PROJECT DESCRIPTION

Problem, Background and Justification

Ants in the Urban/Suburban Landscape:

Ants as structural pests have received considerable attention in pest management programs, and are a primary target of many professional pest control operators. However, ants in the exterior urban/suburban landscape can cause considerable problems associated with: a) nuisance and health problems of stinging species, 2) exacerbation of plant pests by homopteran-tending species, and 3) contributions to interior nuisance and structural problems from outside nesting invaders. A survey of ant species and their pest context encountered by professional pest control operators in Florida (Klotz et al. 1995), revealed that three major species causing problems within structures were commonly found outside as well, and control of outside populations of indoor ants pests has now been recognized as an important component of their pest management around homes (Haack 1991, Oi et al. 1994, Hahn et al. 2001). Problems associated with pestiferous ants in the landscape are frequently encountered by homeowners, building managers, park and open space managers, school officials, and business owners. A survey conducted of insect pest problems and subsequent pesticide use in Maine Public Schools (Murray 2000) reflects the frequency of ant-related problems relative to other pests. Ant were the most commonly identified pest of concern inside school structures (identified by 59% of respondents) and the third most commonly identified concern for outdoor areas (36% of respondents compared with 54% for general stinging insects (which can include ants), and 54% for weeds). Fifty-two percent of respondents in this survey reported taking action against interior ant pest problems sometime in the previous three years and 25% had taken action against exterior ant problems. The most common action taken was the use of baited insecticides for ants. Although ants are such a commonly encountered problem in the urban/suburban landscape, there is currently little region-specific information on local pest species and their management for homeowners and other community-based users in the Northeast region. At the Community and Urban IPM Conference in Manchester, NH in March 2005, the need to "develop IPM outreach to homeowners, retailers of pest management products, and multipliers (media, libraries, teachers)" was ranked as the highest priority by attendees (http://northeastipm.org/priority/2005_urban _conf.htm), and at their June 2005 meeting, the Community IPM Working Group identified "IPM in residential settings" as the most important focus for their group (http://northeastipm.org/work_commpriority2005.cfm). Specific goals of the group include:

1. *Develop a PSMP for residential IPM particularly for suburban outdoor IPM and indoor urban IPM.*
2. *Outreach: Develop and create an outreach campaign for residential IPM (radio, TV, and other creative forums). Develop material and distribute to end-users. Measure success of project.*
3. *Research: General research on residential IPM.*

Web-based resources are available for identification of pestiferous ant species encountered in other regions of the country (e.g. Ohio: ohioline.osu.edu/hyg-fact/2000/2064.html). However, it is important for extension agents, business owners (including PCO'S), and residents in the northeast to have access to a simpler format that is limited only to the species that are of concern in the region. Therefore, a focus of this proposal is to develop region-specific information on the identification, biology, damage/nuisance potential and management of pestiferous ants in the urban/suburban landscape. This will address the objectives 2 and 3 identified above by the Community IPM Working Group. In addition, our user-friendly materials for local ant identification and management will reduce the unnecessary use of insecticides by homeowners that frequently react to any ants in the landscape whether or not they are pestiferous. Our recommendations will emphasize non-insecticidal approaches where possible.

European fire ants:

In addition to species previously known to cause problems for homeowners in the northeast region, (the odorous house ant, *Tapinoma sessile,* the little black ant, *Monomorium minimum*, the cornfield ant, *Lasius alienus*, the Allegany mound ant, *Formica exsectoides*, and the carpenter ant, *Campanotus pennsylvanicus*) the past ten years have seen increasing problems with the invasive ant, *Myrmica rubra*, referred to locally as the European fire ant. This aggressive, stinging ant has become established in many communities along the coast of Maine and New Hampshire, several locations in Massachusetts, and at least one infestation has been confirmed in both New York state and Vermont (Groden et al. 2005). Although we are not certain when this invasive ant was first introduced into these areas, it is clear that the **population densities of *M. rubra* have increased considerably over the past decade, as have the number of areas in which they infest**[1] (Figures 1&2). *M. rubra* populations have colonized disturbed and natural areas around residences, schools, parks, and commercial and municipal buildings where their nest densities in heavily infested areas have averaged 1.4 nests/m^2 (maximum densities ranging from 2-5 nests/m^2) with 300-10,000 foragers per nest (Groden et al. 2005). These ants aggressively defend their territory and readily sting humans, pets and livestock that have the misfortune to move slowly or rest within the large areas where they forage. Numerous homeowners have reported to us that they are unable to use their yards and gardens because of repeated stings by *M. rubra*. Many homeowners, businesses, public park officials and resource managers are relying on insecticide treatments for curbing this pest. The efficacy of these treatments is uncertain, and resurgence of local populations suggests that this strategy provides only short-term control. We also have evidence that the invasive populations of *M. rubra* are negatively impacting native species in infested areas, particularly native ants that are completely eliminated in most *M. rubra* infestation sites (Garnas 2005).

[1] We logged over 100 contacts from home and business owners in coastal towns of Maine between 2002 and 2003 regarding problems with *M. rubra* infestations, and the vast majority were problems that had developed since 1993-4. In addition, in 2004 we surveyed an infestation in Wayne, ME, that resulted from the transfer of the ants (possibly a single colony) in a potted shrub. After 10 years this has spread from the single shrub to an area ca. 100 x 112 m^2.

Figure 1. Current and historic locations of *M. rubra* populations in North America.

