The distribution and abundance of an invasive species: the common myna (*Acridotheres tristis)* on Atiu, Cook Islands.



Photos by J. Mitchell, and from Google Earth

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MSc Biodiversity and Conservation Project

2009

UNIVERSITY OF LEEDS

Contents

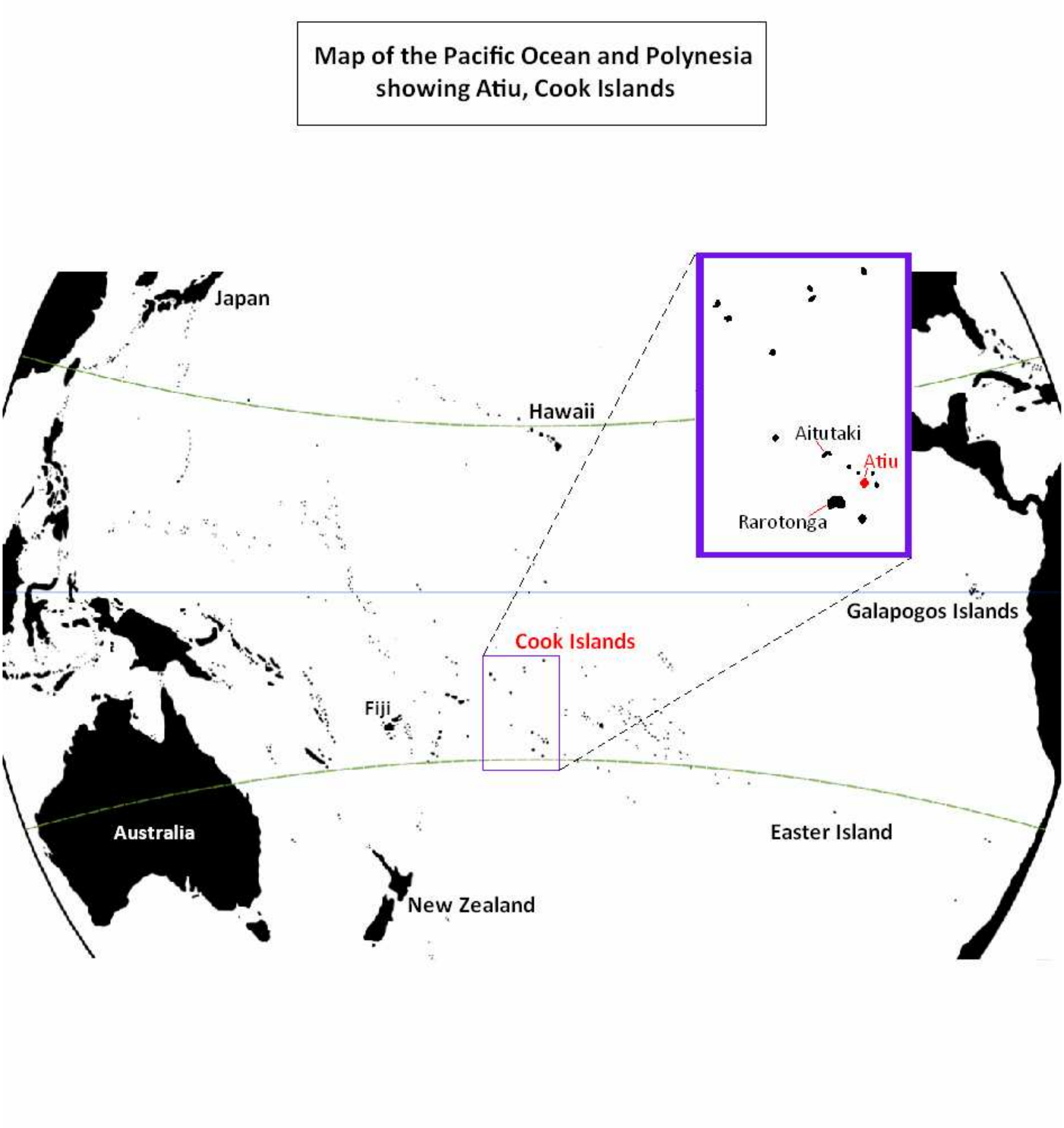

Figure 1. Location of the Cook Islands, South Pacific Ocean

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Abstract

An invasive alien species are known to cause significant economic and environmental damage. Islands are much more vulnerable to the invasion of invasive alien species, and have higher rates of extinction. In the islands of the South Pacific, there are several species Polynesian land birds which are threatened with extinction due to invasive alien species and human interference. Without any intervention from humans, it is likely that these birds will suffer extinction in the next few decades. The island of Atiu in the Cook Islands (South Pacific) supports a range of avian fauna. In 2007 the Rimitara lorikeet (*Vini kuhlii)*, also known locally as the 'Kura' was introduced to Atiu, to make a reserve population, as there were only approximatley 1000 left on the island of Rimitara, French Polynesia. There is concern for this species on Atiu due to the existence of the common myna (*Acridotheres tristis*). The myna is an agressive invasive which is one of the world's worst 100 invasive species. It was introduced to the Cook Islands by the government, with the intention to control the coconut-stick insect *(Graeffea crouani)*, but is now a pest itself. A myna control programme on Atiu is being coordinated and controlled by Gerald McCormack (Cook Islands Natural Heritage Trust), working through George Mateariki, and using funding from various conservation organisations. Poisioning is being carried out by George in order to reduce myna numbers, and a bounty has been set on the birds or for every right foot so that the locals can help as much as possible. This investigation aimed to estimate the total population size on the island to use as a starting count to determine whether the programme is successful or not. Two methods were used which included roost counts to find an estimate of the population, and a transect method using a Distance programme to estimate the number of birds per hectare as well as the level of abundance in various habitat types. The two methods had overlapping results, giving a total estimated range of 3250 to 8460 birds on the island, although it is more likely to be at the higher end of this estimate at around 6000 to7000 birds. Further investigation will need to determine any change in the population size, any changes in habitat composition as well as the impact on the native species, especially the effect on the Kura and its population size.

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1. Introduction

1.1. Invasive alien species

An invasive alien species can be defined as an introduced species that has travelled to a non-native area, and has the ability to establish, thrive and dominate (IUCN 2000). They are known to cause significant economic and environmental damage (Blackburn and Duncan 2001). The movement of species around the world is now known to be a dominating feature to life on Earth (Sax *et al.* 2005).

There are numerous pathways that alien species can be introduced. Deliberate pathways include; the aquarium industry, as species are moved around the world to be sold in pet stores, for resources such as food and drink products, for medicinal purposes, biological control of other invasive species, as pets, for aesthetic reasons, biological research, inadvertent introductions, products of agriculture and horticulture, commercial and domestic shipments, military movement and shipments, within soils, and with the modification of canals and other waterways (Cowie and Robinson 2003). With the arrival of invasive species it is typical for competition, predation and hybridization to occur, resulting in a decrease in biodiversity (Wittenberg and Cock 2005). However the results of introductions can vary greatly; the impact of some species may be very slight or not noticed immediately (IUCN 2000). More serious invasive species can alter the entire function of an ecosystem, making it unsuitable for native species already existing there (IUCN 2000, Wittenberg and Cock 2005). Successfully introduced species are thought to be one of the main reasons causing species extinctions, and is now almost as devastating as habitat loss, primarily caused by humans (IUCN 2000).

