
The Mammals of St Lucia



Species Accounts, Distribution, Abundance, Ecology, Conservation and Management of St Lucia's Native and Introduced Wild Mammals

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EXECUTIVE SUMMARY

St Lucia's mammals are an important part of the biological diversity of the island's forests. As part of the EU-funded project to survey and demarcate the public forest reserve and conduct a comprehensive biophysical inventory and assessment of forest resources, the following objectives were completed. Assessments of the diversity and relative abundance of native and introduced mammals were undertaken from 16th January to 7th April 2009 in five key forest types and mammal species distributions were mapped. This technical report presents the survey findings and discusses information on the status, ecology, and known management needs of St Lucia's mammals. During the survey, eight Forestry Department (FD) staff were trained and mentored in mammal identification and assessment techniques. This component aimed to build capacity for biological assessment within the department and provide conservation and management recommendations for St Lucia's mammals.

St Lucia's native mammalian fauna consist of at least nine bat species: the frugivorous Jamaican Fruit Bat *Artibeus jamaicensis jamaicensis* (39% of captures), the nectarivorous Insular Long-tongued bat *Monophyllus plethodon luciae* (38%), the frugivorous Little Yellow-shouldered Bat *Sturnira lilium luciae*, (10%), the frugivorous Tree Bat (4%), the insectivorous Davy's Naked-backed Bat *Pteronotus davyi davyi* (4%), the insectivorous Common Free-tailed Bat *Molossus molossus molossus* (2%), the insectivorous Brazilian Free-tailed Bat *Tadarida brasiliensis antillarum* (2%) and the piscivorous Greater Fishing Bat *Noctilio leporinus mastivus* (1%). A roost of a ninth species, the omnivorous Antillean Fruit Bat *Brachyphylla cavernarum cavernarum*, was located. The species diversity, composition and trophic structure of St Lucia's bat community is comparable to that of other islands of similar size in the Lesser Antilles that also have a high floral diversity and significant tracts of wet forest. Bat species diversity and abundance were greater in wet and mesic forest than dry forest types, probably due to their greater habitat complexity, abundance of fruiting plants, and greater insect diversity and abundance.

Conserving St Lucia's bats is important to preserve the island's natural heritage and because bats have key ecological roles and are economically important, notably in pollinating fruit crops. The Antillean Fruit Bat, Insular Long-tongued Bat and Tree Bat are regional endemics; that is they are not found anywhere else outside of the Antilles. Furthermore, the Tree Bat subspecies *luciae* only occurs on St Lucia and St Vincent, and the Little Yellow-shouldered Bat subspecies *luciae* is *only* found on St Lucia, giving St Lucia a global responsibility for their stewardship. None of St Lucia's bat species are listed as protected under the Wildlife Protection Act 1980 or the revised Wildlife Protection Act 2001, and it is proposed that all bats be added to Schedule 1 (fully protected wildlife), or at least Schedule 2, as part of the current review and amendment of this Act. Conservation actions for bats should focus largely on habitat protection because their continued survival may largely depend on conserving a full representative range of forest types, including existing forest reserves. Critical to several bat species is the protection of important cave roosts, especially those of the regional endemic Antillean Fruit Bat and Insular Long-tongued Bats. Roost protection should include routine monitoring of bat numbers and of threats to these roost sites. Research on the Tree Bat, Antillean Fruit Bat and the Insular Long-tongued Bat should be particularly encouraged as these bats are regional endemics and are not well known. Research should focus on habitat and roost requirements, diet (food preferences, pollination and seed dispersal studies), and movements of bats. Education programmes on the importance of bats would be beneficial and may prevent some instances of deliberate persecution of bats.

Our attempts to find the other native mammal - the St Lucian Giant Rice Rat *Megalomys luciae* - were unsuccessful. This mammal was last reported in the wild before the year 1881 and is probably extinct, though more extensive surveys are required to confirm this.

The distribution and abundance of the following introduced (alien) mammals were also determined: the Southern Opossum *Didelphis marsupialis marsupialis*, Small Asian Mongoose *Herpestes javanicus*, Brazilian Agouti *Dasyprocta leporina fulvus*, the rats *Rattus rattus* and *Rattus norvegicus*, and feral pigs *Sus scrofa*. The Southern Opossum was found to commonly occur in most habitats in St Lucia, from around sea level to at least 550m, but was more abundant in dry forests than wet and mesic forests. As a non-threatened, introduced species the Southern Opossum is a low conservation priority for St Lucia. Currently, the Southern Opossum is protected by law, but from a conservation standpoint, is not necessary to sustain the hunting ban on the opossum *unless* the FD perceives that opossum hunting practices could inadvertently and seriously endanger people or native wildlife. It is not clear what impact this abundant introduced mammal has on St Lucia's endemic birds, reptiles, invertebrates and plants. Further research is needed to address this question, including dietary studies

and experimental enclosure studies to measure the ecological impact of removing the opossum from selected areas. Reducing their numbers near key nesting iguana and marine turtles nesting sites could benefit St Lucia's reptiles without endangering the overall opossum population. Neither subsistence hunting nor local eradication of opossums is likely to threaten this adaptable and fecund mammal.

The Brazilian Agouti appears to be uncommon and largely restricted to wet and mesic forest in the interior of the island. Though listed as fully protected under Schedule 1 of the Wildlife Protection Act 1980, the agouti is not native and like the opossum, it is not necessary to sustain the hunting ban on the agouti from a conservation standpoint, *unless* the FD perceives that agouti hunting practices could inadvertently and seriously endanger people or native wildlife. It is recognised that some people regard the agouti as naturalised, and do not wish to risk losing the species entirely. There is potential to use this population sustainably, however, either by hunting wild agouti or farming them for human consumption ("minilivestock farming"). A trade-off between protection and exploitation would be to down-list agouti to Schedule 2 of the Wildlife Protection Act ('partially protected'), and prohibit hunting on all protected and state-owned forest lands, but allow agouti to be legally killed or captured for breeding stock on private land. Such measures would protect the 'core' agouti population that resides within state-owned wet forest lands and allow exploitation of agouti that are damaging crops. However, any new strategies for sustainable harvesting of agoutis and other wildlife using dogs or guns need to be considered in the context of FD's policy on hunting since the 1980s, and should take into account the FD's current capacity and resources to effectively regulate hunting. This report recommends specific hunting regulations and farming options.

The Small Asian Mongoose was found to commonly occur in most habitats on St Lucia, from around sea level to at least 550m, but is more abundant in wet and mesic forests than dry forests. The Small Asian Mongoose is not native to St Lucia. As one of the world's worst invasive species, the mongoose needs to be managed to mitigate its threat to native wildlife. St Lucia is too large and current control technologies too limited or labour intensive to attempt a total, permanent eradication of this widespread introduced species, but mongooses could be efficiently controlled in small, sensitive areas of high conservation value (e.g., sites where they present a critical threat to endangered birds, reptiles or other wildlife) using trapping, perhaps in combination with poisoning. Specific management recommendations for mongoose control are described in this report.

Untended domestic animals, many of which have gone wild (feral), are exotics and may pose a significant threat to native wildlife. In St Lucia, pigs have escaped or been deliberately released, and have become feral. Our surveys showed that feral pigs are largely restricted to wet forest on St Lucia and have become locally abundant. They are damaging large tracts of wet forest: rooting up the vegetation, destroying seedlings, contaminating watering holes, and destroying the eggs and young of native (ground nesting) birds and reptiles. No panacea for feral pig control currently exists, and it would probably be too expensive and difficult to eradicate feral pigs from St Lucia. A broad-based strategy, deploying multiple techniques is likely to be necessary to manage the pig numbers. Management recommendations for the control of feral pigs are discussed in this report.

Rats were found to be common in most habitats and occur from around sea level to at least 550m on St Lucia. The Norway Rat *Rattus norvegicus* and the Roof Rat *R. rattus* can have devastating effects on the flora and fauna of islands; suppressing some forest plants, and being associated with extinctions or declines of flightless invertebrates, ground-dwelling reptiles, land birds, and burrowing seabirds. Eradication of rats from mainland St Lucia would be virtually impossible and prohibitively expensive with current technology, and unlikely to last. However, rat eradications from small islands have proved highly successful. St Lucia's small offshore islands have been cleared or are clear of rats, and these restored islands have an incredibly important role to play in the conservation of St Lucia's threatened endemic reptiles. The use of rodenticides and other measures to control rats are discussed.

1. INTRODUCTION

The Lesser Antilles are a chain of islands lying in an arc from the Greater Antilles to north-eastern South America. St Lucia lies in near centre of this arc of islands and is volcanic in origin formed by a series of volcanic eruptions 5 to 18 million years before present (bp) (Newman, 1965). One of the largest islands of the Lesser Antilles, St Lucia has a land area of 616 square kilometres. The island is characterized by very rugged and steep terrain and very little flat land and with a series of complex mountain ranges runs down the centre of the island, rising to 950m at Mt Gimie. The natural vegetation of St Lucia has been described in detail by Beard (1949) and is being updated and revised by the project botanist Roger Graveson.

People

St Lucia was first colonised by Amerindians, the Ciboneys, around 2,500 years before present (bp). By 200AD the Arawaks had established themselves on the island, but were displaced by the Caribs in about the 13th century. Following Columbus, Europeans eventually killed or displaced the Caribs and St Lucia then changed hands many times before being ceded to Britain in 1814. St Lucia became a fully independent nation in 1979. The population, which currently numbers around 160,000, resides largely on or near the coast, with the majority of people living on the north-west of the island.

Forest Resources and Management

Under British administration much of St Lucia's wet forests were logged. Wet forests (rain forest, montane thicket, elfin woodland) occur over 250m are now confined to the relatively inaccessible mountainous interior of St Lucia on areas with slopes too steep to convert to agriculture or log. Remaining elfin woodland is largely confined to Mt Gimie. Most remaining wet forest is state-owned forest lands. Between around 250 and 150m elevation, mesic forest predominates. However this forest has historically been converted to agriculture, mainly banana plantations, and a substantial part of this forest has been illegally logged. Dry forest occurs below 150m on St Lucia. This forest is threatened by infrastructure development and agriculture. There are small fragments of mangrove forests, mainly in the east coast. There are small areas of plantation forests of non-native trees - Blue Mahoe, Mahogany, and Caribbean Pine. Agriculture and tourism are major economic activities on St Lucia, and bananas are the dominant cash crop.

Brief History of Mammal Research in the West Indies

The first comprehensive discussion of the mammalian fauna of the West Indies was that of G. M. Allen (1911), followed by a number of smaller papers dealing with the descriptions of new taxa and reports on collections from various islands. Studies have been published which include mammal specimens collected from St Lucia, but this is the first publication on the mammal fauna of the island. Because islands in the Lesser Antilles contained few mammals and most were bats (there also are many extinct (and a few living) rodents and insectivores) it wasn't until the introduction of mist nets in the 1950s and early 1960s that mammalogists began to take more of an interest in the region. The following studies are relevant to the mammal fauna of St Lucia. Shamel (1931) conducted a detailed analysis of the status of the American members of the free-tailed bat genus *Tadarida*; and Simpson (1956), Koopman (1958, 1959, 1968), Jones and Schwartz (1967), Schwartz and Jones (1967), and Jones and Phillips (1970), described many new bats from the West Indies. Significant contributions to the study of West Indian bats include the revisions by Smith (1972) of the family Mormoopidae, Jones and Phillips (1976) on Antillean *Sturnira*, Swanepoel and Genoways (1978) on *Brachyphylla*, and a number of papers on *Artibeus jamaicensis* (Pumo *et al.*, 1988, 1996; Phillips *et al.* 1989). Major zoogeographic analyses of West Indian mammals have been published by Varona (1974), Baker and Genoways (1978), Morgan and Woods (1986), Jones (1989), Koopman (1989), Woods (1989), Hedges (1996), Rodriguez-Duran and Kunz (2001), Morgan (2001), and Timm and Genoways (2003), and Davalos (2004). Recently, from 2007 to 2009, a team of mammalian systematists led by G. Kwiecinski (Scranton University, USA), S. Pedersen, and H.H. Genoways, and including M. Morton (Durrell Wildlife Conservation Trust) conducted a total of 14 nights of mist netting and searches for bat roosts and recorded nine bat species including a new species record for St Lucia, Davy's Naked-backed Bat *Pteronotus davyi* (Kwiecinski, Pedersen *et al.* in prep.).

Impact of Humans on Native Mammals

These studies suggest that no native non-volant (non-flying) mammals occur in the West Indies, although at least seven endemic mammals once occurred on these islands before human occupation of the region (Morgan and Woods, 1986). The St Lucian Giant Rice Rat *Megalomys luciae* once occurred only on St Lucia but has not been observed in the wild since before 1881 and is probably

extinct (Turvey and Helgen, 2008). Bats have been less affected by human occupation of the Lesser Antilles with only 14% of known species having disappeared during the same period (Morgan, 2001). There appear to be at least nine species of bats that still occur on St Lucia. All bat species are native to St Lucia and two are endemic to the region.

It is clear that a large proportion of the region's original fauna has been exterminated during the last 2,500 years, most certainly due to the activities of humans. Humans have deliberately persecuted native mammals, cleared and modified their habitats, and deliberately and inadvertently introduced (non-native) invasive mammals species to the island, such as the mongoose, rats, cats, dogs, and feral pigs. The mongoose is one of the world's 100 worst invasive species (Lowe *et al.* 2000). The mongoose has been implicated in the decline or extinction of the native animals in the areas where it has been introduced; especially on islands (Baldwin *et al.* 1952; Seaman and Randall 1962; Nellis and Everard, 1983; Coblenz and Coblenz, 1985), and probably hastened the demise of the St Lucian Giant Rice Rat. The agouti and the opossum were probably introduced to St Lucia and other islands in the region by Amerindians, for trade and as food, and may have had a more benign impact on the native flora and fauna.

The Forestry Department (FD) is the principle agency responsible for managing and conserving forest and wildlife resources on St Lucia. The objectives and current policy of the FD is to advance the areas of Forest Reservation (currently 13% of the island), Natural Resource Management, Utilization, Environmental Education, Wildlife Conservation, Co-Management, Research, Recreation, Aesthetics, and Forest Extension. In collaboration with local, regional and international allied agencies the FD works to conserve St Lucia's wildlife through management, research, and education.

Project Objectives

To support these objectives the European Community, under the Saint Lucia SFA2003 Programme of Economic and Agriculture Diversification and Poverty Reduction through Integrated National Resources Management, has provided funds to St Lucia "To survey and demarcate the physical parameters of the public forest reserve and conduct a comprehensive biophysical inventory/assessment and management system of forest resources".

St Lucia's mammals are an important part of the biological diversity of the island's forests and as part of the project the following objectives were completed. Assessments of the diversity and relative abundance of native and introduced mammals were undertaken in five key forest types and mammal species distributions were mapped. This technical report reports on survey findings and includes information on the status, ecology, and known management needs of St Lucia's mammal fauna. During the course of survey work designated national personnel, including FD staff, was trained and mentored in mammal identification and assessment techniques. This component aimed to build capacity for biological assessment within FD and provide conservation and management recommendations for St Lucia's mammalian species. The conservation of St Lucia's native mammals and the control of introduced mammals (e.g. mongoose) should be a high priority for St Lucia. Hopefully this report will demonstrate the diversity and importance of St Lucia mammals.

2. SURVEY AND INTERVIEW METHODS

2.1 Schedule of Fieldwork

The mammal survey team consisted of Dr Clarke, the project mammalogist from the UK, and one-to-two national personnel acting as field assistants to Dr Clarke each day. Field assistants and other personnel from the Forestry Department (FD) were trained in mammal species identification and mammal survey techniques through a series of workshops, discussions and field training with the project mammalogist and other wildlife biologists. The team conducted 65 days of fieldwork from 16th January to 7th April 2009.

2.2 Survey Sites

Five forest types were provisionally identified¹ by Roger Graveson, the project botanist, and Matthew Morton, critical habitats specialist, and twenty sites in total within these habitats were surveyed for

¹ The provisional vegetation map was drafted when the mammal survey began in January 2009, but before the National Forest Demarcation and Bio-Physical Resource Inventory Project team had completed the new vegetation classification system and map for St Lucia. This final, authoritative vegetation classification will be published in 2009 (Graveson, in prep.) and should replace the provisional vegetation map shown in this report.

mammals. The forest types surveyed were wet (rain) forest, mesic forest, dry forest ravines, dry forest hilltops, and mangrove forest (**Table 1; Appendix I**). Survey sites within each forest type were selected so as to have good coverage of the entire island (**Fig. 1**).

Site Descriptions

Wet Forest – the team surveyed mammals along forest trails at Forestiere near Piton Flores, Barre De L'Isle near Piton Lacombe, and at Des Cartiers, Edmund, and Millet Forest Reserves (**Table 1; Fig. 1**). Blue Mahoe (*Hibiscus elatus*), Caribbean Pine (*Pinus caribbea*) and other non-native trees have been extensively planted along reserve boundaries. However, large areas of native forest occur elsewhere, especially on the steepest slopes. All of the aforementioned reserves are located on high elevation steep terrain with the forest bisected by numerous gullies with small streams which contained water even in the rainy season. At Barre De L'Isle and Millet, evidence of logging activities 20+ years previously with subsequent replanting with non-native trees were noted. All reserves were bordered by plantations and human settlements. Evidence of feral dogs and cats originating from these settlements were commonly observed.

Mesic Forest – the team surveyed mammals in mesic forest at Durocher (inland from Mamiku Gardens), alongside a tributary of the River Doree near Piaye, at the River Doree, and inland from Anse La Raye near the waterfall at Venus Estate (**Table 1; Fig. 1**). Bordering these areas there are numerous fruit plantations and gardens, especially bananas. However, recently many banana plantations in mesic forest have been abandoned and native forest appears to be regenerating and reclaiming agricultural lands. Evidence of logging 30-40+ years previously was noted at Durocher and the vegetation in the area has been disturbed by large numbers of feral pigs. At the River Doree and its tributaries sand is mined and feral goats, chickens and pigs are farmed.

Dry Forest - the team surveyed mammals in dry forest slopes and ravines (ravines are defined as the course of streams, however small) just inland from Anse Chastanet, along Union Nature Trail, at Belvedere along the trail leading from the camp site to the beach, and bordering the Sorciere River (**Table 1; Fig. 1**). Near Anse Chastanet extensive stands of good quality (well-developed) dry forest occurs with cactus scrub on the more exposed rocky outcrops and cliff faces, though the area is bisected by numerous dirt roads linking hotel buildings and some of the streams have been destroyed. Well developed dry forest also occurs near the Sorciere River, though low-lying areas have been planted with vegetable crops e.g. taro and cucumber, and damage to native vegetation from feral pigs is fairly extensive. At Union Nature Trail, dry forest only occurs on slopes with low-lying areas near Forestry Headquarters being converted to experimental plantations of non-native trees. Feral dogs and cats are common around Union and at Belvedere.

Dry Forest Hilltop – the team surveyed mammals on a dry forest hilltop called Mount Pimard next to Rodney Bay, inland from Praslin, on Mount Gaiac near Monchy, and at Grand Anse (**Table 1; Fig. 1**). The dry forest vegetation on hilltops has been classed by the project botanist as distinct from dry forest on lower slopes and ravines. On the lower slopes on Mount Pimard, quarrying and housing developments have disturbed the dry forest; though on the upper slopes and summit small stature dry forest and cactus scrub is extensive. Near the survey site at Praslin large strips of dry forest have been cleared to build golf course fairways and greens. Finally, on Mount Gaiac dry forest has been cleared for agriculture along ridge tops. Signs of feral dogs were commonly observed at all dry forest sites on hilltops.

Mangrove Forest – the team surveyed mammals at a stand of mangrove forest just south of Micoud and at a stand of mangrove north of Vieux Fort on St Lucia's east coast (**Table 1; Fig. 1**). Mangrove stands were relatively undisturbed but suffering from encroachment from human settlements.

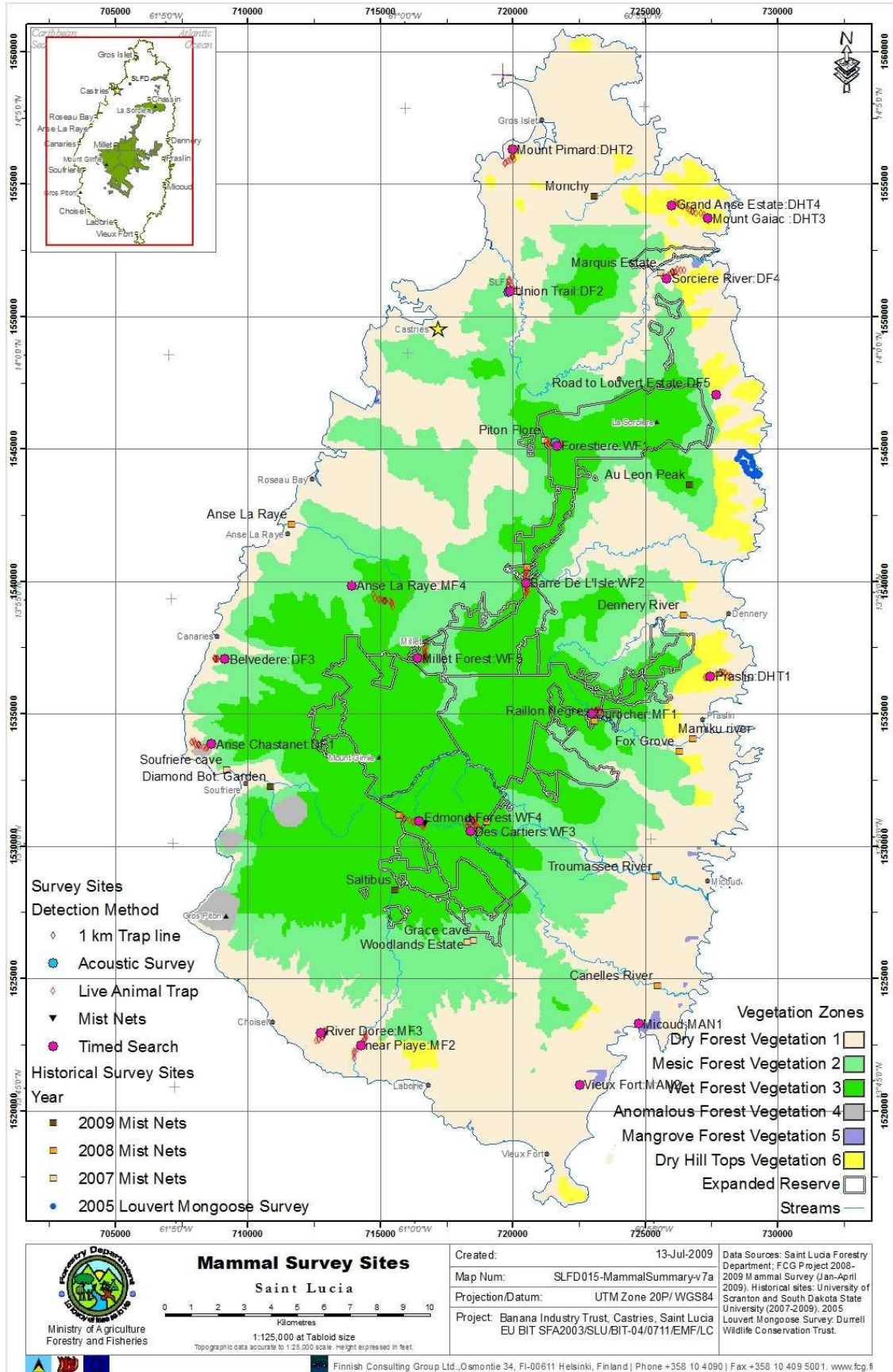


Figure 1. Map of St Lucia showing location of sites where mammals were surveyed.

Table 1. List of sites surveyed for mammals, with geographical coordinates and survey methods employed at each site. *Coordinates are provided for the centre of areas surveyed e.g. mid-way along trap-lines, transect lines or mist nets arrays. VES = Visual Encounter Surveys during Timed Searches.

Site	Forest type	Area	Coordinates (UTM 20P)*	VES	Live traps	Mist nets	Acoustic survey
WF1	Wet	Forestiere	721658E 1545126N	✓	✓	✓	✓
WF2	Wet	Barre des L'Isle	720496E 1539950N	✓	✓	✓	✓
WF3	Wet	Des Cartier	718393E 1530958N	✓	✓	✓	✓
WF4	Wet	Edmund Forest	716477E 1530942N	✓	✓	✓	✓
WF5	Wet	Millet Forest	716413E 1537104N	✓	✓	✓	✓
MF1	Mesic	Durocher	722968E 1534999N	✓	✓	✓	✓
MF2	Mesic	near Piaye	714271E 1522474N	✓	✓	✓	✓
MF3	Mesic	River Doree	712794E 1522948N	✓	✓	✓	✓
MF4	Mesic	Anse La Raye	713930E 1539852N	✓	✓	✓	✓
DF1	Dry (ravine)	Anse Chastanet	708627E 1533853N	✓	✓	✓	✓
DF2	Dry (ravine)	Union Trail	719899E 1550970N	✓	✓	✓	✓
DF3	Dry (ravine)	Belvedere	709141E 1537066N	✓	✓	✓	✓
DF4	Dry (ravine)	Sorciere River	725806E 1551446N	✓	✓	✓	✓
DF5	Dry (ravine)	Louvet Estate	727686N 1547054N	✓	X	X	✓
DHT1	Dry (hilltop)	Praslin	727452E 1636414N	✓	✓	✓	✓
DHT2	Dry (hilltop)	Mount Pimard	719997E 1556318N	✓	✓	✓	✓
DHT3	Dry (hilltop)	Mount Gaiac	727374E 1553720N	✓	✓	✓	✓
DHT4	Dry (hilltop)	Grand Anse	726002E 1554203N	✓	X	X	✓
MAN1	Mangrove	near Micoud	724747E 1523276N	✓	X	X	✓
MAN2	Mangrove	near Vieux Fort	722525E 1520980N	✓	X	X	✓

We used observational, acoustic, and capture methods to survey mammals in all forest types, the exception being mangrove forests near Micoud and Vieux Fort where the difficulty accessing and setting traps and nets in these dense mangrove stands on mudflats precluded the use of capture methods (Table 1).

2.3 Survey Strategy

Mammals are often more difficult to observe compared to other terrestrial vertebrates (amphibians, reptiles and birds), and therefore a combination of observational and capture methods were used to survey the mammalian fauna of St Lucia. This combination of multiple survey methods allowed us to obtain an accurate and relatively complete representation of St Lucia's mammal community given the time constraints. We did not collect voucher specimens due to the conservation nature of the project. Also, the team did not find new mammal species on St Lucia which would warrant taking a voucher specimen. All mammals were correctly identified to species by Dr Clarke before being released at the site of capture. Methods used for surveying mammals are discussed in detail below. For equipment required for mammal surveys see **Appendix VII**.

2.4 Surveys of Non-volant Mammals

Observational Methods

Opportunistic (incidental) observations of mammals were always recorded. This simple method was used to establish the presence of rare or rarely encountered species, specifically feral pigs and agoutis, which could not be surveyed easily by other means. To maximise the number of recorded observations (and thus produce more detailed species distribution maps) we asked all FD staff conducting the timber inventory and also volunteers from overseas conducting a parrot survey to opportunistically record observations and signs of feral pigs and agoutis. The disadvantages of this method, however, are that sampling effort varies and cannot easily be analysed and compared. The mammal survey team also used Timed Searches to establish presence of species in the area and estimate relative abundance (e.g. number of mammals observed per hour or per day). This is a simple and relatively effective method that is useful for surveying rare species or species that are difficult to detect. It is more practical than using distance transects in difficult terrain (Rudran *et al.* 1996; Buckland *et al.* 2001).

At 12 sites the mammal survey team conducted repeated Timed Searches for mammals using VES. Timed searches were undertaken by the project mammalogist and two FD assistants in the early morning from 07.00 to 10.00h (diurnal VES) and/or in the afternoon and evening from 16.00 to 22.00h

(nocturnal VES) over four consecutive days at each site, and observations of wildlife together with data on weather conditions were recorded on standard data sheets (**Appendix II**). During the day the team use binoculars to aid detection of mammals and at night high powered spotlights were used.

The location of all agoutis, opossums, mongooses, rats, monkeys, feral pigs and cats, observed (and heard) were recorded. If possible, individuals observed were classed as adult, pregnant adult or juvenile. For social mammals, group size was also recorded. Agoutis and mongooses often bolt when disturbed and it was unlikely that the same individuals were recorded more than once during each Timed Search.

The team also recorded indirect observations of mammals such as scats (faeces), scratch marks on trees and mud wallows (feral pig), hairs, tracks, and other mammal signs. Because most of St Lucia's mammals are nocturnal and cryptic, their presence at many sites often only inferred indirectly (e.g. feral pigs and cats). Tracks were identified through reference to field guides (Eisenberg 1989; Emmons and Feer, 1990). Identification to species was always possible and the project team constructed a guide to the signs e.g. tracks, of St Lucia's mammal fauna (**Appendix IV**).

Trapping

Live traps were used to measure the relative abundance of opossums, mongooses, agoutis and rats. Live traps consist of an enclosure where the doors are held open by a trigger mechanism that is connected to a treadle on the floor of the trap. When an animal enters the trap, it steps on the treadle and the doors instantly close, trapping the animal inside.

At 16 study sites the team set a trap line for four full days (day and night). Traps were set along natural mammal walkways (areas used by mammals as evidenced by signs) and lured into traps with bait. Trap lines were 1km in length with one trap stationed every 100m for a total of 11 trap stations. At each station we set either one feral cat trap (Albion Manufacturing, Norfolk, UK) or one Tomahawk trap (Tomahawk Live Trap Company, USA). Both trap types are heavy duty galvanised welded mesh traps with a single catch trap with single entry spring door. The feral cat trap's dimensions were 30 x 75 x 25cm and the slightly smaller Tomahawk traps were 25 x 60 x 25cm. In a pilot study comparing three trap types and different baits, feral cat and Tomahawk traps were found to be equally effective at trapping opossum, mongoose, Roof Rats, and Norway Rats. The larger feral cat traps should also trap agoutis (and cats!).

Following the pilot study, the traps were baited with rolled-oats mixed with peanut butter, ripe banana, and small pieces of raw chicken; bait found to be effective at trapping the target species. Traps were baited just before sunset and checked 24 hours later. Trapped mammals were transferred to a holding bag and the following measurements were taken (in mm): head and body length, tail length, hind foot length (without claws), and ear length. Captures were weighed, sexed, and classed as adult or juvenile and reproductively inactive or reproductively active (e.g. males with large testes, pregnant or lactating females).

Trap nights (number of traps set multiplied by the number of days (i.e. 24 hour period) that traps were left open) are the standard sampling unit (e.g. number of opossum captured per trap-night) and were calculated to determine mammal relative abundances. Total trapping effort was 704 trap-nights with 132-220 trap-nights in each of four forest types: wet, mesic, dry forest ravines and dry forest hilltops (**Table 2**). Traps were not set in mangrove forest due to the difficulty safely accessing traps, the risk of trapped animals drowning, and a lack of time.

2.5 Bat Surveys

Mist Netting

Mist nets set in forests are effective at capturing many species of bats and we used this as the primary method to determine bat species distributions in St Lucia and also measure the relative abundance of bats. Mist-net-hour (number of nets set multiplied by the number of hours that nets were left open) are the standard sampling unit (e.g. number of bats captured per mist net-hour). For comparison with the only other mist netting survey of bats on St Lucia by Scranton University and with mist netting surveys of other islands in the Lesser Antilles, we also present relative abundance data (capture rates) as the number of bats captured per net-night (NN). This measure is used because the dimensions and orientations of the mist nets and time they are left open catching bats are not always provided in the literature. Mist nets are effective at capturing most of St Lucia's bat species, the exception being two

species of aerial insectivores: *Tadarida brasiliensis* and *Molossus molossus*. Aerial insectivores often commute and forage above the forest canopy, and even when they are within the sampling range of mist nets, they are able to easily detect and avoid such devices (Berry *et al.* 2004). However, acoustic sampling with bat detectors means their distributions can be surveyed (see below).

To survey bats, the team deployed mist nets at a total of 16 study sites in wet forest, mesic forest, dry forest ravines and dry forest hilltops. Mist nets were not set in mangrove forest. Typically, three mist-nets (either 2.6 x 12m or 2.6 x 6m nets of 38mm mesh in 75 denier, 2-ply polyester, four-shelve nets (Avinet Inc., Dryden, NY)) were erected at ground level and positioned to sample all micro-habitats present at sites: flat well-drained ground, swampy areas, under closed canopy or in the open. Nets were opened just before sunset each night and left open for three hours, typically until 21.00h. The team took care to note environmental factors affecting trapping success such as rain, cloud cover, light intensity, moon phase, and also the presence of predators and fruiting plants. Mist net samples were used to calculate relative abundance and capture rate (bats per mist-net-hour). Sampling effort was equal among forest types, with a total of 120 mist-net-hours (**Table 2**).

Bats were identified to species (by reference to the field key to Antillean bats (Baker *et al.* 1984), also Dr Clarke is a bat specialist and is familiar with the bat fauna of the region), sexed, weighed, and their reproductive status was assessed. Key measurements to aid species identification were sometimes recorded including the length of the forearm, ear, hind foot and calcar, and bats were photographed and notes made of morphological features that aid species identification. Following Simmons and Voss (1998), bats were assigned to broad guilds based on flight morphology and diet: aerial insectivores, frugivores and nectarivores. All data were recorded on bat survey datasheets (**Appendix II**). All bats were released unharmed at the site of capture within three hours of capture.

Acoustic Sampling

Bat detectors allow researchers to hear and subsequently visualize the ultrasonic echolocation calls (high frequency calls produced by bats to navigate their way around the landscape) of most bat species. In Europe and North America bat detectors are regularly used to identify some species of aerial insectivores (Fenton and Bell 1979; Russ 1999); with time-expansion bat detectors proving to be particularly effective. This is because the bat detector's time expansion facility retains most information of the call, in contrast to frequency division which often fails to detect all harmonics (Fenton 2000). Acoustic sampling using time expansion bat has proved very effective at detecting the presence of many species of aerial insectivores in the tropics (MacSwiney *et al.* 2008) (though using bat detectors to estimate bat abundance is problematical); and in this project we used this method to survey the distributions of *Pteronotus davyi*, *Tadarida brasiliensis*, and *Molossus molossus*. All three species (and *Noctilio leporinus*) emit high intensity (loud) echolocation calls that can easily be detected by bat detectors, and their calls appear to be species-specific allowing identification of free-flying bats (*P. davyi* has a particularly distinct call).

Each night, echolocation calls were recorded with a Pettersson D980 bat detector (Pettersson Elektronik AB, Uppsala, Sweden) and stored using a digital recorder (Edirol Europe Ltd, London, UK). For a continuous period of 30 minutes, Dr Clarke recorded using the time-expansion system of the bat detector (10×) any echolocation calls heard. These time-expanded recordings were stored on Channel 1 of the recorder. At the same time, the bat detector was also set to record in frequency Department, and the output recorded on Channel 2 of the recorder.

