

Red Imported Fire Ants – Auckland Airport 2001

OUTLINE FOR CASE-STUDIES ON ALIEN SPECIES

To the extent possible, case-studies should be short and succinct summaries of experience on alien species at the country and regional levels. A case-study should focus on the prevention of introduction, control, and eradication of alien species that threaten ecosystems, habitats or species. Case-studies should include the following sections (a summary of the information may be provided under each heading, and a more detailed paper may be attached; if the information were not available, this should be indicated in the appropriate section):

1. Description of the problem

(a) Location of the case-study

Auckland - New Zealand

(b) History (origin, pathway and dates, including time-period between initial entry/first detection of alien species and development of impacts) of introduction(s)

During the week of 12-18th of February 2001, an Auckland airport New Zealand groundsman was stung by ants when he attempted to flatten a small mound outside an aviation service building. He report the presence of the ants to MAF air cargo on 28th of February and in his report noted that he recalled having seen a small mound at this site a month earlier. Samples were forward to the National Plant Pest Reference Laboratory the same day and confirmation of the species occurred on 1 March 2001.

The infestation consisted of a single mature ant colony estimated to be between nine months and two years old. It was suspected that the ants had hitchhiked either in or on containers and that they were dislodged during unloading or transportation from the aircraft.

RIFA are native to Argentina, Brazil and Paraguay. It is a significant agricultural and urban pest in the USA where it established after an unintentional introduction in 1930-40. RIFA have established on a number of islands in the Caribbean. In February 2001 it was detected in Brisbane Australia, where it has been subject to a multimillion dollar eradication programme. More recently RIFA has been detected on a number of Pacific islands including New Caledonia.

Currently all infested countries pose some degree of risk of transmitting RIFA to NZ. As a result of trade patterns and proximity, RIFA are most likely to be introduced from Australia and the Pacific. An introduction of RIFA from the USA is more likely than from South America or the Caribbean as limited exports arrive at present from these later areas.

(c) Description of the alien species concerned: biology of the alien species (the scientific name of species should be indicated if possible) and ecology of the invasion(s) (type of and potential or actual impacts on biological diversity and ecosystem(s) invaded or threatened, and stakeholders involved)

Pest Identification

Order: Insecta

Family: Formicidae

Subfamily: Myrmicinae

Name: *Solenopsis invicta*

Common name: Red imported fire ant

Acronym: RIFA

Pest importance

RIFA are highly invasive insects because of their high reproductive capacity, large colony size, ability to exploit human disturbances, wide food range, aggressiveness, and ability to sting. Where they establish, they can affect agricultural and horticultural systems, wildlife, natural ecosystems, and people's quality of life; incur medical and pest control costs; and cause damage to roads and electrical equipment.

RIFA are aggressive and readily defend their nests, injecting venom, which consists primarily of alkaloids, into any animal that disturbs the colony. Workers are stimulated to attack by vibrations or in response to a chemical released by other workers when using their stings. Worker ants are able to sting multiple times.

Pest biology

RIFA have four life stages: eggs, larvae, pupae and adults. Four types of adults are found in a mature nest:

- winged, reproductive males
- winged, unmated queens
- mated queens
- non-winged workers

RIFA workers are light reddish-brown to strongly dark brown in colour and range from about 2 to 6mm in length. The winged female is also brownish-red and is slightly larger than the worker ants.

Queens establish colonies after a single mating (nuptial) flight. Flights usually occur following rain, if the air temperature is between 20°C and 33°C. Mating between winged reproductive females and males occurs during a nuptial flight, up to 500 to 600 feet in the air, with the males dying soon after mating. The mated females start descending to the ground within half an hour of taking flight and, if necessary, are able to fly again within a few minutes of landing. Once they land on a suitable site, queens break off their wings and search for a place to dig their nest, usually a vertical tunnel 3 to 12 cm deep, in soil (often under a solid object). Soil does not appear to be essential for nest formation; although uncommon, RIFA queens will nest in moist cracks and crevices of inanimate objects. The queen is unable to sting and is vulnerable to predation during, and immediately after, the mating flight.

Ninety percent of queens complete their burrows within 6 to 7 hours of flying, although it has been estimated that a newly-mated queen can survive several days at a relative humidity of 40-50% if a suitable nesting site is unavailable. After constructing a nest, the queen seals herself off and, under optimum temperatures, lays up to approximately 70 eggs over the next 5 days. After hatching, the queen rears the larvae, with the first brood of adult workers emerging, on average, 22 days after laying, if held at a constant temperature of 29.5°C. **Brood development** is temperature dependent and studies indicate that the range of emergence times can be between 13 and 95 days. Brood development in founding colonies has been observed between approximately 21°C and 35°C, with the development time of the first generation workers decreasing with increasing temperature until approximately 32°C.

During the period from sealing to the emergence of the first workers, the queen does not feed. Instead, she utilises her body reserves, losing approximately 50% of her bodyweight. The workers open the nest and begin to forage for food, rear more workers and care for the queen, who continues to produce eggs and is now reliant on the workers for food. Worker ants can live for approximately 2 to 17 months, depending on their size and the ambient temperature. Queens can live for up to 6 to 7 years and can lay up to 3000 to 5000 eggs per day. The average three year old colony contains approximately 50,000 worker ants and several thousand winged reproductives. Colonies containing as many as 230,000 to 500,000 workers have been reported. In Australia and the USA, winged reproductives are produced for most of the year, with mating flights occurring year round. However, a higher frequency of mating flights has been observed in Australia in the summer and in the US from April to August.

The length of time between colony establishment by a newly-mated queen and the production of the first winged reproductives is approximately 1 year under field conditions. Colonies reach full sexual maturity at 2 to 3 years of age. Two forms of colony exist: monogyne and polygyne. Monogyne colonies have one reproductive female and are founded by mated queens that disperse via flight. The majority of queens fly less than 0.6km, but can travel distances up to 16km or more.

Polygyne colonies have more than one reproductive queen and can found new nests via mating flights and by queens travelling on foot to new locations. As monogyne colonies are territorial, their colonies occur at lower mound densities of up to 250 mounds per hectare compared with reports of up to 1000 to 2000 mounds per hectare for polygyne colonies.

