest area of infestation was in a canal that drains a residential area just south of I-10.

Hurricane Katrina struck the Mississippi coast 29 August 2005 causing a storm surge in the study area ranging from 4.6–5.2 m (FEMA 2005). At the time, there was concern and speculation over the fate of the giant salvinia. Several hypotheses were considered to have merit: 1) The storm surge may have beached much of the plant material on land, rendering the population small enough for control efforts; 2) the salinity of the surge may have killed at least the downstream portion of the infestation; 3) the plant may have been spread to new areas during the flooding; and 4) the growth and spread of remaining giant salvinia may be augmented by increased nutrient levels resulting from the flooding.

The objectives of this study were to: 1) survey the lower Pascagoula River Basin and determine the post-storm distribution and abundance of giant salvinia; 2) control any remaining giant salvinia through physical and/or chemical means; 3) determine the fate of the bio-control agents; and 4) determine if re-introduction of salvinia weevils is needed and if so, to decide where best to release them.

**MATERIALS AND METHODS**

The study area consisted of about 483 km of navigable waterway of the lower Pascagoula River system from near the river mouth at Highway 90 to about 11.26 km north of Interstate 10 (Figure 1). The extent of the survey area was chosen



**Figure 1.** Area of the lower Pascagoula River, Jackson County, Mississippi surveyed for giant salvinia after Hurricane Katrina. The area encompassed by the white line is the pre-storm infestation area. Black dots are survey points with no giant salvinia; white dots are areas where giant salvinia was found. White triangle (arrow) is Martin Bluff, where a population was found in June 2008.

based on pre-Hurricane Katrina giant salvinia presence and was expanded well beyond known pre-storm distribution to determine if the invasive plant had infiltrated other waterways.

Because all records were destroyed when Hurricane Katrina flooded the MDMR offices, pre-storm giant salvinia distribution was approximated and was mapped based on the recollection of MDMR staff. Mapping surveys documented the presence or absence of giant salvinia and other aquatic invasive plants post Hurricane Katrina at about 3,300 points over 37 field days between 1 May and 9 August 2006. Monthly follow-up surveys have been conducted from September 2006 to the present to look for new infestations of giant salvinia. Bi-weekly surveys have been conducted to monitor giant salvinia growth and to spray and/or remove any remaining plants in previously identified areas.

Initial mapping surveys were conducted using a 3 person crew. All crew members also served as invasive plant spotters to maximize detection probability. The speed of the survey

boat was kept under 10 kph to facilitate observation of small fragments of giant salvinia. A data point was created every 300 m. At each point, a Magellan Mobile Mapper CE using ArcPad 6.0 was used to record the presence or absence of giant salvinia and the presence of any other aquatic invasive plants. Surface water temperature and salinity were acquired using a YSI model 556 multi-probe meter and manually entered into the Mobile Mapper as metadata for each location. Digital photos were also taken of invasive plants when found. Survey crews also looked for the presence of salvinia weevils at each location by examining the plants for signs of weevil damage to the leaves. In areas with relatively small, isolated infestations, the plants were removed from the water using a small screened net and secured for later disposal on land. At the end of each survey day, the boat was removed from the water and visually checked for invasive plant matter on the outside and inside of the boat to prevent introduction of invasives into other waters.

Follow-up surveys were less regimented and were performed by slowly cruising the area in a boat looking for areas with the plant. These surveys were combined with control spraying operations. A mixture of 1.5% glyphosate and 0.5% diquat was applied on the remnants left by the storm every 10–14 d through October 2006, after which time no giant salvinia could be found. Monthly surveys of the formerly infested areas occasionally yielded small patches of giant salvinia from April 2007 to June 2008 in the canals north and south of I-10. These areas were treated by mechanical removal and/or herbicide application as noted above.

## RESULTS

The initial survey effort revealed that over 99% of the giant salvinia present prior to the storm was killed either by storm surge salinity or by being deposited on land. However, giant salvinia was found at 19 sites in 7 areas adjacent to the west Pascagoula River (Figure 1), totaling about 2 ha. Surprisingly, the infestation had not spread substantially. Only a few sites were located outside of the original area of infestation, and those were only a few meters from the original infestation. It was also surprising to learn that the surge did

not push the infestation farther upriver. The highest salinity where giant salvinia was found was 1.44, although Biber (2008) reported this species living in salinities of 7 in the lower Pascagoula River.

Two new or previously unknown populations of the plant were located during follow-up surveys. One population of mature tertiary-stage growth was well-hidden in a patch of thick torpedo grass (*Panicum repens*) in a private pond connected to the river by a culvert; the other was in a stand of emergent aquatic vegetation in a puddle at the very end of a silted-in canal. These plants were treated and eliminated.

In June 2008, during a regular survey, a 46.45 m<sup>2</sup> patch of rapidly reproducing young giant salvinia was found just north of Martin Bluff (Jackson County) adjacent to a large marshy area (Figure 1). No giant salvinia had been seen there since Hurricane Katrina. A few plants had been removed just south of this area in April 2006 and none were seen during subsequent surveys.

Although it was thought that all the giant salvinia had been eliminated as of summer 2009, more patches have appeared, likely from hidden areas in the marsh that were not detected. No salvinia weevils were found during any of the surveys.

## DISCUSSION

An extensive river survey determined that the giant salvinia population had been greatly reduced, rather than expanded, as a result of Hurricane Katrina. The reduction was attributed to deposition on land and mortality caused by exposure to salinity (see Biber 2008) during the storm surge. Evidence was found during the survey which may explain one way giant salvinia survived the storm surge. As water rose during Hurricane Katrina, giant salvinia was trapped in the framing of boat houses, which became completely submerged during the storm surge (Figure 2). As the water receded some of the giant salvinia likely fell from the framing and re-infested the area.

After three years, there is still no evidence that any salvinia weevils survived Hurricane Katrina. With most known infestations eliminated, weevil re-introduction is not practical, or advisable. The salvinia weevils would not have enough plant material to be sustained, and the giant salvinia they arrived on could cause a new outbreak.

Mississippi Department of Marine Resources will continue conducting monthly boat and quarterly aerial surveys to look for new infestations and will survey the affected areas every 2 weeks. They will also continue public outreach efforts such as signs at boat ramps and brochures at fishing camps,



**Figure 2.** Giant salvinia draped on rafters of a boat house along the Pascagoula River in the study area nearly a year after Hurricane Katrina.

particularly in areas with close proximity to the infestations.

The timing of this study was fortuitous as the remaining 2 ha of infestation could have easily exceeded the original 769 ha had no action been taken. The state was only able to respond because of the funding obtained for this study. Without a quick response, the infestation would have gotten out of control and become too large to manage. The small area of infestation was key in being able to effectively manage this population of giant salvinia. From the discovery in June 2005 until October 2009, MDMR estimates expenditures of over \$256,000 on equipment, personnel, herbicides, and fuel and 2,110 person-hours to combat the invasion.

Eradication of giant salvinia in all but small enclosed bodies of water has been deemed to be very unlikely, and even then will likely take years (McFarland et al. 2004). Given the size of the lower Pascagoula River, the complexity of its channels and emergent vegetation, and the fact that another population of giant salvinia exists 235 km up-river in the Lower Leaf River (Robles et al. 2008), eradication seems unlikely in this area. However, because Hurricane Katrina reduced the population down to a manageable level, it appears that the state may be able to keep population levels low enough to control them in this area.

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