Call characteristics were measured only from the time expansion recordings. This method of recording allowed only 9% of the real time to be recorded in each 10-min period (Jones *et al.* 2000). However, this protocol was standardized in all habitats which permitted comparison. The first recording period was carried out just after sunset followed by one subsequent sampling period one hour later. To aid species identification, calls were analyzed with BatSound Pro 3.10 (Pettersson Elektronik AB, Uppsala, Sweden). Recordings of calls from free-flying bats were identified by comparison with published calls of these species and echolocation call libraries.

2.6 Mammal Survey Effort

The mammal survey team conducted a total of 120 mist-net hours of sampling effort in wet forest, mesic forest, dry forest ravines, and dry forest hilltops (**Table 2**). No mist nets were set in mangrove forest but the team conducted 4 hours of acoustic sampling with a bat detector in mangrove forest and the other four forest types for a total of 20 hours of acoustic survey.

Table 2. Summary of survey sampling effort at different native forest types on St Lucia.

Forest type	Sampling Effort			
	Timed Searches (person-hours)	Live trapping (trap-nights)	Mist Nets (mist-net-hours)	Acoustic Survey (hours)
Wet	90	220	30	4
Mesic	86	176	31	4
Dry Hilltops	96	132	29	4
Dry Ravines	82	176	30	3.5
Mangrove	16	-	-	4
Total	370	704	120	19.5

Prior to this survey, the only bat surveys that have been conducted in St Lucia have been by a team from Scranton University in the USA. Over a three year period, between 2007 and 2009, Scranton University team visited St Lucia and for 14 nights of mist netting they captured 1,577 bats of nine species, largely to remove specimens from St Lucia to labs in the USA for genetic and morphological research (see **Appendix V**). Despite their large number of captures, the lack of standardisation with their capture methods and unequal sampling effort among their survey sites means it is difficult to interpret Scranton University team's survey results, to compare their findings with this survey or to compare the bat diversity and abundance of different forests. Additionally, many of their sites were outside native forests (e.g. in the botanical gardens) and/or selected so as to capture huge numbers of bats within a short period for future genetic research, and consequently, much of their data are not of use to this project which seeks to inventory different native forest types and manage and conserve bat populations.

Therefore, much of the following analysis and discussion focuses on the data from the current bat survey work by the mammal survey team which focuses on St Lucia's native forests and uses standardised survey methods and attempts to equalise survey effort among sites, allowing one to directly compare the bat fauna of different forest types.

2.7 Interviews

Forestry Department officers and other staff, including range officers, range workers, wildlife officers, and zoo staff, as well as local people (e.g. landowners and agricultural workers), were interviewed. Interviews consisted of a series of open and closed questions. Information was obtained on perceived distribution and abundances of mammal species, hunting activities, consumption and local uses of mammals, mammal folklore, local names, perceptions about importance of mammals (which are native or introduced, role in forests, benefits or harm they may cause) and the need for conservation, management or control.

2.8 Training

Field assistants and other Forest Officers from the Forestry Department (FD) were trained in mammal species identification and mammal survey techniques through a series of discussions and fieldwork training with the project mammalogist (**Table 3**). Because of other Forestry staff commitments in early 2009 (the parrot survey and timber inventory etc) only Mary James was assigned to assist with the mammal survey for the full duration of the survey. Training included how to identify mammal species and their signs (tracks, faeces etc) and training in a wide variety of mammal survey methods i.e. mist netting for bats, live animal trapping for non-flying mammals, Timed Searches using Visual Encounter Surveys for mammals that are rare and/or difficult to detect, and acoustic surveys with bat detectors (**Appendix III**).

2.9 Constraints and Limitations

To survey the distribution and relative abundance of St Lucia's entire mammal fauna among all forest types within three months was extremely difficult, but nevertheless this has been achieved to a large degree, though there are still gaps in our knowledge of the distribution of some mammal species. More time would have allowed more sites to be surveyed and therefore allow statistical comparison of mammal abundances among forest types. Additionally more searches could have been undertaken to locate bat cave roosts and survey agouti and pig distributions – these mammals are difficult to observe

Table 3. National personnel trained & mentored in mammal identification & surveys (in alphabetical order)

Mammal Survey Personnel		
Name	Post	Role
Mr George Antione	Zoo Staff Forestry Officer	Occasional field assistant - received 4 days of training in species identification & survey methods
Mr Timothy Jno Baptiste	Wildlife Section Forestry Officer	Occasional field assistant - received 9 days of training in species identification & survey methods
Mr Alwin Dornelly	Wildlife Section Forestry Officer	Field assistant - received 2 days of training in species identification & survey methods
Ms Mary James	Wildlife Section Forestry Officer	Main field assistant – received 53 days of 'on job training' in mammal identification & survey methods
Mr Stephen Lesmond	Part Time Forestry Officer	Occasional field assistant - received 8 days of training in species identification & survey methods
Mr Randall Marius	Millet Range Forestry Assistant	Field assistant in Millet Range - received 5 days of training in species identification & survey methods
Mr Nereus Mitchel	Soufriere Range Forestry Officer	Field assistant in Soufriere Range - received 12 days of training in species identification & survey methods
Mr Canice Peterson	Millet Range Forestry Officer	Field assistant in Millet Range - received 5 days of training in species identification & survey methods

and require more intensive survey efforts. The work would have greatly benefited from the addition of more Forestry Department officers to assist with surveys. Only one FD officer (Mary James) was assigned to assist fulltime on the mammal surveys. If funds had been available, it would have been advisable to survey every site during the wet and dry seasons so that the effect of seasonality on mammal distribution and relative abundance could be ascertained.

3. SPECIES ACCOUNTS

FAMILY DIDELPHIDAE

Didelphis marsupialis marsupialis Linnaeus, 1758

Southern Opossum



Figure 2. Distribution and abundance of opossum *Didelphis marsupialis* among St Lucia's native forests.

Common (English) Name

Southern Opossum, Black-eared Opossum, Common Opossum

Local Names

Manicou (ma-nee-koo) mannikou

Description

The Southern Opossum is a cat-sized mammal but rat-like in appearance with a long snout, short legs and long, naked, tail that is black near the base and white near the tip. Southern opossums have large black-ears. The fur is in two layers - an underfur of dense and yellow to whitish hair below long, coarse, black guard hairs. Young are blackish with distinct markings. Females have a pouch and are typically smaller than males. Adult Southern Opossum weigh 0.56 to 1.6kg (Emmons and Feer, 1990).

Geographical Distribution

The Southern Opossum is distributed from Mexico, south throughout Central and South America to Peru, Bolivia, and Brazil (Wilson and Reeder, 2005). In the West Indies Southern Opossums are represented by a single subspecies *D. m. marsupialis* that occurs on Trinidad and Tobago, Grenada, St Vincent and the Grenadines (Mustique, Bequia, Cannouan, Union, Carriacou, and Isle Ronde), St Lucia, Martinique, and Dominica (Varona, 1974; Timm and Genoways, 2003). Southern Opossums

are common throughout their range. They are a ubiquitous member of the mammal fauna of wet and riparian forest in most countries and also occur in seasonally dry forests but not in very arid habitats (Gardner, 2007).

Status on St Lucia

It is most likely that the Southern Opossum is not native to St Lucia and was introduced to the Lesser Antilles by humans, probably by Amerindian groups for trade and food. Opossums could have been transported to St Lucia sometime in the last 2,500 years and they are believed to be a relatively recent introduction on some islands (G.M. Allen 1911). A few mammalogists (see Timm and Genoways; 2003), have speculated that suggest that the current distribution of opossums suggests that they may be native to the Lesser Antilles. However, it seems far less likely that opossums could have colonised the islands from mainland South America by overwater 'rafting' up the island chain as far as Martinique, than by being transported by humans. Today opossum are still widely transported by Amerindian groups for trade and food (pers. obs.).

Distribution on St Lucia

The mammal survey team trapped 58 Southern Opossums (and 11 recaptures) and observed an additional 21 individuals, eight of which were road-killed animals. Surveys indicate that on St Lucia the opossum occurs over most of the island, and in most habitats even near densely populated urban areas (e.g. Rodney Bay), from dry forest at around sea level to wet forest at least 550m in Edmund Forest (**Fig. 2**). This species probably occurs at even the highest elevations on St Lucia as elsewhere in its range it is known to occur to around 2,200m (Gardner, 2007). Interviews with range officers and local people reveal that opossum are not uncommon in the following areas: Quillesse Forest, Mahaut, La Tille, Ti Rocher, Belle Vue, Woodlands, Calypso, Grace, Des Cartiers, Patience, Fond Devaux, Palmiste, La Porte, and La Grace.

Habitat Associations

Opossum were trapped at all forest sites except one (mesic forest at River Doree) (**Fig. 2**). Opossum were found to be twice as abundant in dry forests (mean = 14 opossum per 100 TN), than mesic forest (6 per 100 TN) and wet forest (5 per 100 TN) (**Fig. 3**). Opossum were also observed in riparian forest, in fruit plantations and gardens, and in roads and tracks (living or road-killed) in rural, suburban and urban areas. This species has been reasonably well studied in the northern portion of its range on mainland tropical America and its habitat preferences are known (Cordero and Nicolas, 1987; Sunquist *et al.* 1987). These studies agree with this survey's findings that opossums tolerate a variety of habitat types including wet and seasonally dry forests, primary and secondary forests, fruit and cacao plantations, and even urban and suburban areas where they feed on garbage. On Trinidad and Guyana, opossums are frequently encountered at night at suitable habitat e.g. wet and riparian forest, whereas opossum do not appear to as common on St Lucia (F. Clarke pers. obs.). Other mammalogists have noted that opossum are not very common throughout the Lesser Antilles (Timm and Genoways, 2003). Densities of 0.25-0.75 individuals per hectare are found in Venezuela (O'Connell, 1989), and of 0.09-1.32 in Panamá (Fleming, 1973). In some localities populations may explode to high levels then crash to result in the near absence of the species the next year (Adler *et al.* 1997).

Ecology

The opossum is nocturnal and is an opportunistic omnivore that feeds on vertebrates, invertebrates, leaves and fruits in varying proportions depending on availability (Cordero and Nicolas, 1987). Individuals are highly opportunistic, readily shifting their home ranges to adapt to fluctuating resources. However, given a sustained food supply, the home range of adult females may be rather stable (Sunquist *et al.* 1987). The diet of males and females do not differ significantly, but there are differences in food preferences between juvenile and adults. Younger opossums primarily consume invertebrates, fruits, and plant remains, whereas older individuals consume all of these, as well as small vertebrates (Cordero and Nicolas, 1987). The sex ratio of opossum trapped by the mammal survey team on St Lucia was 1:2 – twice as many males were trapped than females, probably because males are less 'trap-shy' than females. Opossums are excellent climbers, and in the breeding season females often construct leafy tree nests for their new families, although burrows and especially

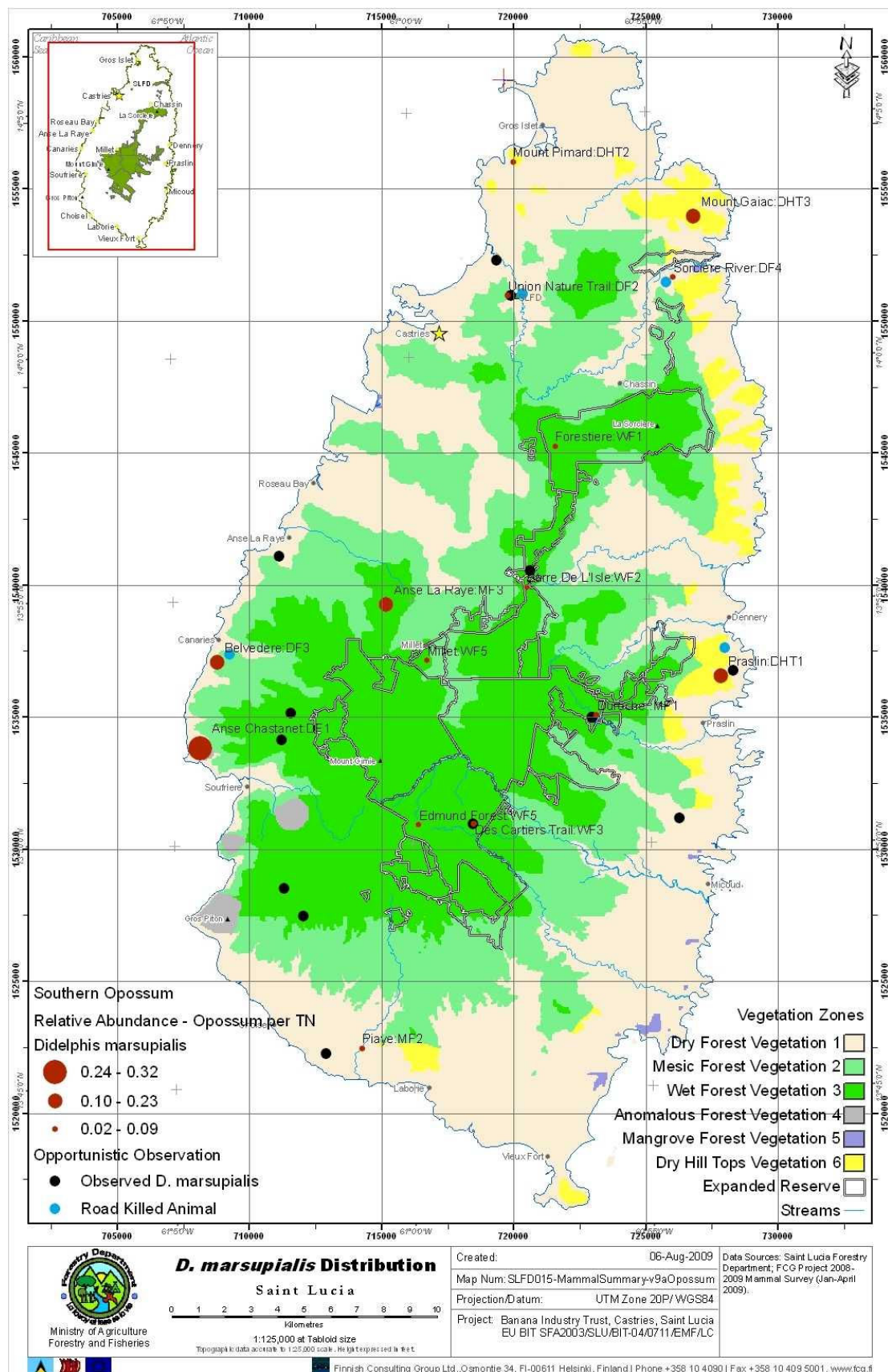


Figure 2. Distribution and abundance of opossum *Didelphis marsupialis* among St Lucia's native forests.

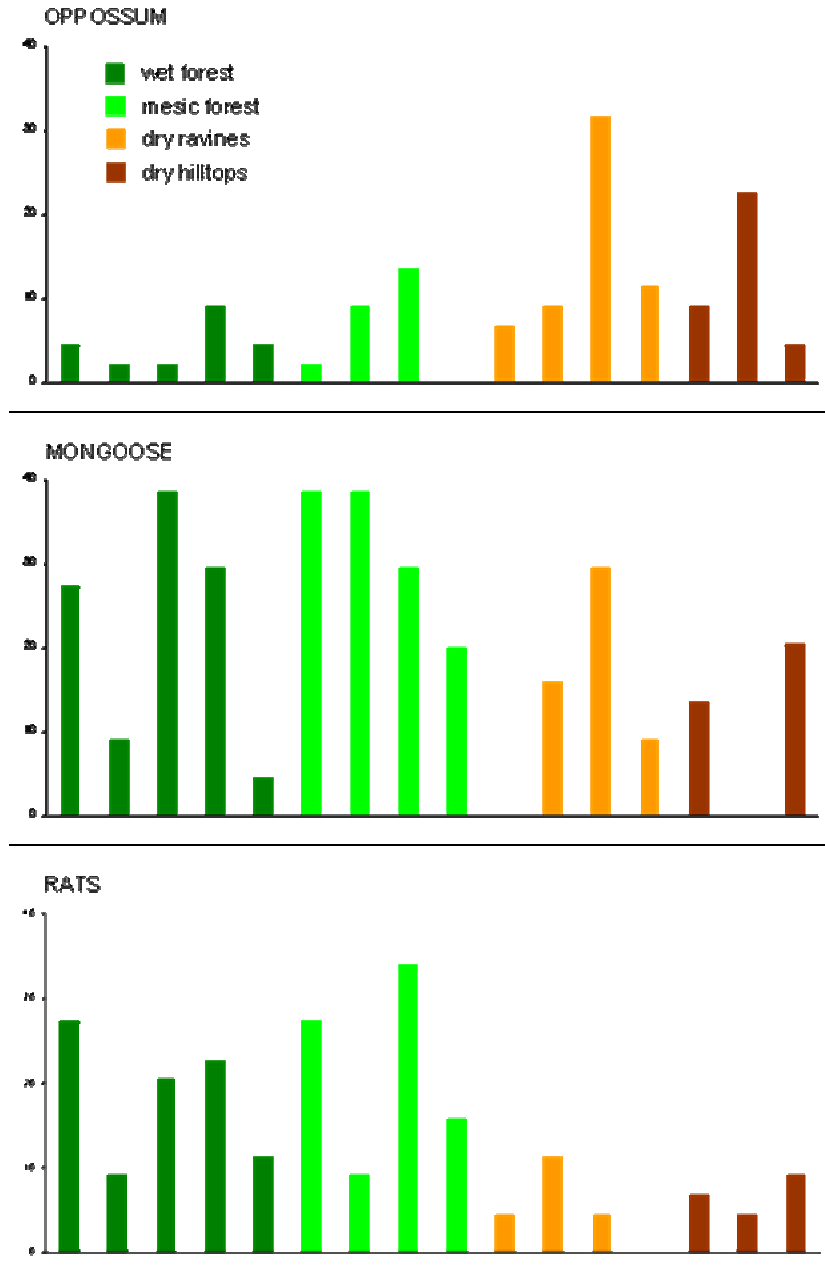


Figure 3. Relative abundances of opossum, mongoose, and rats among 1 km trap lines in St Lucia's native forests. Y-axis: mean number of specimens trapped per 100 trap-nights at each trap line (1 bar = 1 trap line).

tree cavities are more frequently used (Eisenberg, 1989; Cordero and Nicolas, 1987). These trees are critical elements in forests for many cavity-dwelling and nesting/roosting mammals and birds (McComb and Lindenmayer, 1999). Native predators of adult opossums on St Lucia include the *Boa constrictor* (D. Anthony, pers. comm.; Henderson, 2004).

Reproduction and longevity

None of the females trapped by the mammal survey team on St Lucia had babies. Three young (juvenile) opossums were trapped: on 25th and 28th January and 25th February. Adult opossum tend to live solitary lives except during breeding season when males actively court females. Mating usually commences at the onset of the dry season (Fleming 1973; Tyndale-Biscoe and Mackenzie, 1976). After an average of 12 days gestation (max. 14 days) females give birth to an average of six young (max. of eight young), the litter size being partly dependent on availability of food to the pregnant female (de Magalhaes *et al.* 2009). Newborn opossum are tiny (0.2g) but grow rapidly inside the females pouch until they are weaned at around 94 days. The young reach sexual maturity between 8

and 12 months of age (Eisenberg, 1989) and typically will only live for two years in the wild, which is very short for as mammal of such size (de Magalhaes *et al.* 2009). Senescence can be rapid. At the same site on St Lucia on the 31st March and 1st April, two adult males that showed signs of pronounced senescence were trapped. They were emaciated, much of their fur was missing, and they showed significant morbidity. Females can produce two, occasionally three, litters each year, depending on food availability. In summary, the Southern Opossum is a fecund, highly adaptable species.

Traditional Use of Opossum

Although the opossum is common throughout most its range it is hunted for meat only where other game is scarce (Emmons and Feer, 1997). This is also true for St Lucia – opossums are typically only eaten by the poorer rural population. Opossums are hunted by hand, typically by violently shaking coconut trees containing nests until the unfortunate animal(s) fall to the ground. The meat is light and fine grained, but the musky anal glands must be carefully removed as part of preparation. In Mexico, opossums are known as "tlacuache" or "tlaquatzin" and their tails are eaten as a folk remedy to improve fertility. In Trinidad and Dominica the meat is traditionally prepared by smoking then stewing. Opossum oil ("possum grease") is high in essential fatty acids and has been used as a chest rub and a carrier for arthritis remedies given as topical salves. Opossum are not always beneficial to humans. In South America this species is known to be an important reservoir for the parasite *Trypanosoma cruzi* (the cause of chagas, a fatal disease of humans), as well as a wide variety of other infectious agents such as rabies and zoonotic leishmaniasis (Schallig *et al.* 2007).

Conservation Status

The Southern Opossum is listed by IUCN Red List as Least Concern (Brito *et al.* 2008). The opossum is distributed widely, the population is large and does not appear to be declining, it is tolerant of habitat modification, and therefore does not qualify for listing as Threatened. On St Lucia, where opossums are infrequently hunted, this species does not appear to be locally threatened and human consumption does not appear to have a severe negative impact on St Lucia's opossum population. Even on Trinidad and mainland South America where opossum are regularly hunted or killed as predators of poultry this species does not appear to be threatened by humans. Nor does commercial hunting in South America for the fur trade appear to have much impact on populations. Opossum appear to be rarer in the Lesser Antilles and may not be able to withstand commercial hunting pressures. On St Lucia the opossum is one of two mammals (the other being the agouti) that is specifically listed as protected under the Wildlife Protection Act 1980. To conclude there are no major threats known to this widespread and adaptable species, and as an introduced species the opossum is a low conservation priority. Management recommendations for opossum are outlined in **section 5.2**.

FAMILY: NOCTILIONIDAE
Noctilio leporinus mastivus (Vahl, 1797)
Greater Fishing Bat



Photo: M. Morton

Description and Geographical Distribution

The Greater Fishing Bat, sometimes known as the Greater Bulldog Bat, is a large bat (wingspan of ~0.5m) with orange to brown fur, often with a single pale stripe running down the middle of the back. It has a large bulldog-like head and large feet with long, strongly curved and sharp claws. No other bats occurring on St Lucia are similar in appearance. The Fishing Bat is widely distributed bat occurring from Mexico to Argentina and including most of the islands in the Caribbean (Simmons, 2005). In the Lesser Antilles the subspecies *mastivus* occurs on St Lucia and most islands (Baker and Genoways, 1978; Timm and Genoways, 2003). The mammal survey team captured one Fishing Bat on St Lucia at Edmund Forest and the forearm length of this specimen (86.2mm) was within the range of published measurements for this subspecies in the Lesser Antilles (Timm and Genoways *et al.* 2003).

Distribution on St Lucia

The Fishing Bat captured by the mammal survey team was an adult female which was netted in wet forest at 550m elevation at Edmund Forest (**Table 4; Fig. 3**). The bat was netted in association with the Jamaican Fruit Bat, Yellow-shouldered Bat, Naked-backed Bat, Common Free-tailed Bat, and the Brazilian Free-tailed Bat on a wide trail, lacking canopy cover, through wet forest. Numerous small streams flowed through the area which was largely planted with Blue Mahoe and other non-native trees. In 2008, researchers from Scranton University captured one Fishing Bat at the Canelles River and another four near the fishing village Anse La Raye (**Fig. 3**). On St Lucia, the Fishing Bat can thus occur from sea level to at least 550m elevation in suitable habitat.

Habitat Associations

Although few specimens have been captured, on St Lucia, as elsewhere in this species' range in the Lesser Antilles, the Greater Fishing Bat is expected to occur along the island's coastline, especially at calm bays and the estuaries of major rivers, and inland along slow moving rivers and streams to wet forest areas with suitable foraging sites e.g. slow moving streams and ponds (Pedersen *et al.* 1996, 2006, 2007; Genoways *et al.* 1998, 2007b). Fishing Bats are difficult to capture and are undoubtedly more common on St Lucia than records suggest. Their large size and sharp teeth means they often escape from mist nets and avoid capture. Indeed Fishing bats were observed on several occasions in coastal bays and at the Troumassée River. However, they probably have a patchy distribution on St Lucia, as one would have expected to have detected their echolocation calls at survey sites if they were abundant and widely distributed. Throughout their range Fishing Bats are restricted to non-arid areas and on St Lucia are unlikely to occur in forage dry forests.

Diet and Feeding Habits

As its common name suggests the Fishing Bat eats small fish, large insects and small crustaceans (Brooke, 1994). The proportion of fish and insects in their diet has been shown to vary with season in Puerto Rico, with insects making up a larger part of the diet of Fishing Bats in the wet season (Brooke, 1994). Fishing Bats are typically active all night and are most frequently observed, captured or acoustically detected, while foraging at ponds, slow moving streams and rivers, river estuaries, and calm coastal waters (Hood and Jones, 1984). When foraging they use echolocation to detect the 'echo glints' of surfacing fish before gaffing them with their elongated feet and large, sharp claws (Schnitzler *et al.* 1994).

Roosting Requirements

The mammal survey team did not locate roosts of the Fishing Bat on St Lucia. Fishing bats are known to use sea caves as roosts as well as hollows in living and dead trees, including Silk Cottonwood trees *Ceiba pentandra*, Balata *Manilkara bidentata*, Red Mangrove *Rhizophora mangle* and Royal Palms *Roystonea* spp. (Goodwin and Greenhall, 1961; Timm and Genoways, 2003; Pedersen *et al.* 2007). These roosts may contain up to several hundred individuals and are often shared with Jamaican Fruit Bats, Antillean Fruit Bats, Insular Long-tongued Bats, Common Free-tailed bats, and Naked-backed Bats.

Reproduction

On St Lucia, no information exists on Fishing Bat reproduction. It is likely that breeding is seasonal and typical for populations inhabiting other islands in the Lesser Antilles and Trinidad with a pattern of late spring to summer births (April-June) (Goodwin and Greenhall, 1961; Carter *et al.* 1981; Hood and Jones, 1984).

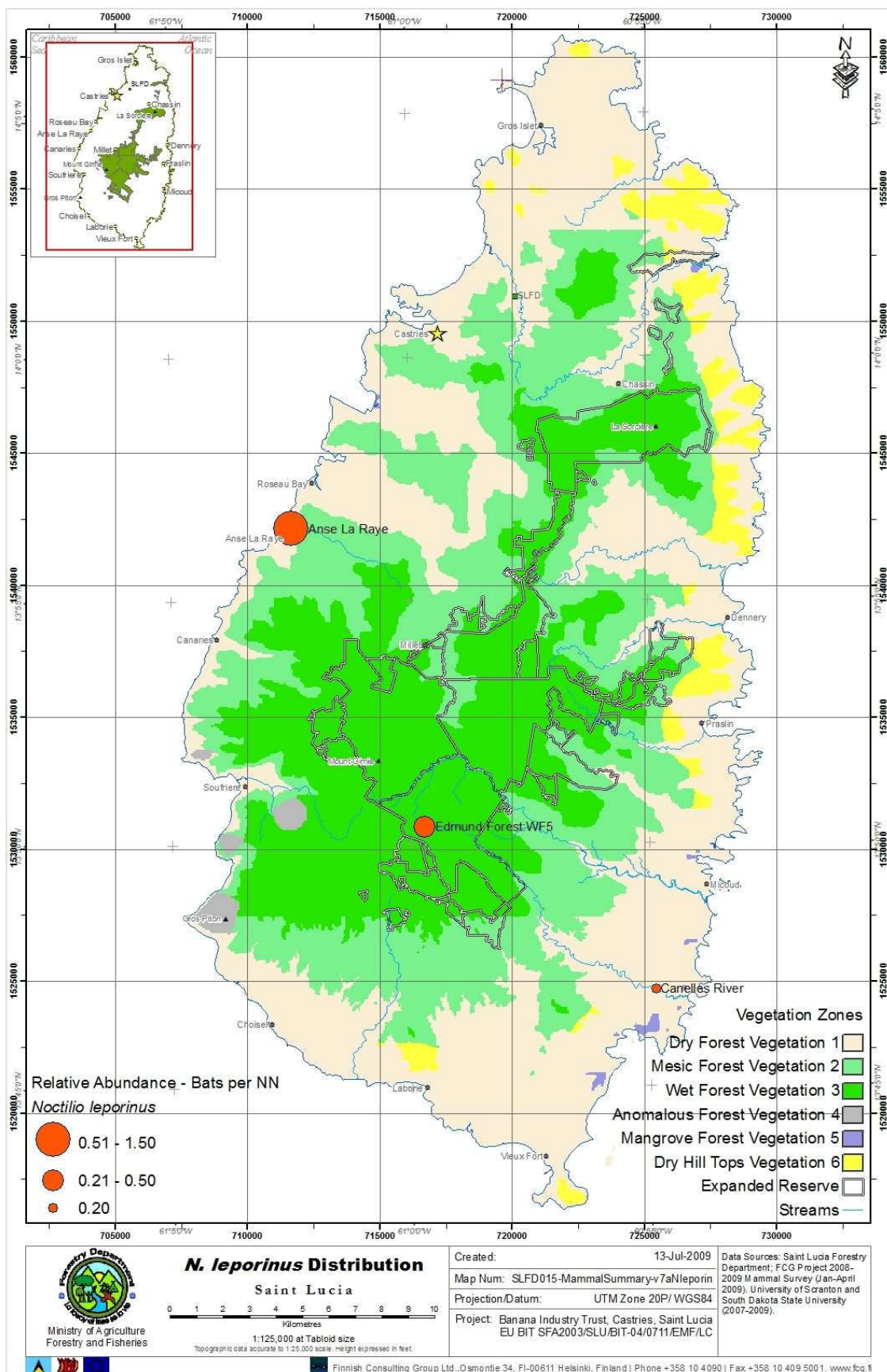


Figure 4. Distribution and abundance of fishing bat *Noctilio leporinus* among St Lucia's native forests.

Threats and Conservation status

The Greater Fishing Bat is listed in the IUCN Red List as of Least Concern due to its wide distribution, presumed large population, occurrence in a number of protected areas, and because it shows some tolerance of habitat modification (Barquez *et al.* 2008c). There is insufficient evidence to say whether Fishing Bats are threatened on St Lucia. Surveys suggest that they occur at low numbers and may be patchily distributed over the island, as appears to be the situation in other islands in the region where they occur. Fishing Bats may be sensitive to pollution of water as well as deforestation which may cause siltation of water-bodies and a decrease in fish numbers. Additionally, Fishing Bats roost in caves and in hollows in mature, large trees; and these roost sites appear to be relatively limited in St Lucia and the Lesser Antilles. Also, the improper and excessive use of pesticides and Persistent Organic Pollutants on St Lucia and in the region may impact this species insect prey and pollute river systems affecting its fish prey, in turn causing declines in the populations of Fishing Bats. Overall, these findings raise cause for concern, and it may be that St Lucia's Fishing Bat population, and those in the region, may be nationally and/or regionally threatened.

FAMILY MORMOOPIDAE
Pteronotus davyi davyi Gray, 1838
Davy's Naked-backed Bat



Description and Geographical Distribution

Davy's Naked-backed Bat is a small bat with dark brown velvety fur. The wing membranes originate from the mid-line of the back of the bat giving the bat a naked-backed appearance, hence the common name. This bat cannot easily be confused with any other bat occurring on St Lucia. The Naked Backed Bat has a wide geographical distribution and occurs from Mexico to northern Venezuela and northwest Peru (Simmons, 2005). The subspecies *davyi* occurs on Trinidad, Grenada, Martinique, St Vincent, Dominica and Guadeloupe (Marie-Galante) (Adams, 1989; Vaughan and Hill, 1996; Genoways *et al.* 2001; Timm and Genoways, 2003). In 2007 researchers from Scranton University captured Davy's Naked Bat on St Lucia, the first record of this species on the island (Kwiecinski, Pedersen *et al.* in prep). Forearm lengths of the specimens captured in this survey (45.5-47.2 mm, n=14) are within the range of published measurements for this subspecies (Genoways *et al.* 2001; Timm and Genoways, 2003).

Distribution on St Lucia

The mammal survey team captured 16 Davy's Naked-backed Bats and, using bat detectors to acoustically survey bats, detected this species at four sites (**Fig. 5**). This and previous surveys reveal that Davy's Naked-backed Bat can occur from around sea level (~10m at Canelles River) to at least 550m elevation on St Lucia (Edmund Forest) (**Fig. 5**). This bat appears to be most abundant in the interior of the island, where there is wet forest (see below).

Habitat Associations

Surveys by the mammal survey team reveal that Davy's Naked-backed Bat occurs in wet and mesic forest and appears to be equally abundant at both forest types (**Tables 4 & 5; Fig. 5**). The mammal survey team also detected the echolocation calls of this species (at sunset) in dry hilltop forest on Mount Gaiac. Examination of the data suggests that these bats may have been commuting through this xeric habitat (possibly from roosts in sea caves) to forage inland at other habitats. Most specimens netted by the mammal survey team were taken at ridge-tops and near streams, the remainder being netted at nature trails through forest.

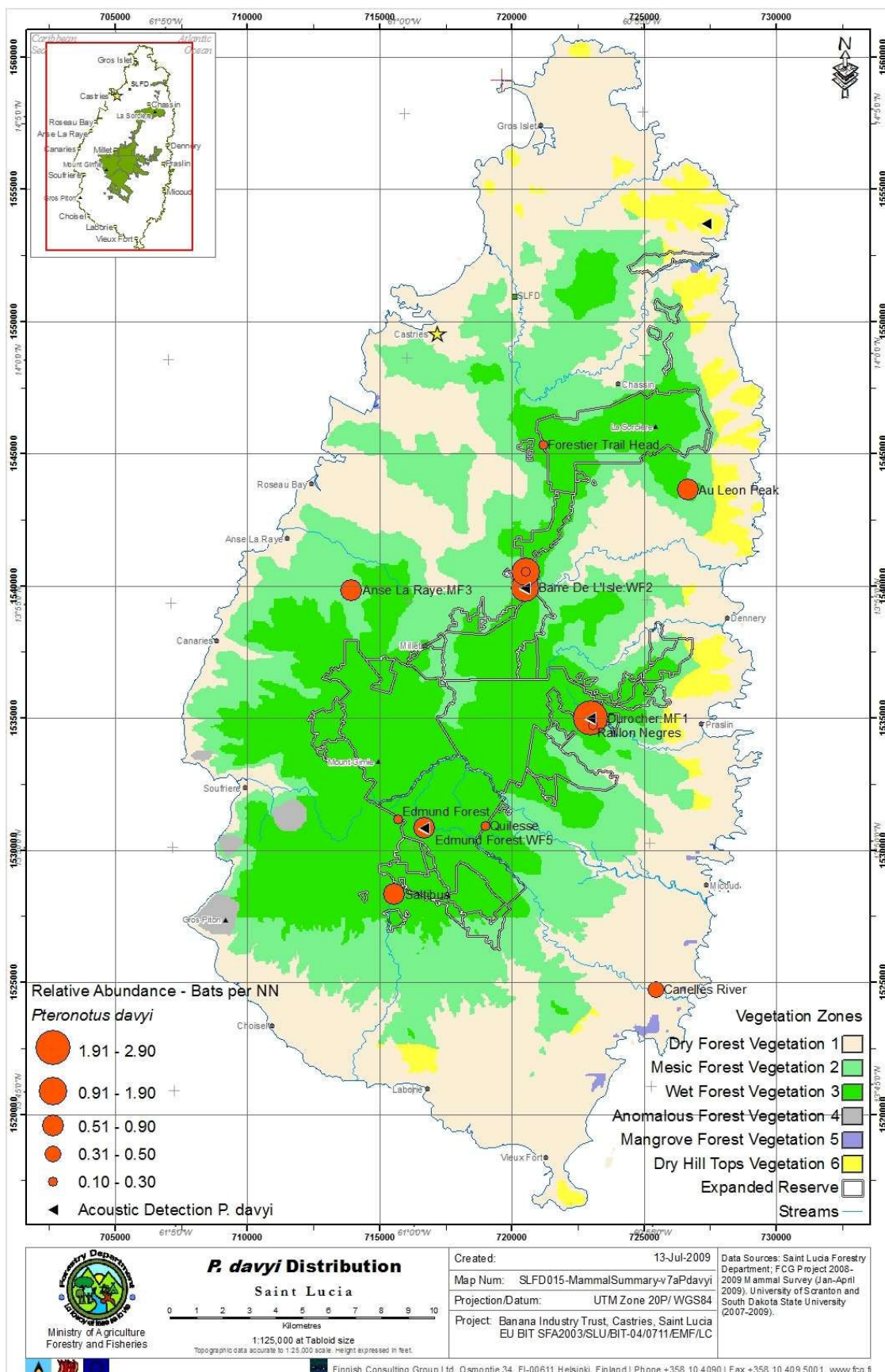


Figure 5. Distribution and abundance of *Pteronotus davyi* among St Lucia's native forests.