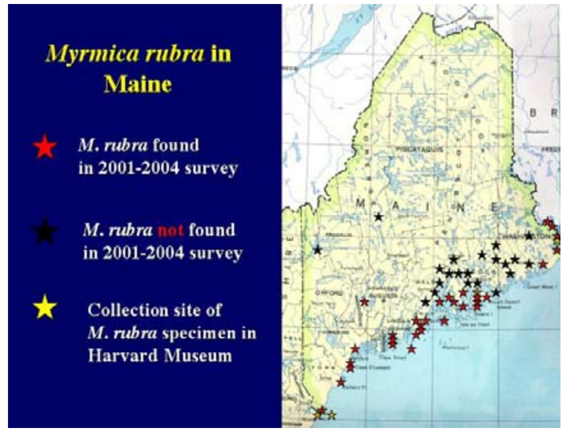

Figure 2. Current pestiferous *M. rubra* populations in Maine.

M. rubra populations in Maine may be exhibiting the typical pattern characteristic of many invasive, exotic species: a prolonged period of adaptation with moderate population increase after establishment, followed by an exponential increase in density and an increase in the rate of geographic spread (Shigesada and Kawasaki. 1997). Populations have spread from 2 locations in Maine in the 1950s to 28 confirmed locations along Maine's entire coast as of 2004 (Groden et al. 2005) and additional sites in other states and Canada. Whatever the cause of the current increase in the rate of spread of this pest, given that its native range spans from the United Kingdom in Western Europe to central Asia and from Scandinavia to the Black Sea (Collingwood 1958, Seifert 1988), it is unlikely that climatic factors alone will limit the spread of these populations in the northeastern U.S**. It is critical to address this issue BEFORE it becomes a more widespread problem.**

The biology of *M. rubra* and its pattern of infestation suggests that their primary means of spread is via colony budding which results in expansion from infested areas into contiguous areas, or via human transport of nests in infested materials (soil, decaying logs, etc.; Groden et al. 2005). Although nuptial flights have been reported in *M. rubra* populations (Boomsma and Leusink 1981, Woyciechowski 1987), evidence suggests that new queens produced by this polygynous ant (multiple queens per colony) reenter their nest of origin and subsequent groups of queens, workers and brood move out a few meters from the main nest to establish new colonies (Seppa and Pamilo 1995, Walin et al. 2001). We have found several infestations in which spread within the same habitat appeared to be limited by a natural (river or channel) or man-made barrier (road). This would suggest that dispersal and establishment of new colonies via flight of queens does not occur or is very limited.

We do, however, have evidence for spread of these fire ants by human activity, particularly with movement of potted plants. A student working in Groden's laboratory brought in ants that were stinging employees when they encountered them in container plants being repotted at a wholesale greenhouse facility in southern Maine. They proved to be *M. rubra.* As described above, we have also confirmed that the first inland infestation in Maine became established from the planting of shrubs purchased from an infested nursery. In August 2005, Groden and Drummond filmed a colony in an infested nursery as it moved its nest from an adjacent stonewall into a potted rhododendron that was for sale. It is likely that infested container plants brought to the NE from Europe are responsible for some of the original infestations, and subsequent movement of plants, soil, mulch, and fill have spread *M. rubra* to new areas. For this reason, **educating people about this invasive pest is the most important step to take to limit its further spread.**

Drs. Groden and Drummond have been conducting research on the ecology and management of *M. rubra* in Acadia National Park over the past three years. Our studies have included investigations of the temporal and spatial dynamics of colonies in infested areas, key habitat characteristics required by *M. rubra,* diurnal foraging patterns, sampling, competition with native ants, impacts of *M. rubra* on arthropod biodiversity and factors contributing to natural mortality and population regulation both in the US and Europe. Investigations were also initiated on a number of least toxic alternatives for *M. rubra* management, including IGRs, nematodes, and boric acid products registered for other ant species. **Our results suggest further research is warranted, particularly with new "least toxic" chemistries and non-insecticide management strategies.**

*Ant management with Baits***:**

Toxic baits are considered more effective for management of pestiferous ants and more environmentally friendly than non-baited insecticide treatments (Williams et al. 2001). Less active ingredient is used in the formulations, and only the organisms that pick up the baits are affected. Baits capitalize on the recruitment and food sharing behavior of ants to spread a toxicant throughout the colony. Stringer et al. (1964) suggest that a toxicant incorporated into a bait should be non-repellent and show delayed toxicity over a wide dosage range to allow time for the toxicant to be distributed throughout the colony. They suggest that an effective material should result in <15% mortality at 1 day and >89% mortality at the end of the study. Rust et al. (2004) suggest that delayed toxicity for Argentine ants (*Linepithema humile* (Mayr)) can be achieved with baits that produce an LT_{50} for foragering workers between 1 and 4 days. Delivering baits via bait stations minimizes environmental exposure and increases selectivity through design of the bait dispenser. For example, access to the bait in KM AntPro® liquid bait dispensers is limited by the size of the opening at the base of the dispenser. However, the economic feasibility of using bait stations as opposed to broadcast baits depends on the volume of bait that a station should contain, and the number of stations required per acre for the particular pest species and ecosystem (Tollerup et al. 2004).

