THE INTEGRATED PEST MANAGEMENT PLAN

CREATED FOR BAKER'S BAY GOLF AND OCEAN CLUB

BY THE ENVIRONMENTAL MANAGEMENT TEAM

OF THE UNIVERSITY OF MIAMI

1.0 INTRODUCTION AND INTEGRATED PEST MANAGEMENT (IPM) OVERVIEW

Living on small tropical islands poses a unique set of constraints made even more poignant when challenged with a proposed client base of wealthy, foreign homeowners and holiday-makers. Potential clients are capable of paying high prices for beauty, and thus expect a concomitant level of personal comfort. A supply of adequate freshwater and achievement of proper waste disposal (particularly sewage), are widely recognized challenges. Furthermore, high temperatures, humidity, and the presence of biting insects can all serve to reduce the attractiveness of the resort as a venue and, in the absence of effective solutions, could render the project unsuccessful from a business standpoint. Additionally, the presence of pests and parasites (such as rats, cats, and scale insects) capable of displacing or decimating native flora and fauna pose a significant threat to the goal of conserving and promoting biodiversity on the property.

The Baker's Bay Club (BBC) Development project on Great Guana Cay, Abacos, The Bahamas prioritizes the incorporation of modern and environmentally-sensitive technologies to minimize negative impacts on natural communities (EIA, 2005). To facilitate these priorities, the project developers ((Discovery Land Company (DLC)) are working with the Biology Department at the University of Miami to implement an Environmental Management Plan (EMP) created for the BBC (Sealey et al, 2005). The EMP focuses on sustainable development and minimizing and monitoring potential ecological impacts from construction, waste disposal and pest management. The Integrated Pest Management Plan (IPM) developed for BBC addresses the problem of biting insect, rat, cat, and plant-parasite insect populations. The IPM presents guidelines for the project to achieve acceptable low levels of pest populations without compromising the environmental integrity of both the site and project goals.

IPM is a widely used and Flint et al. (1991) published a guide for public agency-directed pest management plans, and defined IPM as:
"...a pest management strategy that focuses on long-term prevention or suppression of pest problems with minimum impact on human health, the environment, and non-target organisms. Preferred pest management techniques include encouraging naturally occurring biological control, using alternate plant species or varieties that resist pests, selecting pesticides with lower toxicity to humans or nontarget organisms; adoption of cultivating pruning, fertilizing, or irrigation practices that reduce pest problems; or changing the habitat to make it incompatible with pest development. Broad spectrum pesticides are used as a last resort when careful monitoring indicates they are needed according to pre-established guidelines."

Typical IPM programs use a combination of resource management techniques including source reduction, habitat modification, biocontrol, larvicides and adulticides. These techniques are based on surveillance data compiled with the need and timing of application in mind. Continuing education for both employees and the general public is also an important component of most mosquito-control programs (IFAS, 2005). The goal of the Integrated Pest Management program at BBC is to:

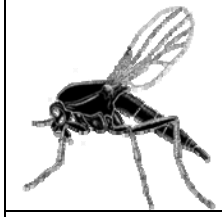
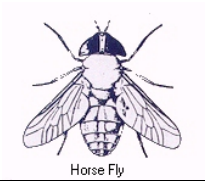
"**achieve a desirable level of insect population densities that does not impinge upon the personal comfort of guests and residents, or upon the natural environment of Guana Cay**."

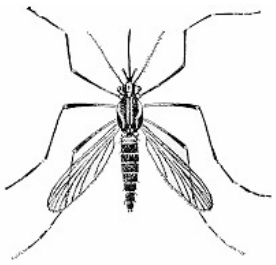
2.0 BITING, AIRBORNE INSECTS BIOLOGY

A. THE PROBLEM

Samples of all pest species at the Guana Cay site should be collected and properly identified by qualified entomologists before commencing any management program. General information on life history and habits for species of concern is provided in Table 1.

Table 1: Pest Biology

BITING INSECT	Life Cycle/Habits
Biting Midges ("No Seeums") Order Diptera 	These flies are commonly called sandlfies or no-seeums in The Bahamas, although they are technically biting midges. True sand flies belong to the Phlebotimine family and are a vector for Leishmaniasis in the regions where they exist such as the Middle East. Adult Biting midges are less than 1/16" long, dark gray to black in color and have one pair of spotted wings. They are small enough to enter dwellings through ordinary 16-mesh window screen. Breeding sites include saltwater wetlands, such as salt marshes and mangrove swamps, freshwater wetlands and tree holes. Larvae are found in mud, sand, and debris around the edges of damp areas including aquatic features and moist vegetation. In the water they are free swimmers and are commonly found on floating twigs or leaf trash. The larvae pupate on floating debris or at the water's edge and, like mosquitoes, the adult females require blood to mature the eggs. Males do not bite. Biting activity is closely related to air movement and much reduced in greater wind speeds. Biting midges are also sensitive to temperature and attracted to animals with higher body heat.2
Horse flies (Doctorflies) Order Diptera, Family Tabanidae, Tabanus spp. (tbc)  Horse Fly	Adults are ¼" to 1¼ " long, and usually exhibit clear or solidly-colored wings and brightly colored eyes. Batches of 25 to 1,000 eggs are laid on vegetation over water or wet sites. Eggs hatch in 5-7 days, and larvae feed upon decaying organic matter or small organisms in the soil or water. The larval stage lasts from one to three years, depending on the species. Mature larvae crawl to drier areas (typically 1-2" below the soil surface) to pupate and emerge as adults, a process lasting about 2 weeks. Adults can live anywhere from 70 days to 2 years depending on the species.3 Doctorflies are typically a seasonal problem (spring/early summer) in The Bahamas. They are daytime feeders and easily cut the skin, hence the name because, like doctors, they "take your blood." They are common in sunny areas and can be problematic at the beach or on boats. They are attracted to such things as movement, shiny surfaces, carbon dioxide, and warmth.

