Norfolk Island Quarantine Survey 2012–2014

A report to the Australian Government
Department of Infrastructure and Regional Development

Australian Government Department of Agriculture

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Contents

Executive summary

Norfolk Island has had various levels of independence from the Commonwealth of Australia. Under the *Norfolk Island Act 1979* it became a self-governing external territory of Australia, with its own community-elected government and overseen by an Administrator appointed by the Governor-General of Australia. These arrangements have changed and are in transition to greater integration with the Commonwealth.

Norfolk Island is currently responsible for its own biosecurity and operates outside the Commonwealth *Quarantine Act 1908*. The concept of biosecurity is known as quarantine on Norfolk Island, and the latter term will be used throughout this report.

In 2010 the Australian Government made a commitment to 'ensure the standards of living of residents of Norfolk Island are comparable with mainland Australia, without sacrificing the benefits to the community of self-government and [to] continue to work with the Norfolk Island Government and local community to improve standards of accountability and transparency within the Government and associated enterprises.'

These principles formed the basis of the Australian Government's Norfolk Island Reform Package, which aims to reduce the Norfolk community's dependence on Commonwealth emergency funding, to empower the community to improve services on the island and to provide steps toward economic diversity.

A key element in delivering the reform package is addressing barriers to investment and promoting the creation of new business opportunities on Norfolk. An independent *Economic Development Report* commissioned by the Australian Government in 2012 identified current border arrangements between mainland Australia and Norfolk Island as a potential barrier to economic growth. A decision regarding the possible extension of the full suite of Australia's border control arrangements, including those for quarantine, could not be made until a pest and disease survey of Norfolk Island was completed and a risk assessment of the data gathered to formulate options for future biosecurity arrangements.

Additionally, gaining access to export markets (including mainland Australia) for plant and animal products involves the importing jurisdiction conducting a risk analysis — hence the need for accurate, current data on the plant and animal pests of Norfolk Island.

To provide baseline data on which to base such a risk analysis, the Australian Government Department of Infrastructure and Regional Development provided funding through a Memorandum of Understanding with the Australian Government Department of Agriculture to carry out survey work (see Appendix 1). The Department of Agriculture used those funds as well as its own resources to develop, facilitate and implement NIQS — the Norfolk Island Quarantine Survey.

NIQS took a multi-faceted approach to gather as much biological data as possible in the time available and to identify and implement measures to enhance quarantine arrangements on the island so that data collected by NIQS surveys would remain relevant and useful.

Quarantine capabilities and capacity on Norfolk Island have now been enhanced. This was achieved by a multi-pronged approach and included community engagement and improved diagnostic capabilities that are now supported by strong links with professionals on the mainland. NIQS has also provided materials and equipment (for example, provision of a high-resolution microscope and imaging to enable specialist assistance), construction of heat treatment facilities, training and competency testing in the use of methyl bromide to the Australian standard, and the provision of a quarantine detector dog together with training of handlers. The multi-purpose laboratory set up for NIQS continues to serve as support for the Norfolk Island Quarantine Service.

The survey determined that there are more than 140 species found on Norfolk Island not found elsewhere in Australia (see Appendix 2). This number will increase as new species are described; however, seven species are of significant quarantine concern — *Hemileia vastatrix* (coffee rust), *Pseudocercospora fijiensis* (black sigatoka), *Liberibacter solanacearum*, *Bactericera cockerelli* (tomato potato psyllid), *Cardiocondyla emeryi*, *Enicodes fichtelli* and *Thrips novocaledonensis* — with a further 10 of some quarantine concern (*Colletotrichum magna*, *Leveillula allii*, *Pseudocercospora epispermogoniana*,

Sphaeronaemella fragariae, Potyvirus Alstroemeria mosaic virus, Potyvirus Veltheimia mosaic virus, *Aedes antipodeus*, *Agistemus novazelandicus*, *Coccinella septempunctata*, *Culex pervigilans*). Further work on pest categorisation needs to be undertaken for other species listed in Appendix 2 to determine if they are of potential quarantine concern. There are many pests of high quarantine concern to Norfolk that occur on the mainland of Australia (for example, fruit flies and silver leaf whitefly) and New Zealand (for example, varroa mites, bovine tuberculosis and fire blight) that are not present on Norfolk. It is recommended that the existing quarantine barrier be maintained or strengthened.

