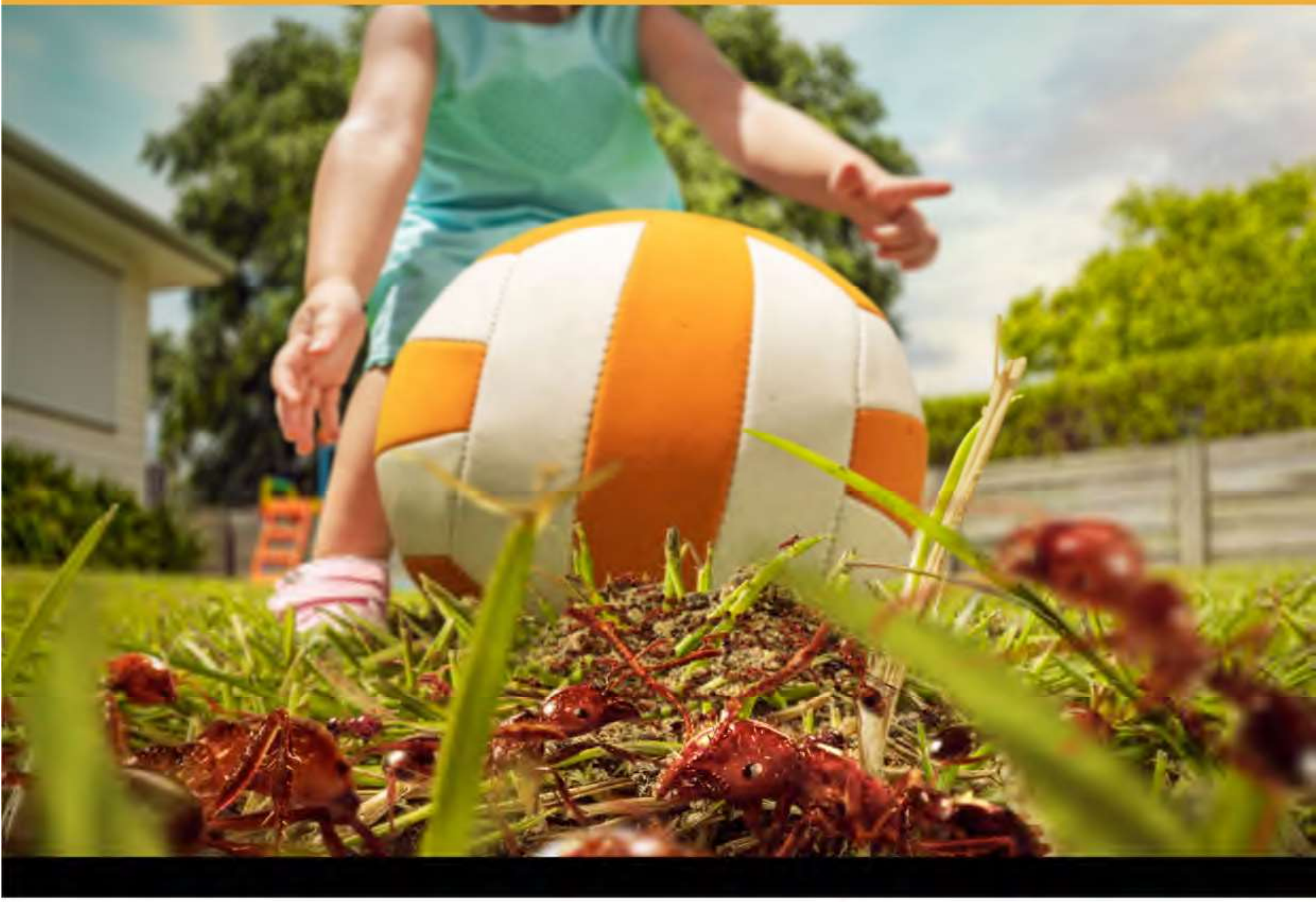
NATIONAL
Fire Ant Eradication
PROGRAM



Eradication Plan 2023 - 2027
APPENDICES

This publication has been compiled by <insert name/s> of the National Fire Ant Eradication Program, Department of Agriculture and Fisheries.

The Department of Agriculture and Fisheries proudly acknowledges all First Nations peoples (Aboriginal peoples and Torres Strait Islanders) and the Traditional Owners and Custodians of the country on which we live and work. We acknowledge their continuing connection to land, waters and culture and commit to ongoing reconciliation. We pay our respect to their Elders past, present and emerging.

Acronyms, abbreviations, glossary

RIFA	Red Imported Fire Ants (*Solenopsis invicta*)
NFAEP	National Fire Ant Eradication Program
FAST	Fire Ant Suppression Taskforce
BQ	Biosecurity Queensland
DAF	Department of Agriculture and Fisheries, Queensland
DAFF	Department of Agriculture, Fisheries and Forestry (Commonwealth)
NEBRA	National Environmental Biosecurity Response Agreement
Polygyne	Multiple queen colony with workers from multiple queens and different relatedness
Monogyne	Single queen colony with workers and a queen from the same family unit
IGR	Insect Growth Regulator
Responsive treatment	Fire ant treatment in response to public reports of fire ants using a combination of methods
RSS	Remote sensing surveillance employs a range of devices and sensors that collect data on subjects from a distance (e.g., aerial, satellite etc)
Multispectral Imagery	Imagery using multiple wavelengths across electromagnetic spectrum including red, green, blue, thermal and infrared
AI	Artificial Intelligence
GBO	General Biosecurity Obligation

Appendix 1 Chronology of RIFA incursions and eradication effort

YEAR	EVENTS
2001	Two separate incursions from the United States were found in South East Queensland at the Port of Brisbane and Richlands in western Brisbane. National Red Imported Fire Ant Eradication Program is launched as an emergency response to fire ants.
2002	Scientific review of the Program finds remarkable progress in one year and recommends funding to eradicate until 2004. If not eradicated suggests changing the treatment focus to containment.
2004	Senate enquiry on the regulation, control and management of invasive species supports a robust strategic approach to managing significant invasive species. Scientific review of the Program finds dramatic reductions in fire ant populations in treated areas and supports the continuation of the Program for two years. Post-quarantine eradication at Port of Brisbane, Queensland.
2006	New incursion of fire ants from Argentina found in Yarwun near Gladstone in central Queensland. Quarantine interception in Melbourne, Victoria. Scientific review of the Program concludes the eradication campaign has delayed fire ant spread by 10–12 years, has greatly reduced polygyne colonies cutting the impact of the fire ants by 50–70 per cent and that fire ants could potentially still be eradicated.
2007	Quarantine eradication in Darwin, Northern Territory.
2009	Quarantine eradications at Port of Brisbane, Queensland and South Australia. Post-quarantine eradication at Lytton, Brisbane.
2010	Roush Review (national Program review) recommends the Program focus on containment of the current infestation for 18–24 months. Resources diverted to remote sensing surveillance. Yarwun 2006 fire ant incursion declared eradicated.
2011	Quarantine eradication in Western Australia. Post-quarantine eradication at Roma, Queensland.
2012	Port of Brisbane 2001 fire ant incursion declared eradicated
2013	New incursion from the United States found at Port of Gladstone, Queensland

2014	Quarantine eradication in Brisbane, Queensland. New incursion from Argentina found in Port Botany, New South Wales.
2015	New incursion from the United States found at Brisbane Airport, Queensland. Quarantine eradication in Melbourne, Victoria.
2016	Port of Gladstone 2013 fire ant incursion declared eradicated. New incursion from Argentina found at Port of Brisbane, Queensland. Independent Review of the National Program finds there is a small window to eradicate the ants and recommends unified long-term national action to fund the eradication Program in South East Queensland. Port Botany 2014 fire ant incursion declared eradicated.
2017	Quarantine eradication in Adelaide, South Australia. The National Red Imported Fire Ant Eradication Program supported by governments nationally begins operations Draft and approval of 10–year Plan on 1 July.
2019	Brisbane Airport 2015 and Port of Brisbane 2016 fire ant incursions declared eradicated. New incursion from China found at Freemantle, Western Australia. A 5 km strip is added to the west boundary of the eradication area in South East Queensland in response to fire ants found in 2017-18. Biennial Independent Efficiency and Effectiveness Review of the National Program makes recommendations to support the Program.
2020	First field trials with new generation remote sensing surveillance cameras take place. Final report of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) review of the Program's movement controls for fire ant carriers supports the scientific principles behind the Program's movement controls.
2021	New incursion of fire ants from the United States found at the Port of Brisbane, Queensland. New independent review of the National Red Imported Fire Ant Program was commissioned by the Program's Steering Committee. 27 recommendations to improve the program and commented fire ants can still be eradicated from SEQ

2022	Operational review was commissioned by DAF and undertaken with the aim of exploring the degree to which the operating model, and DAF's in-kind support, needed to evolve to remain fit-for-purpose at a significantly larger scale across SEQ. Development of the Queensland funded Fire Ant Suppression Taskforce (FAST) FAST community suppression projects begin in Ipswich. Gold Coast and Logan to follow. Draft Eradication Strategy 2023–27 to replace the 10 year plan. Draft response plan 2023 – 27`
2023	Detailed workplan 23-24 developed. Response Plan and Eradication Summary combined to Eradication Plan.

Appendix 2 Technical feasibility of Eradication

This appendix assesses the technical feasibility of the proposed response for eradication of fire ants in SEQ against the following criteria:

- capability to accurately diagnose or identify fire ants
- effectiveness of the control techniques
- level of confidence that all individual fire ants present can be destroyed by the recommended control techniques
- level of confidence that it is possible to remove fire ants at a faster rate than they can propagate until the population is reduced to a non-viable density
- confirmation that the recommended control techniques are publicly acceptable
- endemic pest or disease controls that may limit or prevent establishment
- legislative impediments to undertaking the eradication
- the known area of infestation
- the likely distribution of the pest or disease and dispersal ability of the organism
- identification of the pathways for the entry into, and spread within, Australia of the pest or disease and level of confidence that further introductions are sufficiently low
- the level of confidence that the organism is detectable at very low densities (to help determine if eradication has been achieved), and that all sites affected by the outbreak have or can be found
- surveillance activities that are in place or could be put in place to confirm proof-of-freedom for sites possibly infested by the pest or disease.

4.1 Capability to accurately diagnose or identify fire ants

In comparison with Australian native *Solenopsis* species, *Solenopsis invicta* is easily distinguishable by its generally larger size, polymorphic workers, darker colour and the presence of a middle clypeal tooth.

Diagnosticians use microscopic laboratory diagnosis to positively identify fire ants. Field staff provide preliminary identification, and geneticists undertake genetic analysis to determine social form, population structure and intra-population analysis. A fire ant identification kit is also available which may be used by non-experts to positively identify fire ants in the field.

4.1.1 Field identification

Field officers make preliminary identifications in the field using the following characteristics:

- worker caste is polymorphic
- head and body are a coppery-brown colour, with a darker abdomen
- if visible, nests vary in shape and size, but can be up to 40 cm high dome-shaped mounds without any obvious entrance and exit holes. Foraging holes generally occur every 1–5 m along the underground tunnels.

Samples are then taken of ants with features consistent with the above characteristics and submitted for diagnostic testing.

4.1.2 Laboratory diagnosis

National Program scientific staff diagnose samples using visual examination of morphological diagnostic characteristics as outlined by specialised scientific web databases such as AntWeb and PaDIL.

The diagnostic characteristics of *Solenopsis invicta* are:

- worker caste is polymorphic and ranges in size from 2–6 mm
- head and body are a coppery-brown colour, with a darker abdomen
- propodeal spines are absent
- antennal scrobes are absent
- waist has two segments (petiole and post-petiole)
- antennae have 10 segments, with a two-segment club
- petiolar process is either reduced or absent
- mandibles have four teeth
- a single central seta visible on the lower edge of the clypeus
- anterior clypeal margin has a middle tooth between two lateral teeth.

National Program scientists then send confirmed positive samples for genetic analysis if required. The National Program has made a large investment in progressing genetic analysis of fire ant populations in Queensland. There are two components to the current analysis: determination of social form (monogyne or polygyne) and fragment analysis using microsatellites to determine relatedness.

4.1.3 Determination of social form

Within the National Program, the social forms of fire ant samples are determined using genetic analysis of the Gp-9 alleles. Fire ant workers and queens from monogyne (single queen) colonies always have the genotype BB, whereas fire ant queens from polygyne (multiple queen) colonies have the genotype Bb, and polygyne workers can be either BB, Bb, or bb.

Since December 2007, genetics staff conduct this analysis using a High Resolution Melt (HRM) polymerase chain reaction (PCR) technique developed by Oakey (2009) (from the National Program). During 2007, the National Program validated this method against the standard restriction endonuclease analysis (REA) PCR described by Krieger & Ross (2002). It was necessary to develop this test as the DNA extracted from field samples was of inadequate quality to perform reliable analysis.

The National Program performs a 'bulk' DNA extraction using a pool of 5–10 fire ant workers from a colony. Pooling multiple ants, rather than single ants, from a colony eliminates falsely assigning the monogyne genotype to a polygyne colony (as the BB genotype exists in workers from both types of nests). The National Program performs DNA extraction using a commercial kit (QIAgen DNeasy Blood and Tissue kit) according to the manufacturer's instructions.

Knowledge of social form is useful to the National Program, as both forms have different dispersal characteristics and associated risk of spread, meaning that the operational response to the detection of a polygyne colony can be different to that for a monogyne colony. For instance, the detection of a polygyne colony may require more thorough tracing (and possibly require more intensive treatment methods to reduce the initial high density of colonies), but may not require the same extent of surveillance compared to the discovery of a monogyne colony, as the polygyne social form rarely develop from nuptial flights.

4.1.4 Determination of colony relatedness

Microsatellites are short tandem repeats found within the genes of eukaryotic organisms. These repeats are prone to higher levels of mutation and can be used in genetic analysis to determine kinship and levels of relatedness between individuals. The variable number of repeats can be detected using PCR. An individual's pattern of microsatellite lengths (alleles) at multiple microsatellite sites (loci) in nuclear DNA provides a microsatellite genotype for that individual.
The National Program conducts fragment analysis to determine the following:

- population structure - which aids in the determination of:
  - how many populations are present and how many separate incursions have occurred
  - the presence/absence of sub-structure within a population

- whether a population is demonstrating genetic equilibria (population stability)

- intra-population analysis – which aids in the determination of:
  - estimating the number of founding queens – the relatedness between colonies
  - estimating the dispersal distances of newly detected colonies
  - whether newly identified colonies survived treatment or are a new infestation
  - estimating the number of undetected colonies.

Colony relatedness and population analysis are useful to the National Program as they provide crucial information about the number of times fire ants have established (number of separate incursions), and whether new detections are the result of treatment survival, or the result of colony spread.

4.2 Effectiveness of the control techniques

The incidence of fire ant infestation is reduced through:

- the early detection of fire ant colonies
- the destruction of those colonies and the treatment of all areas around the colonies (based on the limit of natural dispersal of the pest)
- the prevention of new colonies forming in areas outside of the limit of natural dispersal of the pest (as a result of human-assisted spread).

Since 2001, Australia has had measures in place to detect, control and contain fire ants in areas of Queensland where they are known to occur, and measures to eradicate fire ants from known infested areas.

Detection strategies used depend largely on abiotic and resource-related factors (e.g. targeting surveillance to suitable fire ant habitat in proximity to known infestations, and conducting detection surveys at times when treatment will be ineffective due to ant foraging behaviour). Control and containment measures include addressing the risk of human-assisted spread, and eradication measures include the use of chemical products to destroy infestations.

Experience gained in dealing with fire ants in the USA initially provided the basis for developing a course of action for control and eradication of fire ants in Australia. Subsequently, national oversight groups,

4.2.1 Detection methods

The National Program employs a number of surveillance strategies for the detection of fire ants, dependent on abiotic factors that influence fire ant behaviour, infestations levels and available resources.

4.2.2 Containment measures

The key control measures for containment of fire ants is the implementation of movement controls on infested areas and high-risk materials, as well as treatment around the perimeter of the infestation.

Queensland's *Biosecurity Act 2014* (the Act) provides the legislative framework for biosecurity measures designed to safeguard our economy from pests including fire ants. The Biosecurity Regulation 2016 (the Regulation) sets out how the Act is implemented and applied.

4.2.3 Eradication measures

The National Program uses a number of chemical products that have been approved for use under the conditions of the relevant product label or permit. The following section details chemicals currently used in the National Program, as well as their destruction effect on the pest. These chemicals have been employed in the eradication of the Brisbane Airport (2015), Yarwun (2013), Yarwun (2006) and Port of Brisbane (2001) incursions. It is proposed that the same chemicals will continue to be used to treat fire ants in SEQ.

a) Fipronil treatment and effect

The National Program currently uses fipronil in a liquid form to conduct direct nest injection (DNI), in a once only application. Fipronil is a slow-acting poison which is non-repellent and undetectable. It kills insects by both contact and ingestion as it disrupts normal nerve function, and works by blocking the GABA-gated chloride channels of neurons in the central nervous system. The GABA-receptor system is responsible for inhibition of normal neural activity (i.e. prevents excessive stimulation of the nerves). When the system's regular functions are blocked by fipronil, the result is neural excitation and the death of the insects.

b) Insect growth regulator treatment and effect

Currently, broadcast treatment baits are crushed corn impregnated with soybean oil and an insect growth regulator (IGR), either S-methoprene or pyriproxyfen.

