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Assessing landscape-level impacts of red imported fire ants on native faunal communities in pine-dominated forests

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**ASSESSING LANDSCAPE-LEVEL IMPACTS OF RED IMPORTED
FIRE ANTS ON NATIVE FAUNAL COMMUNITIES IN
PINE-DOMINATED FORESTS**

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The School of Renewable Natural Resources

by
Keri E. Landry
B.S., Louisiana State University, 2001
May 2004

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Abstract

Since the accidental introduction of red imported fire ants (*Solenopsis invicta* Buren, RIFA) into Mobile, Alabama in the 1930's, the invasion of this species into other areas across the southeast has increased drastically. RIFA have been implicated in the disruption of ecosystems and decreases in biodiversity. Most research on effects of RIFA on vertebrates and invertebrates have focused on small spatial scales and single species. I examined established populations of RIFA in relation to native ground-dwelling arthropods and small mammal communities in longleaf-pine and pine-hardwood forests. I evaluated the efficacy of using Amdro® to control RIFA and determined the effect of RIFA predation on arthropod and small mammal communities. RIFA suppression occurred in April, August, and October 2003. In the longleaf-pine forest, RIFA suppression was effective in June between years ($P = 0.088$) and treatments ($P = 0.093$). This was consistent with an increase in cotton mice abundance on treated (17.7 ± 2.7) versus control (6.0 ± 2.5) plots ($P = 0.035$), with 90% of cotton mice captured during the June sampling period. Across seasons, significant differences were observed for Collembola in August between years ($P = 0.001$) and in December between treatments ($P = 0.01$). Likewise, abundance of Coleoptera was greater in December between years ($P = 0.023$) and in May between treatments ($P = 0.002$). In the pine-hardwood forest, RIFA suppression was effective in April and June ($P = 0.001$, $P = 0.004$, respectively) when compared across seasons. No significant differences were observed for any small mammal species captured in the pine-hardwood site. Acari were greater on treated (11.0 ± 1.7) than control (4.7 ± 1.9) plots ($P = 0.067$); however, no significant differences were observed for any invertebrate group across

seasons. Although this study is in the initial phase of a 5-year project, the data suggests that RIFA may potentially affect the abundance of selected faunal species in forested ecosystems.

Chapter 1.

Introduction

Since the introduction of red imported fire ants (*Solenopsis invicta* Buren; RIFA) in the 1930s, their range expansion into other areas of the Southeast has increased drastically (MacKay and Fagerlund 1997). RIFA were accidentally introduced into Mobile, Alabama from Brazil or Argentina by dumping infested ballast from coffee ships (Taber 2000). Currently, the range of RIFA extends as far north as southeastern Virginia and as far southwest as Brownsville, Texas with a few patchy areas across the southwestern states including New Mexico, Arizona, and California, and they have potential to expand along the Pacific coast. RIFA have recently been found in Puerto Rico and Australia, an indication of widespread range expansion of this invasive species (Williams et al. 2001). Due to their aggressive nature, RIFA may cause much damage to landscapes they inhabit including pastures, crop fields, roadsides, and urban areas (Taber 2000, Jetter et al. 2002). The fact that fire ants in the United States have a polygyne, or multiple queen form, and also lack of natural enemies, enables RIFA to reach exceptionally high densities and consequently have a substantial impact on native fauna (Gotelli and Arnett 2000, Williams et al. 2001, Eubanks et al. 2002).

RIFA are omnivorous and opportunistic foragers and prey on a multitude of species including vertebrates, invertebrates, and plants (Mueller 1999, Klotz et al. 2003). Brood production, which occurs in seasons with higher temperatures, requires a large amount of protein which corresponds with the breeding season of many ground-dwelling vertebrate species (Wojcik et al. 2001). RIFA may be attracted to the moisture of

newborn animals and hatching eggs, thus ground-nesting vertebrates are more susceptible to predation. RIFA have been implicated in reduction of biodiversity of vertebrates and invertebrates, including other species of ants (Porter and Savignano 1990, Porter et al. 1991, Allen et al. 1994, Vinson 1994, Jetter et al. 2002).

Several studies examining the impacts of RIFA on populations of native fauna have focused on ground-nesting birds. For example, hatching eggs and newly hatched chicks of northern bobwhite (*Colinus virginianus* L.) may be attacked and consumed by RIFA (Pedersen et al. 1996). In a study by Johnson (1961), 33 quail nests were exposed to RIFA in an enclosure experiment, and 19 or approximately 8 % of 242 pipped eggs were attacked. RIFA consumed 15 of these eggs and 4 eggs were attacked by other ant species, such as the Argentine ant (*Linepithema humile* Mayr.). Fire ants were rarely observed entering a nest unless the parent left or abandoned the nest or once a chick pipped a shell and was not successful. Johnson (1961) also tested net effects of RIFA on a quail population through census data on quail and RIFA in Lee County, Alabama and reported no significant effect. However, Mueller et al. (1999) observed significantly greater chick survival in nests treated to reduce RIFA than controls with 22 % mortality in treatment nests and 52 % mortality of broods in control nests. RIFA also have been implicated in the decline of ground-nesting birds in the Alabama Coastal Plain, including eastern meadowlarks (*Sturnella magna* L.), ground doves (*Columbina passerina* Spix), and common nighthawks (*Chordeiles minor* Forster; Mount 1981).

Impacts of RIFA on mammalian species have received little attention, and few studies have been published on interactions of RIFA and ground-dwelling mammals in

their natural ecosystems. Some studies have shown no apparent effect on vertebrate populations by RIFA (Johnson 1961), whereas others have noted detrimental effects (Lechner and Ribble 1996). In a semi-natural enclosed pen, cottontail rabbit (*Sylvilagus floridanus* Allen) litters existed near RIFA mounds with > 25 % attacked by RIFA (Hill 1969). An earlier study with cotton rat (*Sigmodon hispidus* Say and Ord) litters also was conducted in small pens surrounded by RIFA mounds, but no observations of RIFA predation occurred (Johnson 1961). However, fire ants are known to attack and kill small mammals in traps thereby altering trap success (Flickinger 1989). Additionally, Ferris et al. (1998) observed a significant inverse correlation with abundance of small mammals captured during trapping and density of RIFA. Previous studies have shown that RIFA may negatively affect movement patterns of free-ranging northern pygmy mice (*Baiomys taylori* Thomas) in areas of high mound density (Smith et al. 1990, Lechner and Ribble 1996). In laboratory experiments, deer mice have been observed altering their foraging behavior and feeding time to avoid RIFA (Holtcamp et al. 1997).

Although there have been few studies on effects of RIFA on reptiles, available evidence suggests that oviparous species may be vulnerable to predation by ants (Mount 1981, Parris 2002). For example, RIFA were found to consume eggs of the six-lined racerunner (*Cnemidophorus sexlineatus* L.) in field trials (Mount 1981). In a study of alligator nest success, RIFA were present in 36 % of nests surveyed (Reagan et al. 2000). Nest attendance by female alligators was lower for nests with RIFA than those without (61 and 85%, respectively). Overall nest success also was lower in nests with RIFA than nests without (69 and 95%, respectively). RIFA also are known to prey on turtle

hatchlings by killing them or stinging them, which results in weight loss, thereby reducing survival. Allen et al. (2001) reported a significant difference on predation of RIFA between hatchling turtles in a treatment vs. control area within an enclosure. RIFA preyed heavily upon pipped eggs and new hatchlings. RIFA have also been implicated in the decline and extirpation of Texas horned lizards (*Phrynosoma cornutum* Harlan.) from eastern Texas (Allen et al. 1994).

RIFA may negatively impact invertebrates because they feed on a wide variety of species (Taber 2000, Stevens et al. 1999). Therefore, predation by RIFA may be most evident in invertebrate populations; however, particular species of arthropods may have increased fitness by defense mechanisms. Some invertebrates secrete an ant-repellent fluid to deter RIFA and some form shells around themselves which RIFA are unable to penetrate (Clarke and DeBarr 1996). However, RIFA are extremely aggressive, and when they attack in large numbers may overcome these defense mechanisms. RIFA have been documented to reduce abundance of native ant fauna in areas of high densities through competitive displacement (Wojcik 1983, Porter and Savignano 1990). Vinson (1990) documented that RIFA will reduce abundance and diversity of an arthropod community of decomposers on ripe fruit with RIFA comprising 63 to 99 % of individuals after invasion. Porter and Savignano (1990) found RIFA predation to be negatively correlated to a terrestrial arthropod community with a 40 % reduction in species richness corresponding with heavily infested areas of RIFA.