The NIQS survey methodology provides a valuable template for other biosecurity surveys. The time span of the survey (across more than one year); taxa covered (the number of host plants encompassed for testing as well as incorporated amenity and agricultural animals and some of the wild fauna) and number of seasons provided insights into temporal and climatic variability of pests and disease species and population levels, and a robust basis for decision making.

Survey results

Botany

The flora of Norfolk Island is relatively well known; since its discovery in 1774 there have been many reports and botanical surveys — for example, Coyne and Mills have recently published and privately produced a significant number of articles on the botany of Norfolk Island — but previously surveys did not focus on introduced plants across the island. The NIQS weed survey comprised two field surveys complemented by a search of the literature and examination of collections at the Australian National Herbarium, Canberra.

The recorded naturalised flora for Norfolk Island at the conclusion of this survey is 430 species. This survey made a collection of 306 species (see Appendix 2), of which 52 are new records for Norfolk. Two species have not been recorded on mainland Australia, hence of potential quarantine concern, and 11 more are of uncertain status as the taxonomy requires resolution. The mainland has many weed species absent from Norfolk Island.

Invertebrates

Invertebrate surveys comprised six field surveys by two teams of entomologists.

The report includes 1192 invertebrate taxa. Around 145 species of invertebrates are known from Norfolk but are not present on mainland Australia, with a number of species that require further taxonomic resolution. A significant number of these are Norfolk endemic species, but the list also includes a range of species found in New Zealand and/or New Caledonia. Some of this distribution is natural; some reflects import pathways. The identity of some invertebrates remain unresolved. These specimens may belong to new (that is, undescribed) species; the life stage, sex or condition of specimens collected may have precluded accurate identification; the group to which the specimens belong may be taxonomically too complex to allow identification; or a combination of these factors may have made identification impossible.

Many mainland species are absent from Norfolk; for example, neither Queensland fruit fly nor other fruit flies of significance are present on the island. If these or other significant pests from mainland Australia or NZ were to become established on Norfolk Island it is likely they would have effects due to favourable environmental conditions and host availability.

Bees

NIQS represents the first survey of honey bees on Norfolk Island.

The honey bee survey tested for 25 target pests and pathogens (see Appendix 3); only three bee pests (lesser wax moth, *Nosema ceranae* and Lake Sinai 1 virus) were detected, and none appears to be affecting the health of the island's bees.

Isolation and good border management have maintained this status, so there is significant potential for Norfolk's bees to be used as a reference standard in honey bee experimental work worldwide.

Norfolk has no bee pests or diseases that are not also present on mainland

Australia, but there are a large number of very significant honey bee pests and pathogens present in NZ and on mainland Australia that are absent from Norfolk. These pose a high level of threat to the health of Norfolk's bees and there is an immediate threat from bee swarms arriving on board vessels and carrying exotic pests and/or pathogens to the island.

Bacteria

The plant bacteria survey comprised six field surveys by a team of two to three plant pathologists.

Liberibacter solanacearum, the bacteria carried by tomato potato psyllid, was detected on Norfolk Island. This bacterium is not known from the mainland and is a significant pathogen of quarantine concern. It affects a wide range of crops such as tomatoes, capsicums, eggplants, kumera and potatoes. There are several further species for which the taxonomic status is unresolved that also may not be present on the mainland and that may be of quarantine concern. There are many plant bacteria known from mainland Australia that are absent from Norfolk.

Viruses

The NIQS plant virus survey comprised six field surveys by a team of two to three plant pathologists.

Two species (both new) are known from Norfolk Island but are not present on mainland Australia (see Appendix 2); there are many plant viruses known from mainland Australia that are absent from Norfolk.

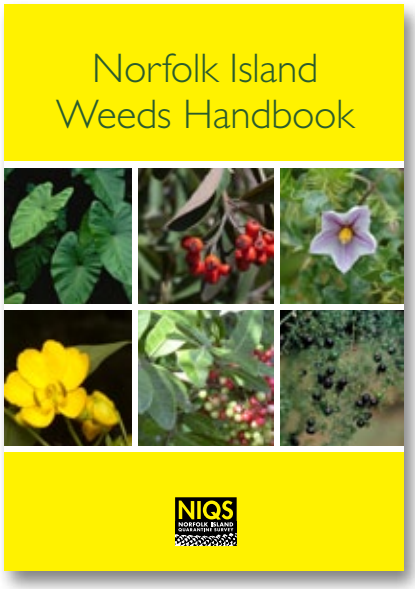
Fungi

The NIQS plant fungi survey comprised six field surveys by a team of two to six plant pathologists with expertise in mycology.