Mosquitoes Family Culicidae of the order Diptera.  *Drawing of Aedes aegypti, USDA.*	Species most likely to be present at Bakers Bay are *Aedes aegypti* and *Culex quinquefasciatus (*Dyar & Knabb, 1915*).* The crab hole specialist *Deinocerites cancer* is also potentially found on site, given the high numbers of land crab burrows (O'Meara, 2005). The salt marsh mosquito *Ochlerotatus taeniorhynchus* is also suspected to occur on the property, based on presence of suitable habitat for its proliferation. Permanent and standing water species deposit eggs directly on the water surface, and these may hatch in one to four days, depending on temperature. Floodwater and container-breeding species deposit their eggs on moist soil or other wet substrates. These may hatch within a few days after being flooded, or the fully developed larvae remain within the eggs for up to a year or more depending on immersion conditions. Larvae (also known as "wigglers" or "wrigglers") live in the water breathing from the surface via a siphon or air tube. Larvae develop from three to four days up to several weeks and molt to pupae, which are often called "tumblers" (due to their rapid, tumbling-like movement when disturbed). Pupae breathe through two respiratory "horns" when at the water's surface, do not feed and typically transform into adults in two or more days. Adults are terrestrial and capable of flight. With piercing-sucking mouthparts, the females feed mostly on animal blood and plant nectar. Adults may remain within a few hundred feet of where they spent the larval stage, although some species may migrate up to 50 miles or more. Eggs develop a few days after females take a blood meal. Females oviposit, and the cycle repeats itself. *Culex* mosquitoes are weak fliers (capable of traveling up to 2 miles), but painful and persistent biters preferring to attack at dusk and after dark. They readily enter dwellings for blood meals. They usually only live a few weeks during the summers. *Deinocerites* sp. appears similar to mosquitoes of the genus *Culex*, but differs by having much longer antennae. Birds, particularly Ciconiiforms, serve as the primary blood source, and there is no evidence to suggest that they are particularly bothersome to humans. Both males and females obtain sugar meals from floral and other plant sources. Adults find refuge in the crab burrows and eggs will be laid in accumulations of water at the bottom. *Ochlerotatus taeniorhynchus*, the salt-marsh mosquito, is likely to be the most important pest species on the island. They use the high marsh areas to lay their eggs in cracks and crevices, where they will dry out, and then hatch with high tides or rainfall events. They can migrate >50 miles and may, at times, immigrate from surrounding islands.[1]

[1]University of Florida and the American Mosquito Control Association Public Health Pest Control WWW site at http://vector.ifas.ufl.edu/. [2]Med Vet Entomol. 2004 Mar;18(1):71-80. [3] Tabanids (horseflies) Sean Strother,* Dermatology Online Journal 5(2): 6

2.1. BITING, AIRBORNE INSECTS PLAN COMPONENTS

A. SURVEILLANCE / MONITORING

The first responsibility in any pest control application is to complete an ecological characterization of the targeted pest. Confident identification and detailed knowledge of habitat usage, feeding habits, resting places, approximate times of activity, mating habits, and egg deposition are essential before procedures are instituted to control a pest organism. Entomologists and insect control professionals know from experience that a lack of understanding of pest behavior often leads to ineffective control measures and unnecessary exposure of the environment and non-target organisms to control mechanisms, such as pesticides.

Effective, efficient, and environmentally-sensitive mosquito control organizations conduct their operations of pesticide application based on surveillance to ensure that the application will have maximum effect on mosquitoes with minimal effect on the environment. **Timed release** of pesticides into the environment, with no biological surveillance or human decision making to assess the need and impact, **is NOT** a part of a responsible mosquito control application. Therefore, it is against good mosquito control practices to advocate automatic release of pesticides simply based on a timer.

Surveillance Methods should focus on:

- Proper identification of the pest species;
- Considerations of species behavior;
- Population density monitoring; landing rates, trap counts, larval development; and
- Weather monitoring.

Why is surveillance and precise identification of target species important?

- Effective and efficient mosquito control programs respond to mosquito density. **Applications of mosquito adulticides are inappropriate if there are no adult mosquitoes present at the time of the application.**
- **Proper timing** of any pesticide application is critical. Successful applications of a mosquito adulticide that specifically target resting or flying mosquitoes can be especially difficult to implement. The product must reach the mosquito in flight, or permeate the vegetation where the mosquitoes rest. The insecticide must come into direct contact with the mosquito, and be of a certain size droplet that has a high probability of actually hitting the insect. Those that are too big will drop before contacting the mosquito and those that are too small will go around the mosquito body without contact. **Every droplet of pesticide that misses a mosquito or has a low probability of contacting a mosquito is a waste of**

product and an unnecessary exposure of the environment and non-target organisms to an insecticide. Knowledge of pest behavior is crucial in order to time the application so that it will be most effective.

Timed release (i.e. predetermined scheduled spraying) can in turn contribute to insecticide tolerance and ultimately resistance of the insect, as well as excess chemical pollution to the environment. ***Indiscriminant, regular interval spraying*** **is not compatible with the environmental goals of BBC and thus** ***is not recommended.***

Problem Areas at BBC

1. Surrounding small islands, especially during periods of northwesterly airflow
2. Intertidal habitats, including mangroves
3. Areas of standing water, including freshwater wetlands and sinkholes
4. Damp sand in coastal areas
5. Heavy brush permitting accumulations of damp soil or water, such as within bromeliads (*Tilandsia* spp.)
6. Crab holes
7. Human-sourced refuse and trash such as tires, pots or other items which may retain vegetative debris and water.

Monitoring Plan

1) "**Surveillance data**" will be collected from insect light traps that are dispersed throughout the property. Insect Light traps (model 512) were purchasedfrom John W. Hock company (www.johnwhock.com). The traps are most accurate in catching adult flying insects when suspended approximately 5-6 feet above the ground and when located near known breeding sources and inhabited areas. The traps contain a battery-powered attractant light and Air-Actuated Gate-System which prevents the escape of any caught insects. The traps are fitted with insect collection bottles, and the bottles are retrieved daily for at least four days a week for identification purposes. The best catches are generally made during the dark of the moon or on overcast nights.