The terms ‘non-native’, ‘exotic’ ‘alien’ and ‘introduced’ are commonly used when referring the species that are found in regions that are not indigenous to them (Sax *et al.* 2005). However these terms do not necessarily mean that the species in question is at all established (Sax *et al.* 2005). Species that are established to a non-native region are best to be considered as ‘naturalised’ (Sax *et al.* 2005). Even though the impact of a new species within a region can be highly significant, it is very rare for species that have been introduced to actually become successfully established. Species are continuously moving around the world and becoming established, but overall this is only a small proportion compared to the numbers that are introduced to new regions and are unsuccessful with naturalisation. Those that occur within conditions that are well within their ancestral niche tend to be those that have a higher success rate at forming self-sustaining populations. It is more common for species that have greater geographical ranges, or those that use a wider variety of resources to become established due to them having a higher tolerance to differences between habitats (Blackburn and Duncan 2001). Those that are more restricted with their habitat suitability have a much lower rate of success (Blackburn and Duncan 2001). However, there are exceptions to this theory, as species that are highly successful in their own distributions do not always take to niches similar to their own. The reason why some species easily become established and others fail is not very well understood (Blackburn and Duncan 2001).

Very few species on earth are only located in the area of their original historic origin, as it is normal for populations to widen, contract or shift their geographical range for reasons such as continental shift over a larger period of time, or changes in habitat, climate, or new competitors and/or predators over short periods of time (Sax *et al.* 2005). Humans are the best example of successful naturally invasive species, and our success is driven by the ability to spread quickly and change habitats to suit human requirements, which is a major cause of other species extinctions (McNeely 2005). Since the time where humans began to become more mobile around the world, there has been a significant increase in the number of invasive species introductions, may they be accidental or intentional. Wherever humans have moved to they have also taken other animal species with them (McNeely 2005). Originally it was mainly domestic species that were taken along by travellers around the world to help avert homesickness or for the resources that they provided, but this also lead to accidental introductions via stowaways on their boats (ICUN 2000). For example, it was custom for travellers such as Polynesians to take pigs, taro, yams, and several plant species with them, and lizards and rats were very common stowaways (McNeely 2005). Trade is also a major factor in the increase of alien transportation, as trade became more important when long-distance travel became easier and more regular (McNeely 2005). Another pathway that increased the rate of alien species success, especially for viral and bacterial species is the Military, who were responsible for the spread of viruses that are now common in day to day life such as measles, e.g. from Europe to the USA by early conquistadors (McNeely 2005).

It is now known that it is accidental introductions that tend to fabricate the most successful invasions (IUCN 2000). The rate of species introduction and establishment is therefore greatly reflected in the areas of human population. Regions with elevated levels of human activity are those that have more non-native species, where as the areas that have lower populations, fewer interactions with people travelling and/or trade, or regions that are completely unpopulated by humans have far fewer invasive species (McNeely 2005).

1.2. Island Ecosystems

As islands are so isolated from mainland areas, they have evolved separately and tend to have much lower levels of biodiversity and higher levels of endemic species (Bergstrom and Chown 1999). Due to these island ecosystems, islands are much more vulnerable to the invasion of invasive alien species, and have higher rates of extinction (IUCN 2000). A well known example of this is the rosy wolfsnail (*Euglandina rosea*), a native to the tropical areas of North America, which was introduced to several islands in the South Pacific and the Indian Ocean as a biological control for the giant African snail (*Achatina fulica*), which was another introduced species and a problematic invasive (IUCN 2000, Cowie and Robinson 2003). In the French Polynesian islands the rosy wolfsnail did predate on the African snail, but there is no evidence in any decline in population (Cowie and Robinson 2003). Unfortunately the only impact that the rosy wolfsnail made is that it had more of a preference to a native endemic species instead, and has had devastating effects on their population (IUCN 2000, Cowie and Robinson 2003).

The islands of the South Pacific are a good example to study as they are easy to observe and monitor for invasive species introductions due to their isolation, small size and lower human populations (Bergstrom and Chown 1999). Due to the trend with low levels of biodiversity and higher levels of endemic species, this means that the impact of any newly naturalised species, whether introduced deliberately or not, can be observed without much difficulty (Bergstrom and Chown 1999). In the islands of the South Pacific , there are several species Polynesian land birds such as parrots, pigeons and kingfishers, but these are become rarer as time passes by (Franklin and Steadman 1991). Without any intervention from humans, it is likely that these birds will suffer extinction in the next few decades (Franklin and Steadman 1991).

2. Study Area

2.1. The Cook Islands

The Cook Islands are a group of 15 Polynesian islands, named after Captain James Cook who sighted some of them in the 1770’s. They were governed by New Zealand from 1902, but independence was claimed in 1965 (Simonett and Franklin 1989). The two countries still have strong economic ties as well as an open immigration agreement (Simonett and Franklin 1989). The nation is also a member of the British Commonwealth (Simonett and Franklin 1989). The islands are widely scattered across 1.95 million km² of the South Pacific Ocean (Franklin and Steadman 1991), and are divided into the northern and a southern group. They can be located directly south of Hawaii and northeast of New Zealand (see fig.1). Throughout the region there is great geographical diversity in the structures of the islands (Franklin and Steadman 1991). They are atoll islands, as they are surrounded by a fringe of coral (Franklin and Steadman 1991). In the southern group there is the capital island of Rarotonga which is a high volcanic island, Aitutaki which is an almost atoll with a lagoon in the centre, and Atiu, Ma'uke, Mitiaro and Mangaia are uplifted volcanic islands which have been raised by fossilised coral limestone (Franklin and Steadman 1991), estimated to have begun rising 2-3 million years ago. This fossilised coral structure is known as 'makatea'. The northern islands are much lower atoll islands, some of which are totally uninhabited by people.

The Cook Islands Natural Heritage Trust (CINHT) estimates there to be approximately 7000 plant and animal species in the Cook Islands, with around 4200 recorded species on the biodiversity database which includes both native and non-native species (McCormack 2006a). A vast majority of islands in the South Pacific, Cook Islands included, have been subjected to the invasion of various alien species (Atkinson and Atkinson 2000). They often have unfavourable effects on the islands that they occur on (Atkinson and Atkinson 2000). Reviews have been produced for the number of invasive land species on the South Pacific islands, including one by the South Pacific Regional Environment Programme (SPREP) in 2000, which recognised 14 species throughout the South Pacific that are considered to be "significant invasive species" (Atkinson and Atkinson 2000). SPREP also recognised that the countries of the South Pacific have suffered much greater losses than the rest of the world in comparison to the number of species that existed before the colonisation of man on these islands (Sherley 2001). A very recent arrival in the Cook Islands is a new species of myna bird on Rarotonga which has now become an established invasive, which is the jungle myna (*A. fusca*) (McCormack 2009). Numbers are estimated to be around 150 individuals, and is not affected by competition with the common myna although they are much shyer (McCormack 2009).

2.2. Atiu

Atiu (fig.2) is an island found in the southern group of the Cook Islands, and is the third largest island after Rarotonga and Mangaia. It is one of the three main islands that make up the Ngaputoru island group, which includes Atiu (2693 ha), Mitiaro (2226 ha) and Ma'uke (1842 ha) (Simonett and Franklin 1989). The other island in this group is much smaller and uninhabited by humans is Takutea (12 ha) which is located 22km away from Atiu, and is maintained as a wildlife sanctuary due to the bird populations it supports. The three main islands are composed of central hills formed by weathered volcanic rock, surrounded by swampy depressions and elevated by limestone makatea (Simonett and Franklin 1989).