Although RIFA are capable of being detrimental on small-scales or enclosed settings, impacts to wildlife on a landscape-level are unknown. Furthermore, there are no

published findings available on effects of large-scale broadcast treatments of bait on RIFA in natural forested areas. A large-scale study would adequately address the ecological interactions of RIFA and native faunal populations. Allen et al. (1994) suggested the need for a long-term, large-scale study with controls and replication to gain an understanding of effects of RIFA on wildlife populations. My study examined the efficacy of broadcast treatments of bait on RIFA populations at the landscape-level. Large-scale effects of RIFA on faunal communities also were tested to determine if reduction of RIFA populations would increase numbers and diversity of selected faunal species on the landscape. This study has the potential to provide fundamental knowledge on large-scale effects of RIFA on wildlife communities. I suspect that populations of RIFA have an effect on small mammal, herpetofaunal, and invertebrate communities, therefore decreasing biodiversity. My objectives were to evaluate effects of using Amdro® to control RIFA on a landscape-level and determine impacts of RIFA suppression on small mammal, herpetofaunal, and invertebrate communities within longleaf-pine and pine-hardwood forests. Each objective is addressed in the following chapters. Invertebrate response to RIFA suppression is presented in Chapter 2. Chapter 3 examines small mammal response to RIFA suppression. Due to small sample size for herpetological communities, a table summarizing capture information is presented in Appendix A. A list of native ant species observed in bait traps and identified is presented in Appendix B.

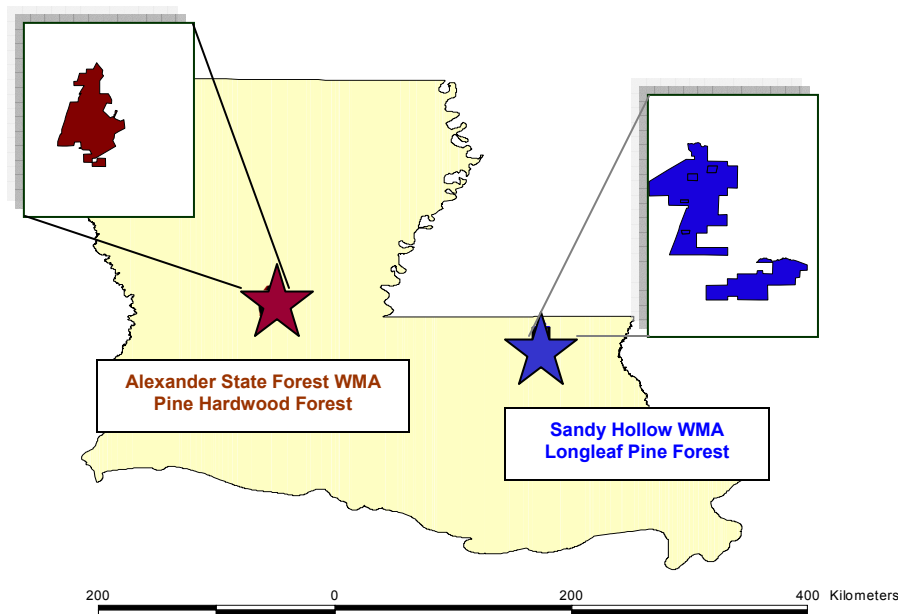


Figure 1.1 Location of Sandy Hollow (longleaf-pine forest) and Alexander State Forest (pine-hardwood forest) WMAs in Louisiana.

Research was conducted at Sandy Hollow and Alexander State Forest Wildlife Management Areas (Figure 1.1). These pine-dominated forests were chosen based on characteristics of RIFA habitat. Pine-dominated forests often exhibit an open canopy and reduced midstory vegetation, allowing a moderate amount of sunlight to reach the forest floor, which is beneficial for ant brood production. RIFA are prevalent in these forests, whereas they are not common in upland-oak and bottomland forests because the canopy may be too dense with almost no sunlight reaching the ground. Each study area had desirable RIFA habitat characterized by high mound densities. Sandy Hollow is owned by the Louisiana Department of Wildlife and Fisheries and is located in Tangipahoa parish 10 miles northeast of Amite, Louisiana. It consists of 1,431 hectares of young longleaf-pine (*Pinus palustris* Mill.), 15-30 years old, on gently rolling hills with 64.75 hectares leased from the Tangipahoa Parish School Board. Sandy Hollow is historically

dominated by open, old-growth longleaf-pine forests but as a result of clearing for timber and conversion to pine plantations now only a small portion of mature trees remain. This area provides essential habitat for threatened and endangered species such as gopher tortoises (*Gopherus polyphemus* Daudin) and red-cockaded woodpeckers (*Picoides borealis* Vieillot) that depend on longleaf-dominated habitats. Management on Sandy Hollow includes prescribed burns and food plots to benefit upland-game birds such as northern bobwhite, dove, and woodcock as well as deer, turkey, and squirrels. Field-trial courses and trails exist throughout the area and are maintained to benefit hunters.

Alexander State Forest is owned by the Louisiana Office of Forestry, managed by the Louisiana Department of Wildlife and Fisheries, and is located in south-central Rapides parish approximately ten miles south of Alexandria. This area consists of 3,275 hectares of primarily mixed loblolly-pine / hardwood forests. Indian Creek Lake, a 1,052 hectare reservoir, and a 121.4 hectare recreation/camping area are located on the area. The predominate forest overstory component is loblolly pine mixed with longleaf pine, slash pine (*P. elliotii* Engelm.), southern red oak (*Quercus falcata* Michx.), blackgum (*Nyssa sylvatica* Marshall), sweetgum (*Liquidambar styraciflua* L.), white oak (*Q. alba* L.), American beech (*Fagus grandifolia* Ehrh.), water oak (*Q. nigra* L.), and willow oak (*Q. phellos* L.). Some common understory plants include *Smilax* spp., *Acer* spp., *Viburnum* spp., deciduous holly (*Ilex decidua* Walt.), and French mulberry (*Callicarpa americana* L.). Hunting is allowed for deer, squirrel, rabbit, quail, and waterfowl in designated areas.

Chapter 2.

Assessing Impacts of Red Imported Fire Ants on Native Ground-dwelling Invertebrate Communities in Longleaf-pine and Pine-hardwood Forests

Introduction

With the introduction of invasive species, there has been an increasing concern of their ecological impacts on indigenous species and disruption of natural ecosystems. Rapid production of huge, aggressive colonies has made ants one of the most widespread and detrimental of invasive faunal species (TsuTsui and Suarez 2002). Among invasive species, red imported fire ants (RIFA), *Solenopsis invicta* Buren, are considered the most dominant invertebrate predators and agricultural and urban pests in their range. Gotelli and Arnett (2000) sampled ants at a biogeographic scale and found that RIFA disrupt native ant communities and reduce diversity in areas where ant species co-exist. Therefore, native ant species are less likely to persist in areas where RIFA occur in high densities than areas where RIFA are excluded.

Frequently disturbed habitats are more susceptible to invasion by introduced species, thus risking a decrease in diversity of indigenous species (Forys et al. 2003). RIFA prefer open or semi-open ecosystems where they may contact many native wildlife species (Allen et al. 1994). In California, where RIFA have recently established colonies, almost 73% of endangered species is susceptible to negative impact (Wojcik et al. 2001). Amphibians and small mammals, that primarily feed on arthropods may be negatively impacted through limited food and altered distribution of resources because of the ecological domination of RIFA (Porter and Savignano 1990, Klotz et al. 2003).

RIFA may limit invertebrate abundance and diversity by directly preying on invertebrates when they occur in high densities and compete with native organisms. The egg and larval life

stages of ground-dwelling invertebrates are especially vulnerable to predation by RIFA (Forys et al. 2003). RIFA contribute to displacement of invertebrate populations and native ant species which may negatively affect local plant communities (Klotz et al. 2003). RIFA also may affect floral assemblages by reducing species that are required insect pollinators of certain plant species and suppressing seed distribution (Klotz et al. 2003).

The multiple queen (polygyne) form of RIFA usually has twice as many mounds as the single queen (monogyne) form so competition may be a major factor where polygyne colonies predominate (Holway and Suarez 1999). Thus, competitive replacement may have an effect on native species to a greater degree than originally thought due to high densities of the polygyne form. Nevertheless, single queen colonies also are capable of competitive replacement of native ants (Holway and Suarez 1999). Some endangered species may be a source of food for RIFA and also suffer because of direct competition for limited food resources (Jetter et al. 2002).

RIFA are very successful and a primary target for control efforts, and they have been implicated in the reduction of local biodiversity of native species (Allen et al. 1994, Klotz et al. 2003). Allen et al. (1997) reported Amdro®, a RIFA bait, may be effective in suppressing RIFA populations on 202-hectare treatment plots. Amdro® can kill colonies in 3-14 days when RIFA workers locate the bait and carry it back to the nest where it is distributed among the colony including the queen (Taber 2000). For my study, broadcast treatments of Amdro® (0.036% hydramethylnon) were used to reduce RIFA on treatment plots. The active ingredient hydramethylnon will degrade after 41 minutes in sunlight and if RIFA do not take to the bait rapidly, making it environmentally safe (Vander Meer et al. 1982).