Monogyne populations also contain lower worker numbers per square unit of area than polygyne populations. Both types of colonies occur in the USA, South America and Australia. RIFA typically build subterranean nests and form mounds that vary in size, depending on soil type, soil moisture and vegetation. Mounds in sandy areas tend to be flat and rather broad, while mounds in clay soils may be up to 0.5 to 1 metre high and 1 metre in width. RIFA can build nests in almost any type of soil, but prefer open areas such as pastures, parks, lawns, meadows and cultivated fields. They are often associated with disturbed habitats such as roadside, and will infest close to, and inside, logs and buildings.

RIFA will frequently infest electrical equipment, as the worker ants are attracted to heat, and utility housing provides extra warmth and dryness for colonies during winter months. Although RIFA defend their mounds from intruders, the mound is often not permanent; colonies frequently migrate. RIFA can develop a new mound 1 to 30 metres or more away from their previous location. Nest disturbance is often cited as a cause of migration but colonies will not consistently relocate if disturbed.

One reference suggests that a queen needs only six workers to start a new colony, although it has been suggested that several dozen are more likely to be required for a successful nest. While the mound is important, it is not essential. As long as there is a small space, which is dark and damp, and a source of food and water, the ants may not form a mound, but nest instead in walls of buildings, cracks, crevices in stone walls or in logs. The minimal mean super cooling temperature (lowest body temperature reached before spontaneous freezing) for field colonies has been recorded at slightly higher than -6°C , with minimal individual super cooling temperature recorded at -7.6°C . It has been suggested that colonies and individuals would survive only minutes at these temperatures. Soil temperature is an important limiting factor in the spread of RIFA, as soil acts as an insulator. Colonies have been observed to survive air temperatures of -14.5°C to -17.8°C and soil surface temperatures of 0°C to -1.9°C . Established colonies are able to move up and down the temperature gradient that develops within the nest, protecting themselves from extreme soil surface and air temperatures.

RIFA are susceptible to dry and hot conditions; exposure for 1 hour at 48°C (0% relative humidity) killed RIFA that had been acclimatised for weeks to a temperature of 32°C or less. Queens held at 40°C died within 24 hours, before laying eggs. Adequate soil moisture is required prior to mating flights and also appears to be necessary for the successful establishment of a nest. In one study, females that were unable to excavate more than a shallow trench in hard-packed soil died.

RIFA are omnivorous, opportunistic feeders and will feed on almost any type of animal or plant material and will cannibalise one another if food is short. However, their primary diet has been shown to consist of insects, other small invertebrates, and plant saps (phloem). RIFA have been reported to feed on a variety of crops, including soya beans, citrus trees, corn (germinating seeds and seedlings), potatoes (young plants and tubers), okra, eggplant, cabbage, peanuts, and watermelon. They are also associated with cotton and sugar cane, as they feed on insects that feed on these products. RIFA are attracted to sugar, certain amino acids and some plant oils containing polyunsaturated fatty acids.

Economic impact assessment (full report attached Appendix 1)

MAF undertook an economic impact assessment in September 2001 and noted the following:

- Estimation of potential economic impacts of RIFA was for the North Island and upper South Island only and was based on minimal government intervention.
- Evaluation of selected impacts was carried out on households, infrastructure and agriculture and suggested that following range expansion and

consolidation, the full annual cost of living with RIFA would be at least \$318 million.

- The present value of the total impacts over a 23 year period of range expansion and consolidation from initial establishment was indicated to be at least \$665 million.

The impacts modelled comprised a combination of damage and treatment costs, given current technology. All unit costs were expressed in 2001 NZ dollars, using, where necessary, consumer price indices (Bureau of Labour statistics, US Department of Labour, Statistic New Zealand) and a five year average exchange rate (Reserve Bank of New Zealand). In expressing future impacts in present value terms, the discount rate was set at ten percent.

(Note: minimal government intervention was identified as a small amount of government expenditures on facilitating the effective management of the fire ant by individuals and groups undertaking their own treatment activities)

Household impacts

The cost component of household impacts was modelled on the following:

- fire ant treatment costs;
- repair and replacement costs;
- medical costs; pet treatment costs; and
- the value of forgone outdoor household activities.

Infrastructure impacts

The cost component of infrastructure impacts was modelled on the following:

- highways;
- electricity, telephone and cable services;
- public access urban areas;
- school grounds; and
- golf courses.

Agriculture impacts

The cost component of agriculture impacts was modelled on the following:

- cattle (beef and dairy) productions;
- grain, arable and horticultural crop production; and
- nursery crop and turf grass production.

(**Note:** that there were a number of impacts not evaluated, most notably the environmental impacts of the fire ant, including the risks to indigenous flora and fauna, which could be considerable. Other unquantifiable costs include the possible reduction of property values in the infested areas, and loss of enjoyment of outdoor recreational activities.)

(d) Vector(s) of invasion(s) (e.g. of deliberate importation, contamination of imported goods, ballast water, hull-fouling and spread from adjacent area. It should be specified, if known, whether entry was deliberate and legal, deliberate and illegal, accidental, or natural.)

Establishment in New Zealand

The establishment of RIFA in New Zealand requires the importation of a viable queen, either as a newly mated female, or through the inadvertent importation of all or part of a RIFA nest.

The following summarises the likelihood of RIFA introduction via each examined pathway. It must be emphasised that any commodity from a RIFA-infested country, that has spent a period of time outdoors and in contact with the ground, should be considered to be a high risk.

Route and Likelihood of introduction

Likelihood -Very high

- Commercial importation of untreated soil that undergoes no inspection or post-arrival quarantine.

Note such an importation is prohibited, but is included here as the point of reference for other pathways

Likelihood - High

- Sea containers – wharf-inspected,
- sea containers – transitional facility-inspected,
- packaging material,
- sea transported and wharf-inspected,
- vehicles,
- used car parts,
- used machinery,
- non-wooden building materials,
- untreated and non-manufactured wooden building material,
- bark,
- hay,
- used electrical equipment.

Likelihood – Moderate

- Sea vessels,
- personal effects (unaccompanied baggage),
- animal containers,
- packaging materials: air,
- packaging materials: sea – transitional facility-inspected,
- nursery stock (dormant bulbs),
- manufactured wooden building materials,
- treated wooden building materials.