<u>On-going population monitoring</u>
Five locations are currently being monitored on a weekly basis to begin a comprehensive analysis of the intensity and seasonality of the problem at Bakers Bay. The traps are located at:

1. Locker room tent
2. Native nursery
3. Guana Seaside Village
4. Lot #94
5. Mangrove Preserve

2) In addition, larval populations should be monitored on a weekly basis using a dip net in existing or created open freshwater areas. As bacterial larvacides (*B.t.i* and Methoprene) will not work on larvae past the fourth instar stage, it is important know when late pupal stages or no larvae are present so as not to waste product.

Pest identification

All pest insects will be properly identified to at least family level, and preferably to genera or species. Biting insects captured in the Insect Light traps are being identified by Dr. Marcia Mundle, professor at the College of The Bahamas.

B. MANAGEMENT TECHNIQUES

Personal and Cultural Methodologies

Learning to live with some pests, unfortunately, is key to an environmentally-sensitive IPM plan. However, this endeavor is also recognized as a major challenge. Areas of focus for BBC are to:

- Design and publish attractive, easy-to-read guides to the environment at Guana Cay that may be disseminated to all guests on arrival. Guides should include details on the types of pests, and how to best protect oneself from them.
- Make topical, personal insect repellents freely available. Herbal alternative products (particularly those containing essential oil of lemon eucalyptus or Neem oil) should be included along with DEET containing repellents. Tests have shown that oil of lemon eucalyptus is more effective at preventing bites than the small concentrations of DEET commonly found in insect repellants, and this

alternative is recommended by the CDC and EPA as protection against mosquitoes, biting flies, and gnats.
- Wash fabrics and upholstery such as cushion covers, curtains, with a permethrin detergent.

Because of their potential toxicity in the environment, an important caveat to usage of pyrethroid chemicals, such as permethrin, would be to ensure the gray or wastewater produced from washing machines is properly treated and does not immediately soak away to the groundwater.

Infrastructure Issues

Planning and design are key components to minimizing chemical usage and dealing with pest problems. Site design options and recommendations include:

- Walkways and thoroughfares for future guests should be designed with pests in mind. Walkways should be short and wide through damp areas. Outdoor living spaces that are open and breezy will also prevent pest problems. Beach sitting / lounging areas should be positioned away from overhanging trees, and umbrellas used for shade instead.
- The undersides of wooden deck areas and boardwalks should be treated with a pyrethroid barrier product. These are attractive hiding places for mosquitoes and biting midges, and can be treated with barrier insecticides that typically last 3 – 4 weeks.
- The use of high quality, narrow-gauge screen to prevent biting midge intrusion is recommended. Screens should be frequently checked and maintained for maximum benefits.
- Biting midges are poor fliers, and proper airflow through the use of ceiling fans in indoor and outdoor spaces can reduce their ability to fly and land.
- Attention should be paid to proper sealing and caulking of all cracks to keep insects out.
- Exterior light fixtures should not be located directly above doors to decks or patios frequently used in the evenings. Flood or spotlights should be positioned a few feet away from the door, and direct the light onto porches and stairs. This light location will illuminate these areas safely and deter mesmerized insects away from doorways.
- Yellow bulbs in yard light fixtures are not as attractive to flies and moths as ordinary white light bulbs. Sodium vapor lighting also does not attract flying insects.
- Non-necessary containers capable of holding standing water should be eliminated.

Breeding Grounds - Larvicides

The application of larvacidal bacterial controls applied to mosquito breeding grounds is a widely-used tool. Larvacides are generally recognized as more environmentally friendly than the chemicals used to kill adult insects, because application methods are more localized. Yet, breeding grounds at BBC **are not localized**. Only a handful of depressional areas maintain standing water on site to which larvacides could be applied. The greatest expanse of breeding area is likely the intertidal shorelines, which exist all around the project site, in addition to adjacent habitats on the Abaco mainland. Therefore, the discrete application of recognized brands, with all quantities, times and results recorded is part of the IPM and will comprise treatment of wetland areas with granular Altosid (larvacide) hormone. Application areas will include the created wetland retention area.

Fogging / Misting Adulticides

A **precautionary approach** is emphasized with respect to all chemical applications at BBC. Pyrethroids pose slight risks of toxicity to humans and are identified as "slightly toxic" or "level 3" pesticides by the EPA (EPA, 2005). Inhaling high levels may bring about asthmatic breathing, sneezing, nasal stuffiness, headache, nausea, poor coordination, tremors, convulsions, facial flushing and swelling, and burning and itching sensations (Occupational Health Services, 1987).

While use of pyrethrin-based chemicals is an effective treatment for controlling populations of adult pests (primarily mosquitoes), effects on other species are not clearly understood. Research suggests that fish, amphibians and crustacean species may be harmed, at various life stages, through pesticide exposure (Smith and Stratton, 1986, Clark et al., 1989). Greulich and Pflugmacher (2003), showed symptoms of poisoning and morphological deformities in tadpoles exposed to cypermethrin and Gonzalez-Doncel et al. (2003), showed persistent sub-lethal effects, including lack of swim bladder inflation, in medaka fish (*Oryzias latipes*), particularly at late embryo stages. Perhaps of even greater concern is the potential for community and food web changes, such as could occur given the demonstrated effect on zooplankton such as the freshwater crustacean, *Daphnia magnis*, exposed to cypermethrin (Christensen et al., 2005). Sub-lethal effects shown in environmentally realistic concentrations of the pesticide in laboratory experiments included reduced feeding rates which could logically exacerbate blooms of phytoplankton, by reducing predation by crustacean zooplankton.

Misting systems are designed to deliver localized, species specific doses of insecticide to minimize exposure of either non-target species or areas. Precise pathways of pollutant transfer in coastal and island systems remains poorly understood (Sullivan-Sealey, 2005) and through operation, overspill, stormwater run-off or atmospheric

deposition, chemicals may reach the near shore marine environment where a Permethrin half-life of 14 days in sea water exposed to sunlight has been shown (Schimmel et al., 1983). Notwithstanding aquatic effects, a half-life of 28 days in soil has been demonstrated for Permethrin (Kaufman et al., 1977) along with a tendency to bind tightly to organic matter (Liu et al., 2001). Given the relatively short half-life it is unlikely that sediment adsorbed pesticide would reach near shore areas at BBC, however as increased run-off is a recognized factor associated with coastal construction, the consequences of chemicals reaching marine near shore areas, including seagrass and mangrove communities which are known nursery and breeding grounds for the young of many marine species, cannot be ignored.