Figure 2. A satellite image of the island Atiu.

2.3. Vegetation and Avifauna

In the Ngaputoru island group of the Cook Islands many alien species are known to dominate in the volcanic soiled areas due to agricultural use, although a higher level of native species can be found in the makatea regions as they are unsuitable for cultivation (Franklin and Merlin 1992). Like with all the islands of the tropical Polynesia, Atiu has never been connected to any type of continental mainland, as it is a volcanic island (Simonett and Franklin 1989). This means that the native species on the island would have arrived by considerable long distance dispersal (Simonett and Franklin 1989). Atiu supports a mixture of native and non-native plant species such as the Pacific banyan (*Ficus prolixa*); which is almost extinct on Rarotonga, but common on Atiu and Mangaia, the endemic Ngaputoru pandanus (*Pandanus arapepe*); only found on Atiu and Ma'uke, and the invasive African tulip (*Spathodea campanulata*) which is a species that the IUCN have declared as one of the worst alien species in "100 of the World's Worst Invasive Species" (IUCN 2000). Species on this list are selected due to their harmful impact on biological diversity, but also their effect on human activities (IUCN 2000).

Atiu also goes by the ancient name of 'Enuamanu', which means 'Island of birds'. It supports a range of avian fauna, including the Atiu swiflet (*Aerodramus sawtelli)*, known as the 'Kopeka' to the locals, which is endemic to Atiu with an estimated population of only 400 individuals. This bird uses echolocation to find their way around in the caves where they roost but not to locate prey such as flying insects as echolocating bats would, and they spend their whole time outside of the caves flying; only landing within their cave nest or on the cave wall (Fullard *et al.* 1993). The Rarotongan flycatcher (*Pomarea dimidiata)*, also known as the 'Kakerori' is a bird that was introduced to Atiu, with the intention of preventing the extinction of this species, as its population on Rarotonga is entirely dependent on conservation effort. Another bird was introduced to Atiu only recently, which is the Rimitara lorikeet (*Vini kuhlii*), as it is endangered in French Polynesia. Examples of other birds that can be seen on Atiu include; the chattering kingfisher (*Todiramphus tuta)*, the Pacific pigeon (*Ducula pacifica*), and the Cook Islands fruit-dove (*Ptilinopus rarotongensis*).

2.4. Rimatara Lorikeet

In April 2007, twenty seven Rimatara lorikeets also known as the 'Kura' were reintroduced to Atiu by Birdlife International, the CINHT, the Te Ipukarea Society (TIS), plus several other conservation bodies (Birdlife International 2008). The Kura is a brightly coloured bird, and a nectarivore; usually found in and around coconut and banana plantations. Historically this species was distributed throughout many of the Southern Cook Islands, known due to fossil records, but numbers depleted as they were over harvested for their red feathers to be used for traditional ceremonial headdresses and clothing (McCormack 2006b). The Kura then became extinct from the Cook Islands as a result of this, and before its reintroduction to Atiu within its former natural range it survived on Rimatara in French Polynesia where it had a population of about 1000 birds. There is also a small population in Kiribati of anciently introduced birds. It is now listed as an endangered species on the IUCN Red List (Birdlife International 2008), and has been protected under CITES (appendix II) since 1981 (McCormack 2008). Atiu was chosen as it is one of the only populated islands in the Cook Islands that is free from the Ship

Rat (*Rattus rattus*), which are nest predators of eggs and nestlings. The island also has no other lorikeet species present to compete with and has similar vegetation to that of Rimatara; therefore it is an ideal island for this reserve population. The reintroduction was highly successful, as there is evidence of breeding due to youngsters being spotted by several locals on the island (McCormack 2008). However, two months after the reintroduction, four of these birds flew over to the nearby island of Miti`aro 50km away, although they are being monitored and have successfully taken to the island (Bartley 2009).

2.5. Invasive Species Management

One reason why Atiu is still free of invasive species such as the Ship Rat is because the community on the island is actively trying to prevent it from invading. On the islands where the Ship Rat is thriving, there is a distinct absence of any lorikeet species, such as on Rarotonga and Miti'aro. Pacific Rat (Rattus *exulans*) populations exist on islands including Aitutaki where the blue lorikeet (*Vini peruviana*) can also be found. This indicated that this rat species would not have an impact on the Kura once it was introduced. Unfortunately, the risk of the Ship Rat invading Atiu is increased due to the island depending on regular weekly shipments from Rarotonga, which provide essential supplies including fuel and food. Locals are encouraged to check any cargo arriving onto the island, report any rats' seen, but especially larger rats (as the Ship Rat is larger than the Pacific Rat), and also report any damaged coconuts as the type of hole made can indicate what type of animal made it. On both Rimatara and Atiu, a quarantine campaign was launched to help monitor and prevent the invasion of Ship Rats (Birdlife International 2008).

Even without the presence of the Ship Rat, there is some concern for the Kura on Atiu due to the existence of the common myna (*Acridotheres tristis*). A nest was found during the first annual census of the Kura, which was undertaken by the coordinator of the Rimatara lorikeet reintroduction programme, Gerald McCormack of the CINHT, in 2008 after the reintroduction onto Atiu. Two adult Kura were seen to be regularly visiting this nest due to them successfully rearing a young fledgling. At one time during observation when the adults were away the fledging was seen climbing onto the top of the nest, but was almost immediately attacked by two adult myna birds. The mynas then flew away, but as soon as the Kura fledgling recovered itself it was attacked by the same two birds, forcing the Kura fledgling to retreat into some dense cover close to the ground. As there were observers close by this prevented another attack by the myna birds, but would also prevent the fledgling calling its parents. Later on that day the observers gave the fledging more space and the parents returned, and an airgun was used to pursue the mynas. The next morning the parents were seen to be chasing away the two mynas and a fight occurred between them which then attracted another fifteen mynas to the area. The fighting continued between the Kura parents and the mynas, but also between the mynas themselves.

3. Study Species

3.1. The Common Myna

The common myna, also known as the Indian myna, is a member of the Sturnidae family, which is the myna and starling family. They are a medium sized bird at around 25cm in height, with brown plumage, black head, white wing and tail patches, and they have a bright yellow bill, legs and feet, and a mask from their beak going around their eyes. There is no sexual dimorphism between males and females in this species. They are highly social birds, and are strongly associated with human development (Tracy and Saunders 2003). They have a habitat preference for open, grassy woodland with hollow-bearing trees, (Pell and Tidemann 1997). Their colonisation is more common surrounding agricultural and human inhabited areas (Tracy and Saunders 2003), and they have stronger preferences to live close to humans as they appreciate food scraps and will even come into houses to steal food (McCormack 2009). They can colonise areas away from human settlements, although these populations occur in much lower densities (Tracy and Saunders 2003). In countries such as Australia, roosts have been found to contain an estimated 5000 individuals, although it is much more common for roosts to have around 40 to 80 birds occupying them (Tracy and Saunders 2003). Individuals will use the same family roost, and will only move away from them during breeding season to make their own nests to lay eggs and rear fledglings (Tracy and Saunders 2003). Movements away from their roosts during the day are only around 3km (Tracy and Saunders 2003). During the day they will usually forage in pairs or in small family groups, and rarely go very far from their own roost (Tracy and Saunders 2003). Late in the afternoon prior to returning to their roosts, the birds will gather into “pre-roost flocks” in open areas, or trees close to their roost (Tracy and Saunders 2003). Once this flock has moved into the roost this is the time when the birds are noisiest, as well as early in the morning before they begin to evacuate their roost. Their breeding season is from August to March in the Southern Hemisphere, and like with many starling species pairs they form monogamous pairs which defend their breeding territories during this time (Tracy and Saunders 2003). Each pair will raise 2 to 3 broods each season, and each brood usually has around 3 to 6 eggs. Their eggs are not unlike though of other starling species, except brighter blue and slightly larger (Tracy and Saunders 2003).