The use of an IGR interferes with the growth and development of ants, thereby breaking the reproductive life cycle, causing starvation of the colony. Ant workers pick up the bait granules and take them back to the colony, where workers extract the toxic oil and feed the bait to both the queen and immature ants, preventing worker replacement through the degeneration of the queen's reproductive organs. The lack of worker replacement results in colony death as the existing worker ants age and die.

In field trials conducted in the USA on methoprene (0.5% active ingredient), with one application, efficacy rates ranged between 66% and 98% (average 83% over several studies). The time taken to reach maximum efficacy ranged from 4–8 months (the 98% efficacy was achieved over eight months) (National Program unpublished data 2011).

In field trials with one application of pyriproxyfen, efficacy rates ranged between 86.9% and 100% (average 95% over five studies). The time taken to reach maximum efficacy ranged from 2–9 months, but in a few studies, efficacy rates of 95–100% were achieved in 2–6 months. Pyriproxyfen is relatively stable in sunlight with a half-life of 3–16 days (National Program unpublished data 2011).

S-methoprene is permitted for use up to the edge of waterways, whereas pyriproxyfen cannot be applied within 8 m of water when using ground-based equipment. S-methoprene is used for the aerial baiting regime.

c) Indoxacarb treatment and effect

The National Program has implemented the use of a fast-acting bait alternative to aid in the treatment of polygyne infestation and in areas that are awaiting the roll out of eradication treatment. Like the IGR baits, this product is made of a corn grit carrier that is impregnated with soybean oil and indoxacarb. Indoxacarb is a slow acting poison that disrupts the insect central nervous system by blocking sodium channels. When the sodium channels are blocked by indoxacarb, the insect stops feeding, becomes paralysed, and dies.

Similar to the IGR baits, indoxacarb bait is collected by foragers and returned to the colony where the toxic oil is extracted and passed through the colony via communal feeding behaviours (trophallaxis). Indoxacarb has the most profound impact on workers and does not cause sterility in colony queens or immature reproductive ants. As such, indoxacarb baits are utilized where the goal is to rapidly reduce the number of worker ants. This product may be used in combination with insect growth regulator baits as part of a broader treatment strategy.

The National Program will continue to investigate existing and new treatment products as they become available, and liaise with the Australian Pesticides and Veterinary Medicines Authority (APVMA) in regard to approvals for these products.

4.2.4 Bait distribution methods

Bait in SEQ will be distributed either aerially, on foot, or using an utility terrain vehicle (UTV) or blower truck, with aerial baiting being the most efficient method of application. Manual application of bait on foot is the most labour intensive and expensive method of treatment, but it is the only option available for use in heavily built-up areas or other areas where it is not possible or practical to treat using mechanical methods. This method involves program staff carrying handheld and operated bait dispersal devices and systematically walking over the area surrounding the fire ant infestation. In heavily vegetated areas and steep terrain, a backpack blower unit may be substituted for, or work in combination with, hand-operated bait spreaders to ensure a more effective coverage of the area.

4.3 Level of confidence that all individual fire ants present can be removed/ destroyed by the recommended control techniques

Australian efficacy data proves that DNI is almost 100% effective in destroying a fire ant colony, and is not subject to foraging activity and associated temperature considerations (National Program unpublished data 2009, 2019).

Published data from the USA indicates that broadcast IGR baiting has proven to be effective against fire ants (Drees *et al*. 1996), with reports indicating 80–95% control within 1–6 months (Barr 2000). A higher level of confidence in achieving eradication of a known infestation is achieved through the conduct of multiple rounds of treatment and combining the confidence obtained from each treatment.

This is represented by the formula:
C=1–(1–C1) x (1–C2) x (1–C3) ... (1–Cn)

Where C is the confidence provided after n treatments, and Cn is the confidence provided by each round of treatment.

Assuming the confidence provided by each round of treatment is constant, the confidence of success over multiple rounds of treatment may be represented by the following formula:

C=1–(1–tE)n

Where tE is the treatment efficacy, and n is the number of treatments conducted in the treatment area.Assuming a treatment efficacy of 80% for each round of bait treatment, **Table 4** demonstrates that a confidence of success in destroying fire ant infestation in the treatment area after six rounds of treatment is 99.994%.

Efficacy per round of treatment (%)	[illegible] (%)					
	1 round	2 rounds	3 rounds	4 rounds	5 rounds	6 rounds
10	10.000	19.000	27.100	34.390	40.951	46.856
20	20.000	36.000	48.800	59.040	67.232	73.786
30	30.000	51.000	65.700	75.990	83.193	88.235
40	40.000	64.000	78.400	87.040	92.224	95.334
50	50.000	75.000	87.500	93.750	96.875	98.438
55	55.000	79.750	90.888	95.899	98.155	99.170
60	60.000	84.000	93.600	97.440	98.976	99.590
70	70.000	91.000	97.300	99.190	99.757	99.927
75	75.000	93.750	98.438	99.609	99.902	99.976
80	**80.000**	**96.000**	**99.200**	**99.840**	**99.968**	**99.994**
90	90.000	99.000	99.900	99.990	99.999	100.000
100	100.000	100.000	100.000	100.000	100.000	100.000

Table 4: Confidence of treatment success over multiple rounds of treatment

However, additional unquantifiable factors such as temperature, terrain and the effectiveness of delivery systems can impact on the confidence of eradication of a colony provided by an individual or series of treatments. The theory also assumes that each treatment is a ‘perfect’ treatment and is applied without error and as specified over the treatment area.

National Program experience has shown that polygyne infestations take longer to kill and more rounds of bait. A National Program trial (concluded April 2016) with Distance® bait at Ebenezer required five rounds of treatment before all colonies were destroyed. Analysis of early National Program data on 60 study sites showed that, using baits alone, all monogyne infestations (n=22) were eradicated in 15–18 months, but polygyne infestations (n=38) were not eradicated until 24–30 months (McNaught *et al*. 2014).

Polygyne colonies have multiple queens (up to several hundred have been recorded in the USA) and higher density of mounds. For IGRs to work effectively, the active chemical must be maintained within the colony at levels high enough to cause brood production to cease and for long enough to allow the colony to age and die. At high initial populations of fire ants, competition between colonies for available bait may result in insufficient quantities of chemical circulating within some colonies, allowing them to persist for longer than populations with lower densities. As well, there is a hierarchy of feeding of queens in polygyne colonies; dominant (alpha) queens are fed first and the other queens get the crumbs from the table. This means that not all queens receive the required dosage of the chemical at each round of treatment.

In order to destroy polygyne infestations faster, the National Program may use a combination of IGR baits and a toxicant or DNI to reduce the initial high density of colonies. However, the National Program will only apply this treatment regime to known polygyne infestations and is unable to implement this for incipient or undiscovered infestations.

Assuming a gross overestimate of the efficacy or accounting for imperfect treatment during each round of treatment, Table 4 also demonstrates that to achieve an acceptable 99% confidence that fire ants have been destroyed in the area after six rounds of treatment, the efficacy provided by each round of treatment may be as low as 53.6%.

This is represented by the formula:
tE=1–(1–C)1/ n

Where tE is the treatment efficacy, n is the number of treatments conducted in the treatment area, and C is the desired confidence to be provided after n treatments.

Therefore:

tE=1–(1–0.99)1/ 6 tE= 53.58%

The National Program will continue to undertake treatment efficacy testing throughout the life of the eradication to maintain confidence that treatment methods used are effective.

4.4 Level of confidence that it is possible to remove fire ants at a faster rate than they can propagate until the population is reduced to a non-viable density

DNI of known fire ant colonies is almost 100% effective in destroying the colony and broadcast baiting has proven to be effective against fire ants (refer to Section 3.2.3).

A treatment program using a combination of DNI and broadcast baiting was used to eradicate fire ants at Yarwun (2006 and 2013), the Port of Brisbane (2001) and Brisbane Airport (2015), with these areas subsequently being declared free of fire ants.

The same strategy is being implemented for eradication of the South East Queensland fire ant incursions. To remove fire ant populations at a faster rate than they can reproduce requires the application of the full treatment regime across all infested areas.

4.5 Confirmation that the recommended control techniques are acceptable

The National Program has operated since 2001, and operates with community support, as evidenced by the continual submission of ant samples by the public. The National Program has applied for and been granted approval for a number of chemical products to be used under the conditions of the relevant product label or permit. All chemicals are used in accordance with label specifications and permits as issued by the APVMA. The National Program will continue to monitor the availability of new chemicals for possible use in the enhanced program.

4.6 Endemic pest or disease controls that may limit or prevent establishment

No endemic pest or disease controls have been identified that may limit or prevent establishment.

4.7 Legislative impediments to implementing eradication

There are no legislative impediments to the implementation of this 10-Year Plan. Fire ants are restricted biosecurity matter under the Queensland *Biosecurity Act 2014*.

4.8 Known area of infestation

The current 'footprint' of this infestation, the area in which controls are applied on the movement of materials likely to harbour fire ants, is approximately 800 000 hectares, but the actual area infested is only a small fraction of that, and is very dispersed and generally low density.

4.9 Likely distribution of fire ants and dispersal ability of fire ants

CLIMEX and Climatch modelling of the potential distribution of fire ants indicates that there are few places in Australia where fire ants could not establish (refer to section 5.2 'Cost-sharing apportionments'). In arid regions, fire ants can colonise anywhere there is a source of water (e.g. surface, accessible groundwater or irrigation). Potential spread modelling was initially based on US climatic limitations such as a low cold tolerance (Buren *et al*. 1974), but fire ants have been seen to survive in areas with winter snow such as the east and west coasts of the USA, and could well reach Canada (Bennett 2016).

Scanlan *et al*. (2006) also modelled the spread of fire ant based on dispersion through the formation of new locations of infestations and spread within each location. The estimations of new locations were based mainly on natural spread, with some allowances for human-mediated spread. This modelling indicated that fire ants could spread to an area of 6 million km2 across Australia. While natural spread may take some time, it may occur sooner as a result of human-assisted spread.

If spread were to occur at the same rate as recorded in Texas in the USA (i.e. 48 km each year between 1957 and 1977 (Hung & Vinson 1978)), fire ants would now extend west to Longreach, north to Bowen and south to Canberra (National Program unpublished data 2017). In China, spread has occurred at an estimated rate of 80 km per year (Lu *et al*. 2008).

4.10 Level of confidence that fire ants are detectable at very low densities and that all sites affected by the outbreak have or can be found

The National Program employs a number of surveillance techniques for the detection of fire ants. The most appropriate method depends on infestation and treatment status, terrain type, infrastructure, available resources and cost efficiency. Most commonly, surveillance is undertaken on foot by a field team, but post-treatment validation processes may use odour detection dogs, in-ground lures and visual surveillance. Community engagement (passive surveillance) is also a very effective surveillance tool, generating valuable positive and negative sample data.

The National Program will consider remote sensing surveillance technologies (RSS) Previously, RSS was used to undertake delimitation activities, but in the future it may be used as a tool to undertake broadscale surveillance and support a clearance methodology.

On-ground visual surveillance, odour detection dogs, and passive surveillance will be employed in SEQ to determine that all infested sites have been found and that fire ants have been eradicated.

Visual surveillance

Members of the field team form a line with pre-set spacing, determined by difficulty of detection as a result of terrain or vegetation type, and move forward to conduct a survey sweep across the land parcel to be surveyed. The method will be repeated until all areas of the land parcel have been inspected.

It is estimated that visual surveillance has an 80% efficacy of detection. The ground/visual search detection rate of 80% is derived from trials conducted in Taiwan by staff of the Biosecurity Queensland Control Centre.

Odour detection dogs

National Program testing indicates that there is an 80–100% confidence level for odour detection dogs in detecting fire ant infestation if present.

Passive surveillance

Passive surveillance by the community is a useful tool to detect infestation within and outside known infested areas. The invasive and aggressive nature of fire ants support their detection through passive surveillance techniques in areas where there is human activity and fire ant awareness material or activity is provided.

Remote sensing surveillance

The need for accurate and reliable RSS has been highlighted in several of the NFAEP reviews to-date and was recommended by the Strategic Review Panel. Investments in this capability have yet to be fully realised, however it is anticipated that this capability will improve as the technology matures and its use becomes more widespread in other contexts. Effective improvement in this form of surveillance will greatly assist the NFAEP to meet its eradication objective.

4.11 Surveillance activities that are in place or could be put in place to confirm proof of freedom for sites possibly infested by fire ants

A pest-free area is defined as 'an area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained' (FAO 1996).

In Australia, principles for the establishment of pest-free areas have been set to provide guidance to Commonwealth and state agencies in making formal decisions about the pest-free status of Australia, or parts of it, and to provide evidence to that effect. These guidelines are provided as a report commissioned by the Department of Agriculture, Fisheries and Forestry and Plant Health Australia, *Guidelines for the Establishment of Pest Free Areas for Australian Quarantine* (Jorgensen et al. 2003).

In cases where the spread of the pest has been clearly delineated and the infested area clearly has some form of natural or artificial boundaries that would in some way limit the spread of a pest (e.g. host availability, climate characteristics or regulated control and containment measures that would limit the spread of the pest out of the area), national principles for the establishment of pest free-areas may be applied as the risk of reinfestation from outside the defined area has been addressed.

a) Estimating a minimum predicted apparent pest prevalence As part of the survey validation process, estimation must be made on the minimum predicted apparent prevalence of the pest within the survey area at the time of survey. In this instance, a determination of minimum predicted prevalence at the time of each survey is based on a conservative but realistic consideration of the likely multiplication, spread and survival of the pest since the 'pest prevalence start date', which is the date after which the last treatment was applied. A conservative approach was taken by assuming that the minimum number of colonies survived treatment (i.e. one colony). Modelling work by Schmidt et al. (2010) provides a quantitative estimate of the increase in fire ant nests over time. The estimates are based on colony point data in SEQ provided by the National Program. A minimum apparent pest prevalence (in nests) may be estimated at the time of each survey round.

b) Estimating sensitivity of surveillance and overall test sensitivity

Collaborative survey sensitivity trials conducted in Taiwan by the National Program provide some guidance for estimating surveillance sensitivity. The trials consisted of multiple passes of surveillance of plots with low to high densities of fire ant mounds. The trials found that, for a fire ant colony where a nest structure is visible, and the area is inspected by National Program staff on foot undertaking an 'emu parade' inspection, an average of 82% survey sensitivity was achieved using the specified inspection method. For large mounds (>30 cm) 100% were detected.

Based on these trials, the National Program assumes a conservative 80% sensitivity of surveillance for detecting a fire ant nest using the specified method. Suspicious samples collected during surveys are considered as 'presumptive positives' and are sent for laboratory diagnosis. The final assessment of the presumptive positive sample taken as part of the field inspection is undertaken through the conduct of two independent diagnostic tests. The initial diagnostic identification is followed by an additional confirmatory analysis by a second diagnostician.

This process also provides for independence by allowing the independent diagnostician to confirm the result by performing the same test. This provides for an extremely high diagnostic test specificity (the probability of a negative test result given that the sample is not fire ant). However, multi-layer diagnostic tests can provide a potential for reduction in diagnostic test sensitivity (the probability of diagnosing a positive test result given that the pest is present) by providing more opportunities for test failure where a final determination is made based on the result at the final level diagnostic test (the test layer where the result comes up negative and the result is considered as negative and no further action is taken). In this case, and in many cases where multiple independent tests are performed, the testing protocol incorporates a number of controls and the provision for the diagnostician to repeat the test where the test result is ambiguous or unexpected based on the results of previous tests.

Further, samples generally include between one and 10 ants. The diagnostic process requires that each ant in the sample is diagnosed, further reducing the likelihood of a sample being fire ant and being dismissed as a negative sample. The test sensitivity is the probability of detection of a red imported fire ant nest, taking account of the survey sensitivity and that provided by the diagnostic test. In this instance, the probability of detection through two statistically independent tests equals the product of the individual probabilities of detection of both tests. It is represented by the following equation:

$$Set = Ses \times Sed$$

Where Set is the test sensitivity, Ses is the survey sensitivity, and Sed is the diagnostic test sensitivity.

No studies have been undertaken on the diagnostic test sensitivity. However, the National Program suggests a 99% diagnostic test sensitivity as a conservative estimate. The estimation of test sensitivity is provided in **Table 5**, which provides likely test sensitivities over a range of diagnostic test sensitivities and a range of survey sensitivities. Assuming a survey sensitivity of 80% and a diagnostic test sensitivity of 99%, an overall test sensitivity of 79.20% is achieved.

Sensitivity of survey	Sensitivity of diagnostic test						
	95.00%	96.00%	97.00%	98.00%	99.00%	99.50%	99.90%
65%	61.75%	62.40%	63.05%	63.70%	64.35%	64.68%	64.94%
70%	66.50%	67.20%	67.90%	68.60%	69.30%	69.65%	69.93%
75%	71.25%	72.00%	72.75%	73.50%	74.25%	74.63%	74.93%
80%	76.00%	76.80%	77.60%	78.40%	79.20%	79.60%	79.92%
85%	80.75%	81.60%	82.45%	83.30%	84.15%	84.58%	84.92%
90%	85.50%	86.40%	87.30%	88.20%	89.10%	89.55%	89.91%
95%	90.25%	91.20%	92.15%	93.10%	94.05%	94.53%	94.91%
99%	94.05%	95.04%	96.03%	97.02%	98.01%	98.51%	98.90%

Table 5: Estimation of test sensitivity for diagnosing fire ant in an area

c) Validation surveillance strategy and determining the likelihood of success

Table 6 provides estimations for the likelihood of detecting pest infestation of some size in an area should every individual colony be encountered by the surveillance activity.

