Division of Environment and Conservation
Ministry of Natural Resources and Environment

Managing myna birds (*Acridotheres fuscus* and *A. tristis*) in the Independent State of Samoa August, 2015

A plan prepared as one of the Management outputs of the GEF PAS project "Prevention, eradication and control of invasive alien species in the Pacific islands", funded by the Global Environment Facility (GEF), implemented by the United Nations Environment Programme (UNEP) and executed by Secretariat of the Pacific Regional Environment Programme (SPREP) in partnership with the Ministry of Natural Resources and Environment (MNRE).

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SUMMARY
This document builds on lessons learned from 10 years of DEC-MNRE action on the myna issue, training workshops on invasive species management, a 2015 myna population transect survey (conservative estimate of total population in Samoa between 129,407 and 188,583 birds), appropriate literature and experiences in Pacific and other countries. Recommendations are made on strategies and the priority information needed to implement those strategies.

Reducing the threat to the people and biodiversity of Malo Sa'oloto Tuto'atasi o Sāmoa from an ever-increasing population of myna (also mynah) birds (*Maina fanua* - Jungle myna (*Acridotheres fuscus*) and *Maina vao* – Common (also Indian) myna (*Acridotheres tristis*) will require implementation of all three strategies of invasive species management; prevention, eradication, control.

The success of these strategies will depend on the collection of essential information, the allocation of sufficient resources, the application of a range of treatment methods and the active participation of village communities. At least 1,775 to 2,580 mynas will need to be removed every week for one year just to stop the population increasing from current numbers.

Currently, the control method is application of toxic bait (DRC-1339 on buttered bread) along roadsides in response to villagers' complaints about mynas. This is not proving successful in reducing the myna population and may result in tolerance or resistance to the toxicant. It is also a danger to non-target species which feed alongside mynas.

For the future, eradication is the strategy that should be chosen for both the common myna and jungle myna on Savai`i. The myna population there (19,214 – 38,716 birds) is lower than on Upolu, the birds are still dispersing, the human population is low and communities want to be actively involved. Jungle mynas are the most common of the two species and they seem to be easier to trap.

A period of pre-feeding followed by toxic baiting will achieve initial knockdown. Reducing habitat suitability, reducing available food sources, nest and egg identification and destruction, roost site identification and disruption, trapping and shooting can be used to complete the project. Further work is required on trapping methods; especially use of large walk-in traps.

Adequate resourcing and logistical support will be essential for this effort as will the ability to carry out operations on both public and private property. To reduce costs and facilitate logistics, training for the eradication tasks could take place at a selected village on Upolu where a community wants to be actively involved.

Reinvasion from Upolu to Savai`i can be addressed by effective biosecurity. Measures will be necessary to prevent mynas leaving from Upolu on any form of public or private transport and landing on Savai`i and to ensure mynas do not use the motu of Manono, Apolima and Nu'ulopa in the Apolima Strait as resting areas in any flight from Upolu to Savai`i. Ongoing control measures at the western end of Upolu, and the port areas in particular, will be necessary to keep myna numbers down and reduce the pressure to leave for new territory.

The transect survey in May 2015 provided a combined estimate for Upolu of between 110,193 and 149,867 birds of both common myna and jungle myna, a very formidable number. Jungle myna is by far the most numerous of the two myna species on Upolu, 90,390 to 119,530, compared to 15,755 to 30,979 common myna.

Upolu has about four times as many mynas as Savai`i and they are more widely dispersed, as is the human population which is about three times greater than Savai`i. A long-term control operation may succeed in reducing the myna population if more birds can be culled than are fledged each year. But there are no reliable data on which to base an estimate of the rate of population increase of each myna species in Samoa and to use in calculating a culling rate.

Very little is certain knowledge in this project. Apart from lack of breeding and roosting information, insufficient rigorous work has been done on the interaction between common myna and jungle myna; although anecdotes abound. Jungle myna is reputed to always be first to take bait and to enter traps, while common mynas observe the outcome before taking any action. A reduction in numbers of jungle mynas may result in an increase in the common myna population as they take over jungle myna habitat.

It is concluded that eradicating mynas on Savai`i and undertaking long-term control of mynas on Upolu are strategies for managing these invasive birds in Samoa. The resources required for these projects will be significant in both monetary and labour terms. Careful planning and attention to detail will lead to successful projects, but only if the village and communities of Samoa are actively involved in the work.

The next steps will involve finalising a long-term workplan to fill in as many information gaps as possible, developing an operational plan for the work on Savai`i and Upolu and seeking funding for those operations.

1. Introduction

Myna (also Mynah) birds (*Acridotheres* spp., Sturnidae (Starling family)) have been targeted for management in Malo Sa'oloto Tuto'atasi o Sāmoa since 2004. They were recognised as a problem on oceanic islands about 250 years ago[1] and have become a nuisance at best and a serious pest at worst in several Pacific Island Countries and Territories[2]. The Government of Samoa has expressed the desire to remove myna birds from the country and has provided money to work towards that goal.

The Global Environment Facility Pacific Alliance for Sustainability (GEF-PAS) Invasive Alien Species project funded by the United Nations Environment Program and executed by SPREP was set up in 2011 to implement the regional Invasive Alien Species Strategy and the Guideline for Invasive Species Management in the Pacific. Under the Management Actions component, the need to determine realistic management goals and best management practices for myna species in Samoa and to write a management plan based on them was identified.

The purpose of this Management Plan is to take the lessons learned from the work of DEC-MNRE in Samoa and others working in the Pacific and around the world and outline a way forward for myna management on Samoa. Information from a training workshop in April 2015 (Annex 1), a transect survey completed in June, 2015 (Annex 2) and a roundtable discussion in August 2015 provided updated information for this document.

1.1 Species description

The two myna birds in Samoa (*Maina fanua* - Jungle myna (JM) (*Acridotheres fuscus*) and *Maina vao* - Common myna (CM) (*Acridotheres tristis*) are often misidentified in Pacific countries. CM have a yellow patch of skin around the eye and are larger than JM (23 to 26 cm long, weight 82 to 143g), have a medium to heavy build and a cocoa brown colour (the head, neck and upper breast of the adult is glossy black) with bright yellow bill, legs and feet.

Figure 1: Similarities and differences between common and jungle mynas. (Illustration: Chloë Talbot-Kelly. In; Watling, Dick. 1982. Birds of Fiji, Tonga and Samoa. Millwood Press, Wellington, New Zealand. Used with permission.)

[1] Etienne Stockland. 2014. Policing the oeconomy of nature: The *oiseau martin* as an instrument of oeconomic management in the eighteenth-century French maritime world. History and Technology: An International Journal.

[2] John Parkes, 2006. Feasibility Plan to Eradicate Common Mynas (*Acridotheres tristis*) from Mangaia Island, Cook Islands. Landcare Research Contract Report: LC0506/184.

JM have a distinctive tuft of feathers forming a small crest on the forehead and at the base of the bill and a yellow eye, but no yellow skin patch They are sleeker and smaller than CM (about 22 to 24cm long, 75% of the size of CM) with a black head with the upper areas being more grey-brown and the chin, breast and belly dark ashy-grey. It has a whitish underside, brownish wings and a typical yellow-orange beak[3]. However, these differences between JM and CM (Figure 1) are often difficult to recognise at a distance, even with binoculars. Gender and age differences are also difficult to determine.

1.2 Significance

JM were introduced to Samoa as biological control agents for ticks on cattle but rapidly dispersed and became troublesome[4]. There is no evidence that they were, or are, effective at controlling cattle ticks (D. Watling, pers. obs., 1975[5] or any other pest insect. Neither were mynas successful in controlling locusts on Reunion and Mauritius[6].

The reason for the introduction of CM to Samoa could not be determined. If it was not a deliberate introduction, the invasion pathway may well have been by vessel from Tutuila where they were established prior to being recorded in Samoa.

1.3 Status

Both JM and CM are recognised as invasive species in many Government documents (e.g. Samoa Environmental Outlook: Developing a vision for the next 50 years[7]), but are not gazetted as pest species. The National Biodiversity Strategy and Action Plan of Samoa[8] refers to assessing "*... the risks* [of mynas] *on native biodiversity* …" and Samoa's National Invasive Species Action Plan[9] describes a control programme.

2. Management Strategies, Goals and Options

Successful management of the myna problem in Samoa will require implementation of all three strategies of invasive species management; prevention, eradication, control. Adequate and long-term resourcing and logistical support will be essential for this effort as will the ability to carry out operations on both public and private property.

2.1 Past Distribution of mynas in Samoa

JM (*Acridotheres fuscus*) were first recorded on Upolu in 1965[10] and by 1988 were all over Upolu with only one bird recorded in Savai`i[11].

CM (*Acridotheres tristis*) were recorded on the eastern end of the Samoan archipelago (Tutuila) in 1980[12] but not in Samoa until 1988.

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[3] Manpreet K. Dhami, Bill Nagle. 2009. Review of the Biology and Ecology of the Common Myna (*Acridotheres tristis*) and some implications for management of this invasive species. Pacific Invasives Initiative, The University of Auckland, Tamaki Campus, Private Bag 92019, Auckland 1142, New Zealand

[4] Natasha Doherty, 2006. Information booklet for the "National Control of the myna" (*Acridotheres* spp.) MNRE.

[5] Dick Watling. 1975. Observations on the ecological separation of two introduced congeneric mynas (*Acridotheres*) in Fiji. Notornis 22, p47.

[6] Etienne Stockland. 2014. Policing the oeconomy of nature: The *oiseau martin* as an instrument of oeconomic management in the eighteenth-century French maritime world. History and Technology: An International Journal.

[7] MNRE. 2012a. Samoa Environmental Outlook: Developing a vision for the next 50 years.

[8] MNRE. 2012b. National Biodiversity Strategy and Action Plan of Samoa.

[9] MNRE. 2008. Samoa's National Invasive Species Action Plan.

[10] Green, R.H. 1965. Western Samoan bird notes. 'Elepaio 26: 19-21.

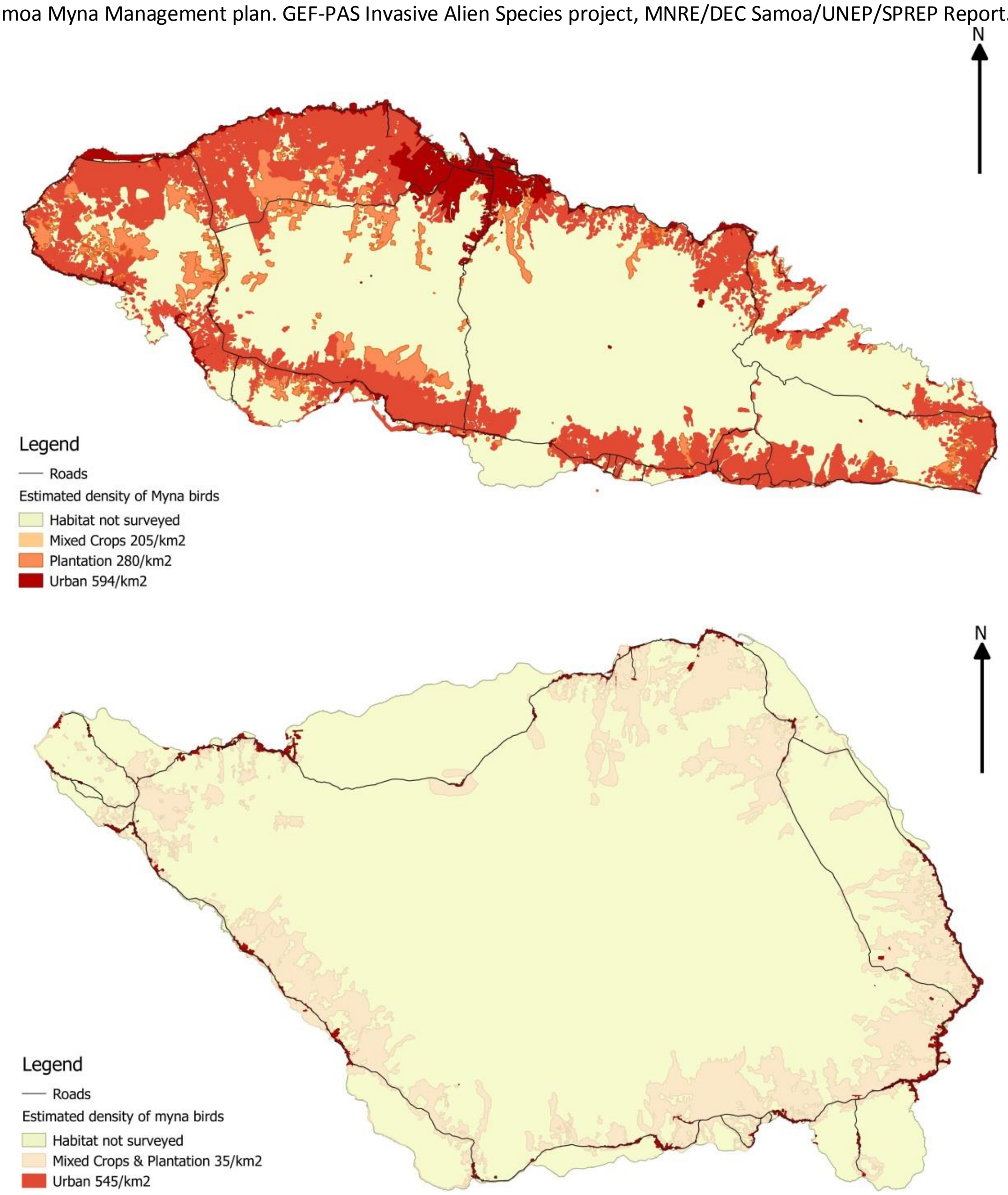
[11] Ulf Beichle, 1989. Common myna on Upolu: first record for the Western Samoa Islands. `Elepaio, 49:12.

2.2 Present Distribution of mynas in Samoa

A transect survey of three habitat types in Samoa (urban, plantations and mixed crops, 24.9% of total national territory) in May 2015[13] provided a population estimate of between 129,407 and 188,583 myna birds in Samoa (Savai`i - 19,214 to 38,716 birds; Upolu - 110,193 to 149,867 birds), a very formidable number.

The population estimate may be very conservative as not all possible myna habitat could be covered in the survey. If mynas were breeding, females may have been on nests at the time of the survey and would not have been counted.

Figure 2: The average myna population (common and jungle mynas) in habitats surveyed on Upolu (top) and Savai`i (lower) in May, 2015 (not to scale). (From: Stuart Young, Gianluca Serra. 2015. Myna survey. Report to inform the Samoa Myna Management plan. GEF-PAS Invasive Alien Species project, MNRE/DEC Samoa/UNEP/SPREP Report.)



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[12] Pepper W. Trail. 1994. Distribution and Status of Mynas in American Samoa. `Elepaio, 54:4. Hawai`i Audubon Society.

[13] Stuart Young, Gianluca Serra. 2015. Myna survey. Report to inform the Samoa Myna Management plan. GEF-PAS Invasive Alien Species project, MNRE/DEC Samoa/UNEP/SPREP Report.

Urban areas of northwest Upolu have the highest population density (Figure 2) and Savai`i has the lowest densities (Figure 2). JM are by far the most frequently seen myna and are more widespread than CM on both islands. Detailed information on current distribution is provided in the transect survey report (Annex 2).

2.3 Population Trends of mynas in Samoa

Myna numbers have increased dramatically since the first report in 1965 and the dispersal of JM has been summarised by others[14]. The CM population increased rapidly; counts on Upolu in 1991 and 1992 showed CM as 15% of all mynas and by 1998 that percentage had increased to 71% CM[15]. By 2004, CM was recorded on Savai`i[16].

The data collected during the May 2015 transect survey provides a baseline for future monitoring of population trends. It is probable that they have still not exploited all potential habitat and their populations may increase further. As the possible consequences of climate change are not at all clear, there may well be subtle effects on invasive, or native, species that could result in increased dispersal of invasives[17].

Mynas lay 2-4 eggs per clutch[18] and in some of their introduced habitat (Hawai`i, Australia, New Zealand) have a longer breeding season than in their native India and lay two clutches a year[19] or between 4 and 8 eggs a year. Fledging success for Samoa is not known.

It is thought that close to the equator (e.g. in Samoa, G. Serra, pers. comm., 2015; and Kiribati, R. Pierce, pers. comm., 2014) mynas breed all-year-round, but no detailed studies have been done and there is no indication of when moulting occurs. Watling[20] implied that, in Fiji, birds were not breeding from June to October. However, chicks were discovered in a nest in Apia in October, 2014 (J. Te`o, pers.comm., 2015).

Until accurate observations about breeding season and reproductive rate are available for Samoa (13° 50′ 0″ S), the rate of population increase can only be estimated from other places. An annual exponential rate of increase of 0.397 (or a finite rate of 1.487) for CM was calculated for Fregate Island (4° 35′ 0″ S) in the Indian Ocean which was similar to that calculated for Ascension Island (7° 56′ 0″ S) in the Atlantic Ocean[21].

If the above rate of increase holds true for Samoa, then up to 77,430 mynas will need to be culled each year to stop population growth. That is almost 1,500 birds a week. The DEC-

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[14] Brian J. Gill, T.G. Lovegrove, J.R. Hay. 1993. SHORT NOTE - More myna matters - notes on introduced passerines in Western Samoa. *Notornis* 40.)

[15] Brian J. Gill. 1999. SHORT NOTES: A myna increase - notes on introduced mynas (*Acridotheres*) and bulbuls (*Pycnonotus*) in Western Samoa. *Notornis* 46, p268

[16] Ian A. W. McAllan, D. Hobcroft. 2005. The further spread of introduced birds in Samoa. *Notornis 52(1)*: 16-20.