Likelihood – Low

- Aircraft,
- accompanied baggage: air,
- accompanied baggage: sea,
- air containers,
- nursery stock (raised from seeds or cuttings),
- soil imported under MAF soil import health standard,
- straw,
- air courier cargo,
- international mail.

Likelihood – Negligible

- Transportation on a person,
- nursery stock (tissue culture),
- beehives.

(e) Assessment and monitoring activities conducted and methods applied, including difficulties encountered (e.g. uncertainties due to missing taxonomic knowledge)

Delimiting and Surveillance around the original colony

MAF undertook an intensive visual search of the area within a 500 metre radius of the known RIFA site. This was followed by a bait surveillance programme of the same area. High risk sites within a five kilometre zone were also baited.

Surveillance methods consisted of the following:

- Pit-fall traps at the original colony site;
- Active visual and attractant bait surveillance within a one kilometre radius of the original colony;
- bait station surveillance of areas of the airport that have not already been surveyed;
- baited surveillance of risk sites such as plant nurseries within five kilometres of Auckland airport;
- Bait station surveillance of excavated airport soil.

2. Options considered to address the problem

(a) Description of the decision-making process (stakeholders involved, consultation processes used, etc.)

In order to advise Government on the progress, effectiveness and recommended direction of the response, MAF convened a Policy Development Advisory Group (PDAG). The PDAG was made up of representatives from MAF, other government agencies, industry and interested groups that may be affected by the outcomes of any decisions made by government.

MAF followed procedures outlined in the MAF Policy statement on responding to an exotic incursion August 2001. This policy statement is predicated on that of the Biosecurity Council as detailed in the link below. <http://www.biosecurity.govt.nz/bio-strategy/library/policy-incursion.htm>

Recommendations on response actions were made to the Chief Technical Officer – Forest Biosecurity.

(b) Type of measures (research and monitoring; training of specialists; prevention, early detection, eradication, control/containment measures, habitat and/or natural community restoration; legal provisions; public education and awareness)

Treatment of the original nest.

Following immediately from the report of the nest, MAF staff visited the site and the colony was treated with insecticides (liquid diazinon, chlorpyrifos granules, and pyrethrum gas). All ants were killed. It was possible however that some ants had flown from the colony before it was found and these ants could have built or be building new colonies. Further surveillance indicated that there were no further red imported fire ant colonies within the high risk area surround the initial site. Additional surveillance was undertaken in the area during spring and summer 2001/2002 to confirm that the incursion was confined to a single colony and no new colonies had established.

RIFA Technical Advisory Group

MAF convened a technical group to provide advice and peer review on the RIFA response. The technical group included science, operational and policy expertise from MAF, Auckland Regional councils, Department of Conservation, Ministry of Health, the Royal Forest and Bird Protection Society, and Flybuster (a pest control operator).

Overseas Experts

RIFA experts from the USA were consulted throughout the response. They provided advice on ant biology, dispersal mechanisms, temperature and climatic dependencies, and surveillance and treatment methods. The experts reviewed all phases of the response to ensure all appropriate measures were being taken to detect any other colonies and prevent RIFA from establishing in New Zealand. A number of overseas experts visited New Zealand during the response. MAF staff also visited Brisbane Australia to assess the RIFA situation there in order to incorporate any learning into the Auckland response programme.

Operational response plan development

An operational plan was developed for the period 1 November 2001 and 31 June 2003.

This plan covered:

- surveillance to detect spread from the original colony site at Auckland Airport;
- surveillance at risk sites to detect possible further existing incursions of RIFA and ensure early detection of any future incursions;
- a publicity campaign to increase public awareness and encourage reporting;
- a RIFA response information management system and field operations response team.

Communication and public awareness

MAF made national and regional media releases to alert communities most likely to encounter RIFA. They distributed approximately 95,000 RIFA fact sheets to households and businesses in the area surrounding the original colony site. They also

distributed fact sheets to public health services, veterinarians, pest control operators and other professionals who were most likely to recognise evidence of RIFA in their work.

MAF's communication plan/publicity campaign included the following components:

- Presentation of information to raise awareness of people who work in risk areas such as garden centres, golf courses, parks, ports etc, and for other people most likely to detect evidence of RIFA;
- Multi-lingual pamphlets, posters, videos and signage;
- Direct mail-outs and provision of information on relevant web-sites.

Legal instruments

RIFA was declared an unwanted organism under section 164c of the [Biosecurity Act 1993](#) by the Chief Technical Officer – Animals 28 March 2001. This declaration enabled access to a range of regulatory powers within the Biosecurity Act 1993 in order to facilitate rapid response actions.

Regulatory powers used included controlled area notices, authorisation of inspectors and authorised persons, inspection and intervention at transitional facilities and containment facilities and direction notices.

Note: A Chief Technical Officer is an independent statutory decision maker appointed under section 101 of the [Biosecurity Act 1993](#).

(c) Options selected, time-frame and reasons for selecting the options

The preferred response option was to conduct delimiting surveillance out to 1 km radius from the nest site and also at high risk sites (suitable habitat) within 5 km radius of the nest site to detect any colonies that may have dispersed from the original nest. The surveillance was conducted twice during the summer of 2001/02, and repeated once again in the summer of 2002/03.

Pitfall trap surveillance was conducted in the immediate vicinity of the nest site to ensure no incipient colonies remained in that area.

(d) Institutions responsible for decisions and actions

Response decisions and lead for response activity – MAF Biosecurity (now known as MAF Biosecurity New Zealand).

On ground operational activities (including treatment and surveillance) – AgriQuality New Zealand Ltd and Flybusters Insect Control.

3. Implementation of measures, including assessment of effectiveness

(a) Ways and means set in place for implementation

An external contractor (AgriQuality New Zealand Ltd) was employed to conduct the surveillance, while another external contractor (Flybusters Insect Control) was employed to conduct the nest treatment, excavation, and to treat any further nests

should they be found. MAF Biosecurity provided the management, logistics, policy, legal, and entomological expertise.