Likelihood of detecting infestation (%) in the survey area should infestation be present											
Test sensitivity (Se)	Number of visible mounds present within the survey area at the time of inspection										
	1	2	3	4	5	6	7	8^A	9	10	20
10.000%	10.000	19.000	27.100	34.390	40.951	46.856	52.170	[illegible]	61.258	65.132	87.842
20.000%	20.000	36.000	48.800	59.040	67.232	73.786	79.028	[illegible]	86.578	89.263	98.847
30.000%	30.000	51.000	65.700	75.990	83.193	88.235	91.765	[illegible]	95.965	97.175	99.920
40.000%	40.000	64.000	78.400	87.040	92.224	95.334	97.201	[illegible]	98.992	99.395	99.996
43.700%	43.780	68.393	82.231	90.010	94.394	96.842	98.225	99.001	99.439	99.685	99.999
50.000%	50.000	75.000	87.500	93.750	96.875	98.438	99.219	[illegible]	99.805	99.902	100
60.000%	60.000	84.000	93.600	97.440	98.976	99.590	99.836	[illegible]	99.974	99.990	100
65.000%	65.000	87.750	95.713	98.499	99.475	99.816	99.936	[illegible]	99.992	99.997	100
70.000%	70.000	91.000	97.300	99.190	99.757	99.927	99.978	[illegible]	99.998	99.999	100
75.000%	75.000	93.750	98.438	99.609	99.902	99.976	99.994	99.998	100	100	100
79.200%	79.200	95.674	[illegible]	[illegible]	99.961	[illegible]	99.998	99.995	100	100	100
80.000%	80.000	96.000	99.200	99.840	99.968	99.994	99.999	100	100	100	100
90.000%	90.000	99.000	99.900	99.990	99.999	100	100	100	100	100	100
100.000%	100	100	100	100	100	100	100	100	100	100	100

A = Predicated minimum apparent pest prevalence after treatment assuming a 12 months period of dispersal and development.

Table 6: Estimation of confidence of pest freedom where the pest was not diagnosed and likelihood of detecting infestation (%) in the survey area should infestation be present

The actual probability of detection is therefore scaled with the number of colonies expected to be encountered, which scales with the proportion of the area of interest to be surveyed.

A Bayesian approach is then used to estimate the probabilities of local eradications, within many small (2 500 hectare) "clearance zones," based on the likelihood of observing zero colonies for a given surveillance effort, the hypothesis that a small infestation will grow through time, and baseline expectations of eradication, conventionally termed "prior" probabilities of eradication.

The overall probability of eradication is then calculated by pooling—via the exponentiation method—the individual within-clearance zone probabilities.

The National Steering Committee has set an overall target probability of freedom to exceed 95%. Program modelling has indicated that a > 17% coverage surveillance effort, annually for 6 consecutive years without a positive detection, in every clearance zone, will result in the target level Proof of Freedom > 95%.

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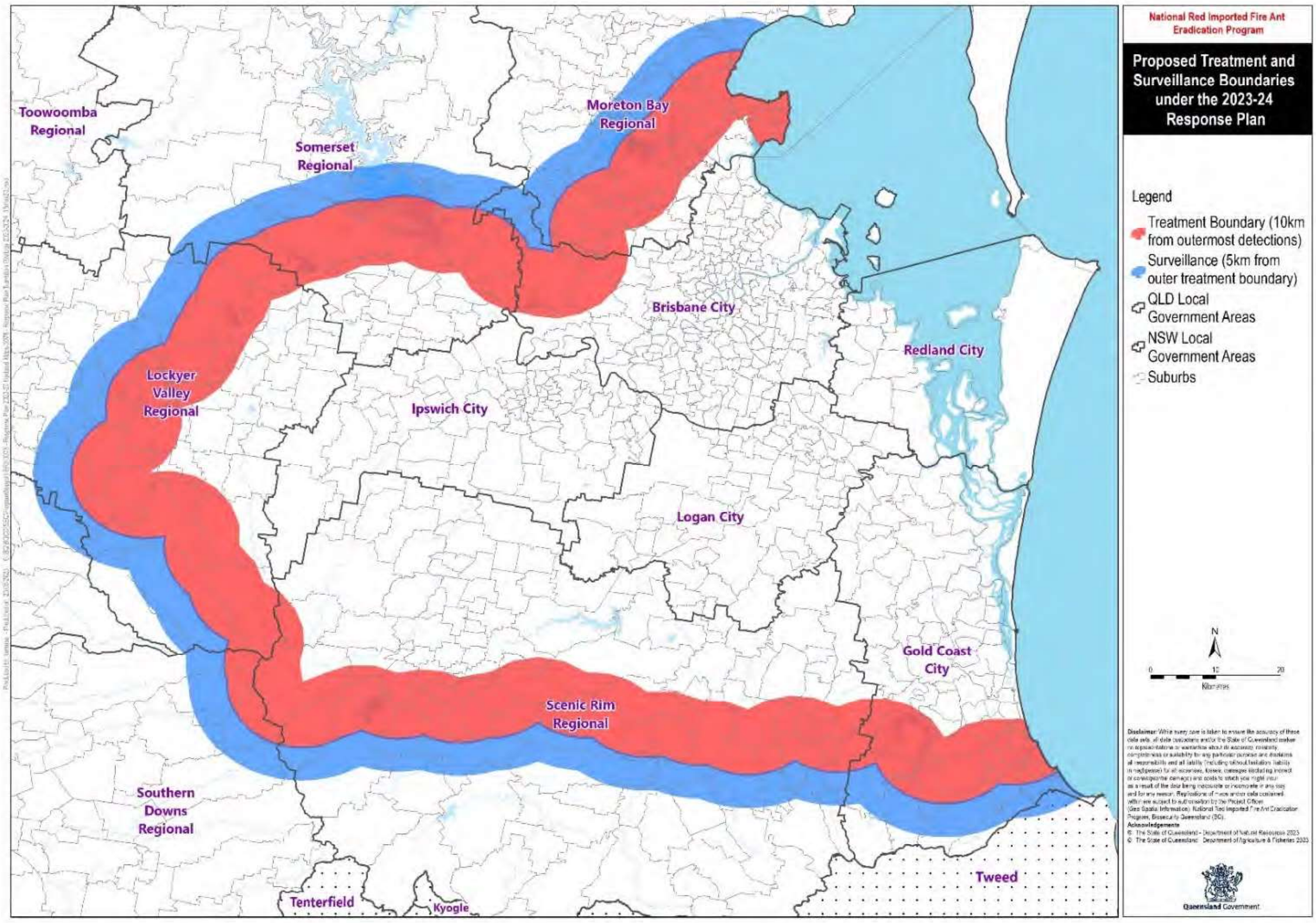
Appendix 3: 2023 – 2027 Response Details



2023–25 Treatment Plan

Establish a boundary zone around the entire containment area and broadscale treat to the containment area boundary (10 kilometres from known detections). The 10 kilometre containment boundary from known detections will be calculated on 1 July 2023. Treatment hectares will be approximately 897,000 per year consisting of three plus three rounds annually over two years. This equates to 299,000 unique hectares treated six times over two years.

Broadscale treatment will consist of three plus three rounds over two consecutive years of IGR consisting of s-methoprene or pyriproxyfen. Broadscale treatment of rural and semi-rural regions will comprise 90 per cent aerial delivery and 10 per cent ground delivery by teams on foot and in all-terrain vehicles.

Treatment of urban areas (Gold Coast, Moreton Bay, and Scenic Rim LGAs) will use a combination of self-management models (community and residential projects), urban ground treatment (field teams), and leveraging FAST partners (e.g., local council treatment of council-managed lands). New urban methods are undergoing planning for pilot projects ahead of the NFAEP eradication band treatment (e.g., FAST Ipswich self-treatment project). Trials have previously been undertaken in other urban areas (e.g., Pimpama) and lessons learnt from these trials will be incorporated into urban treatment planning ahead of the 2023–24 treatment season.

Responsive treatment will continue to detect, treat and accelerate eradication of polygyne-form fire ants across the region following the existing protocol (direct nest injection (DNI) + IGR out to 500 metre radius). One hundred thousand hectares of treatment will be allocated for contingency and/or responsive treatment.

Early innovation investment will explore alternative baits and bait dispersal methods (see innovation section below).

2023–25 Surveillance Plan

Initial delimitation surveillance around the containment area boundary will be a priority (5 km outward from the containment boundary (e.g., up to 15 kilometres from last known detections).

Surveillance calculations have been based on using ground surveillance teams (e.g., ground teams, detection dogs, sentinel sites and traps) to survey 17 per cent of the eradication band (randomly selected). Any new technology and innovative methods resulting from 2023–24 and 2024–25 innovation investment will only improve NFAEP's ability to survey more ground faster. This will improve the probability of detection and improve cost effectiveness.

Target surveillance hectares will be approximately 27,030 hectares. This represents 17 per cent of the total 159,000 hectare area that could be surveyed.

Additional surveillance can be used to increase the confidence that fire ants are absent from an area (e.g., increase surveillance area to more than 17 per cent).

Early innovation investment will explore alternative surveillance tools (see innovation section below).

Thirty ground surveillance teams will be required to achieve the surveillance target.

2023– 2025 Compliance Plan

Human-assisted spread poses a significant risk to fire ant containment and achievement of the Program's objectives. Both residents and industry move potential fire ant carriers daily (e.g., civil construction, farmers, quarries, nurseries, earthmovers and haulage companies, landscaping suppliers etc.).

The NFAEP will scale up compliance activities across the region by initially increasing the compliance workforce by 31 compliance officers. This level of compliance officers will aim to conduct 12,000 audits (including both desktop and physical audits) annually over six local government areas, see **Table A4.1** below.

NRIFAEP has developed and will introduce a risk-based compliance model for implementation across LGA regions. The model will use intelligence-based targeting of high- risk industries and activities. Compliance activities are carried out on various risk industries, which are ranked based on their compliance performance. Future compliance rates, activities, and target industries are adjusted based on the results which are derived as follows:

- set compliance distribution by group and category (e.g., industry or activity)
- carry out the compliance activity for a period (month)
- measure and rank the compliance results
- calculate capacity distribution adjustment for both group and category (e.g., change or adjust the target industry or activity).

Table A4.1: Compliance resourcing requirements for biosecurity zones regional council areas

COMPLIANCE RESOURCES	Moreton Bay	Brisbane	Ipswich	Scenic Rim	Logan	Gold Coast	Total
Landfill, Refuse Stations, Depots	2	1	1	1	1	1	7
Residential, Commercial Developments	3	2	2	2	1	1	11
Landscaping, Nursery Industry (cane etc)	1	1	1	1	1	1	6
Manager		1					1
Senior Compliance Coordinators	1	1	1				3
Principal Compliance Coordinators	1	1	1				3
Admin Officer	0	1					1
Total	8	8	6	4	3	3	32

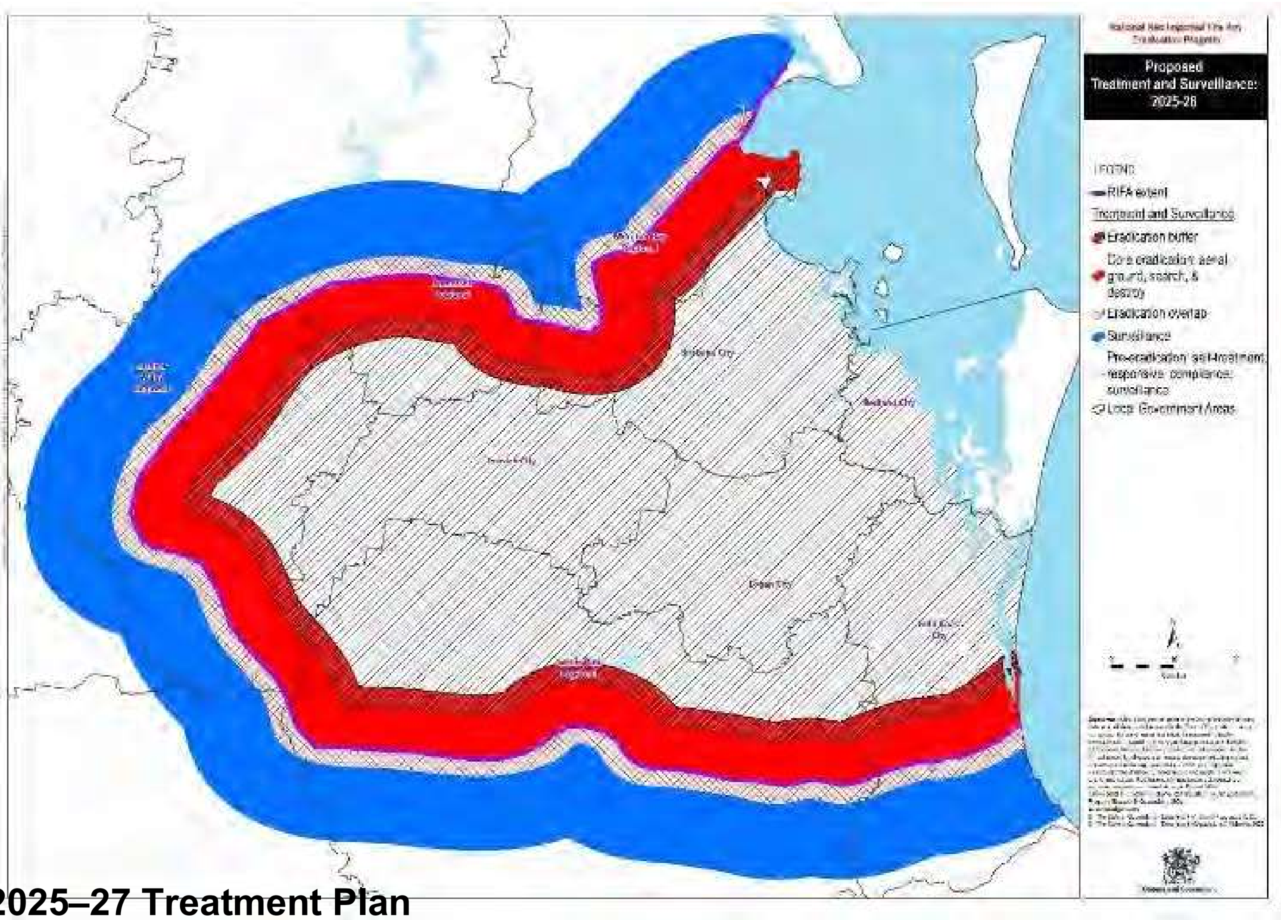
2023–25 Innovation Investment

The NFAEP will use the newly developed structured, rigorous and iterative innovation framework and investment options to test and refine various aspects of the NFAEP's operational capabilities. In the first two years of the plan, NFAEP will invest in innovation focussing on the following areas as well as others as opportunities are presented and meet the necessary benefits criteria.

Table A4.2: Innovation investment 2023–25

INNOVATION STREAM	PROJECT FOCUS	INVESTMENT TIMEFRAME
Bait	Tender to market, purchase and trial alternative baits e.g., more effective, faster acting, and more streamline supply chains to improve efficiencies	2023 and 2024
	All weather baits e.g., water resistant. Provide university funding or grant funds to develop an all-weather bait.	
Drones	Bait dispersal application for treatment (broadscale, semi urban, urban or difficult terrain)	2023 and 2024
	Surveillance applications for clearance and proof of freedom	
RSS	The NRIFAEP RSS program, currently under review, will direct reinvestment in RSS technology after the review is completed or investment in improved RSS solutions if new technology is identified through innovation processes	2023 and 2024

EDNA markers	Using genetic markers (eDNA) to identify infestations or provide evidence for the absence of fire ants at a coarse resolution.	2023 and 2024
Data systems and analytics	Application of big data analytics, bioinformatics and AI to existing and future data to answer key questions that could help accelerate eradication, including reconstituting all available imaging to provide an open data source option for open innovation possibilities	2023 and 2024
Artificial Intelligence	Applications will include acceleration of fire ant identification, analysing past and future data sources	2023 and 2024



2025–27 Treatment Plan

- After the initial two years (2023–25), treatment will move to the next eradication band. Broadscale treatment will be further scaled up to 1.08 million hectares (three plus three rounds of insect growth regulator for the next two years).
- Broadscale treatment will be conducted 10 km inwards from the previous eradication band with a thre kilometre treatment buffer to create an overlap. Combined with a greatly increased compliance effort to prevent human-assisted movement, this will lower the risk of possible reinfestation of areas treated in the previously eradication band. Treatment will comprise approximately 1.08 million hectares per annum consisting of three plus three rounds annually over two years. This equates to 360,000 unique hectares.
- Treatment of urban areas (Gold Coast, Moreton Bay, and Scenic Rim LGAs) will intensify as the eradication band picks up more urban and peri-urban regions. Urban treatment will again build on the lessons learned from FAST partners, leveraging local council treatment of their managed lands. Urban treatment will utilise a combination of urban ground treatment (field teams) and self-management models (community and residential projects). Urban treatment strategies and self-management models will be continually refined through on-the-ground learning and collaboration with FAST and its partners.