[17] Jessica H. Hellmann, J. E. Byers, B.G. Bierwagen, J.S. Dukes. 2008. Five potential consequences of climate change for invasive species. *Conservation Biology*, 22:3, 534-543.

[18] Dick Watling. 2001. A guide to the birds of Fiji and Western Polynesia. Environmental Consulants, Fiji. < http://pacificbirds.com/ >.

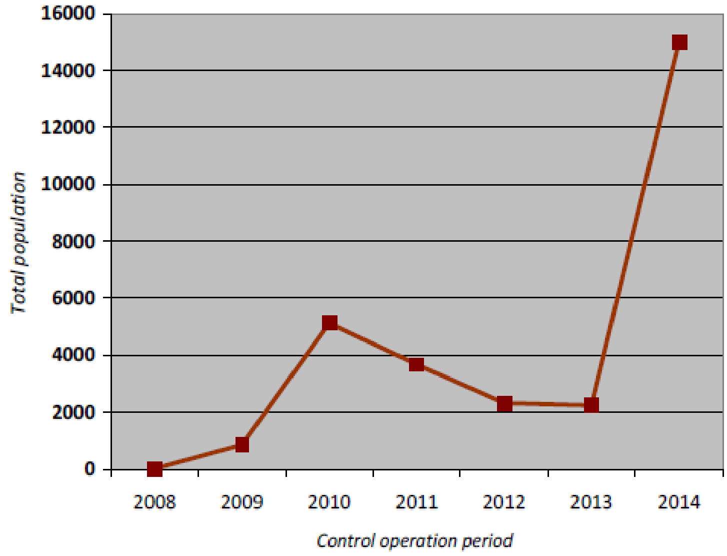
[19] Teresa M. Telecky. 1989. The breeding biology and mating system of the common myna (*Acridotheres* tristis). Ph.D. Thesis, University of Hawai`i.

[20] Dick Watling. 1975. Observations on the ecological separation of two introduced congeneric mynas (*Acridotheres*) in Fiji. *Notornis* 22, p47.

[21] John Parkes. 2012. Review of best practice management of common mynas (*Acridotheres tristis*) with case studies of previous attempts at eradication and control: a working document. Landcare Research Contract Report: LC 986.

MNRE myna team has reported results from 2008 to 2014 showing from less than 2,000 birds to a maximum of 15,000 birds a year (Figure 3) have been counted during bait application. The count is presented as 'kills', but the delayed action of DRC-1339 means that the count is indicative only as it is not recovered carcasses. Monitoring of birds at the baiting site before and after toxic bait application has not been done.

Figure 3: The number of myna birds counted during toxic bait application for each of seven years. (From DEC-MNRE[22])



3. Current management efforts

The myna management team of DEC-MNRE have been working to control mynas since 2004[23]. Those early attempts used Myna Magnet traps to trap birds, but these were not as successful as attempts in Australia where the same trap is used to control CM. Reasons for the lack of success include placement of traps in areas of human activity and lack of financial support for the program [24]. No period of pre-feeding was used in this trapping trial and interference from people and dogs may have been factors (S. Tupufia, pers. comm., 2006). Traps were given to communities, but information on their success is not available and the location of all traps is not known. More trapping was attempted in 2008 but only a few mynas were caught (C. Stowers, pers. comm., 2015).

The myna team was introduced to an avicide (Starlicide®, DRC-1339) in 2008 and ran a trial in three areas in March of 2009[25]. A 4-5 day period of pre-feeding to familiarise mynas with the baits (buttered pieces of bread, mashed ripe bananas, pawpaw) was followed by the application of the toxicant. Mynas preferred bread and pawpaw baits. Toxic baiting was done at three sites and 166 dead mynas were collected. Starlicide® does not act immediately and more mynas may have died away from the trial areas.

Another toxic baiting operation was conducted in June and July of that year[26]. No pre-feeding was done prior to application of the toxic bait. About 422 myna bodies were recovered during

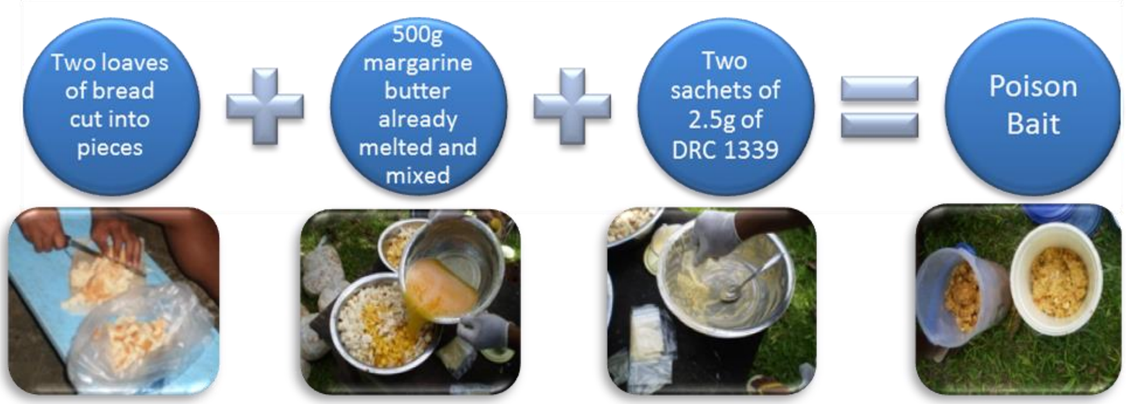
[22] DEC-MNRE. 2014. 13th Myna Bird Control Operation Report.
[23] MNRE. 2006. Proposal for Myna Eradication Campaign in Samoa.
[24].Samani C. Tupufia. 2005. Myna Bird Program Report. MNRE.
[25] MNRE. 2009. Myna Eradication Program. DRC-1339 Trial Report, March, 2009. Terrestrial Resources Conservation Section, Division of Environment and Conservation, MNRE.
[26] MNRE. 2009. Myna bird control project: First Chemical Baiting Operation Report; Apia Town Area, 22 June – 11 July 2009. Terrestrial Conservation Section, MNRE

the three-week operation. It is possible many more mynas died away from the baited areas, but bodies were not recovered.

Application of Starlicide® baits is continuing in response to complaints about mynas causing a nuisance. Current practice is to withhold toxic bait if people or other non-target species are in the same area as mynas.

It is not known whether the toxic baiting programme is successful in reducing the myna population. The limited resources available to the myna team mean that the monitoring that is essential to determine success is not done.

Figure 4: The process used by the DEC-MNRE myna team to prepare toxic bait for use in current myna management practices. (from: DEC-MNRE. 2013. 10th Myna Bird Control Operation Report)



4. Issues to consider concerning current management efforts

4.1 Reports of MNRE myna operations from 2009 to 2015 identify insufficient resources to sustain a prolonged effort as a major problem. In particular, lack of vehicles has limited operations to an average of less than two a year and lack of workers has meant that monitoring for success, documentation of breeding season and roost identification do not occur.

4.2 Non-target species are a serious constraint to toxic baiting. DRC-1339 (Starlicide®) is a poison and is dangerous in its concentrated form (powder). It is unlikely that DRC-1339 baits would affect people, dogs and pigs, but people are concerned about the use of 'chemicals' and the perception of danger and the negative reaction is real.

4.3 An issue of concern was that of non-target birds. As well as JM and CM taking bait, both invasive birds (Red-vented bulbuls (*Pycnonotus cafer*), Feral pigeon (*Columba liva*), Jungle fowl (*Gallus gallus*)) and native birds (Banded rails (Ve`a, *Gallirallus philippensis*), Cardinal honeyeaters (Segasegamau`u, *Myzomela cardinalis*), Samoan starlings (Fui`a, *Aplonis atrifusca*) and Polynesian trillers (Miti, *Lalage maculosa*)) were present.

Banded rails and Polynesian trillers were observed eating toxic bait and carcasses were found. Samoan and Polynesian starling (Mitivao, *Aplonis tabuensis*) are in the Sturnidae family with mynas and may be very susceptible to DRC-1339 but they have not been observed to feed on the ground with mynas.

4.4 The two concerns above mean that the myna team does not use baits in areas where non-target species are present so the operation is severely restricted. Trapping will be necessary.

4.5 There has not been enough rigorous work on the interaction between CM and JM; although anecdotes abound. JM is reputed to always be first to take bait and to enter traps, while CM observe the outcome before taking any action. A reduction in numbers of JM may result in an increase in the CM population as they take over JM habitat.

4.6 This interaction is further complicated by the presence of bulbul (*Pycnonotus cafer*), another invasive bird in Samoa. Again, little is known, other than anecdotally, about the behaviour of bulbul in the presence[27] or absence of mynas. If either, or both, JM and CM populations are reduced, this may result in an increase in the bulbul population and even more damage to food crops.

4.7 One of the useful qualities of DRC-1339 is that it does not kill immediately so, in theory, target species do not associate the bait with its result. This means, however, that the body count of mynas does not equal the number of birds seen taking the bait. The MNRE reports over 7 years give an average carcass count of 26% (n=4, range=0.5%-81%) of the birds seen eating baits. Few counts have been done at roosts, so the effectiveness of the programme cannot be resolved.

4.8 JM are only 75% of the size of CM and the lethal dose for each species of myna has not been determined. Although the literature is silent on tolerance or resistance to DRC-1339, continued exposure to sub-lethal doses may mean tolerance or resistance developing in mynas, making the only avicide available for mynas ineffective.

4.9 There may be registration and use restrictions with DRC-1339. It has only research registration in Samoa at present.

5. Long-term goals

With between 129,407 and 188,583 myna birds in Samoa, at least 2,489 to 3,627 mynas will need to be removed every week for one year. If breeding occurs, that number will be higher. Management methods must be used in ways that do not teach lessons to survivors. If this happens, any methods can quickly become ineffective. Common mynas are alert birds and learn quickly[28]. Jungle mynas seem to be less cautious, but there is little rigorous information available.

Very few myna management operations globally have been successful at removing all birds. A summary of efforts up to 2012 showed that success only occurs when mynas are in very low numbers or on very small islands[29]. Reports from areas where traps and shooting methods are used provide sad reading with small traps catching 10 birds/month, large traps 180 birds/month and shooting numbers quite variable.

The most recently reported myna eradication was on Denis Island, a 131 hectare private island in the Seychelles archipelago in the Indian Ocean[30]. Myna eradication began in 2010

[27] Jennifer H. Bates, Erica N. Spotswood, James C. Russell. 2014. Foraging behaviour and habitat partitioning in sympatric invasive birds in French Polynesia. *Notornis*, 2014, Vol. 61: 35-42.
[28] Andrea S. Griffin, Hayley M. Boyce. 2010. Indian mynahs, *Acridotheres tristis*, learn about dangerous places by observing the fate of others. *Animal Behaviour* 78 (2009) 79–84
[29] John Parkes. 2012. Review of best practice management of common mynas (*Acridotheres tristis*) with case studies of previous attempts at eradication and control: a working document. Landcare Research Contract Report: LC 986.
[30] < http://denisisland.com/blog/2015/07/27/conservation-update-eradication-of-envasive-mynah-birds/ >

and by July 2015 1,100 birds had been removed, 95% by trapping. An expert conservation hunter was brought in to shoot the 66 remaining myna birds on the island that had become trap-shy. A very informative video of that project was made[31].

5.1 Savai`i: eradication of myna species

Explanation: The myna population on Savai`i (19,214 – 38,716 birds) is lower than on Upolu, the birds are still dispersing, the human population is low and communities want to be actively involved. These factors mean that eradication is a realistic strategy and should be chosen for both the common myna and jungle myna on Savai`i.

Areas of largest myna populations should be targeted first to reduce natural increase. Timing should be before the breeding season commences as females may be on nests in remote areas during the breeding season. Monitoring before and after the operation is essential to determine success.

A period of days or weeks of pre-feeding followed by toxic baiting will achieve initial knockdown. Follow-up by the community can focus on reducing habitat suitability, reducing available food sources, nest and egg identification and destruction and roost site identification and disruption. Trapping and shooting by experienced people can be used to complete the project.

To reduce costs and facilitate logistics, training for the eradication tasks could take place at a selected village on Upolu where a community wants to be actively involved and a 'village champion' is prepared to take on responsibility for the work.

5.2 Upolu: long-term control

Explanation: The transect survey in May 2015 provided a combined estimate for Upolu of between 110,193 and 149,867 birds of both common myna and jungle myna, a very large number of birds. JM is by far the most numerous of the two myna species, 90,390 to 119,530, compared to 15,755 to 30,979 CM.

A long-term control operation may succeed in reducing the myna population if more birds can be culled than are fledged each year. But there are no reliable data on which to base an estimate of the rate of population increase of each myna species in Samoa. A conservative assumption of 30% of the population of mynas (both species) on Upolu (130,030 birds) being of breeding age and each pair fledging two chicks a year, means 39,000 juvenile birds need to be culled each year (750/week) to stop the population from increasing. That is more than the entire myna population on Savai`i and would require significant resources. If 40% of birds are breeding and each pair fledges three chicks, then 78,000 juvenile birds would need to be culled each year (1,500/week) to stop the population from increasing.

Upolu has about four times as many mynas as Savai`i and they are more widely dispersed, as is the human population which is about three times greater than Savai`i. If the communities of Upolu could be motivated to focus on reducing habitat suitability (Figure 5), reducing available food sources (this includes municipal food sources such as the Taifagata Landfill, Figure 6), nest and egg identification and destruction and roost site identification and disruption, the rate of increase would slow down. The myna team could concentrate on strategic use of DRC-1399 baits and trapping and shooting operations.

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[31] < https://www.youtube.com/watch?v=MFAXJDyWIBs >

5.3 Biosecurity

JM was intentionally introduced to Samoa, but the invasion pathway for CM is not clear. The eastern islands of the Samoan archipelago had CM prior to Samoa, but Fiji and Hawai`i are also possible sources. They could all be sources of reinvasion.

Keeping Savai`i myna-free after the eradication will rely on effective biosecurity. Particular attention will need to be paid to any form of direct travel between American Samoa and Savai`i. There is probably benefit to myna teams in both Samoa and American Samoa in keeping in close contact with each other.

Measures will be necessary to prevent mynas leaving from Upolu on any form of public or private transport and landing on Savai`i and also to ensure mynas do not use the motu of Manono, Apolima and Nu'ulopa in the Apolima Strait as resting areas on any flight from Upolu to Savai`i. Ongoing control measures (no food available, trapping, disruption) at the western end of Upolu, and the port areas in particular, will be necessary to keep myna numbers down and reduce the pressure for mynas to leave for new territory.

6. Options for management

6.1. Initial knockdown:

6.1.1 a period of pre-feeding followed by application of toxic bait may be successful. However, operations against CM on islands in the Atlantic Ocean lead to a conclusion that DRC-1339 may not be effective as a control agent[32]. Questions included bait aversion, individual bird susceptibility and competition between birds. The situation in Samoa is further complicated by the presence of both JM and CM and bulbul and more work is required to refine the solution.

6.2 Follow-up:

6.2.1 trapping has been used to reduce populations in several countries with some success. The MynaMagnet traps do not appear to be as successful as some. Several designs of traps have been used with the “PeeGees” trap being the most effective on the east coast of Australia. Some areas of Australia are investigating walk-in, aviary-style traps for areas where the myna numbers are high[33].
The use of decoy birds greatly improves the success of trapping.

6.2.2 shooting by professionals who are trained in myna behaviour has reduced numbers in some areas[34], but a continuous effort is required.

6.2.3 Nest-box traps and fishing line nooses on nests have also been used elsewhere.

6.3 Ongoing disruption of myna behaviour:

6.3.1 reducing feeding habitat suitability by leaving grass on open areas to grow long (figure 5) has deterred mynas in places[35].

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[32] Chris J. Feare, 2010. The use of Starlicide® in preliminary trials to control invasive common myna (*Acridotheres tristis*) populations on St Helena and Ascension islands, Atlantic Ocean. Conservation Evidence (2010) 7, 52-61.
[33] Tamworth Regional Council. 2009. Tamworth versus Starlings and Mynas.
[34] Conservation International Pacific Islands Program. 2011. Enhance the breeding capacity of the reintroduced Rimatara Lorikeet (*Vini kuhlii*) by reducing harassment by Common Myna (*Acridotheres tristis*). Biodiversity Conservation Lessons Learned Technical Series 10: Conservation International, Apia, Samoa.
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6.3.2 reducing available food sources, at both small-scale and large-scale, is essential. It is difficult to protect all crops from mynas but food scraps that are not fed to pigs should be buried. Pigs, dogs and other pets should be fed in containers that are myna-proof.

Figure 5: Myna birds showing a preference for short grass at the Mini Golf field at Tuanaimato. (Photo: DEC-MNRE, 2015)

6.3.3 In particular, thought needs to be given to eliminating and excluding mynas from landfills (Figure 6), waste treatment plants and any other municipal or large-scale sources of food.

Figure 6: Mynas feeding at Taifagata Landfill, a major attraction for them. (Photo: DEC-MNRE, 2012)

6.3.4 nest and egg identification and destruction can help reduce population growth. Mynas will nest in buildings as well as palms, bamboo groves, and trees. Communities, especially children, should be alert to nesting behaviour.

6.3.5 roost site identification and disruption may be critical to the success of any project. Mynas do not always stay at the same roost and move from one to another and, during the breeding season, usually only the male is in the roost while the female is on the nest, but disturbing roosting behaviour should be part of the management effort.

