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Regional Integrated Management of Imported Fire Ants (*Solenopsis* spp.) along the Natchez Trace Parkway

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Introduction

The imported fire ants *(Solenopsis invicta* Buren, *S. richteri* Forel, and their hybrid; hereafter collectively referred to as *fire ants)* are myrmicine species that are native to South America but have been accidentally introduced to the United States, Australia (McCubbin and Weiner 2002), Taiwan, Hong Kong, and mainland China. In the U.S., the black imported fire ant (BIFA), *S. richteri*, was introduced into southern Alabama around 1918, followed by the red imported fire ant (RIFA), *S. invicta*, in the late 1930s (Lofgren 1986). The BIFA is now restricted to northeast Mississippi, northwest Alabama, and south-central Tennessee (Shoemaker et al. 1994). The RIFA occurs throughout the southeast from coastal North Carolina west to central Texas, with additional infestations in New Mexico and California (Figure 1). A zone of hybridization exists through central Mississippi, Alabama, and Georgia.

Fire ants create a number of serious problems for humans and wildlife. Some negative impacts of fire ants were reviewed by Vinson (1997), including adverse affects on human recreation. These stinging ants can occur in densities of more than 600 mounds per hectare (Vogt et al. 2003) and rapidly recruit to food and moisture sources, disrupting outdoor activities. Additionally, fire ant stings can result in anaphylaxis in at least 1% of reported cases (deShazo et al. 1990, 1999; deShazo and Williams 1995). Fire ants can have negative impacts on native ants and other arthropods (Vinson 1994; Jusino-Atresino and Phillips 1994; Wojcik 1994), and overall biodiversity (reviewed by Wojcik et al. 2001). In another study, Morrison (2002) demonstrated that arthropod diversity in one area recovered to pre-invasion levels twelve years after fire ant establishment but fire ants had become the domi-

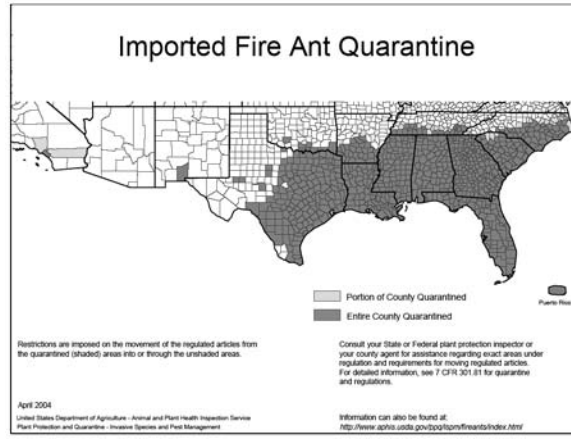

Figure 1. Imported fire ant quarantine areas in the United States.

nant ant species. While fire ant impacts on vertebrate wildlife are difficult to quantify, considerable evidence points to population-level impacts of fire ants on various mammals, birds, and herpetofauna (reviewed by Allen et al. 2004). Fire ants cause direct economic damage by piling soil and debris into areas such as telephone relays, electronic junction boxes, and air conditioning units, and their tunneling activities can even damage paved roads (Banks et al. 1990).

The U.S. Department of Agriculture–Agricultural Research Service (USDA–ARS) is partnering with various state and federal agencies to develop and implement integrated pest management (IPM) strategies for long-term suppression of imported fire ants. The ARS Biological Control of Pests Research Unit (BCPRU) based in Stoneville, Mississippi, is leading a regional integrated management program targeting imported fire ants along the Natchez Trace Parkway. This paper is intended to provide an overview of the rationale for this program, the various components of the program, and the expected outcomes.

Rationale

The Natchez Trace Parkway (NTP) is some 444 miles long and serves to commemorate an ancient trail that at one time connected southern portions of the Mississippi River with salt lick areas in what is now central Tennessee. The park, established in 1938, encompasses nearly 52,000 acres which include the roadway, a right-of-way of variable width, and various byway exhibits, historical sites, and campgrounds. Fire ant mounds have become characteristic features of the NTP viewscape, creating unsightly bare spots (Figure 2) and possibly threatening the health of trees when constructed at their base (Vogt, unpublished data). Mounds also occur in close proximity to the road bed, potentially harming the parkway itself.

For several reasons, the NTP is ideal for a regional integrated management program targeted against fire ants. Stretching from Natchez, Mississippi, to Nashville, Tennessee, the NTP represents an existing north–south transect along which populations of red, hybrid, and black imported fire ants exist (Figure 3). This is important, as apparent and potential differences between red and black fire ant populations may affect the efficacy of control measures (Vogt et al. 2003). Portions of the NTP lie within three separate states (Mississippi, Alabama, and Tennessee), maximizing the potential for collaborative efforts. Numerous habitat types exist along the NTP, each of which may require a different approach to fire ant control. Finally, the NTP offers unique educational opportunities, particularly the potential

Figure 2. A fire ant mound. This mound is approximately 70 cm wide and 30 cm tall.

for educational posters at the various byway exhibits and campgrounds.

Regional integrated management programs offer unique opportunities for research, collaboration, implementation, and technology transfer of meaningful solutions targeted toward specific end-users. Researchers working on related projects in the same area have the opportunity to share data and maximize results. Enhanced collaborative efforts make it possible to pool resources and expertise. Implementation on a regional basis can maximize impact and visibility.