Much of the research available on environmental impacts and fate of pyrethroid insectides has focused on freshwater and agricultural systems, (Christensen et al, 2005, Greulich and Pflugmacher, 2003). Due to the proximity of coral reefs, seagrass beds and mangrove communities to areas of north Guana Cay that will be affected by the proposed work and our lack of certainty that adulticide application for insect control can be carried out in the absence of knock-on environmental effects, it would be irresponsible to wholeheartedly endorse a large-scale misting program.

Treatment of adult populations at BBC using pyrethroid based chemicals is recommended only as a last resort. Regular monitoring (section 4.1.2) must be undertaken and results logged prior to spraying. Where more than 20 landing mosquitoes on a monitor's forearm are counted in a 5 minute survey period, use of stationary foggers and backpack misters will be carried out. Chemicals may include 30-30 permethrin, diluted with mineral oil and foggers should be operated for no more than 10 minutes and not in wind speeds of over 10 knots or rain conditions. Backpack spraying is a preferable alternative as operators can focus on areas frequented by guests. Backpack spraying can supplement fogging/misting in high population conditions and be carried out prior to social events such as early evening gatherings or other functions.

CO_2 TRAPS/MOSQUITO MAGNETS

Mosquito traps emit CO_2 and/or other chemicals as human mimics to lure mosquitoes close to the trap and suck them in with a vacuum or trap with an adhesive. The technology is relatively new; commercial units have been on the market since the 1990's and research into attractiveness of humans to mosquitoes, as well as species-specific attractants to refine and improve methodologies, is ongoing. Traps or magnets can be effective in capturing large numbers of mosquitoes, and are recognized as a low impact, non-invasive, and non-polluting technique. Yet, data on species and range is essential in order for the traps to be effective. Traps are usually only successful in capturing species which breed close to the treatment site, and not those species which may fly up to 50 miles from breeding grounds. Careful placement of traps between mosquito

sources and human activity is important, and efficiency is greatest when they are run continuously.

There are no peer-reviewed, scientific publications that show the devices to be effective for actually controlling mosquitoes, reducing their populations, or reducing biting rates (IFAS, 2005). While traps can help, they cannot be relied upon exclusively for mosquito control (Rutledge, 2005) but are considered an environmentally safe component of the IPM for Bakers Bay.

SUMMARY: SURVEILLANCE AND TREATMENT SCHEDULE

Surveillance

1) Initial sampling and identification of pest species.
2) Weekly or daily landing tests to collect data on biting insect population levels and intensity of the problem

Treatment

Logs of all chemical applications should be maintained.

AS NEEDED	DAILY	WEEKLY	MONTHLY	QUARTERLY	SURVEILLANCE BASED
Guest education (on arrival)	Beach raking	Treatment and maintenance of screens, beach upholstery	Clearing of underbrush from heavily trafficked areas	Larvaciding of on-site wetlands	Back-pack spraying
Operation of CO_2 traps		Clearing of all potential breeding sites (trash and debris) from property	Check screens and buildings for incursions		Operation of foggers

3.0. OVERVIEW: NUISANCE PESTS AND VERMIN

While biting insects directly affect the comfort levels of resort guests and employees, several less obvious pest species live on the island and can impact either human health and/or the islands ecology. Islands are, by their nature, vulnerable to invasions by alien species due to their isolation and fostering of small, unique populations that are specially adapted to harsh island conditions, but are generally poor competitors. Activities associated with the planned development at Bakers Bay may exacerbate an existing situation or introduce new problems. This section describes such invasive species of concern, along with recommended methods of environmentally-considerate population control.

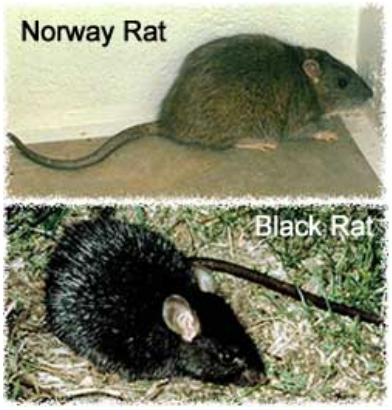
Species recommended for control by the BEST Commission (2003) are rats, feral cats, and dogs. Methods for controlling generally undesirable species, such as cockroaches and house flies, are also discussed.

BEST Commission (2003), *The National Invasive Species Strategy for The Bahamas*. BEST, Nassau, The Bahamas, 34 pp.

3.1. RODENTS

A. THE PROBLEM

Rats and mice have been among the first and most successful predators introduced to islands by humans (Martin et al. 2000). Rats often prey on shorebird eggs and other indigenous fauna, thus contributing to population stress and overall lower environmental quality. Their impact on bird species is particularly significant, as islands containing rat infestations also host lower bird diversity (Campbell 1991). Rats and mice are capable of inflicting damage to structures via gnawing on structural components including wiring, wood, and plastics. The gnawing on wire insulation can result in electrical shorts and fires, and impair machine functioning (as was previously evidenced by rats gnawing through the wires connecting the original weather stations at the Baker's Bay Club native nursery). Successful rodent eradication plans have been implemented in the Caribbean, and in The Bahamas (at Sandy Cay, Exumas).



http://www.aaanimalcontrol.com/Professional-Trapper/howtogetridofrats.htm

Great Guana Cay harbors the two most common species of rats – the Black Rat (*Rattus rattus)* and the Norwegian arboreal rat (*Rattus norvegicus)* and the House Mouse (*Mus musculus*). These three species are nocturnal, and have short generation times and are thus capable of high population numbers.

B. CONTROL METHODS

The haphazard placement of rat poison pellets and rodenticides are not recommended due to their harmful effects to resident Land Crab populations and impaired ecological stability by introducing additional foreign chemicals into the environment. Baited rat traps are most effective and the most ecologically-sound method of controlling rodent populations. Snap traps, which employ a trigger-induced killing mechanism, are commonly used in determining small mammal population densities in scientific studies and employ bread soaked in fish oil for bait (Igual et al. 2006).