7. Monitoring

Monitoring is essential to determine the ongoing progress and success of any management method and the total project effort. The baseline information provided by the May 2015 transect survey can be used to determine progress on a yearly basis by repeating the survey of the transect lines in the three habitat types. Point counts at key places before and after implementation of a management method can also provide useful information.

If a community wants to be actively involved, a 'village champion' could be trained to take on responsibility for monitoring.

8. Objectives and Workplan for 2015-17

The following information is required and a primary objective for a Workplan for the next 12 months could be to collect the information so that a detailed Operational Plan can be prepared by 2017.

ACTION	WHEN	WHO	COMMENT
8.1 Breeding season: When are mynas breeding? Do they follow the seasonal pattern(s) of native birds? Are brood patches obvious on females?	Sep 2015-Aug 2016		Some of this information may be contained in internal reports
8.2 Rate of population increase: How many times a year does a pair lay eggs? How many eggs are laid each time? How many chicks fledge from each clutch of eggs?	Sep 2015-Aug 2016		Some of this information may be contained in internal reports
8.3 Moulting season: When are birds moulting? Do they show any unusual behaviour during the moulting time?	Sep 2015-Aug 2016		Trapped/dead birds can be used. See moulting charts in Training Report (Annex 1).
8.4 Times of hardship Is there any time of the year that food is short for mynas?	Sep 2015-Aug 2016		Agriculture may have harvest records for most crops.
8.5 Roost sites Compass bearings of large groups of birds arriving, or leaving, major feeding sites, e.g. Taifagata Landfill, should be mapped and these flight paths can be plotted on a map to help identify roost sites.	Sep 2015-Aug 2016 (outside of known breeding season)		Some of this information may be contained in internal reports. Schools or communities could help with identifying roost sites.
8.6 Trapping Further work is required on trapping	Sep 2015-Aug 2016		A collapsible, easy-to-move aviary trap

ACTION	WHEN	WHO	COMMENT
methods; in particular use of large, walk-in traps. The best type of trap (PeeGees, aviary-style, etc.) for village use should be determined and a suitable trapping protocol worked out with community members.			should be investigated.
8.7 Community engagement Is there a village community that wants to put in the follow-up work required to remove their mynas? DEC-MNRE could supply the training and apply the initial knockdown toxic bait.	Sep 2015-Aug 2016		Will need a committed village champion to facilitate this.
8.8 Alternative bait(s) Investigate the feasibility of using rice instead of bread as the carrier for DRC-1339. Smaller particles (grains vs chunks) mean birds should eat a lethal dose rather than fly away with it.	Sep 2015-Aug 2016		Compare purchase costs, labour requirements and effectiveness of bread versus rice.
8.9 DRC-1339 feeding trials How much toxin/bait does it take to kill a jungle myna? Less than a common myna?	Sep 2015-Aug 2016		Will require a cage-feeding trial.
8.10 Reducing feeding habitat Mow grass at different heights to see what height keeps mynas away but is still acceptable for maintenance. Observation of unmowed areas will indicate a good height.	Sep 2015-Aug 2016		Mynas will not feed in grass that is too long.
8.11 Sharing lessons learned American Samoa is also working on myna management.	Sep 2015-Aug 2016		There should be advantage in sharing information
8.12 Develop costing for eradication on Savai`i and long-term control on Upolu.	Sep 2015-Aug 2016		Use costs of previous operations to develop baseline budget.
8.12 Incorporate myna management into Climate Change mitigation and resilience programmes and use for funding applications.			Could be part of a broader integration of invasive species management into Climate Change mitigation and resilience programmes.
8.13 Incorporate the above into an Operational Plan as information becomes available.	Sep 2015-Aug 2017		

CONCLUSIONS

Eradicating mynas on Savai`i and undertaking long-term control of mynas on Upolu are strategies for managing these invasive birds in Samoa. Preparation of this management plan has shown that there are significant information gaps which need to be filled before detailed operational planning can begin.

The resources required for these projects will be significant in both monetary and labour terms. Careful planning and attention to detail will lead to successful projects, but only if the village and communities of Samoa are actively involved in the work.

Note: This plan is a living document and should be updated as information becomes available.

ACKNOWLEDGEMENTS

This work was completed under contract to MNRE through funds from the GEF-PAS Invasive Alien Species Project. Many thanks to: Lesaisaea Niualuga Evaimalo and the DEC-MNRE myna team (Czarina Stowers, Moeumu Uili, Fa`afou Leaupepe, Joe Te`o) for sharing their insights and experience; Taupau Maturo Paniani who assisted with MNRE administration and liaison; Gianluca Serra (SPREP) without whose efforts this work (both the transect survey and this Management Plan) would not have happened; Stuart Young who, as a volunteer, organised, led, analysed and interpreted the myna transect survey; and all my friends in Samoa who happily shared information.

ANNEX 1

Report of a

Myna Management Training Workshop

DEC-MNRE, Vailima, Samoa

20-22 April, 2015

Placing assembled myna traps in the field. (Photo: DEC-MNRE)

Report prepared by:
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NEW ZEALAND
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Myna Management Training Workshop, 20-22April, 2015
DEC-MNRE, Vailima, Samoa

INTRODUCTION

The Division of Environment and Conservation of the Ministry of Natural Resources and Environment of the Government of Samoa (DEC-MNRE) is implementing a project as part of the Global Environment Facility - Pacific Alliance for Sustainability (GEF-PAS) Invasive Alien Species project funded by the United Nations Environment Program and executed by SPREP. The project identifies the need to determine realistic management goals and best management practices for myna species in Samoa and use them to write a management plan.

The three-day workshop delivered training on how to use the biology and ecology of the two myna species (*Acridotheres fuscus* and *A. tristis*) in Samoa to develop best management practices and how to map the distribution and abundance of the myna populations. The content was prepared in earlier discussions with DEC-MNRE and SPREP and finalised in interviews with the DEC-MNRE team and SPREP on 16 and 17 April.

The workshop was interactive and used the field experience of the DEC-MNRE Myna Management Team and the specialist knowledge of the instructors to summarise current knowledge and skills and identify any information gaps and training necessary to implement the next stages of the myna project. Workshop attendance information is in Appendix 1.

The topics covered, activities used and findings discussed during the workshop are presented below in Table 1. The schedule for the training is in Appendix 2. The workshop received a very favourable evaluation from participants (see below) although it was stated that three days was not enough for a training course such as this.

Joe Te`o delivering the DEC-MNRE presentation on myna bird work to date. (Photo: DEC-MNRE)

Table 1: Summary of workshop topics, activities practiced and resulting discussion.

Focus	**Activities**	**Summary of workshop discoveries**
Background to project	Discussion and flip charts DEC-MNRE presentation	• origin of project • invasion history • work to date • the future
Myna biology	2, 4, flip chart Presentation Group work Flip charts Discussion Group plenary	• two species common and jungle • jungle myna has a crest while common myna does not • eyes are very different between the two species • jungle myna is darker, common myna is brownish-grey • jungle myna has more orange beak • both species can often be seen feeding and roosting together • mostly seen in pairs or small groups • probably breeding 2-3 times a year - Jan/Feb, June/July, Sep/Oct • wet season probably best breeding season • nesting and breeding can occur on trees, mainly coconut, on house and building roofs (common myna at least) • nests are very simple and can be made of sticks/down/mangrove flowers/plastic • not sure about species differences in breeding activities or success • little is known about moulting • roost sites can be on coconut/ficus/togo vao (*Ardisia* spp)
Myna behaviour	Group work Flip charts Discussion	• birds are visible at 6-8am and 5-6pm • birds are usually seen near people or settlements • also seen on cattle, along roadsides, near homes • mostly see jungle myna, not common myna • common myna walks upright, always alert • jungle myna usually has head down • jungle myna will take bait first • jungle myna will also enter trap first. • mynas consume household food • fly 20m above the ground • birds are smart, brave and confident but very wary and alert • they can escape trap/cages • cats and dogs can't catch them • mix with native birds on the ground • friendly behaviour with some native species; Tulī (*Pluvialis fulva*), Ve`a (*Gallirallus philippensis*) • aggressive to Se`u (*Rhipidura nebulosa*), Miti (*Lalage maculosa*) and Segasegamau'u (*Myzomela cardinalis*) • mynas visit Faatoia with feral pigeons

Focus	Activities	Summary of workshop discoveries
		• disrupt and damage breeding sites for native birds • affect plantations/primary resources (especially banana, pawpaw) • forage about 2km a day (their resident territory or home range) • birds feed until 10 or 11 am
Areas of interest	Group work Flip charts Discussion	• birds consume rubbish materials, eg at landfills • birds drink water at sludge ponds • feeding places: farm/cattle/agriculture, rubbish dumps (municipal and village) • plantations: pawpaw, banana, mango, avocado • may feed and spread weed plants, eg panama rubber tree • roost sites: Moamoa, Tuanaimato, Apia Park, Maluafou College • presence/absence of mynas on Manono and Apolima Islands needs to be confirmed
Myna management	Check, repair and set up Tideman myna traps Presentation Discussion Flip charts	• there is political and community support for managing the myna population • more people are aware of mynas and are asking for help • the number of mynas has increased since 2004 survey • most common treatment method used is toxic bait (bread with Starlicide) • attempted to eradicate a roost at Tuanaimato during SIDS conference • traps do not catch birds in Samoa but do in other countries • 40 traps were purchased, 8 are currently serviceable • pre-feeding is not used. Toxic bait is applied to roadsides from the back of a moving vehicle. • birds can be caught in mist nets at landfill • no other methods (nest destruction, nest boxes, breeding disruption, aviaries) have been tried • a 20c/bird bounty did not work • counts are made of birds coming in to take toxic bait, but no pre-application counts are made • few dead birds are found • roost sites are not usually known • success of toxic baiting programme is not known • rice should be considered as an alternative bait (currently bread is used) if costs and time are saved

Focus	Activities	Summary of workshop discoveries
		• need a monitoring protocol to determine success or failure • dates of crop fruiting would help decide the best time for action • there are non-target issues, but the team is aware of them and tries to avoid baiting when non-targets are present NOTE: Agriculture want birds to remain as they are believed to control ticks on cattle. There is no evidence provided.
Monitoring	Presentation Estimating height Estimating distance Measurements Counts Calculating averages from more than one measurement or count Identifying bird species	• need for baseline information as a reference point • difference between estimates and measurements or counts • need for repetition to get accurate data • essential for estimates or counts before and after treatments – to know whether they worked or not
Estimating populations	Presentation Sampling (rope and stones) Estimates Counts Observations at Moamoa roost site Observations at Taifagata landfill Observations from back of utility vehicle at Taifagata sludge ponds	• estimates of total myna population in Samoa • estimates of the percentage of birds that need to be removed each year to stop the population increasing • bird identification • distance measurement must be perpendicular to road (angle of view from observer) • transects • point counts • survey team = driver + 2 observers + 2 recorders • data sheets will be prepared before survey begins
Analysing the data	Discussion	• 'Distance' computer software will be used to provide analysis
Interpreting and using the data	Discussion	• survey data will be used to identify the best areas and sequences for management action • this will allow a concentrated effort in the areas where the greatest change can be made
What's next?	Trial planning discussion	• trial should investigate cage traps as follow-up to toxic baiting • sludge ponds appear to be the best place for a trial • permissions and notification need to be arranged • interference from people, dogs, weather, etc., needs to be minimised • equipment/materials need to be prepared • scheduling is to be confirmed

RECOMMENDATIONS FROM THE TRAINING WORKSHOP:

1) More information is essential to determine the myna bird breeding and moulting seasons.
ACTION: When community people ring up to complain, the myna team to record whether birds are nesting, have eggs, or have chicks. Also record date and place. (Note: *some data already exist and can be analysed*).
ACTION: Myna team to look for and record brood patches on any birds found after operations.
ACTION: Myna team to assess a sample of birds found for stage of moult using moult chart (Appendix 3). A data sheet for recording this information will be provided separately.
ACTION: MNRE should ask Agriculture to provide fruiting times for crops that myna prefer.

2) More practice is required for estimating distance, identifying species and counting/estimating and recording number of birds.
ACTION: Myna team to arrange to have more practice opportunities.

3) Myna flight paths from major feeding sites, eg Taifagata Landfill, should be mapped.
ACTION: Myna team should take compass bearings of large groups of birds arriving, or leaving, feeding sites. These directions can be plotted on a map and used to help identify roost sites.

4) Roost sites should be identified and mapped.
ACTION: MNRE to engage schools/communities in identifying roost sites. Perhaps a bounty could be paid for each verified roost?

5) Agriculture Ministry wants birds to remain as they are believed to control ticks on cattle.
ACTION: Agriculture to provide evidence that mynas are effective control agents for cattle ticks.

6) Broken/damaged Tideman traps should be repaired if possible (inventory of traps is in Appendix 4).
ACTION: Myna team to repair as many traps as possible to working order.

7) Rice should be considered as a bait alternative to bread.
ACTION: Myna team to compare budgets to see whether costs and time can be saved by using rice instead of bread as bait.

8) More work is necessary to develop trapping knowledge and skills.
ACTION: Consultant to work with DEC-MNRE and SPREP to develop trial of trapping options.

EVALUATION

Participants decided on the positive and negative aspects of the course during a group discussion when the instructors absented themselves from the room. Participant’s comments are in Appendix 5.

Participants discuss a survey strategy at the Taifagata Landfill site. (Photo: DEC-MNRE)

APPENDIX 1
Attendance at Myna Management Training Workshop

FirstName	LastName	Division	Position	20/04	21/04	22/04
Czarina	Iese-Stowers	DEC	Senior Terrestrial Biodiversity Conservation Officer		y	y
David	Moverley	SPREP	Invasive Species Advisor	y	y	y
Faafou	Leaupepe	DEC	Terrestrial Biodiversity Conservation Officer	y	y	y
Fini	Male	DEC	Casual worker	y	y	y
Joe	Te'o	DEC	Terrestrial Biodiversity Conservation Officer	y	y	y
Josef	Pisi	DEC	Senior National Parks &Reserves Officer	y	y	y
Kim	Keleti	DEC	Casual worker	y	y	y
Lesaisaea Niualuga	Evaimalo	DEC	Principal Terrestrial Biodiversity Conservation Officer	y		y
Moeumu	Uili	DEC	Senior National Parks &Reserves Officer	y	y	y
Posa	Skelton	SPREP	PILN	y		
Taupau Maturo	Paniani	DEC	Invasive Species Coordinator	y	y	
Taveuni	Malolo	DEC	National Parks & Reserves Officer	y	y	y
Vaatele	Anoifale	DEC	Casual worker	y		
Instructors:						
Bill	Nagle	Consultancy	Consultant	y	y	y
Gianluca	Serra	SPREP	GEF-PAS Coordinator	y	y	y
Stuart	Young	SPREP	Volunteer	y	y	y

APPENDIX 2

DRAFT timetable: Myna Management Training Workshop

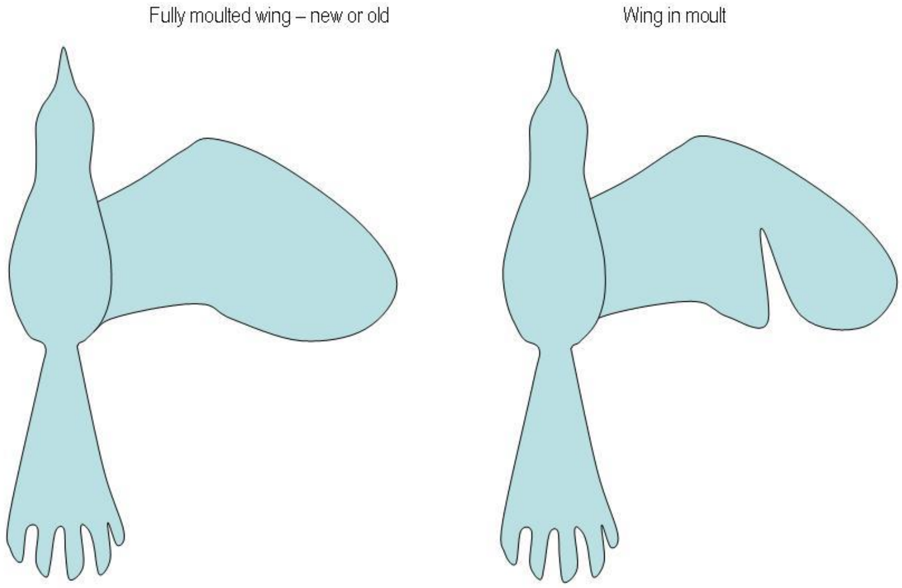
Mon 20	**Focus**	**Topics**	**Method**	**Leader**
0830	Introductions, etc	Relationship to mynas		Maturo
0900	Background to project	Genesis, work to date, GEF-PAS,	Discussion and flip charts	Niualuga Bill
0930	Myna biology 1	Personal observations What do we know? What do we need to know	2, 4, flip chart Group plenary	Bill
1030	**Break**			Maturo
1045	Myna biology 2	Species Breeding Moulting	Slideshow	Bill
1130	Myna behaviour	Species Foraging and other behaviours		
1200	Areas of interest	Rubbish dumps (municipal and village), roost sites, no-go areas	Discussion	Bill
1230	**Break**			Maturo
1330	Myna management 1	What has been tried already? What worked; why and how do we know? What was not successful; why not?	Discussion and flip charts	Bill
1500	**Break**			Maturo
1515	Myna management 2	Management methods • Pre-feeding • Trapping • Toxic bait • Other methods (mist nets, nest destruction, nest boxes, breeding disruption, aviaries) Myna behaviour Food sources/phenology Monitoring Non-target issues Political/social/funding issues	Discussion and flip charts	Bill
1630	**Finish**			Bill