Most studies evaluating effects of RIFA on invertebrates have been at small scales and focused on a single species. Small scale studies may not be able to adequately assess ecological changes in faunal communities in forested ecosystems (Allen et al. 1994). Furthermore, there are no published studies evaluating impacts of RIFA on multiple faunal assemblages in forest ecosystems. This current study will provide new knowledge needed to improve inferences regarding large-scale ecological impacts of RIFA in forested ecosystems.

My objective was to determine landscape-level impacts of RIFA on multiple native faunal communities including ground-dwelling vertebrates and invertebrates. For the invertebrate portion of the study, my main focus was evaluating impacts of RIFA on native ground-dwelling invertebrate communities. Therefore, my objective was to evaluate the effect of Amdro® for suppression of RIFA in two pine-dominated ecosystems. The first null hypothesis tested was that RIFA abundance would remain constant between Amdro® treated and untreated control plots. The second null hypothesis tested was that RIFA abundance would remain constant among pre-treatment and post-treatment years. Our second objective was to determine effects of RIFA predation on ground-dwelling arthropod communities in two pine-dominated forests. The null hypothesis tested was that arthropod densities would be similar on Amdro® treated plots relative to untreated controls.

Methods

Experimental Design

The experimental design consisted of three replicates of two-hectare plots each within longleaf-pine and pine-hardwood forests. The plots were at least 0.16 km (0.1 mile) apart to ensure no movement of animals across treatments. I randomly assigned treatments to three

plots in each forest type and the remaining three served as untreated controls. I measured arthropod abundance and diversity on each two-hectare plot within each forest type for two consecutive years, one-year pre-treatment and one-year post-treatment.

Treatment

For my study, broadcast treatments of Amdro® (0.036% hydramethylnon) were used to reduce RIFA on treatment plots within each forest type. Broadcast treatments of Amdro® (0.036% hydramethylnon) were applied using hand-held broadcast spreaders at a rate of 1.68kg/ha (1.5lb/acre) to suppress RIFA. Several persons stood arm-length apart and walked the entire area of each plot for an even application of the granular bait on the surface of the ground. With this method, the bait was distributed low to the ground through the forest litter, beneath shrubs, and woody vegetation to allow all RIFA foragers access to bait, and therefore increase the chance of suppressing RIFA. RIFA control was conducted in April, August, and October 2003.

RIFA Response

I chose to measure RIFA foraging as a measure of their impact on the ecosystem. Sampling occurred every other month beginning in February 2002 until December 2003. I estimated RIFA abundance and activity using bait traps made of 20-ml scintillation vials and four grams of Vienna sausage placed inside the trap (Figure 2.1). I placed ten vials 18 m apart diagonally across each plot. Each vial was wrapped in aluminum foil to avoid heat-related ant mortality. I placed open vials on the ground in the morning during ant foraging cycles for approximately one hour before 1100 hours to sample RIFA when they are most active. I

collected vials and capped them following one hour of exposure to allow RIFA to begin foraging, but not to use all of the bait and leave the trap. Ants were sorted and counted by species.



Figure 2.1. Ant bait traps containing Vienna sausage.

Invertebrate Response

Ground-dwelling invertebrate sampling was conducted using pitfall traps for two consecutive days during February, May, August, and December in 2002-03 on each treated and control plot. Traps consisted of paired pitfall arrays with one 1.8 m long, 25.4 m wide piece of aluminum flashing placed vertically in the soil with an insect pitfall trap at each end (Figure 2.2). Pitfall traps consisted of one 400 ml, tri-corner plastic beaker buried so the top was flush with the soil surface. A 250 ml collection beaker fit tightly inside each 400 ml, tri-corner plastic beaker. Each collection beaker was filled with Prestone LoTox Antifreeze and trap contents were retrieved after 48 hours. Insects trapped in the antifreeze were transferred to sample cups and then to 70% ethanol. Invertebrates were sorted, identified to order, and counted.



Figure 2.2. Invertebrate paired pitfall drift fence array.

Statistical Analysis

I used one-way Analysis of Variance (ANOVA) to test effects of Amdro® to suppress RIFA by comparing abundance and activity of ants by season and between treatments and years. I also used one-way ANOVA to test effects of RIFA on ground-dwelling invertebrates by comparing relative abundance of species by season and between treatments and years. Biological significance was considered at $P < 0.10$ because my study was conducted at a large spatial scale, and therefore limited small sample sizes (Tacha et al. 1982, Allen et al. 1997). Analyses were performed using SAS version 9.0 software package (SAS Institute Inc., 2002).

Results

RIFA Suppression

The data presented were obtained using Amdro® (0.036% hydramethylnon) to suppress RIFA in April 2003, however, re-treatment was required in August and October 2003 because RIFA rebounded in or reinvaded treated plots. Amdro®, containing 0.73% hydramethylnon was applied in October 2003 and was more effective at RIFA suppression with re-treatment occurring in April 2004.

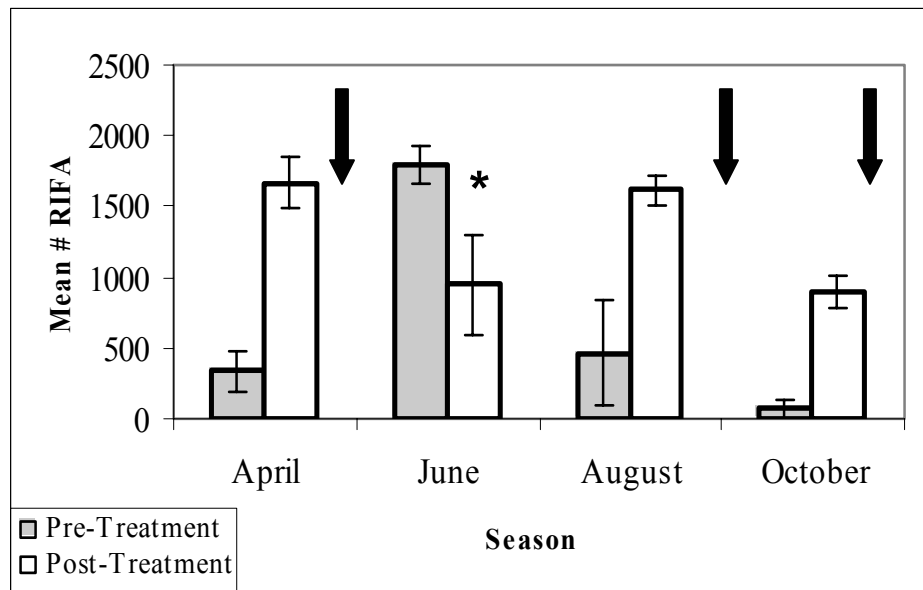
Longleaf-pine Forest

For pre-treatment (2002), RIFA abundance was relatively constant between treated and control plots ($F_{1,4} = 1.39$, $P = 0.305$). RIFA suppression was greater on treated plots for pre-treatment in April ($F_{1,4} = 32.20$, $P = 0.005$), August ($F_{1,4} = 9.09$, $P = 0.04$), and October ($F_{1,4} = 36.94$, $P = 0.004$) when compared to post-treatment (Figure 2.3A). RIFA abundance was lower overall for 2002 (pre-treatment) suggesting that environmental conditions were more favorable for RIFA in 2003. When I compared number of forager RIFA by season, there was a substantial reduction in the mean number of RIFA in June on treated plots between pre-treatment (2002) (1790.0 ± 138.2) ($M \pm SE$) and post-treatment (2003) (945.7 ± 348.7) ($M \pm SE$) ($F_{1,4} = 5.07$, $P = 0.088$) (Figure 2.3A) and treated (945.7 ± 348.7) ($M \pm SE$) and control plots (1768.3 ± 139.4) ($M \pm SE$) post-treatment (2003) ($F_{1,4} = 4.80$, $P = 0.093$) (Figure 2.3B).