The traps recommended for use are called **Protecta Bait Stations**, and are also currently utilized on the University of Miami campus. These boxes can be outfitted with commercially-available poison rodent bait and snap traps, and are available at http://www.pestcontrol-products.com/rodent/#lowprofile. Bell Laboratories, Inc. produces the Protecta Bait Stations and Fastrac bait, a non-anticoagulant containing Bromethalin that attacks the central nervous system. The Bell Laboratories website reports that 7-8 grams of bait will kill a rat, while 2.5 grams will kill a mouse.

The small entrance hole to the Protecta Bait Stations will prevent Land Crabs from entering the traps. The traps should be placed flush against edges, near active holes and cracks, or any frequented areas or areas where fecal pellets have been observed. Rats seem to be most trappable before the moon is half full (Fry 2001), but traps should be left out continually.

Prevention Measures: Rodents may be best prevented from returning after eradication measures are undertaken through proper sanitation and maintenance techniques, in addition to ongoing trapping. The following measures are recommended by the Department of Entomology at Virgina Tech (Fisher 2003):

- Store food (including pet food and grains) in glass, metal, or thick plastic containers with tight fitting lids.
- Promptly and thoroughly clean up any spilled food materials.
- Garbage is often the main source of food for rats and mice. Keep all trash receptacles tightly covered and empty them often. Plastic trash bags will not keep rodents out so remove trash daily.
- Remove any ready water sources. Fix leaking pipes, faucets, or irrigation systems. Also, if possible, remove standing water found in ditches, depressions, or other similar situations.
- Remove fallen fruits and nuts from any outside trees.
- Trim trees, bushes, grass, vines, or any other plants at least 12 to 18 inches away from the structure.
- Seal any holes and cracks within the siding of the building that can be used by rats or mice to gain access into the structure. In a rodent management program, the best materials to use when sealing large holes and cracks include 1/4-inch hardware cloth, 19-gauge or thicker sheet metal, plaster, or mortar. Smaller holes can be sealed using caulk or copper wool. Remember to look for holes in the building at every height, not only in the first three feet above the ground. Rats and mice will also enter a structure via

the eaves, the roof, the attic vents, and where pipes and wires penetrate the walls and roof.
- Weather strip around doors and windows and if possible, use raised metal doorsills.
- Seal air conditioning units well. These units provide warmth, a nesting site, and a ready source of water.
- Repair broken sewer pipes. Rats will dig into and use broken sewer pipes as an entryway into a structure.
- Cap drains with perforated caps that are firmly attached to the floor.
- Clean up storage areas and other cluttered spaces, thus reducing nesting sites and protected places where rodents feel comfortable moving around.
- Remove woodpiles, rock piles, and any other outdoor heaps of materials that may provide nesting sites for rats or mice.

C. SUMMARY: SURVEILLANCE AND TREATMENT SCHEDULE

Surveillance

1) Initial sampling and identification of pest species. Both the on-site EMT and the University of Miami EMT have already identified the two rat species present on the property as the Black rat and the Norwegian Arboreal rat.

2) Sitings or reports of rat presence by any staff member (particularly nursery staff members) should be recorded for population tracking purposes.

Treatment: Logs of all bait station locations, bait employed and the date trapping initiative began should be maintained. Trapping should be conducted CONTINUALLY regardless of visible signs of rat presence on the property.

DAILY	WEEKLY
Check Protecta Bait Stations for captures	Refresh bait source employed, if necessary

3.2 FERAL CATS

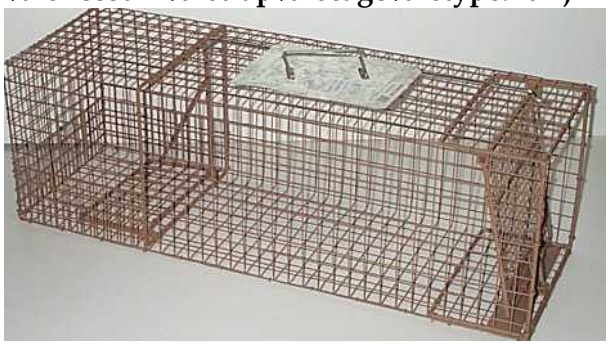
A. THE PROBLEM

Feral or stray cats have had significant impacts on biodiversity in island systems, and are listed as one of the 100 worst invasive species (Lowe et al. 2002). Feral cats are particularly problematic in decimating small mammal, bird, and reptile populations in islands; in The Bahamas, feral cats are attributed to reduced populations of Sandy Cay Rock Iguanas (Fry 2001), Grand Bahama Brown-headed Nuthatch (Hayes et al. 2004), the Bahama Parrot (Gnam and Burchsted 1991), and several Long Island bird species (Buden 1992). Although the literature contains no record of feral cat impact on land crab populations, such interactions have been recorded from other island systems (Alexander 1979, Algar et al., Merton et al. 2002) and therefore feral cats are most likely impacting Land Crab populations in The Bahamas. Additionally, cats are known hosts for a number of diseases and parasites, including *toxoplasmosis*, hookworm, and "ground itch." Conservation techniques employed to control cat populations on islands have been successful in preventing extinctions and restoring ecosystems in the past decade (and is reviewed by Nogales et al. 2004). In order to prevent further negative impacts on bird, reptile, and land crab populations on Great Guana Cay, control and eventual eradication of feral or stray cats is suggested.

B. CONTROL METHODS

Methods employed in cat population control include trapping (gin traps or cage traps), hunting (with dogs, rifles, or guns), poisoning, and viral disease introduction. Trapping has been cited as the most effective method employed due to its success on 44 islands (Nogales et al. 2004). Toxins and biological controls are reported to be most successful at the beginning of an eradication operation, while hunting and trapping proved to be most effective at eliminating all cats.