Twenty-four species of fungal plant pathogens (listed in Appendix 2) known from Norfolk Island have not been recorded from mainland Australia; there are many fungal plant pathogens known from mainland Australia that are absent from Norfolk. Additionally there are several host-fungi combinations that occur on Norfolk Island that have not been recorded from elsewhere in Australia.

Zoonoses and animals

The NIQS survey of zoonoses and animals comprised three field surveys



by a veterinary officer supported by an animal biosecurity staff member and Norfolk's veterinarian. The data and samples collected by this survey were supplemented by material provided by the island's veterinarian, and vector monitoring was carried out by Australian Government Department of Agriculture entomologists. There are no animal pests or diseases on Norfolk Island that are not also present in mainland Australia.

Two species of mosquitoes were found on Norfolk that do not occur on the Australian mainland (see Appendix 2). There are many species of mosquitoes and midges known from mainland Australia and New Zealand that are absent from Norfolk.

Pathways

Biologically, the terrestrial component of Norfolk Island's flora and fauna is highly isolated, with a high rate of endemism. Cargo vessels and regular passenger aircraft are the main human-assisted pathways for pests and pathogens of quarantine concern to Norfolk. Casual pathways such as irregular aircraft arrivals, cruise liners and itinerant yachts pose different but still significant threats.

Capability and capacity building

An important element of NIQS and a unique example of its practical contribution to the Norfolk Island community was its ability to provide reliable, valid data to support maintenance of the island's plant and animal health status into the future for both export and import pathways. This was achieved by an array of capability and capacity building activities, some aimed at community awareness and others directly involving Norfolk Island Quarantine Service personnel.

Community capacity building was initiated through the island's first-ever plant health clinic, conducted at the 2014 Norfolk Island Agricultural show and publication of a handbook of Norfolk Island weeds to enable community members to identify and report exotic weed species. NIQS also provided *ad hoc* support to community members during surveys and responses to enquiries from landholders; a quarantine awareness exercise at the Norfolk Island Central School; and a demonstration of detector dog activities to support biosecurity awareness curriculum development at the Central School.

NIQS engaged with the Norfolk Island Quarantine Service to develop the island's capability and capacity in plant health surveillance, plant health diagnostics and biosecurity (quarantine) through deploying and monitoring an array of fruit fly traps across the island using lures in 39 locations to target three species of fruit flies. Surveillance for honey bee pests as part of the National Honey Bee Pest Surveillance Program has been set up. Diagnostics capabilities are now supported by strong links with professionals on the mainland, materials for preservation of specimens and through the provision of a high quality microscope setup that includes the ability to take high-resolution images for specialist assistance offshore. Biosecurity processes have been enhanced by the construction of heat treatment facilities, training and competency testing in the use of methyl bromide to the Australian standard, and provision of a quarantine detector dog together with the training of handlers.

NIQS documents the flora, fauna and associated pests and other organisms present on Norfolk Island.

This report does not purport to reflect the quarantine (biosecurity) status or appropriate quarantine (biosecurity) arrangements for Norfolk Island or mainland Australia.

Import measures are needed and must be determined by a pest risk analysis or from existing internationally accepted measures.

Introduction

NIQS surveys of plant pests and animal diseases were conducted over a period of 18 months to cover all seasons. Survey components varied in their intensity of testing and surveillance undertaken, with less attention being paid to particular groups of pests and diseases that are already well known. Survey data provide a robust baseline for decisions on quarantine arrangements but do not claim to be complete.

An interesting example of the level of previous information about Norfolk's plant and animal health status is that questions were raised about investigating pests and pathogens of apples, since 'apples are not grown on Norfolk Island.' Field work rapidly demonstrated that several apple varieties are in fact grown on the island. Decisions about quarantine management must be based on robust data rather than accepted wisdom.

Previous, unpublished quarantine surveys of Norfolk Island have been limited in time and focus, and the information they gathered is generally accessible only within the quarantine system. Primary work was done on plant pests and diseases by Grimshaw *et al.* in 1999 and Paton *et al.* in 1980. Other disease-based surveys have investigated specific issues: work by Grimshaw *et al.* was instigated by the desire to export kentia palms and this was the focus of their report, though the report included a range of other sampling over a two-week period in October 1999. The survey by Paton *et al.* from 4-15 February and 3-14 November 1980 covered a broader range of issues, but did not claim to be comprehensive and recommended significant further work. This survey focused on pests and diseases of Norfolk Island pine *Araucaria heterophylla* but also incorporated other targets (Paton *et al.*, 1984). NIQS is thus the first comprehensive survey that comprehensively documents the plant and animal pests and diseases of quarantine concern to Norfolk Island.