(b) Achievements (specify whether the action was fully successful, partially successful, or unsuccessful), including any adverse effects of the actions taken on the conservation and sustainable use of biodiversity

The actions were fully successful with no adverse effects on conservation and sustainable use of biodiversity. Due to the urban locations of the find and the early establishment phase of the nest, non target impacts associated with treatment were negligible.

(c) Costs of action

Approximately \$1.432 million.

4. Lessons learned from the operation and other conclusions

(a) Further measures needed, including transboundary, regional and multilateral cooperation

Instigation of the National Ant Surveillance Programme

As a result of this incursion MAF instigated a National Invasive Ant Surveillance Programme, surveying high risk sites for exotic ant species. Sites include major seaports, transitional facilities (facilities where devanning of containers occurs post border) and airports. In any given year, up to 80 % of international port locations are checked. Further surveillance is undertaken at targeted transitional facilities where trace back operations identify high risk goods and containers (included empty container washing facilities, sites where containers are devanned from high risk areas such as the pacific and Brisbane).

Surveillance for this programme is undertaken in favoured ant habitats as listed below.

Tree trunks (visual inspection and bait at base if appropriate), flowers and trunks of trees, shrubs and poles, building edges and foundations, concrete slab edges, cracked concrete, disturbed sites, drains and culverts, electrical generators and fittings, exposed rocks, fence palings, grass areas, verges, hot water pipes and heaters, isolated weeds, logs, loose gravel, low vegetation (including grass), plant pot bases, road margins, rubbish piles, shiny surfaces, soil, tree crotches and hollows, vertical surfaces, weed and plant re-growth, wooden structures, underneath stones or concrete rubble.

Bait placement

Baits were either protein based (blended peanut butter and soybean oil, and sausage meat) or sugar based (cotton wool soaked in 20 % sugar solution).

Pottles of the bait were placed out in a grid in areas with favoured ant habitat. One protein based and one sugar based stations was placed in each grid with the baits being at least 100 cm apart. Bait stations were placed out on days when the air temperature was consistently at least 20°C, with low or no wind, and it was unlikely

to rain between placement and collection. Bait stations had to be collected 2 hours after being laid then sent back to the reference laboratory for identification.

(b) Replicability for other regions, ecosystems or groups of organisms

The same principles and approach have been used for two further red imported fire ant eradication programmes in New Zealand. A response was carried at the Port of Napier in 2004 (which has recently been confirmed as eradicated), and a current investigation of a find at Whirinaki which is ongoing.

A number of principles developed in the Auckland response have been transferred to these later finds, including:

- criteria use to define the high risk areas around a find (based on flight distances of alates and the suitability of surrounding habitat);
- definitions of suitable habitat for RIFA
- use of delimiting surveillance in these high risk areas and the use of pitfall traps in areas surrounding the nest site; and
- methods for direct treatment of the nest.

Key improvements and or differences in response actions include:

- surveillance at high risk air and sea ports in New Zealand is now covered in an annual surveillance programme, rather than as part of the response surveillance programme;
- the two recent incursions have involved the use of aerial application of insecticidal ant baits where surveillance is not possible; and
- tracing the movement of items that can harbour red imported fire ants has been undertaken for the two recent responses with surveillance taking place at sites that received those high risk items.

The same investigation and response approach has been used for incursions of other exotic ant species. Difference in actions may however occur depending on the scale and site of the incursion.

(c) Information compilation and dissemination needed

Useful references

Hazard identification and import release assessment: The introduction of red imported fire ants into New Zealand via the importation of goods and arrival of craft from Australia, the Caribbean, South America, and the USA. MAF Biosecurity 5 August 2002.

<http://www.biosecurity.govt.nz/files/pests-diseases/animals/risk/rifa-release-assessment.pdf>

MAF Biosecurity New Zealand Red Imported Fire Ant fact sheet

<http://www.biosecurity.govt.nz/files/pests-diseases/animals/invasive-ants/red-imported-fire-ants/red-imported-fire-ants-fact-sheet.pdf>

MAF Biosecurity New Zealand “Pest risk analysis – Ants on sawn timber imported from the South Pacific Region <http://www.biosecurity.govt.nz/files/pests-diseases/forests/risk/ants-on-sawn-timber.pdf>

THE POTENTIAL ECONOMIC IMPACTS OF THE RED IMPORTED FIRE ANT IN NEW ZEALAND

MAF Policy

September 2001

Abstract

This paper outlines the estimation of the potential economic impacts of the red imported fire ant in the North Island and upper South Island of New Zealand under minimal government intervention. Evaluation of selected impacts on households, infrastructure and agriculture suggests that, following range expansion and consolidation, the full annual costs of living with the red imported fire ant would be at least \$318 million. The present value of the total impacts over a 23-year period of range expansion and consolidation from initial establishment is indicated to be at least \$665 million.

Introduction

Native to Southern Brazil, the red imported fire ant, *Solenopsis invicta*, (the fire ant) has established in many of the southern states of the USA. In February 2001 it was detected for the first time in Brisbane, Australia. A fire ant nest was found subsequently at Auckland international airport. This nest was destroyed and the ants killed and, to date, there have been no further signs of the fire ant in New Zealand.

Omnivorous, opportunistic and aggressive, the fire ant has become a significant environmental, economic and human health pest outside of its native range and has the potential to establish across much of New Zealand.

The purpose of this economic impact assessment is to estimate the potential costs to New Zealand of the fire ant, were it to become established. The benefit of successfully preventing the fire ant from establishing in New Zealand is the avoidance of these costs.

Methodology

The impacts of the fire ant in New Zealand, were it to establish here, are estimated on the basis of the impacts experienced currently in Texas and other southern states of the USA, where the fire ant is well established and its impacts documented, with adjustment for New Zealand conditions.

The economic impact assessment models the impacts of the fire ant under not quite no government intervention but minimal government involvement in the form of a small amount of government expenditure on facilitating the effective management of the fire ant by individuals and groups undertaking their own treatment activities. This

provides a baseline with which to compare control options available to government to avert, reduce or postpone the impacts of the fire ant in New Zealand.

The impacts modelled comprise a combination of damage and treatment costs, given current technology. Individuals and groups who may be affected by the fire ant may treat their properties to reduce the level of damage of which they are at risk. Fire ant treatment may, however, be technically and/or economically feasible only up to a point.