Surveys by Scranton University netted all but two individuals in wet forest (**Appendix V**). The two specimens netted outside wet forest were taken in riparian vegetation along Canelles River. Elsewhere in this species' range, Davy's Naked-backed Bat is known to show a broad tolerance for habitat types from wet to seasonally dry habitats typically below 500m elevation (Handley 1976; Adams, 1989; Emmons and Feer, 1997; Genoways *et al.* 2001). However, on St Lucia, Davy's Naked-backed Bat is largely associated with wet and mesic forest on St Lucia but can occasionally be found in riparian vegetation through the dry forest. Davy's Naked-backed Bat has been netted in association with all of the bat species occurring on St Lucia.

Diet and Feeding Habits

Davy's Naked-backed Bat is an insect-eating bat that uses echolocation to hunt airborne insects, especially Lepidoptera (butterfly and moths), Coleoptera (beetles) and Diptera (flies) (Adams, 1989). They leave from their roosts at sunset to forage and are most active in the first part of the night (Bateman and Vaughan, 1974). Davy's Naked-backed Bat is capable of fast, enduring flight and it typically forages close to ground within range of mist nets and bat detectors (Bateman and Vaughan, 1974). The echolocation calls of this bat were recorded by the mammal survey team (**Fig. 6a**). Their echolocation calls were found to consist of multiharmonic calls lasting around 6ms with the second harmonic being most intense with most of the energy in the call concentrated at 71.6kHz (high to low frequency = 72.3 - 57.9kHz). This species echolocation calls have a distinctive shape and cannot be confused with the calls of any other bat on St Lucia. The calls of Davy's Naked-backed Bats from St Lucia are similar to the calls produced by the same subspecies occurring on Dominica (Jennings *et al.* 2004).

Roost Requirements

No roosts of Davy's Naked-backed Bat were found by the mammal survey team on St Lucia. Davy's Naked-backed Bat is known to be an obligate cavity-roosting species (Adams, 1989). This species typically roosts in the darker recesses of moist caves and mines, less typically in man-made structures, and apparently occupies suitable caves regardless of the environs i.e. whether in xeric or moist habitats (Adams, 1989; Emmons and Feer, 1990). It has been suggested that the distribution of Davy's Naked-backed Bat in the West Indies may be limited by availability of suitable caves in which to roost (Timm and Genoways, 2003). Roosts of this species often number many thousands of bats (Adams, 1989). In the Lesser Antilles and Trinidad this bat has been found roosting in association with Jamaican Fruit bat and Brazilian Free-tailed Bat (Goodwin and Greenhall, 1961; Adams, 1989).

Reproduction

The mammal survey team captured one pregnant female on St Lucia on the 6th April. On Dominica, pregnant females have been captured in May and lactating females in July. Naked-backed Bats are known to be seasonal breeders, typically giving birth to a single baby per year (Wilson, 1979). Births are coincident with the onset of the rainy season, when insect availability is greatest (Bateman and Vaughan, 1974).

Conservation and Threats

The Lesser Naked-backed Bat is listed by the IUCN Red List as being of Least Concern in view of its wide distribution, presumed large population, tolerance of a broad range of habitats, it occurs in a number of protected areas and because is not thought to be declining (Dávalos *et al.* 2008). However, this species is an obligate cave roosting species and suitable cave systems may be limited on St Lucia (and in the region) due to its igneous geology, which may limit numbers of this bat. Disturbances to or destruction of cave roosts in the region may threaten this species. The improper and excessive use of pesticides and POPs on St Lucia and in the region may impact this species' insect prey, in turn causing declines in the populations of Lesser Naked-backed Bats.

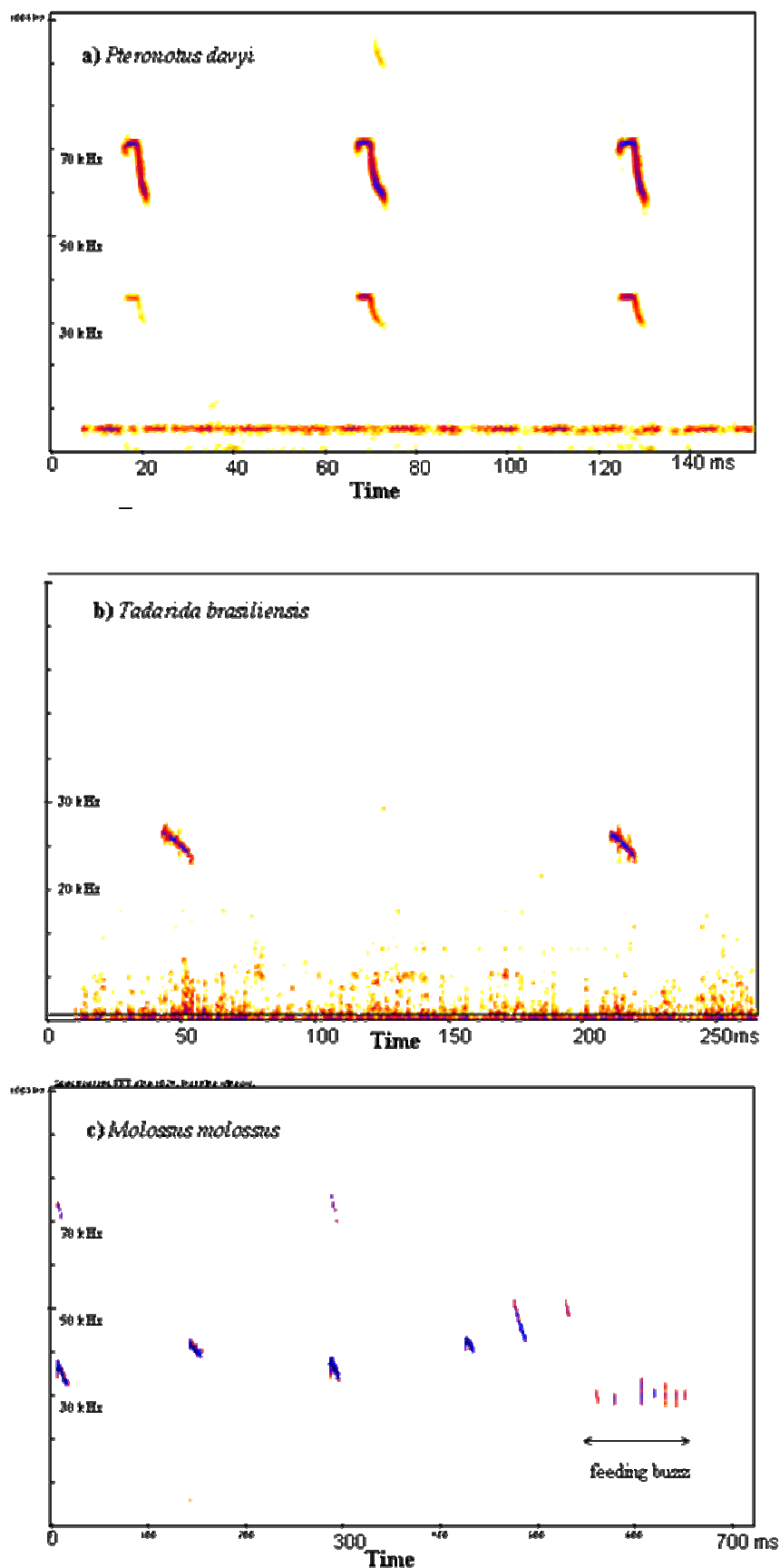


Figure 6. Echolocation calls (frequency changes over time) of three bat species from St Lucia. a) Three search phase calls of Davy's Naked-backed Bat *Pteronotus davyi* recorded at Mount Gaiac, b) Two search phase calls of a Brazilian Free-tailed Bat *Tadarida brasiliensis* recorded at Union Nature Trail, c) several search phase calls and a feeding buzz of a Common Free-tailed Bat *Molossus molossus* recorded at Anse Chastanet,

FAMILY: PHYLLOSTOMIDAE
Ardops nichollsi luciae (Miller, 1902)
Tree Bat



Photo: M. Morton @ Durrell Wildlife Conservation Trust

Description and Geographical Distribution

The Tree Bat is a medium-sized bat with a distinct noseleaf, brownish fur, yellow ear-rims, and a white spot on each shoulder. This species is endemic to the Lesser Antilles and occurs from St Eustatius in the north to St Vincent in the south (Simmons, 2005). It is native to St Eustatius, Antigua and Barbuda, Dominica, Guadeloupe, Martinique, Montserrat, Netherlands Antilles, Saba, St Kitts and Nevis, St Lucia, and St Vincent and the Grenadines. Of the five currently recognised subspecies, the subspecies *luciae* only occurs on St Lucia and St Vincent (Jones and Schwartz, 1967). Forearm lengths of the specimens captured by the mammal survey (range 46.6–47.3mm, n=9) team fell within the range of published measurements (Jones and Schwartz, 1967).

Distribution on St Lucia

The mammal survey team captured 17 Tree Bats. This and previous surveys reveal that the Tree Bat primarily occurs in wet forest above 300m elevation on St Lucia (**Fig. 7**), although previous work has netted this species repeatedly at a site (Grand Anse) near sea level (M Morton, pers. comm.).

Habitat Associations

Surveys reveal that the Tree Bat is uncommon on St Lucia (**Table 4; Fig. 7**). The mammal survey team netted all Tree Bats at streams or ridge tops in wet forest. This and previous surveys have netted Tree Bats with the Jamaican Fruit Bat, Insular Long-tongued Bat, Little Yellow-shouldered Bat, Antillean Fruit Bat, Lesser Naked-backed Bat and the Common Free-tailed Bat on St Lucia. On other islands the Tree Bat has been captured primarily in native wet primary and secondary forest especially near streams and ponds, and very occasionally in fruit plantations such as banana plantations and cacao groves, and dry forest (Jones and Genoways, 1973; Vaughan *et al.* 1996; Genoways *et al.* 2001, 2007a). The absence of Tree Bats from some islands, such as Barbuda and Anguilla, and its rarity on others, is likely the result of this bats requirement for tracts of forest, especially native wet forest.

Diet and Feeding Habits

The ecology of the Tree Bat is poorly known. It is a fruit eating bat (Jones and Genoways, 1973) and probably feeds on figs and other small fruits. These rare bats are unlikely to cause significant damage to commercially valuable fruit crops.

Roosting Requirements

The survey team did not find Tree Bat roosts on St Lucia. Very few roosts of these bats have ever been discovered. The Tree Bat appears to roost exclusively in the foliage of trees and other types of arborescent vegetation (Jones and Genoways, 1973); on Montserrat, radio-tracked individuals of this species switched tree roosts on a daily basis (M. Morton, pers. comm.). Roosts consist of solitary individuals or small groups.

Reproduction

Reproductive data for Tree Bats is limited. None of the females captured by the mammal survey team were pregnant or lactating and no juvenile bats were captured. On other islands pregnant females have been captured in March, April, and May, and lactating females have been captured in April (Jones and Genoways, 1973; Genoways *et al.* 2001, 2007a). Births appear to be timed to coincide with the period of greatest food availability.

Conservation and Threats

The Tree Bat is listed by IUCN Red List as of Least Concern in view of its abundance within its restricted distribution, its presumed large population, and because its habitat is unlikely to be declining fast enough to qualify for listing in a more threatened category (Dávalos and Rodriguez, 2008).

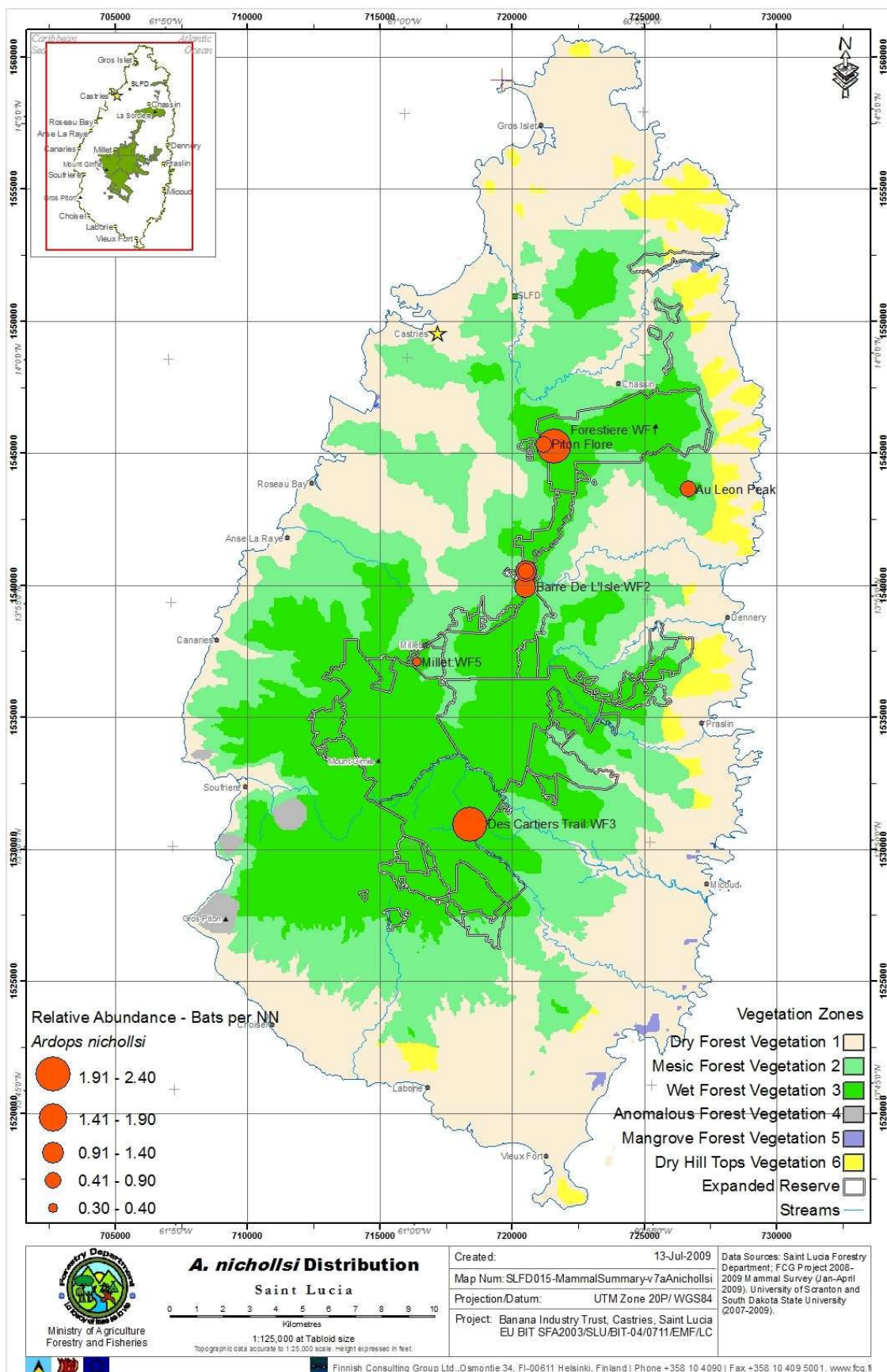


Figure 7. Distribution and abundance of the tree bat *Ardops nichollsi* among St Lucia's native forests.

However, caution needs to be exercised when interpreting IUCN categories of threat when data are deficient for this and most other bats in St Lucia and the region. This species appears to be uncommon on St Lucia and appears to need relatively large tracts wet forest to thrive, which is rare or lacking on most islands in the region, partly due to a long history of uncontrolled logging of wet and mesic forest. Also, it has been suggested that this species' requirement for roosting in large trees make the Tree Bat vulnerable to hurricanes (Pedersen *et al.* 1996), the severity and frequency of which is predicted to increase substantially in line with global climate change (Webster *et al.* 2005). In conclusion, the Tree Bat appears to be uncommon on St Lucia, habitat loss and hurricanes may threaten this species throughout the region, raising doubts about its listing by the IUCN Red List as being of Least Concern.

FAMILY: PHYLLOSTOMIDAE
Artibeus jamaicensis jamaicensis Leach 1821
Jamaican Fruit Bat



Description and Geographical Distribution

The Jamaican Fruit Bat is a medium-sized, brown to dark grey bat with a distinct nose-leaf (a fleshy leaf-shaped protuberance at the end of the nose which aids echolocation) and (sometimes faint) whitish facial stripes. It is a very widely-distributed and locally abundant bat, occurring from Mexico to Argentina (Ortega and Castro-Arellano, 2001). In the Lesser Antilles, the Jamaican Fruit Bat occurs on all islands, except the smallest islands and islets, and is typically the most abundant fruit bat (Genoways *et al.* 1996, 1998, 2001, 2005, 2007ab; Pedersen *et al.* 1996, 2003; Vaughan and Hill, 1996; Larsen *et al.* 2006).

Distribution on St Lucia

The mammal survey team captured 158 Jamaican Fruit Bats. Surveys reveal that this species is distributed over the most of St Lucia and occurs from sea level to at least 550m elevation e.g. Edmund Forest (**Fig. 8**). In other parts of the Jamaican Fruit Bat's range, this species has been recorded at more than 2,000m elevation in high elevation cloud forest (Eisenberg, 1989).

Habitat Associations

Surveys reveal that the Jamaican Fruit Bat is the most abundant (dominant) fruit bat on St Lucia and occurs in wet, mesic and dry forest (**Tables 4 & 5; Fig. 8**). It is most abundant in wet forest, less abundant in dry forest, and has not been recorded on dry forest hilltops (**Tables 5 & 6**). The Jamaican Fruit Bat was captured in all wet and mesic forest sites surveyed; with capture rates in wet forest being double those in mesic forest and more than ten times those in dry forest (**Table 6**). In wet forest most Jamaican Fruit Bats were netted at trails through closed forest (and to a lesser extent at streams); whereas in dry forest all individuals were netted in riparian vegetation along seasonal watercourses (dry at the time of these surveys). Scranton University's surveys appear to support these findings, large numbers of Jamaican Fruit Bats were netted in wet forest and, when taken in dry forest, all specimens were netted in the moistest sites e.g. ravines in dry forest and riparian vegetation along the Dennery, Troumassee, and Mamiku Rivers. Scranton University also commonly captured the Jamaican Fruit Bat in fruit plantations and man-made habitats on St Lucia e.g. Diamond Botanical Gardens (**Appendix V**). This and previous surveys have netted the Jamaican Fruit Bat in association with all other bat species occurring on St Lucia.

The Jamaican Fruit Bat has been the subject of detailed studies and its ecology is well known. Surveys of this bat on other islands in the Lesser Antilles, Trinidad, and the mainland, confirm our findings that the Jamaican Fruit Bat occurs in a wide variety of habitats, including seasonally dry forests and human-modified habitats, but is most common in wet forests (Goodwin and Greenhall, 1961; Eisenberg 1989; Handley *et al.* 1991; Genoways *et al.* 1996, 1998, 2001, 2005, 2007ab; Pedersen *et al.* 1996, 2003, 2005, 2006, 2007; Vaughan and Hill, 1996; Larsen *et al.* 2006). In

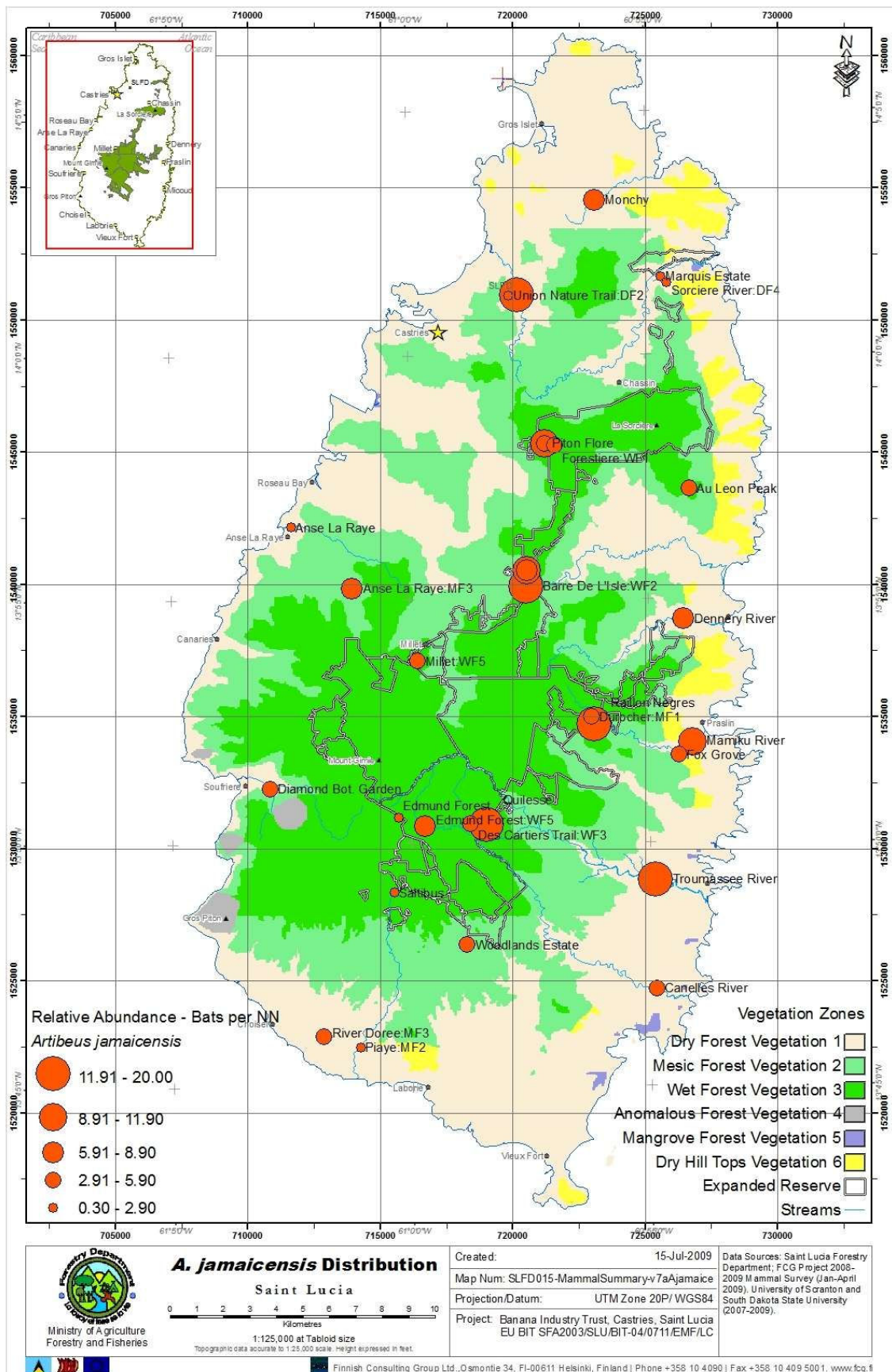


Figure 8. Distribution and abundance of *Artibeus jamaicensis* among St Lucia's native forests.

summary, the Jamaican Fruit Bat is undoubtedly one of the most widely distributed and abundant of St Lucia's bats.

Diet and Feeding Habits

On St Lucia, little is known of the diet of the Jamaican Fruit Bat. However, this species' diet is well known from studies elsewhere in this species range (Goodwin and Greenhall, 1961; Gardner, 1977; Handley *et al.* 1991; Kunz and Diaz, 1995). The Jamaican Fruit Bat is a frugivore that exploits a wide variety and number of plant species, and occasionally consumes insects. A list of the plants and plant parts known to be consumed by the Jamaican Fruit bat is provided by Ortega and Castro-Arellan (2001). In spite of the variety of plant species exploited by the Jamaican Fruit Bat, only a few compose the majority of its diet at any given locality (Handley *et al.* 1991). *Ficus* (Moraceae) and *Cecropia* (Cecropiaceae) are especially important part of the diet of the Jamaican Fruit Bat and the occurrence of this species in drier habitats appears to be due to the presence of fig trees among riparian vegetation in dry areas (Humphrey and Bonaccorso, 1979). The Jamaican Fruit Bats captured in dry forest areas on St Lucia i.e. the lower reaches of the Socriere, Dennery, Troumassee, and Mamiku Rivers, were probably attracted by figs and other fruiting trees among the riparian vegetation (**Fig. 8**).

The fur of all Jamaican Fruit Bats captured in dry forests in late March and April was covered in large quantities of pollen from an unidentified plant, staining the bats yellow over their entire bodies. Bats are highly mobile organisms and phytophagous (plant-eating) bats may shift from foraging in wet forest to dry forest towards the end of the dry season to exploit the high numbers of flowering plants occurring there. The Jamaican Fruit Bat usually carries fruits from the source to a feeding roost, which can be close or several hundred metres away, making it an effective seed disperser (Handley *et al.* 1991). On St Lucia, the Jamaican Fruit Bat is expected to be an important pollinator of fruit crops. Because of the 'ecosystem services' this bat provides, i.e. pollination and seed dispersal, the Jamaican Fruit Bat should be valued by St Lucians, despite the fact that flocks of this species can cause some damage to fruit crops.

Roosting Requirements

The mammal survey team did not find Jamaican Fruit Bat roosts on St Lucia. On other islands in the Lesser Antilles and Trinidad this fruit bat is known to roost in a wide range of structures, including among foliage, in caves, under rock overhangs, in rock fissures, hollow trees, foliage, and even man-made structures such as buildings (Genoways *et al.* 2007ab; Pedersen *et al.* 2007a,b; Goodwin and Greenhall, 1961). These bats also modify the leaves of various plants, especially palms, to produce day-roosting "tents" (Kunz and McCracken, 1996).

The Jamaican Fruit Bat often roosts in association with other bat species and in the Lesser Antilles has been observed roosting with Fishing Bats *Noctilio leporinus*, Insular Long-tongued bats *Monophyllus plethodon* and the Antillean Fruit Bat *Brachyphylla cavernarum* (Pedersen *et al.* 2007; Genoways *et al.* 2007a,b). At a distance, inexperienced observers can easily confuse the Antillean Fruit Bat with the Jamaican Fruit Bat. Both are leaf-nosed bats of similar size. Noise levels, activity, and grouping of individuals can be useful aids in the identification of bat species occupying a roost. Communal roosts of the Jamaican Fruit Bat are quiet, tend to consist of solitary bats and small clusters of individuals (e.g. harems in which a single male bat will defend 3-5 females), and may number up to a few hundred individuals at most. In contrast, the roosts of the Antillean Fruit Bat often contain thousands of closely grouped, noisy, squabbling individuals.

Reproduction

Little information exists on the reproductive patterns of the Jamaican Fruit Bat on St Lucia. On the 19th February, the mammal survey team found two females that appeared to be at an early stage of pregnancy, and three 'late stage' palpably pregnant females were captured in April (two females on 1st April, one female on 7th April). Although this species can breed at any time of year, the capture of pregnant females in April suggests that on St Lucia, as elsewhere in this species' range, births are timed to coincide with greatest food availability. Peak births typically coincide with the onset of the wet season when fruit is most available. Population studies of Jamaican Fruit Bats on Jamaica show that each female may breed up to twice per year (bimodal polyoestry) depending on the availability of resources (Genoways *et al.* 2005). On islands in the Lesser Antilles pregnant females have been captured in between January and August, with lactating females and juveniles captured from March to August (Pedersen *et al.* 1996, 2003, 2005, 2006, 2007; Genoways *et al.* 2001, 2007a,b).

Systematics

Throughout its large geographical range the Jamaican Fruit Bat shows considerable morphological variation (Ortega and Castro-Arellano, 2001). Morphological variation in Antillean populations of this species has recently been reviewed and several subspecies that may warrant species status have been described (Genoways *et al.* 2001; Timm and Genoways, 2003). The nominate subspecies *jamaicensis* is distributed from Jamaica through the Lesser Antilles to St Lucia; whereas Jamaican Fruit Bats occurring on St Vincent are much larger in size than other populations in the Lesser Antilles and have been assigned to the subspecies *schwartzii* (Jones, 1978). There is also some variation in the dentition of populations of the Jamaican Fruit Bat in the West Indies with respect to the absence of the third lower molars (Genoways *et al.* 2001).

Around 10% of the Jamaican Fruit Bats captured by the mammal survey team had very dark grey fur and indistinct facial stripes and were probably the subspecies *schwartzii*; whereas the remainder had medium-brown fur, more obvious facial stripes, and were probably the subspecies *jamaicensis*. Dentition was not examined but there is overlap in the range of forearm lengths of a subset of each morph measured (FA = 60.0-64.2mm, n=11) for dark bats with indistinct stripes versus FA = 58.2-62.0mm, n=16) for lighter coloured bats with indistinct stripes). A research team led by Scranton University is conducting research on the systematics and genetics of Jamaican Fruit Bats on St Lucia which may lead to taxonomic revision and the granting of full species status for the two subspecies i.e. *Artibeus jamaicensis* and *Artibeus schwartzii* (Kwiecinski *et al.* in prep).

Threats and Conservation Status

The Jamaican Fruit Bat is listed in the IUCN Red List as of Least Concern in view of its wide distribution, presumed large population, and because it is unlikely to be declining at nearly the rate required to qualify for listing in a threatened category (Miller *et al.* 2008). This may need to be revised if St Lucia's Jamaican Fruit Bat population is split into two species. Assuming a single species, *A. j. jamaicensis*, this bat does not appear to be nationally or regionally threatened. This bat is common in most habitats on St Lucia. Additionally, the plasticity in diet and choice of roost sites, and its tolerance of low to moderate levels of forest disturbance (Clarke *et al.* 2005a,b), may make the Jamaican Fruit Bat less vulnerable to man-made and natural forest disturbances (e.g. hurricanes) than other bat species occurring on St Lucia. This species should be valued by St Lucians and conserved due to its role as a highly effective seed disperser and plant pollinator, maintaining plant diversity and promoting forest regeneration. The economic cost of Jamaican Fruit Bats and other fruit-eating bats as pests of some fruit crops is outweighed by their important ecological roles and pollinators of commercial fruit crops (Kalko, 1998).

FAMILY: PHYLLOSTOMIDAE

Brachyphylla cavernarum cavernarum Gray, 1834
Antillean Fruit Bat



Photo: M. Morton @ Durrell Wildlife Conservation Trust

Description and Geographical Distribution

The Antillean Fruit Bat is a large, stocky bat with long, whitish-yellow to greyish-brown fur and a short, broad (stumpy) noseleaf. The genus *Brachyphylla* is endemic to the Antilles. The Antillean Fruit Bat is native to Puerto Rico, the Virgin Islands, Antigua and Barbuda; Barbados; Dominica; Guadeloupe; Martinique; Montserrat; Puerto Rico; St Kitts and Nevis; St Lucia; and St Vincent and the Grenadines (Simmons, 2005). Of the three recognised subspecies, *cavernarum* occurs on St Lucia and throughout the Lesser Antillean islands except Barbados (Swanepoel and Genoways, 1978).

Distribution on St Lucia

Although the Antillean Fruit Bat was not captured by the mammal survey, several thousand (estimated by visual count at ~5,000) were observed roosting in a sea cave a few hundred metres north of the village of Soufriere (**Fig. 9**). Surveys by Scranton University netted a small number of Antillean Fruit

Bats at this sea cave, a land cave (Grace Cave), in five wet forest sites, riparian vegetation in a dry forest area (near Monchy), and the Diamond Botanical Gardens (**Fig. 9; Appendix V**). Antillean Fruit bats can therefore occur from sea level to at least 550m elevation on St Lucia.

Habitat Associations

Mist net surveys suggest that the Antillean Fruit Bat is patchily distributed on St Lucia with only two known large roosts of this bat on the island i.e. Soufriere and Grace Caves (**Fig. 9**). The great majority of the Antillean Fruit Bats captured by Scranton University were netted at wet forest sites (**Fig. 9; Appendix V**). Only three specimens were captured outside wet forest: two at Diamond Botanical Gardens and one in riparian vegetation near the village of Monchy. Bats were netted in association with all of the bat species occurring on St Lucia with the exception of the Fishing Bat. These limited data suggest that the Antillean Fruit Bat is most abundant in wet forest on St Lucia, but occasionally frequents gardens and moist sites in xeric areas e.g. riparian vegetation.

In the Lesser Antilles, Antillean Fruit Bats have been observed or captured in a variety of habitats ranging from the xeric vegetation such as dry scrub vegetation and dry wooded ravines, though to gardens, fruit plantations and wet forest (Pedersen *et al.* 1996, 2005; Genoways *et al.* 2005, 2007a,b). The Antillean Fruit Bat can obviously tolerate xeric habitats as this bat occurs on very arid, low-lying islands that are largely covered by degraded scrub vegetation e.g. St Barthélemy, Anguilla, Antigua and Barbuda (Larsen *et al.* 2006; Pedersen *et al.* 2006, 2007; Genoways *et al.* 2007c). In summary, the Antillean Fruit Bat seems to prefer to forage in wet forest, but is tolerant of arid conditions and probably occurs in most forest types on St Lucia, though it is patchily distributed.

Diet and Feeding Habits

The ecology of the Antillean Fruit Bat is poorly known. Its diet is broad and consists of fruit of many plant species e.g. mango, sapodilla, and papaya, as well as pollen, flowers and, often, insects (Gardner, 1977; Swanpoel and Genoways, 1983). Antillean Fruit Bats have been observed to displace feeding Jamaican Fruit Bats from fruit trees (reported in Swanpoel and Genoways, 1983). As with the Jamaican Fruit Bat, the Antillean Fruit Bat forms flocks that may descend on fruiting trees and can cause localised damage to some fruit crops, though their value as pollinators of commercially valuable fruit crops means that they are beneficial to St Lucia.