- Responsive treatment will continue to treat and accelerate eradication of polygyne-form fire ants detected across the region following the existing protocol (DNI + IGR to 500 metres). 100,000 hectares will be allocated for contingency/responsive treatment.
- Clearance surveillance will be introduced as ground surveillance commences in the 2023–25 eradication band.
- Based on compliance results, targeted treatment of high-risk areas, industries, or activities may be required (e.g., land clearing or development sites).

2025–27 Surveillance Plan

- Target surveillance will be approximately 62,900 hectares. This represents 17 per cent of the total 370,000 hectares area that could be surveyed.
- Clearance surveillance by ground teams will scale up significantly (essentially doubling). Ground surveillance of the previously treated eradication band will begin using multiple methods (e.g., ground teams, sentinel sites and traps).
- Urban surveillance will increase as the eradication band covers more peri-urban and urban areas. An increase in reliance in ground team surveillance and detection dogs in residential areas will be required.
- New surveillance technology from innovation investment (2023–25) may be implemented to enhance surveillance and reduce the amount of ground surveillance required.
- Self-monitoring programs including community and citizen science initiatives will be explored to ensure an adequate quantity of negative results is obtained.
- Clearance surveillance will be conducted for the next two years prior to commencing proof of freedom surveillance.
- Thirty five ground surveillance teams will be required.
- Self-management compliance model from 2023–25 will be continually refined.
- Compliance activities will increase as the staffing level is scaled up and efficiencies are realised.
- The compliance effort will remain high across the region with 12,000 audits annually over six local government areas, see **Table A4.1** above.

APPENDIX 4

NATIONAL FIRE ANT ERADICATION PROGRAM

WORK PLAN

SOUTH EAST QUEENSLAND

2023–24

Purpose

The National Biosecurity Committee (NBC) has provided in-principle support for the Draft Response Plan 2023–27 (Response Plan) and acknowledged that decision on the total funding for the four-year Response Plan will not be in place for 1 July 2023. Due to the complexity and magnitude of NFAEP, NBC has requested a 12-month work plan for 2023–24 detailing transition activities while broader deliberations continue. The Work Plan 2023-24 will be provided to NBC as an addendum to the Response Plan.

This Work Plan 2023-24 outlines the operational activities and detailed budget for response effort proposed to be undertaken in 23-24. This transition period - year 1 of the proposed Response Plan - will allow the NFAEP to maintain existing skills and workforce, build capacity to expand operations, implement tools to reduce human-assisted movement of the pest, and trial treatment in urban areas prior to full deployment in 2024–25.

The cost to deliver this effort under the Work Plan in 2023–24 is $84 million. This is a reduction from the $133M proposed under the Response Plan. Funding is proposed to be sourced from jurisdictions current committed funds and the bring forward of all remaining funds approved under the 10-year Eradication Plan, NFAEP deferrals in 2022–23, and other Queensland sourced funds.

Within the reduced budget, the NFAEP has identified key activities that will be undertaken to address the components of highest risk under the Work Plan for 2023–24.

Activities and deliverables include:

Containing the spread of fire ants

The first 12-months of planned treatment under the Work Plan 2023–24 was drawn 10 km out from known infestation on 10 May 2023. NFAEP will prioritise planned treatment along the southern boundary to contain the spread in the south and south-west by treating the outer 5 km of the proposed 10 km eradication band (see **Map 1** below).

Delimiting surveillance will be conducted a further 5 km beyond the 10 km treatment area (15 km from last known detections) under the Work Plan 2023–24. A target of 8% surveillance will be undertaken

The Program will continue to work with the Fire Ant Suppression Taskforce (FAST) to initiate surveillance and treatment of urban areas.
Due to recent detections on the Gold Coast, surveillance activities in the proposed 5km band will encroach into Northern NSW in 2023-24. The NFAEP will work with the NSW Governme nt to ensure operational activities can occur legally in NSW.

Activities and expected deliverables

- **Map 1** below represents revised treatment and surveillance activities proposed under the 12-month work plan.
- Three rounds of broadscale fire ant treatment in the south-west rural region (Southern Downs and Scenic Rim local government areas), administered by 90% aerial and 10% ground teams.
- Two rounds of treatment in the south-east urban region (Gold Coast), administered by ground teams only.
- Delimiting surveillance (8% of the surveillance area targeted by risk) conducted by ground teams only. The target in subsequent years will be 17% of the surveillance area.
- A risk-based approach will be undertaken for detections of importance, prioritising detections in the eradication band (15 km from last known detections on 10 May 2023)
- FAST will continue to build on existing achievements through:
  - community suppression projects in highly infested areas
  - mobilising government (local, state and the Commonwealth) to suppress fire ants on land they manage

– creating transitional partnerships to help large landowners meet their general biosecurity obligation (GBO) by providing assistance for broadscale treatment, bait and, in some cases, distribution equipment or treatment plan design.

Map 1: Revised treatment and surveillance activities proposed under the Work Plan 2023–24.

Budget

The funding available to the NFAEP for 2023–24 is proposed to be sourced from a combination of pre-approved funds from the current 10-year Eradication Plan, deferred underspend from 2022–23 and approved funds from the Queensland Government for the Response Plan.

Revised forecast costings 2023–24

NFAEP ACTIVITY	2023–24 (Map 1)
Operational services	
Bait	$14,281,309.00
Aerial services	$11,608,579.00
Labour	$ 22,035,320.00
Total	**$47,925,208.00**
Compliance	
Labour	$2,715,700.00
Compliance on costs	$784,300.00

Total	**$3,500,000.00**
Business Services	
Finance	$1,150,000.00
Workplace health and safety	$350,000.00
Human resources	$800,000.00
Learning and development	$200,000.00
Business services on-costs	$1,984,682.54
Directorate	$2,200,000.00
Directorate on-costs	$165,000.00
Total	**$6,849,682.54**
Strategy and policy	
Labour	$1,079,104.00
Strategy and policy on-costs)	$75,896.00
Total	**1,155,000.00**
Logistics and supply chain	
Rent	$2,111,219.62
Facilities services and maintenance	$1,000,000.00
Fleet vehicles—various	$2,000,000.00
Remote service tablets	$400,000.00
Mobile phone services	$250,000.00
Labour—supply chain management	$2,000,000.00
Total	**$7,761,219.62**
Scientific Services	
Labour	$2,340, 000.00
Scientific services on-costs	$1,160, 000.00
Total	**$3,500,000.00**
Communication and engagement	
Labour	$3,400,000.00
Creative production (design and production)	$300,000.00
Advertising and promotion	$3,000,000.00
Digital enhancements	$500,000.00
Social research	$280,000.00
Engagement—workshops and forums	$50,000.00
Team support costs (software/professional development)	$100,000.00

Total	**$7,630,000.00**
Information services	
Labour	$1,766,672.58
Application services	$1,612,216.35
Technical services	$1,500,000.00
Total	**$4,878,888.93**
Innovation investment (see description below)	**$1,000,000.00**
Grand Total	**$84,200,000.00**

Assumptions

- *Representative of Consumer Price Index (CPI) has been included in draft budget calculations at the request of the NFAEP Steering Committee (set at the current Queensland Treasury value of 7.5%). The CPI will be periodically adjusted and set to reflect actual.*
- *Representative of a baseline increase in surveillance costs to account for known methodologies as indicated in the draft Proof of Freedom Strategy.*
- *Surveillance calculations have been based on using ground surveillance teams (e.g., ground teams, detection dogs, sentinel sites and traps) to survey 8%t of the eradication band (randomly selected).*
- *Any new technology and innovative methods resulting from 2023–24 and 2024–25 innovation investment will improve surveillance efficiencies.*
- *Workforce includes Department of Agriculture and Fisheries (DAF) employees (as per approved restructure) and contingent labour hire (treatment and surveillance activities only).*
- *Bait costs to not increase above forecast estimates based on early-stage negotiations with the supplier.*

Improving the legislation and providing guidance

The NFAEP, through the Biosecurity Regulation 2016 (the Regulation), will shortly release a general biosecurity obligation (GBO) guideline relating to fire ant detection, treatment and movement. It will focus on highlighting the obligation for landowners and managers to look for and treat fire ants if detected. NFAEP will determine if the GBO guideline can then be incorporated into the Regulation as a Code of Practice. This process will be given high priority with the aim of amending the Regulation in the next 12 months.

Activities and expected deliverables

- Introducing a GBO guideline for both residents and industries that deal with fire ant carriers including soil, hay, mulch, and potted plants.
- Review and amend the soil movement guideline, as required.
- Identify changes to the Biosecurity Regulation to support compliance and make changes in accordance with Queensland Government processes.
- Determining how landholders can be held legally responsible to eradicate fire ants on their land under the Code of Practice.
- Review existing penalty infringement notices to ensure adequate deterrence.
- Queensland—New South Wales cross-border planning and communication activities.

Expand the compliance capability

Human-assisted spread poses a significant risk to fire ant containment and achievement of the NFAEP objectives. The NFAEP will significantly expand compliance activities across the region by increasing the compliance workforce. The compliance function will implement a model incorporating all local government areas targeting high-risk industries and activities to ensure the areas where the highest levels of noncompliance are addressed.

Activities and expected deliverables

- Uplift of new compliance officers to build the capacity to deliver the compliance objectives.
- Develop and implement an intelligence-based compliance model.
- Training and capability development for existing and new staff members to enhance knowledge of the *Biosecurity Act 2014* and powers of entry.

Mobilising the community

Communication and engagement over the next 12 months will drive community and industry action and advocacy in the following areas:

- Encourage community fire ant surveillance.
- Build support among stakeholders for program treatment and surveillance work.
- Encourage stakeholders to manage fire ants on the land they own or manage.
- Reduce the likelihood of stakeholders spreading fire ants.

Eradicating fire ants requires a whole-of-community approach. Scaling up of communication and engagement activities will heighten awareness of fire ants, their potential impacts, and build motivation among stakeholders to support and contribute to the fight against the pest.

The Program's communication and engagement strategies, which are well established and currently underway, will run year-round. The Program will continue to focus on three key priority areas:

- Look for, report and treat fire ants: encourage stakeholders across South East Queensland (SEQ) and in northern New South Wales to check their properties for and report fire ants, and if they find fire ants to treat them.
- Let our fire ant teams in: build stakeholder support and reputation of the Program, to help the operation of planned fire ant treatment and surveillance work in set areas.
- Don’t spread fire ants: empower stakeholders working in SEQ and northern New South Wales so they can confidently comply with the Regulation if working with fire ant carriers sourced from within the fire ant biosecurity zones.

Activities and expected deliverables

- Significant increase in communication, marketing and engagement activities, including mass-media advertising that persuades stakeholders to work with and support the Program to fight fire ants.
- Strengthen relationships with industry bodies and their members who are working with fire ant carriers to reduce the human-assisted spread of the pest, including through webinars and attendance at industry events.
- Increase the size of the engagement team to enable multiple community grassroots community engagement projects to build local support and action.
- Develop a new fire ant training model enabling stakeholders to complete a self-paced online course, regular webinars and train-the-trainer workshops for large organisations with dedicated training officers.
- Further enhance to the NFAEP website fireants.org.au, empowering stakeholders to make informed decisions about fire ant management.

Prioritise key business services procurement

Transition planning and procurement of key capabilities such as infrastructure, assets, bait, labour and digital systems will be needed to execute the 2023–24 Work Plan. The plan will not enable NFAEP to execute any long-term contractual arrangements, until a formal commitment (from funding partners) is achieved in relation to the Response Plan.

Science and innovation trials

During 2023–24, NFAEP will progress an assessment of drones as a cost-effective tool for the distribution of bait, to complement the existing modes of delivery. NFAEP has initiated a pilot project following successful demonstration flights of remotely piloted aircraft/drones (RPA) in a broadcast baiting scenario. Field testing will establish the potential operational use of drones to deliver precision bait treatments, which will then inform options to integrate drones into the treatment program, alongside helicopters, all-terrain vehicles and ground teams.

The NFAEP will undertake trials to improve or extend the use of insect growth regulator and fast-acting insecticide baits, with a focus on seasonality of treatment and bait sequencing.

Field trials to test the viability of detecting environmental DNA (eDNA) will be initiated, in collaboration with academic partners.

NFAEP will maintain core business around genetic analysis of fire ant samples to monitor population change, to provide critical advice to guide the treatment approach and compliance requirements. Diagnostic services including providing fire ant identification services to the community, training material for odour detection dogs and live colonies for community education events will also be continued.

Activities and expected deliverables

- Assessment of the cost-effectiveness and landscape context of drone use to distribute bait.
- Seasonal bait trials to determine the option of extending the treatment season into winter.
- Sequence bait trials to determine if an alternate baiting regime is more effective.
- Genetic sampling and analysis to document new incursions, locally and interstate.
- Identification of polygyne nests to direct a treatment response and monitor annual percentage change.
- Annual assessment of genetic clusters to monitor genetic fitness and treatment effectiveness.
- Initial trials of eDNA field detections to determine the viability of ongoing investment.
- Fire ant identifications from public reports with annual statistics.

12-month (2023–24) key performance indicators

The following key performance indicators (KPIs) have been developed under the revised first year of the Response Plan.

STRATEGIC GOAL	Key performance indicator 2023–24
Treatment	3 treatment rounds in outer 5 km Southern Downs and Scenic Rim local government areas (rural) 2 treatment rounds in outer 5 km Gold Coast City (urban)
Surveillance	8% of the surveillance area to be surveyed

Improving the legislation and providing guidance	Changes to GBO guideline for residents and industries that deal with a fire ant carrier Review soil movement guideline, as required Penalty infringement notice review Queensland—NSW cross-border planning
Expand the compliance team	Uplift of new compliance officers Training and capability development for new staff members to enhance knowledge of the *Biosecurity Act 2014* and powers of entry.
Mobilising the community	An increase in percentage of households within the Containment and Eradication areas that disclose they look for fire ants in targeted surveys. Awareness of fire biosecurity zones that help prevent the movement of fire ant carriers. • Residents • Industry stakeholders

National Fire Ant Eradication Program funding contributions

Funding arrangements for cost-share partners under the 10-year Eradication Plan

Table 2: Contributions 2023–24

Jurisdiction	Committed 2023–24 funding	All remaining funding from 10-year Eradication Plan to be brought forward 2023–24	Total funding for 2023–24 from 10-year Eradication Plan
Commonwealth	$ 6,216,982	$ 21,960,017	$ 28,176,999
NSW	$ 2,216,568	$ 6,649,703	$ 8,866,271
Victoria	$ 1,729,154	$ 5,187,463	$ 6,916,617
Western Australia	$ 1,955,137	$ 6,230,072	$ 8,185,209
South Australia	$ 1,583,398	$ 4,988,449	$ 6,571,847
Australian Capital Territory	$300,200	$ 900,600	$ 1,200,800
Tasmania	$84,969	$ 293,293	$ 378,262
Northern Territory	$76,016	$ 262,461	$ 338,477
Queensland	$ 0	$ 0	$ 0
Total	**$ 14,162,424**	**$ 46,472,058**	**$ 60,634,482**

Table 3: Queensland contribution 2023—24

Jurisdiction	Deferrals from 2022–23	Queensland centrally held funds from 2023–27 Response Plan	Total funding from Queensland
Queensland	$ 10,000,000	$13,682,000	$ 23,682,000

Table 4: Total available NFAEP funding 2023—24

Total of all NFAEP funding	**$84,316,482**

Year 1 transition - Response Plan 2023–2027

- Setting containment boundary 10 km from recent detections (May 2023)
- Setting surveillance boundary 15 km from recent detection (May 2023)
- Targeting areas at greatest risk of fire ant spread high risk areas of spread further south and west
- Treatment of urban areas in the first year of the plan
- Protection of the southern containment area
- Protection of the south-western containment area
- Surveillance and responsive treatment in areas that are not receiving broadscale treatment
- Risk based approach for detections of importance, prioritising detections in the eradication band (15 km from last known detections)