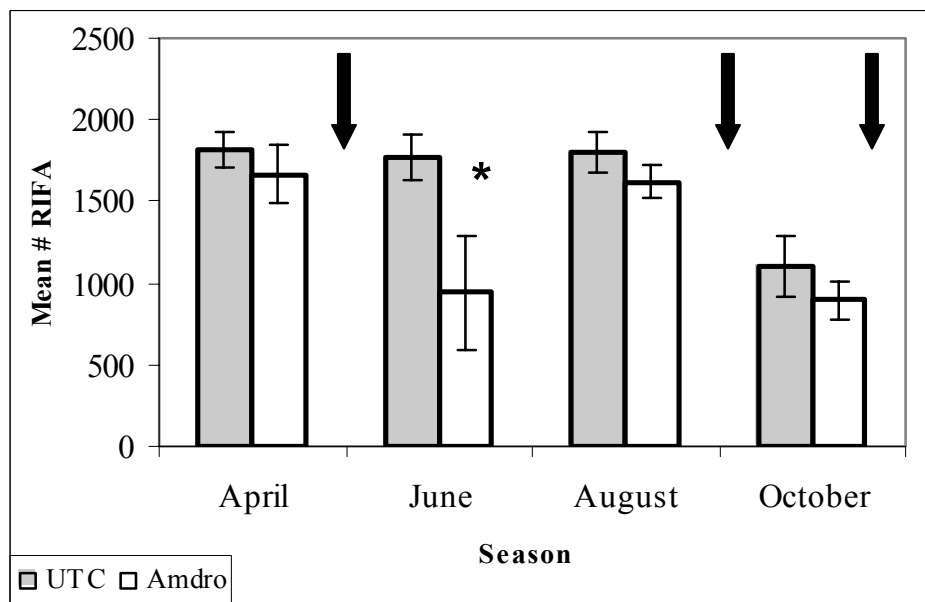
Pine-hardwood Forest

For pre-treatment (2002), the mean number of individuals between treated (5760.7 ± 914.7) ($M \pm SE$) and control plots (4862.3 ± 1475.2) ($M \pm SE$) was also relatively constant ($F_{1,4} = 0.27$, $P = 0.632$). For post-treatment, Amdro® was effective in suppressing RIFA when comparing treated (2841.3 ± 80.3) versus controls (6269.0 ± 512.3) ($F_{1,4} = 43.70$, $P = 0.003$). Across seasons, significant differences existed between pre-treatment (1206.0 ± 491.8) and post-treatment (65.7 ± 64.7) in April ($F_{1,4} = 5.29$, $P = 0.083$) and June (1794.3 ± 110.3 and 552.3 ± 93.0 , respectively) ($F_{1,4} = 74.10$, $P = 0.001$) (Figure 2.4A). Amdro® significantly reduced ants in April (65.0 ± 65.0 and 1689.3 ± 173.2 , treated and controls, respectively; $F_{1,4} = 77.06$, $P = 0.001$), June (552.3 ± 93.0 and 1685.7 ± 166.1 ; $F_{1,4} = 35.44$, $P = 0.004$), and October (663.3 ± 223.7 and 1425.7 ± 267.3); ($F_{1,4} = 4.78$, $P = 0.094$; Figure 2.4B).

A)



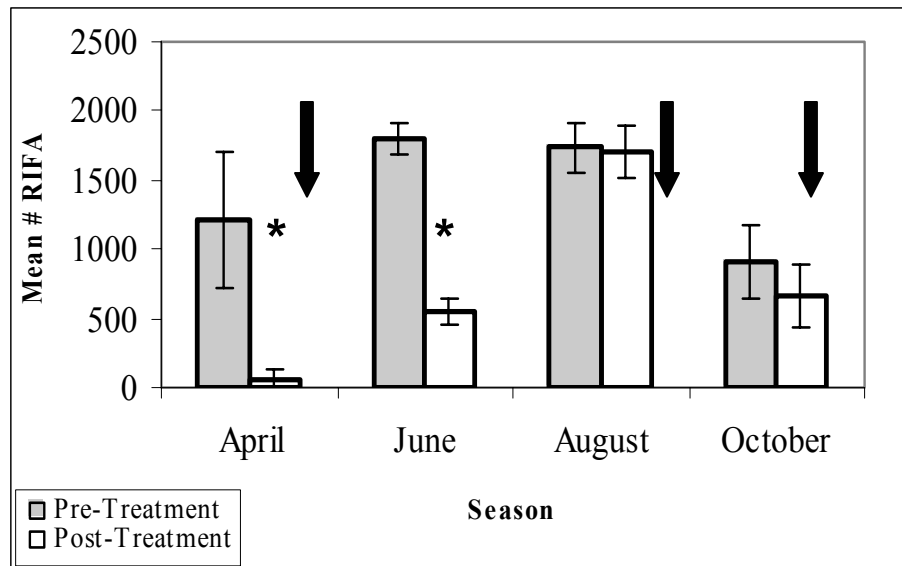
B)



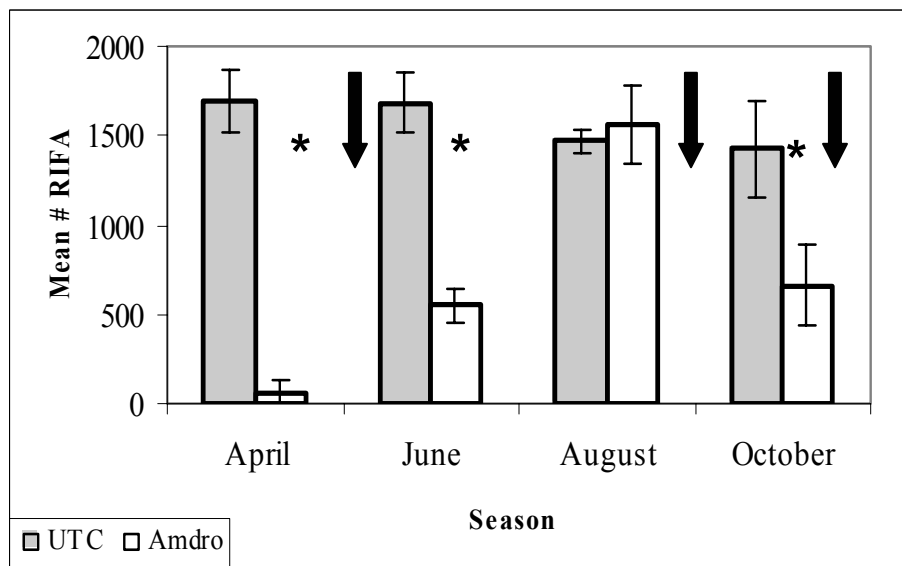
“*” indicates significance for treatment at $p < 0.10$

Figure 2.3. Mean number of RIFA captured in Vienna sausage food traps by season between pre-treatment (2002) and post-treatment (2003) years on treated plots (A) and on Amdro® treated and control plots post-treatment (B) in a longleaf-pine forest. Arrows represent when selected plots were treated with Amdro®.

A)



B)



“*” indicates significance for treatment at $p < 0.10$

Figure 2.4. Mean number of RIFA captured in Vienna sausage food traps by season between pre-treatment (2002) and post-treatment (2003) years on treated plots (A) and on Amdro® treated and control plots post-treatment (B) in a pine-hardwood forest. Arrows represent when selected plots were treated with Amdro®.

Ground-dwelling Invertebrate Response

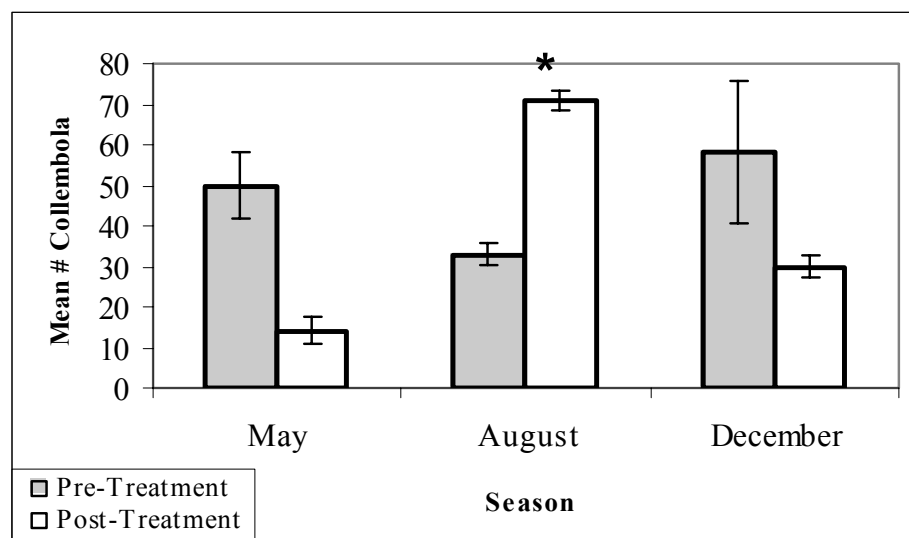
Longleaf-pine Forest

Species composition of ground-dwelling invertebrate orders suggests that similarities exist between treated and control plots prior to manipulation (Table 2.1). Collembola abundance was greater in August ($F_{1,4} = 96.01$, $P = 0.001$) (Figure 2.5A) post-treatment. More Collembola were captured on treated than control plots in December ($F_{1,4} = 14.07$, $P = 0.01$) (Figure 2.5B). Likewise, significant increases in Coleoptera were observed in December post-treatment ($F_{1,4} = 12.89$, $P = 0.023$) (Figure 2.6A). Increases in Coleoptera were observed in May ($F_{1,4} = 49.00$, $P = 0.002$) (Figure 2.6B) when treated and control plots were compared.