Tues 21	**Focus**	**Topics**	**Method**	**Leader**
0830	Monday recap			Bill
0845	Myna management 3	Methods recap • Pre-feeding		Bill

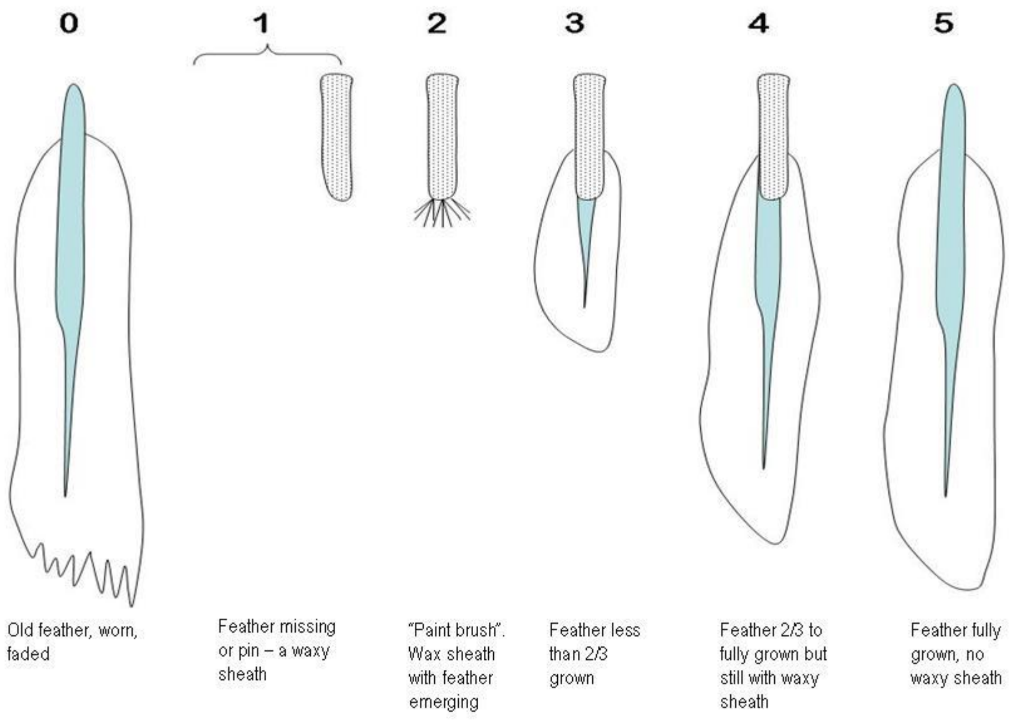
Tues 21	Focus	Topics	Method	Leader
		• Trapping • Toxic bait • Other methods (mist nets, nest destruction, nest boxes, breeding disruption, aviaries) monitoring program to assess efficacy of management, trial planning		
0945	Monitoring 1	Baselines Counts and estimates Repetition		Bill
1030	**Break**			Maturo
1045	Monitoring 2	Before and after treatments – how do we know they worked?		Bill
1200	**Break**			Maturo
1300	Estimating populations 1	Permissions Notification Interference Point counts Transects Counts or estimates		Stuart & Gianluca
1400	Interpreting the data	Confounding		Stuart & Gianluca
1500	Break			Maturo
1515	Estimating populations 2	Demonstrations • Count • Survey estimate		Stuart & Gianluca
1630	**Finish**			Stuart & Gianluca

Wed 22	Focus	Topics	Method	Leader
0830	Tuesday recap			Bill
0845	Estimating poulations 3	Field survey practice		Stuart & Gianluca
1045	**Break**			Maturo
1100	Analysing the data			Stuart & Gianluca
1200	**Break**			Maturo
1300	Using the data			Stuart & Gianluca
1500	**Break**			Maturo
1515	What's next?	Trial planning Equipment/materials Scheduling		
1630	**Finish**			

APPENDIX 3
Wing in moult and moult scoring



Moult scoring



APPENDIX 4
Inventory of Tideman traps stored at Vailima

Item	Colour	No. Good	No. Faulty
Bottoms	brown	9	0
Tops	green	8	0
Lids	green	7	0
Doors	brown	8	4
Funnels	brown	16	9
Valves	green/silver	17	4
Perches1	green	9	0
Perches2	brown	20	1
Food tray	green	13	0
Water dish	green	20	2

Appendix 5
Evaluation comments from participants at Myna Management Training Workshop

What worked well?
Understood the characters and features of myna birds
Learnt more skills on how to trap myna birds based on Samoa's perspective/surrounding
Activities and exercises were logical and easy to follow
Know how to set up the Tideman traps as they are very new to most participants
Field visits (landfill and roost at Moamoa) were relevant especially the new survey/count method practiced today (22/4/15)
Estimating the distance of myna birds was very important and very good practice

What was not so good?
Not enough participants
Three days was not long enough

What else is needed?
More practice on transect method
More training days, three days is not enough
Energiser
More funds
New management method apart from what we have implemented already

Common Myna

Jungle Myna

2015 MYNA SURVEY

Report to inform the Samoan Myna Management Plan

Stuart Young and Gianluca Serra

GEF-PAS INVASIVES PROJECT
MNRE/DEC, SPREP, UNEP

SPREP
Secretariat of the Pacific Regional Environment Programme

ABSTRACT

In May 2015, 74 line transects in three different habitat types (plantation, mixed crops, urban) were surveyed on Upolu and Savai'i islands, Samoa, with an aim of estimating the population size, density and distribution of two invasive bird species, Common Myna (*Acridotheres tristis*) and Jungle Myna (*Acridotheres fuscus*). Based on the available literature, the surveyed habitats were identified as preferred foraging habitat for the two myna species. The three habitats make up 24.9% of Samoa's land area.

Survey data were analysed using the Distance program. It was estimated that the population of myna birds occurring in the plantation, mixed crops and urban habitats of Samoa is approximately 158,995 (+- 29,588). Approximately 130,030 (+- 19,837) myna were estimated to live on Upolu and 28,968 (+- 9,751) on Savai'i, across the three habitat types. Survey results also revealed that both species show a significant preference for urban habitat.

In addition to Upolu being the initial point of introduction of both species, it is likely that this island has the higher population of myna birds as there is more urban habitat available (the preferred habitat type).

Jungle Myna were estimated to be the most numerous (population estimate: 133,925 +- 24,321), occurring on both islands and in all surveyed habitat types. Jungle Myna seem to have saturated the urban habitat available in Upolu and therefore have proceeded to colonise plantations and mixed crops adjacent to urban areas.

Common Myna (population estimate: 23,367 +- 7,612), having reached the shores of Samoa ca. 20 years later than Jungle Myna, show highest density in urban environments. They are concentrated in the north-west section of Upolu, with only a few individuals observed on the east coast of Savai'i.

Introduction

Jungle Myna (*Acridotheres fuscus*) and Common Myna (*Acridotheres tristis*) were introduced into Samoa between the 1960s and the 1980s, possibly as an attempt to control livestock insect pests, i.e. ticks and fleas (Doherty, 2006; Esera, 2012). Common Myna are known to eat a wide variety of insects (Sengupta, 1976) and in India, their native country, there is some evidence that they control agricultural crop insect pests (Kirk, Evenden, & Mineau, 1996). However, there is no evidence that they feed on cattle ticks or fleas.

There are many reasons to be concerned about the spread of Jungle Myna and Common Myna. Other than their potential effect on the insect biodiversity of Samoa, they may become severe agricultural pests, with the potential to reduce Samoa's agricultural exports. When insects are scarce, fruit and seeds make up a more important component of their diet and at such times, Common Myna can impact on agricultural production (Martin, 1996). Sixty years after their introduction to New Zealand, Common Myna have switched their diet preference from insects to fruit (Sengupta, 1976), causing agricultural crop losses (Dawson & Bull, 1970).

Mynas have also been implicated in the spread of invasive alien plants in some parts of the world, by acting as seed dispersal agents e.g. Lantana vines in Hawaii (Pimentel, Zuniga, & Morrison, 2005). In addition, mynas can potentially contribute to the spread of parasites e.g. the mite *Ornithonyssus bursa*, which can cause dermatitis in humans (Central Coast Indian

Myna Action Group Inc, 2003) and disease e.g. avian malaria *Plasmodium circumflexum* (C. Feare & Craig, 1998), especially in areas where mynas congregate in close proximity to humans, such as communal roost sites (Peacock, Rensburg, & Robertson, 2007).

In countries where myna birds have become established they have quickly become a pest species, posing a serious threat to biodiversity (Grarock, Tidemann, Wood, & Lindenmayer, 2012; S. Lowe, Browne, Boudjelas, & De Poorter, 2004; Pell & Tidemann, 1997; Tidemann, n.d.); spreading invasive plants (Doherty, 2006); damaging fruit crops (Dawson & Bull, 1970) and acting as an annoyance to people (ABC, 2014; Central Coast Indian Myna Action Group Inc, 2003; Tidemann, n.d.).

The Jungle Myna was introduced to Apia, Samoa, in the early 1960s. It remained localised around Apia township until 1979 (Dhondt, 1976). Between 1979 and 1989 it spread rapidly around Upolu (Child, 1979; Gill, Lovegrove, & Hay, 1993; Reed, 1980) and colonised south-east Savai'i sometime after 1984 (Bellingham & Davis, 1988; Reed, 1980).

During July 1986 Jungle Myna were first noted in American Samoa, possibly introduced by boat from Samoa (Engbring & Ramsey, 1989). By 1993 Jungle Myna were considered well established in Samoa (Evans, Fletcher, Loader, & Rooksby, 1992; Trail, 1994), and by 1998 they were scattered around Savai'i and common in most inhabited areas of Upolu (Gill, 1999). In 2004 the Jungle Myna was found throughout most of the northern, eastern and south-eastern parts of Savai'i (McAllan & Hobcroft, 2005).

The first record of Common Myna in Samoa is from 1988 (Beichle, 1989). It is possible they arrived by boat from American Samoa, as an individual was first sighted in Pago Pago Bay, Tutuila in 1980 (Potter, 1981). By 1992 the Common Myna was established in Apia (Evans et al., 1992) but still relatively uncommon compared to the number of Jungle Myna (Trail, 1994). Up until 1999 the Common Myna was still restricted to suburban Apia (Gill, 1999).

By 2004 Common Myna had spread from Apia township to form a continuous population from at least Afega in the west, to Vailele in the east, and south to Vailima (i.e. the north-western coastal sector surrounding Apia). Outlying populations were also observed at Laulii in the east and at Faleolo International Airport, and a population was found established on Savai'i, from Siufaga south to Fatausi, in an area centred on Tuasivi (McAllan & Hobcroft, 2005).

Common Myna and Jungle Myna have been introduced to and become pests in many South Pacific countries (Gill et al., 1993). Several countries have attempted eradication or control efforts; most without monitoring programs to assess the effectiveness of control (Copsey & Parkes, 2013; Manpreet & Nagle, 2009; Nagle, 2006; Parkes & Lattimore, 2006).

Samoa's Ministry for Natural Resources and Environment (MNRE) began to manage the myna bird population in Samoa in 2004 through the use of traps (Doherty, 2006); then in 2008 the Samoan cabinet authorised the use of poison baits (Copsey & Parkes, 2013; Esera, 2012).

Over a 4 year period (2008-2012) MNRE estimated a 100% increase in the number of myna birds across Upolu and Savai'i (Esera, 2012), but the method used for establishing population estimates is unknown. Since the introduction of myna control programs by MNRE no standardised monitoring system has been put in place to assess if the programs are having an impact on myna population size, density and distribution.

As part of a regional GEF-PAS Invasive Project (MNRE/UNEP/SPREP) a survey was conducted in May 2015 to establish baseline data for myna population size, density and distribution across the three most preferred foraging habitats on Upolu and Savai'i, to support the preparation of Samoa's first Myna Management Plan.

Aims

The survey aimed to:

1. estimate the population size, density and distribution of myna birds within three specific habitat types (urban, plantations and mixed crops) on the two main islands of Samoa, Savai'i and Upolu, to provide baseline data for use in the Samoan Myna Management Plan; and
2. establish standardised monitoring methods to support future population monitoring efforts.

Methods

Habitat types

A literature review suggested that myna birds in general and in Samoa, prefer disturbed habitats and urban environments (Evans et al., 1992; Manpreet & Nagle, 2009; Tidemann, 2005). In addition, previous bird surveys in Samoa did not record any myna species in forested areas (Evans et al., 1992; SPREP, 2012). Therefore, to maximise survey effort and to make good use of limited funds and time, three habitat types most likely to be regularly used by myna birds were selected for the transect surveys: mixed crops, plantation and urban habitats.

The three habitats make up 24.9% of the total surface area of Samoa. These habitat types were identified using a GIS habitat layer compiled as part of the FAO Technical Co-operation Programme (FAO, 2005). Table 1 provides a definition of each habitat type from the SamFRIS classification system (FAO, 2005).

Table 1. Description of habitat types (adapted from SamFRIS classification descriptions).

Main Category	*Description*
Plantation	Permanent agricultural installations, mostly tree crops or continued / repeated planting of crops such as coconuts or banana.
Mixed Crops	Land currently and recently cultivated with a mixture of herbaceous and tree crops such as root crops, taro, yam, cassava, breadfruit etc. This includes areas of current cropping and adjacent areas recently abandoned and now overgrown with secondary shrub and tree species.
Urban	All settlement areas, encompassing continuous developments, industrial or commercial built-up areas, scattered isolated houses, gardens, inner-city parks. All roads (hard surfaced or loose) and infrastructure related facilities (e.g. airports / airstrips, ports, wharves, sports compounds etc.)

Using QGIS the coverage area of each habitat type was determined in square kilometres (km^2) for Upolu and Savai'i (**Error! Reference source not found.**). The number of transects surveyed in each habitat type was proportional to its area of coverage.

Table 2. Area of each habitat type by island and the number of transects within each habitat type.

	Area (km^2)		*Number of transects*	
Habitat	*Upolu*	*Savai'i*	*Upolu*	*Savai'i*
Mixed Crops	77.7	24.83	9	3
Plantation	269.83	263.67	25	25
Urban	59	18.15	8	4
Total	406.53	306.65	42	32

Surveys

Several methods to estimate population were considered: counts at landfill sites, roost counts and transect surveys. As there is only one designated landfill site on Upolu and one on Savai'i, it was decided that counts at landfill sites would not provide a good estimate of the total population. Roost counts were considered to be impractical at this stage due to the time it would take to locate enough active roosts. Transect surveys, within the myna foraging habitats, were selected as they allow for a large area to be quickly surveyed and can provide robust population estimates and a basis for ongoing monitoring.

Using Distance and QGIS (QGIS Development Team, 2015) software a random stratified grid design was used to establish 74 x 1 km long survey transects proportionally distributed across the three selected habitat types (plantation, mixed crops, urban) (**Error! Reference source not found.Error! Reference source not found.**) on the two main islands of Samoa, Upolu (Map 1) and Savai'i (Map 2). Forty two transects were surveyed on Upolu and 32 on Savai'i.

From preliminary eradication trials on St Helena and Ascension islands there is some evidence that Common Myna forage within 3 km of their communal roots (C. J. Feare, 2010). In Samoa, positioning transects at least 3 km apart would reduce the total number of transects to a non-statistically viable level. As such, it was decided that 2 km would be the minimum distance between transects to minimize possible double-counting of birds and obtain a statistically robust number of samples.

Transect surveys were undertaken during May 2015. All transects (Maps 1 and 2) were located along roads (Maps 3 and 4) and were surveyed from a 4WD utility vehicle, which was driven at an average speed of 5.5 km/hour. Two survey teams were in the vehicle; each team comprised an observer and a scribe. One team surveyed the left side of the road and the other surveyed the right side. The same observers were used for all transects and stayed on their respective sides of the vehicle to maintain consistency. The observers and scribes were staff from MNRE/DEC whom were in-service trained in myna bird surveying.

Transect surveys commenced each morning 10 minutes after sunrise, to allow the myna birds time to disperse from their roost sites, and continued for 2.5 hours. Afternoon surveys commenced 3 hours before sunset and continued for 2 hours. Survey times were based on the periods of the day when myna birds are most active and visible. On average 3-4 transects were surveyed during each morning / afternoon period.

All myna birds seen on the ground or perched, were counted. Their perpendicular distance from the vehicle (i.e. perpendicular distance from the transect line) was estimated in metres. Practise with MNRE/DEC staff/observers in estimating distances was carried out prior to the surveying. Where possible, myna birds were recorded to species level, otherwise just to genus. This information was recorded on a data sheet (Annex 1) and later entered into Excel.

Data analysis

Bird survey data were entered into the population estimating programme Distance, along with transect length, habitat type and total coverage area (km^2) of each surveyed habitat.

Outputs from the Distance programme show the myna population size for both islands, with a standard error (SE) and 95% confidence intervals, and the density of birds per square kilometre, with a standard error (SE) and 95% confidence intervals. The data from each island were analysed separately and where possible the density per habitat type and/or by myna species was also estimated. Myna bird density was calculated by the Distance programme by dividing the estimate of population size (n. of birds) by the area of habitat surveyed (km^2).

Standard error bars were used to indicate the accuracy of the population estimates. Standard error is a statistical term that measures the accuracy with which a sample represents a population. In statistics, a sample mean deviates (is different) from the actual mean of a population; this deviation is the standard error. The smaller the standard error, the more representative the sample will be of the overall population. The standard error is also inversely proportional to the sample size; i.e. the larger the sample size, the smaller the standard error because the statistic will approach the actual value (McDonald, 2014).