The common myna bird was introduced to the Cook Islands by the government, firstly to Rarotonga in 1906, then to the outer islands a few years later (McCormack 2005). Atiu saw the arrival of the myna bird in 1915, and colonies were released on Aitutaki and Ma'uke in 1916 (McCormack 2005). They were introduced with the intention to control the coconut-stick insect *(Graeffea crouani)* which was accidentally introduced to Rarotonga and the surrounding islands via ancient voyaging canoes (McCormack 2005). It became problematic due to their extreme abundance, and diet which is exclusively coconut palm leaves, causing devastation to crops (McCormack 2005). At the time there were no insect-eating bird species existing on any of the islands that could efficiently control the outbreak, and an introduction of the myna was feared because they were also known to feed on fruit crops (McCormack 2005). However, it was soon realized that if nothing was done about the stick-insects then there would be devastating effects (McCormack 2005). Once introduction occurred they were protected by the Government to ensure that they became established, and a fine was endorsed for anyone killing or injuring them as it would threaten their existence (McCormack 2005). Presently the myna is highly established throughout the Southern Cook Islands and is currently considered to be a pest itself.

The common myna is now known as one of the most widespread invasive species throughout the SPREP region. This is another invasive species which the IUCN have declared as one of the worst alien species in "100 of the World's Worst Invasive Species" (IUCN 2000). The common myna was originally native to India and south-east Asia, and is currently well established in a vast majority of the South Pacific Islands (Atkinson and Atkinson 2000), and Australia (Tidemann 2002). The species is well known for its ability to reduce biodiversity due to predation and competition with native birds and other wildlife, particularly birds that are hollow-nesting (Tidemann 2002). For example; during breeding season the Mangaia kingfisher (*Todiramphus ruficollaris)* use hollows to rear their young. They feed their fledglings by resting on the outside of the nest. This is a problem as this leaves them vulnerable to attack by the mynas, and it is estimated that the myna reduces the breeding success of this species of kingfisher by 20-30% (pers.com. G.McCormack). The Kura however will go into their nests to feed their young, therefore are less threatened by myna attack by using this method. They are also a problem for humans and are a general annoyance as they cause a significant level of damage to fruit such as bananas, mangoes and pawpaw which only ripen in a very short window of time, and other food such as chilies. They are also known to threaten chickens, and are commonly found in and around pig pens, especially when the pigs are being fed coconuts. In addition to this they spend their nights in communal roosts, which are extremely noisy due to the level of birds using them, and cause a lot of issues due to fouling where they are located (Tidemann 2002).

3.2. Eradication

A majority of people in the Cook Islands would like to see the common myna disappear (McCormack 2009). Due to the myna birds causing stress to the Kura on Atiu, especially during time of breeding, this has highlighted the need for the number of myna birds to be significantly reduced, with a possibility of eradication. The Critical Ecosystem Partnership Fund (CEPF) is providing the funding towards the protection of Atiu biodiversity, which includes the reduction of the myna birds. If this is successful then the project will move onto an eradication programme, as a means to assess the effect of the total removal of these birds on the island. This project will also tie into the continued success of the Kura reintroduction project.

For eradication project to be successful there needs to be proper planning, commitment, and the species will need to be prevented from re-invading (Clout and Veitch 2002). Even though invasive species cause more of an impact on islands, it is also easier to meet the necessary eradication conditions, although the most successful eradications on islands in the past have tended to be those of invasive mammals (Clout and Veitch 2002). The method of eradication is usually site specific, as methods that are practical in one area may be unsuitable in another. Myna birds were introduced to Australia in 1862 where they are also considered as a pest, and three eradication methods have been considered (Pell and Tidemann 1997, Tidemann 2002). Poisoning, which would be unsuitable as it is non-specific to the mynas, habitat modification, which causes problems as this requires the removal of trees which could be important roosting sites for various species, and fertility control, which is impractical and expensive (Tidemann 2002). From this it is clear that there is no quick fix with the eradication of this species, but it is being attempted never the less.

There are many examples of previous eradication attempts on islands and the results often depend on the type of species being targeted. There are very few examples with the eradication of birds on islands, but there has been a lot of success with the removal of rats. For example, in 1993 Pacific rats were eradicated from the island of Tiritiri Matangi, New Zealand. A study by Graham and Veitch (2002) compared the recorded bird numbers from three years before the eradication and three years after. The eradication caused a significant impact on the number of bird populations on the island, as there were both increases and decreases in bird numbers (Graham and Veitch 2002). Increased population sizes would be due to the absence of predation and competition for food, and decreased populations would be caused by changes in habitat disposition (Graham and Veitch 2002).

The myna control programme on Atiu is being coordinated and controlled by Gerald McCormack (CINHT), working through George Mateariki, better known as 'Birdman George'. George is a local celebrity on Atiu, who operates bird tours for visitors to the island, giving them information about the island and knowledge of the many bird species as well as other flora and fauna. He was also involved with the Kakerori recovery programme and the reintroduction of the Kura. With the help of George and his assistant Maara (employed with funding from the CEPF), Gerald makes the final decisions on the methodology used to kill the mynas, and the duration in which these are carried out.

For eradication to be successful there are three major steps that need to be taken. Firstly, the birds need to be located, then figure out what sort of procedures would be effective to reduce numbers, but also know how many there are to get rid of. The first two steps have already taken place in the following ways: - The birds were found with the involvement of the students of Enuamanu School. The students took part in locating the myna bird roosts all over the island by going out in groups in the evenings at the time when the birds returned to their roosts over a two week period. This was done in May 2009 with the help of Birdman George, teacher Bazza Ross, and Gerald McCormack. The school was awarded 25NZD per roost that was found, and the students raised a total of 900NZD by finding 36 roosts. For the second step Birdman George began poisoning the mynas in May 2009, using DRC1339 poison (a Stalicide), and a range of bait such as rice and coconut with the cream squeezed out due to it neutralizing the poison. As this is taking place on an island it is much easier to monitor, and as mynas have a preference for open spaces the poisoning sites can be well supervised to avoid other birds, such as chickens feeding on it. This has been a challenge as myna birds learn very quickly, although a numerous birds have been killed using this method. The locals on Atiu have also been involved in the control of the mynas, as there has been a bounty put on the birds. They are awarded 1NZD per bird or for every right foot, 2NZD per active nest found during breeding season. George and the land owner decide how to get rid of the nests found. The bounty is recorded by George, and the money awarded to each person/family monthly by Gerald. They have been encouraged to use chicken/foul traps as this is an effective method, or airguns provided by Gerald, under the management of George. The third step is the main of this investigation. Knowing how many birds there are on the island is important as this indicates how many there are that need to be got rid of. It is also essential to know in order to recognise how effective the eradication techniques are.

4. Aim

This project will assess the distribution and abundance of the common myna on Atiu. The purpose of this is to determine an approximate estimation of myna birds on the island as a starting count, as this is very important for the eradication process. The project will also highlight if there are any areas of the island that they have a preference to, which will be an advantage for finding appropriate site to poison at. This will develop an understanding of their ecology, which is useful to control populations or eradicate if possible.