Roosting Requirements

Two cave roosts of Antillean Fruit bats have been found on St Lucia. A roost near the village of Soufriere is in a sea cave - a tapering vertical fissure through rock around 3-4m at its widest point at sea level and extending about 5-10m upwards. At the time of visiting (March 2009) this roost consisted of several thousand noisy squabbling Antillean Fruit Bats, visually estimated at ~5,000 individuals, but no other bats species were observed. Multi-species occupancy of bat roosts is not uncommon and Antillean Fruit Bats have been found roosting in association with Jamaican Fruit Bats and Insular Long-tongued Bats in the region. This roost is well known to locals. Indeed tourists are often encouraged to swim around the bay to the roost or are taken in small boats by locals. The second cave, Grace Cave, was located inland in an area of mesic forest, and contained a large roost of Antillean Fruit Bats

Surveys on other islands in the Lesser Antilles show that the Antillean Fruit Bat primarily roosts in caves, though they occasionally have been found roosting in buildings and other man-made structures (Swanpoel and Genoways, 1983; Pedersen *et al.* 1996, 2003, 2007; Genoways *et al.* 2007c). As with cave roots on St Lucia, roosts of Antillean Fruit Bats on other islands can be large, consisting of several thousand individuals. Roosts are noisy and can therefore be easily distinguished from those of the Jamaican Fruit Bat (see species account for Jamaican Fruit Bat). Antillean Fruit Bat roosts are sometimes not occupied suggesting that these bats move between roosts (Pedersen *et al.* 1996). It is unclear why they do this, but their relocation may be related to a number of factors including changes in the availability of resources (fruit availability), disturbances to roosts or to locate suitable sites to nurse young i.e. maternity roosts. It is likely that the distribution and availability of suitable caves for roosting may shape patterns of distribution and abundance of Antillean Fruit Bats on and among islands.

Reproduction

No information exists on the reproductive pattern of the Antillean Fruit on St Lucia. On other islands in the Lesser Antilles, pregnant females have been found from March to mid-May and lactating females

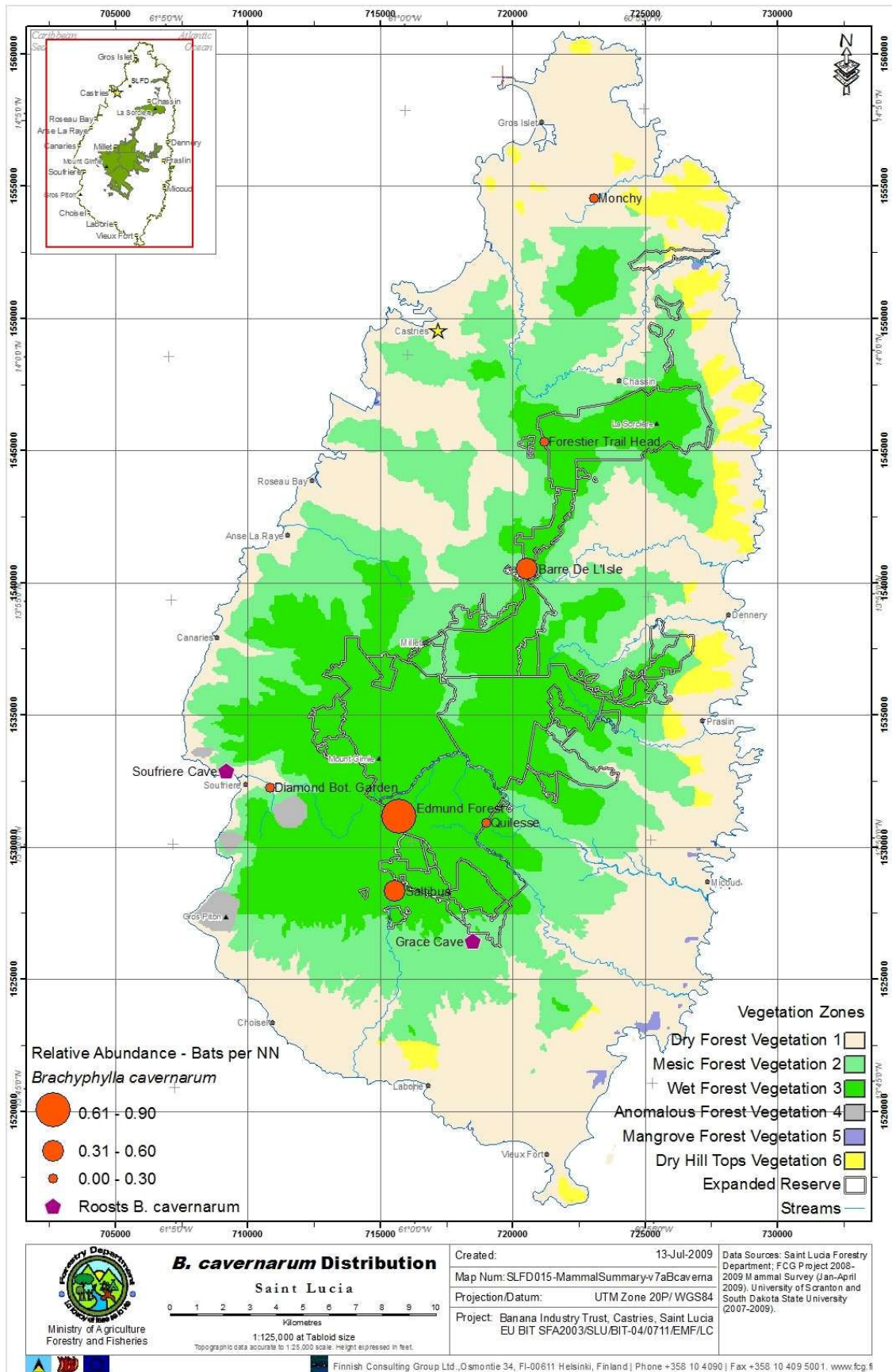


Figure 9. Distribution and abundance of *Brachyphylla cavernarum* among St Lucia's native forests.

and juveniles from May to July (Genoways *et al.* 2001, 2007abc; Larsen *et al.* 2006; Pedersen *et al.* 1996, 2003, 2005, 2006, 2007). This information suggests that births are timed to coincide with the onset of the wet season and greatest fruit availability. Depending on resource availability, it is possible that females may breed again later in the year.

Threats and Conservation Status

The Antillean Fruit Bat is listed in the IUCN Red List as of Least Concern in view of its abundance within its restricted distribution, its presumed large population, and its tolerance to some degree of habitat modification (Rodriguez and Dávalos, 2008b). Furthermore, it has been suggested that Antillean Fruit Bats may be less vulnerable to the effects of hurricanes and habitat disturbances than other bats in the region due to their catholic diet and preference for roosting in caves (Pedersen *et al.* 1996). However, caution must be exercised when interpreting the listing of bats in IUCN threat categories when data are limited for Antillean Fruit Bats and most other bat species or assuming that the threats throughout its geographical range are similar in type and severity. The Antillean Fruit Bat is patchily distributed on St Lucia and only two roosts are known. Phosphate mining, quarrying, and filling in or blocking of caves to develop areas for tourism appears to be a problem on some islands (Genoways *et al.* 2007b). Because all of this species population is concentrated at only a few cave roosts on St Lucia (as appears to be the case on other islands), these roost sites represent a single point of vulnerability for a very large proportion of the entire population. Alarmingly, there are unconfirmed reports of a proposal to dam the Vieux Fort River which would create a reservoir at Grace Cave the location of one of the only two known Antillean Fruit Bat roosts on St Lucia. In conclusion, the Antillean Fruit Bat appears to be patchily distributed on St Lucia and the region and may be threatened by disturbance to or destruction of cave roosts.

FAMILY: PHYLLOSTOMIDAE
Monophyllus plethodon luciae Miller, 1902
Insular Long-tongued Bat



Description and Geographical Distribution

The Insular Long-tongued bat, sometimes called the Insular Single-leaf Bat, is a small, dark brown bat with a diminutive heart-shaped noseleaf and a long muzzle and tongue. This species is a regional endemic, occurring only on islands in the Lesser Antilles (Simmons, 2005). This species is native to Anguilla, Antigua and Barbuda, Barbados, Dominica, Guadeloupe, Martinique, Montserrat, St Kitts and Nevis, St Lucia, and St Vincent and the Grenadines, with the subspecies *luciae* occurring on all of these islands except Barbados (Schwartz and Jones, 1967; Pedersen *et al.* 2003, 2005; Timm and Genoways, 2003). Measurements of specimens captured by the mammal survey team (forearm length = 41.1–45.3mm, n=11) are within the range of published measurements for this subspecies (Schwartz and Jones, 1967; Genoways *et al.* 2001).

Distribution on St Lucia

The mammal survey team captured 155 Insular Long-tongued Bats. This, and previous, surveys of St Lucia's bat fauna have netted the Insular Long-tongued Bat in association with all of the bat species occurring on St Lucia. Surveys reveal that this species occurs from around sea level (11m at Dennery River) to at least 550m elevation (Edmund Forest) on St Lucia (**Fig. 10**). On Dominica, this species is also distributed from sea level to 550m (Schwartz and Jones, 1967). It is likely that this species even occurs at St Lucia's highest peaks e.g. Mount Gimie.

Habitat Associations

Surveys reveal that the Insular Long-tongued Bat is abundant on St Lucia and occurs in wet and mesic forest but not dry forest hilltops (**Fig. 10, Tables 4 & 5**). A few individuals were captured by the team from Scranton University at the Troumassee and Dennery Rivers which flow through dry forest areas. However, these individuals were probably attracted by foraging opportunities in the moist riparian vegetation areas. The Insular Long-tongued bat, however, is largely restricted to and most abundant in wet and mesic forests on St Lucia (**Fig. 10, Tables 4 & 5**).

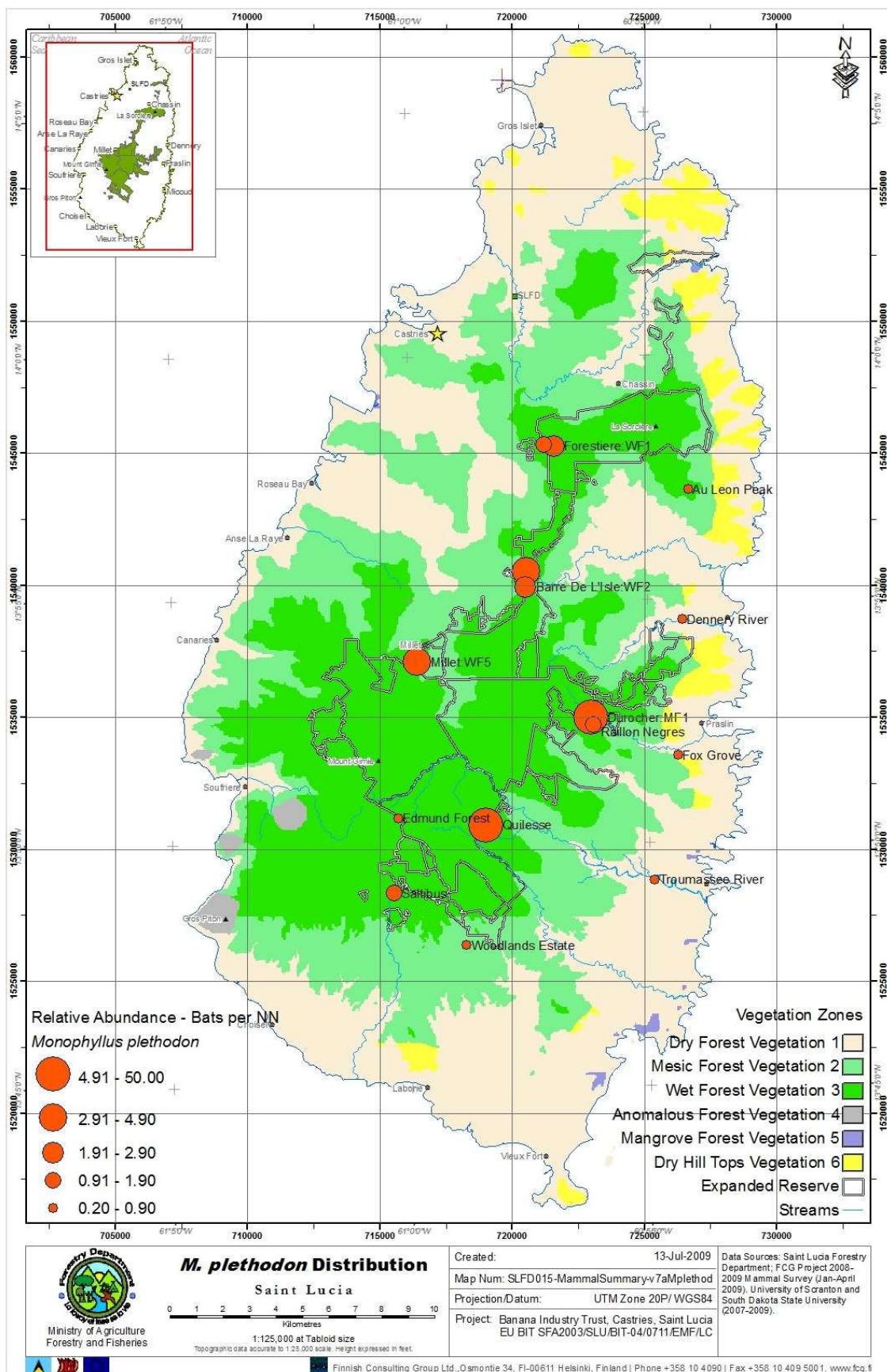


Figure 10. Distribution and abundance of *Monophyllus plethodon* among St Lucia's native forests.

Although surveys by the mammal survey team reveal this bat to be more abundant in mesic forest than wet forest (**Table 5**), the high capture rate in mesic forest is undoubtedly inflated due to the capture of a large number of Insular Long-tongued Bats at one site. At Durocher, a mesic forest site bordered by fruit plantations, mist nets intercepted a huge flock of Insular Long-tongued Bats and in less than three hours, 128 individuals were captured. These bats were probably commuting to feed on the ripening fruits at these plantations. In wet and mesic forest sites, specimens were typically netted at trails through mature, closed-canopy forest (e.g. nature trails, feral pig trails), and only rarely in small or streams and rivers. Scranton University also captured the Insular Long-tongued Bat in man-made habitats on St Lucia, e.g. Diamond Botanical Gardens (**Appendix V**).

Bat surveys on other islands in the Lesser Antilles confirm our findings that the Insular Long-tongued Bat is not uncommon in wet forest, riparian vegetation, fruit plantations and other cultivated areas, but is much rarer in xeric vegetation, such as dry forest and cactus scrub (Vaughan *et al.* 1996; Genoways *et al.* 2007abc, Pedersen *et al.* 1996, 2005, 2006, 2007; Timm and Genoways, 2003). Where this species has been captured in xeric landscapes, specimens were netted in wooded ravines and sinkholes, small fruit plantations and gardens, near fig trees, or at cave roosts (Schwartz and Jones, 1967; Pedersen *et al.* 2006, 2007; Genoways *et al.* 2007c).

Diet and Feeding Habits

The Insular Long-tongued Bat is primarily a nectar-feeding bat that also includes fruit and some insects in its diet (Homan and Jones, 1975). Nothing is known about which plants are utilised by this bat on St Lucia, though the mammal survey team captured large numbers near ripening fruit plantations. The Insular Long-tongued Bat is likely to be an important pollinator of native plants and also fruit crops.

Roosting Requirements

The mammal survey team did not find roosts of the Insular Long-tongued Bat on St Lucia. This bat is known to be an obligate cave roosting species. Roosts of Insular Long-tongued Bats have been discovered on other islands. This bat often roosts in association with Jamaican Fruit Bats, Antillean Fruit Bats, and Fishing Bats, but unlike these species, it prefers to roost in the darker, moister recesses of caves, such as deep crevices; and may be overlooked when roosting in small numbers (Pedersen *et al.* 2007; Genoways *et al.* 2007ab).

Reproduction

Little information exists on the reproductive patterns of the Insular Long-tongued Bat on St Lucia. Two palpably pregnant females were captured on 26th March and one pregnant female was captured on 1st April. On Dominica, females captured in March, April and June were pregnant (Homan and Jones, 1975; Genoways *et al.* 2001), and on Barbuda, lactating females were captured in June (Pedersen *et al.* 2007). These data suggest that births are timed to coincide with the period of greatest food availability.

Threats and Conservation Status

The Insular Long-tongued bat is listed by IUCN Red List as of Least Concern because of its presumed large population size, and because its habitat is unlikely to be declining fast enough to qualify for listing in a more threatened category (Rodriguez and Dávalos, 2008a). Again caution must be exercised when interpreting IUCN Red List listings as this species' population size is only presumed to be large. Potential threats to this obligate cave roosting bat are mining and quarrying of caves, human intrusions and disturbance of cave roosts. This species is not uncommon in most forests and habitats on St Lucia, with the exception of dry forest and other xeric habitats, and therefore is probably not nationally threatened. This species should be valued by St Lucians and conserved due to its role as a plant pollinator and the ecological services it provides, which include pollination of commercial important fruit crops.

FAMILY: PHYLLOSTOMIDAE
Sturnira lilium luciae (Jones & Phillips, 1976)
Little Yellow-shouldered Bat



Description and Geographical Distribution

The Little Yellow-shouldered Bat is a medium-sized, greyish to reddish-brown bat with a distinct noseleaf. Adult males possess shoulder glands that produce a yellowish or reddish staining of shoulder hairs, giving this bat its common name. The Little Yellow-shouldered Bat is widely distributed from Mexico to Uruguay (Simmons, 2005). In the Lesser Antilles it occurs on Anguilla, Antigua and Barbuda, Barbados, Dominica, Grenada; Guadeloupe, Martinique, Montserrat, Netherlands Antilles, St Kitts and Nevis, St Lucia, and St Vincent and the Grenadines (Barquez *et al.* 2008a). A number of subspecies are recognised. The subspecies *luciae* occurs only on St Lucia. The type locality is listed as ½ mile south of Boguis, Dauphin Parish (Jones and Phillips, 1976). Forearm lengths of specimens captured by the mammal survey team (range = 43.7–44.4mm, n=10) fell within the range of published measurements for this subspecies (Jones and Phillips, 1976; Genoways, 1998; Timm and Genoways, 2003).

Distribution on St Lucia

The mammal survey team captured 41 Yellow-shouldered Bats (**Table 4**). Surveys reveal that this species occurs from around sea level (e.g. Mamiku River) to at least 550m elevation (e.g. Edmund Forest) on St Lucia but is largely restricted to the interior of the island in wet forest (**Fig. 11**).

Habitat Associations

Surveys reveal that the Little Yellow-shouldered Bat is not uncommon on St Lucia and occurs in wet forest, mesic forest, dry forest ravines, riparian vegetation, and gardens (e.g. Botanical Gardens) but does not occur on dry forest hilltops (**Tables 4 & 5; Fig.11**). Surveys by the mammal survey team revealed this bat to be far more abundant in wet forest than other forest types (**Table 5**), at least during the dry season. Capture rates suggest that this bat is 10 times more abundant in wet forest than mesic forest or in dry forest. Little Yellow-shouldered Bats were most commonly netted at nature trails and streams in clearings (absence of canopy cover) in wet and dry forest. Little Yellow-shouldered Bats were netted in association with all of the other bats species occurring on St Lucia. In summary the Little Yellow-shouldered Bat is largely restricted to and most abundant in wet forest on St Lucia.

On many of the islands in the Lesser Antilles the Little Yellow-shouldered Bat appears uncommon (Jones & Phillips, 1976). In the Lesser Antilles this species has been captured mainly in wet forest, at streams in wet forest, and to a lesser extent in fruit plantations (Jones & Phillips, 1976; Vaughan *et al.* 1996; Genoways *et al.* 1998, 2001). Genoways (1998) suggests that Little Yellow-shouldered Bats are relatively uncommon on many of the Lesser Antillean islands because they require native wet forest to thrive and not agricultural areas. Our findings support this hypothesis.

Diet and Feeding Habits

The Little Yellow-shouldered Bat mainly feeds on fruit, though pollen, nectar and insects are also included in its diet. Nothing is known about the plant species utilised by this bat on St Lucia. Dietary studies of Little Yellow-shouldered bats at other parts of its geographical range have shown that as many as 28 families and 83 species of plants are known to be utilised (Gardner, 1977; Mello *et al.* 2008). However, Little Yellow-shouldered Bats are known to show a strong preference for the fruits of Solanaceae, and they are effective dispersers of the seeds of *Solanum*, though they occasionally feed on Piperaceae and Cecropiaceae (Mello *et al.* 2008).

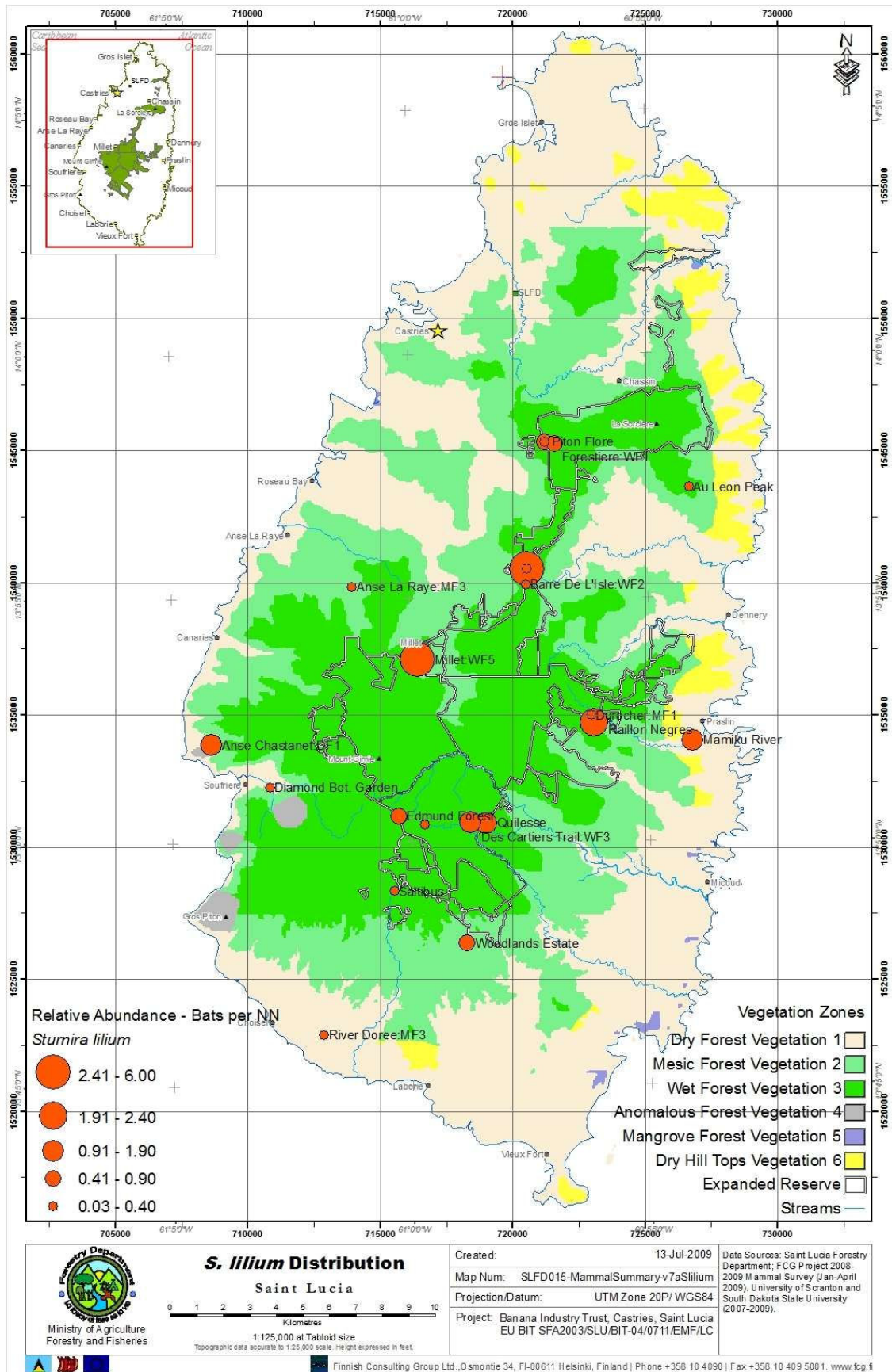


Figure 11. Distribution and abundance of the bat *Sturnira lilium* among St Lucia's native forests.

Roosting Requirements

The mammal survey team did not find roosts of the Little Yellow-shouldered Bat on St Lucia. Roosting preferences of this species on other islands in the Lesser Antilles have not been reported. This bat is known to roost in caves, tree-hollows, and man-made structures such as buildings (Gannon *et al.* 1989).

Reproduction

Little information exists on the reproductive patterns of the Little Yellow-shouldered Bat on the Lesser Antilles. None of the females captured by the mammal survey team were pregnant or lactating and no juvenile bats were captured. On Grenada, females captured in May were found to be lactating (Genoways *et al.* 1998). Elsewhere in this species range the Little Yellow-shouldered Bat can breed up to twice per year, with births concentrated in the wet season (Mello, 2008).

Threats and Conservation Status

The Little Yellow-shouldered Bat is listed by IUCN Red List as of Least Concern in view of its wide distribution, presumed large population, it occurs in a number of protected areas, and because it is unlikely to be declining fast enough to be considered threatened (Barquez *et al.* 2008a). Surveys suggest that this species is not uncommon in St Lucia and occurs in most forests and habitats except the driest habitats and is probably not nationally threatened, but more surveys are required to confirm this. No current threats are known to this species. Little Yellow-shouldered Bats may benefit from the decline in banana cultivation on St Lucia which has led to regeneration of wet forest on former plantations and an expansion of state-owned forest lands.

FAMILY: MOLOSSIDAE

Tadarida brasiliensis antillularum (Miller, 1902)
Brazilian Free-tailed Bat



Description and Geographic Distribution

Superficially similar in appearance and size to the Common Free-tailed Bat (see next species account), the Brazilian Free-tailed Bat has light brown fur and a wrinkled upper lip (deep vertical grooves); whereas the Common Free-tailed Bat has darker (reddish-brown) fur and a smooth-skinned upper lip. The Brazilian Free-tailed Bat has a very wide geographical distribution occurring from Mexico to Venezuela and Peru, and including the Greater and Lesser Antilles and Trinidad and Tobago (Simmons, 2005). In the Lesser Antilles, the Brazilian Free-tailed bat occurs on Anguilla, Antigua and Barbuda, Barbados, Dominica, Grenada, Guadeloupe, Martinique, Montserrat, Netherlands Antilles, St Kitts and Nevis, St Lucia, and St Vincent and the Grenadines. There are five recognised subspecies. The subspecies *antillularum* is the most widespread and occurs on St Lucia and all the aforementioned islands (Timm and Genoways, 2003). Forearm lengths of the specimens captured by the mammal survey team (38.4-39.5mm, n=6) are within the range of published measurements for this subspecies (Timm and Genoways, 2003).

Distribution on St Lucia

The mammal survey team captured six Brazilian Free-tailed Bats and using bat detectors to acoustically survey bats detected this species at two sites (**Table 4**). This and previous surveys reveal that the Common Free-tailed Bat can occur from around sea level to at least 550m elevation on St Lucia (Edmund Forest) (**Fig. 12**).

Habitat Associations

Mist netting and acoustic surveys by the mammal survey team reveal that on St Lucia the Brazilian Free-tailed Bat occurs in wet forest, mesic forest, and dry forest but not on dry forest hilltops (**Table 4**, **Fig. 12**). Too few captures mean that it is not possible to say which of the forest types surveyed are favoured by this species. All of the specimens captured on St Lucia have been taken at rivers and to a

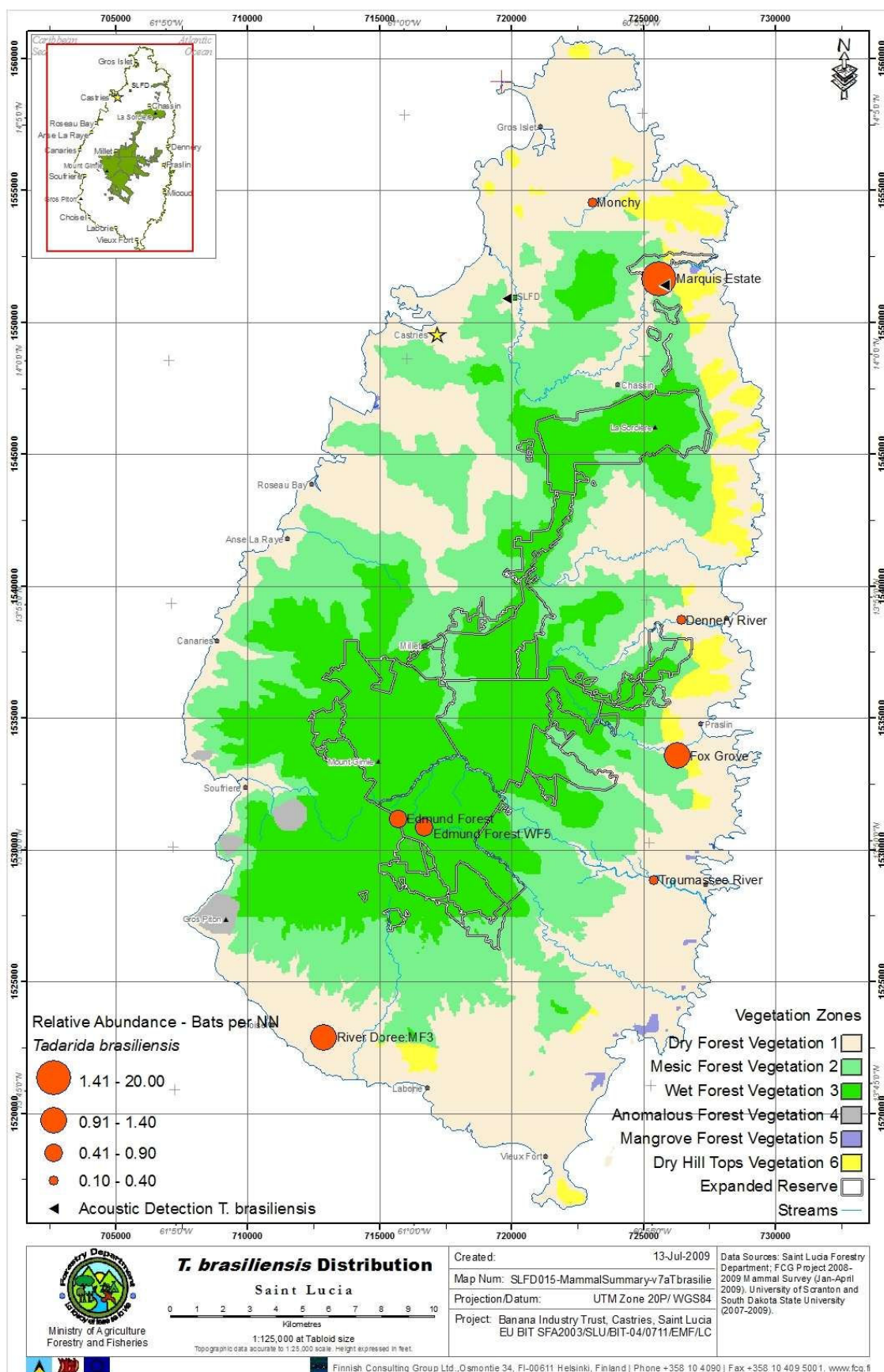


Figure 12. Distribution and abundance of the bat *Tadarida brasiliensis* among St Lucia's native forests.

lesser extent at trails and clearings in forest. Mist netting surveys by Scranton University yielded an especially large number of Brazilian Free-tailed Bats (147 specimens) at a river flowing through xeric habitat on the northeast of St Lucia (**Fig. 12; Appendix V**).

Elsewhere in the Brazilian Free-tailed Bat's geographical range, this bat is abundant and has been captured in a wide variety of habitats including in wet, mesic and dry forests (Eisenberg, 1989; Wilkins, 1989; Timm and Genoways, 2003). The Brazilian Free-tailed Bat is not uncommon in the Lesser Antilles (Baker and Genoways, 1978), and is probably more abundant on St Lucia than surveys would indicate, though less common than its close relative the Common Free-tailed Bat. This is because this species typically forages high above the ground out of the range of mist nets and bat detectors and where within the range of capture devices this species often detect and avoid mist nets as they have highly developed echolocation capabilities. The Brazilian Free-tailed Bat has been netted in association with all of the bat species occurring on St Lucia.

Diet and Feeding Habits

Despite their widespread distribution and abundance, relatively little is known about the ecology of these species and very little information is available on Brazilian Free-tailed Bat populations outside North America. The Brazilian Free-tailed Bat is an insect eating bat that uses echolocation to hunt airborne insects, especially, in order of importance, dipterans (flies), hymenopterans (ants, bees & wasps), lepidopterans (moths), and homopterans (bugs), in open, uncluttered spaces, often high above landscapes (Eisenberg, 1989; Wilkins, 1989; Whitaker and Rodriguez-Duran, 1999). The echolocation calls of this bat were recorded by the mammal survey team (**Fig. 6b**). The search phase of their echolocation calls last around 13 ms with most of the energy in the call concentrated at around 27.1kHz (high to low frequency of calls = 28.4 - 23.5kHz). The echolocation calls of Brazilian Free-tailed Bats are known to be highly variable and may vary depending on background (ambient) noise or the presence of other bats of the same species (Gillam and McCracken, 2007). They can sometimes be confused with the calls of the Common Free-tailed Bat, though typically the calls of the Brazilian Free-tailed bat are of lower frequency.

Roosting Requirements

No roosts of Brazilian Free-tailed Bats were found by the mammal survey team on St Lucia. In North America, roosts containing millions of individuals of Brazilian Free-tailed Bats are common; but in the Lesser Antilles much smaller roosts have been observed (100-1,000 bats) (Wilkins, 1989). In the Lesser Antilles this species roosts in crevices, caves, under culverts and bridges, and in tree hollows e.g. Red Mangrove (Genoways *et al.* 2001; Timm and Genoways, 2003; Pedersen *et al.* 2006). However, more typically in the Lesser Antilles the Brazilian Free-tailed Bat roosts in inhabited and uninhabited houses and other man-made structures (Timm and Genoways, 2003).

Reproduction

None of the females captured by the mammal survey team were pregnant or lactating and no juvenile bats were captured. Elsewhere, pregnant females have been found from May to July and lactating females from April to September (Genoways *et al.* 2001, 2007a; Larsen *et al.* 2006; Pedersen *et al.* 2003, 2006). Maternity roosts consist entirely of females and their young. Free-tailed bats can give birth twice a year, though one pregnancy each year is more common.

Conservation and Threats

The Brazilian Free-tailed Bat is listed in the IUCN Red List as Least Concern in view of their wide distribution and presumed large populations (Barquez *et al.* 2008d). On St Lucia and in the Lesser Antilles this species is widespread and appears to be quite common and is not likely to be nationally or regionally threatened, though on some Antillean islands populations may be threatened by mining in caves. Brazilian Free-tailed Bats are probably beneficial to humans and important in ecosystems, as large numbers of these bats may consume millions of small mosquito-sized insects each night, though their impact on controlling mosquito populations has historically been exaggerated. The tendency of this species to aggregate in huge numbers can lead to the accumulation of guano in commercially significant amounts, though in the Lesser Antilles roosts tend to be smaller in size than on continental America and guano is probably extracted for local use as fertilizers but not sold.