To allow for more detailed analysis the island of Upolu was further divided up into two sections: the north west (highly urbanized) and the rest of Upolu (less urbanized, comparable to Savai'i) (Table 3), with approximately even representation of transects and habitat types in each section.

In some instances there were insufficient records of myna birds in each habitat for Distance to make a reasonable density estimate. In these cases the data was pooled across habitat types and analysed to obtain a reasonable density estimate.

Table 3. Area of each habitat by section on Upolu and the number of transects in each section.

	Area (km^2)		*Number of Transects*	
Habitat	*NW Upolu*	*Rest of Upolu*	*NW Upolu*	*Rest of Upolu*
Mixed Crops	35.23	42.46	4	5
Plantations	114.66	155.23	12	13
Urban	44.05	13.96	5	3
Total	193.94	211.66	21	21

While commuting between transects and other locations, any myna birds that could be positively identified to species level were recorded. A GPS location was taken where the bird(s) were sighted and a note was made about the number of individuals.

The preference of myna birds for one of the three foraging habitats was assessed by comparing the habitat availability to the relative occurrence of myna birds in each habitat.

Habitat availability is derived by comparing the proportion of a surveyed habitat (measured in km^2) divided by the total area of surveyed habitat, as shown in the equation below.

Habitat availability = a*rea of habitat surveyed / total area of surveyed habitats*

i.e. the habitat availability of urban habitat on Upolu

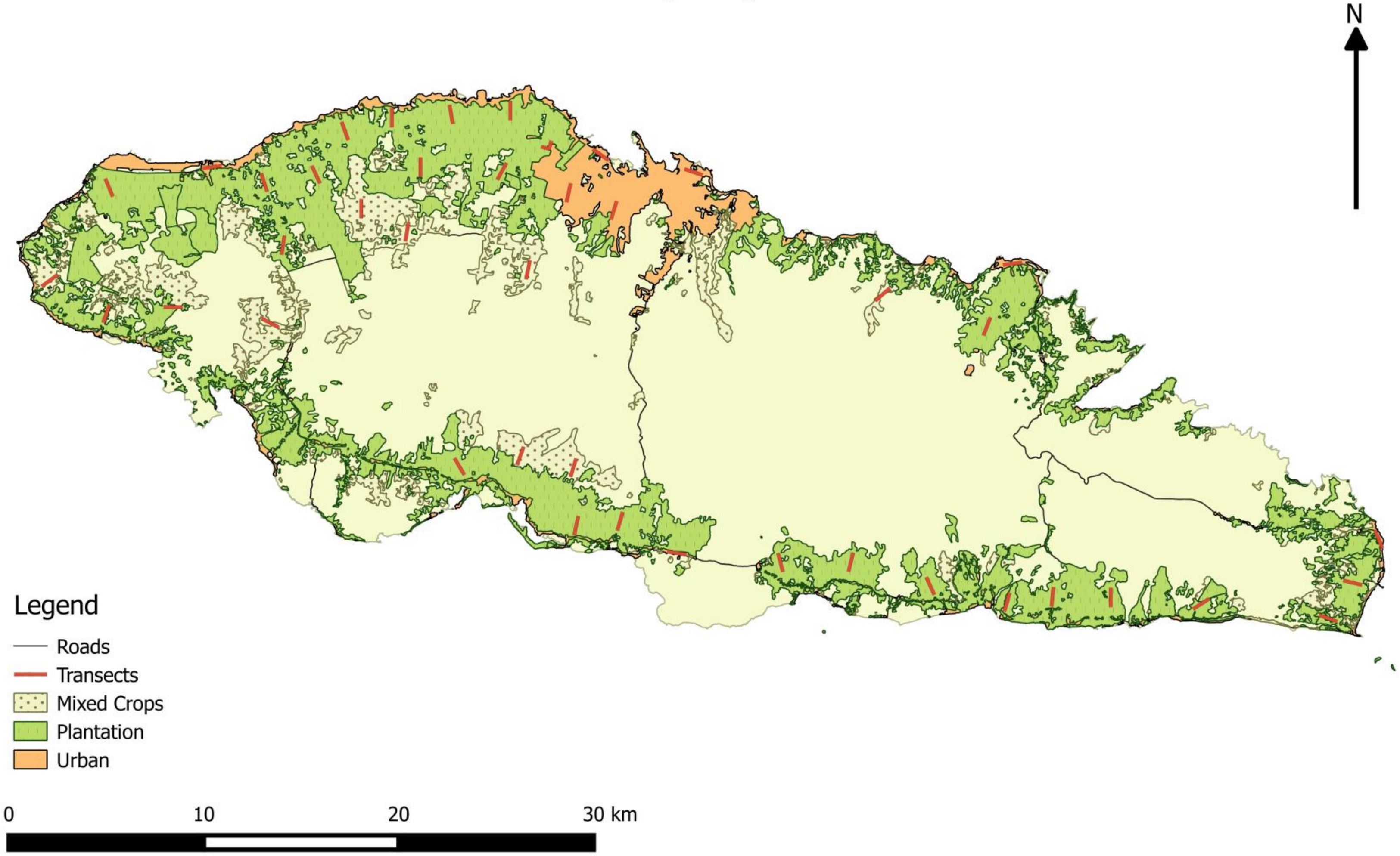
= 44.05 (area of urban habitat) /193.94 (total area of surveyed habitats)

= 0.227

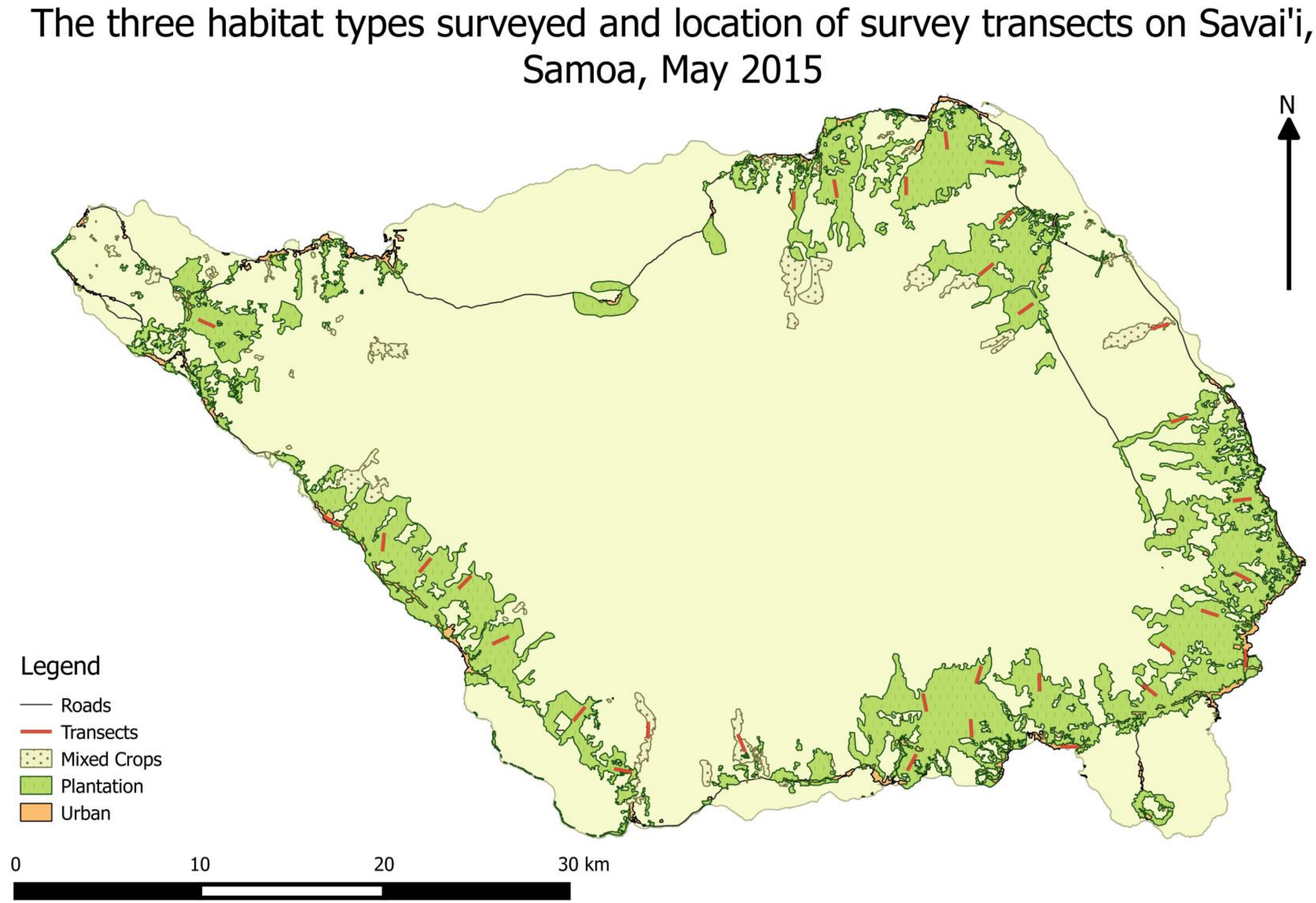
Relative occurrence is the number of birds in a habitat divided by the total number of birds across all habitats surveyed.

Relative occurrence = *number of birds in a surveyed habitat/total number of birds counted across all surveyed habitats*

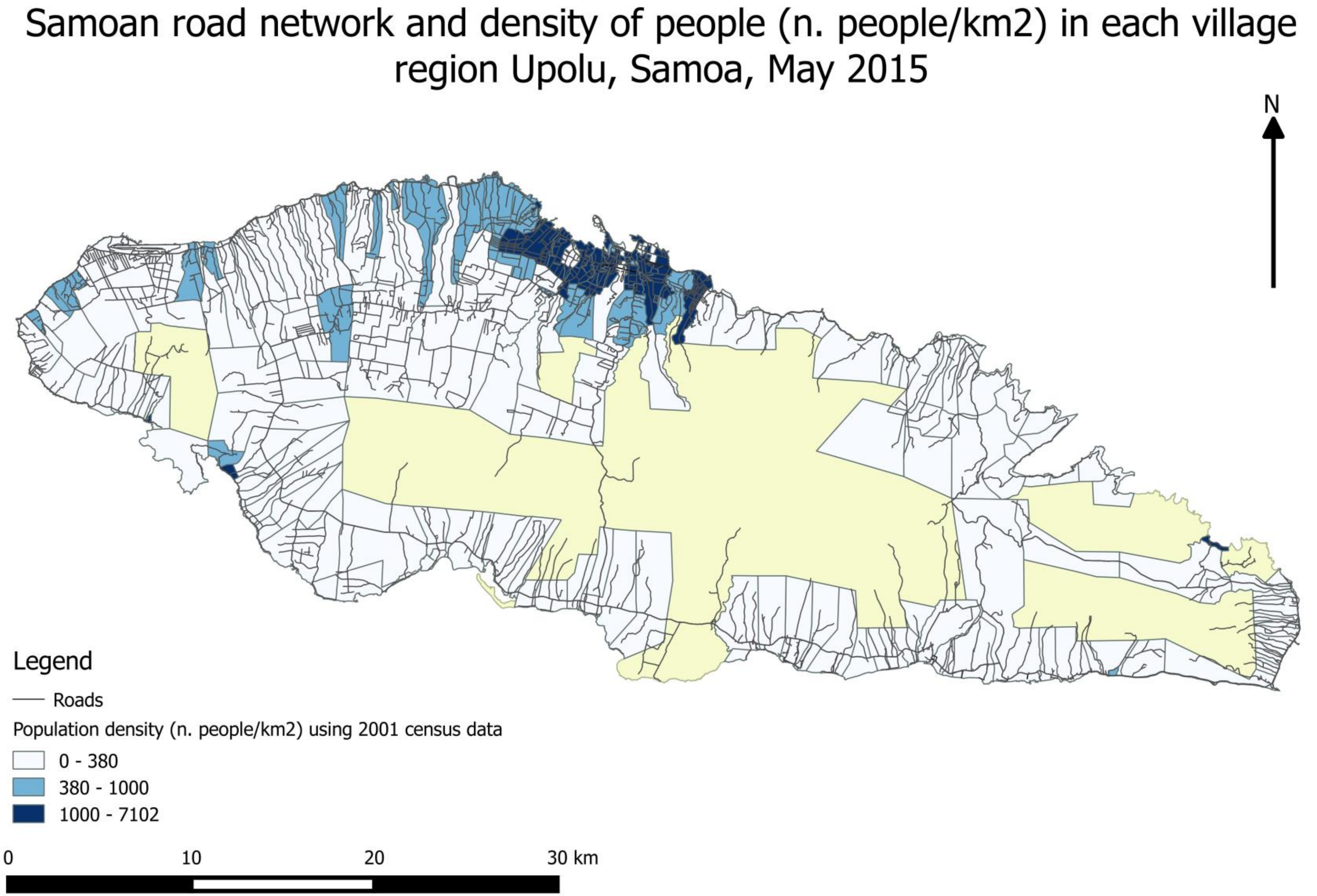
The three habitat types surveyed and location of survey transects on Upolu, Samoa, May 2015



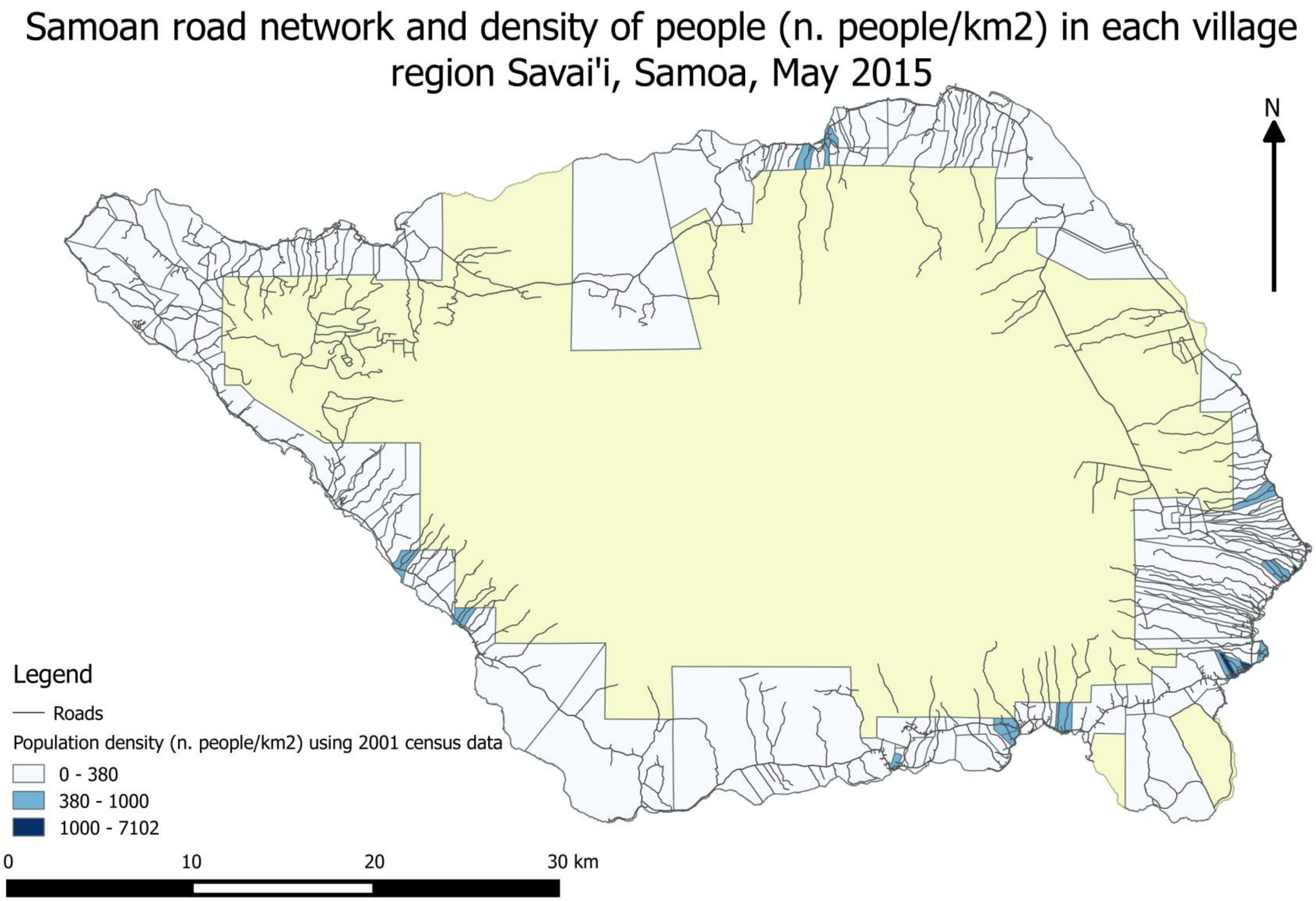
Map 1. Distribution of survey transects and habitats surveyed on Upolu, Samoa.



Map 2. Distribution of survey transects and habitats surveyed on Savai'i, Samoa



Map 3. Average density of people per village region (2001 census data) and road network on Upolu, Samoa.



Map 4. Average density of people per village region (2001 census data) and road network on Savai'i, Samoa.