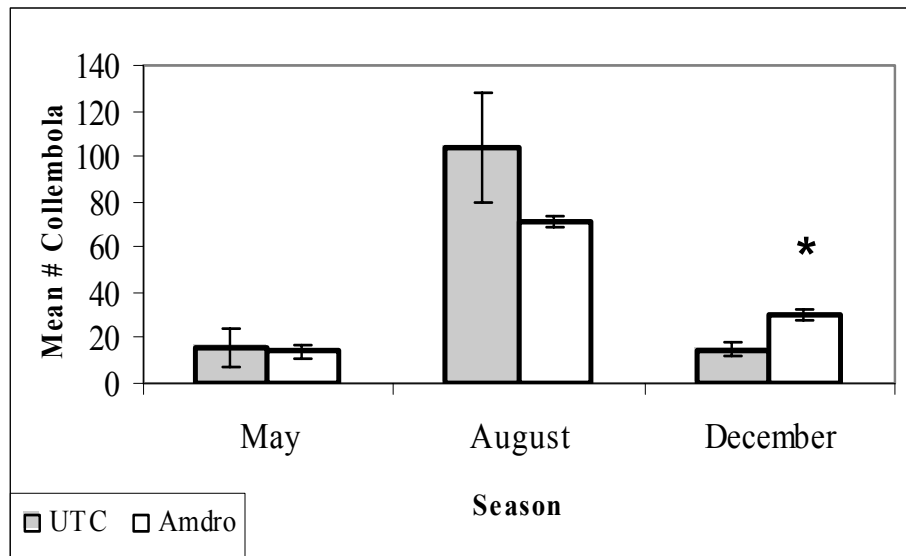
Pine-hardwood Forest

Ground-dwelling invertebrate orders also appeared to be similar between forest types prior to manipulation (Table 2.2); however, Acari differed from treated (11.0 ± 1.7) and control plots (4.7 ± 1.9) ($F_{1,4} = 6.22$, $P = 0.067$) (Figure 2.7). There were no significant differences observed by season for any ground-dwelling invertebrate groups captured.

A)



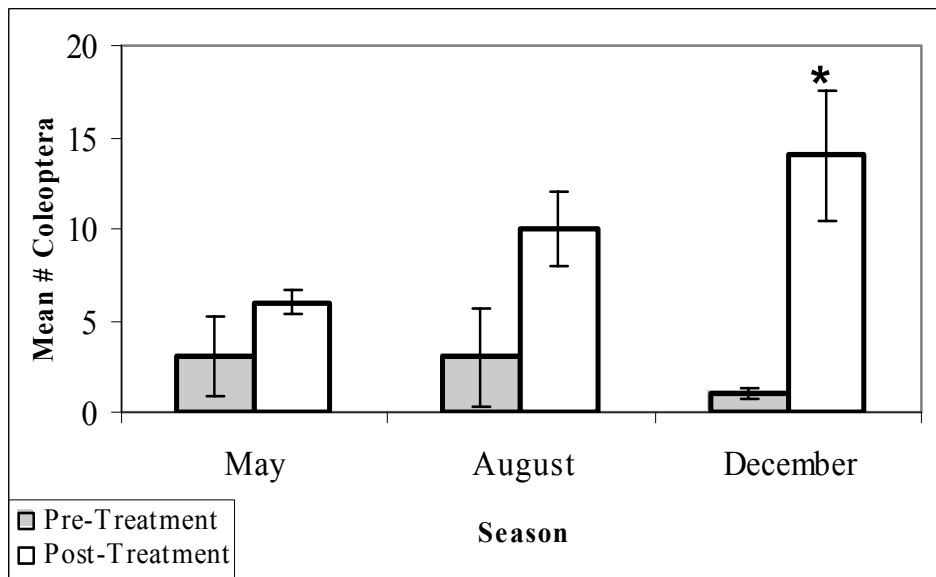
B)



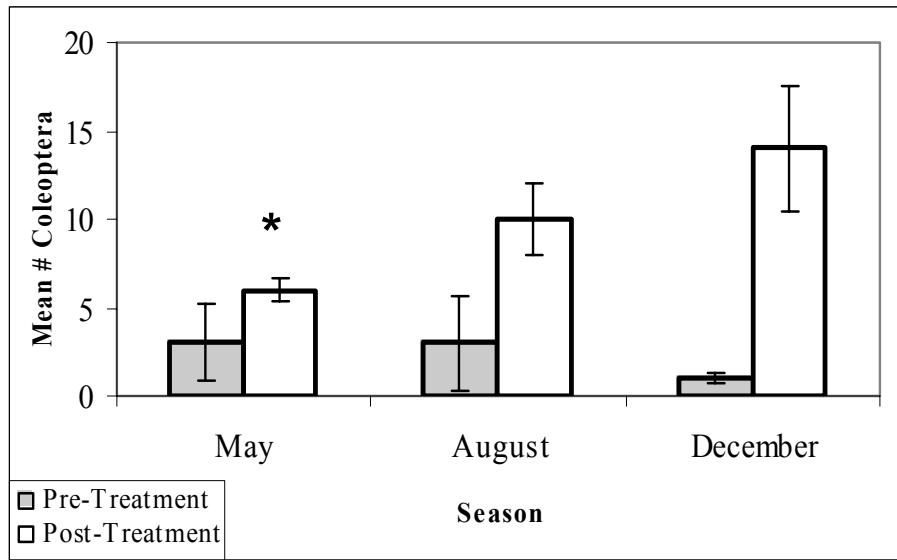
“*” indicates significance for treatment at $p < 0.10$

Figure 2.5. Mean number of Collembola captured in pitfall traps by season between pre-treatment (2002) and post-treatment (2003) years on treated plots (A) and on Amdro® treated and control plots (B) in a longleaf-pine forest.

A)

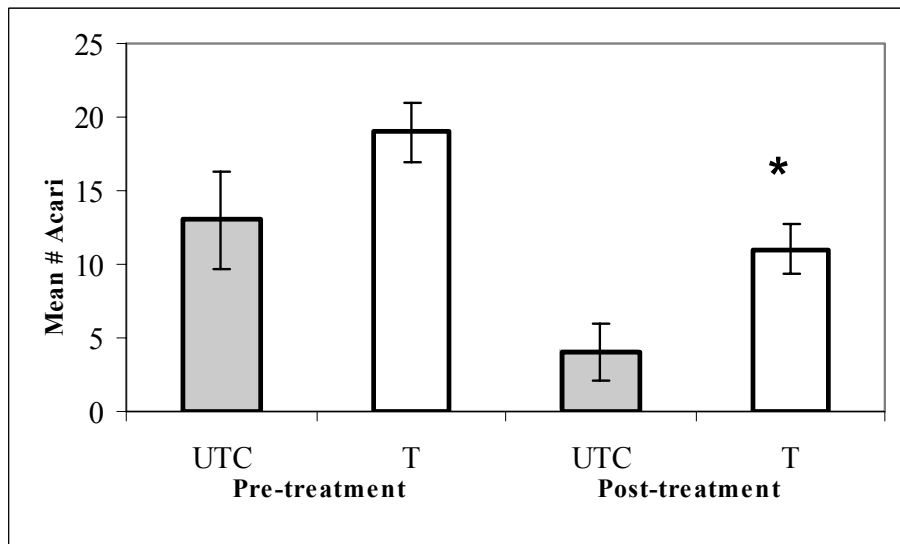


B)



“*” indicates significance for treatment at $p < 0.10$

Figure 2.6. Mean number of Coleoptera captured in pitfall traps by season between pre-treatment (2002) and post-treatment (2003) years on treated plots (A) and on Amdro® treated and control plots (B) in a longleaf-pine forest.



“*” indicates significance for treatment at $P < 0.10$

Figure 2.7. Mean number of individuals in Order Acari trapped in pitfall traps for Amdro® treated and control plots by pre- and post-treatment years in a pine-hardwood forest (Alexander State Forest WMA).

Table 2.1. Orders of invertebrates with mean number of individuals (Mean \pm SE) observed in pitfall traps on Amdro® treated and control plots for pre-treatment (2002) and post-treatment (2003) at Sandy Hollow WMA (longleaf-pine forest).