Toxicants for pestiferous ant control have been formulated on both solid and liquid baits. Liquid baits are particularly attractive to sugar-loving ants, such as *M. rubra,* that naturally tend homopterans and feed on floral and extra-floral nectarines (Brian 1954, Garnas 2005). One toxicant currently available in liquid sugar bait formulations, boric acid (Terro Ant Killer II, Senoret Chemical Co, St. Louis, MO; Gourmet Liquid Ant Bait; and others), has been used against ants since the early 1900s. However, recent studies have demonstrated the effectiveness of **low** concentrations of boric acid in sucrose baits against pestiferous ants (Klotz and Williams 1996). Klotz and Moss (1996) found that using a bait of 1% boric acid in a 10% by weight sucrose solution provided optimum control of Florida carpenter ants. This mixture was sufficiently sweet to initiate recruitment. However, higher concentrations of sugar were reported to attract greater numbers of Argentine ant, as we have found with *M. rubra* (Figure 4). However, sugar concentrations of 25% or more resulted in crystallization of the bait in the field, limiting consumption by the ants (Klotz et al. 1998). Low boric acid concentration (1% and less) have been found to be more effective at reducing Argentine ant and southern imported fire ant (*S. invicta)* populations because higher concentrations can be repellant and kill ants too quickly (Klotz et al. 1997, Klotz et al. 2000). Similar positive results with baited boric acid solutions have been demonstrated for the ghost ant *(Tapinoma melanocephalum)* and Pharaoh ant *(Monomorium pharaonis* L.) (Klotz et al. 1996).

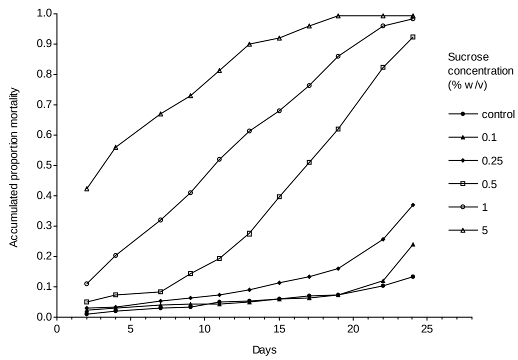

Figure 3. Accumulated proportion mortality with days of exposure to five boric acid concentrations in 10% sucrose bait solution.

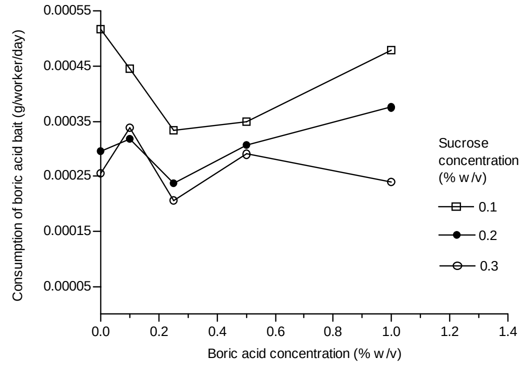

Figure 4. Consumption affected by concentrations of sucrose and boric acid.

We evaluated the toxicity of boric acid in sucrose baits to *M. rubra* workers in laboratory assays with continuous exposure to bait over 18 days. LT_{50}'s ranged from 119 days to 1.81 days between 0.1% and 5% boric acid (w/v) solutions (Figure 3). Consumption rates did decline with boric acid concentrations of 1% (w/v) and above. However in second experiment with lower boric acid concentrations, consumptions rates were more strongly impacted by sucrose concentration (Figure 4). Workers consumed more bait with 10% sucrose (w/v) compared with 20 and 30% solutions. Mortality, though, was directly related to boric acid consumption rates (g/worker/day) (Figure 5), suggesting that lower sucrose concentrate baits may be more effective in the field. However, consumption rates of isolated workers in the laboratory may reflect individual satiation and may not be experienced in a colony setting where food is passed on to other members. Our field studies demonstrate that *M. rubra* recruit more heavily to solutions with higher sucrose concentration (Figure 6). Therefore, we assume that the optimal boric acid bait for *M. rubra* will be 0.5% boric acid in 25% sucrose (the concentration maximum suggested

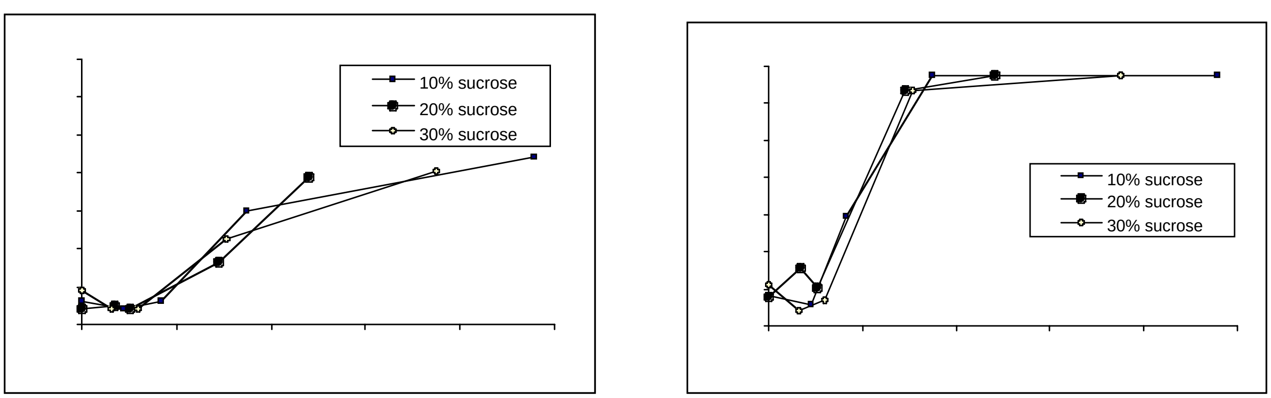

Figure 5a,b. Mortality of *M. rubra* workers relative to their consumption of boric acid in three sucrose concentrations (10%, 20%, and 30%) after 11 and 18 days of exposure.