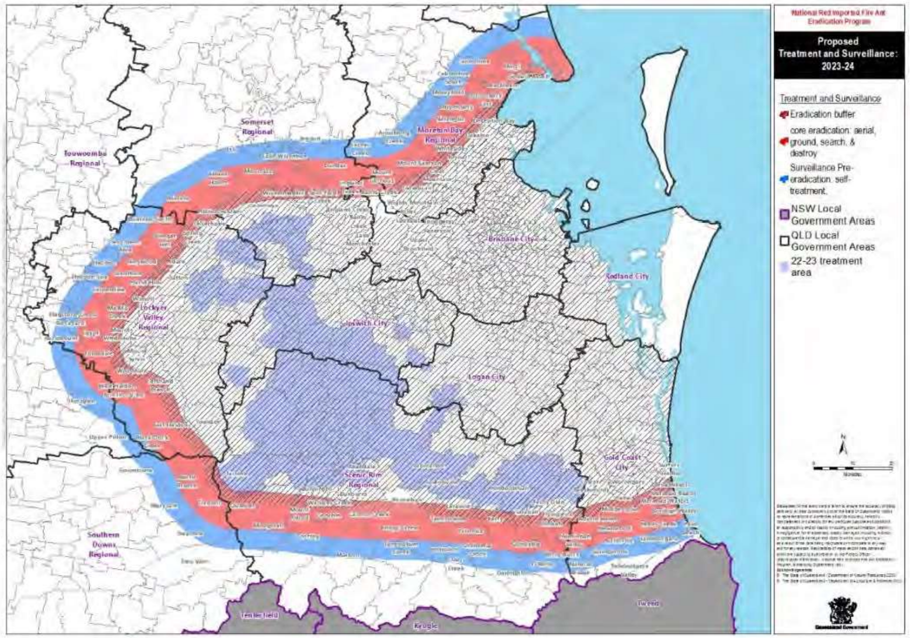


Figure 1: Proposed treatment and surveillance under the Response Plan 2023–27

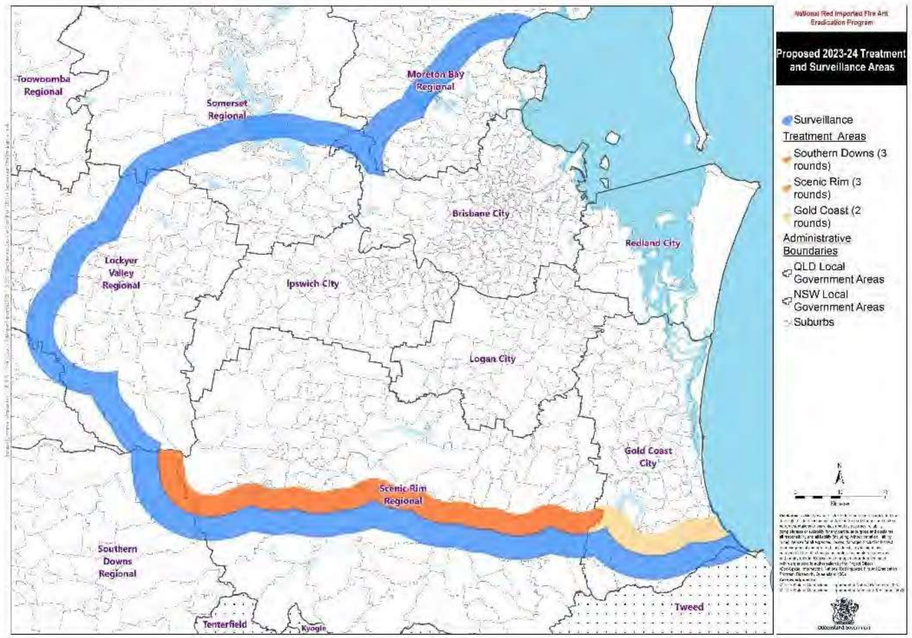


Figure 2: Proposed treatment and surveillance under the Work Plan 2023–24

APPENDIX 5 National Fire Ant Eradication Program Strategy: Proof of Freedom (PoF)

Authors' note:

Progressing this Proof of Freedom (PoF) strategy is somewhat complex as it relates an eradication strategy, a robust strategy for verifying eradication, as well as the scientific and quantitative methods required to conclude freedom from fire ants. To understand the strategic component of PoF, you must first understand how statistical modelling techniques are used to transform surveillance returns into certainty in freedom. All care has been undertaken to cite the relevant scientific material to help understand these techniques, and to summarize the relevant content from those sources as it relates to proving freedom from fire ants.

If you are not familiar with Bayes's rule, concepts of Bayesian updating, binomial probability, and issues related to imperfect detection, it is recommended to go straight to section 3.1 to understand probability and how it is applied in this situation. It is also highly recommended to read the scientific papers cited in this document, to genuinely help the reader understand the topic of freedom surveillance.

Thank you!

Glossary

Term	Definition
Alternative baits	Baits that are currently not used by the Program
Clearance Zones	Divisions of the current geographic extent of the fire ant infestation in Australia, that are to be cleared of fire ants individually (CZ)
Community treatment	Supplemental treatment of fire ants by individual landowners, or small interest groups.
Clear / Clearance	Describing the state of, or process of, local eradication and confirmation of eradication within a CZ
Eradication	Complete, permanent removal of fire ants from an area
Isolated colonies	Observed colonies that do not imply the existence of more nearby colonies
Surveillance	Use of a particular method or technique to detect fire ants within a defined area. In most cases, refers to visual, ground-based inspection by humans, or detection dogs.
Treatment gap	Areas where treatments: 1) are not applied, 2) are applied inadequately,3) are not applied at the recommended frequency, which undermine the strategic ability to eradicate
Unsuitable habitat	More properly, non-habitat, or *unsuitable areas*; places or conditions whence fire ants cannot contribute to a sustained fire ant population.

1 The Road to Complete Eradication: Proof of Freedom

PoF is the final declaration of a pest eradication initiative—in this case the eradication of Red Imported Fire Ants (fire ants) from Australia, by the National Fire Ant Eradication Program (the program). PoF can only be declared upon attainment of meaningful, quantifiable evidence of the absence of fire ants. Such evidence comes in the form of knowledge of eradication treatments and a planned strategy, supplemented with active surveillance to demonstrate that fire ants have been eradicated.

As of 2022, eradication efforts have confined Australia's fire ant infestation to South East Queensland (SEQ). To demonstrate PoF, the program will pass through three phases: *eradication, clearance* (involving surveillance and eradication if detected), and final *PoF surveillance*. To be clear, the evidence for PoF is attained steadily throughout all three phases, but the mode of attainment is different in each phase. After each phase, a decision point for progression to the next phase is required (**Table 1**).

PoF can only be declared when surveillance demonstrates a very high probability that SEQ is free from fire ants.

Table 1. Phases of Eradication

Phase	Activity	Time period	Area incorporated
Phase 1: Eradication Treatment	Three rounds of IGR each year for two consecutive years	2 years	Clearance Zones (CZ) within the Eradication band
Decision point 1: No evidence of fire ants; Prior P(Freedom) > 0.5 established for Clearance Zones (CZ); Individual CZs declared "clear"			
Phase 2: Clearance	Surveillance only. If fire ants detected, revert to Phase 1, according to response protocols	5 years	CZs within the Eradication band immediately after treatment. Minimum 17% surveillance of area within each CZ.
Decision point 2: Target P(Freedom) reached in CZ; Individual CZs declared "clear"			
Phase 3: Final Proof of Freedom	Resourcing (FTE and bait stockpiles) maintained on standby basis; minimal "maintenance" surveillance. If fire ants are discovered, revert to Phase 1.	When overall P(Freedom) is very high	All cleared CZs
Decision point 3: Target Overall P(Freedom) is reached; program declares Freedom: Maintains agreements			

PoF is the complete absence of fire ants and will result in the program ceasing all activities related to eradication. The exact moment of total eradication is unknown, and PoF will be achieved though surveillance (data) and statistical analysis / modelling to make informed evidence-based decisions.

In general, the PoF process is very simple: perform eradication activities over an area, survey to verify success, and retreat if necessary. The main issue then becomes determining how much surveillance is necessary to conclude success, which is the main objective of this document. However, surveillance to verify freedom from fire ants requires an effective, integrated eradication and containment strategy to be possible; it is not possible or reasonable to prove eradication of a large infestation if local, permanent eradication (herein referred to as "clearance") of small portions (herein termed "Clearance Zones") of the larger infestation are not probable. Therefore, in this document we describe two strategic processes:

1. How to execute an eradication strategy that allows for clearance of smaller areas, taking into account risk from reinfestation, and
2. How to use surveillance to infer clearance success, and eventually total eradication.

2. Clearance Zones (CZs)

The complete eradication of fire ants from Australia will occur sequentially through the partitioning of the geographic extent of the fire ant population into CZs - a coordinated process that commences from the outer areas first. The CZs system (*sensu* Anderson *et al.* 2017) is a *model* system used to stratify clearance surveillance and is depicted as a grid system overlaying the operational area (**Figure 1**). Each grid cell or CZ is 5km x 5km, or 2500ha, which is the minimum size to consider non-adjacent CZs as spatially independent in their infestation state. In this system, the local eradication of fire ants and verification of absence of fire ants within a CZ is called "*clearance*."

In general, fire ants are removed from individual CZs, and only after all CZs have been "cleared," can PoF be declared.

In the CZ system, all CZs belong to a local neighbourhood of nine CZs (the individual CZ plus the eight adjacent CZs), and to be "*cleared*," each zone must progress according to the following five rules (**Figure 2**):

1. All CZs commence as "*assumed infested*."
2. All CZs must receive 2 years' eradication treatment, immediately followed by 5 years' intensive* "*clearance*" surveillance without a detection.
3. All CZs within the local neighbourhood must have received eradication treatment followed by 5 years' intensive "*clearance*" surveillance without a detection
4. All CZs within the neighbourhood of an infested CZ must receive intensive "*clearance*" surveillance annually until the infested CZ has completed the eradication treatment and subsequent 5 years' surveillance to confirm containment within the known infested CZ.
5. All detections during clearance surveillance reset that CZ to "assumed infested" whereby eradication treatment* re-commences.

All CZs must have either ongoing eradication treatment or ongoing surveillance until they are cleared, and no CZs can be "cleared" until all neighbouring cells have been cleared.

*Eradication treatment in response to a clearance surveillance detection is done in accordance with the detection response protocol, which is a standard treatment distance from the outermost known colonies.

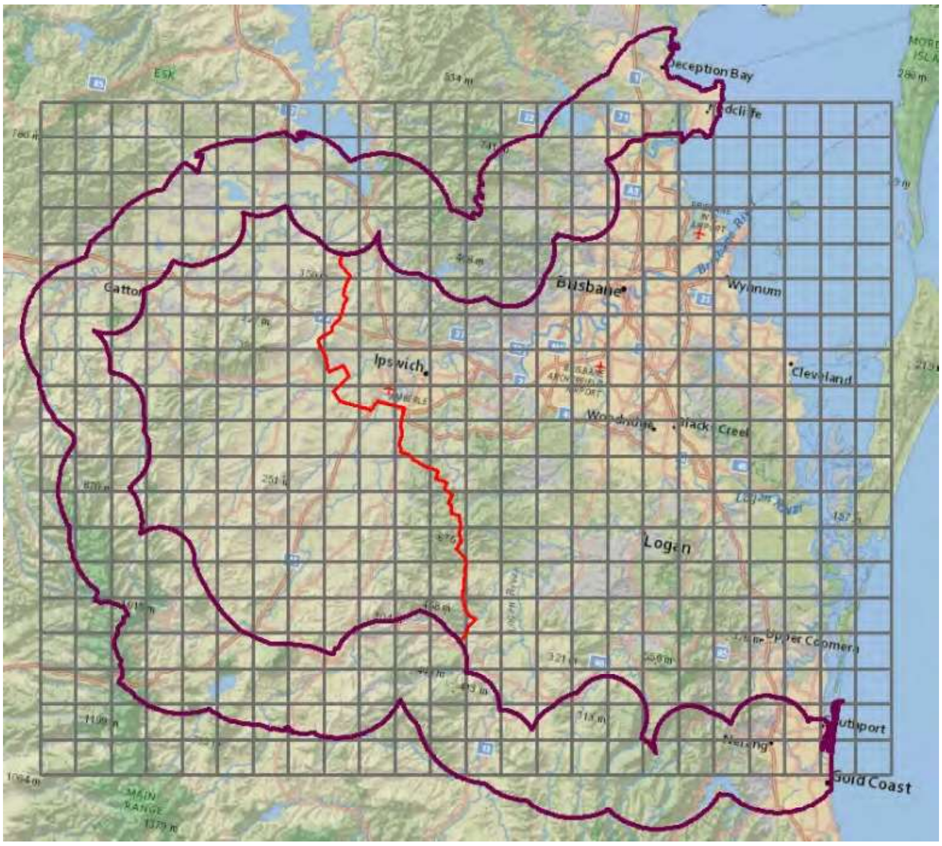


Figure 1. The Clearance Zone system

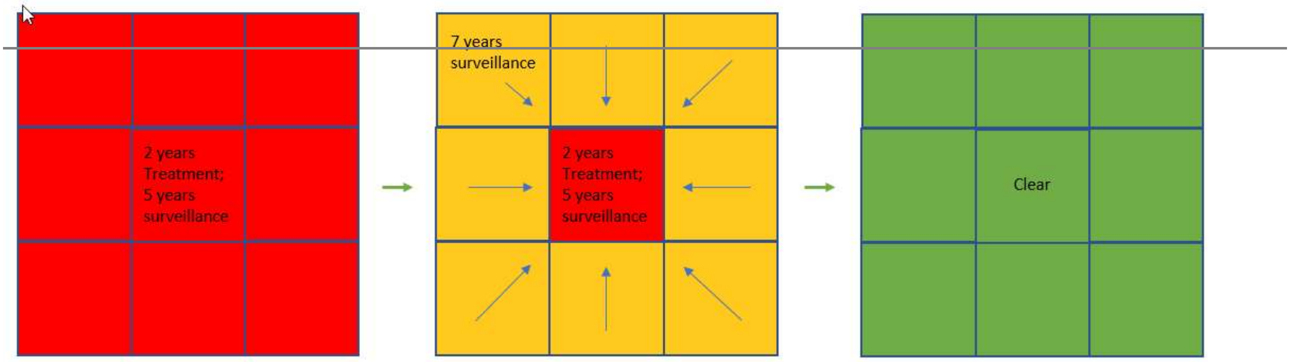


Figure 2. The clearance of a neighbourhood of CZs. Red cells are known infested.

In the CZ system, infestation status of each CZ affects the ongoing activities within its neighbours, but not in non-adjacent CZs. Again, this model is based on the view that an infestation within a 5-km CZ is a threat—via flight spread—to infest one or more of its neighbours, since an infestation could never be >2.5 km from the border of the nearest neighbouring (including those diagonally adjacent) CZ. Also, any infestation can never be < 5 km from the edge of the nearest non-adjacent (including diagonally adjacent) CZ.

This is important because this structure allows for a system where adjacent (including diagonally adjacent) CZs are not independent in their infestation risk—based on flight distances—while non-adjacent CZs (excluding diagonally adjacent CZs) can be treated as independent in their infestation risk. For a network of CZs, if as few as 1/9 of CZs remain infested, the worst-case scenario is that there are no CZs that are non-adjacent to infested CZs, i.e. all uninfested CZs are immediately threatened by infested CZs (Figure 3). Therefore, eradication treatment must occur in such a way that a target ≥ 90% of CZs are latently free from fire ants following treatment.

This 90% value corresponds to the initial expected success rate of eradication treatment (no gaps, 3 rounds / year, 2 consecutive years) on a per CZ basis, which is also the "prior" estimate of absence of fire ants in any individual CZ to be used when updating certainty in freedom according to Bayes's rule. For an explanation of Bayes's rule, prior expectations, and Bayesian updating, particularly as it relates to PoF, see **Sections 3 and 4**.

During post-eradication ("clearance") surveillance, eradication failures are identified, and a responsive treatment is applied. Conservatively, if proper eradication treatment is carried out, we expect those failures to be approximately no more than 10% of CZs. However, for the purposes of having certainty in freedom, we can tolerate up to a 40% failure rate by having a conservative surveillance requirement for proving freedom (see Section 5 for freedom surveillance requirements). For more on this failure rate, please see Sections 4.1.

Further surveillance without a detection is then sufficient to update the within-CZ probability of freedom.

The distinction between an initial "prior" estimate of p(absence) and the final "posterior" estimate of p(absence) is important because the prior estimate merely establishes that there is some expectation of failure, while surveillance and subsequent estimates of freedom help pinpoint the exact locations of failures, while eliminating other CZs as potential failures. Surveillance is necessary to identify which CZs might be failures, and therefore require further eradication treatment. For final PoF targets and surveillance requirements, please see **Sections 3 and 4**.

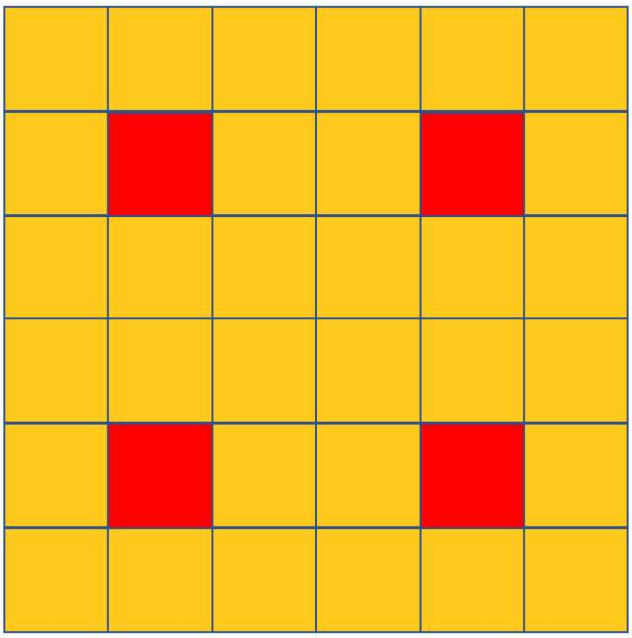


Figure 3. A network of infested (red) and uninfested (orange) CZs, where 1/9 of all CZs are infested, and therefore all CZs are infested or threatened by adjacent infestation.