The fire ant, as a pest in both urban and rural areas, can have a very wide range of impacts. The economic impact assessment models selected impacts on:

- households;
- infrastructure; and
- agriculture.

All unit costs are expressed in 2001 New Zealand dollars, using, where necessary, consumer price indices (Bureau of Labour Statistics, US Department of Labour; Statistics New Zealand) and a five year average exchange rate (Reserve Bank of New Zealand). In expressing future impacts in present value terms, the discount rate is set at ten per cent.

Household impacts

The cost components of the household impacts modelled are:

- fire ant treatment costs;
- repair and replacement costs;
- medical costs;
- pet treatment costs; and
- the value of forgone outdoor household activities.

Fire ant treatment costs

The average annual cost per household of fire ant treatment is set at \$133.31 (Lard *et al.*, 2001a). This comprises expenditure on materials, equipment and professional pest control services, for treatment of, predominantly, gardens, landscapes and children's play areas, but also outside electrical and other equipment and, to a limited extent, inside houses. This does not include the value of time spent by householders on treatment activities.

Repair and replacement costs

The average annual cost per household of repairs to property and equipment and replacement of equipment, including electrical equipment, damaged by the fire ant is set at \$150.65 (Lard *et al.*, 2001a). Again, the value of time spent by householders on these activities is not included. No adjustment is made for differences in the average size and other characteristics of residential properties in Texas and New Zealand.

There is a wide range in the average annual household treatment, repair and replacement costs reported in the USA (Loope, 2000; Miller *et al.*, 2000; University

of Arkansas, 2001), in which the costs reported by Lard *et al.* (2001a) are around mid-range.

Medical costs

In modelling medical expenses associated with fire ant stings, it is assumed that each year 32 per cent of the population of infested areas are stung by the fire ant (Lofgren and Adams, 1982). Of these, it is assumed that three per cent seek medical attention and 0.5 per cent have serious or life-threatening reactions requiring hospitalisation (Texas A&M University, 2001) of, on average, one day in length (Adams and Lofgren, 1982). It is assumed that each person seeking medical attention consults a GP at least once, with an average of two GP consultations per person assumed for the seven per cent receiving medical attention for secondary infections (Adams and Lofgren, 1982). The costs of this medical attention are set at \$38.36 per GP consultation (Statistics New Zealand) and \$654.97 per hospital bed per day (Scott *et al.*, 2000), with the addition of transportation costs of \$3.19 per GP consultation and \$6.38 per hospitalisation (Scott *et al.*, 2000). The average cost of medication, either first aid, such as antiseptics and insect bite or sting treatments, or prescription, such as antibiotics and asthma treatment medications, is assumed to be \$1.50 per person stung. Additional to these costs are labour productivity losses due to absence from work and the value of any lives lost. Further medical costs, as well as fatalities, may arise from accidents resulting from fire ant damage to equipment, including electrical equipment (e.g. security lighting, traffic lights).

The medical costs modelled are low compared with average household medical expenses due to fire ant stings reported in the USA (Diffie and Sheppard, 1991; Lard *et al.*, 2001a; Miller *et al.*, 2000). The proportion of the population stung by the fire ant can range from 30 to 60 per cent (VanGelder, 2001), exceeding 50 per cent in heavily infested areas (Loope, 2000), of whom between 0.5 per cent (University of Queensland, 2001) and 5 per cent (Loope, 2000) seek medical attention, with a little under one per cent of the population hypersensitive to the fire ant stings (Lennon, 1998; Merchant, 1998; VanGelder, 2001; Vinson, 1997).

Pet treatment costs

The average annual cost of treating pets for fire ant stings is set at \$2.23 per household across all households (based on the city findings reported in Lard *et al.*, 2001a). This comprises expenditure on injections and medicated shampoos. Miller *et al.* (2000) reports a slightly lower average veterinary expense per household, whilst a considerably higher average expenditure per pet owner on veterinary costs related to fire ant stings is reported in Texas A&M University (2001). As in humans, some individuals may have severe allergic reactions to fire ant stings. Veterinary expenses in such cases can be considerable. Fire ant stings can cause death in small or weakened animals, representing an additional cost in terms of the loss of the value of these pets to their owners.

Forgone outdoor household activities

It is assumed that 27 per cent of households reduce their use of, or stop using, their gardens or yards due to the presence of the fire ant (Lard *et al.*, 2001a). The outdoor household activities reported to be curtailed include gardening, landscaping, picnicking, sunbathing, swimming and children's play. The average value of forgone

activities is set at \$281.87 per year for each household curtailing its outdoor activities (Lard *et al.*, 2001a).

The above unit costs are applied to New Zealand population and household data (Census 2001 - provisional, Statistics New Zealand). A potential household impact not modelled is reduced residential property values for infested sites relative to non-infested sites.

Infrastructure impacts

Also modelled are wider infrastructure impacts on:

- highways;
- electricity, telephone and cable services;
- public access urban areas;
- school grounds; and
- golf courses.

Highways

The annual cost of repairing highway potholes resulting from the fire ant tunnelling under road surfaces is set at an average of \$344.86 per kilometre (the mid-point of the values in Morrison Silva, 1991), under low level fire ant treatment at a cost of \$143.36 per kilometre (Morrison Silva, 1991). These costs are modelled for New Zealand's state highways (Transit New Zealand, 2000), which comprise just under 12 per cent of the total length of formed roads and streets in New Zealand (Statistics New Zealand, 1999).

Electricity, telephone and cable services

The average annual cost to electricity, telephone and cable companies of repairing or replacing equipment damaged by the fire ant is set at \$14.15 per capita (Segarra *et al.*, 1999; US Census Bureau). No adjustment is made for different per capita electricity and communications use in Texas and New Zealand.

Public access urban areas

Average annual fire ant treatment and repair and replacement costs in urban areas accessed by the public are set at \$142.31 per hectare (Lard *et al.*, 2001a). These areas include parks, sports fields, outdoor swimming pools, recreation areas, cemeteries, airports, lawns and landscaping around offices and other buildings and roadways and footpaths adjacent to grassed areas providing suitable habitats for the fire ant. This cost is applied to all urban areas (built up areas, consisting of any contiguous group of buildings larger than the minimum mapping unit of one hectare) and urban open spaces (MAF Land Cover Database Statistics, 1996/97).