Results

Transects

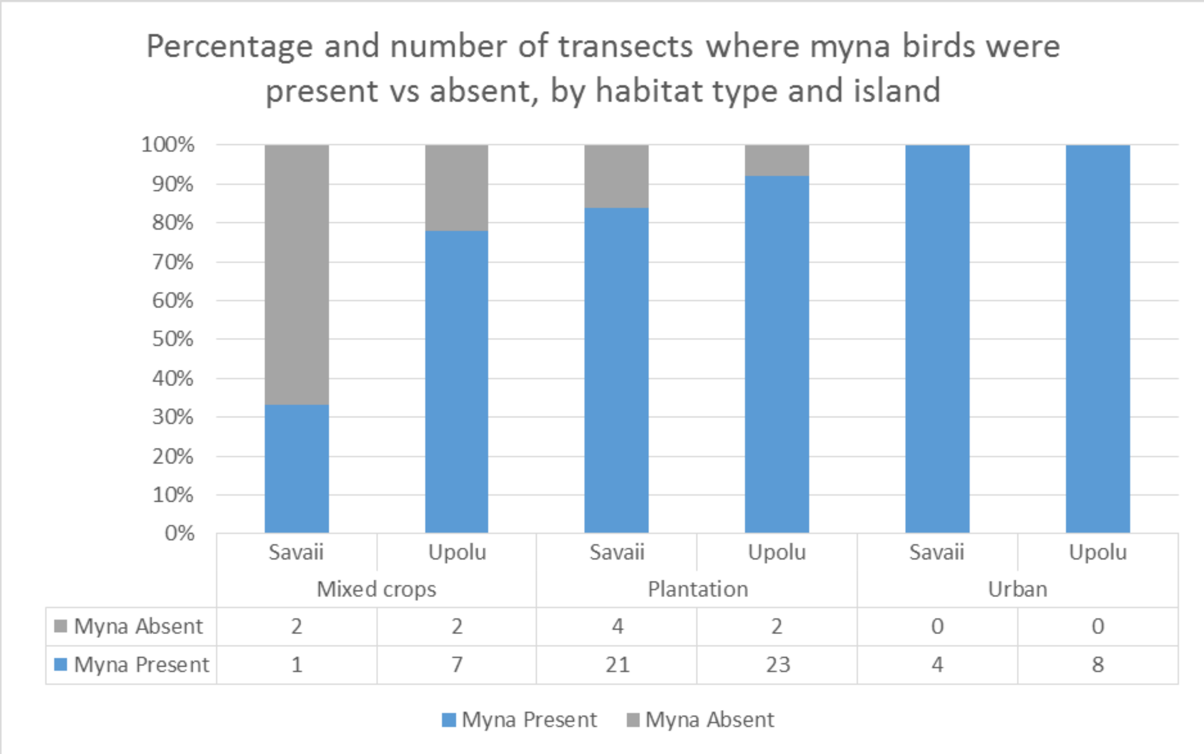


Figure 1. Percentage and number of transects with myna birds present vs absent by habitat type and island.

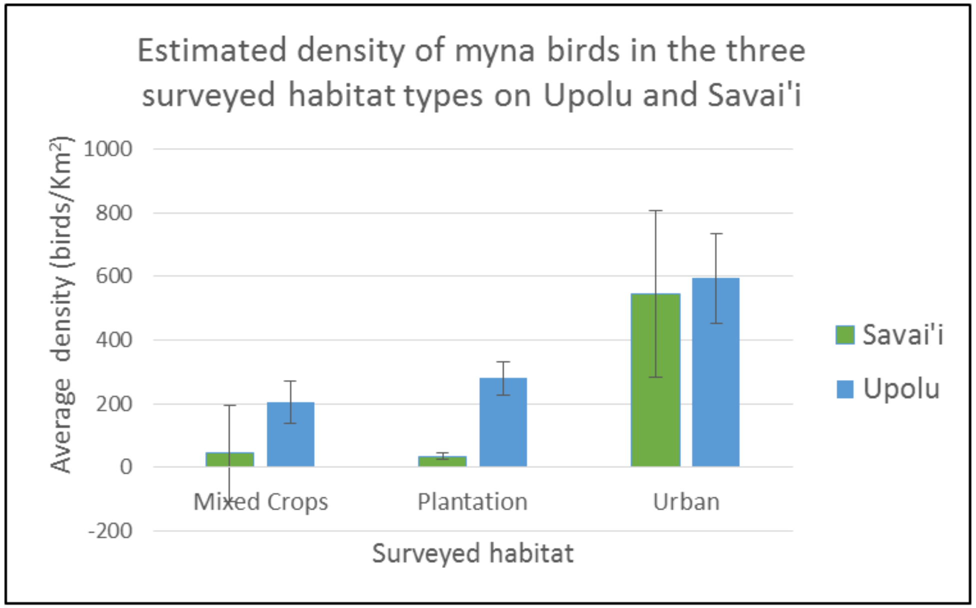
On Upolu myna birds were recorded in 7 of the 9 mixed crop transects, 23 of the 25 plantation transects and all 8 urban transects (Figure 1). On Savai'i myna birds were recorded in 1 of the 3 mixed crops transects, 21 of the 25 plantation transects and all 4 urban transects.

Distance analysis

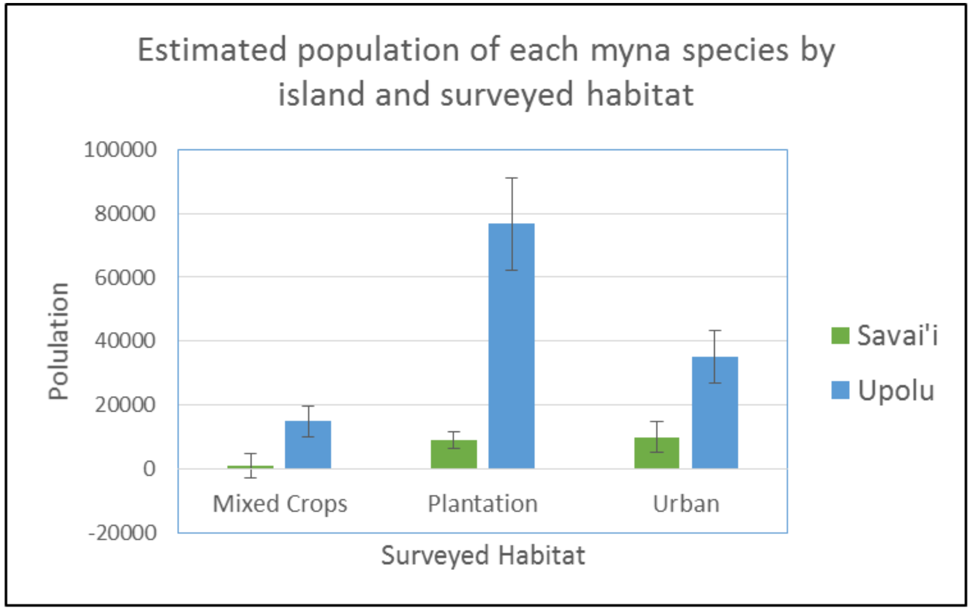
The Distance programme estimated the population of myna birds in Samoa to be 158,995 with a standard error (SE) of +/- 29,588 (Table 4). The total number of myna birds for each island, and the total number of each species on each island, were also calculated (Table 4). As Common Myna birds were not recorded on any of the Savai'i transects a population estimate could not be made.

Table 4. Estimated population size and density (n. birds/km^2) for both myna species on each main island and within each habitat type.

All Myna records	Population size	Range (based on SE)	Density	Range (based on SE)
Savai'i	28,965	19,214 – 38,716	94	63 - 126
Mixed Crops + Plantation	9,894	6,996-12,792	34	24 - 44
Urban	9,904	5,167 – 14,641	545	285 - 807
Upolu	130,030	110,193 – 149,867	320	271 - 370
Mixed Crops	14,879	10,043 – 19,715	205	139 - 272
Plantation	39,097	31,452 – 46,742	281	228-333
Urban	35,082	26,766 – 43,398	594	454 - 736
Samoa Total	**158,995**	**129,407-188,583**		



a)

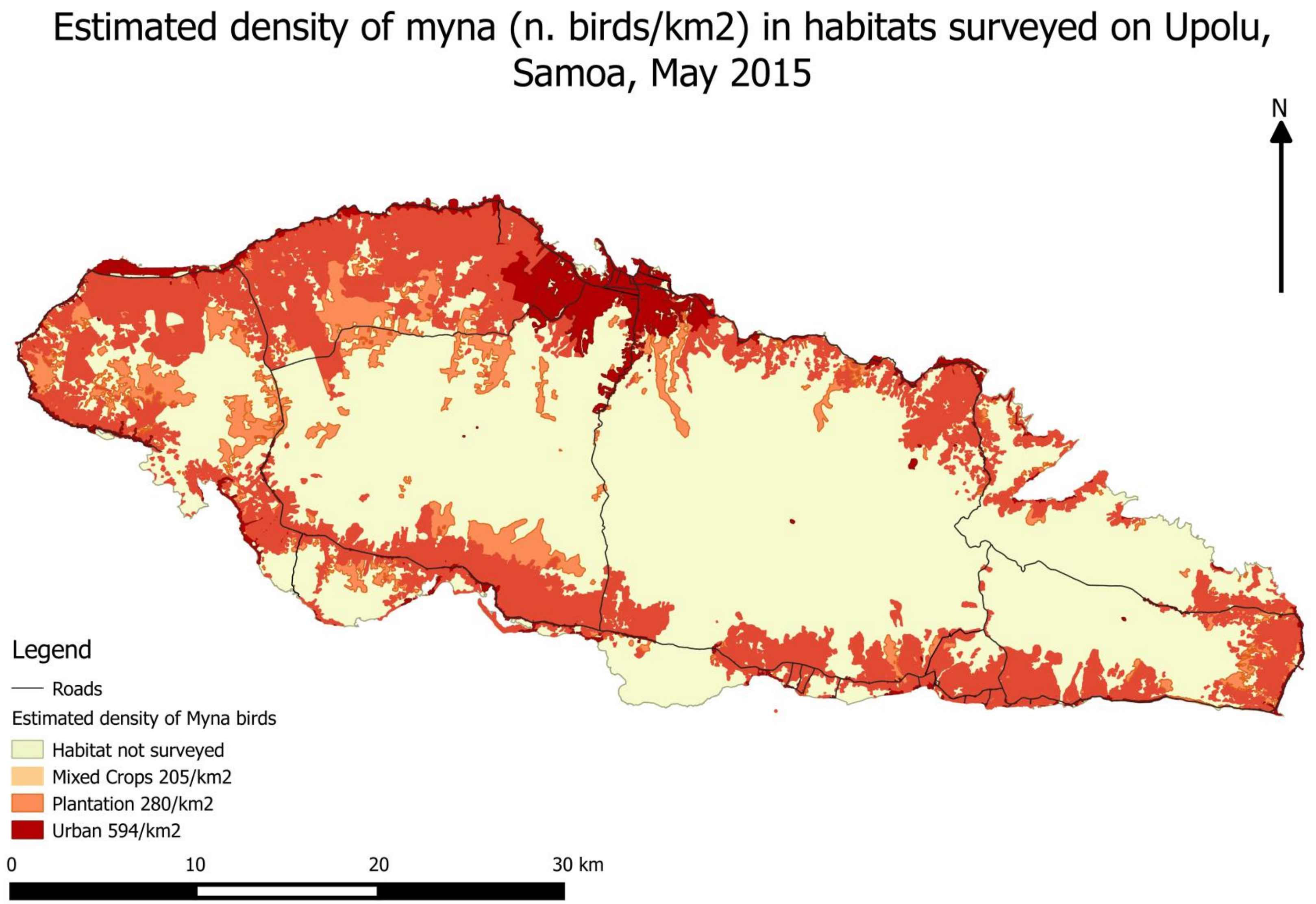


b)

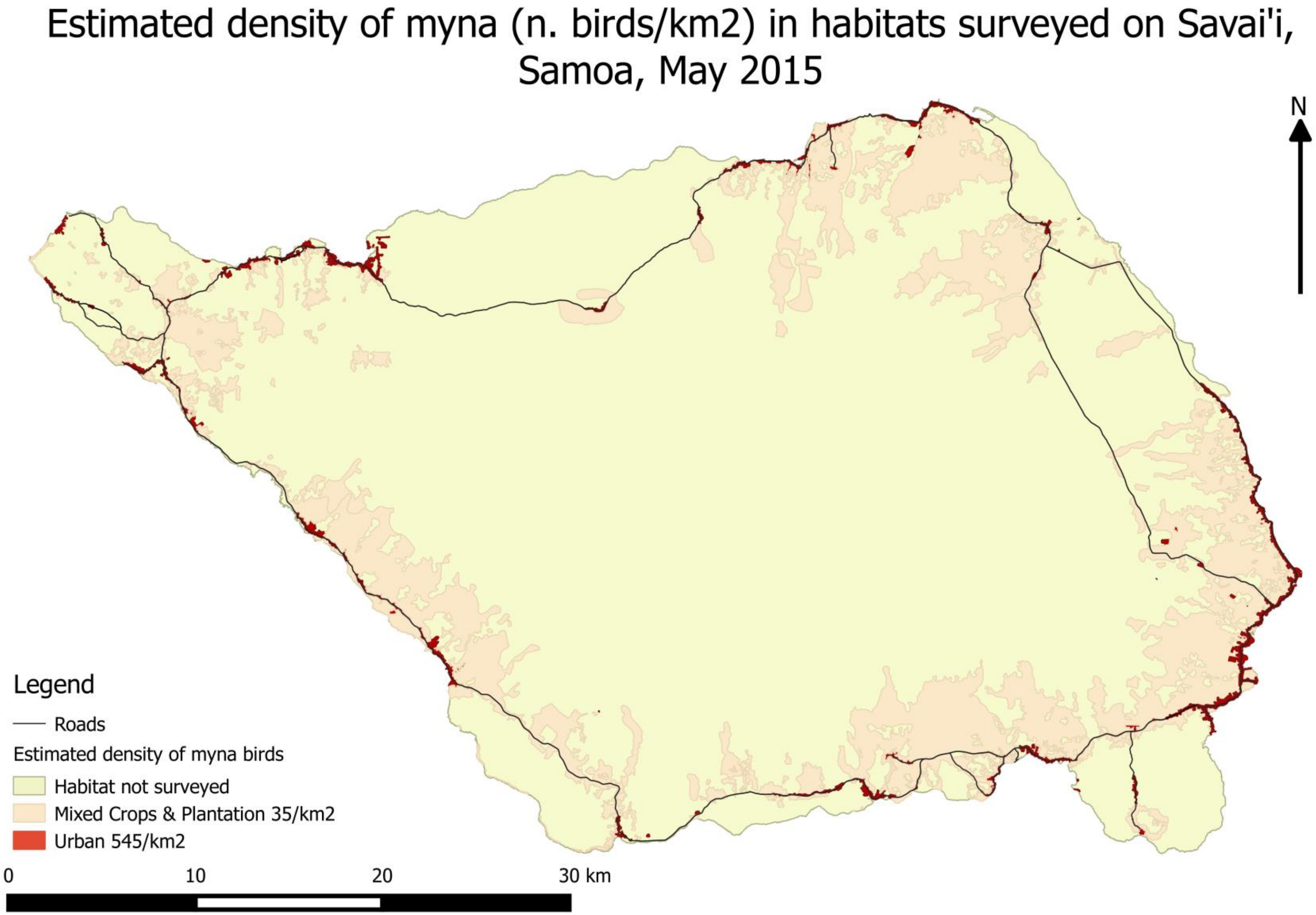
Figure 2. Estimated a) density and b) population of myna birds by surveyed habitat type on each of the two main islands of Samoa. With standard error bars.

From the data in Table 4 we can see that Upolu recorded the highest population (130,030) and density (320/km^2) of myna birds between the two islands. Upolu also recorded highest densities in all habitats. The density of myna birds in the urban habitat on both Upolu and Savai'i is very similar and much greater than the densities recorded in the other habitat types. On Upolu the plantation habitat is the next most densely populated habitat followed by mixed crops. On Savai'i the density of myna birds in the mixed crops and plantation habitat is much lower than all the other recorded densities.

The highest densities of myna birds were recorded in the urban habitat of both islands (figure 2 a), but in terms of absolute numbers the highest figure was recorded in the plantations of Upolu (Figures 2 b). The information from Table 4 is also presented in the corresponding maps 5**Error! Reference source not found.** and 6.