FAMILY: MOLOSSIDAE
Molossus molossus molossus (Pallas, 1776)
Common Free-tailed Bat



Description and Geographical Distribution

The Common Free-tailed Bat, sometimes called Pallas' Mastiff Bat, is a small dark brown to reddish-brown bat that has a tail that extends well beyond the edge of the tail membrane, hence the common name. This species has a wide distribution from Mexico to Venezuela and Peru, and including the Greater and Lesser Antilles and Trinidad and Tobago (Simmons, 2005). The Common Free-tailed bat has been recorded from at least 11 islands in the Lesser Antilles and probably occurs on most. The taxonomy is in need of revision. Antillean populations of free-tailed bats have reviewed by Timm and Genoways (2003). A number of subspecies have been described. The subspecies *molossus* occurs on St Lucia as well as Guadeloupe, Dominica, Martinique, St Vincent, The Grenadines, Grenada, and Barbados (Timm and Genoways, 2003). Forearm lengths of the specimens captured by the mammal survey team (39.2-40.7mm, n=8) are larger than the range of published measurements for this subspecies on neighbouring islands, i.e. St Vincent and Dominica (Timm and Genoways, 2003).

Distribution on St Lucia

The mammal survey team captured eight Common Free-tailed Bats and, using bat detectors to acoustically survey bats detected this species at seven sites (**Table 4, Fig. 13**). This and previous surveys reveal that the Common Free-tailed Bat is distributed over most of St Lucia and can occur from around sea level to at least 550m elevation (Edmund Forest) (**Fig. 13**).

Habitat Associations

Mist netting and acoustic surveys by the mammal survey team reveal that on St Lucia the Common Free-tailed Bat occurs in wet forest, mesic forest, and dry forest, but not on dry forest hilltops (**Table 4, Fig. 13**). Too few captures mean that it is not possible to say which forest types are favoured by this species. However, this and previous surveys of St Lucia's bat fauna suggest that the Common Free-tailed Bat most commonly occurs at rivers, streams and ponds regardless of the environs i.e. whether watercourses are in wet forest or dry forest areas (**Fig. 13**). In particular, the team from Scranton University recorded high capture rates of Common Free-tailed Bats at a number of St Lucia's major river systems (**Fig 13; Appendix V**). Mist netting surveys have yielded only a handful of specimens away from fresh water bodies on St Lucia. One specimen netted by the mammal survey team just before sunset at a clearing in dry forest next to the coast (Anse Chastanet) may have been commuting from a (sea cave) roost, and a second was netted at a nature trail in wet forest; whereas the team from Scranton University netted four specimens at the botanical gardens (**Appendix V**). The Common Free-tailed Bat has been netted in association with all of the bat species occurring on St Lucia.

Undoubtedly the Common Free-tailed Bat is far more abundant on St Lucia than surveys would indicate. This is because this species has highly developed echolocation abilities and therefore bats often detect and avoid mist nets. Indeed hundreds of Common Free-tailed Bats can be seen early each evening flying above most of St Lucia's towns. Elsewhere in this species' range the Common Free-tailed Bat appears to be tolerant of both wet and dry forests (Eisenberg, 1989). On other islands in the Lesser Antilles it has been captured at openings and trails through wet forest, in abandoned fruit plantations, near streams and over bodies of freshwater including swimming pools (Genoways *et al.* 2001, 2007a; Timm and Genoways, 2003; Pedersen *et al.* 2007). Common Free-tailed Bats are, however, most commonly observed flying above towns, as this species frequently roosts in houses and other buildings, whether inhabited or not.

Diet and Feeding Habits

The Common Free-tailed Bat is an insect-eating bat that uses echolocation to hunt airborne insects, especially moths (Lepidoptera) in open, uncluttered spaces (Eisenberg, 1989). Common Free-tailed

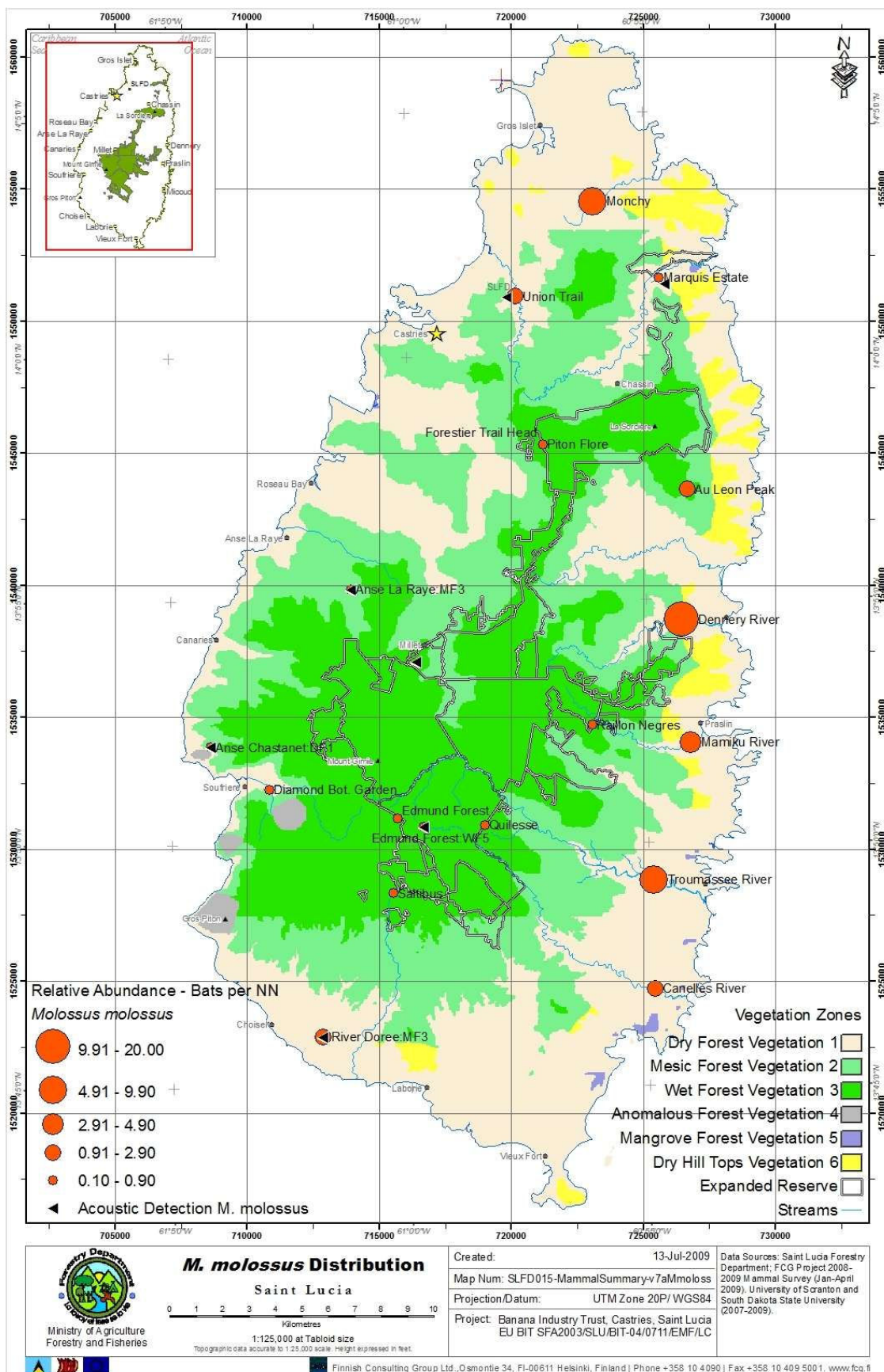


Figure 13. Distribution and abundance of the bat *Molossus molossus* among St Lucia's native forests.

Bats forage for only a few hours after sunset and then before sunrise (Chase *et al.* 1991). They frequently forage near stream and ponds and are most frequently captured in mist nets set over large calm pools of water with little or no canopy. These areas allow these bats to drink, while only slightly slowing their rapid flight (Eisenberg, 1989). They are often the most common bat captured at freshwater in dry areas. Their echolocation calls were recorded by the mammal survey team (**Fig. 13**). While searching for prey (search phase calls), Common Free-tailed Bats broadcast narrow-band calls of 6.4ms organized in pairs of pulses that alternated in frequency. The first signal of the pair is at 44.1kHz, the second at 48.1kHz. Frequency alternation of search calls is interpreted as a mechanism for increasing the temporal continuity of scanning, as well as increasing the detection range (Mora *et al.* 2004). When approaching insect prey, the time interval between the production of calls shortens (i.e. bats have a higher call rate) and the bandwidth (range from high to low frequency) of each call increases. Apparently, this allows the bat to more accurately determine distance and prey position (Mora *et al.* 2004).

Roosting Requirements

The mammal survey team located five a number of roosts of the Common Free-tailed Bat on St Lucia. All were in abandoned or unoccupied buildings within wet forest e.g. Foresters Houses at Edmund and Millet Forests. Each roost was estimated to contain several hundred Common Free-tailed Bats. The Common Free-tailed Bat is known to use a wide variety of roosts, including hollow trees and logs, caves and rock fissures and palm trees (Eisenberg, 1989). However, this species frequently roosts in buildings, especially in crevices under the roofs of houses whether inhabited or not. Man-made structures are probably the primary roosting sites of Common Free-tailed Bats on St Lucia.

Reproduction

None of the female Common Free-tailed Bats captured by the mammal survey team on St Lucia were pregnant or lactating and no juvenile bats were captured. On other islands in the Lesser Antilles, pregnant females have been captured from April to August and lactating females in July (Pedersen *et al.* 1996, 2003, 2005; Genoways *et al.* 1998, 2001, 2007ab; Timm and Genoways, 2003; Larsen *et al.* 2006). This species may give birth twice a year depending on resource availability.

Conservation and Threats

This species is listed by the IUCN Red List as Least Concern in view of its wide distribution, presumed large population, and because it is unlikely to be declining at nearly the rate required to qualify for listing in a threatened category (Barquez *et al.* 2008b). Although rarely captured in mist net surveys, this bat is a common resident in occupied and uninhabited buildings in St Lucia and probably highly abundant throughout the island and on others in the region. There are no major threats to this highly abundant species, nationally or regionally. Although some populations may decline following severe hurricanes, perhaps due to a reduction in the availability of suitable roosts sites as hurricanes rip off roofs and destroy roost sites, populations appear to recover.

FAMILY: DASYPROCTIDAE
Dasyprocta leporina fulvus (Kerr, 1792)
Brazilian Agouti



Agouti from St Lucia (photo: M. Morton)

Common (English) Name

Brazilian Agouti, Red-rumped Agouti, Orange-rumped Agouti

Local names

Agouti (Ar-goo-tee)

Description

The Brazilian Agouti is a large rodent about the size of a domestic cat (40-60cm in length and 3-6kg in weight), but ungulate in appearance; with long slender legs, a large rump, and strongly humped back.

The forefeet have four strong toes, and the hind feet have three long, strong toes, and hoof-like nails. On St Lucia agouti tracks cannot easily be confused with the other mammal tracks (**Appendix IV**). Agoutis on St Lucia and other islands in the Lesser Antilles are generally dark brown; whereas mainland populations are more orange-reddish (see above photo).

Geographical Distribution and Abundance

The Brazilian Agouti occurs in the Lesser Antilles, and on Trinidad, Venezuela, Guianas, and eastern and Amazonian Brazil (Wilson and Reeder, 2005). Originally three species of agouti were described from the Lesser Antilles, but mammalogists now believe that all of the agoutis in the West Indies are descendants of animals introduced to the islands by humans. Populations of agouti were established as far north as the Virgin Islands. The pattern appears to be *D. I. leporina* (from Brazil) to the Virgin Islands; *D. I. albida* on St Vincent and Grenada; *D. I. noblei* on Guadeloupe, St Kitts, Dominica, and Montserrat; and *D. I. fulvus* on Martinique and St Lucia (Woods, 1993).

Status on St Lucia

The Brazilian Agouti is not native to St Lucia. The agouti was introduced to the West Indies by humans, probably by Arawak or Carib Amerindian groups in pre-Columbian times, for food and trade. The agouti may have been introduced to St Lucia around 25,000 years bp by early Amerindian colonists. Even today agoutis are still widely transported by Amerindian groups for trade and food (pers. obs.).

Distribution on St Lucia

The mammal survey team only observed the Brazilian Agouti on three occasions despite 370 person-hours of Timed Searches within forest. On the 31st of March at 15:45h an adult was observed crossing a road through a mixed area of mesic and riparian forest and fruit plantations near Venus Estate (**Fig. 14**). On the 6th April at 17:30h another adult was observed only 500m from where the first animal was observed. This may have been the same animal. On both occasions the agoutis were moving towards riparian forest in the direction of a large river, perhaps to drink. A third agouti, also a solitary adult, was observed at Edmund Forest crossing a trail in a mixed area of wet forest and (mature) Blue Mahoe plantings at around 470m elevation.

Brazilian Agoutis were observed by a group of parrot survey volunteers from Durrell Wildlife Conservation Trust on four separate occasions. All sightings were within state-owned wet forest (**Fig. 14**). The parrot survey effort was substantial, with at least a dozen volunteers and FD staff working and camping in wet forest for many hours each day for during January and February, yet few agoutis were observed. Agoutis are notoriously difficult to capture or observe systematically (Jorge and Peres, 2005). That said, that only a handful of agoutis were observed despite several thousand person-hours of wildlife surveys within suitable agouti habitat at localities where hunting is rare, strongly supports the experience of many mammalogists working in the region that agouti are uncommon in the Lesser Antilles - certainly compared to their natural range (Timm and Genoways, 2003; F. Clarke, pers. obs.). Additionally, few tracks of agouti were found, perhaps due to this species rarity, but also because the ground was quite dry at the time of surveys (the dry season), resulting in fewer areas for mammals to leave tracks.

Interviews with FD staff, range officers, landowners and rural St Lucians, confirm the findings of surveys the Brazilian Agouti is rare on St Lucia and is largely restricted to wet and mesic forest in the interior of the island (**Fig. 14**). Brazilian Agoutis are reported to occur at the following localities: Quillesse Forest, Mahaut, La Tille, Ti Rocher, Belle Vue, Woodlands, Calypso, Grace, Des Cartiers, Patience, Fond Devaux, Palmiste, La Porte, and La Grace. There are no credible reports of agouti occurring in dry forest on St Lucia, though it is possible that individuals could be attracted to gardens, riparian forest, and the moister areas and streams in dry forest areas, where agouti can have regular access to fresh water and can raid fruit and vegetables crops. It is likely that agouti are most numerous on St Lucia where gardens and fruit plantations (where they can forage easily) border areas of wet, mesic, and riparian forest with streams and dense undergrowth (where they can den up and escape from their main predators - man, dogs and cats) and streams; but nowhere on the island can the agouti be considered common. It does not inhabit any of the offshore islands.

Habitat Associations and Abundance

Outside of the Lesser Antilles within their natural geographic range, agoutis *Dasyprocta* have been relatively well-studied (Cant, 1977; Smythe, 1987; Janson and Emmons, 1990; Wright *et al.* 1994;

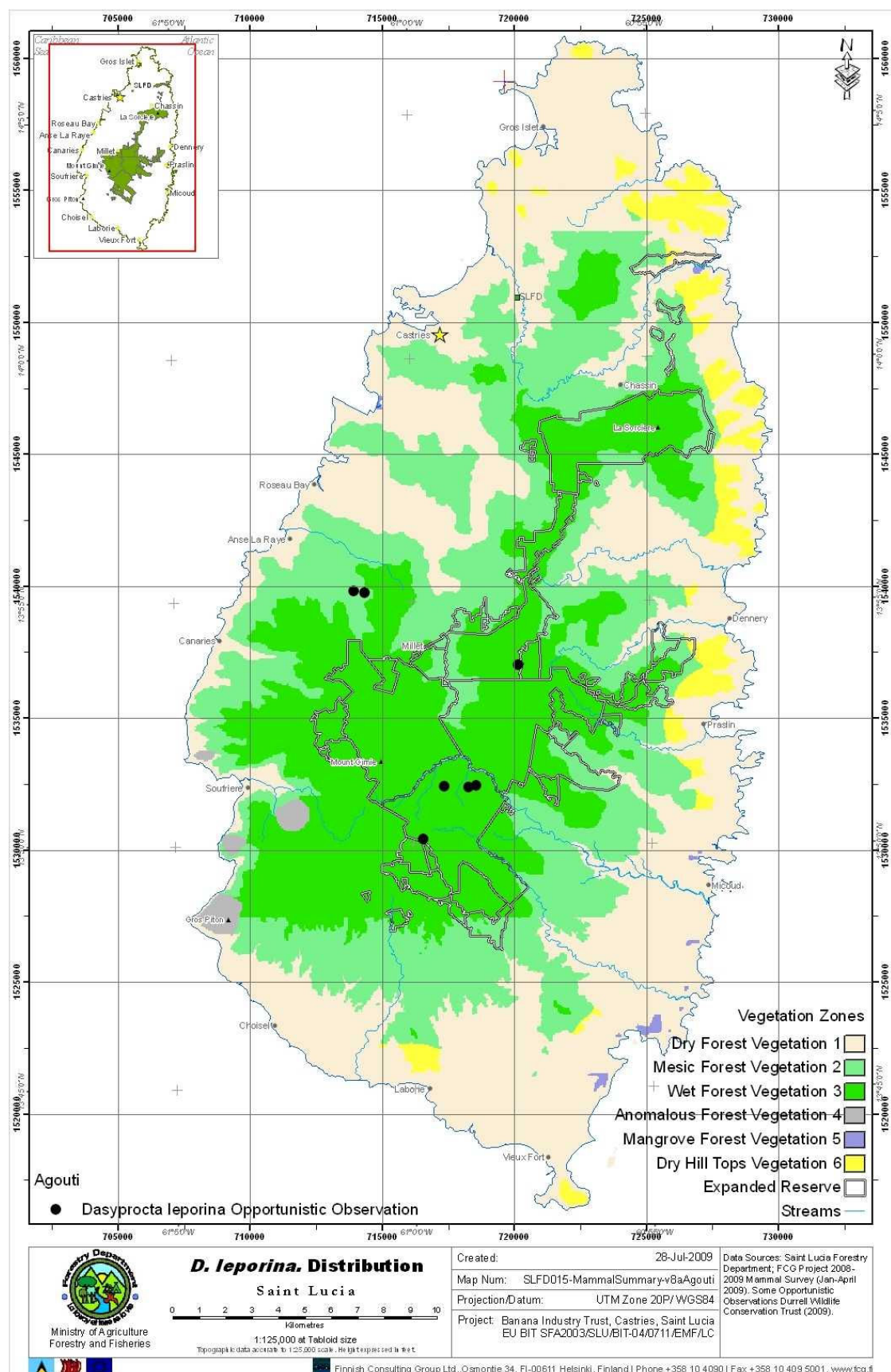


Figure 14. Distribution and abundance of the agouti *Dasyprocta leporina* among St Lucia's native forests.

Henry, 1999; Peres, 1999; Haugeasen and Peres, 2005; Jorge and Peres, 2005). They can be found in many types of forests, such as montane forest, lowland wet forests, seasonally dry moist forests, savannah woodland, even swamp forests; and they can thrive in secondary growth areas such as secondary forests and plantations (Smith, 1974; Smythe, 1978; Eisenberg and Thorington, 1973). The proximity of fresh water and availability of fruit appear to be key factors determining the suitability of habitat for agouti (Smythe, 1978).

Within their natural range agoutis are often one of the most abundant mammals in forests. However, the population density of agouti appears to be highly variable over their geographic range (Jorge and Peres, 2005). Reported mean density estimates for of agoutis are 31 per km² (Pinkaiti, Brazil), 8 km² (Tikal, Guatemala), 5 per km² (Manu, Peru), 5 per km² and 8 per km² (two sites in central-western Brazilian Amazonia), and 84 km² (Barro Colorado Island, Panama) (Cant, 1977; Janson and Emmons, 1990; Wright et al. 1994; Peres, 1999; Haugeasen and Peres, 2005; Jorge and Peres, 2005). The density of agoutis may be primarily regulated by the local abundance of tree species which produce large seeds on which they rely on during periods of fruit scarcity (Jorge and Peres, 2005). Other than in this project, the only systematic surveys of agoutis in the Lesser Antilles was in Dominica, where numbers of agouti were found to be similar among a variety of habitats and elevations, including disturbed areas (Magin, 2003). The agouti appears to be somewhat more abundant on Dominica than other islands in the Lesser Antilles, perhaps due to the island's extensive forest cover and the absence of mongoose.

Ecology and Behaviour

Agoutis are ground-dwelling herbivores, eating seeds, fruits, and other succulent plant parts (Smith, 1974; Smythe, 1978; Henry, 1999). They are naturally diurnal (active by day) or crepuscular (active early morning and late afternoon: agouti are most often encountered after 16:00 hours), but when heavily hunted they can become nocturnal (Emmons and Feer, 1997). Agoutis are sometimes active on bright moonlight nights. They are a shy, active species, and are quick to flee when they are disturbed. They run with a bounding bouncing gait and when alarmed may raise their long rump hairs in a fan. Alarm calls may consist of a series of low grunts or loud squeals and barks, and they frequently stamp their hind feet on the ground. However, agoutis are quite resilient to disturbances and are highly adaptable. Agouti social units typically consist of loosely formed territorial pairs, often together with one or two of their offspring (Smythe, 1978; Dubost, 1988). Home range sizes for agoutis have been estimated from 2 to 8.5 per ha per pair (Smythe, 1978; Silvius and Fragaso, 2003; Jorge and Peres, 2005). Pairs defend their territories and take refuge from predators in dens in burrows that are often lined with roots, leaves, and hair.

Within their natural geographic range agoutis are important seed dispersers. When food is plentiful they cache large quantities of large seeds in holds to overcome periods of food scarcity (Smythe, 1978). This behaviour helps to disperse the seeds of tropical trees (e.g. Brazil Nut *Bertholletia excelsa*), and can promote reforestation. The seasonal scarcity of fruit is also known to limit populations, by increasing mortality. This particularly affects sub-adult agouti, as they do not possess territories with caches of buried seeds. Sub-adult mortality in the Panama study was 70 percent during the season when fruit was scarce, but as little as 5 percent when fruit was plentiful (Smythe, 1978). The diet of Brazilian Agouti in French Guiana was found to differ with season – fleshy fruit was favoured when available but large seeds, plant parts and animals (e.g. ground-nesting birds) were relied upon during periods of low fruit availability (Henry, 1999).

Agoutis are abundant in most tropical forests outside the Lesser Antilles and therefore they are an important prey item for large carnivorous animals, especially felids (cats), large constricting snakes, and larger raptors (Smythe, 1978). It is not clear whether they have had a largely beneficial or detrimental impact on St Lucia's forests and wildlife. Research is especially needed to determine the diet of agouti in St Lucia's forests. Important questions are: which native seeds and fruits do they eat, do they disperse the seeds of native plants, and are germination enhanced and forest regeneration promoted? Certainly they are regarded as pests by many farmers; eating the fleshy parts of agricultural crops, sugarcane and banana plants. On St Lucia, adult Brazilian Agoutis probably have few natural predators other than the Boa constrictor. It is other introduced mammals - humans, the mongoose, dogs and feral cats - that pose a threat to the Brazilian Agouti on St Lucia (Allen, 1911).

Reproduction

Agouti can breed throughout the year and females can breed twice a year, usually giving birth to one to three young - twins being most common (Smythe, 1978). Therefore populations can usually recover rapidly from exploitation when protected. The very precocious young are suckled for about two months. They grow fast, reaching sexual maturity at 6 to 9 months, depending largely on the level of nutrition. Life expectancy in captivity can exceed 10 years. In Panama, Smythe (1978) noted that most young agoutis were observed when fruit was most abundant. There is no information on the reproduction patterns of agoutis on St Lucia. All of the animals observed during surveys were adults without accompanying young. However, it is likely that young are weaned to coincide with greatest fruit availability on St Lucia.

Traditional Use

Agoutis are valued for food, and are hunted throughout their range. In some areas, where human populations are low, or traditional hunting patterns remain, populations of agouti have remained stable. Smythe (1978) gave a meat production estimate of 4.5 kg/ha in moist forests in Panama. Without hunting regulations, over-exploitation has occurred in some areas near villages, towns, and other population centres (Mares and Ojeda, 1984). The agouti appears to be uncommon in the West Indies (perhaps with the exception of Dominica) and the Brazilian Agouti population on St Lucia probably could not withstand unregulated and poorly policed hunting within state-owned protected forest lands. With the increase in human populations, forest clearance, and the introduction of predators such as cats and the mongoose, agoutis have become rare on many islands in the Lesser Antilles. In fact they may never have been common in the Lesser Antilles where they have been introduced.

In Dominica, agoutis are a popular game species. Hunting mainly occurs at a low intensity around farms, and there is a low level of commercial hunting for the restaurant trade (Magin, 2003). In response to concerns over the sustainability of levels of hunting, biological surveys of agouti were undertaken by Fauna & Flora International and Dominica's FD as part of the Development of a National Strategy for Sustainable Wildlife Use in Dominica (Magin, 2003). Agoutis are not native to Dominica and therefore of low conservation priority. However, in light of the cultural importance agouti in Dominica as a popular game species, the study recommended a ban on commercial hunting (but that local subsistence hunting should be allowed to continue) to maintain a viable population of agouti. On Trinidad and Guyana hunters erect low platforms next to trees with heavy fruit fall or where there are crops that agouti like to raid and then spearing agoutis that come to feed (pers. obs.). Agoutis are also frequently hunted with dogs which drive them into burrows or hiding areas.

On St Lucia, Brazilian Agoutis are illegally hunted by setting snares and other home made traps and devices. Less commonly they are hunted with dogs. On the whole Brazilian Agoutis are rarely hunted by St Lucians, though the meat is considered quite 'tasty'. Hunters usually remove the anal scent gland from their kill so as not to spoil the taste of the meat. Farmers on St Lucia frequently complain about agoutis damaging their crops, especially newly planted vegetables, and want to be able to legally trap and kill agoutis that 'trespass' on their farms and gardens. Some farmers probably exaggerate the abundance of agouti in their area because they want to trap agouti on their land.

Agoutis are often kept as 'domestics' in parks and gardens of Latin America or in Amerindian communities, and they may make affectionate pets. On St Lucia a small number of Brazilian Agoutis are kept at the zoo run by the FD and appear to be doing well in captivity. There is interest in agouti as a candidate for "minilivestock farming" – farmed or 'ranch'd' for meat production.

Conservation Status

The Brazilian Agouti is listed by the IUCN Red List as Least Concern in view of its wide distribution, presumed large population that is unlikely to be in decline, occurrence in a number of protected areas, tolerance to some degree of habitat modification, and lack of major threats (Emmons and Reid, 2008). There are no major threats to this species on St Lucia. Although agoutis are frequently hunted locally, this is not seen as a major threat at current levels. On St Lucia, the agouti is only one of two mammals (the other being the opossum) that is specifically listed as protected under the Wildlife Protection Act 1980. As a non-threatened, introduced species the Agouti is of low conservation priority. Management recommendations for agoutis are outlined in **section 5.3**.

FAMILY: HERPESPIDAE
Herpestes javanicus
(E. Geoffroy Saint-Hilaire, 1818)
Small Asian Mongoose



Common (English) Name

Small Asian Mongoose, Small Indian Mongoose, Golden Spotted Mongoose

Local names

Mongoose (ma-goose)

Description

The mongoose has a long, slender body and relatively short legs. The snout is long and the ears are small. The tail is long, muscular at the base and tapers gradually to the tip. Adults have a head and body length of 50 to 70cm and weigh between 0.3 and 0.7kg. Adult females are smaller than males, with a maximum head and body length of ~58cm (Nellis, 1989). Males have a more robust head. On St Lucia, there was little variation in the coat colour and patterning of mongooses encountered. Most had light to medium brown fur with gold speckling.

Geographical Distribution

The taxonomy of the Small Asian Mongoose (*Herpestes javanicus*) is constantly under debate (see Vernon *et al.* 2006) and the species has also been referred to as *H. auropunctatus* (e.g. Nellis, 1989). Here we regard them as conspecific. The Small Asian Mongoose originates from Asia (including India, Pakistan, southern China, Java, Iran, and Iraq), but has now been introduced to a number of countries, including St Lucia and many other islands in the West Indies (for complete list of countries - see Wilson and Reeder, 2005). The first documented introduction of mongoose to the West Indies was in 1870 when an unknown number of animals from India were introduced to Trinidad (for a history of mongoose introductions see - Hoagland *et al.* 1989). Subsequently, in 1872, four males and five female mongooses (one pregnant) from Calcutta were successfully introduced to Jamaica (Espeut, 1882). Ten years later, the mongoose population on Jamaica had grown rapidly and became the source for introductions to other islands in the West Indies. Mongoose introduced to Puerto Rico and Barbados (from Jamaica) were the probable source of animals introduced to St Lucia (Hoagland *et al.* 1989). The Small Asian Mongoose has now been introduced to at least 29 islands in the West Indies including (year of introduction in parentheses) Antigua, Barbados (1877). Beef Island, Buck Island (1910), Cuba (1866), Grenada (1882), Guadeloupe, Hispaniola (1895), Jamaica (1872), La Desirade, Marie-Galante, Martinique, Nevis, Puerto Rico (1887), St Croix (1884), St John, St Kitts (1884), **St Lucia**, St Martin (1888), St Thomas, St Vincent, Tortola, Trinidad (1870), and Water Island (Barbour, 1930; Nellis, 1989; Hoagland *et al.* 1989; Hays and Conant, 2007).

Status on St Lucia

An introduced species, the mongoose is not native to St Lucia. It is well established and documented that mongoose was introduced to the West Indies by Europeans in the late 19th and early 20th centuries (Hoagland *et al.* 1989). The mongoose was intentionally introduced to St Lucia by the British in the late 19th century to control rodent numbers in plantations. It is also, perhaps wrongly, assumed that the mongoose was also introduced to eradicate snakes, specifically the St Lucian Pit Viper (fer de lance snake) *Bothrops caribbaeus* (Hinton and Dunn, 1967). It is believed that the mongoose was first introduced to St Lucia in 1888 (Hoagland *et al.* 1989).

Distribution on St Lucia

The mammal survey team trapped 144 mongooses (80 males and 64 females, including six recaptures) and observed an additional 19 individuals, seven of which were road-killed animals. Parrot survey volunteers reported only four mongoose observations whilst working in wet forest, but are believed not to have recorded every sighting. In 2005, as part of work by St Lucia's FD and the Durrell Wildlife Conservation Trust to reduce predation on the eggs and young of endemic iguanas (*Iguana* sp.), 76 mongooses were trapped and killed in an area of ca. 1km² around an iguana nesting beach

near Louvet. Surveys indicate that the mongoose occurs throughout St Lucia from around sea level to at least 550m elevation (Edmund Forest) (**Fig. 15**).

Habitat Associations on St Lucia

Trapping data reveals mongoose to be most abundant in mesic forest (mean: 32 mongooses per 100 Trap-Nights (TN)), followed by wet forest (22 per 100TN), and dry forests (13 per 100TN); though mongoose abundances did not differ significantly among the forest types (**Fig. 3**). In addition to trap captures in forests, the mammal survey team commonly observed mongooses in fruit plantations and gardens, coastal areas (e.g. near beaches), in rural and suburban areas, and even in densely populated urban areas. Mongooses were frequently encountered foraging along roadside verges, crossing roads and tracks during the day time, or road killed. In short, the mongoose is a ubiquitous inhabitant all native forests and most other habitats on St Lucia. They are not very wary of humans and are one of the most commonly encountered of St Lucia's mammals.

The ecology of the Small Asian Mongoose has been studied in other parts of its introduced range (Nellis, 1989). These studies confirm the findings of our surveys on St Lucia that the mongoose can occur in a variety of habitats including wet forests, open deciduous (dry) forests, shrublands, grasslands, and even urban areas; but that secondary forests, degraded sites, edge habitat, and areas of forest with 'open canopies', such as selectively logged forest are preferred to primary or closed-canopy wet forests (Pimentel, 1955; Lekagul and McNeely, 1977; Nellis and Everard, 1983; Simberloff *et al.* 2000). In the West Indies, mongooses appear to be less abundant in areas of high rainfall but on St Lucia surveys suggest that the mongoose is more abundant in mesic and wet forest than dry forest. Mesic forest on St Lucia appears to be ideal mongoose habitat judged by the abundance of mongoose. Mesic forest areas often consist of degraded forest land (selectively logged or partly converted to fruit plantations and gardens) with a relatively open canopy. The habitat is not too wet, and the numerous farms in mesic forest areas attract rats and mice on which mongoose predate.

Ecology

The Small Asian Mongoose is terrestrial, seldom climbing trees, and feeds (mostly during the day) on a wide variety of animal prey, which includes rats, birds, reptiles, frogs, crabs, insects, and even scorpions (Pimentel, 1955; Nellis and Everard, 1983). The Small Asian Mongoose also occasionally includes plant material in its diet, and at some localities their diet may consist largely of fruit for part of the year (Hays and Conant, 2007). On the whole, invertebrates (mainly centipedes, scorpions, and cockroaches) outnumber vertebrates in the diet of mongooses in the West Indies (for stomach content data see Nellis, 1989; Henderson, 1992; Vilella, 1998). The proportions of these dietary items vary according to their seasonal availability. This high level of dietary plasticity (mongoose truly are 'omnivores'), and the voracity which it hunts food, has probably contributed to the success of the Small Asian Mongoose as an invasive species.

The population biology of this species is the subject of intensive research on US Virgin Islands and Jamaica (Hoagland *et al.* 1989). Mongooses were not found to be territorial. The sex ratio of mongoose populations was close to 1:1 and population densities averaged 6.4 animals per ha for Virgin Islands and 2.6 animals per ha for Jamaica. The densities of (introduced) Norway Rats (*Rattus norvegicus*) were negatively correlated with mongoose densities, suggesting that the mongoose is an effective predator of Norway Rats in the West Indies. Similarly, the sex ratio of mongooses trapped by the mammal survey team and by the Durrell Wildlife Conservation Trust on St Lucia approached 1:1. Slightly more males were trapped than females in both studies, probably because females are more 'risk averse' ('trap shy') than males. Analysis of our survey site data did not find correlations between mongoose abundance (number of animals captured per trap-night) and either the abundance of rats (Pearson's correlation coefficient $r = 0.4$, $P=0.12$) or opossums ($r = -0.17$, $P=0.52$). However, judged by the number of headless rats we caught in traps (rats whose heads had become stuck between Tomahawk trap wires and were killed by mongoose), rats on St Lucia are commonly predated upon by mongoose. Nevertheless, mongooses are not effective at controlling rat populations as mongooses are mainly active during the day; whereas rats are nocturnal and quite resilient to predation pressures.