School grounds

The average annual costs of treating for the fire ant and undertaking repairs or replacements for fire ant damage in school grounds are set at \$220.65 per hectare (Lard *et al.*, 2001a). This includes the value of the time spent on these activities by school personnel. Expenditure on fire ant treatment comprises over 70 per cent of these costs, with almost all schools hiring professional pest control services. School ground areas are taken from Treeby (1997).

Golf courses

Average annual fire ant treatment and repair and replacement costs for golf courses are set at \$1,512.09 per hectare (Lard *et al.*, 2001a). The largest component of this is expenditure on replacement, particularly of irrigation systems. Estimates of golf course area are taken from Treeby (1997).

Additional to the above are costs to other private businesses. These costs may be minimal in heavily built up areas less suitable for fire ant establishment but could be considerable for businesses located close to areas providing attractive habitat for the fire ant. In addition to expenditure on fire ant treatment and repairs and replacements for fire ant damage, other impacts may include disruption of work and loss of business due to the presence of the fire ant, absence from work of staff stung, increased wastage of organic materials, more secure storage of organic materials and waste and more frequent waste disposal.

Agricultural impacts

The impacts of the fire ant on agriculture are modelled for:

- cattle (beef and dairy) production;
- grain, arable and horticultural crop production; and
- nursery crop and turfgrass production.

Cattle production

The impacts of the fire ant on cattle production are modelled as incurring an average annual cost of \$9.84 per head of cattle (Barr and Drees, 1996; USDA, 1997). This encompasses a wide range of damage and treatment costs, the largest of which are repair and replacement costs for damage to electrical equipment and insecticide expenditures. This average cost is applied to both beef and dairy cattle in New Zealand (MAF, 1999) although, in practice, costs to these two sectors may differ. No adjustment is made for the effect on average cost per head of cattle of higher stocking densities in New Zealand than in Texas.

Grain, arable and horticultural crop production

The fire ant can impact on production of a wide range of crops, from grain and arable to vegetables, fruits (including citrus and grapes) and nuts, depending on the availability of preferred food sources and climatic conditions. Costs arise through not only reductions in crop yields, due to either feeding or plant damage, but also damage to equipment, including irrigation systems, machinery and electrical equipment, structural damage, disruption of harvesting and other field operations and the need for fire ant management measures.

The impacts of the fire ant on crop production are modelled as incurring an average annual cost of \$45.98 per hectare (Segarra *et al.*, 1999; USDA, 1997) across all grain, arable and horticultural crops (MAF, 1999; MAF, 2000), assuming the costs identified for six major Texas crops to be indicative of the general impacts across all crops.

Lard *et al.* (2001b) reports slightly lower costs across all agricultural producers than the sum of the above costs in cattle and grain, arable and horticultural crop

production. Teal *et al.* (1998) derives a considerably higher point estimate of the costs to cattle producers, but within a very wide range.

Nursery crop and turfgrass production

Although it is a relatively small sector, nursery crop and turfgrass production is included in the economic impact assessment due to its significance as a means of fire ant dispersal. Average annual treatment costs to comply with quarantine requirements for movements of nursery crops and turfgrass are set at \$1,847.02 per hectare (the midpoint between Sparks *et al.*, 1999, and VanGelder, 2001). Nursery crop production area (MAF horticultural statistics, June 2000) is doubled to include turfgrass for which production area data are not available.

Not included in the above agricultural impacts is the potential positive contribution of the fire ant to agriculture through its impacts on populations of agricultural pests, both invertebrates and vertebrates (e.g. rabbits). A number of the pest insects on which the fire ant is known to prey are not present in New Zealand, however, and the fire ant may also prey on insects beneficial to agriculture, including predators of insects which transmit plant diseases. It has been suggested that the construction of mounds by the fire ant may contribute to improved soil quality, by aerating the soil and enriching soil nutrients, but the effect on pasture or crop yield is uncertain.

Additional to the agricultural impacts represented in the economic impact assessment are effects on other agricultural sectors for which fire ant impact data are not available. The fire ant is likely to have impacts on other livestock production, both outdoor (most significantly, sheep, but also other animals, including horses) and indoor (e.g. feedlots and poultry houses). The fire ant may invade bee hives and feed on developing bee larvae, occasionally destroying weak colonies. It can also have impacts on fish farming and production aquaculture, affecting not only activities on land and access to water courses, but also insectivorous fish through stings inducing changes in feeding behaviour or, alternatively, causing envenomisation.

The impacts of the fire ant on forestry are likely to be limited. Although the fire ant does sometimes nest at the base of tree trunks and in trees, it likes open, sunny areas. Relatively few colonies are found in shady, wooded areas (Drees *et al.*, 2000) and the fire ant is rarely found in mature forests and other areas of heavy shade, other than where these have been disturbed by fires or storms (Western Region Integrated Pest Management Network, 2001). There may, however, be some impacts at forest edges, young stands may be susceptible to infestation and damage (including by scale insects tended by the fire ant) and fire ant management may be particularly necessary in forest tree nurseries. The fire ant may also affect harvesting and other forestry operations, through damage to electrical equipment, stings to workers and the need for fire ant treatment and management measures, given that the fire ant can establish and be transported in wood products.

A further way in which the fire ant may affect New Zealand's agricultural and forestry sectors is through impacts on exports. Additional inspection and/or treatment of exports, including of containers and packing materials, may be required, or market access reduced, if existing procedures for other pests are determined to be inadequate to detect and/or treat for fire ant nests or newly mated queens in exports to destinations where the fire ant is not yet, but has the potential to become, established.

Australia may be particularly sensitive in this respect for New Zealand exports to areas not yet infested.

There may also be secondary impacts such as reduced agricultural land and business values in infested areas.