Arthropods	Common Name	Pre-treatment		Post-treatment	
		Treated (M \pm SE)	Control (M \pm SE)	Treated (M \pm SE)	Control (M \pm SE)
Acari	mites & ticks	7.0 \pm 3.2	30.7 \pm 13.1	10.3 \pm 4.7	6.0 \pm 2.1
Araneae	spiders	43.3 \pm 3.2	33.0 \pm 2.1	42.3 \pm 3.2	38.7 \pm 3.5
Coleoptera	beetles	16.3 \pm 3.8	23.3 \pm 6.7	30.7 \pm 5.9	28.7 \pm 6.0
Collembola	springtails	222.3 \pm 32.3	202.7 \pm 21.9	116.0 \pm 3.1	135.0 \pm 24.8
Diptera	flies	16.0 \pm 3.2	11.3 \pm 1.2	19.0 \pm 3.8	18.0 \pm 2.0
Hymenoptera	ants, bees & wasp	412.3 \pm 76.4	413.3 \pm 78.0	166.3 \pm 47.2	459.3 \pm 238.5
Orthoptera	grasshoppers	17.3 \pm 4.3	23.7 \pm 7.2	21.7 \pm 4.3	36.7 \pm 4.8

“*” indicates significance at $P < 0.10$

Table 2.2. Orders of invertebrates with mean number of individuals (Mean \pm SE) observed in pitfall traps on Amdro® treated and control plots for pre-treatment (2002) and post-treatment (2003) at Alexander State Forest WMA (pine-hardwood forest).

Arthropods	Common Name	Pre-treatment		Post-treatment	
		Treated (M \pm SE)	Control (M \pm SE)	Treated (M \pm SE)	Control (M \pm SE)
Acari *	mites & ticks	19.3 \pm 2.0	13.3 \pm 3.3	11.0 \pm 1.7	4.7 \pm 1.9
Araneae	spiders	44.0 \pm 2.0	44.7 \pm 7.5	41.0 \pm 1.2	36.7 \pm 2.7
Coleoptera	beetles	21.7 \pm 5.8	15.7 \pm 1.9	11.0 \pm 5.0	13.3 \pm 2.8
Collembola	springtails	350.7 \pm 47.6	431.7 \pm 36.7	177.0 \pm 2.6	208.7 \pm 34.7
Diptera	flies	12.0 \pm 4.0	12.3 \pm 3.8	25.3 \pm 18.4	6.0 \pm 0.6
Hymenoptera	ants, bees & wasp	286.0 \pm 54.3	178.0 \pm 43.9	103.3 \pm 18.4	102.7 \pm 26.0
Orthoptera	grasshoppers	7.3 \pm 0.9	10.3 \pm 2.4	6.7 \pm 3.3	9.3 \pm 3.7

“*” indicates significance at $P < 0.10$

Discussion

Amdro® is effective at reduction of RIFA in pastures and on small areas (< 2 hectares; Apperson et al. 1984). My data support the large-scale results of Allen et al. (1997) with RIFA suppression effective particularly in June. My data suggest that Amdro® (0.036% hydramethylnon) is effective at short-term reduction of RIFA colonies on large areas and in natural forested ecosystems, although multiple applications may be required for long-term

suppression of RIFA. Because treatments were applied in late spring and summer, the greater suppression of RIFA in the pine-hardwood forest than in the longleaf-pine forest may be due to greater understory vegetation at that site. Dense understory vegetation promotes cooler soil temperatures and allows RIFA to forage more extensively, making baits more effective. This vegetation also may prevent the degradation of the bait by sunlight. Likewise, the lower level of suppression observed at the longleaf-pine forest may have resulted from sparse ground cover and bare ground that allowed quick degradation of Amdro® particles. Bait applications should likely be applied when temperatures allow RIFA to forage extensively. Perhaps bait could be applied in early morning in areas of sparse ground cover.

Ground-dwelling invertebrates may be particularly vulnerable to predation by RIFA. Several studies reported that RIFA have substantial impacts on biodiversity of invertebrate communities, including isopods, mites, scarabs, and spiders, through predation or competitive replacement (Porter and Savignano 1990, Wojcik et al. 2001). Some studies have provided evidence of detrimental effects of RIFA on non-ant arthropods with 30% reduction in species richness and 75% reduction in numbers of individuals (Porter and Savignano 1990). Forsys et al. (2001) reported that all immature stages (egg, larvae, and pupae) of the Schaus swallowtail (*Papilio aristodemus ponceanus* Heraclides), which is federally endangered, were consumed by RIFA in a laboratory experiment. In a field experiment, RIFA were present in 50% of transects and may be detrimental to success of the swallowtail as well as other endangered and threatened species. RIFA have the potential to impact particular invertebrate groups thereby altering the abundance of fauna in forested ecosystems.

In the longleaf-pine forest, ground-dwelling Coleoptera and Collembola were greater following RIFA suppression, which suggests that RIFA may have periodically foraged heavily on individuals in these two invertebrate groups. Collembola are an important prey item for generalist predators (Bilde et al. 2000). Vogt et al. (2002) reported that Collembola were the primary food source taken by RIFA in pasture habitats. In a study examining long-term impacts of RIFA on arthropod communities, Coleoptera were significantly higher on treated areas when compared to controls (Morrison 2002).

In the pine-hardwood forest, mite and tick numbers increased following RIFA suppression. I demonstrated that suppression of RIFA foragers will likely result in a more even distribution of mites and ticks throughout the plots. The significant differences in treatment observed for mites and ticks in pine-hardwood forest may be due to a reduction in predation from suppression of RIFA. RIFA were observed as the primary factor contributing to tick mortality in both pasture and thicket areas in Texas (Fleetwood et al. 1984). In Oklahoma, RIFA attacked several insect species with ticks mainly consumed in wooded habitats (Vogt et al. 2002). These data are consistent with the data found in my study which suggests that RIFA may have substantial impacts on tick populations.

RIFA are capable of being detrimental at small-scales or in laboratory settings; however, impacts to wildlife on a landscape-level are still unclear. This study provides initial results for the large-scale impacts of RIFA on native, ground-dwelling invertebrate communities in pine-dominated ecosystems. At this time, we have determined the effects of moderate suppression of RIFA foragers on ground-dwelling invertebrates in two ecosystems. This study is the initial phase of a five-year project and the data suggests that RIFA may potentially affect abundance of

invertebrates in forested ecosystems. This will be further elucidated as the study continues.

Because research on the impacts of RIFA on native invertebrates in Louisiana pine-dominated forests has not been published, the research presented here provides baseline information for the continuation of a long-term project and for future research efforts.

Chapter 3.

Assessing Impacts of Red Imported Fire Ants on Native Ground-dwelling Small Mammal Communities in Longleaf-pine and Pine-hardwood Forests

Introduction

Red imported fire ants (RIFA) are well known nationwide as a threat to wildlife, agriculture, and humans. RIFA have the potential to negatively affect ground-dwelling vertebrates because they are the dominant invertebrate predators when occurring in areas of high mound density (Klotz et al. 2003). Because RIFA have a high reproductive capacity and dispersal ability, they are able to quickly invade and disrupt natural ecosystems (Porter and Savignano 1990). As the numbers of multiple-queen (polygyne) colonies of RIFA continue to increase and exceed the number of single-queen (monogyne) colonies, negative effects on native vertebrates have become an increasing concern (Allen et al. 1994). Most research has focused on impacts of RIFA on invertebrates and native ant fauna. However, RIFA have been implicated in reducing biodiversity of ground-nesting birds, herpetofauna, and ground-dwelling mammals (Jetter et al. 2002).

RIFA have been implicated in the decline of northern bobwhite (*Colinus virginianus* L.) by hindering activity patterns, killing chicks, and reducing abundance of invertebrates which are a major food source for bobwhite (Mueller et al. 1999). RIFA are believed to contribute to the decline of Texas horned lizard (*Phrynosoma cornutum* Harlan) populations by adversely affecting their primary food source, other ant species (Wojcik et al. 2001). RIFA may potentially affect anuran populations by feeding on newly-metamorphosed endangered Houston toads (*Bufo houstonensis* Sanders;

Freed and Neitman 1988). Mueller (2001) reported observations of a white-tailed deer fawn being attacked by RIFA and causing it to move across a pasture; therefore, increasing risk of predation. RIFA suppression has been positively correlated to white-tailed deer fawn recruitment in Texas with fawn estimates double on treated versus control plots (Allen et al. 1997). There have been reports which suggest RIFA negatively affect reproductive success of small mammals (Allen et al. 1994).