3. Surveillance Requirements

A fire ant infestation, no matter how small, will spread if not destroyed. Following initial eradication treatment efforts, detection is essential to initiate further eradication treatment of remnant fire ant nests. As such, clearance surveillance serves two purposes:

1. Early detection of remnant fire ant colonies
2. Attaining evidence of absence of fire ants for containment / PoF.

Evidence of absence of fire ants comes in the form of non-detection from structured surveillance. Since we are primarily concerned with the presence or absence of fire ants, we state the following principles for surveillance:

1. The presence of an entire larger infestation is inferred from the detection of one or more colonies within that infestation.
2. The goal of surveillance is not to detect every colony within an infestation, but rather to simply detect one or more colonies.

Before determining the clearance surveillance requirement for early detection, and to reach some target certainty in absence of fire ants, we must first understand how prior expectation, imperfect detection, and scale of inference combine to infer the infestation status of a place.

3.1 Bayes's Rule for Estimating the Probability of Freedom: Priors, likelihoods, and posterior probabilities

Logically, we propose to use non-detections from structured surveillance to help infer absence of fire ants following eradication efforts. In almost all surveillance systems, detection is imperfect. In other words, it is possible to search for fire ants and not detect them, even if they are present. To conclude the probability of actual absence, given non-detection, it is most convenient to use Bayes's rule, which explicitly incorporates the effect of imperfect detection on inference from surveillance, and updates our level of certainty about the true state of a system, which we describe as a *hypothesis.* For example, a hypothesis that we can evaluate using Bayes's rule is the absence of fire ants from a place following an eradication effort. When evaluating the probability of absence given a non-detection, Bayes's rule takes the following form:

$$\mathrm{P(Absence\ |Non\text{-}detection)} = \frac{\mathrm{P(Non\text{-}detection\ |\ Absence)} \times \mathrm{P(Absence)}}{\mathrm{P(Non\text{-}detection\ |\ Absence)} \times \mathrm{P(Absence)}\ + \mathrm{P(Non\text{-}detection\ |\ Presence)} \times \mathrm{P(Presence)}}$$

3.1.1 Example Calculations Using Bayes's Rule

In the above equation, we can choose **as an example** to assign the following values to the terms:

P(Non-detection | absence) = 1 (100%) ; we assume zero ultimate false-positives; this is also known as the "likelihood" of observing the data

P(Non-detection | Presence) = 0.2 (20%); this is 1 – 0.8, where 0.8 is the detection probability given presence; this is also known as the "likelihood" of observing the data

P(Absence) = 0.9 (90%); this is what is known as the "prior" probability or baseline expectation of absence

P(Presence) = 0.1 (10%); this is 1 – the prior, or the prior or baseline expectation of presence

The resulting value is:

$$0.978 = \frac{1 \times 0.9}{1 \times 0.9\ + 0.2 \times 0.1}$$

or a 97.8% chance of absence, based on data *and* prior expectation.

Now consider a case where the same data are collected, but in a place we knew with 100% certainty there were no fire ants, such as at the bottom of the deepest trench of the ocean:

P(Non-detection | absence) = 1 (100%)

P(Non-detection | Presence) = 0.2 (20%)

P(Absence) = 1 (100%); again, this is what is known as the "prior" probability or baseline expectation of absence

P(Presence) = 0 (0%); again, this is 1 – the prior, or the prior or baseline expectation of presence

The resulting conclusion is:

$$1 = \frac{1 \times 1}{1 \times 1\ + 0.2 \times 0}$$

or a 100% chance of absence.

You can see how the prior expectation is required for inference, and how it is incorporated into the convenient Bayes's rule.

Bayesian updating is the algorithm for using Bayes's rule to explicitly and serially update our level of certainty about a hypothesis. In first case described above, we "update" our certainty in absence from 90% to

97.8%. If we were to repeat the search, we can now substitute the updated certainty into the prior certainty of Bayes's rule:

$$0.996 = \frac{1 \times 0.978}{1 \times 0.978 + 0.2 \times 0.022}$$

We have serially "updated" the certainty in absence to 99.6%. Wintle *et al.* (2005) demonstrated that the above updating algorithm can be simplified by exponentiating the likelihood **P(Non-detection | Presence)** by the number of time to be updated *n,* where in the above case *n* = 2:

$$0.996 = \frac{1 \times 0.9}{1 \times 0.9 + 0.2^2 \times 0.1}$$

In the simplified algorithm posed by Wintle *et al.* (2005), the exponentiated likelihood is a constant. In our system, we intend to use continually changing likelihoods, based on continually changing hypotheses, which we will discuss in the next sections. Therefore, the Wintle *et al.* (2005) algorithm is not directly applicable to our PoF process without some additional modifications.

3.1.2 Spatial scaling and hypothesis-variant estimation of P(Non-detection | Presence)

In **Section 3.1**, we demonstrated Bayesian updating of certainty in absence based on prior expectation and negative surveillance returns. However, it's **critically important** to understand that ***all terms*** in the simple model above relate only to the area searched. In other words, if a detection rate of 80% for visual inspection is used, the inspection method dictates that it can ONLY apply to area inspected. We are likely only to inspect a fraction of an area about which we are to make inference. This is *sampling*. In the simplest case, where the hypothesis is that a single colony is present and the objective is detective one or more colonies (*according to Section 3: surveillance rule 4*), the detection rate for some search effort—and therefore the inference from such effort—is proportional to the *amount* of the area of interest that is searched. For example, if we are to infer absence of fire ants over a 2500-ha area, we must consider how much of that area is searched, and not simply use the per-unit detection rate of 80%.

However, following eradication treatment, our hypotheses about the state of an infestation change through time to reflect the amount of spread that has occurred since the conclusion of eradication treatment. In other words, as time passes, our hypothesis about the infestation progresses from, "*There are fire ants present,"* to, "*Fire ants have been present for a number of years, and have been increasing in local population size and distribution commensurate with known fire ant biology."* This directly impacts the likelihoods in Bayes's rule, as time passes and the hypotheses change, according to the following rules and assumption:

1. Following eradication treatment, all remnant infestations will grow from a single undetected colony, which is the lowest detectable infestation size.
2. All infestations grow at a reasonably well-modelled rate and shape
3. There are no "*isolated*" colonies detected after a year of spread
4. All surveillance methods have imperfect detection
5. Detection error can be described with *sensitivity* and *specificity*. These figures are assigned to **individual objects**. Sensitivity is the chance of detecting a single object, or the proportion of objects expected to be detected. Specificity is equal to 1 *minus* the false positive rate.
    a. For our purposes, we assume the false positive rate is negligible.
6. If there is no bias in detectability between objects to detect, then the probability of detecting at least one object increases with the number of objects available to detect. This is modelled by the complement to the binomial probability mass function evaluated at zero: 1- [p(0) = choose(n, 0) p^0 $(1\text{-}p)^{n-0}$], where *n* is the number of objects available, and *p* is the detection rate. Therefore, the probability of detecting one or more object of candidate size *n* and detection rate *p* simplifies to 1-[$(1\text{-}p)^n$].
7. **The detector must encounter the object during surveillance**. For example, the individual fire ant mound **must** be within the range of the detector to be detectable and included.
8. The probability of identifying a single object is the Encounter Rate multiplied by the Detection Rate. That is, the chances you are in a correct location to detect the fire ant mound, multiplied by the chances of you seeing it.

These rules and assumptions allow us to infer absence given negative surveillance, while considering

1. We are partially sampling the landscape
2. Our detection methods are imperfect
3. Population growth of fire ants makes non-detection increasingly unlikely.

In other words, we allow that the probability of detecting one or more colonies increases as an infestation age and increases in size. Following initial eradication treatment efforts, we essentially hypothesize that anu ndetected, unobserved remnant infestation has an age of zero years, and a minimal population size of one, which is the most conservative and hardest-to-detect state. Each year, the hypothesis is updated to reflect a n undetected, unobserved infestation that one year older and has one years' additional growth and spread. Since each new hypothesis has a new population size and distribution, each new hypothesis must carry a new probability of detecting one or more colonies—and therefore a new likelihood of observing zero colonies —for any given surveillance effort. These values are essential terms in Bayes's rule for updating certainty in a hypothesis.

3.1.3 Estimating P(Non-detection | Presence) for a growing infestation

Infestation spread and surveillance simulations are required to estimate the chances of detecting one or more colonies in a growing infestation. Colonies in a spreading infestation are not uniformly distributed; they are clumped (**Figure 4**.). Because of the clumpiness of colony distributions, analytical estimates of the chances of detecting an infestation can be difficult for any given surveillance effort (see McCarthy *et al.* 2012). This is because, as we stated in Section 3.1.1, the detector must encounter a colony to detect it, and the possibility of encountering any number of colonies depends on the clumpiness of those colonies. If we apply a model system of "surveillance grids" to a growing infestation, we could estimate the surveillance effort required to detect one or more colonies of a growing infestation.

The central limit theorem that would allow us to use a binomial approximation of the chances of successful sampling (our goal in this exercise), relies on virtual sampling *with replacement; however*, we are unlikely to sample our grid of surveillance cells with replacement, i.e. if we are to sample five cells, they are likely to be five different cells, with no repeats. This constitutes sampling *without replacement*, where every sampled cell is immediately removed from the candidate set, and the marginal chances of detecting an infestation, should it exist, increase. So, because of clumpiness of growing infestations, and because of sampling without replacement, surveillance simulations are required to estimate the chances of detecting one or more colonies in a growing virtual infestation.

In our spread simulations, we only consider the case of "natural" spread via flight, which is the most common and most reliably modelled case. It is true that occasional long-distance flight dispersals may happen under the rarest of circumstances, as well as human-assisted movements, which do pose a real risk to containment and eradication. However, the purpose of this modelling exercise is not to measure absolute risk of spread. Rather the purpose is to have a means to estimate the relationship between the age of an infestation and the expected detection rate, and thereby have a reliable figure to include in the Bayesian updating of PoF. In other words, accounting for long-distance dispersals, including human assisted movement, says very little about whether an infestation should be eminently detectable at its origin. If an infestation should be detected, and is not, that non-detection adds evidence that the infestation in fact does not exist, regardless of whether a long-distance dispersal occurred. The aim is to have accurate estimates of detection error for a typically spreading infestation, whereby non-detection can be used to conclude some certainty in absence.

3.1.3.1 Methods: Simulating Spread

A critical value for modelling spread is the potential distance any newly-mated fire ant queen is expected to fly—and establish—from its original colony. Observing flight distances and survival is very difficult, considering:

- The size of a fire ant queen
- Establishing the location of the parent nest.

A published study on flight distances (Helms & Godfrey (2016) suggests distances of between 2.8 km and 4.2 km, with the average somewhere between 540 m and 810 m. Importantly, this flight distance is straight-line, level flight, and does not include flight ascending to mating height, maintaining mating altitude, or descending to the ground. These results are consistent with previous empirical studies (Markin et al. 1971, summarized in Tschinkel 2013) showing that the majority of successfully establishing queens land very close (≤ 400m) to the original nest, while an ever decreasing, yet noticeable, proportion establish up to 1.6 km away, decreasing at a rate that would mean ≥99.9% of establishments would be within 3.5 km of the original nest.

Wylie *et al.* (2021) also report that, at the Port of Gladstone—which is one of the only isolated fire ant infestations in history with genetic analysis performed on >70% of the population—the average distance flown was 420 m, and ranged up to 1.2 km.

The second critical value is the reproductive rate of newly established monogyne fire ant colonies. Tschinkel (2013) summarizes many studies to arrive at the rate of roughly 1.5 progeny / established colony / year, for an average of six years.

Therefore, to simulate spread, we created a computer program that, starting with a "seed" of a single colony, create at random 0, 1, 2, or 3 new colonies, and virtually disperse the new colonies towards a random direction, at a distance (km) drawn from a random Gaussian kernel distribution where we set the parameter σ = 0.8 (**Figure 5**). For every time step, every existing colony underwent the same process. We ran 100 simulations each for 5 generations, which are notionally years. Table 2 is drawn from the results of those 100 simulations.

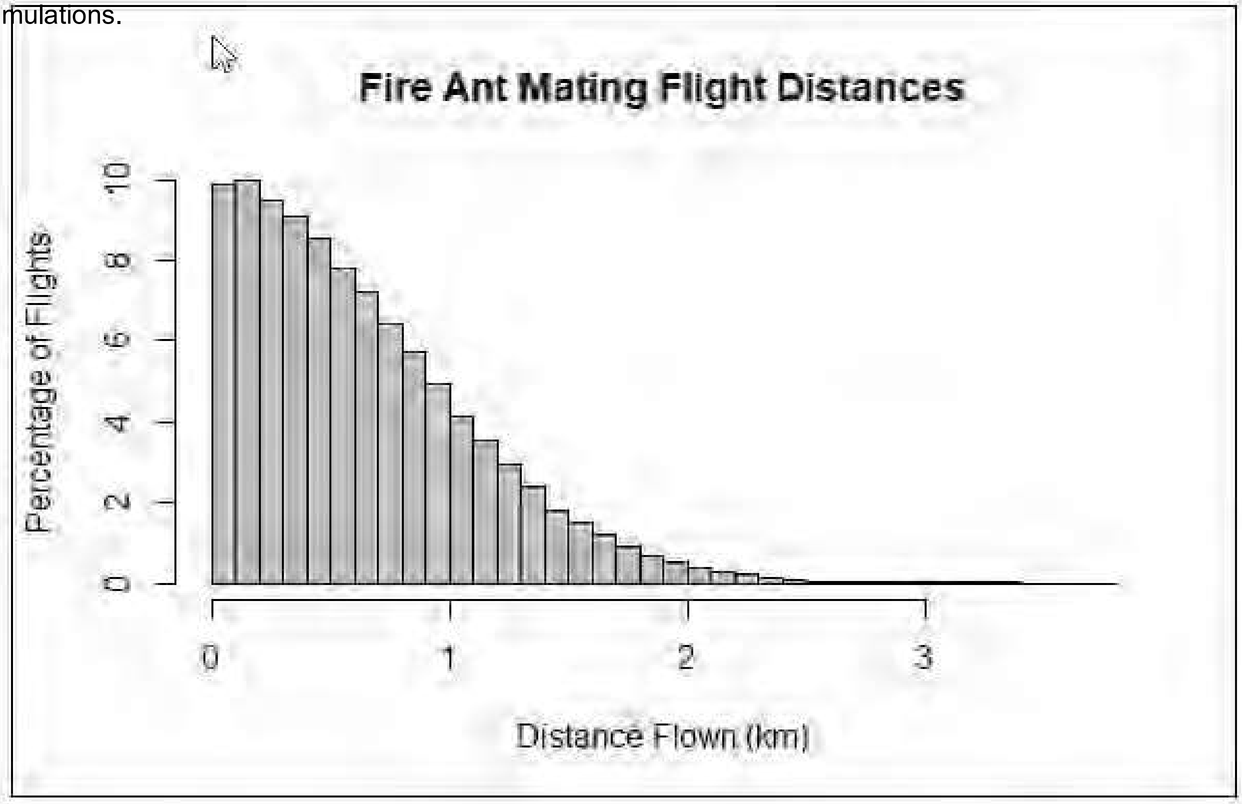


Figure 5. Simulated distribution of 100,000 fire ant mating flight distances, drawn randomly from a Gaussian kernel distribution where *σ* = 0.8, and the distance unit is kilometres.

It is important to note that the above simulation does not account for human assisted movements, or extreme cases of long-distance, wind-assisted flights, but rather to construct a reasonable scenario to help predict the detectability of a typical, outwardly spreading infestation.

3.1.3.2 Methods: Simulating Surveillance

For each of 100 spread simulations generated (described in Section 4), we overlayed a network of cells depicted in **Figure 4**. Instead of using 25 cells being 1 km x 1 km (100 ha) each, 169 "surveillance" cells were created (13 cells x 13 cells) approximately 14.8 hectares each (ex. **Figure 6a**), each represents a single day's effort for a single ground-based field crew conducting 100% visual surveillance.

25 levels of virtual search effort were defined as displayed on the y-axis of **Table 3** as the number of 15-ha grids to be virtually surveyed. For each of the 25 levels of effort,15,000 random allocations of cells were virtually searched. For example, spread simulation #1, the effort level of 10 cells searched (≈ 150 ha), 15,000 sets of 10 cells were generated, drawn without replacement from the candidate set of 169 cells. Therefore, there were 100 spread simulations x 25 effort levels x 15000 random allocations = 37.5 million random search allocation generated.

Then, for each of the 37.5 million search allocations, the number of simulated colonies encountered by the search was extracted, should it have occurred in each of the five years of every spread simulation, and estimated the probability of positively identifying ≥ 1 of those colonies encountered, according to the binomial probability mass function described in **Section 3.1.1**Rules and Assumptions #6, where p = 0.8, which is our best estimate of the detection rate for ground-based visual surveillance (Wylie *et al.* 2021), and n = the number of nests encountered virtually. **Figure 6b** shows an example of a single such extraction, where the simulated spread is in year two, and the search allocation 7 x 15 ha searches (105 ha total).