Government expenditure

The economic impact assessment models the impacts of the fire ant under not quite no government intervention but minimal government involvement in the form of a small amount of government expenditure on facilitating the effective management of the fire ant by individuals and groups undertaking their own treatment activities. The areas from which the data on the impacts of the fire ant are drawn have long histories of attempts, at both Federal and State levels, at fire ant control, albeit more latterly focused on management rather than eradication or containment. Although these attempts have often been of limited success, without them the impacts of the fire ant may well have been greater and/or occurred earlier. Thus the impacts modelled are not consistent with zero government intervention. In addition, it could be argued that a complete absence of government involvement would not realistically occur. Assessment of the impacts of the fire ant under minimal government involvement provides a baseline with which to compare control options involving greater levels of government intervention, such additional border control measures to prevent the fire ant from entering and establishing in New Zealand or, if it has already established, a programme of eradication or aggressive containment, in order to avert, reduce or postpone the impacts of the fire ant in New Zealand.

Average annual government expenditure on facilitating the effective management of the fire ant is set at \$0.11 per capita. This is based on current legislative appropriation for community management, surveillance, quarantine (for movements of high risk materials such as nursery plants), regulatory and educational activities in infested areas under the Texas Imported Fire Ant Research and Management Plan (Texas A&M University, 1998; Texas A&M University, 2001).

Proliferation of the fire ant in New Zealand

Range

Climatic modelling (CSIRO Entomology, 2001) suggests that the fire ant could establish across much of the North Island and upper South Island of New Zealand. The fire ant is therefore modelled as having impacts in:

- the Auckland region, comprising the Auckland, Manukau, North Shore and Waitakere city council areas;
- the rest of the North Island; and
- the upper South Island, comprising the Tasman, Nelson, Marlborough and Canterbury regions.

Although the climate of Canterbury may be marginal for fire ant population growth, the economic impact assessment includes some impacts in this region given that Christchurch is the main point of entry to the South Island, from both the North Island

and infested areas overseas. The fire ant is thought unlikely to occur in significant numbers further south except for isolated infestations in favourable microclimates.

Density and activity

Climate is likely to limit not only the range of the fire ant, but also the density of nests within this range and the level of fire ant activity around these nests. Consequently, the above impacts of the fire ant are likely to be of somewhat smaller magnitudes in New Zealand than in the southern states of the USA, from where the impact data derive. The relative magnitudes of these impacts in New Zealand are assumed to average:

- two thirds in the Auckland region;
- one half across the rest of the North Island; and
- one quarter across the upper South Island.

Rate of spread

Additionally, climate is likely to constrain the rate of spread of the fire ant. Callcott and Collins (1996) identify two rates of range expansion of imported fire ant in North America: an average of 147,642 hectares per annum over the period 1918-53 and an average of 2,400,703 hectares per annum over the period 1958-95. Although the latter may be considered more applicable given the greater volumes of traffic and levels of human activity today than in the first half of the twentieth century, slower rates of spread are likely initially until the fire ant population is sufficient to support this rate of spread. In the absence of information on how much slower the rate of spread would be in New Zealand than in North America, the same factors are applied as assumed for the relative magnitudes of impacts, identified above. How long it would take for the fire ant to spread across each region is estimated on the basis of application of these relative magnitudes to Callcott and Collins’ slower average annual rate for the Auckland region and faster average annual rate for the rest of the North Island and the upper South Island. Given that much of this spread is human assisted, enabling fire ant establishment to “jump” to new regions, these periods are assumed to overlap rather than run consecutively.

The impacts of the fire ant depend on not only its range but also the density of nests within this range. It is assumed that range consolidation takes as long again as range expansion. Under the assumption of initial establishment in Auckland in mid-2001, the impacts of the fire ant are modelled according to the spread indicated in Table 1.

Table 1: The spread of the fire ant in New Zealand

| Region | Establishment | Range expansion complete | Range consolidation complete |
|--------------------|----------------------|-------------------------------------|---------------------------------------------|
| Auckland region | 2001/02 | 2005/06 | 2010/11 |
| Other North Island | 2003/04 | 2011/12 | 2020/21 |
| Upper South Island | 2008/09 | 2015/16 | 2023/24 |

For each region, the annual impacts of the fire ant are phased in over the period of range expansion and consolidation (assuming the growth in annual impacts to increase at a diminishing rate), reaching full annual magnitude only upon completion of range consolidation.

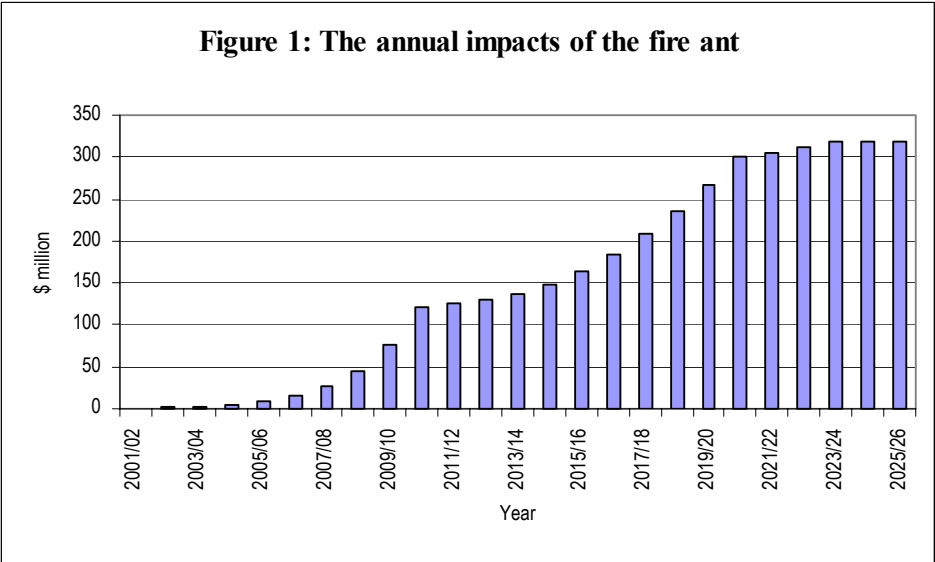
Results

Following range expansion and consolidation, the full annual costs associated with the above impacts of the fire ant in New Zealand are \$318 million. As indicated in Table 2, these costs are dominated by impacts on households.