A Feral Cat Cage Trap (http://www.wapoultryequipment.com/CTCVT/Cat%20-%20Possum%20trap%20cage%20type.htm)



Traps employing bait as well as olfactory and auditory stimuli have been effective in controlling cat population on New Zealand; luring cats with Felid Attracting Phonic (FAP) producing cat call sounds, as well as blended mixtures of urine and feces allowed for the removal of 230 cats from Cocos Islands (Algar et al. 2003). Some cats were also hand-caught. Common cat baits used in traps include food items such as sausage and fish, and suspending bait serves to prevent non-target species from entrapment. Catnip and matatabi powder have also proved to be promising cat lures, and may be more effective than social odors, including urine (Clapperton et al. 1994).

We recommended use of a wire mesh snap trap, as pictured above. The traps should be 30" x 11" x 12", which is SMALLER than the traps previously purchased by the Bahamian government used for preliminary trapping purposes during July 2006. Smaller-sized traps will

prevent feral cats from hurting themselves during transit, and will enable easier handling of the animal after it is brought to Marsh Harbour.

Estimation of population size

Methods for feral cat population estimation have been described by Van Rensburg et al. (1987). The island study area is stratified into coastal and interior zones, and further divided into equal sized grid blocks.

Population size ($\hat{Y}$) is estimated as

$$\hat{Y} = \Sigma N_i y_i$$

where Ni is the total number of grid blocks in the *i*th zone and yi is the average number of cats observed or caught in each of the sampled grid blocks.

Cat with a marine iguana in its mouth.
Foto: Heidi Snell.

Fate of trapped cats

Feral cat health is generally low to moderate due to ease of parasite contraction and viral disease spread within family units. Reported gastrointestinal parasite rates have been reported as high as 45%, roundworms at 25 to 75%, hookworms at 10-60%, and *Giardia* at 5% (Urban Integrated Pest Management, University of Arizona). Feral cats are generally not recognized as natural rabies vectors, but can be exposed to the virus through wildlife attacks by other carnivores (rabies is not suspected to be prevalent on Great Guana Cay due to absence of suitable vector species). FIV and FeLV affects less than 2-4% of feral cat populations (lower than in domestic cats), and distemper is relatively rate in feral cats (SPCA).

C. CONTROL PLAN

Our goal is to eradicate feral cats on the island, and continue trapping to monitor the introduction of new cats. An pilot project conducted by the UM EMT during July 2006 employed 15 cage traps approved by Mr. Pinder, Director of The Bahamas Ministry of Agriculture. These traps were loaned by Mr. David Knowles, and were placed at various locations around the Baker's Bay Club property. The traps were baited with fish and catnip, and checked daily. Dr. Derek Bailey, a veterinarian based in Marsh Harbour, will continue to assist with cat sterilization and euthanization when necessary.

Captured cats will be sent to Dr. Bailey by the 3 p.m. ferry on the day they are caught. Tests for Feline Leukemia Virus (FeLV) and Feline Immunodeficiency Virus (FIV) will be administered, and any cats testing positive for either of these diseases or who show signs of intense parasite infections will be euthanized. Data collected on disease incidence will be employed in his ongoing study of disease spread on offshore cays. Healthy cats will be spayed or neutered (at $70 per cat for both disease testing and sterilization), and home placement attempts will be made in Marsh Harbour. Cats that are not placed will be released back into the field with notched ears to indicate previous capture.

Dr. Bailey's info:
Island veterinary Clinic
Dr. Derek Bailey
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RESULTS OF FERAL CAT TRAPPING PILOT PROJECT, JULY 2006

The BBC Environmental Management Team initiated the feral cat trapping project, as part of the Integrated Pest Management Plan, at the southern end of the Bakers Bay Property and Guana Seaside beginning 8 July 2006. Shenique Albury picked up 15 traps from Mr. David Knowles in Abaco prior to the arrival of the UM Environmental Monitoring Team and Earthwatch volunteers, who set and monitored nine traps to establish a protocol and synopsis of trapping methods. The traps received were large "Humane Box Traps" (Safeguard Brand 52842) measuring 42"x15"x18"H. The manufacturer suggests a smaller trap for cats; the traps employed in this initial project were designed for large raccoons.

Over the past two years, the UM EMT has recorded first the presence of feral cats around the Guana Seaside resort, and since January of 2006, a noticeable increase in cats not only around the resort but on the BBC property proposed preserve. The opening of roads and increased human activity on the BBC property may have facilitated feral cats to move north. The cats were seen as a significant threat to wildlife on the BBC property, particularly birds and small herpifauna. The EMT was particularly concerned with the threat of cats in the coastal buffer zone to emerging turtle hatchlings and nesting shore birds. The Integrated Pest Management Plan (IPMP) calls for the removal and control of both feral cats and rats on the BBC property. Although cats may not be an immediate threat to Bahamas parrots on Guana Cay, the experiences gained on this eradication project could help other groups starting to trap cats on Abaco.

Nine trap locations were selected where cats had been sighted near Guana Seaside and on to the southern edge of the BBC property. Traps were placed on the ground with vegetation cover. The traps were baited with leftover chicken, tinned corned beef, or tinned tuna fish and set in the evenings at approximately 6 pm. Traps were checked in the mornings at 7 am and closed during the day to prevent trapping. During the summer, the potential for dehydration and heat stress in trapped cats was considered, and thus trapping was only done at night. Trapped cats were secured in the traps and accompanied into Marsh Harbour to Dr. Bailey's office. Cats were tested for Feline Immunodeficiency Virus (FIV) and Feline Leukemia (FeLV), and euthanized if positive results were obtained. Healthy cats were either sterilized and returned to Guana Cay, or adopted out in Marsh Harbour. Pregnant cats were generally found to be in poor health and euthanized upon Dr. Bailey's recommendation.
Dr. Bailey and his veterinary staff were very concerned that the humane traps were too large to ensure the safety of cats and raccoons. Trapped cats were visibly stressed in the trap, and had sufficient room to injury themselves. Several cats were observed ramming themselves against the cage doors and inflicting cuts on the head and face. The veterinary staff often had difficulty injecting sedatives into the caged cats as they could easily move about the cages. Dr. Bailey recommended the acquisition of smaller cages with barriers capable of pushing trapped animals to one corner of the trap to enable easy injections of sedative through the cage. The Safeguard Company sells a smaller size trap specifically for cats (Humane Box Traps 53200 35"x11"x12" or

52830 30"x11'x12" (Safeguandm P.O. Box 8, New Holland, PA 17557 USA). Smaller cages would be easier to handle and reduce injury to the cats.