Map 5. Estimated density of myna birds in the three habitat types surveyed on Upolu, Samoa



Map 6. Estimated density of myna birds in the habitat types surveyed on Savai'i, Samoa

Table 5. Estimated population of each myna species on each island and within each habitat type

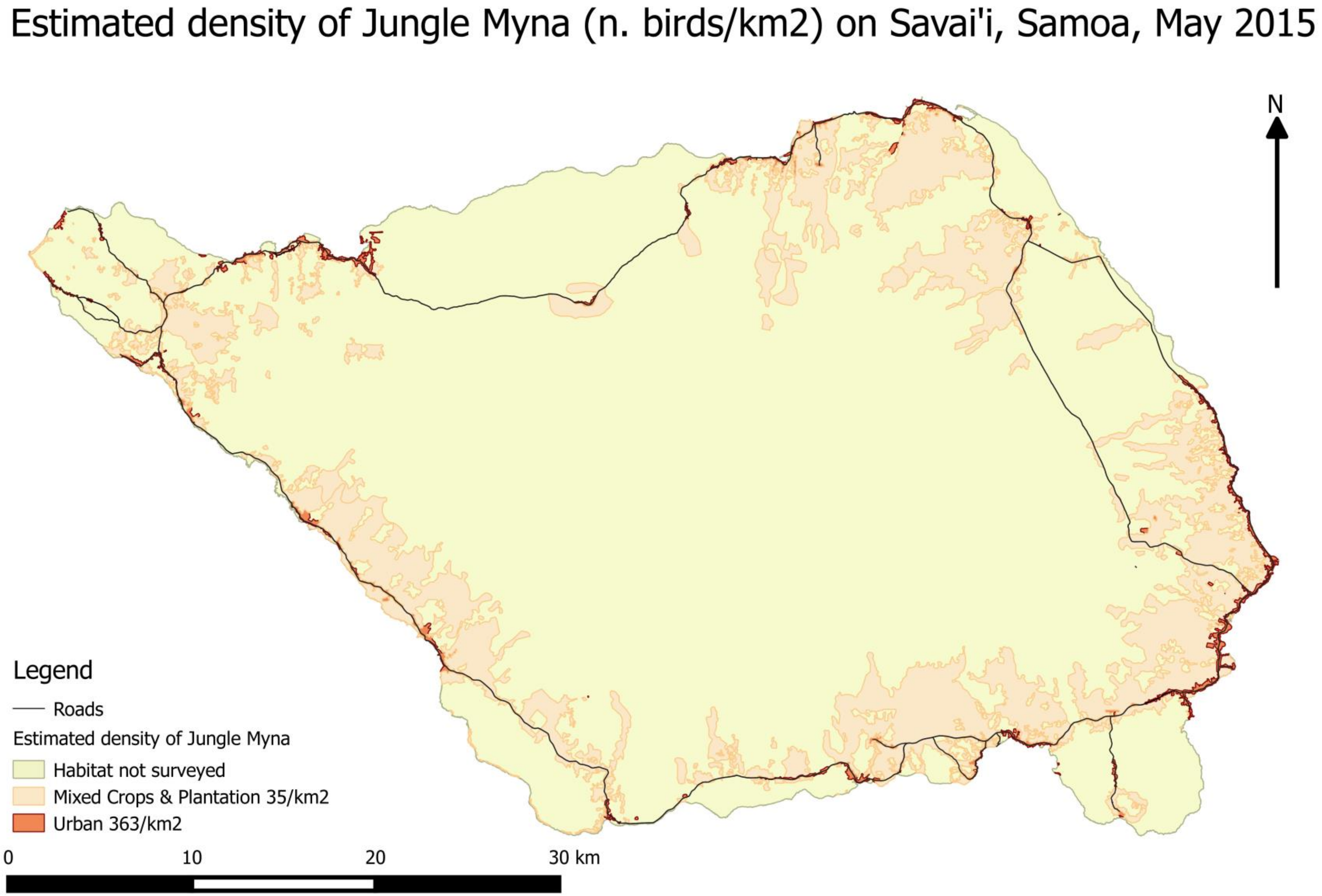
Jungle Myna	Population size	Range (based on SE)	Density	Range (based on SE)
Savai'i	25,872	17,369 – 34,375	84	57 - 112
Mixed Crops + Plantation	10,162	7,064-13,260	35	24 - 46
Urban	6,584	3,595-9,573	363	198-527
Upolu	104,960	90,390 – 119,530	258	222 - 294
Mixed Crops	14,761	10,615-18,907	190	137-243
Plantation	66,234	52,122-80,346	245	193-298
Urban	17,753	12,656-22,850	301	215-387
JM Samoa Total	***133,925***	***109,604-158,246***		
Common Myna	**Population size**	**Range (based on SE)**	**Density**	**Range (based on SE)**
Savai'i	NA	NA	NA	NA
Upolu	23,367	15,755 – 30,979	163	110 - 216
CM & JM Samoa Total	***157,292***	***125,359-189,225***		

Table 5 shows the estimated populations and densities of each species of myna bird on the two main islands and within the surveyed habitat types. Jungle Mynas are the most populous myna on both islands. On Savai'i the density of Jungle Myna varies from 34 birds/km^2 in the mixed crop and plantation habitats, to 363 birds/km^2 in the urban habitat.

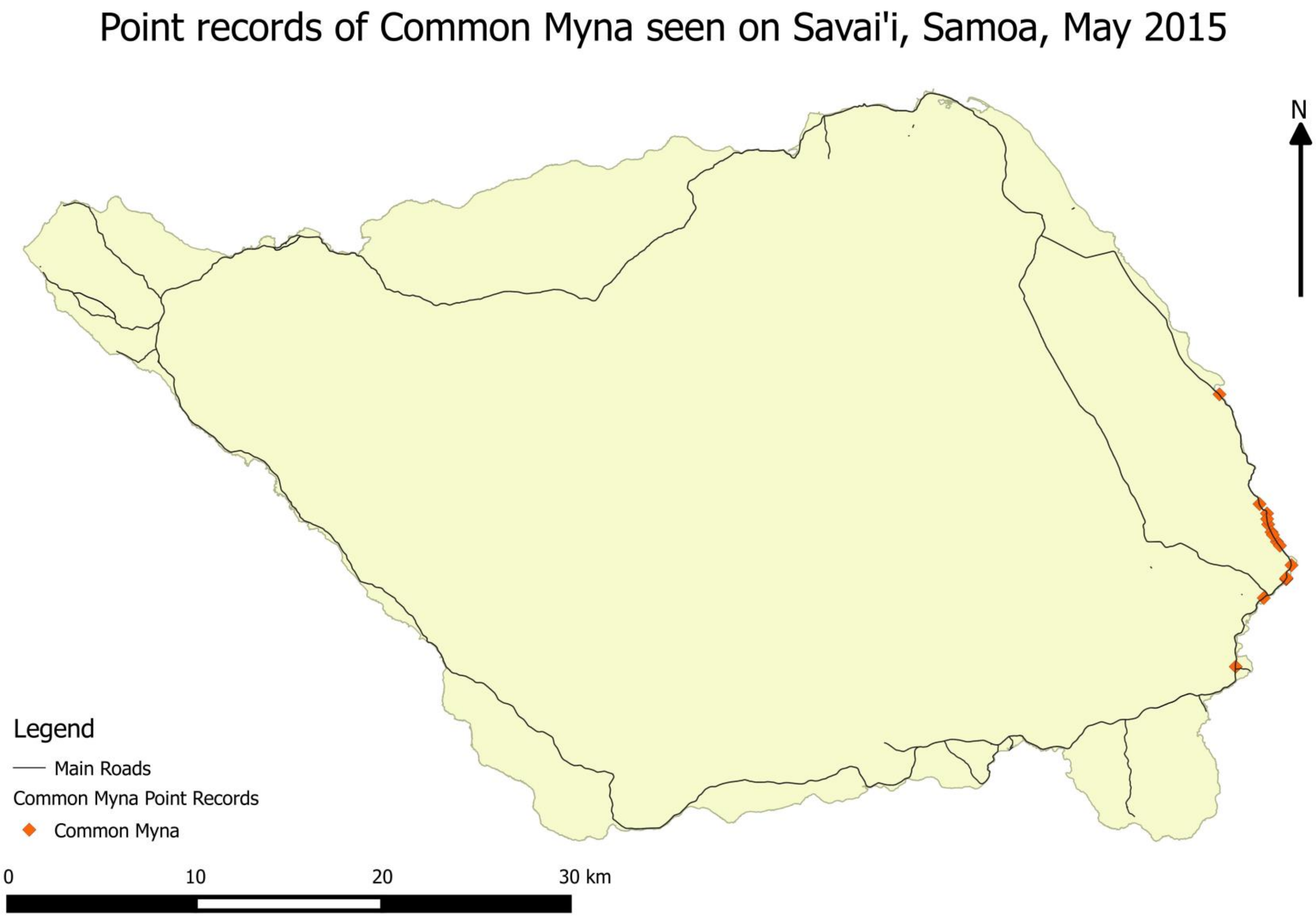
There is less variation in the density of Jungle Mynas on Upolu with the densities ranging from 189 birds/km^2 in mixed crops habitat to 301 birds/km^2 in urban habitat. While the density of Jungle Myna in the urban habitat of Savai'i and Upolu is similar, the densities of Jungle Myna in the plantation and mixed crops on Savi'I is much lower than on Upolu. There are about four times more Jungle Myna (104,960) on Upolu than Common Myna (23,967).

We were unable to estimate a density for Common Myna on Savai'i as none were recorded along transects. The density of Common Myna on Upolu is much lower than the Jungle Myna.

Map 7 shows the estimated density and distribution of Jungle Myna on Savai'i. There were several incidental sightings of Common Myna on Savai'i. This data is displayed in Map 8.



Map 7. Average density of Jungle Myna in surveyed habitat types on Savai'i, Samoa



Map 8. Point records of Common Myna sighted during surveys on Savai'i, Samoa.

Table 6 shows a more detailed analysis of the myna data from Upolu. Here the densities of myna birds in the north-west section is presented along with myna densities for the rest of Upolu. It is clear that there are more than four times the number of myna in the north-west section than in the rest of Upolu (Table 6). The densities of myna birds for each of the surveyed habitats in the north-west section is greater than the corresponding habitats on the rest of Upolu. Overall the urban habitat in the north-west section has the highest density of myna birds (693 birds/km^2).

Table 6. Estimated population and density (n. birds/km^2) of myna birds in the north- west (NW) section of Upolu vs the rest of Upolu.

Upolu	Popn size	Range (SE)	Density	Range (SE)
NW Upolu	106,070	88,345 – 123,795	547	456 - 638
Rest of Upolu	26,305	21,164 – 31,446	124	100 - 149
NW Upolu (MC)	12,815	9,882 – 15,748	364	280 - 447
Rest of Upolu (MC)	2,652	1,347 – 3,957	62	32 - 93
NW Upolu (PL)	60,273	47,300 – 73,246	526	413 - 639
Rest of Upolu (PL)	15,499	12,718 – 18,280	100	82 - 118
NW Upolu (UR)	30,533	20,947 – 40,119	693	476 - 911
Rest of Upolu (UR)	4,715	3,336 – 6,094	338	239 - 436

The information from Table 6 is visually presented in Figure 3 and Map 10 and 11.

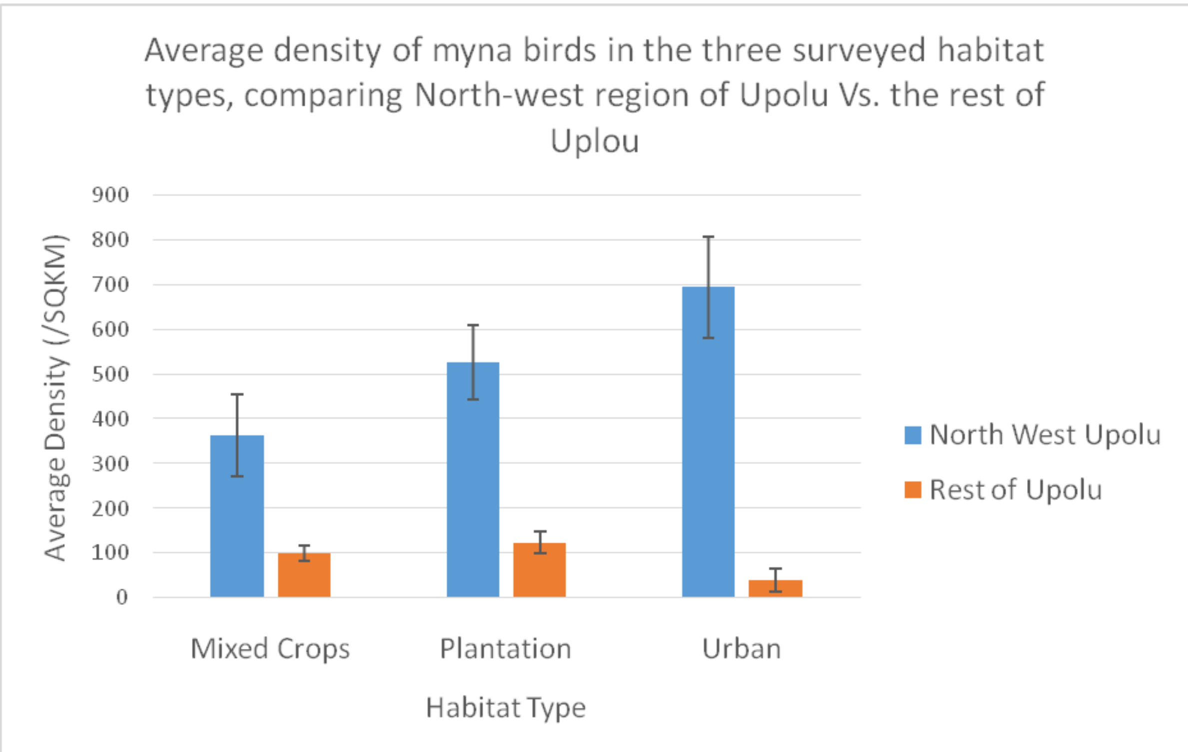
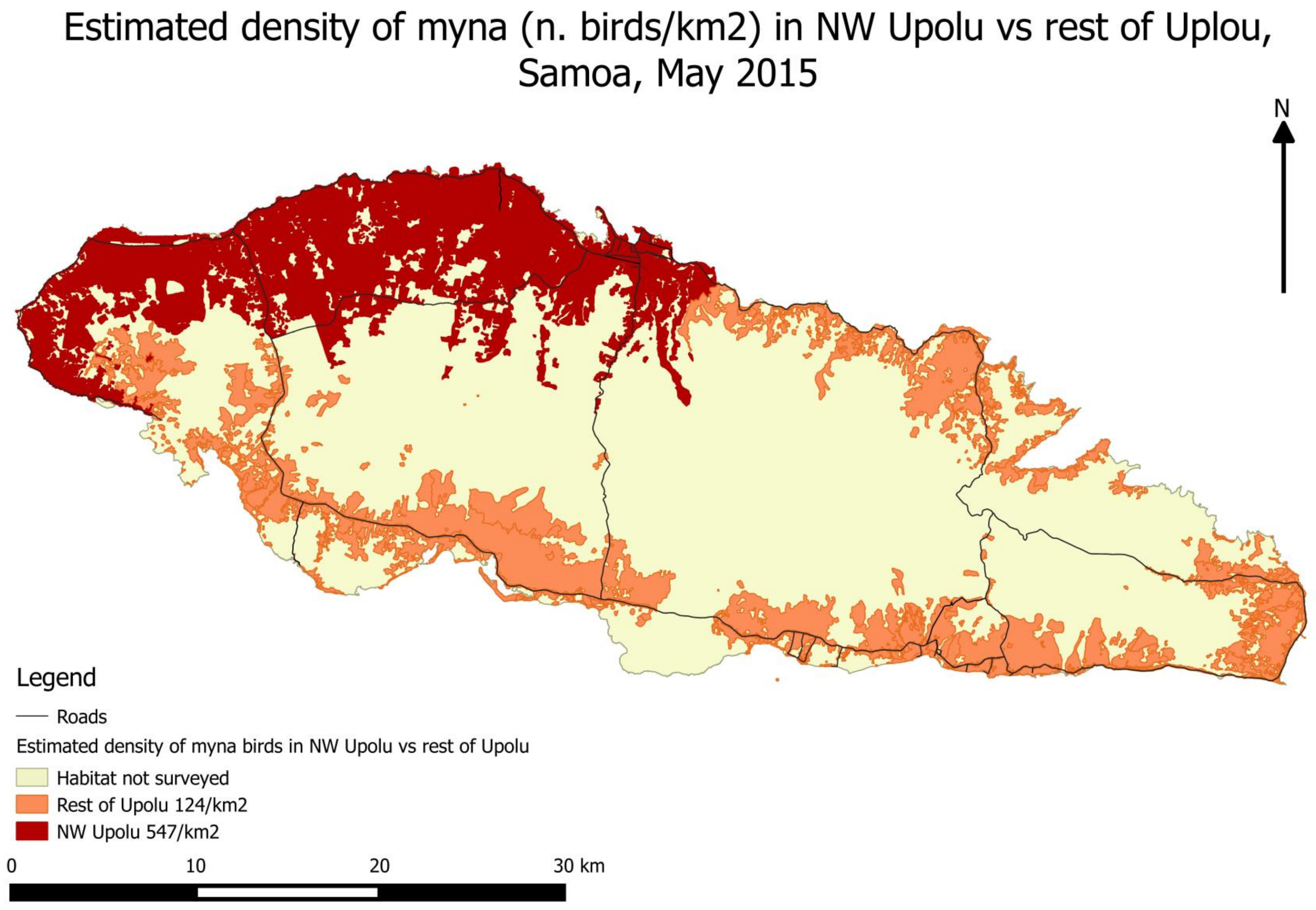
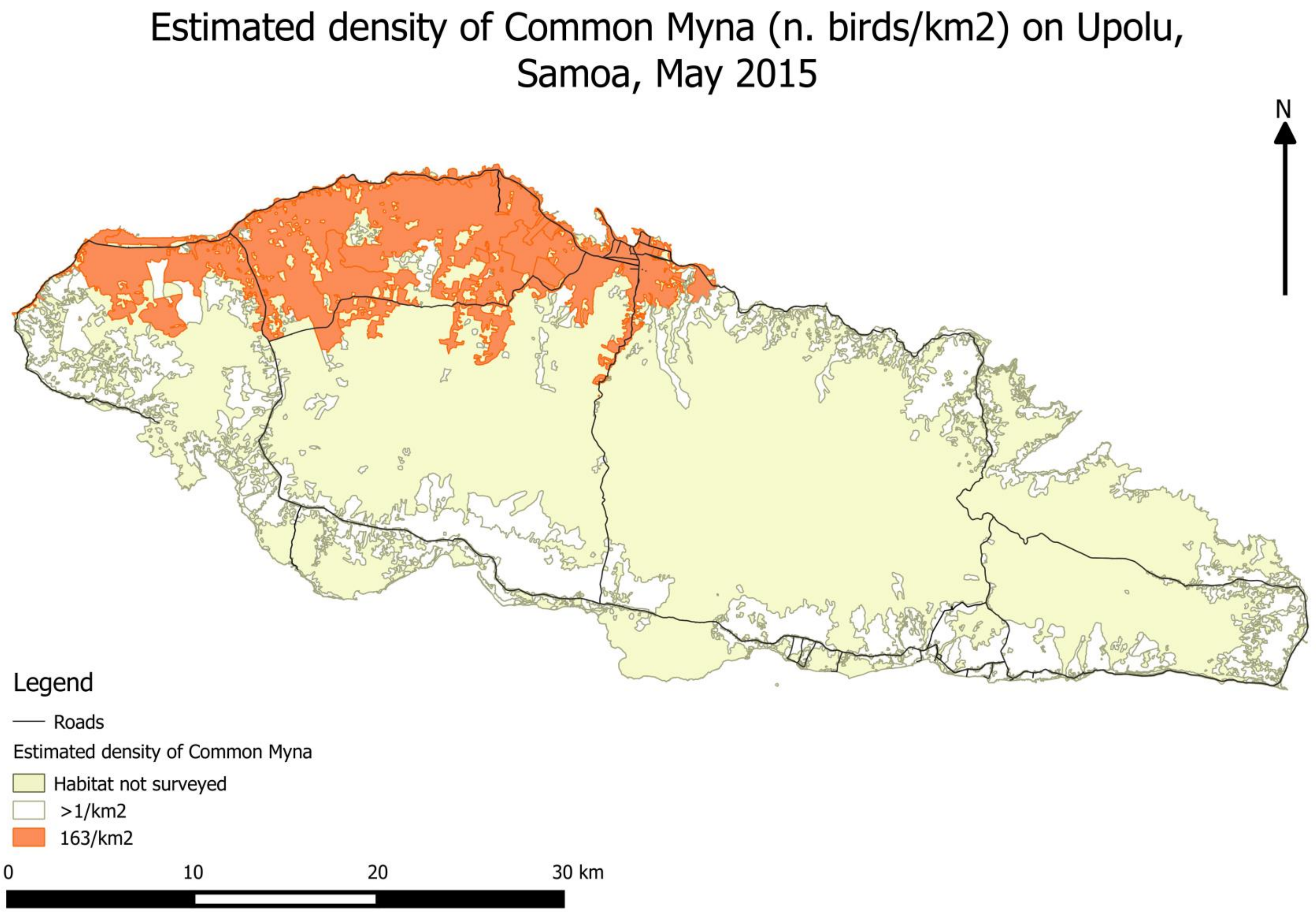