Attempts to eradicate the myna birds from Atiu are currently being undertaken, although it is not yet clear how effective these methods will be. If the myna bird population can be reduced by 75%, then it is clear that the attempt to eradicate is effective, but if populations are only reduced by 10%, then attempts are ineffective and the project efforts should be abandoned. By finding an estimate of population numbers, the rate of decline can be monitored efficiently.

5. Methods

Poisoning began before data collection commenced (early May 2009). It is estimated that around 150 birds were killed prior to counts taking place. Data collection took place from late May until early July 2009. Two methods were used to estimate the result for the population size of myna birds, which are the following:

5.1. Roost counts

Using roost counts to estimate population size is a commonly used method, and it is known to be a relaible way to assess trends or fluctuations of a population (Cougill and Marsden 2004).

On Atiu the roosts were found using the information that the students of Enuamanu School collected. Two extra roost locations were provided by Birdman George, giving a total of 38 roosts on the island. Ten roosts were selected at random for the counts to take place (fig. 3). Each roost was repeatedly observed at sunrise (from 6.30am) as the birds were leaving their roosts, and also at sunset (from 5.30pm) as the birds were coming back to their roosts for the night. For each roost the maximum counted number was used, and an average number was found for all ten roosts. A standard deviation and standard error where then found for the average so that the total population range could be found. The average number is only a 50% estimate (approximately) of the total birds on the island. This is because with many of the roosts the detection rate was poor, as it was only possible to see one side of a roost due to only having one person observing and due to dense vegetation and/or inaccessible areas, and the birds were flying in from all directions. This method will only estimate the number of birds on the island, but not an indication of their abundance.

5.2. Transects

The transect method will estimate how many birds there are on the island in total, as well as their abundance indicating any preferences to areas on the island. Transects were walked along roads and forest paths all over the island. They were all walked at a moderate pace and repeated in the mornings at around 7.30am after roost counts, then in the afternoons from 3pm before evening roost counts, as this is when the myna birds are most active throughout the day. Birds that were seen or heard around the transect line up from 0 to 100 metres away (where possible) were counted, and categorised by their distance away from the road. Their distances where measured using a range finder.

The transects were put into different categories depending on the habitat type or area (fig. 4). These habitat types were found using a study by Simonette and Franklin 1989 (fig.5), which is an assessment of the habitat status based on land cover discovered by combining aerial photographs and habitat analysis using geographic information system (GIS), done on both Atiu and Mitiaro. A total of 23 different vegetation types were recorded on Atiu. As this study was completed in 1989, it is now out of date as much of the vegetation has changed. To solve this issue, the vegetation types were grouped to find to total coverage of four different areas to be used for this study. This includes the village (which is an area that is unchanged) at 37 ha, the coastal road area at 80 ha, horticultural inland at 512 ha, and makatea at 560 ha. The horticultural inland contains the largest proportion of land, which includes coconut plantations, remaining large cultivated fields (20% of fields from the 1989 study are remaining), Albizia (*Falcataria moluccana*) forest, and tree crops of secondary forest. The vegetation that was not included in this group is that which no longer exists, or are areas which are not suitable areas for the transects to take place. This includes; fern lands (which are now pine), the lake and swamps, riparian forest, the village (as this is grouped separately), secondary forest, and large cultivated fields (as they have reduced by an estimated 80%, now dominated by Acacia (*Acacia crassicarpa*)).

Using the population estimating programme Distance, the data from morning and evening replicates was inputted, along with each transect length, the habitat type and the total coverage area in hectares of the habitat that the relevant transects were in. The Distance programme then deduces how many birds there are per hectare of land, and the total number of birds of the four habitat types selected will give an estimation of the myna bird population size on the island. This method is essentially representing the population of the entire island as the rest of the islands habitats are those where only a few vagrants are present, such as in the makatea, swamplands and the dense secondary forest.

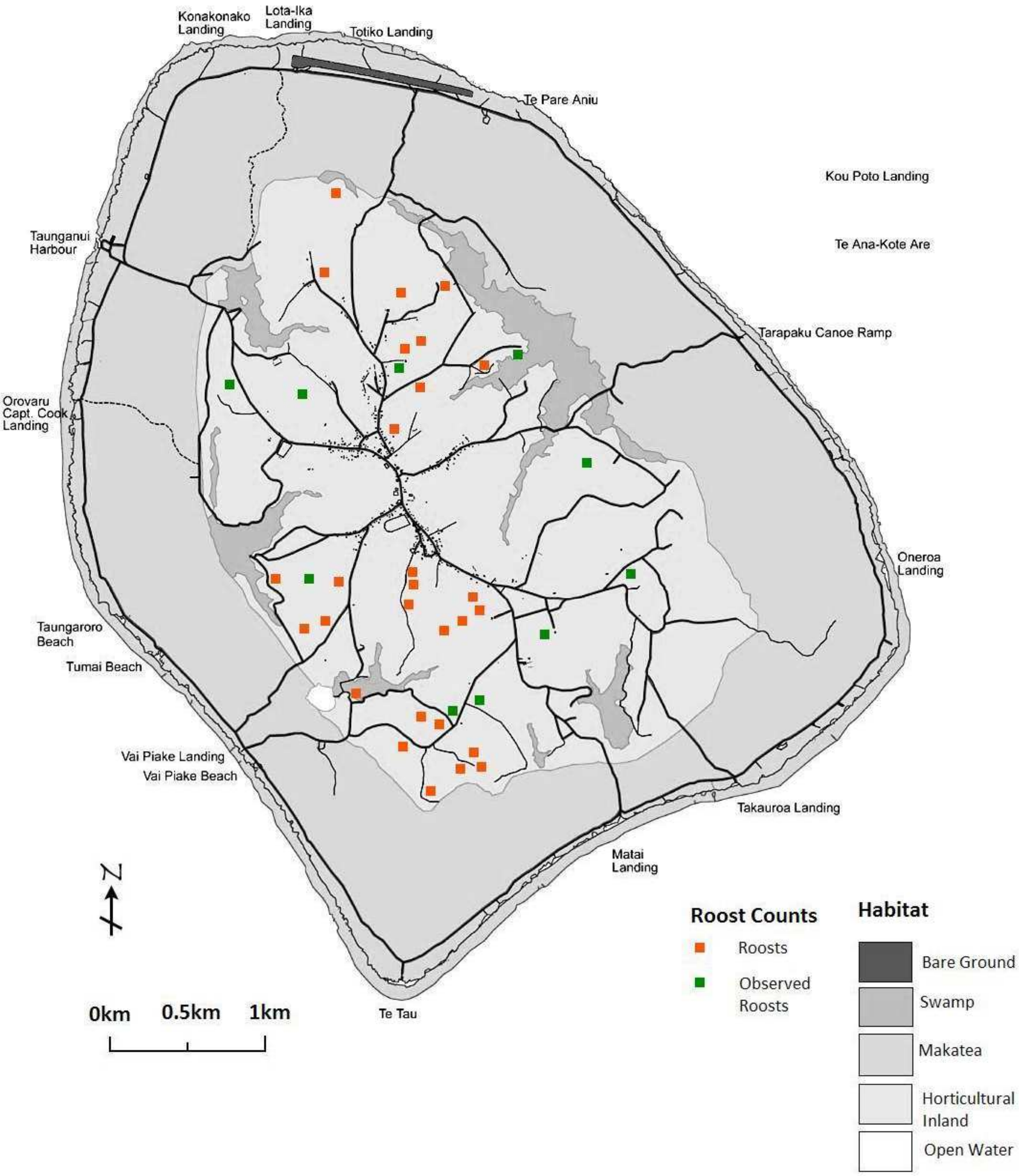

Figure 3. A map of the island Atiu, showing the distribution of Myna bird roosts found by the students of Enuamanu School. This map indicates the roosts that were observed for morning and evening roost counts.