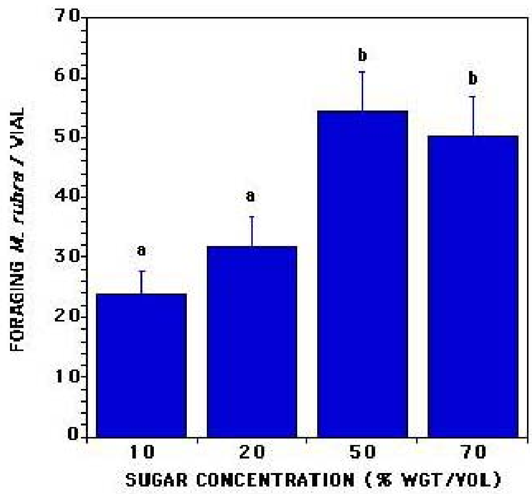

Figure 6. Recruitment of *M. rubra* to baits of different sucrose concentrations.

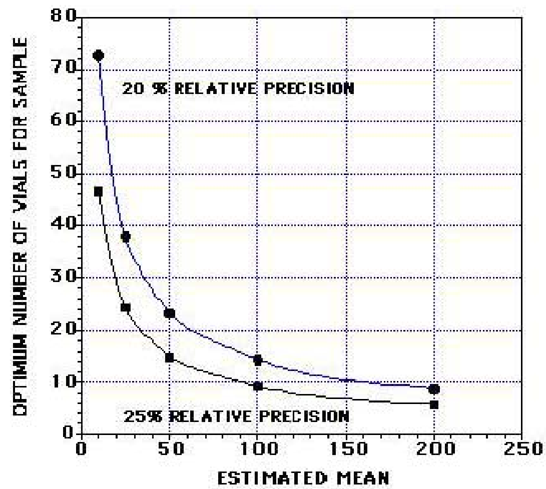

Figure 7. Optimal sample sizes for random sampling of *M. rubra* forager populations with sucrose baited traps

by Klotz et al. 1998 to avoid crystallization.)

In 2004, we conducted an experiment in which subsets of colonies (three queens, approximately 300 workers and 2.5 grams of brood) were established in nest boxes consisting of a 4.8 l main nest chamber with two inverted plastic pots covering moist sponges for brood chambers, connected to a 0.4 l foraging chamber via a 20 cm plastic tube. Treated colonies were provided a continuous supply of 0.5% boric acid in 25% sucrose via a cotton-plugged vial introduced into the foraging chamber. Control colonies were fed 25% sucrose and both treated and control colonies were kept moist and supplemented with live insects for protein. After 8 weeks, number of queens and amount of brood were all significantly lower and the numbers of dead (Figure 8) were significantly higher in the boric acid treatment. However, in this same experiment, commercial ant products with active ingredients of *Beauveria bassiana* conidia

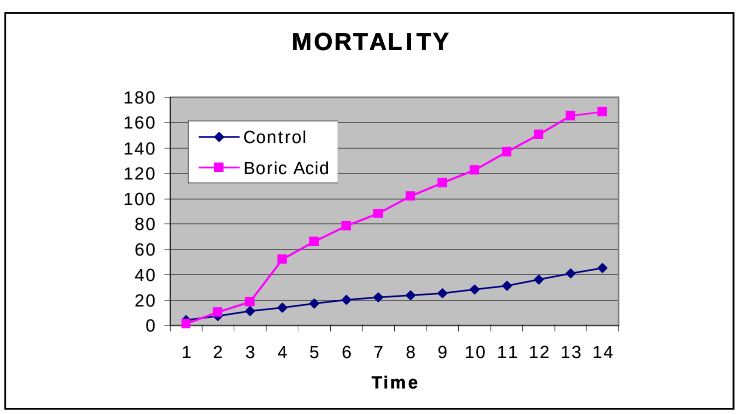

Figure 8. The cumulative average number of dead workers per colony with exposure to 0.5% boric acid in 25% sucrose solution.

(Mycotrol®), spinosad (Justice®), avermectin (Advance®), hydramethylnon (Amdro®) and methoprene (Extinguish®) showed no significant difference in percent reduction of colony size after two months (p=0.845; Table 1).

Table 1. Effects of insecticides on colonies of *Myrmica rubra* exposed to treatment for 2.4 or 24 hours in the laboratory.

Treatment	Time	Quantity of insecticide	Mean percent of colony remaining after 2 months (± SE)	Mean percent of cadavers with pathogens (± SE)
Amdro®	2.4 hours	0.5g	72.2±14.7	3.8±0.8
Amdro®	24 hours	0.5g	71.2±32.9	3.9±2.3
Advance®	2.4 hours	0.5g	55.5±16.8	9.4±7.2
Advance®	24 hours	0.5g	91.9±46.0	3.3±1.9
Justice®	2.4 hours	0.5g	63.9±24.7	8.6±4.8
Justice®	24 hours	0.5g	54.5±16.5	7.0±3.0
Extinguish®	2.4 hours	0.5g	80.6±10.0	16.7±11.6
Extinguish®	24 hours	0.5g	53.7±24.5	12.5±6.6
Boric Acid 0.5%	Continuous		0	6.0±1.0
Beauveria bassiana	24 hours	5.8*10^8 conidia	46.7±3.3	26.0±6.4
B. bassiana with Justice®	24 hours	5.8*10^8 conidia 0.5g Justice®	83.4±4.2	7.6±5.9
Control			51.5±11.3	1.4±0.7