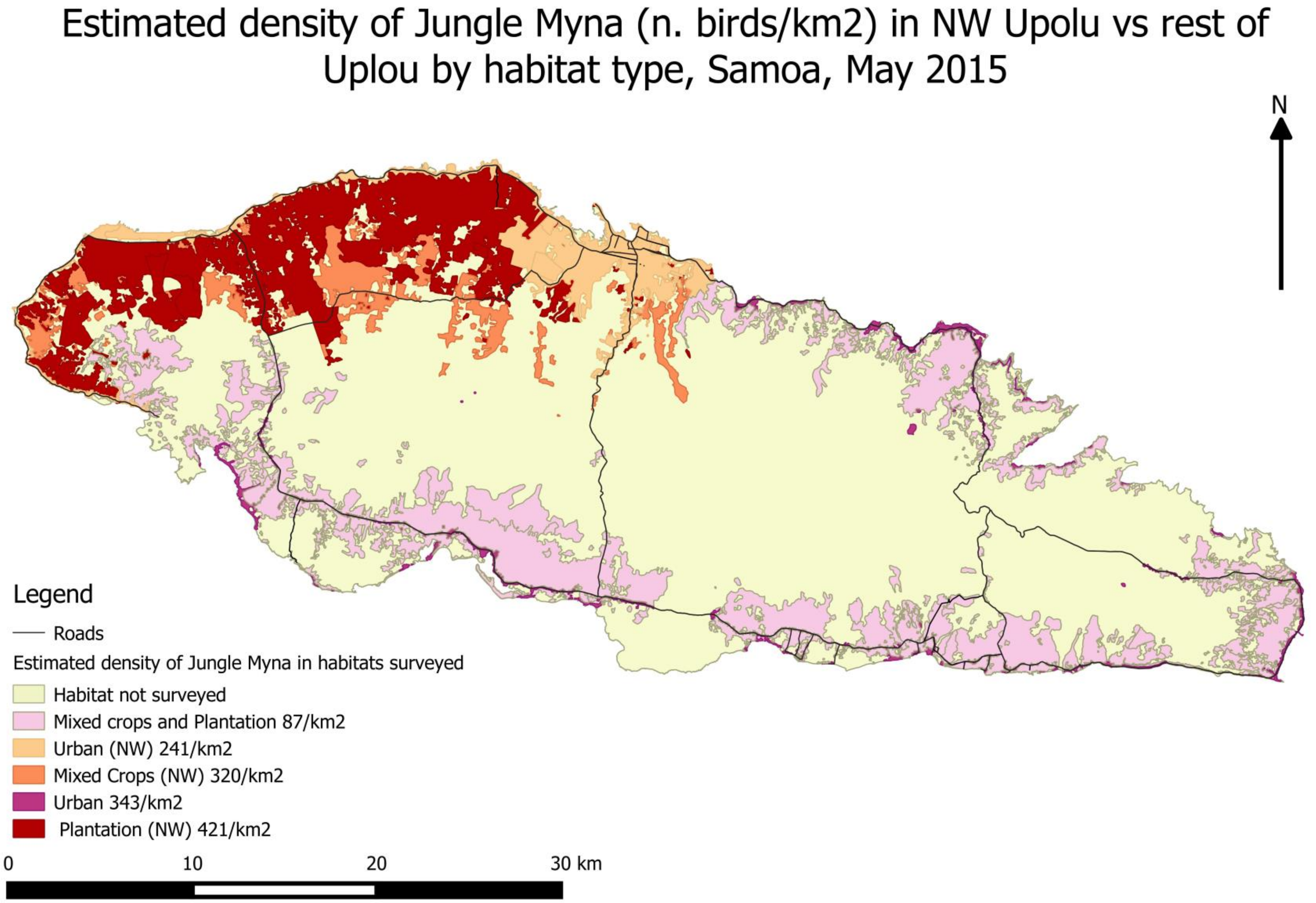
Figure 3. Average density of myna birds recorded in the three surveyed habitats, comparing North-West section of Uplou agains the rest of Uplou. Data from table 4.



Map 9. Average density of myna birds in NW Upolu vs rest of Upolu, Samoa.



Map 10. Average density of Common Myna in the habitats surveyed on Upolu, Samoa



Map 11. Average density of Jungle Myna on Upolu, comparing surveyed habitats in NW section to surveyed habitats in the rest of Upolu, Samoa.

The comparison of percentages of availability of the three habitats versus the relative occurrence of myna birds shows a significant preference of both species for the urban habitat (Figures. 4-6).

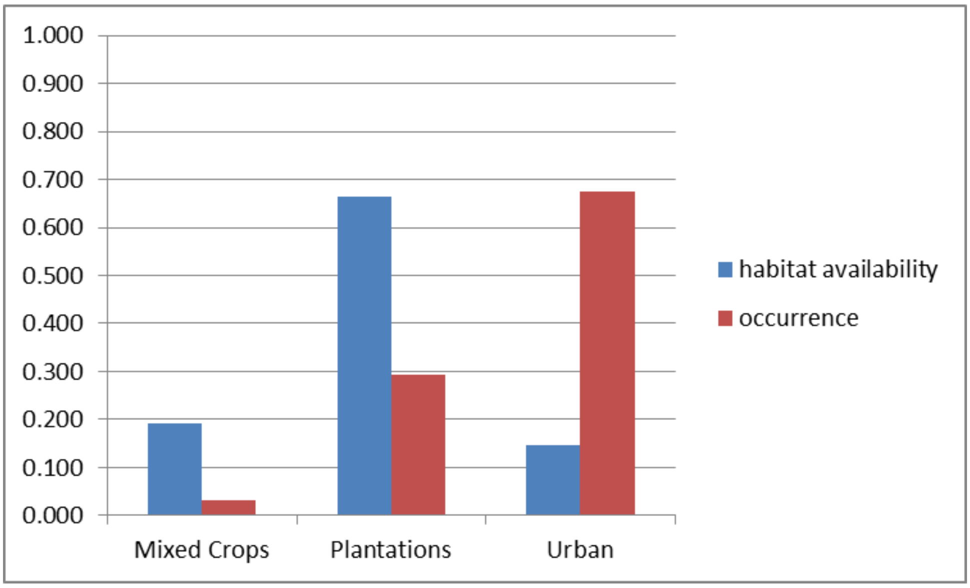


Figure 4. The proportion of available habitat versus the relative occurrence of Common Mynas in the three surveyed habitats on Upolu.

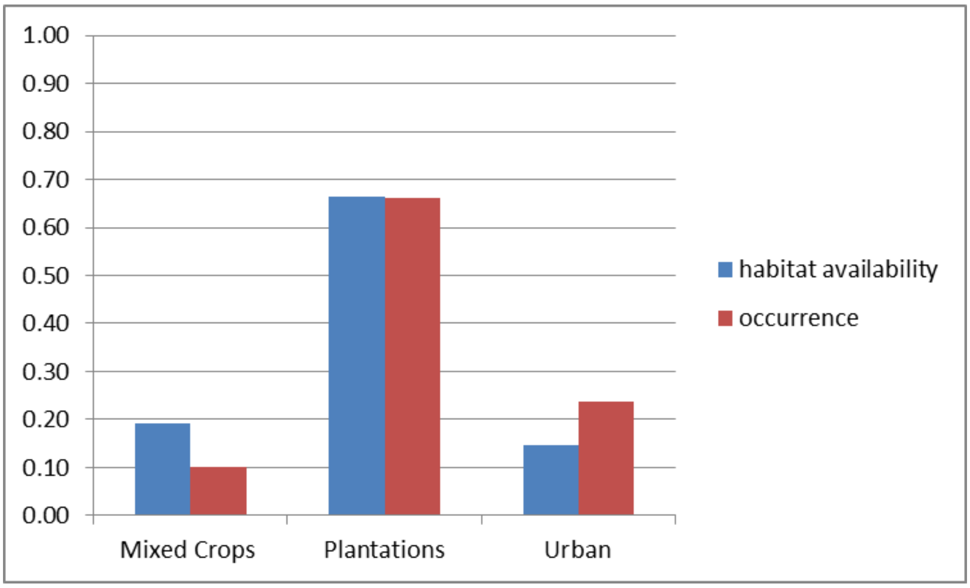


Figure 5. The proportion of available habitat versus the relative occurrence of Jungle Mynas in the three surveyed habitats on Upolu.

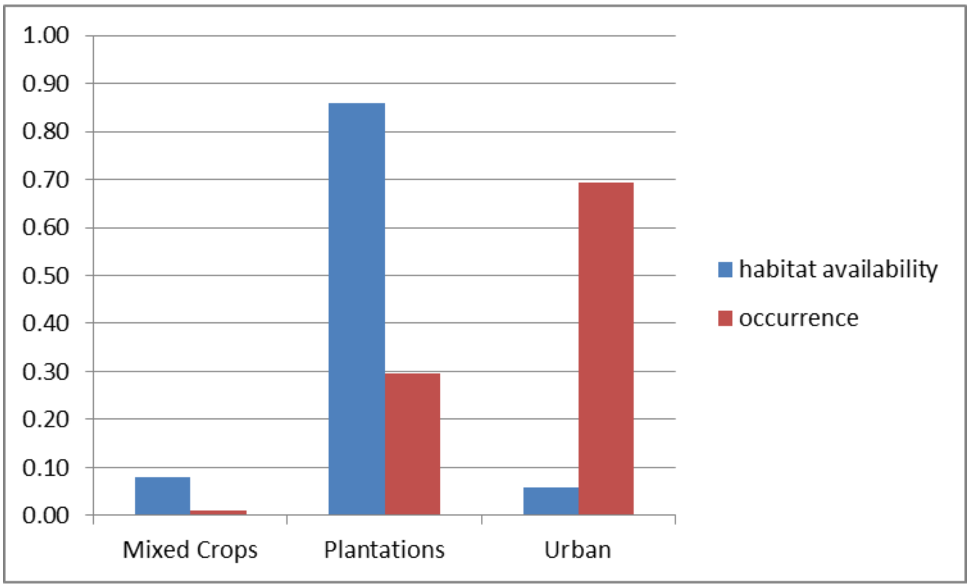


Figure 6. The proportion of available habitat versus the relative occurrence of Jungle Mynas in the three surveyed habitats on Savai'i.

Discussion

Population of myna birds

Based on the results of the surveys it is estimated that in May 2015 the population of myna birds (both Common and Jungle Myna combined) occurring within the three habitats surveyed in Samoa is between 129,407 and 188,553 (158,995 +- 29,588). It is also estimated that the total population of myna birds on Upolu is approximately 130,030 +- 19,837, and the population on Savai'i (mostly Jungle Myna) is approximately 28,968 (+- 9,751).

These figures clearly reflect the history of invasion by the two species in Samoa; both species were introduced to Upolu first, with Jungle Myna being introduced approximately 20 years earlier than Common Myna.

We speculate that these estimates are ca. 10-20% lower than the actual total population occurring within Samoa to allow for the fact that less preferred habitats by myna birds, according to literature, were not surveyed (e.g. mangroves, and secondary forest).

However, the data collected will serve well as baseline information that can be used in the future, by means of the same survey method, to monitor the occurrence of this invasive species on Samoa.

Distribution of myna population

From our results we can see that the population and density of myna birds is not evenly distributed between the two main islands. The island of Upolu has a significantly larger myna population than Savai'i, with both species of myna mostly recording higher densities on Upolu on an overall basis, most likely due to the fact that they have been present on Upolu for longer and there is a lot of favourable habitat.

Of the three habitat types myna bird densities were highest in the urban habitat, on both islands, followed by the plantation and mixed crops habitat types.

Both species show a significant preference for the urban habitat type, where most infrastructure is located, including roads (which act as invasion corridors), and where the highest density of people is found. This is consistent with the history of invasion and with the fact that both myna species benefit from living in close association with humans (Canning, 2011; Manpreet & Nagle, 2009; Tidemann, 2005), as people create favourable habitat for the mynas.

Due to the above, the majority of the myna population on Upolu is found in the north-west section, from Apia past Mulifanua wharf to Monono Uta on the west coast. Similarly on Savai’i most of the myna birds recorded were in urban areas especially on the more populous eastern side of Savai'i.

The preference of Jungle Mynas for urban habitat is clearer on Savai'i where the invasion is still in its early stages. On Upolu it is less clear because this species seems to have started colonizing less preferred sub-optimal habitats (plantations and mixed crops), possibly due to the saturation of urban habitat, or they may have greater ecological flexibility and more generalist behaviour. Or possibly direct competition with the larger Common Myna, has forced them into less favourable habitat.

On Savai’i the Jungle Myna appears to have successfully started their invasion. They are rapidly saturating the urban areas and have started to infiltrate the plantation areas. There were only few incidental records of Common Myna on the east coast. They have been there since 2004 and it is likely they are still in the early stage of their invasion.

Common Myna are known to have a close association with people, preferring urban areas and permanent cultivated lands (Crisp & Lilli, 2006; K. Lowe, Taylor, & Major, 2011; Peacock et al., 2007; van Rensburg, Peacock, & Robertson, 2009), often choosing to nest in more highly modified habitats, and in artificial structures rather than in native vegetation (K. Lowe et al., 2011). As such, it is likely they will spread through the more highly urbanised areas on the east coast before invading other urban areas on Savai’i.

Future distribution of myna in Samoa

Across the world, mynas avoid closed forest, but occupy habitats including desert oases, grasslands, woodlands (especially for nesting), secondary forest and mangroves – from sea level to 3000 m above sea level. Mynas are strongly commensal – attracted to human habitation and modified habitats (with available food supply) - but they are highly adaptable and perfectly capable of existing without humans (Tidemann, 2005).

As urban areas spread it is likely more forest will be cleared, with new roads made into plantations and secondary forests. These actions will assist myna birds through the creation of new favourable habitat and road networks could act as invasion corridors, by providing preferred foraging habitat along roadsides (Amico, Rouco, Russell, Román, & Revilla, 2013).

As the urban areas of Upolu and Savai’i become saturated with mynas it is possible the Common Myna may dominate urban areas pushing Jungle Mynas to plantations and mixed crops habitat before invading secondary forests. Without a suitable management plan that is well executed, the population, distribution and impacts of myna birds in Samoa will continue to increase.

Acknowledgements

We would like to thank the staff of MNRE, Taupau Maturo Paniani, Niualuga Evaimalo, Czarina Stowers, Faafou Wynette Leaupepe, Fini Male, Vaatele Anoifale, Kim Keleti, Tave Malolo and Taalili Leituala for all their assistance in organising and participating in the surveys. Thank you to Bill Nagle and James Atherton for advice, guidance and comments on this report.

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Annex 1 – Myna survey proforma

MNRE GEF IAS MYNA SURVEY SHEET

TRANSECT _________ DATE / /2015 NAME OF OBSERVER ______________________

START TIME: ____________ END TIME: ______________ SIDE OF CAR: Left / Right (circle)

MAX DISTANCE OBSERVABLE: ____________________

	Distance from car (m)	# individuals	Species			Notes
			M	J	C	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
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