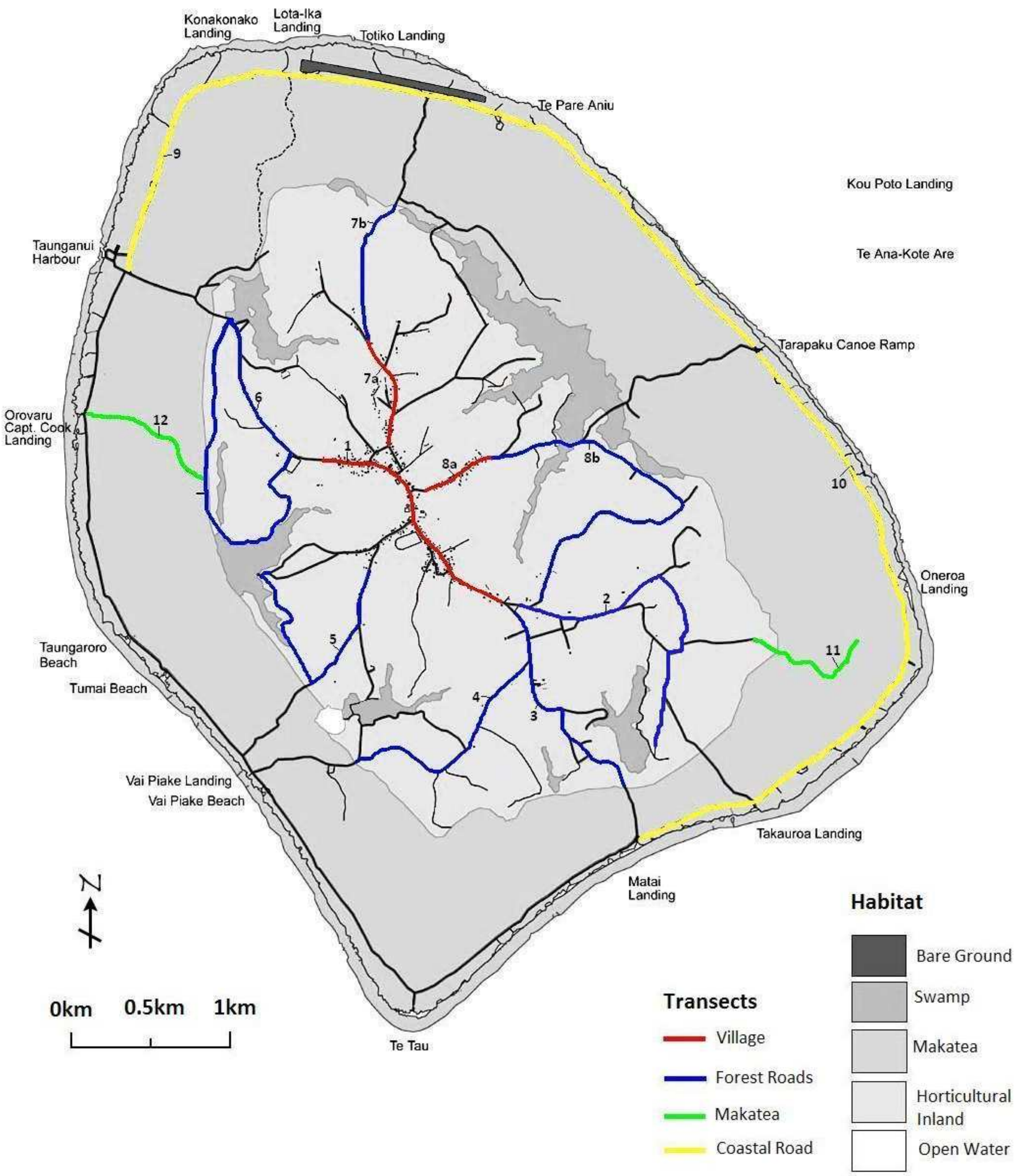

Figure 4. A map of Atiu, showing the locations where Myna bird counts were taken using a transect method. The numbers indicate the different transects, and results of these are shown in Appendix I. Transects are colour coded depending on the habitat type or areas that they occur in.

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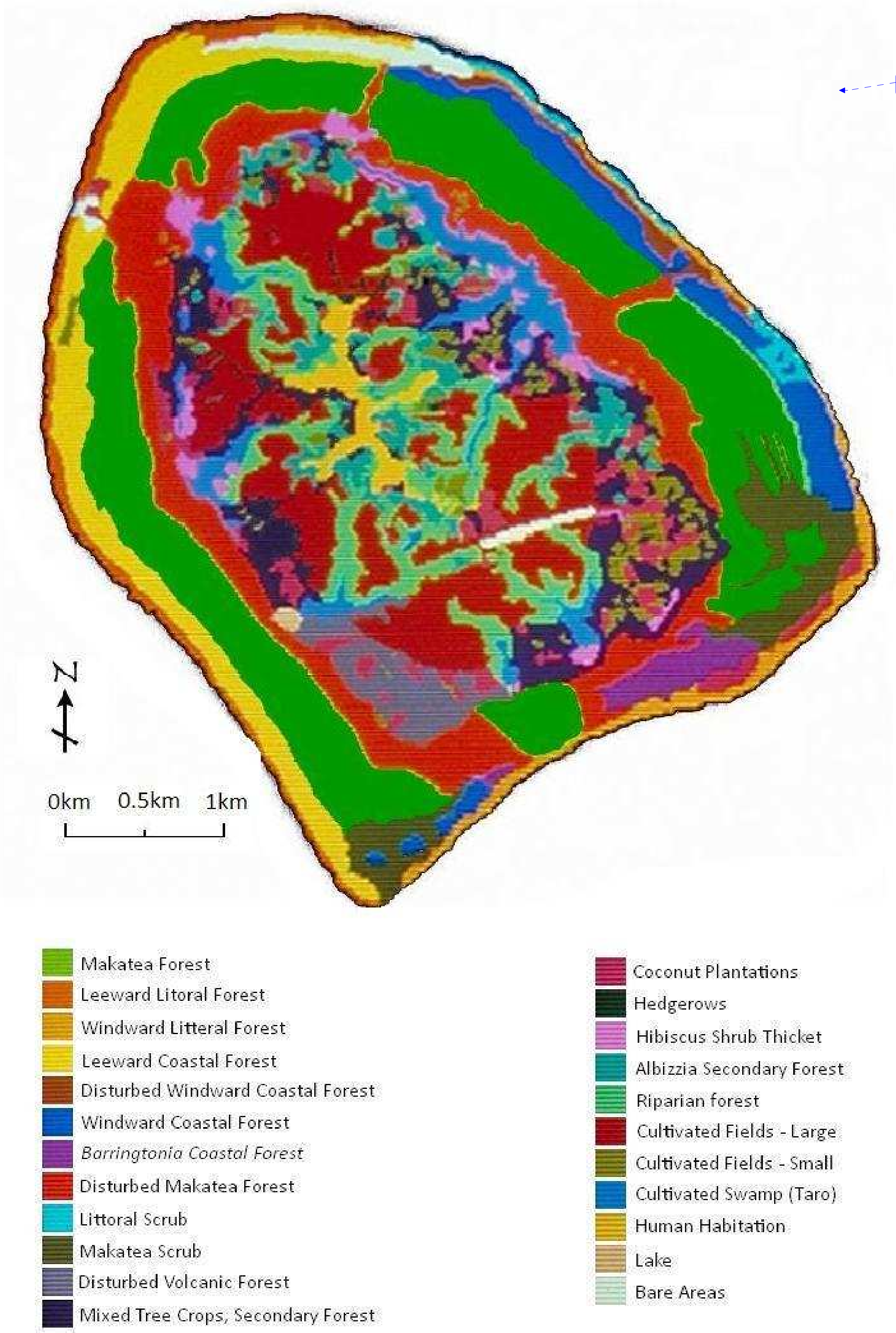