In contrast, in a large field study conducted on Mount Desert Island in 2003 and 2004 in cooperation with Acadia National Park and many private homeowners, we evaluated broadcast applications of hydramethylnon (Amdro®, 2 applications), methoprene (Extinguish®, 1 application), the combination of these materials (1 application of Extinguish® followed 10 days later by 1 application of Amdro®)[2], and bait stations of boric acid on *M. ruba* populations in individual yards ranging from 514 – 26,500 m^2. Only the treatments of hydramethylnon alone, and the combination resulted in significant reductions in *M. rubra* foragers (Fig. 9). However, boric acid bait stations used in this field study were modeled after those developed by Klotz et al. (2000) for Argentine ant, and considerable problems were encountered with quality and delivery of the bait. Combined results from both of these experiments (contained nest and field trial) suggest that further field studies are needed to effectively evaluate boric acid bait stations vs. broadcast treatments for this pest ant. Our experience with the KM AntPro liquid bait dispenser have resulted in better control of the quality of the liquid baits and more consistent delivery.

[2] Both of these materials have been demonstrated to reduce activity of other pestiferous ants and the combination is currently being used in an area-wide pest management program for red imported fire ant (*Solenopsis invicta*) in the southeastern U.S (Pereira 2003).

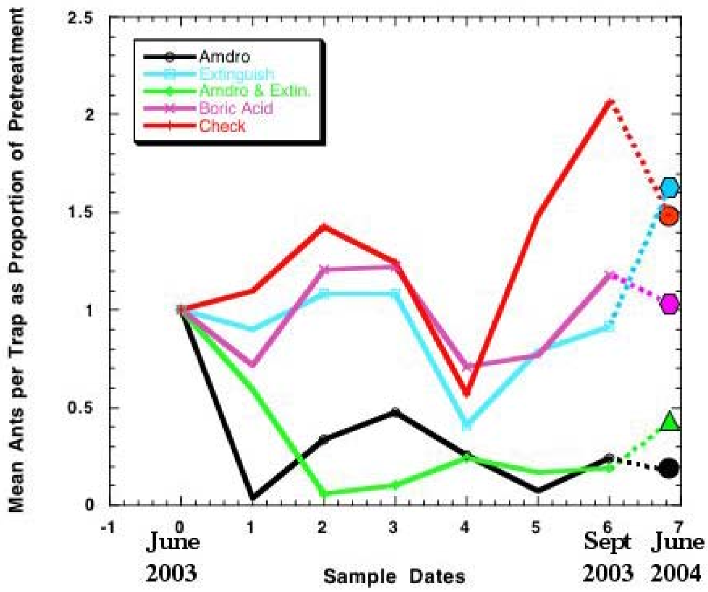

Figure 9. Impact of insecticide treatments on *Myrmica rubra* foraging activity in large plot field trial on Mount Desert Island in 2003.

In addition to boric acid liquid bait stations, solid bait stations such as the Maxforce Outdoor Refillable Bait Station® offered by Bayer, are being promoted for use in the landscape around homes and businesses to control a variety of pestiferous ants (e.g. "do-it-yourself PestControl": http://www.doyourownpestcontrol.com/SPEC/pick-maxforceant1.htm; Pestproducts.com: http://www.pestproducts.com/maxforce_ant_bait_stations.htm; E-bug: http://www.e-bug.net/cgi-bin/store/commerce.cgi?product=Baits). The active ingredient in Maxforce®, fipronil, has been shown to be very effective in reducing populations of fire ants and carpenter ants (Collins and Callcott 1998, Scharf et al. 2004). We have observed that *M. rubra* foragers will readily pick up the oil coated solid bait granules of Amdro® and similar products, and return them to the nest[3]. However, to effectively deploy a bait station strategy for control of *M. rubra,* it will be necessary to determine the distance over which they forage and the time required for toxicants in baits to be successfully transferred throughout the colony. Therefore, we are proposing to take a methological approach to developing a bait station strategy that optimizes the density of stations and the duration of baiting.

Objectives and Anticipated Impacts:

Research:

R1) Develop and evaluate "least toxic" strategies for homeowners and businesses for management of the European fire ant, *M. rubra*, using bait station strategies.

Extension:

[3] We assume that they will collect similarly formulated solid baits with fipronil, though we will conduct preliminary tests to ascertain this.

E1) Survey pest control operators in participating states and extension workers throughout the NE region to determine the most commonly reported species of ants causing problems for homeowners, businesses and schools in the NE.

E2) Develop a web-based key to the common ant pests in urban/suburban landscapes in the NE region.

E3) Develop and distribute web-based and printed materials for homeowners and businesses (including pest control operators) on common pestiferous ants in the urban/suburban landscape and their management.
*Particular emphasis will be directed towards raising the awareness of the biology, ecology, potential spread and methods of managing *M. rubra*. Products and activities will also be designed to allow us to further track the spread of this pest.