Program Components

Several collaborators are working with the BCPRU on different components of this program. These include Mississippi State University, Department of Entomology and Plant Pathology; USDA–Animal and Plant Health Inspection Service; Alabama A&M University, Department of Plant and Soil Science; Tennessee State University, Otis Floyd Nursery Research Center; and Tennessee Department of Agriculture. The various research projects being pursued along the NTP fall within three broad categories: (1) biological control of imported fire ants, (2) preservation of native ant species, and (3) enhanced monitoring methods for imported fire ants

Biological control of imported fire ants. Several species of phorid flies (Diptera: Phoridae) are parasitoids of ants. Phorids in the genus *Pseudacteon* parasitize *Solenopsis* spp. fire ants, and three species have been approved for release in the U.S. *(P. curvatus* Borgmeier, *P. tricuspis* Borgmeier, and *P. litoralis* Borgmeier). These tiny flies lay a single egg in a fire ant worker. When the larva hatches, it migrates to the head of the ant and eventually consumes the contents, causing the head to fall off; thus the common name "decapitating flies." The flies disrupt fire ant foraging and other activities, and their establishment and spread in the U.S. as classical biological control agents may help tip the ecological balance more in favor

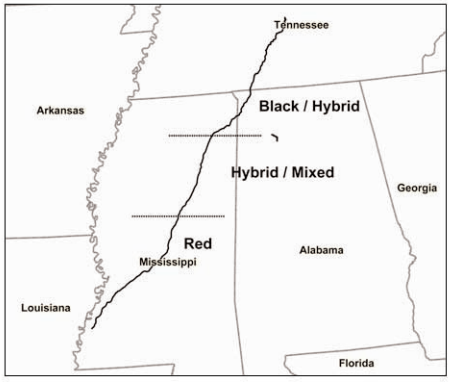

Figure 3. Approximate distribution of red, hybrid, and black imported fire ants along the Natchez Trace Parkway (line from southwest Mississippi to central Tennessee).

of native ants (Porter et al. 1997). Of the three species listed above, *P. curvatus* has been established along the NTP, releases of *P. tricuspis* are ongoing, and releases of *P. litoralis* are in the planning stage. Ongoing research includes periodic sampling of release and control sites in an attempt to determine population-level effects of phorids.

A microsporidian disease of fire ants, *Thelohania solenopsae* Knell, Allen and Hazard (Microsporidia: Thelohaniidae), was first discovered in the U.S. in the late 1990s (Williams et al. 1998). Efforts along the NTP include a survey (nearing completion) of disease incidence, intermediate host determination, and disease augmentation. In another project, fire ant populations are being surveyed for additional pathogens such as bacteria and fungi that might be useful in augmentative releases or for formulation as commercial products.

Preservation of native ant species. Researchers with the Mississippi Entomological Museum are conducting a thorough survey of the ant fauna along the NTP, which will provide baseline data for the regional program; this survey has already resulted in several species being identified as new state records (R. L. Brown, personal communications). Several projects along the NTP are designed to minimize impact of fire ant control measures on population densities of native ant species. Bait application timing and placement could potentially be altered to minimize bait retrieval by native ants. Some native ants that occur along the NTP greatly slow or cease foraging at night (Vogt et al. 2004); however, in one trial, mid-day and late-evening bait applications had similar negative effects on native ants (Vogt et al. 2005). Experiments with different bait timing regimes are ongoing. Additional research involving bait placement is ongoing.

Current bait products are generally effective against fire ants, but are not species-specific and are susceptible to degradation from weather extremes. Methods are being developed for making current and new bait formulations more species-specific and weather resistant. Promising bait formulations that appear to be more attractive to fire ants and less attractive to native ants will be field tested in the near future. In a related project, potential fire ant repellents are being tested and developed; these would be useful for excluding fire ants from sensitive areas such as electrical junction boxes and telephone relays. This work has already resulted in a new, more efficient bioassay to determine repellency of compounds (Chen 2005).

Enhanced monitoring methods for imported fire ants. In an effort to reduce costs associated with sampling fire ants on the ground and enhance the capability to make management decisions on a regional scale, BCPRU researchers are developing remote sensing technologies for quantifying fire ant mounds. Fire ant mounds have several unique characteristics that make them suitable targets for some sensor types, including shape, texture, topography, temperature, and vigorous vegetation growing at their periphery. Multispectral (Vogt 2004) and thermal aerial imagery are being tested and developed as tools to quantify fire ant mounds. Data will be used to study landscape effects on fire ant populations, and establish risk assessment criteria to predict fire ant population densities.

Researchers with Mississippi State University are conducting extensive ground surveys to characterize landscape effects on fire ant populations, specifically in forested and transitional habitats. These data will contribute to our ability to predict problem areas and will have implications for bait and pesticide placement. This aspect of the program will also con-

tribute to our knowledge of interactions between fire ants and native ants in habitat types that are under-represented in the fire ant literature.

Expected outcomes

The regional integrated management program for fire ants along the NTP is expected to produce useful data to further our knowledge of fire ant biology and ecology, and new technologies for managing imported fire ants. New control methodologies will be widely applicable beyond the NTP, while new data on native ant distribution will assist the NTP in cataloguing natural resources, and educational efforts will directly influence park visitors.

Biological control efforts have already expanded the overall distribution of phorid flies in the U.S. and introduction of additional phorid species along the NTP may provide a sustainable reduction in fire ant population densities. Similarly, augmentation of microsporidia that infect fire ant colonies may contribute to long-term decline in population densities. Research on infection rates along the NTP may shed light on differences between red, black, and hybrid imported fire ants.

New bait technologies involving improved products and application methods will be useful for preserving native ant species; this aspect of the program is particularly relevant to our national parks but will be useful throughout the range of fire ants. Finally, more efficient monitoring methods, including remote sensing technologies, will reduce the costs associated with sampling fire ant mounds over large areas, give researchers new tools for evaluating the effects of biological control agents on fire ant populations, and provide the necessary information for making management decisions on a regional scale.

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