Figure 5. A land cover map of Atiu, from photointerpretation of 1985 air photos. Taken from Simonette and Franklin 1989.

6. Analysis and Results

6.1. Roost Counts

One of the roosts had a very poor detection rate due to dense trees obstructing the observation, therefore this outlier was not included in the data set and only 9 roosts were used in the analysis. The average number of birds per roost was found, and then multiplied by the number of roosts on the island. The assumption that it is a 50% detection rate is a major source of uncertainty. The standard deviation and standard error were found to give the upper and lower 95% confidence, giving the estimated range of the population size. The results are as follows:

Roosts	Highest count
1	53
2	39
3	85
4	36
5	81
6	162
7	73
8	218
9	74
Average	**91.22**

std dev	60.303
std error +/-	20.101
Average x no. roots	3466.44
Total (x 50%)	**6932.89**
Total +/-	1527.67
Upper 95% confidence	**8460.56**
Lower 95% confidence	**5405.21**

This shows that the estimated range of the myna population size is between 5405 and 8461 birds

6.2. Transects

The outputs from the Distance programme show the density of birds per hectare, the certainty range of this density, the population size per hectare and the certainty range for that population size in each habitat observed. The total is the estimated number of birds on the whole island. The results are as follows:

Habitat Type	Area (Ha)	Density (Ha^{-1})	Range (80% Certainty)	Population Size (per ha)	Range (80% Certainty)
Coastal Road	80	2.3	0.5-9.8	184	40-784
Village	37	26.6	17.7-39.9	984	655-1476
Horticultural Inland	512	6.5	5.0-8.5	3328	2560-4352
Makatea	988	0	0	0	0
Total				4496	3255-6612

4,934 +/- 1,680

rounded 5,000 range 3,500 to 6,500

7. Discussion

During data collection there were some visible trends in the distribution of the myna birds on the island. Firstly, there were no myna birds seen or heard during the two transects done in the makatea forest. This area consists of dense vegetation, and people rarely go into it as the fossilized coral is difficult to walk on. The only track at present that is used frequently is a path used for tourist walks to the Anatakitaki Caves, where the Kopeka can be found (southwest of the island), but there was still a distinct absence of myna birds. It was also noticed that the majority of birds seen during the transects was in the village area, which was expected due to it being known that myna birds have a preference to be around human settlements (Tracy and Saunders 2003). This is reflected in the transect results as this habitat type had the highest density of birds per hectare. This is advantageous for the project to reduce myna population numbers, as this indicates that they do prefer to be around people. If they had more of a preference for the dense forest this would make efforts much more complex due to access and difficulty with control methods and regulation. Another observation was that there seemed to be resurgences in some areas after poisoning occurred. This can be explained as the birds naturally move around the island at random, not always returned to the same place to feed every day (Tracey and Saunders 2003). Also if the populations are being successfully reduced this could possibly cause them to group together more when foraging. Another observation is that the mynas had actually begun to copy the Kura by mimicking their calls and by using the same technique that the Kura uses for feeding from the banana flower. This observation shows that there may be some competition between the myna birds and the Kura, as the mynas are now using their resources as well as what they already used since the Kura got introduced not so long ago. Myna species are known to be intelligent birds, and have the ability to imitate other species, which has been recently proved to be learnt not just from the repetition of a call or action (Foss 2006). This may be a contributing factor into the success of myna bird species.

With the two methods used, the results generally support each other as there is some overlap in the estimated range of the population size. The roost count method showed there to be a higher range than that of the transect method. The main issue with the results is that there is now way of knowing which one is the most accurate, therefore only a rough estimate can be made. By combining the results it can be concluded that there are between 3250 and 8460 myna birds on the island. It is known that roost counts are a reliable method for monitoring population sizes, as long as counting is done to detect the actual differences in roost size over a monitored time, and not the daily variation in roost size (Cougill and Marsden 2004). As the roost counts seemed to give a higher range, this suggests that the range is at the higher end of this estimation. This means that it is more probable that the actual population size of myna birds is around 6000 to 7000. This estimation gives a good starting count of the population size to be used to monitor the success or failure of the myna control programme. Further investigation will indicate what level the population has declined by due to the control programme, if at all. If the population size has only declined slightly, this shows that the programme is not every effective and should be abandoned.

One of the main issues with the removal of myna birds from Atiu, is that there may be some other unexpected impacts, especially as it has almost been a century since their introduction to the island. It may cause both negative and positive impacts on the existing flora and fauna due to changes in habitat disposition, and the reduction of competition that the mynas would have caused (Graham and Veitch 2002). The impact of eradication can vary greatly depending on the type of species that is being removed, whether it has replaced any native taxa or not and whether any other species could then replace it, or if other subordinate species to the one being removed would then become dominant in its absence (Zavaleta *et al.* 2001). As Atiu is an island there will be no risk of other new species replacing the myna. There is also no other aggressive invasive species on the island that could ever cause as much damage what the myna does now. The main concern would be the increase in the level of invertebrates, as this was the reason why the myna birds were introduced in the first place.

Poisoning will carry on by Birdman George; although the more that are killed the harder it will get to find them as they will become rare. If the control attempt is successful and the population is vastly decreased, the last few hundred birds may need to be hunted and killed. If these birds were left then the population would quickly recover and flourish once more.

7.1. Recommendations

To evaluate the success or failure of the myna bird control programme, it is necessary to follow up this investigation a year or two prior to when the control began (Wittenberg and Cock 2001). This should include the monitoring of any changes in the population size, the condition of the island such as the level of damage to vegetation (e.g. paw paw and bananas) caused by the mynas, but also from the likely increase in invertebrate populations which may have a negative impact on crops, and finally any changes in species disposition, with particular consideration to the Kura. This may involve a separate investigation into the Kura, for the impact of myna bird reduction and any changes in its population size. It is known that the Blue Lorikeet found on Aitutaki survives well in the presence of myna birds, but we do not know if this is the same for the Kura, therefore there may be some unexpected results.

8. Acknowledgments

I would like to thank Gerald McCormack for his supervision and help during my stay in the Cook Islands and for trusting me with this project, Birdman George for letting me work with him and for his help with my roost counts along with his assistant Maara. I would also like to thank the people on Atiu who make my stay very enjoyable and for their hospitality, especially Bazza Ross and Marshall Humphries for great food and for keeping me entertained. Also to the students of Enuamanu School for helping me with my data collection and for finding all the roosts on the island, and Sarah Green (a medical student from the University of Newcastle on placement) and Deborah Mantle (a fellow University of Leeds student also doing her project on Atiu) for their company, help and encouragement with our time spent on Atiu. My I would also like to thank Steve Compton and Chris Wright for their support and guidance as supervisors whilst back in the UK, and finally Reyna O'Higgins, Charlotte Rowley and Charlotte Bickler (a.k.a team Bragg) for their great company and encouragement whilst writing this project in the few weeks running up to the hand in.