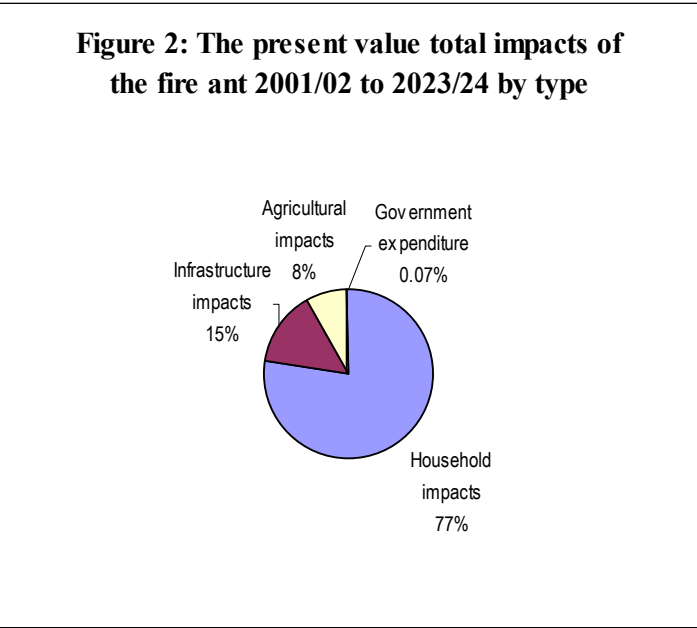
Table 2: The full annual impacts of the fire ant (2001 NZ\$)

| Impacts | Annual cost (million) | Percentage of total annual cost |
|-------------------------------------------------|------------------------------|----------------------------------------|
| Households | | |
| Fire ant treatment costs | 83.154 | 26 |
| Repair and replacement costs | 93.971 | 30 |
| Medical costs | 3.487 | 1.10 |
| Pet treatment costs | 1.391 | 0.44 |
| Forgone outdoor household activities | 47.120 | 15 |
| Total household impacts | 229.124 | 72 |
| Highways | 1.701 | 0.54 |
| Electricity, telephone and cable services | 25.103 | 7.90 |
| Public access urban areas | 11.778 | 3.71 |
| School grounds | 0.433 | 0.14 |
| Golf courses | 7.212 | 2.27 |
| Total infrastructure impacts | 46.227 | 15 |
| Cattle (beef and dairy) production | 36.814 | 12 |
| Grain, arable and horticultural crop production | 5.131 | 1.62 |
| Nursery crop and turfgrass production | 0.179 | 0.06 |
| Total agricultural impacts | 42.124 | 13 |
| Government expenditure | 0.201 | 0.06 |
| Total | 317.675 | 100 |

The annual impacts of the fire ant over a 23-year period of range expansion and consolidation from initial establishment in mid-2001 are illustrated in Figure 1, with full annual impacts from 2023/24.

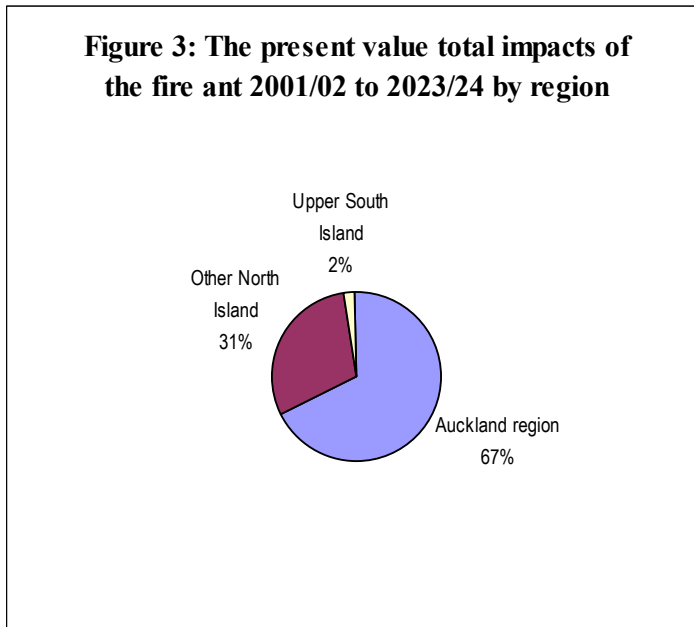


The present value of the total impacts over the period 2001/02 to 2023/24 is \$665 million. As Figure 2 indicates, over three quarters of these costs are due to household impacts. Of these, over two thirds occur in the Auckland region. Infrastructure impacts and government expenditure are similarly concentrated in the Auckland region and agricultural impacts in the rest of the North Island.



It is therefore not surprising that, as illustrated in Figure 3, two thirds of the present value total impacts over this period occur in the Auckland region (of which all but two per cent are household and infrastructure impacts). The concentration of all but agricultural impacts in the Auckland region is attributable to not only the warmer climate more favourable to the fire ant, but also this being where the fire ant first establishes in New Zealand (impacts in this region therefore occurring sooner and, accordingly, having relatively higher values in present value terms). Impacts in the

upper South Island are low in comparison given the lower population, less favourable climate and distance from the initial establishment of the fire ant.



With future growth in key variables, such as population, the impacts could be greater. Conversely, over time, research into fire ant control may improve the effectiveness and/or reduce the cost of fire ant treatment.

The key uncertainty in this economic impact assessment is the extent to which the fire ant would proliferate in New Zealand in terms of its range, density, activity and rate of spread.

Additional to the impacts modelled are costs and possibly some benefits associated with a number of impacts not evaluated. A potentially major area of impacts is that of the environmental impacts of the fire ant, and of fire ant treatment, including effects on native species. Given uncertainty as to the impacts of the fire ant on New Zealand's indigenous flora and fauna and, both directly and indirectly, on recreation and tourism activities, together with difficulties in determining the value to society of the environmental assets affected, the environmental impacts of the fire ant are not represented in this economic impact assessment but could be considerable.

Conclusion

This evaluation of selected impacts on households, infrastructure and agriculture suggests that, following range expansion and consolidation, the full annual costs of living with the fire ant, under minimal government intervention, in the North Island and upper South Island of New Zealand would be at least \$318 million. The present value of the total impacts over a 23-year period of range expansion and consolidation from initial establishment is indicated to be at least \$665 million. This is dominated by impacts on households and impacts in the Auckland region. Not included in these

estimates are a number of impacts not evaluated, most notably the environmental impacts of the fire ant, including risks to indigenous flora and fauna, which could be considerable.

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