Reproduction

One heavily pregnant female was captured on 1st April in mesic forest. Ten juvenile mongooses were trapped in March: the 24th January (1), 13th March (1), 17th March (2), 19th March (3), 24th March (1), 25th March (1), and 26th March (1). This last juvenile showed significant morbidity (sunken eyes) and

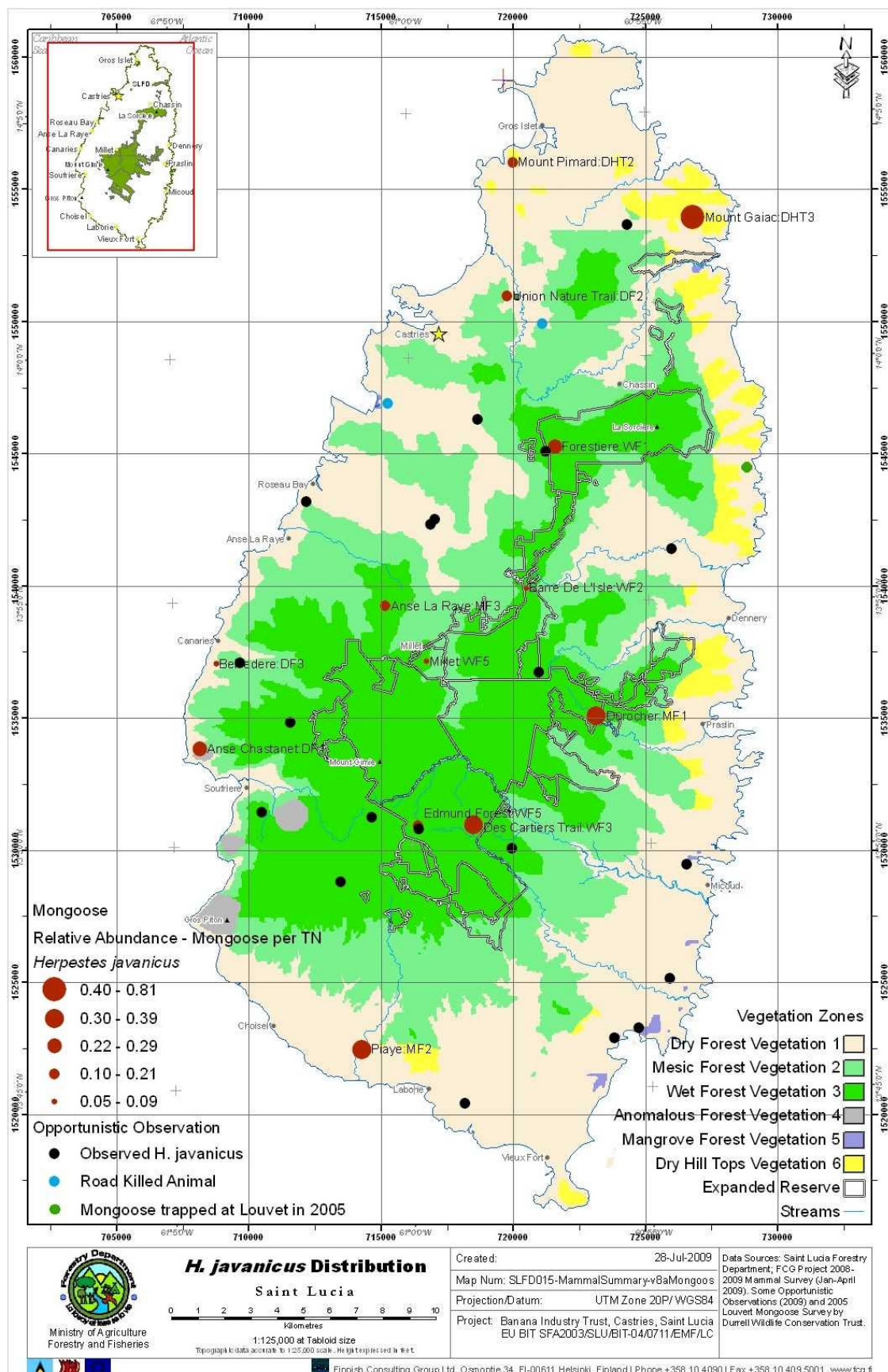


Figure 15. Distribution and abundance of mongooses *Herpestes javanicus* among St Lucia's forests.

appeared to be dying, but there were no obvious sign of injury. Female mongoose can breed two or three times each year and produce litters of two to four at quite short intervals. The gestation period is about seven weeks (Lekagul and McNeely, 1977). The young grow rapidly; they are weaned by five weeks and females can reproduce from the age of 10 months. The life expectancy of a wild mongoose is around three to four years.

Impact of Mongoose Introductions on Native Animals

The Small Asian Mongoose has been implicated in the decline or extinction of the native animals in the areas where it has been introduced, especially on islands (Baldwin *et al.* 1952; Seaman and Randall 1962; Nellis and Everard, 1983; Coblenz and Coblenz, 1985). The Small Asian Mongoose is a voracious and opportunistic predator. In most cases, the native animals of the West Indies evolved in the absence of predatory mammals so they are particularly threatened by mongoose predation. Unsurprisingly, the IUCN lists the Small Asian Mongoose as one of the world's 100 worst invasive alien species (Lowe *et al.* 2000). In the West Indies the Small Asian Mongoose has been implicated in the decline of many bird, reptile and mammal species (Seaman and Randall, 1962; Henderson, 1992; Malhotra and Thorpe, 1999). Mongooses also frequently eat invertebrates but the impact of this predation on invertebrate populations has not been studied.

On the British Virgin Islands, for example, the mongoose is implicated in the near-extinction of the ground-nesting Quail Dove (*Geotrygon mystacea*), and is a major predator on the eggs and hatchlings of Hawksbill Turtles (*Eretmochelys imbricate*) (23% of eggs were destroyed by mongooses) (Small, 1982). On Grenada, Garman's Ground Lizard (*Ameiva ameiva*) is now close to extinction; on Guadeloupe the mongoose is believed to have contributed to the demise of the burrowing owl (*Speotyto cunicularia*), the extinction of the lizard *Ameiva juliae* and the sharp decline in populations of two species of snakes (*Liophis juliae* and *Alsophis antillensis*) and the Mabuya Skink, (*Mabuya mabouya*); and on Jamaica introduction of mongooses has been linked with the extinction of several endemic animals, including the Giant Galliwasp lizard (*Celestus occiduus*), the Black Racer snake (*Alsophis ater*) the Jamaican Poorwill (*Siphonorhis americanus*), the Jamaican Petrel (*Pterodroma caribbaea*) and the Jamaican Rice Rat (*Oryzomys antillurum*) (Nellis and Everard, 1983; Coblenz and Coblenz, 1985; Hendersen, 1992; Lorvelec *et al.*, 2004). To conclude, it appears that small diurnal ground dwelling and nesting animals are most susceptible to predation, and can even be driven to extinction, by mongooses.

On St Lucia a number of animal declines and extinctions may largely be attributable to the introduction of the mongoose. The St Lucian Giant Rice Rat *Megalomys* sp. may have become extinct due to predation by mongoose (and other introduced predators). The last records of this species in the wild (late 19th century) are coincident with the introduction of the mongoose to St Lucia. On St Lucia the Small Asian Mongoose has been implicated in the reduction in numbers of ground lizards and has contributed to the eradication of the St Lucia Racer *Liophis ornatus* and the St Lucia Whiptail *Cnemidophorus vanzoi* on the main island, restricting the lizard and snake to the mongoose-free islet of the Maria Islands (Malhotra and Thorpe, 1999). However, to attribute all species declines and extinctions in the West Indies to the introduction of the mongooses would be misguided. Since European settlement of the islands, much of the native vegetation has been cleared by man and critical wildlife habitats lost; native animals have been deliberately persecuted by humans (e.g. snakes); and a number alien mammals, introduced hundreds of years before the mongoose, also predate on native wildlife (rats, cats, dogs) and/or destroy wildlife habitat (feral pigs and goats). Finally, the mongoose is a reservoir of pathogenic forms of the bacteria *Leptospira interrogans* responsible for the disease leptospirosis, and a vector of rabies in the West Indies (Lorvelec *et al.*, 2004).

Conservation Status

This Small Asian Mongoose is not listed by the IUCN as Least Concern because it has a wide distribution, presumed large population, and is unlikely to be declining at nearly the rate required to qualify for listing as Threatened (Wozencraft *et al.* 2008). As non-threatened, introduced species that is a major threat to the continued survival of many of St Lucia's native animals, the Small Asian Mongoose is not a conservation priority. The mongoose is one of the worst invasive species, and needs active management to mitigate its threat to St Lucia's native wildlife. Management recommendations for mongoose are discussed in **section 5.4**.

4. ST LUCIA'S BAT COMMUNITY

4.1 Species Diversity

Four hundred and two bats were captured by the mammal survey team representing eight species from four bat families (**Table 4**). A ninth species, the Antillean Fruit Bat, was observed but not captured. Surveys by Scranton University yielded the same species. St Lucia's bat community is thus composed of at least nine species (ten, if the proposed split of *Artibeus jamaicensis* into two species is upheld). All are native and permanent residents of St Lucia despite their mobility. Three species, the Tree Bat, Insular Long-tongued Bat and the Antillean Fruit Bat, are regional endemics of conservation importance. For a simple identification key to the bats of St Lucia see **Appendix VI**.

4.2 Relative Abundance

In descending order of the number of individuals captured during this survey, St Lucia's bat community consists of the Jamaican Fruit Bat (39% of captures), Insular Long-tongued bat, (38%), Little Yellow-shouldered Bat (10%), Tree Bat (4%), Davy's Naked-backed Bat (4%), Common Free-tailed Bat (2%), Brazilian Free-tailed Bat (2%) and the Greater Fishing Bat (1%). The Jamaican Fruit Bat is undoubtedly the dominant fruit bat in St Lucia's bat community, as it is on other islands in the region. Davy's Naked-backed Bat, the Common Free-tailed Bat, and the Brazilian Free-tailed Bat are probably more abundant in the community than capture numbers would suggest due to their apparent abilities to detect and avoid mist nets. Additionally, the Brazilian Free-tailed Bat often forages high above the ground out of the range of nets and detectors. Although the bat detector is a valuable tool in determining the distribution (presence/absence) of these species on St Lucia in acoustic surveys, currently it is not possible to use detectors to reliably determine bat abundance.

4.3 Community Structure

St Lucia's bat community consists of three insectivores (Davy's Naked-backed Bat, Common Free-tailed Bat, and Brazilian Free-tailed Bat), three frugivores (Jamaican Fruit Bat, Tree Bat, Little Yellow-Shouldered Bat), one nectarivore (Insular Long-tongued Bat), one omnivore (Antillean Fruit Bat), and one piscivore (Greater Fishing Bat). The species diversity, composition and trophic structure of St Lucia's bat community is comparable to that of other islands of similar size in the Lesser Antilles that also have a high floral diversity, especially with significant tracts of remnant wet forest e.g. Martinique. Genoways *et al.* (2007a) suggest that the region consisting of the Lesser Antillean islands of St Lucia, Dominica, Montserrat and Guadeloupe, Martinique, and St Vincent should be considered as the "Lesser Antillean Faunal Core" because of faunal similarities between these islands.

Considering St Lucia is an isolated oceanic island, the level of bat endemism is relatively low at the species level, as it is for the Lesser Antillean region. Of the bat species occurring on St Lucia, six have a widespread distribution (Greater Fishing Bat, Davy's Naked-backed Bat, Jamaican Fruit Bat, Little Yellow-shouldered Bat, Brazilian Free-tailed Bat, Common Free-tailed Bat), one is a regional endemic (Antillean Fruit Bat) and two are Lesser Antillean endemics (Insular Long-tongued Bat, Tree Bat). Low levels of bat endemism is likely due to the high mobility and dispersal abilities of bats that means they are able to move between islands. It is likely that there has been and continues to be frequent and multiple colonisations of islands in the Lesser Antilles by bats. A number of bat species occur on neighbouring islands and may potentially occur on St Lucia. The Greater Fruit Bat *Artibeus lituratus*, Miller's Long-tongued Bat *Glossophaga longirostris*, and the Greater Naked-backed Bat *Pteronotus parnellii* occur on St Vincent and the Funnel-eared Bat *Natalus stramineus* occurs on Martinique.

Table 4. List of bat species and number of individuals captured in forest types. A = Acoustically surveyed i.e. echolocation calls of species detected. P = present (netted) on previous surveys (numbers not recorded; M Morton, pers. comm..)

Taxon	Forest Type				Totals
	Wet	Mesic	Dry Ravine	Dry Hilltop	
NOCTILIONIDAE					
<i>Noctilio leporinus</i> Greater Fishing Bat	1	-	-	-	1
MORMOOPIDAE					
<i>Pteronotus davyi</i> Davy's Naked-backed Bat	7(A)	9(A)	-	A	16
PHYLLOSTOMIDAE					
Glossophaginae					
<i>Monophyllus plethodon</i> Insular Long-tongued Bat	27	128	P	-	155
Stenodermatinae					
<i>Artibeus jamaicensis</i> Jamaican Fruit-eating Bat	103	46	9	-	158
<i>Ardops nichollsi</i> Tree Bat	17	-	P	-	17
Sturnirinae					
<i>Sturnira lilium</i> Little Yellow-shouldered Bat	35	3	3	-	41
MOLOSSIDAE					
<i>Molossus molossus</i> Common Free-tailed Bat	1(A)	6(A)	1(A)	A	8
<i>Tadarida brasiliensis</i> Brazilian Free-tailed Bat	2	4	A	-	6
<i>Number of species recorded</i>	8	6	4	2	8
<i>Number of individuals captured</i>	193	196	13	0	402

4.4 Bats and St Lucia's Forests

The mammal survey team conducted standardised surveys with equal survey effort at different sites allowing direct comparison of the bat fauna among the main native forest types occurring on St Lucia.

Table 5. Relative abundance of bat species among different forest types. Values are mean number of bats captured per 10 MNH (mist-net-hours). Survey effort among forests was equal, with a total of 120 MNH.

	Wet Forest	Mesic Forest	Dry Forest		Overall means
			ravines	hilltops	
<i>Artibeus jamaicensis</i>	34.3	14.8	2.8	0	13.2
<i>Monophyllus plethodon</i>	9	41.3	0*	0	12.9
<i>Sturnira lilium</i>	11.7	1.0	1.0	0	3.4
<i>Ardops nichollsi</i>	5.7	0	0*	0	1.4
<i>Pteronotus davyi</i>	2.3	2.9	0	0	1.3
<i>Molossus molossus</i>	0.3	1.9	0.3	0	0.7
<i>Tadarida brasiliensis</i>	0.7	1.3	0	0	0.5
<i>Noctilio leporinus</i>	0.3	0	0	0	0.1

* Present – captured by M. Morton -but data are not standardized with the current survey protocol so is not comparable

All of St Lucia's bats species occur in wet forest at least up to 550m elevation (the maximum height at which surveys have been carried out to date). Additionally, bat abundance (capture rates) is greatest in wet forest. Captures of Jamaican Fruit Bats and Little Yellow-shouldered Bats were greatest in wet forest. Thus all of St Lucia's frugivorous bats appear to strongly favour wet forest over mesic and dry forests. The increased habitat complexity, abundance of fruiting plants, and increasing insect diversity

and abundance that in the tropics is commonly associated with wetter habitats probably results in increased feeding and roosting opportunities for many species of bats resulting in these habitats harbouring more species and individuals than xeric vegetation. The Tree Bat and the Little Yellow-shouldered Bat, although they can occur in mesic forest and dry forest, also strongly favour (clearings in) native wet forest and are far less abundant at drier vegetation, disturbed forests or other vegetation types e.g. fruit and cacao plantations. Of all the frugivores, the Jamaican Fruit Bat has the most catholic diet and appears to be broadly tolerant of habitats ranging from wet through to seasonally dry forests on St Lucia, even occurring at huge numbers at fruit plantations, gardens at other man-made habitats. Nevertheless, wet forest is clearly favoured by the Jamaican Fruit Bat and this forest type is necessary to maintain healthy populations of all of St Lucia's fruit eating bats.

All of St Lucia's bats, with perhaps the exception of the Greater Fishing Bat and the Tree Bat, can occur in mesic forest. On St Lucia this forest type historically has been extensively disturbed and cleared by human activities. Currently, most mesic forest areas are composed of a mosaic of remnant undisturbed forest, selectively logged forest, and many fruit and cacao plantations. Most of St Lucia's fruit crops originate from plantations in the mesic forest zone and fruit plantations undoubtedly offer feeding opportunities and attract frugivorous and nectarivorous bats. Frugivorous bats tend to be less abundant in mesic forest than wet forest, but our capture data suggests that the Insular Long-tongued Bat is most abundant in mesic forest. However, this finding is an anomaly that can be explained. All Insular Long-tongued Bats netted in mesic forest were captured within a period of only a few hours at a single site. This site was near many fruit plantations and it is likely that nets intercepted a large flock of this species attracted to the abundant fruit at this mesic forest site.

The vegetation on dry forest hilltops, e.g. cactus scrub on rocky outcrops, appears to be unsuitable habitat for St Lucia's bats during the dry season, as no bats were captured during surveys in this habitat. The two species, acoustically detected on dry forest hilltops (Davy's Naked-backed Bat, Common Free-tailed Bat) were probably commuting through this habitat from sea cave roosts to forage at moister habitats inland. Although several bats species were found to occur in dry forest, all were captured or detected at moist sites such as ravines, seasonal watercourses, and rivers flowing through xeric areas. Insectivorous bats (Common Free-tailed Bat, Brazilian Free-tailed Bat) are probably attracted to these areas to drink and to feed on the greater abundance of insects that occur over bodies of freshwater in xeric areas (Rydell *et al.*, 1999; Macswiney *et al.* 2009). Frugivorous bats (Jamaican Fruit Bat, Little Yellow-shouldered Bat) and nectarivorous bats (Insular Long-tongued Bat) probably favour the moister areas of dry forests to feed on the high abundance of flowering plants which often occur there towards the end of the dry season and/or to forage for figs that are often concentrated in riparian habitats in xeric areas (MacSwiney *et al.* 2007). Because surveys by the mammal team survey team were conducted only during St Lucia's dry season it is not possible to examine temporal movements of bat species among different forests. However, bats are mobile and species may track the availability of resources as they change seasonally, perhaps moving between wet and dry forests to forage on a seasonal basis. For example, all of the Jamaican Fruit Bats captured in dry forest towards the end of the dry season were covered in pollen and were probably attracted to the dry forests' abundance of flowering plants at this time of year.

St Lucia's insectivorous bats species appears to be less dependent on forests than fruit- and nectar-eating bats. Both free-tailed bats species frequently forage high above landscapes, especially the Brazilian Free-tailed Bat and can occur on largely islands devoid of vegetation other than highly degraded scrub vegetation such as St Barthélemy and Antigua (Larsen *et al.* 2006; Pedersen *et al.* 2006). On St Lucia, the Common Free-tailed Bat, Brazilian Free-tailed Bat, and Davy's Naked-backed Bat appear to favour riparian vegetation and/or calm bodies of freshwater within landscapes. The Fishing Bat probably occur in any vegetation type so long as there are slow-moving streams and ponds where this bat can fish, but is obviously absent from dry forest and xeric habitats towards the end of the dry season when seasonal water bodies dry up. This bat is not wholly on forests to persist on islands, because Fishing Bats can roost in sea caves and forage along coasts. Too few captures of Antillean Fruit Bats on St Lucia means that it is difficult determine their habitat-associations. This omnivorous bat has been netted at wet forest and St Lucia's botanical gardens. It is probably most common at wet forest on St Lucia, though it may occur in more arid habitats such as dry forest areas, as the Antillean Fruit Bat's catholic diet often includes insects, flowers and pollen. Furthermore, on other islands in the Lesser Antilles, it is known to tolerate xeric habitats.

4.5 Importance of Bats

The conservation of St Lucia's bat fauna is important in order to conserve the islands' natural heritage and because bats have key ecological roles and are of economic importance to the island.

St Lucia's Natural Heritage

The Antillean Fruit Bat, Insular Long-tongued Bat and Tree Bat are regional endemics; that is they are not found anywhere else on earth outside of the Antilles. Furthermore, the Tree Bat subspecies *luciae* only occurs on St Lucia and St Vincent, and the Little Yellow-shouldered Bat subspecies *luciae* is only found on St Lucia. For this reason alone, these bats should be protected as an important part of the natural heritage of St Lucia and the Antilles.

The bats of the New World tropics, which include St Lucia, have diverse diets, which include fruit, pollen, nectar, arthropods, and even small vertebrates (Gardner 1977; Patterson *et al.* 2004). Fruit- and nectar-feeding species, such as the Jamaican Fruit Bat and the Little Yellow-shouldered Bat, play key roles in tropical forests as insect-predators, seed-dispersers and pollinators, maintaining plant diversity and promoting forest regeneration in degraded land; other bat species, such as the Common Free-tailed bat and the Brazilian Free-tailed Bat, consume large quantities of nocturnal insects and probably play an important role in the control of insect numbers (Charles-Dominique 1986; Foster *et al.* 1986; Kalko 1998; Patterson *et al.* 2004). Bats are often more effective seed dispersers than birds. Bat-dispersed plants such as *Piper*, *Cecropia*, and *Solanum* are among the first to occupy natural and man-made clearings, promoting regeneration of forests.

The enormous variety of foods that bats exploit, coupled with the various foraging methods and roosting structures they use, have led to high levels of local abundance (Patterson *et al.* 2004). This, coupled with the roles of bats as dispersers and pollinators, suggests they significantly influence forest dynamics and, if St Lucia's native forests are to be conserved and managed in a sustainable way, it is important that healthy populations of bat species are maintained. Finally, the high local abundance of some bat species could mean that they form an important part of the diet of some of St Lucia's native and non-native wildlife. Known predators of fruit bats include *Boa constrictor* and the Southern Opossum *Didelphis marsupialis*.

Economic Importance

It is difficult to quantify the economic importance of bats to St Lucia but it is likely to be significant as fruit- and nectar-feeding species such as the Jamaican Fruit Bat and the Insular Long-tongued Bat pollinate many plants of economic importance to humans e.g. mango, banana, cashew, and calabash. Naked-backed Bats and free-tailed bats consume large numbers of insects nightly and may regulate insect populations, including major insect pests of crops. St Lucians living and farming near bat caves roosts occasionally remove the bat droppings (guano) accumulated on cave floors to fertilise their crops. Guano is an excellent fertilizer, being high in phosphorus and nitrogen.

4.6 Threats to St Lucia's Bats

Globally, many bats populations are thought to be declining, although the evidence for reductions is often circumstantial (Hutson *et al.* 2001). In the Caribbean, habitat loss is likely to be the major threat to bat populations. There is not enough information to determine whether populations of St Lucia's bat species are in decline. However, St Lucia's bats face a number of threats that may affect populations.

Habitat Destruction and Modification

Catastrophic events – Forests on Caribbean islands periodically face catastrophic events such as hurricanes and volcanic eruptions (Lugo, 2000). Research on Montserrat shows that hurricanes may be hugely detrimental to populations of some bat species, with dramatic and sudden population declines after hurricanes hit islands (Pedersen *et al.* 1996). Even several years after major hurricanes, populations of Jamaican Fruit Bats and Insular Long-tongued Bats on Montserrat had not fully recovered, probably attributable to shortages of nectar and fruit. Recovery from population crashes may be slow because of the low reproductive rates of bats. Not all bats species populations decline so rapidly, however. The omnivorous Antillean Fruit Bat, the insectivorous Common Free-tailed Bat, and the fish eating Fishing Bat, appear little affected by hurricanes. It has been suggested that bats that rely on fruit and nectar and roost primarily in trees and foliage such as the Tree Bat and Jamaican Fruit Bat, are likely to be most affected by hurricanes as these catastrophic events often cause widespread and severe damage to forests resulting in a loss of suitable trees for roost sites and a reduction in fruit and nectar production that may last for several years before trees recover (Pedersen

et al. 1996). In contrast the Antillean Fruit Bat roosts in caves which may shelter these and other bats during severe storms and these omnivorous bats can feed on insects when fruit and nectar production is depressed. Despite these findings, it should be noted that all of the bat species occurring on St Lucia and elsewhere in the region have evolved in ecosystems exposed to regular catastrophic events such as hurricanes: none are ecological specialists and all have adaptations allowing them to deal with hurricanes. A caveat to this is the severity and frequency of major hurricanes is predicted to increase substantially in line with global climate change (Webster *et al.* 2005).

Anthropogenic forest-disturbances - On St Lucia and elsewhere in the region, native forests have been cleared, logged and disturbed by human activities. Obviously, clear-cutting has a detrimental affect on bat populations through a permanent loss of bat habitats and therefore feeding and roosting opportunities. Historically, St Lucia's native wet and mesic forests have also been selectively logged (though this practice has largely been abated) and also extensive areas of mesic forest have been cleared when establishing fruit plantations. Low- to medium-intensity disturbances to wet forests may cause a decline in the abundance of specialist bat species. However, St Lucia's bat species are generalists (with perhaps the exception of the Tree Bat) and research has shown that providing that forest composition and structure remain essentially intact, most bat species are little affected (Clarke *et al.*, 2005a,b). In fact disturbed tropical forests harbour many more individual bats than undisturbed forests, principally a result of an increase in the abundance of a few frugivorous species (Brosset *et al.* 1996; Medellin *et al.* 2000; Ochoa, 2000). On Trinidad, low intensity selective logging appears to benefit Jamaican Fruit Bats and has little affect on Little Yellow-Shouldered Bats, species that both occur on St Lucia (Clarke *et al.*, 2005a,b).

Most fruit-eating bats, such as the Jamaican Fruit Bat, are dietary generalists and it is likely that many species may take advantage of an increase in fruit production by pioneer plants in logged forest, even if these fruits do not form the core of their diet. Indeed many bats are able to shift their diets partially or adapt their behaviour to compensate for an alteration in the availability of their main food types, perhaps explaining why selective logging and other forms of low intensity forest disturbances are not detrimental to many species. For example, most nectarivorous and frugivorous bats also consume some insects and may alter the quantities of nectar, fruit and insects in their diet as the availability of these foods change seasonally (Patterson *et al.* 2004). Additionally, the fruit plantations that are grown in areas of mesic forest probably benefit some bats through increased feeding opportunities i.e. many bats feed on commercial fruit crops such as bananas and mango. In summary, the plasticity in diet and foraging behaviour and high mobility of many bats may make them less vulnerable to localized and/or low intensity disturbances to tropical forests than other animals. Action plans to conserve bats need to take into account the plasticity in diet, foraging behaviour and high mobility of many fruit bats and seasonal changes in habitat-use by bats as they adapt their behaviour to exploit shifting resources.

Disturbances to Roosts

Loss of trees - Logging typically targets the largest canopy-forming trees. These mature trees are often hollow or contain cavities that are important refugia for cavity-dwelling mammals. Fishing Bats, Antillean Fruit Bats, and Free-tailed Bats often roost in cavities in trees. Some bats, such as the Jamaican Fruit-Bat and the Tree Bat, also roost among foliage. Nevertheless with the exception of the Tree Bat none of St Lucia's bat fauna are obligate tree roosting species: they also roost in caves and human structures.

Disturbances to caves - The Insular Long-tongued Bat and the Antillean Fruit Bat are obligate cave roosting bats, and Free-tailed Bats, Fishing Bats and Jamaican Fruit Bats frequently roosts in caves. Caves may buffer and protect these bats from severe storms such as hurricanes. Communal nursery roosts of bats, where mothers suckle and raise babies, are often located in caves. Additionally, at cave roosts, large numbers of bats may congregate and if roosts are destroyed or disturbed then a large proportion of the whole bat population may be affected. Mining, quarrying, phosphate (guano) exploitation occurs on islands throughout the Caribbean and may be especially detrimental to bat roosts in caves. For example on the islands of Nevis and St Martin, caves systems appear to be becoming increasingly rare due to the practice of backfilling hollows, abandoned mines, and caves to develop areas (Pedersen *et al.* 2003, 2005). On St Lucia, only a handful of important bat cave roosts are known e.g. Antillean Fruit Bat roosts at Grace Cave and a sea cave at Soufriere. Currently these roosts do not appear to be threatened. Locals occasionally remove guano from cave roosts to fertilize

their cops, but because this happens infrequently and such disturbances are of low intensity, the bat roosts are unlikely to be seriously disturbed.

Use of Pesticides

The insecticide DDT and other Persistent Organic Pollutants (POPs) are still widely used in the Caribbean and St Lucia (Rawlins *et al.* 2008). POPs are toxic chemicals that persist in the environment for years before breaking down, and there are known links between POPs exposure and an increased frequency of diseases and abnormalities in many wildlife species, including fish, birds, and mammals (<http://www.epa.gov/international/toxics/pop.htm#affect>). In the USA spraying with DDT has caused increased mortality in bats and this insecticide is thought to have played a role in the declines in the populations of Brazilian Free-tailed Bats (Hutson *et al.* 2001). In addition pesticides aim to reduce insect populations and insect diversity with concomitant affects on populations of insect-eating bat species such as Fishing Bats, Lesser Naked-backed bats, and Free-tailed Bats. Organic pollution often reaches rivers altering aquatic ecosystems and the insects associated with it, in turn affecting bats.

Deliberate Persecution

There does not appear to be any systematic, deliberate persecution of bats on St Lucia. However, many locals may not appreciate the importance of bats to St Lucia and may kill bats and remove bat roosts from their houses. Free-tailed Bats can be noisy inhabitants of roof spaces, leave droppings and therefore are probably unwelcome guests. The removal of Free-tailed Bat roosts from human habitations is unlikely to pose a threat to populations of these abundant, adaptable and widespread bat species. If removal of free-tailed bats is to be acceptable, it should be in the context of a greater public awareness that these bats represent only two (in fact only probably one) bat species out of nine. The perception of this species as a pest should not be extended to all bat species; as most have negligible to no impact on householders. Education programs should encourage respect for St Lucia's native animals and their importance to St Lucians and their natural environment.

Reduction in Water Quantity and Aquatic Habitats

Over-development of an island may deplete natural springs and/or lower water tables that are absolutely critical for the maintenance of healthy forested ecosystems on which many mammals depend. Additionally, the presence of (surface) fresh water is important to many bat species. Free-tailed Bats, for example, are often netted or observed above rivers and ponds where they will drink fresh water and fed on insects attracted to water-bodies. Fishing Bats forage for fish along slow moving streams and rivers. Frugivorous bats, such as the Tree Bat, are most commonly captured among riparian vegetation and are probably attracted to fruiting fig trees in these habitats.

Introduced Predators

There are few predators of bats on St Lucia, other than the *Boa constrictor*, the Southern Opossum and birds of prey. The introduced mongoose probably does not pose a threat to bats as it is primarily a ground-dwelling mammal and, given the abundance of alternative prey items at ground level, e.g. – frogs and lizards - they probably rarely kill bats. Feral cats may opportunistically kill bats but are unlikely to be a threat to bat populations. It is unlikely that any of these native and introduced predators have a significant impact on populations of bats.

Lack of information

Lack of information has been suggested to be one of the greatest constraints to bat conservation as extremely few bats species have been well studied (Hutson *et al.* 2001). Of the bats occurring on St Lucia only the Jamaican Fruit Bat, Brazilian Free-tailed Bat and the Fishing Bat have been well studied. The Jamaican Fruit Bat has been intensively studied (see Species Accounts). Hardly anything is known about the ecology of bats that are endemic to the region – the Tree Bat, the Antillean Fruit Bat, Davy's Naked-backed Bat, the Fishing Bat, and the Insular Long-tongued Bat. Despite the success of these mammal surveys, there are still gaps in our knowledge of the ecology of most of St Lucia's bats and more surveys are required to accurately determine their distributions and abundances. Due to time and funding constraints only four to five sites were surveyed in each forest type and care must be exercised when interpreting results from short-term studies. It would have been better to conduct surveys at each site during the wet and dry seasons to examine seasonal changes in habitat use. Particularly importantly is the identification and mapping of important bat roosts, work which requires considerable survey effort and was not feasible during the three months that was allocated to survey all of St Lucia's bats and non-volant mammals.

5. MANAGEMENT OF MAMMALS

5.1 The Bats

The are bats St Lucia's only native, extant mammals and are a conservation priority for this reason and because of their importance in pollinating fruiting plants, and maintaining St Lucia's natural ecosystems, especially forests.

Species Protection

None of St Lucia's bat species are listed as protected under the Wildlife Protection Act 1980 (or the revised Wildlife Protection Act 2001), however it has been proposed that all (except possibly *M. molossus*) be added to Schedules 1 (fully protected wildlife) or 2 (partially protected wildlife) as part of the current review and amendment of this Act. None of the bat species occurring on St Lucia are considered by the IUCN as globally threatened at the species level (<http://www.iucnredlist.org/>). However, caution must be exercised when interpreting IUCN listings in a national context as key data on bat species distribution abundances and ecologies are often limited or lacking, especially for small islands states such as St Lucia. Although these surveys have gone some way in filling in gaps in our knowledge of the bats of St Lucia and the region, important information that will guide conservation efforts still needs to be obtained. Specifically, to protect bat species it is recommended that roosts of the following species should be identified and protected: Antillean Fruit Bat roosts (as this species maybe concentrated in a few large roosts making this bat especially vulnerable); Fishing Bat (roosts may be patchily distributed), and Insular Long-tongued Bat and Davy's Lesser Naked-backed Bat (both species may be roost-limited).

It is fortunate that all bat species occur within state-owned forest lands, though important roosts of some (e.g. Antillean Fruit bats) may occur on private lands. Because of the lack of any significant international trade in these bats, none of the bat species occurring on St Lucia are included in the appendices of the Convention on International Trade of Endangered Species of Wild Flora and Fauna (CITES) (<http://www.cites.org/>). Conservation actions for bats should focus on habitat protection as opposed to species protection. The continued survival St Lucia's bats may largely depend on adequate protection of a full representative range of forest types, including existing forest reserves.

Habitat Protection

Wet forest – The remaining wet forests should continue to be protected as these forest types are very important for bats. All of St Lucia's bats occur in wet forest, often at high abundances. The Tree Bat and the Little Yellow-shouldered Bat most commonly occurs at wet forest. Currently, wet forests on St Lucia are well represented in state-owned forest lands. The recent acquisition and gazetting of additional forests by the St Lucian government is to be commended, as this has expanded the Forest Reserve area to more than 13% of the island.

Mesic forest - is regenerating since the abandonment of many banana plantations following the recent World Trade Organisation ruling on tariffs and trade that resulted in a decrease in banana exports. The state should continue to purchase plantations in mesic forest areas and allow these forests to regenerate to protect wildlife and water catchment. Most of St Lucia's bats occur in mesic forest. The government should not allow further clearance or disturbance to primary wet and mesic forests, good quality mature secondary forests (selectively logged and regenerating for many years) or areas around rivers and streams in mesic and wet forests, as these are likely to be especially important to Tree Bats and Little Yellow-shouldered Bats.