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10. Appendix

10.1 Appendix I

Raw Roost Count Data

	No. of Observations			
Roost	**AM**		**PM**	
1	39	-	**53***	41
2	52	-	20	44
3	**39***	-	23	29
4	78	-	**85***	-
5	31	**36***	27	36
6	**76***	-	68	-
7	-	-	**162***	-
8	58	-	**73***	-
9	-	-	**218***	-
10	-	-	**74***	-

Only the highest roost counts were used from each roost to find an average number in the analysis. These are indicated by a '*' and coloured blue. The roost coloured in orange in the outlier that was not included in the investigation.

10.2 Appendix II

Raw Transect Data – showing data from each transect, from AM and PM observations

Transect: 1
Habitat type: Village
Length: 1.7km

	No. of Observations							
	AM						PM	
Distance from transect line (m)	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**
0-5	41	40	60	28	37	24	24	13
5-10	25	28	20	13	22	17	31	9
10-20	12	28	10	7	43	50	23	7
20-30	13	20	10	12	9	14	6	13
30-40	9	13	7	1	6	24	13	3
40-50	8	14	5	5	7	3	19	0
50-75	6	0	7	10	19	12	17	0
75-100	2	0	1	0	5	13	11	0
Total	**116**	**143**	**120**	**76**	**148**	**157**	**144**	**45**

Transect: 2
Habitat type: Horticultural Inland
Length: 2.3km

	No. of Observations					
	AM				PM	
Distance from transect line (m)	1	2	3	4	1	2
0-5	21	8	31	5	13	15
5-10	6	3	7	3	7	13
10-20	2	2	10	13	4	6
20-30	5	2	6	4	5	20
30-40	5	0	8	0	23	15
40-50	4	2	5	0	0	0
50-75	0	0	1	2	6	2
75-100	0	0	0	0	0	0
Total	**43**	**17**	**68**	**27**	**58**	**71**

Transect: 3
Habitat type: Horticultural Inland
Length: 1.7km

	No. of Observations					
	AM				PM	
Distance from transect line (m)	**1**	**2**	**3**	**4**	**1**	**2**
0-5	27	13	26	14	16	9
5-10	6	4	15	10	6	8
10-20	19	7	11	14	8	18
20-30	7	5	8	7	7	6
30-40	2	5	2	0	0	3
40-50	0	0	0	0	0	0
50-75	14	0	1	3	0	0
75-100	0	0	3	2	0	0
Total	**75**	**34**	**66**	**50**	**37**	**44**

Transect: 4
Habitat type: Horticultural Inland
Length: 1.6km

	No. of Observations					
	AM				PM	
Distance from transect line (m)	**1**	**2**	**3**	**4**	**1**	**2**
0-5	22	2	13	8	15	11
5-10	4	2	5	4	2	2
10-20	7	11	6	0	1	27
20-30	0	0	8	3	11	6
30-40	1	1	2	0	3	5
40-50	9	0	0	0	5	5
50-75	0	0	0	0	0	4
75-100	0	0	0	0	0	0
Total	**43**	**16**	**34**	**15**	**37**	**60**

Transect: 5
Habitat type: Horticultural Inland
Length: 2.0km

	No. of Observations					
	AM				PM	
Distance from transect line (m)	**1**	**2**	**3**	**4**	**1**	**2**
0-5	3	5	11	2	4	1
5-10	4	5	6	3	2	0
10-20	7	5	10	3	1	4
20-30	2	0	5	4	1	6
30-40	1	0	2	2	2	1
40-50	0	0	0	0	0	0
50-75	0	0	0	0	0	0
75-100	0	0	0	0	0	0
Total	**17**	**15**	**45**	**19**	**10**	**12**

Transect: 6
Habitat type: Horticultural Inland
Length: 2.8km

	No. of Observations			
	AM		PM	
Distance from transect line (m)	**1**	**2**	**1**	**2**
0-5	51	45	5	15
5-10	10	10	8	10
10-20	18	7	13	9
20-30	10	7	3	3
30-40	8	3	0	0
40-50	0	1	8	0
50-75	1	0	2	2
75-100	0	5	0	0
Total	**98**	**78**	**39**	**39**

Transect: 7a
Habitat type: Village
Length: 0.9km

	No. of Observations							
	AM				PM			
Distance from transect line (m)	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
0-5	4	1	8	2	5	8	6	7
5-10	3	0	24	13	2	20	42	14
10-20	9	11	19	6	15	9	1	35
20-30	20	5	2	9	8	8	0	10
30-40	8	0	5	18	2	4	1	3
40-50	0	3	2	11	2	4	3	6
50-75	0	0	1	0	5	0	0	1
75-100	0	0	4	0	2	0	0	0
Total	**44**	**20**	**65**	**59**	**41**	**53**	**53**	**76**

Transect 7b
Habitat type Horticultural Inland
Length 1.1km

	No. of Observations							
	AM				PM			
Distance from transect line (m)	**1**	**2**	**3**	**4**	**1**	**2**	3	4
0-5	16	15	13	3	6	2	1	4
5-10	7	2	4	2	0	1	0	1
10-20	11	6	12	7	12	5	0	0
20-30	2	9	7	5	7	3	2	2
30-40	0	2	2	5	2	2	2	3
40-50	1	0	0	0	2	0	0	0
50-75	1	0	0	0	0	0	0	0
75-100	0	0	0	0	0	0	0	0
Total	**38**	**34**	**38**	**22**	**29**	**13**	**5**	**10**

Transect: 8a
Habitat type: Village
Length: 0.6km

	No. of Observations		
	AM		PM
Distance from transect line (m)	**1**	**2**	**1**
0-5	8	9	1
5-10	9	3	0
10-20	9	14	0
20-30	9	8	0
30-40	2	10	0
40-50	0	9	0
50-75	0	0	0
75-100	0	0	0
Total	**37**	**53**	**1**

Transect: 8b
Habitat type: Horticultural Inland
Length: 3.1km

	No. of Observations		
	AM		PM
Distance from transect line (m)	**1**	**2**	**1**
0-5	21	16	8
5-10	7	18	3
10-20	9	7	8
20-30	0	3	7
30-40	3	0	4
40-50	0	0	0
50-75	0	0	0
75-100	0	0	0
Total	**40**	**44**	**30**

Transect: 9
Habitat type: Coastal Road
Length: 6.1

	No. of Observations		
	AM	PM	
Distance from transect line (m)	**1**	**1**	**2**
0-5	32	11	21
5-10	10	10	5
10-20	3	4	6
20-30	5	6	0
30-40	0	1	0
40-50	1	0	0
50-75	0	0	0
75-100	0	4	0
Total	**51**	**36**	**32**

Transect: 10
Habitat type: Coastal Road
Length: 4.9

	No. of Obs.
	PM
Distance from transect line (m)	**1**
0-5	17
5-10	1
10-20	3
20-30	3
30-40	0
40-50	0
50-75	0
75-100	0
Total	**24**

No birds were seen on the transects throughout the makatea (transects 11 and 12)