<u>*Anticipated Impacts*</u>*:*

Safeguarding human health and the environment	If the bait station strategy for managing *M. rubra* is successful, it would greatly reduce the potential human health and non-target environmental risks associated with broadcasting insecticide for control of this pest. This would be particularly significant in homes, schools and public parks where this pest, if left unmanaged, is currently severely impacting the use. Successful use of boric acid bait stations would also represent a switch to a lower risk pesticide. The survey and subsequent development of a key and information on the biology and management of other pestiferous ants in the urban/suburban landscape also has the potential to lead to reduction in pesticide use and risk. As not all ants are pestiferous, and even with those that are, treatment with insecticide may not be the most effective way to manage the problem. With information available to homeowners, PCO's and extension personnel, more appropriate choices can be made.
Economic benefits	Bait station strategies for management of *M. rubra* will likely result in reduced cost for management, as insecticides will be concentrated in a location frequented by the ants rather than broadcast in areas where it may not be picked up by foragers. There may be costs associated with purchase of the bait stations, but these are likely to be one time costs, as these stations are reusable from one year to the next. By providing region specific information to extension personnel on identification and management of pestiferous ants, they save considerable time that otherwise they would spend sifting through current materials developed in other regions for that that is relevant to the NE. Also, schools, park managers and PCO's are also likely to save time and money when the information is readily at hand, and they do not treat ants that are not going to cost problems.
Implementation of IPM	The large field trial described in R1.c. will evaluate three different IPM strategies: management of *M. rubra* in the landscape using 1) liquid boric acid bait stations, 2) solid bait stations, and 3) with broadcast baits. This will be conducted on large yards of property

	owners and public parks within infested areas. We expect to develop four educational products as part of this project: 1) a web-based key to pestiferous ants in the NE urban/suburban landscape, 2) a set of voucher specimens to be distributed to the appropriate extension personnel within each state in the region; 3) a factsheet on biology and management of pestiferous ants in the urban/suburban landscape; and 4) a fact sheet on management of *M. rubra*. Fact sheets will be available on the websites of each of the participating institutions. We expect these sites to be heavily utilized through the spring, summer, and fall in the NE region by homeowners and school officials, park managers and businesses.

Approach and Procedures

Research:
Objective R1**.** *Evaluate "least toxic" strategies for homeowners and businesses for management of the European fire ant, M. rubra, using bait station strategies.*

To develop bait station strategies for management of *M. rubra,* we will first determine the distance that workers will forage over time from their nest to a food source in order to determine the maximum spacing between bait stations which will provide suitable distribution of the bait per area. To determine the appropriate duration of baiting, we will first quantify in the laboratory the maximal rate of transfer of bait from foragers to the remainder of the colony with both liquid sucrose bait and solid oil/protein bait. Then, using a single bait type, we will similarly evaluate the transfer of bait in a more natural setting in the field where there are likely to be competing food sources. We will use the results of these experiments to design bait station strategies for both liquid sucrose bait with boric acid and solid oil/protein bait of two commercial toxicants, hydramethylnon and fipronil. These strategies will be compared in a large field trial with a broadcast insecticide standard (hydramethylnon) for which we have had previous success, and an untreated control. Specific sub-objectives and details of experiments follow:

a*) Determine the effective land area serviced by an individual bait station.*

A field study will be conducted to determine the spread of bait from feeding stations throughout an *M. rubra* population using the marking technique developed by Vega and Rust (2003). The spread of liquid bait[4] will be assessed by deploying a single feeding station at each of 4 sites. Stations will consist of a KM AntPro liquid bait dispenser filled with 0.01% Fluorescent Brightener 28 + NaOH in 50% sucrose solution. We have found that *M. rubra* will readily feed at these dispensers when baited with sucrose solutions. Ants will be fed the marked solution for 2 weeks. The spread of bait throughout the population will be monitored by collecting foraging ants at set distances from the bait station over time. Ants will be collected by deploying 20 ml

[4] This experiment is designed to measure foraging distance. We expect the foraging distance to be independent of food type, therefore we propose to limit this experiment to one bait type.

scintillation vials with gauze soaked in 25% sucrose for 30 min. Initial collections will be made at 2, 4, 8,16 and 32 m from the station after 24 hrs of feeding. Five vials will be deployed per distance from each bait station and 5 individual ants will be randomly collected per vial for processing. Subsequent samples will be collected at 3 d and 1, 2, 3, and 4 wks post deployment, and at increasing distances based on the previous sample date results. (Vega and Rust (2003) reported the longevity of this marker in Argentine ants to be at least 60 d with no marker related mortality. We expect a similar longevity and low mortality with *M. rubra*, but preliminary tests will be conducted to confirm this.) Individual ants will be tested for the marker using TLC plates observed under long-wave UV light as described by Vega and Rust (2003). This experiment will be initiated in June of year 1. Data will be analyzed with non-linear regression to determine optimal bait station spacing in the field (Stubbs and Drummond 1997).

b) Determine the time required for successful transfer of bait from foragers to the rest of the colony.

The rate of transfer of bait through trophallaxis from foragers to other workers and larvae within the nest will determine the delay of mortality needed for a toxicant to be effectively distributed throughout a colony. The maximal rate of transfer will be evaluated in the laboratory with five *M. rubra* colonies collected from the field. Two standardized subsets consisting of three queens, approximately 300 workers and 2.5 grams of brood will be collected from each colony. The workers and brood will be anesthetized using CO_2 and measured by weight. Each subcolony will be transferred into clear plastic nest boxes similar to those used in 2004. These consist of a main nest chamber (24 x 17 x 9 cm^3) connected to a foraging chamber (12 x 10 x 4 cm^3) via a 36 cm plastic tube. The sides of both the main nest chamber and foraging chambers are coated with Fluon and the boxes are fitted with clear plastic lids. The main nest chamber contains two inverted plastic pots covering moist sponges for brood chambers. Subcolonies will be starved for three days after which one subcolony from each of the five nests will receive a food bait containing either unprocessed peanut oil dyed with calco blue (1% wt:wt in oil) on a solid based bait (Oi et al. 2000), and the other sub-colony will receive 1% Nile blue A (88% dye content) in a liquid sucrose-based bait. The baits will be introduced into the foraging chambers. The rate of transfer of bait through the colonies will be determined by examining workers at 40x magnification outside the brood chambers and workers and larvae within the brood chambers at 6, 12, 24, 48 and 96 hrs after introduction of dyed bait. Repeated measures ANOVA will be used to compare the spread of bait over time through the colonies with the different bait types[5].

c) Field test the optimal bait strategy for management of M. rubra.