Beyond potential effects on reproduction, small mammal communities may be negatively affected through reductions in ecosystem carrying capacity and habitat quality (Ferris et al. 1998). RIFA may alter ecosystems and affect particular wildlife species by feeding on newborn mammals and therefore reducing reproductive success (Jetter et al. 2002). In laboratory experiments, deer mice (*Peromyscus maniculatus*) have been observed altering foraging behavior in the presence of RIFA; however, the extent to which this takes place in their natural habitat is unknown (Holtcamp 1997). Northern pygmy mice (*Baiomys taylori* Thomas) have been observed avoiding areas where RIFA occur in high densities (Smith et al. 1990); however, impacts of RIFA on free-ranging rodents are unclear (Killion and Grant 1993). There has been evidence of RIFA attacking cotton rats (*Sigmodon hispidus*) in traps and altering trap success (Flickinger 1989). Some rodent species may prefer microhabitats where RIFA are present in low densities (Lechner and Ribble 1996), suggesting behavioral changes because of the presence of RIFA.

Landscape- and community-level evaluations of the influence of RIFA on ground-dwelling small mammals are limited. Most studies evaluating effects of RIFA on

vertebrates have been on small scales and single species. Small scale studies are not able to adequately assess ecological changes in faunal communities in forested ecosystems (Allen et al. 1994) and no published studies evaluating impacts of RIFA on faunal assemblages in forest landscapes exist. This study will provide information needed to improve inferences made regarding large-scale ecological impacts of RIFA on ground-dwelling small mammals in forested ecosystems.

My objective was to assess landscape-level impacts of RIFA on multiple native faunal communities including ground-dwelling vertebrates and invertebrates. For the vertebrate portion of the study, my main focus was evaluating impacts of RIFA on native small mammal communities. Specifically, I evaluated the efficacy of Amdro® in suppression of RIFA in two pine-dominated ecosystems. The first null hypothesis tested was that RIFA abundance would remain constant between treated (i.e. RIFA suppressed) and untreated control plots. The second null hypothesis tested was that RIFA abundance would remain constant among pre-treatment and post-treatment years. My second objective was to determine effects of RIFA predation on ground-dwelling small mammal communities. I tested the null hypothesis that relative abundance of small mammals would be similar on treated plots relative to untreated controls.

Methods

RIFA Treatment and Response

See Methods in Chapter 2 on pages 12 and 13.

Small Mammal Sampling

I measured small mammal populations during January/February in 2002-04 and June/July in 2002-03 on each treatment and control plot. I trapped small mammals for four consecutive nights during each period using Sherman live traps placed 10 meters apart in a 5 x 5 grid formation. I baited each trap with peanut butter and oats wrapped in wax paper and secured at the rear of the trap. I covered traps with sufficient vegetation to prevent overheating or freezing and checked them beginning at sunrise each morning. To prevent predation of captured small mammals by RIFA, I used a granular contact insecticide (Talstar, FMC Corporation) at 1.97 g/m² distributed over a 1 meter radius around each trap. I identified small mammals to species, weighed them with a Pesola spring balance, assigned age and sex, and marked them using the toe-clipping method. (Rudran 1996). This research was conducted under LSU AgCenter Institutional Animal Care and Use Protocol A-00-03.

Statistical Analysis

I used one-way ANOVA to test effects of Amdro® to suppress RIFA by comparing abundance and activity of ants between treatments and years, and by season (April, June, August, and October). I also used one-way ANOVA to test effects of RIFA on small mammals by comparing relative abundance of species between treatments during pre-treatment and post-treatment. Biological significance was considered at $P < 0.10$ because my study was conducted at a large spatial scale, and therefore limited by small sample sizes (Tacha et al. 1982, Allen et al. 1997). Analyses were performed using the SAS version 9.0 software package (SAS Institute, Inc., 2002).

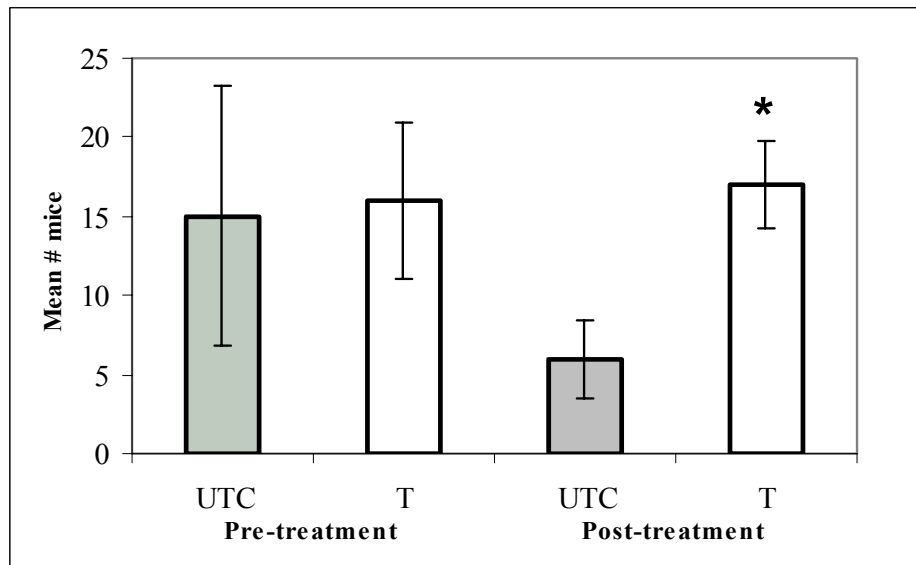
Results

RIFA Suppression

See Results in Chapter 2 on pages 14 and 15.

Small Mammal Response

In the longleaf-pine forest, cotton mice accounted for 90% of captures on treated plots during June sampling period when compared to other seasons. For pre-treatment, no significant difference was observed for mean number of cotton mice (*Peromyscus*



“*” indicates significance for treatment at $p < 0.10$

Figure 3.1. Mean number of cotton mice (*P. gossypinus*) captured on Amdro® treated and control plots during 2002 (pre-treatment) and 2003 (post-treatment) in a longleaf-pine forest.

gossypinus) in treated (16.3 ± 5.0) and untreated control (15.7 ± 8.2) plots ($F_{1,4} = 0.00$,

$P = 0.948$). During 2003, mean number of cotton mice differed between treated

(17.7 ± 2.7) and untreated control (6.0 ± 2.5) plots ($F_{1,4} = 9.88$, $P = 0.035$) (Figure 3.1).

In the pine-hardwood forest, cotton mice numbers remained constant from pre-treatment

(3 ± 2.1) ($F_{1,4} = 1.55$, $P = 0.281$) to post-treatment (3.3 ± 1.7) ($F_{1,4} = 0.03$, $P = 0.872$).

For post-treatment, no differences were observed for hispid cotton rats (*Sigmodon hispidus*), between treated (3.7 ± 2.2) and untreated control (3.0 ± 3.0) plots ($F_{1,4} = 0.03$, $P = 0.866$). For both forest types, cotton mice were the most abundant small mammal species captured followed by hispid cotton rats. Other species trapped included white-footed mice (*P. leucopus*), golden mice (*Ochrotomys nuttalli*), fulvous harvest mice (*Reithrodontomys fulvescens*), and southeastern shrews (*Sorex longirostris*); however, sample sizes were unbalanced across treatments and too small to conduct statistical analyses.

Discussion

Ecological impacts of RIFA invasion on non-arthropod species are currently receiving more attention (Wojcik et al. 2001). Because of their aggressive nature, RIFA may alter structure of ecological communities, therefore potentially reducing abundance and diversity of faunal assemblages (Ramakrishnan and Vitousek 1989). Ground-nesting vertebrates such as reptiles, birds, and mammals are particularly vulnerable to predation by RIFA.

Amdro® is effective at reducing RIFA in pastures and on small areas (< 2 hectares; Apperson et al. 1984). My data support the large-scale results of Allen et al. (1997) with RIFA suppression being effective, particularly in June. My data suggest that Amdro® (0.036% hydramethylnon) is effective at short-term reduction of RIFA colonies on large areas and in natural forested ecosystems, although multiple applications may be required for long-term suppression of RIFA. Because treatments were applied in late spring and summer, the greater suppression of RIFA in the pine-hardwood forest than in

the longleaf-pine forest may be due to greater understory vegetation at that site. Dense understory vegetation promotes cooler soil temperatures and allows RIFA to forage more extensively, making baits more effective. This vegetation may also prevent the degradation of the bait by sunlight. Likewise, the lower level of suppression observed at the longleaf-pine forest may have resulted from sparse ground cover and bare ground that allowed quick degradation of Amdro® particles. Bait applications should likely be applied when temperatures allow RIFA to forage extensively. Perhaps bait could be applied in early morning in areas of sparse ground cover.

In the longleaf-pine forest, there appears to be an inverse relationship between abundance of cotton mice and RIFA. By reducing RIFA from an ecosystem, cotton mice may be released allowing a uniform distribution across treatment plots and more individuals to colonize the area. Significant reductions in RIFA during June were consistent with the reproductive period of cotton mice. Although reproduction occurs year round, it decreases later in summer when temperatures reach extremes (Lowery 1974). About 90% of all cotton mice captures occurred during the June trapping period, suggesting that the reduction of RIFA noted in June was positively correlated with the abundance of mice. Since cotton mice are primarily ground-nesters and young are born helpless, reducing RIFA populations likely increased survival of offspring (Wilson and Ruff 1999).