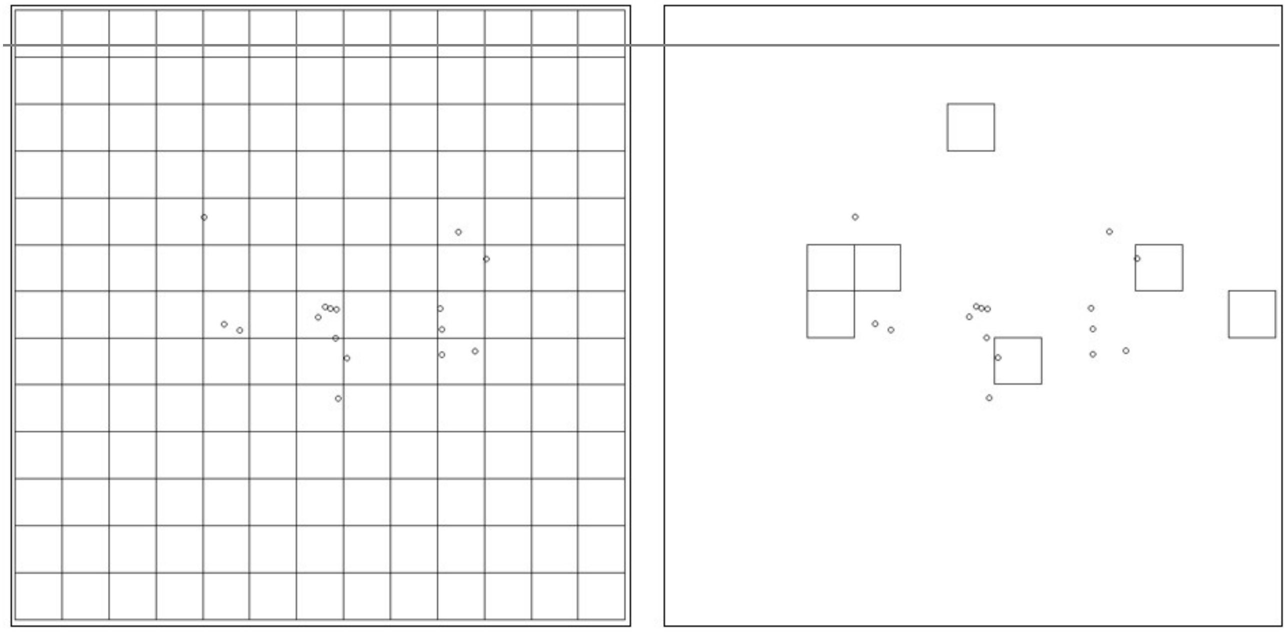


Figure 6. a) Example simulation of spread in year two, overlaid by 15-ha surveillance cells, and b) an example random search allocation of seven surveillance cells, encountering two colonies.

3.1.4 Simulation Results: Detection Rates

Table 2 shows the resulting detection rates, as estimated from simulations, for each of 25 levels of surveillance effort, at each year following the completion of eradication treatment. For convenient application of the Wintle et al. (2005; see Section 3.1.1) algorithm, instantaneous detection rates from our simulations have been transformed into cumulative detection probabilities, according to the following algorithm:

$CP(detection)_{t,j} = 1-(1- CP(detection)_{t-1,j}) \times (1- P(detection)_{t,j})$

where CP(detection) is the cumulative detection probability, and P(detection) is the instantaneous detection probability, for every surveillance effort level *j* and every year post-treatment *t*.

Table 2. Simulated cumulative detection probabilities for each year following eradication treatment (x axis), and for each level of surveillance effort (y axis; hectares of visual inspection), for a spreading infestation within a 2500-ha clearance zone.

Annual Surveillance / CZ (ha)	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
30	0.0089067	0.0294882	0.0777720	0.1805660	0.3747548	0.6454800
60	0.0177067	0.0576939	0.1481428	0.3259145	0.6053574	0.8711827
105	0.0318933	0.1017976	0.2506369	0.5058855	0.8067254	0.9717836
135	0.0435733	0.1346484	0.3175890	0.6024908	0.8811279	0.9897520
180	0.0587733	0.1777199	0.4024815	0.7101769	0.9414073	0.9976063
210	0.0663467	0.1998872	0.4458283	0.7592274	0.9616016	0.9989995
255	0.0788800	0.2358697	0.5108137	0.8220922	0.9804434	0.9997334
285	0.0922667	0.2680985	0.5589973	0.8586376	0.9878682	0.9998908
330	0.1005867	0.2950299	0.6059882	0.8938954	0.9936328	0.9999686
360	0.1168533	0.3286507	0.6466170	0.9156685	0.9959521	0.9999860
405	0.1273600	0.3580522	0.6885490	0.9380186	0.9979035	0.9999957
435	0.1369600	0.3809710	0.7166923	0.9501711	0.9986702	0.9999981
480	0.1497067	0.4102635	0.7504186	0.9630777	0.9992780	0.9999993
510	0.1560000	0.4260552	0.7690426	0.9692013	0.9995030	0.9999997
555	0.1772800	0.4667247	0.8055871	0.9787469	0.9997563	0.9999999
585	0.1835733	0.4822845	0.8208335	0.9824705	0.9998325	0.9999999
615	0.1900800	0.4977903	0.8354802	0.9856804	0.9998887	1.0000000
660	0.2052800	0.5264577	0.8580625	0.9896147	0.9999394	1.0000000
690	0.2150400	0.5452630	0.8718475	0.9917718	0.9999609	1.0000000
735	0.2315200	0.5733450	0.8902472	0.9940814	0.9999785	1.0000000
765	0.2428267	0.5924007	0.9019327	0.9953532	0.9999862	1.0000000
810	0.2613867	0.6211303	0.9173433	0.9967431	0.9999928	1.0000000
840	0.2648000	0.6293793	0.9226653	0.9972341	0.9999947	1.0000000
885	0.2768533	0.6495638	0.9331441	0.9979899	0.9999971	1.0000000
915	0.2842667	0.6627168	0.9397364	0.9984123	0.9999981	1.0000000

Eradication treatment and biosecurity requirements

To achieve the target of >90% of CZs being free from fire ants after eradication treatment, the following must be met:

a) The entire CZ and all neighbouring CZs must receive eradication treatment with at least three rounds of IGR bait each year for **at least** two consecutive years, possibly up to four consecutive years (for overlap/buffer areas). The timeframes may change if more effective alternative baits become available.
b) There are no gaps in treatment.
c) The first round of baiting each year ideally occurs early in the treatment season. Any places not receiving early treatment must be treated as soon as possible in the subsequent scheduling round, along with all neighbouring sites within 1.5km of the gap.
d) Rigorous biosecurity measures must be in-place and enforced, mitigating the risk human-assisted movement poses to local (CZ-level) absence of fire ants.

The 90% target is achievable, as most remnant infestations are the result of gaps in treatment, or failure to treat according to plan (three rounds / year for two consecutive years).

4 Clearance Surveillance: Updating Certainty in Freedom

In Section 3, we reviewed Bayes' rule, Bayesian updating, and demonstrated how spread and surveillance simulations can be used to generate likelihoods which can be used to update certainty in freedom, considering our hypotheses that any remnant infestations will grow in size and become easier to detect. In this section we will show how we use our likelihoods, combined with prior expectations of eradication, to update certainty in clearance, and ultimately total eradication.

4.1 Prior Certainty in Clearance (i.e. local eradication)

If a no-gaps strategy, with three completed treatment rounds is applied for two consecutive years, we estimate there would be a 90% rate of local freedom from fire ants in treated CZs. The evidence for this estimate is based on surveillance results from Area 1 and Western Boundary.

Over the course of three years, beginning in summer of 2017, Area 1 received broad-scale IGR treatment. While the Program did a remarkable job executing a huge campaign aimed at eradication, there were very few large, contiguous places—the size of a clearance zone, for example—that received three rounds of IGR treatment, with a properly placed "early" round, each year for two consecutive years, with *no gaps*. In fact, outright gaps, missed treatments, and other treatment weaknesses, were so numerous that predicting the locations of eradication failures was nearly impossible. Despite that, two plus years' surveillance returns from Area 1 and Western Boundary have shown that the vast majority of remnant infestations have stemmed from the survival—and subsequent spread—of minimal number of remnant colonies at the centre of each residual location. In other words, even though no places in Area 1 ever received sufficient *eradication* treatment, actual local eradication in most places was possibly imminent with perhaps one more years' treatment. Of the many residual infestations detected, there have been several isolated cases (notably the Summerholm and Washpool infestations) where numerous, widespread gaps and missed treatments cannot be implicated as the cause for failure. Furthermore, while Summerholm and Washpool are confusing and troubling because of an apparent lack of explanation, they seem to be exceptional and rare.

Based on evidence that a no-gaps, complete treatment strategy would effect a 90% CZ-level success rate, and because we have shown that a 90% success is a critical target for containment of remnant infestations, we have chosen 0.90 (90%) as our *prior* expectation in CZ-level clearance (i.e. local eradication). By using negative surveillance returns (Bayes's Rule) the program can update certainty in the eradication of fire ants (Anderson *et al.* 2017).

We can now simply insert each entry from Table 2 into Baye's Rule *sensu* Section 3.1.1, with a starting Prior(absence) = 0.9, and achieve the resulting **Table 3**, which show the probability of clearance (local freedom) at the CZ-level.

Table 3. CZ-level probability of clearance (local freedom) based on surveillance simulations and an initial prior certainty = 0.9 (90%).

Annual Surveillance / CZ (ha)	1 Years	2 Years	3 Years	4 Years	5 Years	6 Years
30	0.9008023	0.9026618	0.9070543	0.9165498	0.9350411	0.9621017
60	0.9015964	0.9052226	0.9135333	0.9303205	0.9579928	0.9858889
105	0.9028796	0.9092560	0.9231372	0.9479557	0.9789765	0.9968746
135	0.9039388	0.9122838	0.9295206	0.9577006	0.9869642	0.9988626
180	0.9053209	0.9162842	0.9377424	0.9688021	0.9935318	0.9997341
210	0.9060111	0.9183568	0.9419969	0.9739445	0.9957516	0.9998888
255	0.9071556	0.9217411	0.9484480	0.9806157	0.9978318	0.9999704
285	0.9083813	0.9247936	0.9532886	0.9845360	0.9986538	0.9999879
330	0.9091448	0.9273599	0.9580571	0.9883480	0.9992930	0.9999965
360	0.9106411	0.9305837	0.9622187	0.9907168	0.9995504	0.9999984
405	0.9116103	0.9334214	0.9665518	0.9931603	0.9997671	0.9999995
435	0.9124976	0.9356454	0.9694820	0.9944939	0.9998523	0.9999998
480	0.9136784	0.9385034	0.9730170	0.9959143	0.9999198	0.9999999
510	0.9142625	0.9400514	0.9749801	0.9965896	0.9999448	1.0000000
555	0.9162432	0.9440617	0.9788553	0.9976441	0.9999729	1.0000000
585	0.9168306	0.9456051	0.9804812	0.9980561	0.9999814	1.0000000
615	0.9174387	0.9471481	0.9820482	0.9984115	0.9999876	1.0000000
660	0.9188624	0.9500142	0.9844740	0.9988474	0.9999933	1.0000000
690	0.9197789	0.9519038	0.9859607	0.9990866	0.9999957	1.0000000
735	0.9213306	0.9547395	0.9879522	0.9993428	0.9999976	1.0000000
765	0.9223983	0.9566734	0.9892211	0.9994840	0.9999985	1.0000000
810	0.9241562	0.9596039	0.9908995	0.9996383	0.9999992	1.0000000
840	0.9244802	0.9604486	0.9914805	0.9996928	0.9999994	1.0000000
885	0.9256263	0.9625219	0.9926263	0.9997767	0.9999997	1.0000000
915	0.9263325	0.9638778	0.9933486	0.9998236	0.9999998	1.0000000

4.1.1 Revising the Prior

While a prior expectation of 90% is desired and achievable, it is not guaranteed. If surveillance returns in the two years immediately following eradication activities indicate that failure is substantially higher than 10%, then the prior expectation can be modified accordingly, and program analyses can be adjusted accordingly. **However, a conservative surveillance effort (see section 5) is robust to a CZ-level failure rate of up to 40% (prior probability of local freedom = 60%), while still resulting in an overall probability of freedom, across all CZs, that is > 50%.**

5 Overall Proof of Freedom

The surveillance required per CZ to progress to PoF across the entirety of SEQ depends on:

1. the number of CZs
2. the initial (prior) probability of each individual zone being free from fire ants prior to surveillance.

The main goal of clearance surveillance is to clarify which CZs do not have fire ants, and then to update our confidence in absence of fire ants of those CZs.

In order to estimate the overall proof of freedom across all CZs, we simply exponentiate the *per CZ* certainty in clearance (local freedom) by the total number of CZs. There are 350 CZs that will need to be progressed through the PoF Framework. Therefore, we can raise each entry in Table 3 to the power of 350 to calculate overall certainty in freedom. Those results are shown in **Table 4**. According to this table, following eradication treatment, annual surveillance *without a detection* must exceed 435ha (17%; 29 team days), for five consecutive years of ground-based surveillance per CZ to achieve >95% of overall freedom.

Table 4. Simulated overall chance (%) of total eradication across 350 CZ's for yearly surveillance effort (ha; y axis) and consecutive years without a detection (years; x axis), per CZs. Highlighted region represents > 50% overall chance

Annual Surveillance / CZ (ha)	1 Years	2 Years	3 Years	4 Years	5 Years	6 Years
30	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.69
105	0.00	0.00	0.00	0.00	0.06	33.43
135	0.00	0.00	0.00	0.00	1.01	67.15
180	0.00	0.00	0.00	0.00	10.32	91.11
210	0.00	0.00	0.00	0.01	22.54	96.18
255	0.00	0.00	0.00	0.11	46.78	98.97
285	0.00	0.00	0.00	0.43	62.41	99.58
330	0.00	0.00	0.00	1.65	78.07	99.88
360	0.00	0.00	0.00	3.82	85.44	99.95
405	0.00	0.00	0.00	9.05	92.17	99.98
435	0.00	0.00	0.00	14.48	94.96	99.99
480	0.00	0.00	0.01	23.86	97.23	100.00
510	0.00	0.00	0.01	30.25	98.09	100.00
555	0.00	0.00	0.06	43.80	99.06	100.00
585	0.00	0.00	0.10	50.61	99.35	100.00
615	0.00	0.00	0.18	57.33	99.57	100.00
660	0.00	0.00	0.42	66.79	99.77	100.00
690	0.00	0.00	0.71	72.63	99.85	100.00
735	0.00	0.00	1.44	79.45	99.92	100.00
765	0.00	0.00	2.25	83.47	99.95	100.00
810	0.00	0.00	4.08	88.11	99.97	100.00
840	0.00	0.00	5.01	89.80	99.98	100.00
885	0.00	0.00	7.50	92.48	99.99	100.00
915	0.00	0.00	9.67	94.01	99.99	100.00

However, if a CZ contains a remnant infestation, the program needs to detect that infestation within two years following eradication treatment. Instantaneous detection rates (see mention in Section 3.1.4) from spread and surveillance simulations show that the minimum required annual surveillance to confer a ≥ 50% chance of detecting an infestation within two years is 405 ha (27 team days, or 16% of a CZs total area) of ground-based surveillance (Table 6; Section 6) per CZ. Therefore, the recommendation to survey 17% each CZ is also good for early detection.

For simplicity and to be conservative, the program will maintain the 17% surveillance for five years following eradication treatment, which would confer a 95% chance of overall eradication. That is, for clearance surveillance, every CZ undergoes a minimum five consecutive years of intensive, ground-based surveillance, without a detection, at a rate of at least 17% coverage annually.

Furthermore, a 17% surveillance rate for five years without a detection is robust to a CZ-level failure rate of up to 40% (prior probability of local freedom = 60%), while still resulting in an overall probability of freedom, across all CZs, that is > 50%.

6 Clearance Surveillance: Early Detection

Figure 4 illustrates a simulated spreading infestation within a neighbourhood of twenty-five cells, each 100 hectares (1 km x 1km) in area.