Feral Cat Trapping Initial Results:
Feral cats were caught both in the immediate vicinity of Guana Seaside as well as in the bush on the BBC property. Cats caught and fate:

- 9 July 2006: Pregnant female approximately two years old caught behind Guana Seaside Rental house; negative for FIV and FeLV; euthanized.
- 10 July 2006: Male approximately two years old caught in front of Guana Seaside former cook's house; positive for FIV; euthanized.
- 11 July 2006: Male kitten approximately two months old caught in bushes immediately behind Guana Seaside hotel building; negative for FIV and FeLV; adopted out in Marsh Harbour.
- 11 July 2006: Pregnant female approximately two years old caught behind Baker's Bay guard house; negative for FIV and FeLV; euthanized.
- 22 July 2006: Female approximately two years old caught next to Guana Seaside trash cans; negative for FIV and FeLV; spayed and released back into Guana Cay.
- 25 July 2006: Pregnant female approximately two years old caught at Lay-Down area; negative for FIV and FeLV; unborn kitten removed and kept by vet to be weaned and eventually adopted out, mother cat spayed and released back into Guana Cay.

Spayed cats to be released back onto Guana Cay have notched ears for identification purposes.

INITIAL OBSERVATIONS AND RECOMMENDATIONS FOR THE ABACO CAT ERADICATION PROJECT:
1. It is imperative that male cats be caught and either neutered or euthanized to control further feral cat population growth. The capture of male cats is likely to be more difficult due to their wilder nature and possible avoidance of traps. We recommend that the Baker's Bay Environmental Staff continue trapping efforts at key locations around the Baker's Bay property. Female cats that are pregnant or lactating will have high energetic demands, and thus will be more likely to be trapped.
2. Trapping around garbage dumps and feeding areas (e.g. of human occupation) is likely the easy part of addressing the growing feral cat population problem. Truly feral cats will avoid people and be much more difficult to catch. These wild cats are likely having the biggest impact on wildlife. A consistent and relentless trapping program will eventually prevent more cats from becoming feral and thus reduce threats to wildlife.

For Bakers Bay, suggested additional trapping sites include the Baker's Landing kitchen area and solid waste staging areas, as well as coastal zone sites where cat sightings have been reported. Trapping needs to be continuous.

3. We propose a community workshop in Guana Cay settlement to talk about the impacts of feral cats on both wildlife and the threat to domestic cats. We would wish to solicit dedicated volunteers to trap and neuter wild cats. Additionally, community workshops would be aimed at current Great Guana Cay resident education on the importance and justification of feral cat population control programs as a component of island stewardship. Cooperation of Baker's Bay staff, Ministry of Agriculture, as well as Guana community members, will further

contribute to successful population control initiatives if residents are advised against feeding feral cats, and urged to sterilize and collar any pets.

SPECIFIC RECOMMENDATIONS FOR BAKERS BAY

1. **Purchase 8 to 10 smaller traps immediately to continue trapping efforts.**
2. **Authorize staff to develop a trapping schedule to be maintained through the next year as part of the pest management programme.**
3. **Work with the Ministry of Agriculture to sponsor workshops for other groups to begin cat trapping with corporate sponsorship.**

There is a great need for public education on the impact of feral animals on wildlife as well as the threat of disease transmission to domestic cats. The trapping and transporting of the cats to the vet is labour intensive. The success of the programme will depend on community support and dedicated volunteers.

We found that MOST people supported the trapping initiative, knowing that the cats were to be treated humanely at the veterinarian's office, and supported neutering and release of healthy animals that are likely fed by humans. The UM EMT is currently developing a proposal to hold a community workshop on feral cat control in the Guana Cay community.

D. SUMMARY: SURVEILLANCE AND TREATMENT SCHEDULE

Surveillance

1) Sitings or reports of cat presence by any staff member should be recorded for population tracking purposes.

Treatment

Logs of all trap locations, bait employed and the date trapping initiative began should be maintained. The EMT recommends trapping schedules of one-week duration each month. Trapping should be conducted CONTINUALLY regardless of visible signs of cat presence on the property, particularly near the south side of the property.

EACH EVENING	EACH MORNING	MONTHLY
Refresh bait and set trap	Check trap for captures; if empty, close trap during the day	Conduct trapping regime for one-week duration

3.3. FIRE ANTS

A. THE PROBLEM

In addition to their undesirable nature as stinging pests, ants of the genus *Solenopsis* are some of the most invasive species on the planet. Fire ants feed directly on crop and landscape plants, and commonly protect other insects which do the same. Unsightly mounds also contribute to

road destabilization via removal of the soil by the ants. Fire ants are generally territorial and swarm when disturbed or threatened, yielding them capable of inducing multiple stings to passersby who might happen to stand in a nest.

The Bahamas hosts the tropical fire ant, *Solenopsis geminate,* as well as the invasive red ant *Solenopsis invicta*. The first collection of *S. invicta* in Abaco occurred in May 2000 (Davis, Vander Meer, and Porter 2001).

B. CONTROL METHODS

Identification of the fire ant species present in an area and determination of the density of active mounds are imperative prior to undertaking control measures. Ant population determination may be accomplished by collecting ants attracted to bait (the US National Park Service recommends using a piece of hamburger and honey placed in a piece of aluminum foil) placed 10 yards apart. The number of ants attracted to the bait per unit time would yield an accurate estimation of ant population size in the area of interest.

Successful elimination of a fire ant mound requires killing the queen. Simple measures such as dumping 3 gallons of boiling water into each mound have been reported to eliminate approximately 60% of mounds treated, and any surviving mounds should be treated again. The effectiveness of biological control agents, such as the parasitoid Phorid fly, is currently being investigated in conjunction with other pest control methodologies, but efforts conducted in control of South Carolina and Georgia fire ant populations have been promising. Field releases of the Phorid fly in Florida began in Spring 2000.