Dry forest - is probably the most threatened group of forest types in the Lesser Antilles (WWF, 2007). On St Lucia, dry forests are threatened by infrastructure development, agriculture, and rock quarrying. Almost all dry forest land is privately owned and is not under any form of protection, leaving it open to further exploitation and degradation. Due to the extreme environmental conditions, regeneration of dry forest is very slow, and disturbed dry forest may support fewer wildlife species. Although our surveys suggest that relatively few bats occur in dry forests, this habitat's importance to bats is likely to vary seasonally. Fruit- and nectar-feeding bats, such as the Jamaican Fruit Bat and the Insular Long-tongued Bat, may switch from foraging in wet forests to dry forests to take advantage of the abundance of flowering plants that occur there towards the end of the dry season. It is therefore important that dry forest be protected on St Lucia. Ideally a dry forest reserve should be contiguous with other protected forest (state-owned forest lands) so that there is a corridor of native forest running

from high elevation wet forest through mesic and dry forest to the coast. This would facilitate seasonal movements of bats and other mammals between forests and along altitudinal gradients. There is some evidence for seasonal altitudinal migration for populations of Little Yellow-shouldered Bats occurring on montane forests (Giannini 1999; Mello *et al*, 2008). This illustrates the need to preserve habitats along elevational gradients for the conservation of migratory species.

Riparian vegetation and rivers in dry forests and in other forest types on St Lucia appear to be important to many bats. The figs on which many bats and other mammals feed upon are abundant beside rivers and riparian forests in xeric areas probably act as flyways for bats commuting between roosts and feeding sites. This is an important point as bats often roost and forage in different areas and conservation actions such as habitat protection initiatives need to take account of this. Common Free-tailed Bats drink in rivers and forage for insects over the water and above riparian vegetation. Riparian vegetation should be retained in areas developed for agriculture and infrastructure development. Retaining vegetation along rivers will also help to minimize siltation and water pollution, thereby benefiting insects and, in turn, bats and other animals.

Within state-owned forest lands all snags (dead or dying standing trees) should be retained in landscapes and not cut as they are critical elements for cavity-dwelling mammals such as bats. It is important to maintain a diverse vegetation structure if bat diversity is to be maintained. Areas being regenerated and replanted by the Forestry Department should be planted with native tree species that are more likely to be beneficial to native mammals and other wildlife. Figs and other native trees producing fruits favoured by many mammals, birds and other wildlife should be retained in forests.

Roosts – Critical to the conservation of many bat species is the protection of important cave roosts, especially those roosts of the regional endemics Antillean Fruit Bat and Insular Long-tongued Bats, such as Soufriere Sea Cave and Grace Cave. Important cave roosts should be periodically inspected by Forestry Department officers and steps taken, where necessary, to protect roosts from disturbances which may scare away bats. Cave roosts may offer vital protection to bats during severe storms, such as hurricanes (Pedersen *et al*. 1996; Fleming and Racey, 2009).

Any large roosts (i.e. used by large numbers of bats, of any species except perhaps Common Free-tailed Bat) should be considered important focal sites for bat conservation on St Lucia. What 'large' means in practice will vary by species: for Antillean Fruit bats or Jamaican Fruit Bat it might be thousands of individuals; for the Brazilian Free-tailed Bat, Insular Long-tongued Bat and Davy's Naked-backed Bat it might be hundreds. For the Little yellow-shouldered Bats and Fishing Bats it might be tens of individuals. However, these figures are just guides that should be revised as more data on roost populations becomes apparent: the point is to protect the larger roosts for each species. The Tree Bat seems unlikely to roost in large numbers, and to change roost trees frequently; in this species, roost protection and habitat protection are likely equivalent. The Common Free-tailed Bat seems unlikely to need roost protection. Roost protection should include monitoring of bat numbers and of threats to the roost sites.

Surveys and Monitoring

There is insufficient information to determine whether any of St Lucia's bat species are in decline. Monitoring (repeated surveys at same sites using systematic standardised sampling) would be required to examine population trends and for early warning of bat population declines.

Currently, monitoring of St Lucia's bats is not highly recommended for a number of reasons:

1. Difficulty of sustaining a long term monitoring programme. Given the reluctance of most people to work at night in forest because of the endemic St Lucian pit viper *Bothrops caribbaeus*, and because bats are a lower conservation priority for the FD, it is difficult to imagine the FD or other bodies on St Lucia running a sustained monitoring program.
2. Monitoring of forest bats is problematical. Some species are difficult to detect and to maximise detection probabilities it is recommended that there should be at least four visits to each survey site each year. Furthermore, sites should not be surveyed on consecutive nights due to "trap shyness" of bats, and repeat surveys of sites should be sufficiently spaced in time and occur in both the wet and dry seasons (Meyer, Clarke *et al.*, in press). At least 10 sites should be monitored regularly to detect changes in the bat population. It is likely that financial and time constraints would preclude running of an effective bat monitoring program on St Lucia.

3. Conservation urgency. Surveys suggest that several of St Lucia's bats species are uncommon, may be patchily distributed, or may be vulnerable because of their specific roosting requirements or relatively specialised ecologies (Antillean Fruit Bats, Tree Bats, and Fishing Bats). No species that are endemic to St Lucia (all bats also occur on other islands), but if bats were lost from St Lucia then important ecological services would be lost (e.g. pollination, seed dispersal) which would have a significant ecological and economic impact on the island. St Lucia does have endemic subspecies (the Little Yellow-shouldered Bat subspecies *luciae* only occurs on St Lucia), and hence global responsibilities to ensure these unique bats in particular are secure.

If a decision were taken to monitor bats, then the monitoring programme could use the data from bat surveys by the mammal survey team (surveying the same 10 sites in wet and mesic forest) as baseline information to compare with capture data obtained in future surveys. Mist nets should be used. Acoustic surveys are not recommended as key target species for monitoring are the Antillean Fruit Bat and Tree Bats, neither of which produce high intensity (loud) echolocation calls and are therefore difficult to acoustically survey. An alternative approach would be to identify, map and then monitor key bat roosts i.e. large roosts of Antillean Fruit Bats and Insular Long-tongued Bats and maternity colonies. Roosts would be discovered, and a list of key bat roosts made, as FD officers go about their usual activities and fieldwork. Roosts could then be visited regularly and the number of bats of each roosting species estimated. For methods to estimate bat numbers at roosts see Kunz *et al.* (1996). Evidence of disturbances to roosts should also be recorded and monitored, such as guano removal.

Lack of Information - Research Recommendations

Research on the biology and ecology of St Lucia's bats should be encouraged. This could take the form of collaborative research and cooperation between the Forestry Department and the University of the West Indies and overseas universities and conservation organisations. Foreign universities and conservation organisations are most likely to obtain funds and have the necessary experience to support research, but should work closely with the Forestry Department so that information is not lost to St Lucia and training and professional development of Forestry Officers by these organisations can occur.

Research on the Tree Bat, Antillean Fruit Bat and the Insular Long-tongued Bat should be particularly encouraged as these bats are regional endemics and are not well known. Research should focus on habitat and roost requirements, diet (food preferences, pollination and seed dispersal studies), and movements of bats. Tree-dwelling bats such as the Tree Bat are especially difficult to study but it is important to determine their ecology, such as which trees are used and how frequently, as these bat appear to be relatively rare on St Lucia and other islands, and small populations are known to be at most at risk of extinction. It is important to identify, map, study, bat roosts so they can be protected accordingly, especially caves that contain large aggregations of regional endemics e.g. Antillean Fruit Bat and Insular Long-tongued Bat. Research is recommended on survey and monitoring methodologies, and it is especially important to develop effective and feasible methods to monitor key bat roosts. Finally, the status of *Artibeus* should be reviewed if taxonomic revision occurs.

Given the abundance of most bat species it is difficult to argue against collecting bats for scientific research. Nevertheless unregulated scientific collection may have had an impact on some populations of bats and, for some species, it is best to work on a precautionary principle e.g. the Tree Bat *Ardops nichollsi*. Over-collection of Naked-backed Bats *Pteronotus* spp. on Jamaica and other Caribbean islands (this bat is popular research animal for echolocation studies and university dissections) appears to have had a detrimental affect on populations (Hutson *et al.* 2001). With regard to limits on the numbers of bat specimens that can be collected under licence, it is recommended that St Lucia follows the guidelines set in other countries, where more detailed studies have been carried out. This can be considered an interim, precautionary measure until more accurate figures for St Lucia's bat species and their population dynamics are obtained: see the Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. No more than 25 individuals of each species should be collected per annum. The licence quota should include parts of specimens regardless of whether they come from one animal or different ones (e.g. 1 bat skull = 1 bat specimen). Pregnant and nursing females should not be taken unless the research required this, i.e. reproductive studies. Although this number may seem low, it is important to realise that bats have low reproductive rates: females typically give birth to a single baby each year. Those wishing to possess larger

numbers of bat species should justify the inclusion of larger numbers. They should also demonstrate, in advance, that (a) the population of the species in question can sustain higher take or (b) the results of the work are of significant importance to management of bats on St Lucia. Research programmes should justify the benefits to St Lucia and its management of natural resources, to science, the quality of the research, and the measures taken to minimise the numbers of bats killed and disturbances to important bat roosts.

Pesticides and Water Pollution

St Lucia should take measures to rapidly replace POPs, such as DDT, with safer alternatives. St Lucia is signatory to the Stockholm Convention on persistent organic pollutants, which was adopted in 2001 and entered into force 2004, that requires Parties to take measures to eliminate or reduce the release of POPs into the environment (<http://chm.pops.int/>). Such actions would benefit the insectivorous bats - Common Free-tailed Bats, Brazilian Free-tailed Bats, and Lesser Naked Backed Bats - as well as Fishing Bats.

Legislation

Bats are not currently protected under the Wildlife Protection Act No. 9 of 1980, a proposed change in the amendment to this act currently under review. The current act makes it illegal to a) hunt, capture, buy, sell import/export, or keep captive any wildlife unless authorized by the Forestry and Land Department; b) Attempt to trade in anyway whatsoever eggs, young, or any part belonging to wildlife and protected wildlife, or c) Destroy or damage nest of protected wildlife. Offences committed under this Act carry a maximum penalty of one year imprisonment or maximum fine of EC \$5,000.00 on summary conviction. All of St Lucia's nine bat species should be listed as protected species under the Wildlife Protection Act, but no other legislation is currently required to conserve St Lucia's bat species.

Education

Education programmes on the importance of bats to St Lucia's natural environment and their economic importance would be beneficial and may prevent some instances of deliberate persecution of bats. Many St Lucians are unaware that the island has as many as nine species with differing natural histories and that many pollinate plants and disperse their seeds.

5.2 Southern Opossum

Species Protection

As a non-threatened, introduced species the Southern Opossum is a low conservation priority for St Lucia. The opossum is specifically listed as protected under the Wildlife Protection Act 1980. Penalties for breaking the law are a maximum fine of \$5,000 or in default of payment of fines a maximum of one year in prison. It is recommended that the current legislation governing opossums should be reviewed and possibly revoked. From a conservation standpoint, is not necessary to sustain the hunting ban on the opossum or other non-native species, *unless* the FD perceive that opossum hunting practices could inadvertently and seriously endanger people or native wildlife. It would appear to be unnecessary and unfair to prosecute poor local St Lucians for occasionally hunting opossum for personal consumption. Opossum should at least be down-listed from Schedule 1 (fully protected) to Schedule 2 of the Wildlife Protection Act, which would list opossum as 'partially protected'. It is highly unlikely the demand for opossum meat would be great enough for hunting to have a significant effect on opossum numbers. Unlike several other islands in the West Indies, there is not a large market for wild mammal meat on St Lucia. Opossums are very resilient to hunting pressures (for meat and pelts) and populations on Trinidad and South America appear little affected by such exploitation, though it should be noted that on St Lucia, opossums appear to be less common. Limited subsistence hunting is unlikely to have an impact on St Lucia's opossum population.

Lack of Information - Research Recommendations

It is not clear what impact this introduced mammal has had on St Lucia's endemic birds, reptiles, invertebrates and plants. Research is needed to address this question, including dietary studies and experimental enclosure studies (to measure the ecological impact of removing the opossum from selected areas). Southern Opossum is likely to form part of the diet of the St Lucian *Boa constrictor*, and perhaps the St Lucian Pit Viper, but it is unlikely to be an essential prey item for either snake.

Control Measures

Although this species probably has a largely negative impact on native biodiversity, measures to eradicate this introduced species are unlikely to be affordable or successful on a large scale (see

section on mongoose management). The Southern Opossum is now fully ensconced in St Lucia's forests. It is highly adaptable and fecund and the population probably could recover rapidly from intensive hunting, trapping or poisoning of individuals. It is not currently feasible to attempt to eradicate every opossum from St Lucia. Nor would this be acceptable to many St Lucians.

Targeted, localised intensive trapping at iguana and important marine turtle nesting sites during the nesting season is recommended, however. Opossum and other predatory introduced mammals – the mongoose, rats, feral cats - could be intensively trapped at reptile nesting areas and perhaps also in areas where white-breasted thrashers (*Rhamphocinclus brachyurus*) nest (see mongoose management) because the removal (killing) of mammals is likely to substantially decrease predation on eggs and hatchlings, benefiting the conservation of St Lucia's wildlife. The FD and Durrell have piloted mammal removal programmes around iguana nesting sites, e.g. Louvet beach. FD should now take the lead on this, identify key nesting areas and seasons, and each year; undertake mammal removal from a number of key reptile-nesting sites. Even if future studies later find the opossum to be a true native (an unlikely scenario), the opossum population is large and secure, and certainly not in need of conservation measures.

In summary, the Southern Opossum is considered not native to St Lucia, though it may have been introduced several thousands years before present and is considered by many St Lucians as 'naturalised'. Reducing their numbers near key nesting iguana and marine turtles nesting sites could benefit St Lucia's reptiles without adversely impacting the overall opossum population. Subsistence hunting of opossums should be allowed and is unlikely to threaten this adaptable and fecund mammal. It is recommended that the opossum be removed from the list of mammals specifically protected under the Wildlife Protection Act 1980.

5.3 Brazilian Agouti

Species Protection

The agouti is only one of two mammals specifically listed as fully protected under the Wildlife Protection Act 1980, Schedule 1. (Note the scientific name of the Brazilian Agouti is listed in the Act as *Dasiprocta agouti* but should be *Dasyprocta leporina*). The Brazilian Agouti is not native to St Lucia even though it is regarded as 'naturalised' by many St Lucians. Current penalties for breaking this law are a maximum fine of \$5,000, or in default of payment, a maximum of one year in prison. It is recommended that the current legislation governing agoutis should be reviewed and possibly revoked. From a conservation standpoint, is not necessary to sustain the hunting ban on the agouti or other non-native species, *unless* the FD perceive that agouti hunting practices could inadvertently and seriously endanger people or native wildlife. It appears unfair to prosecute St Lucians for occasionally hunting agouti on private lands for personal consumption. The agouti is already cited as a crop pest, and Part 4, Section 19, of the Wildlife protection Act 1980 already allows for the granting of licences to kill agouti on private land. Removing agouti from the list of protected wildlife or down-listing the agouti could allow farmers to kill or capture agouti that 'trespass' on their land and damage crops without licences first having to be granted. If FD wants to continue to protect agouti, a compromise/trade-off between protection and exploitation could be to down-list agouti to Schedule 2 of the Wildlife Protection Act ('partially protected'), and prohibit hunting on all protected and state-owned forest lands, but allow agouti to be legally killed or captured for breeding stock (see minilivestock farming) on private land. Such measures would protect the 'core' agouti population that resides within state-owned wet forest lands and allow exploitation of agouti that are damaging crops.

If FD aims to conserve Brazilian Agouti as a 'naturalised' species and also allow sustainable hunting of agouti within state-owned forest lands, then it is recommended that FD should first issue licences before hunters can kill agouti on state-land, there should be limits to the numbers that can be taken ('bag limits') based on informed estimates of the agouti population size (to be determined from research), and a closed season (when hunting is not allowed) corresponding to the agoutis' breeding season (to be determined from research). Areas within state forests where hunting is permitted should be gazetted and clearly demarcated on the ground, and FD staff would need to effectively police and enforce hunting laws and regulations. Designating and enforcing low hunting or zero hunting zones would be critical to create population strongholds on the island and ensure the long-term survival of this species.

FD strategies for sustainable uses of agoutis and other wildlife that employ hunting methods such as dogs or guns need to be considered in the context of FD policy on hunting since the 1980s and into

the future. This policy has been largely in line with the Wildlife Protection Act of 1980 which, as its name suggests, has taken a protectionist approach, rather than an active management one. This approach is recognized within FD as having been one of the factors responsible for the successful recovery of the St Lucia parrot and, most likely, other wildlife species. Some people in FD support the idea of moving towards more active wildlife management, including sustainable uses through regulated hunting. But this appears to remain a minority point of view within FD, with the current ongoing legislative review and proposed amendment of the Wildlife Protection Act suggesting an ongoing protectionist approach. The reasoning behind this is articulated within FD as concern over FD's current capacity and resources to effectively regulate hunting. However, the existing and amended Act do still allow for closed and open hunting seasons to be declared. It should be noted that whilst agouti are currently classed as protected wildlife, it is possible they may be re-classed with only partial or no protection in the amended act (A. Toussaint, pers. comm.). The use of dogs for hunting in St Lucia appears to have unintended collateral impacts on wildlife, with dogs indiscriminately taking protected species including the St Lucia Iguana (M. Morton, pers. comm.). If hunting is allowed, FD needs to make sure that it does not encourage irresponsible gun use or permit the use of hunting with dogs in forest reserves.

In summary, from a conservation standpoint there is no need to protect the agouti, but from a logistical viewpoint, given the difficulty policing hunting activities and the possibility of threatened or endemic wildlife (e.g. parrots) being killed by hunters or dogs, it may be advisable to not to lift the ban on hunting in protected areas and state-owned forest lands.

Habitat Protection and Management

Brazilian Agoutis predominantly occur within state-owned protected forest lands and it is likely that no habitat protection measures are currently required. Agoutis are also highly tolerant of modified environments such as secondary forests, plantations and crop lands: habitats well-represented on St Lucia.

Minilivestock Farming - 'Agouti Ranching'

The term "minilivestock" (sometimes "microlivestock") is used to describe farming with little-known small animals that can be used effectively in the enhancement of animal protein production and even provide inhabitants in developing countries with a regular and stable source of income. A good example of this is the guinea pig (*Cavia porcellus*), which was domesticated and bred for eating as long as 2,500 bp (Stahl and Norton, 1987). Microlivestock potentially could be highly productive in environments that are not suitable for other kinds of animals, such as steep hillsides, highly degraded areas, forested landscapes and even urban environments in the tropics. In some parts of the tropics, large farm animals may not be suitable, while a local species of microlivestock may thrive. Consequently, minilivestock farming and sustainable use of wildlife in the new world tropics agouti has recently been the subject of much interest in developing sustainable livelihoods and protecting forest biodiversity in developing countries (see Panel on Microlivestock, National Research Council, 1991; Ojasti, 1996).

St Lucia's FD has expressed an interest in agouti farming as an example of the sustainable use of "forest products". Captive breeding of agoutis in the tropics has been quite successful, and historically agoutis have often been kept as pets by Amerindians. On St Lucia, agoutis could be captured on farms and private lands to form the founding breeding stock for agouti farming. The main reference work for minilivestock farming of agoutis is "*The Agouti (Dasyprocta leporina, D. aguti) Booklet and Producers Manual*" (Roxann and Brown-Uddenberg, 2004). This manual is specifically written for the benefit of agouti farmers and producers. It is extremely comprehensive and reviews the scientific information related to the species covering all aspects of taxonomy, morphology, health, reproductive patterns, housing, and social behaviour. The manual outlines in detail the process of setting up an intensive agouti farm, based on the authors' more than ten years of experience on agouti production in Trinidad. The authors suggest areas of further research to improve husbandry. It is recommended that St Lucia's FD liaise closely with the counterparts in Trinidad and Tobago, specifically the Wildlife Section of the Forestry Division, Ministry of Agriculture, and The Open Forage-Animal Production Laboratory [OTF-APL], Department of Food Production, Faculty of Science and Agriculture, University of West Indies, on how to proceed with minilivestock farming of agouti on St Lucia.

The following is a brief discussion of the most salient points on agouti farming relevant to St Lucia. It is recommended that when establishing captive populations of agouti on for minilivestock farming in St

Lucia, the breeding animals should be obtained from St Lucia's wild Brazilian Agouti population. This is because it is preferable to select the closest available natural population for breeding stock as a precaution against the introduction of different genotypes and new wildlife diseases. Agoutis adapt well to captivity, they rapidly lose their nervousness, and, with appropriate care, they can be bred without difficulty. Agoutis can be fed on foods such as leafy vegetables, fruit, potatoes, and bread scraps. They need to be kept in fenced enclosures to stop attacks by predators and to prevent agouti from escaping back into the forest or eating crops. If groups of agouti are to be bred, they require large areas with plenty of cover to avoid fighting e.g. derelict banana plantations may be suitable. Enclosures would need to provide freshwater and dense undergrowth e.g. log piles for animals to hide. With larger group sizes, fewer young are successfully reared. Young should be removed from the adults soon after weaning to rear them in smaller enclosures or cages. Males are especially territorial and may need to be separated to avoid injuries.

There are a number of advantages and limitations to minilivestock farming of agoutis. Advantages include:

1. Agoutis are forest dwelling rodents that might provide a source of meat and income, without damaging or having to convert forests to pastureland to raise cattle, sheep and goats.
2. Agoutis are tolerant of disturbed and secondary forests and will thrive in disturbed areas as long as there is adequate ground cover.
3. An agouti is a reasonably sized meal. A dressed carcass can weigh 1 to 3kg, and the meat is good quality and tasty.
4. Tame agoutis in captivity are fecund. They can reproduce rapidly in captivity with proper husbandry.

Obstacles and limitations to agouti ranching are:

1. Experiments have revealed agoutis to be highly susceptible to foot and mouth disease. Veterinary bills may make small-scale minilivestock projects prohibitively costly for some farmers.
2. The male agouti's intolerance of rival males and of the offspring is a major obstacle to captive breeding. This will severely limit stocking densities. The territoriality of individuals may be the most significant obstacle to establishing economically viable minilivestock farming of agoutis on St Lucia.
3. Live agoutis have strong smelling anal glands that could be offensive to farmers and people residing near farms.
4. Husbandry experiments are required to understand the nutrition, growth rates, and reproduction of St Lucia's agoutis before encouraging local farmers to attempt to farm them.
5. There may not be high enough demand for farmed agouti meat to make minilivestock farming of agouti lucrative, especially when wild agoutis are available to be hunted. Currently, there is no (legal) market on St Lucia for agouti products and one would have to be created. Market research is needed to ascertain whether it would be commercially viable to farm and sell agouti meat in St Lucia.
6. Cultural attitudes. In Trinidad, where wild and farmed agouti meat is available, wild meat is strongly preferred by locals who think it "healthier and more natural". Culturally, West Indians typically favour wild meat, and minilivestock reared agouti would be regarded as 'farmed meat'. Cultural attitudes are deep grained and hard to overcome.

Lack of Information - Research Recommendations

There is need research on diet of wild Brazilian Agouti in St Lucia's native forests, home range sizes of pairs, densities, breeding season, impact of seed predation/seed dispersal on native trees and forest dynamics. Due to the steep terrain where agoutis occur on St Lucia, density estimates will be hard to obtain.

5.4 Small Asian Mongoose

Control Measures

The Small Asian Mongoose is one of the world's worst invasive species, and this introduced species needs managed to mitigate its threat to St Lucia's native wildlife. Mongooses in St Lucia will have to be managed for a long time into the future. The island is too large and current control measures too limited or labour intensive for any attempts at a total, permanent eradication of this widespread introduced species. Although a trapping programme on the relatively small island of St John (US Virgin Islands) achieved at least temporary short-term success at reducing mongoose numbers and

reducing predation on marine turtles, massive trapping programmes on the larger West Indian island of Trinidad have proved completely unsuccessful (Coblentz and Coblentz, 1985; Williams, 1918). Even large-scale, long term mongoose control (trapping) programmes on several Japanese islands have as yet had a limited impact on mongoose numbers, despite their substantial investment in time and labour (Yamada and Sugimura, 2004).

Historically, the main methods that have been used to control introduced mongooses are trapping programmes and use of chemicals (poison). In the short term, mongooses could be most efficiently controlled or even eradicated over small, sensitive areas of high conservation value (e.g., site where they present a critical threat to endangered birds, reptiles or other wildlife) using trapping, perhaps in combination with poisoning.

Trapping - In order to control mongooses on islands and remove them from sensitive areas, the favoured way is trapping, mostly using Tomahawk or box traps (Coblentz and Coblentz, 1985). On Mauritius, Pink Pigeon populations have increased in areas that have been intensively trapped, and it is inferred that trapping has achieved some success as an emergency measure to conserve this endangered bird (Roy *et al.* 2002). Although trapping programmes are often very successful at removing animals in the short term, unfortunately they need to be run almost constantly if mongoose numbers in areas are to remain low, as mongooses can re-colonise trapped areas very quickly (Roy *et al.* 2002; Hays and Conant, 2007). Nevertheless, trapping programmes appear to have some success at reducing mongoose predation on native animals. For example, trapping of mongoose around vulnerable marine turtle nesting beaches led to much greater breeding success for hawksbill turtles on St John Island (US Virgin Islands) (Coblentz and Coblentz, 1985) and Fajou Island (Guadeloupe) (Lorvelec *et al.*, 2004). For nesting birds and reptiles trapping only need to occur before nesting and hatching.

In 2005, as part of work by the FD and Durrell Wildlife Conservation Trust to reduce predation on nesting native iguana, around 48 traps were set for 5 days each week from 1st March to 24th June around the Louvet River and Beach (M. Morton Durrell Wildlife Conservation Trust, unpublished; see **Fig. 16**). A total of 76 mongooses (46 males, 30 females) were trapped and killed, and after about five few weeks of trapping relatively few mongooses were being trapped (95% of the total mongoose catch was trapped and killed by week five), suggesting that localised intensive trapping had reduced mongoose numbers in the area. However, further research is needed to evaluate if trapping significantly reduced predation on iguana eggs and hatchlings.



Figure 16. Trap locations around an iguana nesting area - Louvet Beach. Most traps were set down in pairs a few metres apart and were set at access points to the nesting area, around the perimeter of the nesting area, and among nests. Transects marked in red were used for monitoring iguana nesting activity (photo courtesy of M. Morton, Durrell Wildlife Conservation Trust).

Fencing - Fencing is too costly a technique to prevent mongoose from accessing most areas of conservation value even relatively small nesting areas, and such barriers may not prevent predation by other introduced mammals that are better climbers e.g. opossums and feral cats.

Poisons - Diphacinone, an anticoagulant poison, has been used to control mongooses in Hawai'i and they appear to be very susceptible to this chemical (Hays and Conant, 2007). However, there is a risk to native animals and poisoning methods need to be developed to prevent poisoning of non-target species (Roy *et al.* 2002). Management of mongooses needs to be carefully considered an integrated with management of other invasive species. For example, removing mongooses without also removing cats and rats from islands and islets may be disastrous for native species if the absence of mongoose leads to increased rat and cat populations (Roy *et al.* 2002).

Fertility Control - Reducing the fertility of mongooses via baits placed in the field is not an option as the technology has yet to be developed.

Specific management recommendations for mongoose on St Lucia are:

- Where eradication of mongooses is not possible (on St Lucia's main island), protection of vulnerable wildlife species should be achieved with intensive localised trapping at sensitive areas of high conservation value. (Areas of high conservation value, such as key iguana and turtle nesting sites, are to be identified in a forthcoming report by the Critical Habitat Specialist M. Morton).
- Intensive localised trapping of mongooses is recommended at the sensitive sites on the main island, especially during the nesting and hatching seasons of affected native species.
- Other key native species that might benefit from focal mongoose control efforts include birds that nest on or near the ground, such as the white-breasted thrasher and the St Lucia nightjar.
- Control of mongooses should be integrated with control of other invasive mammals such as rats and cats, because controlling mongooses alone may release rats from predation pressure and cats from competition for prey.
- Research is needed to evaluate the limited use of poisons to control mongooses in sensitive areas of high conservation value. A poisoning campaign would need to exploit behaviours unique to mongooses to reduce non-target impacts.
- Research is needed to evaluate and compare the efficacy of different control measures (trapping, poisoning, fences) at reducing mongoose predation and increasing the nesting and hatching success of threatened and/or endemic wildlife.
- FD should consult and work closely with Durrell Wildlife Conservation Trust which has considerable experience controlling introduced mongooses in environmentally sensitive areas for the purposes of conserving endangered birds in Mauritius and endemic and threatened reptiles in St Lucia.

Recommended Trapping Methodology

Tomahawk traps or an equivalent trap type (e.g. Haverhart traps) should be used in trapping programmes as are excellent at capturing mongoose and other introduced mammals i.e. rats, opossums and feral cats. Locally made mongoose traps made of chicken wire are inexpensive and easy to produce but rarely trap adult opossum or feral cats, and, therefore, are not preferred over Tomahawk traps. Whatever the design, traps should be at least 25 x 60 x 25cm. Traps should be baited with chicken pieces (gizzard, heart, liver) as this bait type was found to be inexpensive and effective at attracting mongooses. Oily fish is a good substitute if chicken is not available.

Appropriate trap placement would be have 1) **entry points traps** situated at obvious (mongoose) entry points to sensitive conservation areas such as iguana and turtle nesting beaches (e.g. dry river beds, riparian forest, and edge habitats which mongoose frequent), 2) **perimeter traps** around the perimeter of conservation areas (e.g. around iguana and turtle nesting areas, to stop predators entering the 'predator-free zone'), and 3) **core traps** within the area that is intensively managed to create a predator-free zone. These core traps should be strategically placed to coincide with areas of high breeding and nesting activity of the target species to be conserved e.g. next to iguana and turtle nests. For an example of effective trap placement to reduce mongoose predation in an area of high conservation value see **Fig. 16**.

The minimum trap density should be one trap every 0.25 km². Placing more than one trap at each trap site could improve the number of captures. As mongooses are not territorial, it is possible that more

than one mongoose is present within small areas at any one time. As cats and rats are also major predators of native wildlife, mongoose trapping should be carried out as part of a regime that targets all of the predator species together. Tomahawk traps should target most introduced mammal predators – feral cats, opossum, mongoose, Roof Rats, and Norway Rats, though rats quickly learn to avoid traps and poisoning is most successful at controlling rodents. Setting, baiting, and checking traps and trapping protocols is discussed in detail **section 2.3**.

Traps need to be checked each day and rebaited. Trapped mongooses and other introduced mammals should be humanly killed. Trapping should last the duration of the entire nesting and hatching seasons of the target species, which equates to at around four months for iguanas (March to June). To help conserve the St Lucian Iguana, mongoose trapping should ideally be undertaken from March through to August which equates to this species' expected breeding season. However, given the difficulty accessing the relatively remote sites where iguanas nest, it is probably more feasible to trap for one month. Where feasible, there should be monitoring of the nesting and hatching/fledgling success of native reptiles and birds to determine the efficacy of mongoose trapping programmes.

The Future of Mongoose Control?

Trapping is labour intensive and difficult sustain in the long term and use of poisoned bait may have a role in controlling mongoose numbers, though more research is needed. Baits poisoned with diphacinone placed in the environment have a high probability of being taken by the Small Asian Mongoose (Creekmore *et al.* 1994). There is a need to formulate poisons, or use mixed baits so that they quickly kill multiple target species (i.e. cats, rats and mongooses). Controlling multiple predators may be a better control strategy where there is a risk of the other some introduced predators increasing in abundance as a result of single species control. However, poisoning campaigns often affect non-target species. Additionally, the dosage of poisons within bait formulations may be species specific and dosages will need to be calculated to quickly kill animals. Animals should be killed quickly and humanely, so that ethical objections to poisoning campaigns are not raised.

Lack of information – Research Recommendations

More research is needed. Any improvements in control and management of the Small Asian Mongoose on St Lucia will undoubtedly require a greater understanding of its behaviour and ecology of this species, especially its impact on native and other non-native species, and the efficacy and uptake of poisoned baits in the field.

Legislation

As with rats and mice; the Small Asian Mongoose should be listed as not protected (Schedule 3) in the Wildlife Protection Act 1980. Mongoose should be listed as an introduced species and regarded as vermin with appropriate control measures taken.

Education

St Lucians should be educated as to which mammals are native and of ecosystem importance and a conservation priority and which are introduced and pose a threat to native wildlife.

5.5 Feral Pigs

Introduction

Unsupervised domestic animals, many of which have gone wild (feral), are exotics and may pose a significant threat to native wildlife. Christopher Columbus introduced domestic pigs (*Sus scrofa* Linnaeus, 1758) to the West Indies during the 1400s, where they rapidly proliferated, escaped and became pests. From these early colonial times to the present day, pigs have been farmed on St Lucia. Even today, pigs frequently escape and become feral with resulting damage to native forests and wildlife. Many farmers deliberately allow their pigs to forage freely in the forest and are not always successful in recapturing them.

Feral pigs are generalists. Their omnivorous diet allows them to utilize a variety of food sources and to thrive in a wide range of environments. The majority of their diet consists of grasses, shoots, roots, tubers, fruit, and seeds, but they also eat small vertebrates and large quantities of invertebrates. Feral pigs are highly social but adult boars are mostly solitary. Like domestic swine, litter size depends on the sow's age, nutrition, and time of year. Feral swine are capable of producing two litters per year with average litter size varying from 4.2 to 7.5 piglets, but up to 10 piglets can be born during ideal conditions (Taylor *et al.* 1998). Pig numbers can recover rapidly following cessation of hunting and

management programmes, making feral pigs a real 'problem invasive species' for St Lucia's native wet forests.

Feral pigs can have devastating effects on agriculture and the natural environment (Seward *et al.* 2004). Shortly after Christopher Columbus introduced swine to the West Indies, feral pigs consumed agricultural crops such as maize and sugar cane (Donkin, 1985). Pigs root up large areas while searching for food with their snout and disrupt ecological processes, such as plant succession, and alter species composition. Specifically, rooting by pigs disturbs the seed bank, increases siltation in rivers, reduces surface vegetation and alters the soil by increasing soil temperature, increasing or decreasing the nitrogen content, increasing oxidation and increasing the leaching of nutrients and minerals (Wolf and Conover, 2003). Rooting creates large, unattractive open spaces, reduces vegetation cover and increases the growth of invasive weeds (Wolf and Conover 2003). Pigs are voracious and their diet on St Lucia may include native (ground nesting) birds and endemic reptiles. Feral pigs can be significant predators of marine turtle nests by excavating and feeding on the eggs (Stancyk, 1982). They may also have an impact on St Lucia's native invertebrates, which they probably consume in large amounts. Feral pigs can also transmit diseases to humans, such as leptospirosis, brucellosis and foot and mouth (Wolf and Conover 2003).

Distribution and Habitat Associations on St Lucia

The mammal survey team and parrot survey volunteers recorded the presence of feral pigs (observations of pigs or their signs) during surveys. Few pigs were observed, but evidence of their presence (tracks, trails, wallows, faeces) was obvious (**Appendix IV**). With the exception of a few records of pig signs in dry forest (near the Sorciere River) and mesic forest (near the River Doree) which were probably from recently escaped domestic pigs (pig signs were not far from abandoned pig pens), all observations of pigs and pig signs were in wet forest (**Figure 17a**). There were so many pig trails, other signs of pig presence, and evidence of damage to forests by pigs, that often the parrot survey volunteers and FD staff conducting timber inventories did not bother to record their geographical location. The map therefore shows only a small proportion of the number of pig trails and wallows found in wet forest, though all observations of live pigs are shown (**Figure 17a**).