A large-scale field trial will be conducted comparing the KM AntPro liquid bait dispenser filled with a sucrose-based boric acid bait with the Maxforce Outdoor Refillable Bait Stations

[5] Preliminary experiments will be conducted in which workers are pulse fed each of the dyes in order to determine if the rate of uptake and persistence in the body tissues varies between the calco blue and Nile blue A. If significant differences are found, separate analyses of bait transfer over time will be run for the different baits.

(MORBS)[6] filled with either the commercial solid bait formulation of hydramethylnon (Amdro®) or fipronil (Maxforce®) using the density of bait stations necessary to provide exposure of all colonies within a plot over a period of 3 weeks. These bait station treatments will be compared with a broadcast application of hydramethylnon and an untreated control, resulting in five treatments: 1) KM AntPro liquid bait dispenser filled with a sucrose-based boric acid bait, 2) MORBS filled with hydramethylnon, 3) MORBS filled with fipronil, 4) broadcast application of hydramethylnon, and 5) an untreated control. Each of these treatments will be replicated in four 0.25 ha infested areas on Mount Desert Island (similar to the large scale field study conducted in 2003-2004). A completely randomized design will be used with pre-treatment measures of ant foraging strength, monitored with sucrose baited vials, used as a covariate. Our previous studies have found that 20 sucrose-baited vials per site provide estimates within 20-25% precision for commonly observed densities of 30-60 ants per vial. (Figure 7). After application(s) of treatment materials all plots will be monitored every three weeks for worker activity throughout the summer by deploying 20 sucrose baited traps / plot for a two hour time period. A RCB repeated measures ANCOVA will be used to detect differences due to treatment on worker ant foraging force.

Extension:

***Objective E1**. Survey pest control operators in participating states and extension workers throughout the NE region to determine the most commonly reported species of ants causing problems for homeowners, businesses and schools in the NE.*

Specimen mailers consisting of a 20 ml plastic scintillation vial filled with 10 ml of 70% isopropyl alcohol, a whirl-pak plastic bag with vermiculite, and a preaddressed, padded envelope will be distributed to pest control operators at workshops organized in the three participating states (ME, NY, DE). All-day workshops will be organized with presentations by the PD's and invited consultants on the biology and current pest management practices for pestiferous ants in the urban/suburban landscape. Workshop attendees will be asked to use the specimen mailer to return samples of ants that they encounter on service calls for homeowners and businesses within the state. A brief survey will be included with each mailer to acquire information on the nature of the pest problem (stinging, nuisance, etc.), habitat characteristics, the location of the ants and nest (if known), and the duration of the problem. Additional mailers will be distributed to participants in school IPM program meetings, and any other similar venues in each of the states. Five hundred samples per state will be solicited.

University of Maine PD's will compile a set of voucher specimens for pestiferous ant species for each of the participating states such that the specimens mailed back to the home institution within each state can be identified by a local student worker. Any samples that are too difficult to identify will be sent to the University of Maine, where project personnel will consult experts at the Harvard Museum of Comparative Zoology and other institutions if necessary.

In addition to specimens collected directly, attempts will be made to contact extension offices within the NE region to gather and compile any additional data that may exist on the identification of pestiferous ants submitted by homeowners and businesses within the region.

[6] Preliminary experiments will be conducted to ascertain that *M. rubra* foragers will recruit to MORBS during year one. If not, other solid bait stations designs similar to those presented by Tollerup et al. (2004) will be evaluated.

This data will be added to that from the samples that we collect to compile a listing of the most frequently occurring pestiferous ants in the urban/suburban landscapes in the NE region.

Objective E2. *Develop a web-based key to the common ant pests in urban/suburban landscapes in the NE region*

A dichotomous key will be developed to differentiate the ants that were found in our survey to commonly cause problems for homeowners, businesses, and schools in the NE region. The key will be based on the ants' morphological characters, nesting habits and pestiferous nature. It will include line drawings and digital photos of morphological characters with definitions of anatomy, and be designed for "ease of use". This key will be posted on the web and access information and a set of voucher specimens will be distributed to extension personnel throughout the region.

Objective E3. *Develop and distribute web-based and printed materials for homeowners, schools, and businesses (including pest control operators) on common pestiferous ants in the urban/suburban landscape and their management.*

**Particular emphasis will be directed towards raising the awareness of the biology, ecology, potential spread and methods of managing M. rubra. Products and activities will also be designed to allow us to further track the spread of this pest.*