Chemical control of fire ants is ecologically appropriate when directed at individual mounds located in selected high human-use areas, as they require much less insecticide than broadcast treatment strategies. A summary of commonly-used chemical fire ant controls follows.

Chemical Agents for Fire Ant Control (summarized from www.nature.nps.gov)

Method	Comments
Mound drench	Mound drenches are most effective when conducted after rains when the ants have moved up within the mound in search of drier soil, and when applied directly onto and to the surrounding two feet of the mound. Mound drenches may be conducted with liquid or granular insecticides, and are applied at a ratio of 1 gallon insecticide per six inches of mound diameter.[1]
Mound Injection	Insecticides are directly injected into the mound using a "termite rig" with a soil injector tip. The mound is injected in a circular pattern, and may require further treatment with high temperature vapors to increase penetration of the product.
Baits	Baits consist of a toxicant, sterilant/toxicant, or a growth regulator, and are sprinkled around and on mounds. Application in The Bahamas will be most effective late in the afternoon or early evening during foraging times, and during dry spells as the bait must be kept dry.

[1]www.greensmiths.com/fireant

The EPA-certified and ecologically-friendly Safecide® IC (ortho-boric acid) is non-carcinogenic and contains no toxic residues. This compound may be applied as a powder or in spray form directly to fire ant mounds, and is recommended for regulated use on Baker's Bay property if non-chemical controls prove ineffective.

Preventative Measures
As ants nesting near buildings move through them via small cracks and crevices, appropriate caulking and/or sealing of such gaps will prevent population entry from public structures and houses. Fire ants are frequently imported in potted landscaping plants, and Baker's Bay Club's employment of native cultivation of landscaping plants on the island will prevent additional fire ant populations from establishing on the property.

C. SUMMARY: SURVEILLANCE AND TREATMENT SCHEDULE

Surveillance

1) Initial sampling and identification of pest species.

2) Identification of nest locations around the property.

Treatment

Logs of all nest locations, control measures employed, and any chemical applications should be maintained.

AS NEEDED
Treat nests with boiling water first; treat any persistent nests with recommended insecticide Safecide® IC or boric acid

4.0. PESTS OF HORTICULTURE

Within horticulture, an important component of IPM is controlling invasive species. In cooperation with the *The National Invasive Species Strategy for The Bahamas* (BEST Commission (2003)), Baker's Bay will work to control invasive species which may stem from:

> " 1. Intentional introduction of species for use in biological production systems, i.e. agriculture, forestry, fisheries and landscaping, as well as recreational and ornamental purposes and for biological control of pests;
> 2. Intentional introduction of species as a commodity for uses where there is a known risk of escape or release to the wild, i.e. zoos, aquaculture, mariculture, aquariums, **horticulture**, pet trade, etc.; and
> 3. Unintentional introduction of species through pathways involving transport, trade, travel or tourism" (BEST, 2003).

Chemicals will be used prudently and judiciously in nursery and golf course operations. Additionally, as outlined in the BBC Environmental Management Plan, a log book will be kept and submitted to the Environmental Management Team. These logs will be used to cater usage, applying chemicals as minimally as possible.

4.1. NURSERY OPERATIONS

The onsite nursery at BBC utilizes primarily native plants, importing species minimally. When imported species will be thoroughly inspected as BBC intends to adhere to the, "Voluntary Code of Conduct for Nursery Professionals", outlined in the, *The National Invasive Species Strategy for The Bahamas* (BEST, 2003).

Voluntary Code of Conduct for Nursery Professionals
From *The National Invasive Species Strategy for The Bahamas*.
B.E.S.T. Commission (2003)

1) Ensure that the invasive potential of plants is assessed prior to introducing and marketing a plant species new to The Bahamas. Invasive potential should be assessed by the introducer or qualified experts using risk assessment methods that consider plant characteristics and prior observations or experience with the plant elsewhere in the world.

2) Additional insights may be gained through extensive monitoring on the nursery site prior to distribution.
3) Work with local experts and stakeholders to determine which species are either currently invasive or will become invasive. Identify plants that could be suitable alternatives in your area.
4) Develop and promote alternative plant material through plant selection and breeding.
5) Where agreement has been reached among nursery associations, Government, academia and ecology and conservation organizations, phase out existing stocks of invasive species in areas where they are considered to be a threat.
6) Follow all laws on importation and quarantine of plant materials across political boundaries.
7) Encourage customers to use non-invasive plants.

4.2. GOLF COURSE OPERATIONS

Fungal diseases and pests are common nuisances in golf course turf, with the Dollar spot (*Sclerotinia homoeocarpa)* fungus and a small black beetle (*Ataenius spretulus*) being primary ones (Johanningsmeier, 1997). For golf courses, the term 'pests' includes diseases, fungi, weeds, insects, and animals that destroy or reduce turf-grass quality. The goal of Integrated Pest Management (IPM) is to limit pest populations to sufficiently low thresholds to avoid economic damage to golf course operations with the least possible hazard to people, property, and the environment. IPM at BBC will favor natural pest manipulation by selecting proper turfgrass, seeding, irrigation, and fertilization practices, however it does not exclude chemical controls when required. A qualified pest control advisor, certified in groundwater protection will prepare a detailed plan for the course, following final plantings which will be developed based upon a 1 hectare test plot which will be established. IPM for the golf course will follow guidelines outlined by the United States Golf Association (www.usga.org).

United States Golf Association Recommendation for Integrated Pest Management (USGA, 1986)

1. **Regulatory.** Use only certified seed, sod, and sprigs to establish turf.
2. **Genetic.** Select only turfgrass cultivars that are adapted to the intended use and that are suited for the ecological region in which they will be used.
3. **Cultural.** Turf is able to resist attacks by pests when it is healthy and strong. Proper turfgrass cultural practices should always be used.
4. **Physical.** Isolate areas where pests are a problem.
5. **Biological.** When possible, favor the use of natural predators to control pests.
6. **Chemical.** Use selectively and only as labeled.

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