Particular small mammal species may be restricted by areas of high RIFA density thereby limiting resource selection (Killion et al. 1990, Jetter et al. 2002). Since cotton mice will feed on invertebrates (Wilson and Ruff 1999), the abundance and availability of

this prey item may have increased with the reduction of RIFA. In the longleaf-pine forest, Coleoptera were positively affected by RIFA suppression, particularly during May and December, which likely increased prey availability for cotton mice (Figure 2.6).

The lack of response to the reduction of RIFA by cotton mice in the pine-hardwood forest could be attributed to their semi-arboreal behavior and an abundance of microhabitats to occupy (Loeb et al. 1999). Cotton mice will inhabit fallen logs, stumps, low-growing shrubs, and brush piles, which were found in the pine-hardwood forest, but not in the longleaf-pine site because of burning regimes. Also, cotton mice have been observed occupying elevated nests as much as six meters above ground (Wilson and Ruff 1999). In the pine-hardwood forest, understory vegetation was dense and primarily woody, which provided cotton mice the opportunity to escape RIFA, whereas in the longleaf-pine forest the understory was entirely herbaceous with a reduced midstory which limited rodents to nesting on the ground.

RIFA are capable of being detrimental on small-scales or in laboratory settings; however, impacts to wildlife on a landscape-level are still unclear. This study provides preliminary results of potential landscape-level impacts of RIFA on native small mammal communities in pine-dominated ecosystems. Although this study is in the initial phase of a five-year project, my findings suggest that RIFA may potentially affect abundance of ground-dwelling vertebrates in forested ecosystems.

Chapter 4.

Conclusions

Because of their aggressive nature, RIFA may negatively affect ground-dwelling small-mammal, herpetofaunal, and invertebrate communities in forest ecosystems. My primary objectives were to determine impacts of RIFA on these faunal communities and also to examine effects of using Amdro® to suppress RIFA. The data collected for herpetofaunal sampling were not presented because sample sizes were too small to conduct statistical analyses. When sampling herpetofauna in longleaf-pine and pine-hardwood forests, a combination of techniques should be used to increase sample size and diversity of species captured. For my study, I used three pitfall arrays for each 2-hectare plot, however other types of traps, such as funnel traps and coverboards, should be used as well as pitfall arrays to obtain a representative sample of the population.

My results were obtained using Amdro® (0.036% hydramethylnon) to suppress RIFA in April 2003; however, re-treatment was required in August and October 2003. Amdro®, containing 0.73% hydramethylnon, was applied in October 2003 and was more effective at suppressing RIFA with re-treatment occurring in April 2004. Although RIFA were more abundant overall in 2002 (pre-treatment) compared to 2003 (post-treatment) in the longleaf-pine forest, abundance was significantly reduced in June after treatment. Reductions in RIFA activity occurred for all seasons (April, June, August, and October) between treated and control plots with significant reductions in June. It appears that RIFA foraging decreased following initial treatment in April, but

because of the lower percentage of hydramethylnon and warmer temperatures during summer, colonies of RIFA rebounded in or reinvaded the treated plots.

In the pine-hardwood forest site, mean number of RIFA foragers were reduced on treated plots post-treatment. Across seasons, significant differences were observed on treated plots in June when comparing 2002 (pre-treatment) to 2003 (post-treatment). Furthermore, RIFA abundance was significantly reduced in June and April on treated plots versus controls during 2003 (post-treatment).

In the longleaf-pine forest, significant differences were observed for Collembola in August when comparing pre- and post-treatment and in December between treated and control plots. Significant differences were found for Coleoptera in December between pre- and post-treatment and in May between treated and control plots for 2003. Mean number of individuals overall for Acari, Araneae, and Coleoptera were higher on treated versus control plots, however differences were not significant. For small mammal response in longleaf-pine forest, mean number of cotton mice was significantly different between treated and untreated control plots during 2003. Cotton mice accounted for 90% of captures on treated plots during June sampling period, which coincides with significant reductions in RIFA abundance.

In the pine-hardwood forest site, mite and tick abundance was greater on treated plots than controls for 2003 (post-treatment). There were no significant differences observed by season for any invertebrate groups captured. Although abundance of Araneae and Diptera was higher on treated plots when compared to untreated controls, no significant differences were observed. For small mammal response, cotton mice numbers

remained constant from pre-treatment to post-treatment. No significant differences were observed for cotton mice and hispid cotton rats between treated and untreated control plots. For both forest types, cotton mice were the most abundant small mammal species captured followed by hispid cotton rats. Other species trapped included white-footed mice, golden mice, fulvous harvest mice, and southeastern shrews; however, sample sizes were unbalanced across treatments and too small to conduct statistical analyses.

For reducing RIFA in forested ecosystems, Amdro® (0.73% hydramethylnon) should be used to achieve long-term (~ 6 months) suppression. Also, Amdro® (0.73% hydramethylnon) is effective at large-scale suppression of RIFA in longleaf-pine and pine-hardwood forests (up to 2 hectares). Since Amdro® degrades rapidly in sunlight, treatment should be applied in early morning hours during the summer months when RIFA foragers are most active and will forage extensively on the bait. This study suggests that RIFA may negatively affect particular invertebrate groups and small mammal species, thereby potentially altering some ecosystem processes. The data presented provides the initial results of a 5-year project and new information regarding the landscape-level impacts of RIFA in forested ecosystems.

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Appendix A. Herpetofaunal Species

Herpetofaunal species captured in pitfall traps on Sandy Hollow (longleaf-pine) and Alexander State Forest (pine-hardwood) Wildlife Management Areas.

Sandy Hollow WMA			Alexander State Forest WMA		
Family Name	Scientific Name	Common Name	Family Name	Scientific Name	Common Name
Scincidae	<i>Scincella lateralis</i>	ground skink	Scincidae	<i>Scincella lateralis</i>	ground skink
Bufo	<i>Bufo quercicus</i>	oak toad	Hyla	<i>Hyla squirella</i>	squirrel treefrog
Microhylidae	<i>Gastrophryne carolinensis</i>	narrow-mouthed toad	Microhylidae	<i>Gastrophryne carolinensis</i>	narrow-mouthed toad

Appendix B. Non-target Ant Species

Native ant species captured in Vienna sausage food traps at Sandy Hollow (longleaf-pine) and Alexander State Forest (pine-hardwood) Wildlife Management Areas.

Sandy Hollow WMA		Alexander State Forest WMA	
Sub-family Name	Scientific Name	Sub-family Name	Scientific Name
Formicinae	<i>Brachymyrmex</i> spp.	Formicinae	<i>Brachymyrmex</i> spp.
Formicinae	<i>Prenolepsis imparis</i>	Formicinae	<i>Prenolepsis imparis</i>
Formicinae	<i>Camponotus pennsylvanica</i>		
Myrmicinae	<i>Solenopsis</i> spp.	Myrmicinae	<i>Solenopsis</i> spp.
Myrmicinae	<i>Monomorium minimum</i>	Myrmicinae	<i>Monomorium minimum</i>
Myrmicinae	<i>Pheidole</i> spp.	Myrmicinae	<i>Pheidole</i> spp.
Myrmicinae	<i>Crematogaster ashmeadi</i>	Myrmicinae	<i>Crematogaster</i> spp.
Myrmicinae	<i>Leptothorax</i> spp.	Myrmicinae	<i>Aphaenogaster rudis-texana</i> complex
Dolichoderinae	<i>Tapinoma sessile</i>	Dolichoderinae	<i>Tapinoma sessile</i>
Dolichoderinae	<i>Dorymyrmex</i> spp.	Dolichoderinae	<i>Dorymyrmex</i> spp.

Vita

Keri Landry was born on July 23, 1979 in Baton Rouge, LA. She graduated from Brusly High School and immediately began her college career in the fall of 1997. She always had a passion for nature and the outdoors and pursued her Bachelor of Science degree in Wildlife Management at Louisiana State University. She has held several internship positions throughout college including positions with the United States Fish and Wildlife Service at Lacassine National Wildlife Refuge in Lake Arthur, Louisiana, the Jones Ecological Research Center in Newton, Georgia, and Homochitto National Forest in Meadville, Mississippi. She gained experience working with endangered and threatened species including gopher tortoises, red-cockaded woodpeckers, and freshwater mussels. She has also worked with alligators, waterfowl, and shorebirds. Upon graduating with her Bachelor of Science degree, she was accepted into graduate school under the direction of Dr. Michael Chamberlain and Dr. Linda Hooper-Búi. Master of Science degree in Wildlife Ecology with a minor in Entomology will be awarded in May 2004.