Information about the biology/ecology and management of the pestiferous ants in the urban/suburban landscape will be compiled and developed into web-based factsheets for schools, homeowners, PCO's and other businesses. A particular factsheet will be developed on *M. rubra* management, which will include recommendations based on the research conducted as part of this project. In addition, updates will be made to the current web-based version of the factsheet on the biology and potential spread of *M. rubra* in the NE region. An initial printing of 3,500 copies of factsheets will be made and distributed throughout the NE region for the Pest Management Industry, schools, Extension, and Master Gardener programs in the NE states, as well as Horticultural industry annual meetings. These will include directions to further information that will be available on each of the cooperating institutions' webpages, including at UMaine: Pro New England (http://pronewengland.org/PROInfo.htm), Cooperative Extension Pest Management (http://www.umext.maine.edu/topics/pest.htm), and Maine Master Gardener (http://www.umext.maine.edu/mgmaine/welcome.htm) websites; Maine Department of Agriculture: Board of Pesticide Control (http://www.state.me.us/agriculture/pesticides/gotpests/), School IPM (http://www.state.me.us/agriculture/pesticides/schoolipm), and Agricultural, Natural, and Rural Resources IPM (http://www.maine.gov/agriculture/oanrr/IPM.htm) websites; at Cornell: the NYS IPM website, Entomology diagnostic lab fact sheet web site and the Cornell Gardening web site; and at Univ. of Delaware: Cooperative Extension Urban Entomology Program website (http://www.ag.udel.edu/extension/pesticide/urbanentomology.htm)

Table 2. Timetable for completing research and extension objectives.

Objective	Task	Time frame
R1.a.	Conduct field experiment	June-July 2006
R1.b.	Conduct laboratory experiment	July-August 2006
R1.c.	Conduct preliminary evaluations on utilization of MORBS by *M. rubra.*	July 2006
R1.c.	If necessary, evaluate other solid bait station designs	August 2006
R1.a & R1.b.	Analyze and write-up data	Sept.-Oct. 2006
E1	Conduct PCO workshops and distribute survey materials in each of the participating states.	Nov. 2006-Feb. 2007
E1	Collect samples and identify specimens	March 2007-Nov. 2007
R1.c.	Conduct large field study	June-Sept. 2007
R1.c.	Analyze and write up field data	Sept-Oct. 2007
E2	Develop key to pestiferous ants	Nov. 2007-Jan. 2008
E3	Develop fact sheets and web pages on pestiferous ants, distribute information.	Jan.-May 2008

Evaluation Plans

The primary deliverable products from this project will be "least toxic" strategies for management of the European fire ant, *M. rubra*, in urban/suburban landscapes in the NE, and several educational and training tools on pestiferous ants in the urban/suburban landscape for industry, extension, and general public use. We have designed our research so that the results from the research objective will be applicable to managing the ant for a variety of stakeholders, NE pest control operators, municipal, state and national park managers, area businesses and homeowners. If the boric acid management strategy is effective, products currently being marketed for other pestiferous ants (such as Terro Ant KillerII®) may be adapted for use, or the materials (sucrose, borax) are readily available for people to mix and apply on their own. The solid bait products are also commercially available. Given that we regularly receive requests for non-insecticide and least toxic management options for *M. rubra*, we believe that if effective, these strategies would be rapidly adopted by people in communities currently plagued with this pest, especially since current "off the shelf" insecticides are not working.

We will be providing clientele with the informational materials needed for identification and management of pestiferous ants via several different outlets (fact sheets, presentations, and web pages). Webpages will be designed to record the number of times that they are accessed and downloads and distribution of factsheets will be tracked.

The ultimate success of this project will be measured by the future spread of *M. rubra* in the NE, and reduction in broadcast insecticides for control of pestiferous ants in the urban/suburban landscape. PDs will be involved in continual monitoring of the spread of *M. rubra*. The webpages will include an on-line comment form that will allow both homeowners and industry members to pose questions and make comments regarding *M. rubra* and other species of pest ants.

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APPENDIX TO PROJECT DESCRITION

- *Myrmica rubra* Factsheet -

KEY PERSONNEL

PD: Dr. Groden, Assoc. Professor of Entomology, **University of Maine**, will coordinate the project, and will work with other collaborators to plan and execute the PCO workshop, ant survey, and development of subsequent extension materials on pestiferous ants.

Co-PD: Dr. Drummond, Professor of Entomology/Extension Specialist, **University of Maine,** will assist Dr. Groden in planning of extension products.
Drs. Groden and Drummond will plan all field and laboratory research and will direct the post doctoral research associate and student workers. **The Post Doctoral Research Associate at the University of Maine** will carry out the laboratory and field research and will assist with the PCO workshop, distribution of survey materials, identification of the samples, and development of the extension products.

Co-PD: Ms. Carolyn Kass, Senior Extension Associate, Cornell University, will be responsible for subcontractual commitments with Cornell University: this will include: working with Maine PD's in the organization and execution of the PCO workshop in NY; distribution, collecting, and processing of survey materials (including overseeing student workers); consulting with co-PD's on development of extension products; and distribution of extension products in NY.

Co-PD: Dr. Susan Whitney King, **Extension Specialist IV, University of Delaware,** will be responsible for subcontractual commitments with University of Delaware: this will include: working with Maine PD's in the organization and execution of the PCO workshop in DE; distribution, collecting, and processing of survey materials (including overseeing student workers); consulting with co-PD's on development of extension products; and distribution of extension products in DE.

All PD's will be responsible for submitting information for reports and writing or overseeing presentation and publication of results.

<u>Other Collaborators:</u>
Dr. James Dill, **Extension Specialist Pest Management**, **University of Maine,** will assist with planning and conducting the PCO workshop in Maine and collaborate with development of web-based materials and links to existing pest management websites.

Dr. Kathy Murray, IPM Entomologist and Maine School IPM Program Coordinator, **ME Dept. of Agriculture, Food and Rural Resources**, will assist with the planning and conducting of the PCO workshop and survey of PCO and school IPM participants in Maine, and assess with distribution of final project products in Maine.