Surveys show that feral pigs are largely restricted to wet forest on St Lucia and have become locally abundant. It is unsurprising that feral pigs apparently favour wet forest on St Lucia, where they can easily root and wallow, over grassland areas with dry soils. Furthermore, wet forest areas tend to be less accessible and they are somewhat protected from hunting. Feral pigs have voracious and omnivorous feeding habits, and, on St Lucia, our team observed they are damaging large tracts of wet forest; rooting up the vegetation, destroying seedlings, and contaminating watering holes, and perhaps also destroying the eggs and young of native (ground nesting) birds and reptiles. They appear to be damaging people's gardens and farms (M. Morton, pers. comm.). Additionally, in some dry forest areas, such as Grande Anse, pigs are being turned loose to forage, though these pigs are not considered feral because they belong to locals (M. Morton, pers. comm.). These pigs in dry forest areas are probably a threat to ground-nesting birds, such as white-breasted thrashers. In the medium to long term, they are likely to have a very major negative impact on forest dynamics through altering tree succession (by eating and damaging seeds and seedlings of some species, while creating favourable conditions for others). Interviews with FD range officers and other staff suggest that feral pigs are especially common in Quillesse Forest, Palmiste, Des Cartiers, Mahaut, and Fond Devaux. The perceptions of FD staff are that feral pigs are becoming more abundant at all of these localities.

Control Measures

No panacea for feral pigs control, management, or eradication currently exists. The effort required is probably too large to attempt to eradicate feral pigs from St Lucia. Besides, more farmed pigs will undoubtedly escape and become feral. Therefore controlling, rather than eliminating, feral pig numbers in areas of conservation concern and state-owned forest lands, is considered the best option for St Lucia's FD. Common methods to manage feral pig populations are hunting, trapping and poisoning (Anderson and Stone, 2003; Cruz *et al.* 2005). Creation of a post of 'Invasive Species Officer' would be a useful step in controlling invasive mammals and other wildlife, and this person coordinating mammal control measures such as feral pig hunting and mongoose trapping

Hunting is a widely used method to control feral pig numbers. Pigs can be shot with firearms and/or snared (Anderson and Stone, 1993). St Lucians occasionally use pitfall traps to capture and kill feral pigs (M. Morton pers. comm.). Hunting has been used to eradicate pigs from small islands, particularly

when used in combination with poisons (O'Brien and Lukins, 1990, Cruz *et al.* 2005). On Montserrat, the FD has begun shooting pigs in some forest areas. This action appears to have either reduced numbers and range of pigs or caused them to become more wary and difficult to observe, but unfortunately the control effort largely ceased. However, a new Darwin Initiative-funded project was launched in 2009 to address pigs and other ungulates on Montserrat, and may provide useful lessons for St Lucia. It is recommended that St Lucia's FD liaise closely with Montserrat's FD and the Darwin researchers to learn lessons on pig management. Measures that are successful in controlling pig numbers in Montserrat's forests are highly likely to work in St Lucia's forests.

FD strategies for sustainable uses of wildlife that employ hunting methods have been discussed above under agouti. Feral pigs are not considered as wildlife under the Wildlife Protection Act and so are not protected. For invasive species (including feral pig) control, FD recognizes that a broad-based strategy, deploying multiple techniques is likely to be necessary. It is recognized that currently hunting of pigs with guns, by non-FD private hunters, is done as sustainable use and that this is failing to control the pig population. It is also felt that arming FD officers would be inadvisable, based on past history. There would be a need for a disciplined body of hunters were this method to be useful (A. Toussaint, pers. comm.). As noted under agouti, the use of dogs for hunting in St Lucia appears to have unintended collateral impacts on wildlife (M. Morton, pers. comm.).

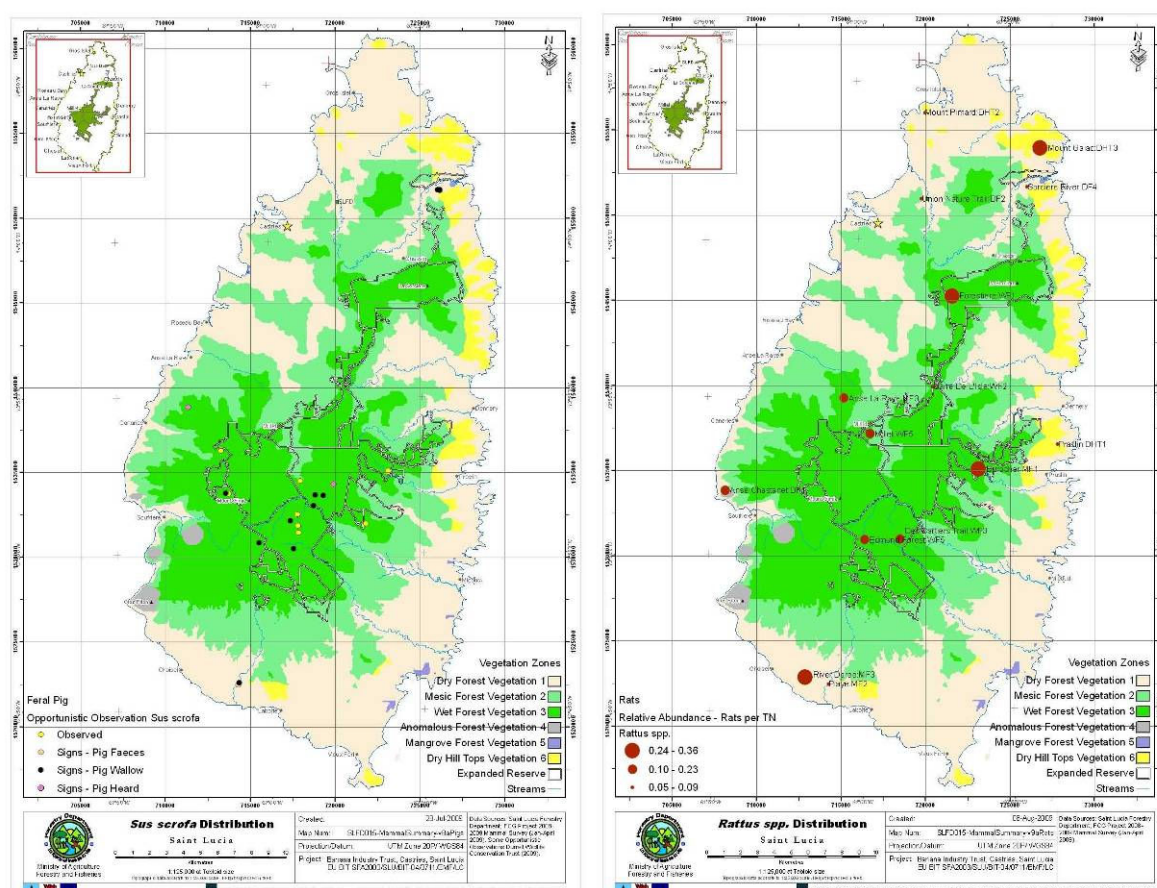


Figure 17. Distribution and abundance of introduced mammals: a) feral pig *Sus scrofa* and b) rats *Rattus spp.* among St Lucia's native forests.

Poisoning with sodium monofluoracetate (compound 1080, or warfarin) has been used to reduce feral pig populations in Australia (Hone, 1983). However, it should be noted that most poisonous compounds used to kill feral pigs are highly toxic to most animal species, and thus the pros of using them for managing pig numbers needs to be balanced with the potential impact on non-target species (Stone *et al.*, 1988; Cruz *et al.* 2005). Additionally, pigs often vomit the poison within hours of ingestion of poison, which may necessitate the use of high doses of anti-emetics (anti-sickness medicine), to aid the ingestion of lethal amounts of poisons and the certain death of pigs (Wolf and Conover, 2003). Compared to trapping, shooting and poisoning, other methods are not practical or too costly.

Frightening devices are ineffective and fencing is often too costly to keep pigs out of sensitive conservation areas (Hone and Atkinson, 1983). However, recently, relatively inexpensive, solar-powered electric fences are being used to keep animals out of sensitive areas and potentially could be used to exclude feral pigs from areas of high conservation value, i.e. iguana and white-breasted thrasher nesting sites. For an evaluation of electric fencing at restricting feral pig movements see Reidy *et al.* 2008. In future, oral contraceptives may have a role in controlling pig numbers but more research is needed to develop pig contraceptives and effective methods at delivering them to feral populations.

On St Lucia, hunting of feral pigs is occasionally permitted in some ranges (e.g. Millet Forest) but not others. Within these areas, pigs are hunted with dogs or snared. In those ranges where pig hunting is encouraged, permission is granted to only a few trusted locals who are only allowed to hunt pigs and not other species.

Management Recommendations

- FD should be the main body responsible for managing St Lucia's feral pig population, but will require additional resources to do so effectively.
- Hunting of feral pig within protected areas and state-owned forest lands should be permitted and encouraged, but closely regulated.
- A small number of reputable hunters should be licensed to cull pigs in each of the five forest ranges where feral pigs occur. Alternatively FD staff should undertake culling activities.
- Poisons should not be used to manage the feral pig population without further research and trials (carefully and safely conducted), because the chemicals used to poison feral pigs are highly toxic to other wildlife.
- The efficacy of different hunting methods needs to be evaluated – shooting versus snares – in controlling pig numbers in St Lucia's forests. Hunting pigs by setting snares is recommended as it is less likely to threaten native birds and reptiles than using firearms or hunting dogs (see Anderson and Stone, 1993).
- Licensed hunters should be policed by FD (regular, random, unannounced inspections of hunter's activities) to ensure that hunters are not killing or harming native wildlife and that illegal hunting does not occur with protected areas. If hunters are licensed to shoot feral pigs in forest lands, then only a few licences should be granted to experienced and trustworthy hunters (e.g. National Hunters Association) that are properly policed by FD to ensure that native wildlife is not harmed. Alternatively, FD could employ staff dedicated full-time to controlling feral pigs and other invasive wildlife (NB These are just options and their use should be considered not just within the context of the species control under discussion in this report, but also within the wider context of FD policy on hunting in general).
- The efficacy of different hunting methods needs to be evaluated – shooting versus snares – at controlling pig numbers in St Lucia's forests.
- Monitoring of pig abundance is important to gauge the effectiveness of management activities. The numbers and locations of all pigs observed or killed should be recorded using a GPS and mapped.
- Domestic pigs should be marked and livestock owners should be fined heavily if their pigs are found to have escaped into the wild.
- The ecology of feral pigs in St Lucia (e.g. activity patterns, group size and home range) should be considered in management strategies to control pig numbers or reduce their negative impact. In the tropics, feral pigs appear to be most active in early morning and late afternoon and hunting pigs at these times of day is likely to be most productive (Diong, 1982).

5.6 Roof Rats and Norway Rats

Although not a target of our mammal surveys, rats were commonly trapped during survey work. The rats (genus *Rattus*), called waart by St Lucians, are not native to St Lucia. They entered St Lucia with the first explorers from Europe and the slave boats from Africa. Two rat species have been introduced to the island. The Roof Rat *Rattus rattus* (sometimes called the Black Rat) is smaller (150 to 250g) and sleeker in appearance than the Norway Rat and is more arboreal. The Norway Rat *Rattus norvegicus* (sometimes called the Grey Rat) is a larger, more robust rat (200 to 500g), and is typically more restricted to urban areas. Both species have very variable coat colours. The Roof Rat can be discriminated from the Norway Rat by its more pointed muzzle, longer whiskers, and larger ears, but it can be difficult to correctly assign juvenile to species and the most reliable way of telling them apart is by examining their dentition. The biology of rats is well-known, has been discussed by numerous

authors, and is not repeated here. For a discussion on the behaviour and ecology of *Rattus* see Barrett (1974), Lund (1994) and MacDonald and Fenn (1994).

Distribution and Habitat Associations on St Lucia

Ninety-four rats were trapped and 12 were recaptured. Sixty-seven of the captures appeared to be Norway Rats with the remaining 27 captures being Roof Rats, though the mammal survey team had problems identifying around 12% of captures to species with 100% certainty. From here on, all captures are therefore referred to as rats, *Rattus* spp. *Rattus* were found to over most of St Lucia from around sea level to at least 550m elevation (at Edmund Forest) but were significantly more abundant in mesic forest (mean = 22 *Rattus* per 100 trap nights (TN)) and wet forest (18 per 100 TN) than in dry forests (6 per 100 TN) (**Figs. 3 & 17b**). *Rattus* are attracted to farms, plantations, gardens and human dwellings where there is scraps and garbage which probably explains why most rats were trapped in mesic forest areas.

Impact of Rats on Native Wildlife of the West Indies

The Norway Rat and the Roof Rat can have devastating effects on the flora and fauna of islands (Townsend *et al.* 2006). They suppress some forest plants, and are associated with extinctions or declines of flightless invertebrates, ground-dwelling reptiles, land birds, and burrowing seabirds. Globally, Roof Rats have been associated with declines or extinctions of the largest number of indigenous vertebrate species (at least 60 species), including small mammals. In the West Indies, Roof Rats have been implicated in the sharp decline of the White Cays Iguana *Cyclura rileyi cristata* in the Bahamas and the Antigua Racer snake *Alsophis antiguae* in Antigua (Daltry *et al.* 2001; Daltry, 2008). These species are now restricted to one or two small islands from which rats have been eradicated. On St Lucia, the offshore islands of Praslin, Rat, Maria Major and Maria Minor provide an important refuge for endangered St Lucia Whiptail lizards *Cnemidophorus vanzoi* and, on the Maria Island only, the St Lucia Racer *Liophis ornatus*. Thankfully, rats have never managed to colonise the Maria Islands. They were eradicated from Praslin Island in 1993, and Rat Island and Dennery Island in 2005, by using a combination of trapping and poisoning (with the anticoagulant rodenticide brodifacoum), and whiptail lizards were subsequently introduced to the islands in 1995 following successful eradication of rats (Daltry, 2000; Varnham, 2005 a,b). Rat eradications from small islands have proved highly successful. Worldwide, Howald *et al.* (2007) reported that 332 successful rodent eradications had been undertaken by 2007, and only 35 had failed. Rodenticides were used in all successful eradication campaigns.

Control Measures

There has been a long history of rodent control in the West Indies (Williams, 1986). The impact of rats on St Lucia's native fauna and rat control and eradication on St Lucia's offshore islands (Rat, Praslin, and Maria Islands) has been the focus of much work by conservation organisations working with St Lucia's FD, especially the Durrell Wildlife Conservation Trust (M. Morton) and, to a lesser extent, Fauna & Flora International (Dr. J. Daltry). These conservation organisations should be sought for advice on how to control and eradicate rat populations to conserve St Lucia's native wildlife. Methods to control *Rattus* populations should take into account the different ecologies of *R. norvegicus* and *R. rattus*; the latter being more arboreal and less likely to be controlled by poisoned bait placed at ground level. The eradication of rats from mainland St Lucia would be virtually impossible with current technology, prohibitively expensive, and unlikely to last (because rats could readily reinvade St Lucia via cargo boats and other vessels). However, St Lucia's small offshore islands can be more easily cleared and kept clear of harmful invasive wildlife, such as rats, and these restored islands have an incredibly important role to play in the conservation of St Lucia's threatened endemic reptiles. Key publications on the eradication and control of rats on St Lucia are Daltry (2000), Varnham (2005 a,b), and Howald *et al.* (2007).

5.7 Other Mammals

Domestic Pets

Domestic animals that have reverted to the wild are known to be very influential, but there are very little objective data on their ecological impact in the Caribbean. Feral dogs and cats may attack wildlife, including iguanas and agouti. Cats are also major predators of birds. A domestic cat was trapped at Forestiere, and many dog faeces/tracks were observed in wet and mesic forest.

Exotic Pets

Exotic (alien) mammals can pose a problem to native wildlife when these pets escape or are deliberately released. Groups of monkeys are occasionally reported to the FD. There is a known small group of monkeys living wild near a community near Monchy, thought to be spider monkeys *Ateles* spp., a Central and South American monkey that usually requires closed-canopy wet forest to thrive. Locals appear to be feeding these animals, but there is no evidence that the group is breeding and one individual reportedly died in early 2009. Monkeys have become established on several islands in the West Indies and can rapidly increase, becoming pests of crops and threatening local wildlife. It is recommended that the keeping of exotic mammals on St Lucia is prohibited. Failing that, licences should be mandatory to import and regulate the keeping of exotic pets.

Extinct Native Mammals

The St Lucian Giant Rice Rat *Megalomys luciae* (Forsyth Major, 1901) (Family: Cricetidae) was not found despite trapping, including in dry forest and riparian vegetation around Sorciere River on the northeast of St Lucia where there have been reports of an unusual rodents seen. This endemic rodent, found only on St Lucia, is thought to have become extinct in the 19th century. The St Lucian Giant Rice Rat is listed by the IUCN Red List as Extinct because it has not been confirmed since the before the year 1881 (Turvey and Helgen, 2008). According to the extremely few descriptions of this species, *Megalomys luciae* was a large rodent (~500g) with uniform rich brown fur above and paler below, and was thought to be largely arboreal. One museum specimen exists (the holotype) at the Natural History Museum, London (catalogue number: British Museum, NHM 1853.12.16.2) (**Fig. 18**).



Figure 18. Natural History Museum holotype of the St Lucian Rice Rat (*Megalomys luciae*) skin, skull, and upper dentition. Specimen catalogue number 1853.12.16.2 (photo credit: NHM, London).

A number of St Lucians farming around the Sorciere River have reported an unusual looking rodent eating their crops, that they name the pilorie (pee-lo-ree). Locals describe this as being a mouse-sized rodent, smaller than *Megalomys luciae*. This raises the intriguing possibility that another, hitherto unknown rodent may occur here. Elsewhere, in the Desbarra/Barre Coulon area, an unidentified rodent, conspicuously larger than *Rattus*, and with a glossier coat, was reported to the FD in 2007 (M. Morton pers. comm.). This warrants further investigation and trapping should be carried out in the area.

The St Lucian Giant Rice rat probably became extinct due to the introduction of cats, rats, and possibly the mongoose (although the last records of the St Lucian Rice rat in the wild slightly predates the introduction of the mongoose around 1888), but also persecution by humans and habitat loss. It is possible that a small population(s) still exists somewhere on the island but much more extensive surveys would be required to confirm this. At least seven species of rodents have become extinct in the Lesser Antilles within the period of human occupation of the region. The extinction of the magnificent, unique, St Lucian Giant Rice Rat illustrates the need for conservation measures, including the need for establishing and expanding protected areas, management of forests and other natural habitats for wildlife, and the control of introduced mammals, if St Lucia's remaining native animals are to persist and thrive.

6. ACKNOWLEDGEMENTS

This project was funded by the European Community under the Saint Lucia SFA2003 Programme for Economic and Agriculture Diversification and Poverty Reduction through Integrated National Resources Management. Forestry Department officers Mr George Antione, Mr Timothy Jno Baptiste, Mr Alwin Dornelly, Ms Mary James, Mr Stephen Lesmond, Mr Nerius Mitchel, Mr Randall Marius, Mr

Canice Peterson, and Mr Melvin Smith, are acknowledged for assistance with mammal surveys. The bat survey team from Scranton University, especially Drs Gary Kwiecinski, Hugh Genoways, and Scott Pedersen, for contributing their bat capture data. Mr Jorma Peltonen (FCG Ltd) and the banana Industry Trust for allowing Dr Clarke the opportunity to study and survey St Lucia's mammals. Project Leader Dr Robert Tennent (Finnish Consulting Group, FCG) for arranging accommodation, facilitating fieldwork and procurement of equipment. Prof. Paul A Racey (Aberdeen University) for the loan of bat detectors. Project Critical Habitats Specialist Mr Mathew Morton (FCG and the Durrell Wildlife Conservation Trust) for loan of live animal traps, general advice, use of photographs, and help with mapping. Project GIS Specialist Vijay Datadin (FCG) for mapping. Project Conservation Biologist Dr Jenny Daltry (FCG and Fauna & Flora International) for facilitating the mammal project work, her expert advice on wildlife conservation, use of photographs, help constructing guide to mammal signs, and for reviewing this report, and last but not least, Project Botanist Mr Roger Graveson is acknowledged for his assistance in selecting survey sites.

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APPENDIX I IMAGES OF ST LUCIA'S NATIVE FORESTS AND HABITATS SURVEYED



a) Wet forest near Piton Flores at 300m elevation.



b) Mesic forest mixed with plantations inland from Anse La Raye at 150m elevation.



c) Dry forest at 50m elevation at Anse Chastanet

APPENDIX II MAMMAL SURVEY DATASHEETS

Timed-Searches (VES) Datasheet for Non-volant Mammal Survey

Transect:		Date:		Time start:		Time end:	
Rain:	Heavy	Moderate	Light	None			
Survey team:							
Comments:							

Time	Species	Observed?	Signs?	Number	Notes

Key for completing Timed Search datasheet

- TRANSECT – the name of site e.g. Dry Forest 1
- TIME START/TIME END – the time in 24-hour clock that the point counts commence and terminate e.g. 1pm should be recorded as 13:00.
- RAIN – will be recorded as heavy, moderate, light or none (no rain).
- SURVEY TEAM – the names of the team conducting the line transect survey.
- TIME – the time of day that each mammal is observed should be recorded.
- OBSERVED – tick box if mammal observed.
- SIGNS – if mammal not observed but signs are evident, write in box the type of sign e.g. faeces, tracks, scratch marks, mammal heard.
- NUMBER – number of mammals.

Mammal Trapping Datasheet

Date: _____ Forest type: _____ Transect/trap line #: _____ Length of trap line: _____ Number of traps: _____ Trap interval: _____
 Comments: _____

Rec #	Trap station #	Trap type	Species	Sex	Age	Mass (g)	HB (mm)	Perf?/ Testes	Foetus/ Lactating	New record/ Recapture?	Comments

Notes for completing mammal trapping data sheet
 REC: record a sequential record number for each data entry. Use this unique number to make additional notes elsewhere.
 TRAP: record the specific trap, trap type and trap station #.
 TRAP TYPE: e.g. Tomahawk trap, feral cat trap, Sherman trap...
 SPECIES: record your field species identification here.
 SEX: record what sex you think the individual is.
 AGE: record age if possible based on external characters.
 MASS: record the weight of bag and animal - weight of bag above the horizontal line; your value for weight of the animal below the horizontal line, use grams.
 HB: head-body length
 PERF?/TESTES: record if the vagina is perforate or imperforate or the size of the testes.
 FETUS/LACT: record if you can feel a foetus or if lactating.
 MAMMARY FORMULA: record the mammary formula for the captured mammal.

Bat Survey Datasheet

Site:	Date:	Nets open:	Nets closed:
Moon phase:	Light conditions:		
New + <u> </u> , 1 st Q + <u> </u> , Full + <u> </u> , 3 rd + <u> </u>	VERY LIGHT MODERATELY LIGHT		
Rain:	MODERATELY DARK VERY DARK		
Survey team:	Heavy Moderate Light None		
Comments:			

Time	Species	Biometrics (mm)	Sex, age class, reproductive status and other notes
		FA: Ear:	
		HF: Calcar:	
		FA: Ear:	
		HF: Calcar:	
		FA: Ear:	
		HF: Calcar:	
		FA: Ear:	
		HF: Calcar:	

Key for completing bat datasheets

TRANSECT – the name of sites e.g. Dry Forest 1. NETS OPEN/CLOSED – the time in 24-hour clock that mist nets are opened to capture bats and then closed e.g. 7pm should be recorded as 19:00. NB Mist netting should commence just before sunset (18:00 h) and last for 4 hours, typically until 22:00h. MOON PHASE – recorded from the calendar, adding the no. of nights since the beginning of the current phase. LIGHT CONDITIONS – will be recorded as VERY LIGHT = light enough to read; MODERATELY LIGHT = light enough to see a considerable distance; MODERATELY DARK = light enough to see a hand held in front of ones face but little else; and VERY DARK = too dark to see hands. RAIN – will be recorded as heavy, moderate, light or none (no rain). SURVEY TEAM – the names of the mammal survey team conducting mist netting. TIME – the time of day that each bat is captured should be recorded. FA – record the length of the forearm from the elbow to the wrist (made with wing at least partially folded). EAR – record the length of the ear from the notch to the tip of the ear. HF – record the length of the hind foot from the anterior edge of the base of the calcar to the tip of the longest toe (not including the claw). CALCAR – record the length of the calcar from the base to the tip. NOTES – take detailed notes that will aid species identification e.g. number facial stripes or mid-back stripe and note sex, age class and reproductive status e.g. juvenile male, adult female, pregnant, lactating, post-lactating.

APPENDIX III SURVEY METHODS AND TRAINING



a) Tomahawk live animal trap set in dry forest to trap non-flying mammals e.g. opossum, mongoose.



b) FD officers Mary James and Timothy Jno Baptiste removing opossum from Tomahawk trap.



c) Holding a rat for further examination.



d) Using a calliper to measure the forearm length of a bat.



e) FD officer Mary James using a spring balance to weigh a bat.



f) Road-killed mongoose.



g) Many St Lucians are aware & proud of their natural heritage.

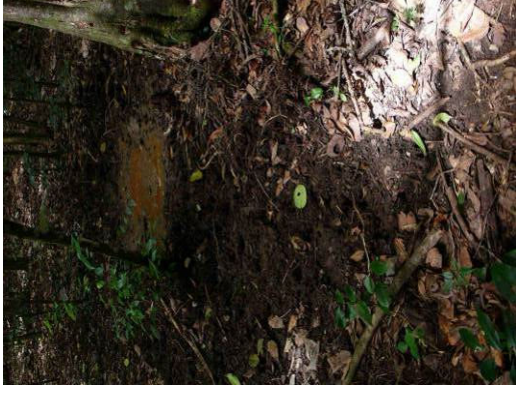
APPENDIX IV PHOTOGRAPHIC GUIDE TO MAMMAL SIGNS



a) Feral pig faeces (droppings).
Can also be masses of pellets.



b) Forest damage by feral pigs.



c) Pig trail leading to pig wallow.



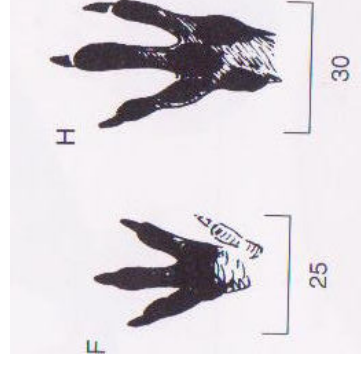
d) Feral pig print in sand.



e) Marks caused by feral pigs rubbing against tree.



f) Marks on tree caused by tusks of adult male pig (boar).



g) Drawing of Agouti footprints (not to scale) – front feet have four toes and back have three. (reproduced from Reid, 1997)



h) Southern Opossum footprints in soft mud (photo credit: Dr Jenny Daltry FCG-FFI)



i) Mongoose footprint in soft mud (photo credit: Dr Jenny Daltry FCG-FFI).

APPENDIX V SCRANTON UNIVERSITY BAT SURVEY CAPTURES – net number ranged from 1-11 each night (average 5)

Locality	Date	(UTM 20P)	<i>B. cavernarum</i>	<i>M. plethodon</i>	<i>S. lilium</i>	<i>A. nicholli</i>	<i>A. jamaicensis</i>	<i>Nieporinus</i>	<i>P. davyi</i>	<i>T. brasiliensis</i>	<i>M. molossus</i>
Union trail (18m elev.)	15 June 2007	720149E 1550955N					114				9
Forestier trail head (300m)	16 June 2007	721188E 1545338N	2	10	1	5	66		1		1
Piton Flore (300m)	16 June 2007	721188E 1545338N			4	4	24				1
Marquis Estate (25m)	17 June 2007	725581E 1551666N					18			147	1
Grace cave (165m)	18 June 2007	718502E 1526435N	8								
Woodlands Estate (226m)	18 June 2007	718289E 1526362N		4	5		34				
Barre Des L'Isle (294m)	19 June 2007	720533E 1540540N	6	34	3	5	75		3		
Soufriere cave (0m)	19 June 2007	709179E 1532878N	2								
Fox Grove (52m)	29 July 2008	726275E 1533572N		1			18			4	
Mamiku River (3m)	29 July 2008	726790E 1534062N			1		9				3
Troumassee River (40m)	30 July 2008	725388E 1528858N		1			83			1	40
Raillon Negres (255m)	30 July 2008	723057E 1534721N		7	12		66		1		1
Quillesse (283m)	31 July 2008	718999E 1530930N	1	59	18		212		2		2
Edmund Forest (550m)	01 August 2008	715687E 1531170N	8	6	5		26		1	7	4
Anse La Raye (1m)	02 August 2008	711626E 1542156N					8	4			
Canelles River (10m)	02 August 2008	725442E 1524730N					22	1	2		8
Barre de isle ridge (294m)	03 August 2008	720533E 1540540N	3	27	15	7	54				
Dennery River (1.1m)	03 August 2008	726428E 1538725N		1			27	7		1	70
Monchy (25m)	13 March 2009	723077E 1554562N	1				39			1	34
Diamond Bot. Garden (47m)	14 March 2009	710827E 1532264N	2		1		33				4
Saltibus (398m)	15 March 2009	715533E 1528340N	2	6	1		3		3		4
Au Leon Peak	16 March 2009	726658E 1543650N		2	1	4	18		5		8

APPENDIX VI IDENTIFICATION KEY TO ST LUCIA'S BAT FAUNA

First check whether bat has a noseleaf - a fleshy leaf-shaped protuberance at the end of the nose.

Noseleaf present (the Leaf-nosed Bats, family Phyllostomidae)

Large bat (forearm length = 61-70), whitish-yellow to buff-brown fur, small and **stumpy noseleaf, short tail present** but no tail membrane (Antillean Fruit Bat, *Brachyphylla cavernarum*)

Large bat (forearm = 55-69mm), brown fur, often **faint stripes above eye**, conspicuous noseleaf, **no tail present** but there is a narrow tail membrane: (Jamaican Fruit Bat, *Artibeus jamaicensis*)

Medium sized bat (forearm = 40-43mm), dark brown fur, small heart-shaped noseleaf, **very long muzzle and tongue, short tail present**: (Insular Long-tongued Bat, *Monophyllus plethodon*)

Medium sized bat (forearm = 45-54mm), light brown long fluffy fur, **yellow ear-rims, white tufts (spots) of fur on shoulder**, conspicuous noseleaf, **no tail**: (Tree Bat, *Ardops nichollsi*)

Medium sized but robust bat (forearm = 38-45mm), **shoulders stained orange**, conspicuous noseleaf, **no tail**, short, strong, hairy legs: (Little Yellow-shouldered Bat, *Sturnira lilium*)

Noseleaf absent

Very large bat (forearm = 83-89mm), brown to orange fur with pale stripe running down middle of back, bulldog-like head, **large feet with long sharp claws**: (Greater Fishing Bat *Noctilio leporinus*)

Medium sized bat (forearm = 41-49mm), dark **velvety fur**, wing membranes originate from the mid-line of bat's back, giving bat a **naked-backed appearance**: (Davy's Naked-backed Bat, *Pteronotus davyi*)

Small bat (forearm = 36-39mm), light-brown to reddish fur, long tail extends well beyond edge of tail membrane, **wrinkled upper lips**: (Brazilian Free-tailed Bat, *Tadarida brasiliensis*)

Small bat (forearm = 36-41mm), dark-brown fur, **dog-like face**, similar in appearance to Brazilian Free-tailed Bat (above) but with **smooth upper lips**: (Common Free-tailed Bat, *Molossus molossus*)

A number of bat species occur on nearby islands and potentially may be discovered on St Lucia. Their descriptions are as follows. The Greater Naked-backed Bat *Pteronotus parnellii* occurs on St Vincent. It is similar in appearance to Davy's Naked-backed Bat which occurs on St Lucia but is larger (forearm = 50-65mm). The Greater Fruit Bat *Artibeus lituratus* occurs on St Vincent. Similar in appearance to the Jamaican Fruit Bat (which occurs on St Lucia), the Greater Fruit Bat is larger (forearm = 67-73 mm) and has four distinct facial stripes. Miller's Long-tongued Bat *Glossophaga longirostris* occurs on St Vincent. Miller's Long-tongued Bat is smaller (forearm = 35-40mm) than the Insular Long-tongued Bat (which occurs on St Lucia) and its tail does not stick out from end of tail membrane. Finally the Funnel-eared Bat *Natalus stramineus* occurs on Martinique. This tiny, delicate bat is unmistakable with its minute eyes, and large, triangular, funnel-shaped ears, and very long tail.

APPENDIX VII EQUIPMENT LIST FOR MAMMAL SURVEY

EQUIPMENT LIST FOR SURVEYING BATS	
Item	Quantity
GPS unit	1
Mist nets 12m x 2m (2-ply 36 or 38mm mesh)	3
Mist nets 6m x 2m (2-ply 36 or 38mm mesh)	2
Digital Camera	1
Metal tent pegs (to secure guys)	40
Nylon string (for guying out net poles)	100 m
Cotton drawstring holding bags (medium sized).	20
Close pegs (for hanging up bats in cotton holding bags)	40
Clipboard	1
Datasheets and Indelible ink pens	Multiple
Field Guides for identifying species and signs	1
Petzi Mega Zoom head torches and spare bulbs	1 per person
Powerful hand torch and spare bulbs	1 per person
Callipers	2
Pesola spring balances: (50g x 0.5g and 300g x 2g).	2
Hand lens (10 x)	1
Plastic pipette and vial with honey/water solution	1
70% ethanol for preserving voucher specimens	100ml
Thin leather gloves for handling bats (golfing or pilot gloves)	1 per person
Thick leather gloves for handling bats (to wear over thin pair)	1 per person
Compass	1
Tarpaulin (10 x 20ft)	2
First aid kit	1
Whistles and mobile phones for emergency communication	1
Cutlass	1
D980 Pettersson Time-expansion Bat Detector	1
Edirol Digital Recorder, Stereo audio lead & SD card and silica gel	1
Batsound (Sound Analysis Software)	1
EQUIPMENT LIST FOR TRAPPING MAMMALS & VES	
Large live animal traps (for feral cats, opossum)	12
Medium live animal traps (for mongoose, rats)	12
Pillow cases or sacs for holding mammals	2
Syringes & Ketamine for anaesthetising large mammals	Multiple
Gentian violet or scissors for marking mammals	1
Mammal bait – oily fish, rolled oats and biscuits, banana and raw chicken	Multiple
30cm ruler and 50m measuring tape	1
Digital camera	1
GPS unit	1
Binoculars	1
Field Guides for identifying species and signs	1
Clipboard, datasheets and indelible ink pens	1
Compass	1
Plastic bags & vials for collecting signs (e.g. faeces, hair)	Multiple
Stakes or tent pegs for anchoring traps	20
Nylon string	1 large roll
Cutlass	1
Rolls of duct tape	2
Fluorescent flagging tape for marking location of traps	Multiple
First aid kit, whistles and mobile/satellite phones for emergency	1