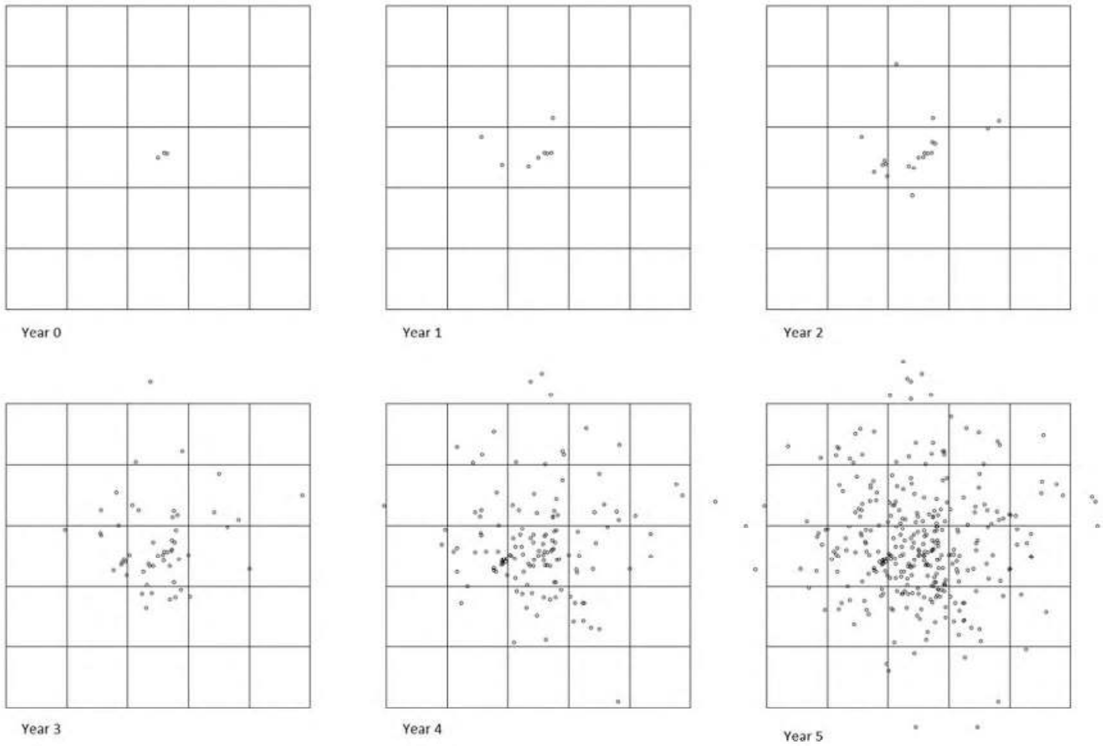


Figure 4. Simulated annual spread of fire ants. Large boxes are 5km x 5km, each small box is 1km x 1km

Table 5. Maximum distance across simulated infestations (N = 100) emerging from a single remnant nest, for each year of spread

Year Post-Treatment	Maximum Span (m)					Mean Conservative Treatment Area (ha)
	Min	5%	Mean	95%	Max	
0	0	0	0	0	0	0
1	0	12.46	871	1825	2098	238
2	55	570	1802	3190	4620	1020
3	0	1446	2894	4420	5552	2631
4	2081	2770	4015	5564	6034	5064
5	1931	3455	5424	7298	8135	9242

Figure 4 and **Table 5** display that by year three of spread, on average, an infestation will be about 3 km across. Upon detection, without knowing the exact spatial relationship between the detected colony and its family members (it could be on the right edge, or the left edge, or in the centre, etc.), a conservative 3km treatment must be extended in every direction to capture the entire infestation.

In year two, the required responsive treatment would be roughly the area of an entire CZ, which is convenient because it allows us to maintain an expected failure rate of 10% without assuming secondary failures due to spreading infestations. Therefore, we recommend initial clearance surveillance have a target time-to-detection of **2 years.**

Based on spread and surveillance simulations, **Table 6** shows the average probability of detecting one or more colonies of a spreading infestation, given the level of annual search effort.

Table 6. The average instantaneous probability of detecting one or more colonies of an outwardly growing infestation located within a 2500-ha CZ, based on 100 simulated infestations, and simulated randomly placed (without replacement) 15-ha searches.

Annual Surveillance / CZ (ha)	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
30	0.0089067	0.0207665	0.0497508	0.1114627	0.2369792	0.4329904
60	0.0177067	0.0407080	0.0959868	0.2086872	0.4145512	0.6735848
105	0.0318933	0.0722072	0.1657080	0.3406208	0.6088465	0.8540087
135	0.0435733	0.0952243	0.2114061	0.4174929	0.7009577	0.9137893
180	0.0587733	0.1263740	0.2733394	0.5149554	0.7978329	0.9591462
210	0.0663467	0.1430301	0.3073830	0.5655271	0.8405202	0.9739443
255	0.0788800	0.1704335	0.3598130	0.6363190	0.8900744	0.9863665
285	0.0922667	0.1937043	0.3974562	0.6794523	0.9141792	0.9910011
330	0.1005867	0.2161890	0.4410943	0.7307071	0.9399911	0.9950753
360	0.1168533	0.2398212	0.4736228	0.7613595	0.9520006	0.9965420
405	0.1273600	0.2643613	0.5148345	0.8009914	0.9661760	0.9979545
435	0.1369600	0.2827343	0.5423354	0.8241174	0.9733131	0.9985608
480	0.1497067	0.3064317	0.5767918	0.8520630	0.9804462	0.9990787
510	0.1560000	0.31997056	0.5975966	0.8666475	0.9838639	0.9993230
555	0.1772800	0.3518143	0.6354362	0.8906804	0.9885340	0.9995562
585	0.1835733	0.3658763	0.6539287	0.9021608	0.9904420	0.9996574
615	0.1900800	0.3799268	0.6724081	0.9129610	0.9922288	0.9997412
660	0.2052800	0.4041394	0.7002643	0.9268317	0.9941644	0.9998218
690	0.2150400	0.4206876	0.7181834	0.9357939	0.9952514	0.9998762
735	0.2315200	0.4448066	0.7427598	0.9460735	0.9963616	0.9999128
765	0.2428267	0.4616829	0.7594027	0.9526158	0.9970220	0.9999304
810	0.2613867	0.4870527	0.7818334	0.9605969	0.9977915	0.9999611
840	0.2648000	0.4958913	0.7913372	0.9642346	0.9980755	0.9999622
885	0.2768533	0.5154010	0.8092209	0.9699345	0.9985347	0.9999773
915	0.2842667	0.5287585	0.8213263	0.9736541	0.9987986	0.9999815

According to **Table 6**, **the required effort to confer a ≥ 50% chance of detecting a remnant infestation within the target two years is 405 ha per 2500 ha CZ, or the equivalent of 16% of the area under consideration.**

It is important to consider that, while we placed the origin of our simulated infestations in the centre of each surveillance cell array, notionally representing a CZ, there is no guarantee that real infestations will in fact begin in the centre of real CZ, or any analogue thereof. That is why in the CZ System, the neighbourhood status structure described in Section 2 is critical for dealing with detecting infestations that straddle CZs.

7 Final Proof of Freedom

Following the clearance of CZs, a possibility human assisted movement remains from non-cleared CZs could cause reinfestation of previously cleared CZs. The location and timing of human assisted movement is difficult to predict. Therefore, our models of spread and detection following eradication treatment **are not robust** to human assisted movements reinfesting CZs.

Therefore, the final Phase 3: Final PoF involves a minimal amount of “maintenance” surveillance in all cleared CZs, until all CZs have undergone successful clearance. At that time, the program may elect to continue maintenance surveillance for an undetermined time period.

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Appendix 6 Budget Details

Response Plan Forecast Costings 2023–25

Due to the dynamic situation of delivery and technology options, funding will be split into two tranches. Tranche one will commit funds to Phase One of the Eradication Strategy (FY23/24 - FY24/25). A Gate Review will be completed during the FY24/25. This will measure whether the Program's outcomes have been successful in meeting the defined objectives and if so, result in the release of the next two years (FY25/26-FY26/27) of funding. Tranche two funding is committed for the remaining two years of this eradication strategy (FY25/26 - FY26/27). A Program Review will take place during FY26/27 to define the continuing national response plan beyond FY26/27 to achieve eradication by 2032.

Table A6.1: Response Plan Forecast Costings 2023–25

ACTIVITY	2023–24 (MAP 1)	2024–25 (MAP 1)
Treatment Hectares (Broadscale)		
Bait	$38,032,800.00	$40,885,260.00
Aerial Services	$28,000,000.00	$30,100,000.00
UTVs	$20,000.00	$21,500.00
Responsive Treatment	$100,000.00	$107,500.00
Labour	$14,467,027.14	$15,552,054.18
Total	$80,619,827.14	$86,666,314.18
Surveillance Hectares (Target ~17% of total)		
Labour	$8,850,816.00	$9,514,627.20
Support (on costs)	$1,149,184.00	$1,235,372.80
Total	$10,000,000.00	$10,750,000.00
Compliance activities (audits, inspections etc)		
Estimated Total Compliance Costs	$4,575,128.46	$4,918,263.10
Business Services		
Finance	$1,150,000.00	$1,236,250.00
Workplace Health and Safety	$350,000.00	$376,250.00
Human Resources	$800,000.00	$860,000.00
Learning and development	$450,000.00	$483,750.00
Business Services (on costs)	$1,984,682.54	$2,133,533.73
Directorate	$2,200,000.00	$2,365,000.00
Directorate (on cost)	$165,000.00	$177,375.00

Total	$7,099,682.54	$7,632,158.73
Strategy & Policy		
Labour	$1,516,023.97	$1,629,725.77
Strategy and Policy (on costs)	$79,790.74	$85,775.04
Total	$1,595,814.71	$1,715,500.81
Logistics & Supply Chain		
Rent	$2,111,219.62	$2,269,561.09
Facilities Services & Upkeep	$1,046,915.68	$1,125,434.35
Fleet Vehicles Various	$2,921,966.45	$3,141,113.93
Remote Service Tablets	$452,870.63	$486,835.92
Mobile Phone Services	$272,062.85	$292,467.57
Labour (Supply Chain Management)	$2,399,257.89	$2,579,202.23
Total	$9,204,293.11	$9,894,615.09
Scientific Services		
Labour	$2,892,509.64	$3,109,447.86
Scientific Services (on costs)	$1,056,710.25	$1,135,963.51
Total	$3,949,219.88	$4,245,411.37
Marketing and Media		
Labour	$5,370,000.00	$5,772,750.00
Creative production (design & production)	$300,000.00	$322,500.00
Advertising (Fire ant campaign)	$2,000,000.00	$2,150,000.00
Digital enhancements	$500,000.00	$537,500.00
Social research	$280,000.00	$301,000.00
Engagement - workshops/forums	$50,000.00	$53,750.00
Team support costs (software/PD)	$100,000.00	$107,500.00
Total	$8,600,000.00	$9,245,000.00
Information Services		
Labour	$1,766,672.58	$1,899,173.02
Application Services	$1,612,216.35	$1,733,132.58
IT Technical Services	$3,071,111.08	$3,301,444.41
Total	$6,450,000.00	$6,933,750.01

Innovation Investment (see description below)	$1,000,000.00	$1,000,000.00
Grand Total	$133,093,965.85	$143,001,013.29

Response Plan Forecast Costings 2025–27

Table A6.2: Response Plan Forecast Costings 2025–27 (Table 3 assumptions)

ACTIVITY	2025–26	2026–27
Treatment Hectares (Broadscale)		
Bait	$43,951,654.50	$47,248,028.59
Aerial Services	$32,357,500.00	$34,784,312.50
UTVs	$23,112.50	$24,845.94
Responsive Treatment	$115,562.50	$124,229.69
Labour	$16,718,458.24	$17,972,342.61
Total	$93,166,287.74	$100,153,759.33
Surveillance Hectares (Target ~17% of total)		
Labour	$10,228,224.24	$10,995,341.06
Support (on costs)	$1,328,025.76	$1,427,627.69
Total	$11,556,250.00	$12,422,968.75
Compliance activities (audits, inspections etc)		
Estimated Total Compliance Costs	$5,287,132.83	$5,683,667.79
Business Services		
Finance	$1,328,968.75	$1,428,641.41
Work Place Health and Safety	$404,468.75	$434,803.91
Human Resources	$924,500.00	$993,837.50
Learning and development	$520,031.25	$559,033.59
Business Services (on costs)	$2,293,548.76	$2,465,564.92
Directorate	$2,542,375.00	$2,733,053.13
Directorate (on cost)	$190,678.13	$204,978.98
Total	$8,204,570.63	$8,819,913.44
Strategy & Policy		
Labour	$1,751,955.21	$1,883,351.85
Strategy and Policy (on costs)	$92,208.17	$99,123.78

Total	$1,844,163.38	$1,982,475.63
Logistics & Supply Chain		
Rent	$2,439,778.17	$2,622,761.54
Facilities Services & Upkeep	$1,209,841.93	$1,300,580.08
Fleet Vehicles Various	$3,376,697.48	$3,629,949.79
Remote Service Tablets	$523,348.62	$562,599.76
Mobile Phone Services	$314,402.64	$337,982.83
Labour (Supply Chain Management)	$2,772,642.39	$2,980,590.57
Total	$10,636,711.23	$11,434,464.57
Scientific Services		
Labour	$3,342,656.45	$3,593,355.69
Scientific Services (on costs)	$1,221,160.78	$1,312,747.84
Total	$4,563,817.23	$4,906,103.53
Marketing and Media		
Labour	$6,205,706.25	$6,671,134.22
Creative production (design & production)	$346,687.50	$372,689.06
Advertising (Fire ant campaign)	$2,311,250.00	$2,484,593.75
Digital enhancements	$577,812.50	$621,148.44
Social research	$323,575.00	$347,843.13
Engagement - workshops/forums	$57,781.25	$62,114.84
Team support costs (software/PD)	$115,562.50	$124,229.69
Total	$9,938,375.00	$10,683,753.13
Information Services		
Labour	$2,041,610.99	$2,194,731.82
Application Services	$1,863,117.52	$2,002,851.33
IT Technical Services	$3,549,052.74	$3,815,231.69
Total	$7,453,781.25	$8,012,814.84
Innovation Investment (see description above)		
Grand Total	$152,651,089.29	$164,099,921.01

Assumptions

- Representative of Consumer Price Index has been included in draft budget calculations at the request of the Steering Committee (set at current QLD Treasury value of 7.5 per cent). Note during the execution of the response plan Consumer Price Index will be periodically adjusted and set to reflect actual.
- Representative of a baseline increase in surveillance costs to account for known methodologies as indicated in the draft Proof of Freedom Strategy.
- Surveillance calculations have been based on using ground surveillance teams (e.g., ground teams, detection dogs, sentinel sites and traps) to survey 17 per cent of the eradication band (randomly selected).
- Any new technology and innovative methods resulting from 2023–24 and 2024–25 innovation investment will improve surveillance efficiencies.
- Workforce includes Department of Agriculture and Fisheries (DAF) employees and contingent labour hire.

Appendix 7 Monitoring and Evaluation Framework

Purpose

The purpose of the NFAEP Monitoring and Evaluation Framework (M&E Framework) is to provide a structured and rigorous platform from which to provide streamlined reporting to the National Steering Committee, eradication partners and beneficiaries of a fire ant-free Australia and enable continual improvement in efficiency and effectiveness. The M&E Framework has been prepared by the NFAEP in accordance with best practice guidance provided by Queensland Treasury, Queensland Audit Office and other global sources.

The relationship between performance monitoring, risk assessment, evaluation, triggers and reporting through decision making bodies in the governance model is outlined below in **Diagram 11**. The occurrence of high residual or increasing risks and incidents outlined in the risk section below would trigger an assessment and/or evaluation of existing mitigating activities. If resulting outcomes indicate that it is insufficient, this would trigger a review of the NFAEP by the National Steering Committee to assess whether the NFAEP's objectives for the period FY23–24 to FY26–27, particularly the contraction of eradication effort across SEQ, remains achievable. Informed by advice of the National Steering Committee, AGSOC would then review the trigger with the intention deciding to continue with changes or discontinue and transition to an alternative management approach.

Monitoring performance summary

Table A7.1: Key Performance Indicators

Measure category	Performance indicators	Definition and purpose	Method and frequency	Targets
Effectiveness (Compliance)	Compliance rate of targeted high-risk industries (activities) across local government areas	This measure will ensure effective, targeted delivery of compliance activities that address non-compliance that contributed to human-assisted movement	Monitoring compliance interactions and resulting outcomes from audits and investigations (monthly)	10% annual increase year on year increase in compliance rate across high-risk industry categories (TBC baseline to be established, target re-visited)
Efficiency (Compliance)	Cost per unit of compliance audits undertaken	This measure will monitor the costs of undertaking compliance audits to indicate broader compliance efficiency and ensure efficient delivery of compliance outcomes	Quantifying cost to undertake compliance audits (cost per audit) (annual)	Target to be determined once year one baseline data has been captured
Effectiveness (Eradication)	Confidence in surveillance methodologies deployed to rural, peri-urban, urban areas that provide evidence of proof of freedom	This measure will track performance of surveillance as it is deployed to increase confidence	Monitor outcomes of surveillance for accuracy against the proof of freedom methodology, (annual)	Proof of freedom through surveillance tools at pilot sites achieved by 2025–26
Effectiveness (Eradication)	In accordance with the Proof of Freedom Plan the proportion of planned eradication band (see **Figure 1**) that delivers >90% confidence in absence of fire ants over a two-year period (equivalent to six rounds of IGR over two years per band)	This measure will track effective delivery of eradication effort by measuring resulting probability after a combination of treatment and surveillance methods may be deployed	Monitor annual treatment and surveillance operations coverage and 'gaps' (annual)	>90% coverage of planned eradication band (see **Figure 1**) over a two-year period (2% gaps)

Efficiency (Eradication)	Cost per hectare to initiate clearance surveillance	This measure will monitor the costs associated with eradication efforts to clear land of fire ants and ultimately proof of freedom	Treatment and surveillance costs per hectare calculated over a two-year period within the eradication model	Efficiency target to be determined after first year of the eradication plan
Effectiveness (Workplace health and safety)	Column: Proportionate reduction of incident reports through TABS by staff, and compliant with reporting requirements under workplace health and safety procedures	This measure will monitor the effectiveness of workplace health and safety measures to ensure staff are safe and satisfied with the work environment	Workplace health and safety incident reports received (monthly)	100% of incident reports completed within 30 days