Animal health studies have been conducted on Norfolk since the 1950s, but these mostly focused on a single host or pathogen issue and survey results were not always published, making access to some of them difficult or impossible. Attention has been paid to animal issues since the earliest days of European settlement with King reporting on sheep scab in 1789, just a year after the island was settled. Since then animal issues have been reported on a semi-regular basis, with cattle in particular subjected to frequent testing. All accessible previous accounts were used in selecting targets for the animal health survey component of NIQS.

The ecosystems of Norfolk Island differ significantly from mainland Australia. The natural plant community is based primarily on trees in the family Araucariaceae, not the Myrtaceae as on mainland Australia. The principal vertebrates on the island are birds: according to the Australian Government Department of the Environment's checklist of Norfolk Island birds, there are around 60 resident or regularly present migratory species and a further 60 or so occasional visitors or vagrants. There are few species of other vertebrates on the island: Gould's wattled bat

Chalinolobus gouldii and the eastern free-tailed bat *Mormopterus norfolkensis* are now thought to be extinct, and the native gecko *Christinus guentheri* and the skink *Oligosoma lichenigera* now survive only on offshore rock stacks and on Philip Island.

Polynesians of unknown origin are thought to have settled briefly on the island around seven to eight hundred years ago, but Norfolk was then uninhabited until 1788. Several mammal species have been introduced for human consumption or through commensal or parasitic relationships with humans and there are now 11 species of mammals on Norfolk Island: humans, cows, dogs, cats, goats, sheep, two species of rats, mice, pigs and horses.

There is a broad range of introduced plants on Norfolk including production, amenity and weedy species. Introduction is thought to date back to Polynesian visitors, who brought with them bananas and flax in addition to the Polynesian rat. Now most of Norfolk and all of Phillip and Nepean Islands are highly modified environments; these islands were uninhabited and completely treed when Europeans arrived.

The geology of the offshore islands differs from the diverse (and well studied) soil types of Norfolk Island, which range from relatively poor clay soils to rich, deep, weathered volcanic soil, though the organic matter in the soils is lowered considerably with loss of tree cover (research by Hutton and Stephens 1956, Holloway 1977; Abell and Falkland 1991, and Jones and McDougall 1973 provide a good foundation to managing agricultural production across the island). Nonetheless there have been periods, particularly during the early European settlement of Norfolk, when agricultural productivity was very high. A great diversity of agricultural plants was also introduced to the island during these periods of high production and many of these varieties and species survive either under production or in remnants of old agricultural land. Some plant pests and pathogens may have arrived in the early years of settlement, but they have little apparent impact on production.

While a small number of new plant pests have arrived on Norfolk Island in recent times despite strict quarantine controls, it is likely these incursions will decrease as border capabilities have strengthened, even during the NIQS survey period — especially since the introduction of the island's quarantine detector dog.

As mentioned, the term quarantine is used on Norfolk to refer to what most other jurisdictions now regard as biosecurity. For the purposes of this paper quarantine is used to encompass all the policies and measures a jurisdiction implements to minimise harmful effects from invasive species. In the broader sense it refers to all activities aimed at preventing the introduction and/or spread of a species of concern; in the narrower sense it is the official confinement of organisms that carry a risk of invasiveness and that not are already present — in other words, species that can enter and establish and that have the ability to spread aggressively, to intrude or overwhelm other organisms. This can apply to organisms affecting human health and culture, food safety and agricultural, natural terrestrial or aquatic ecosystems.

The impacts of invasive species range from negligible to extremely high, and can be difficult to understand. Some components are clearly measurable such as loss of human lives, or financial costs such as loss of agricultural production or increase in management costs. Many other impacts are less easily measured; these include environmental impacts, impingements on human life styles and amenity losses. In part the challenges of quantification come from the fact that many invasive species either do not establish or necessarily become pests if they do establish. Some are immediately problematic; others may have negligible short-term impact but may, after several to many generations (which may take months to years), reach sufficiently high levels to become problems. Changes in local conditions, from broad-scale habitat modification to a single event such as the introduction of a more efficient pollinator that enables greater seed set in a 'sleeper weed' may result in previously benign species (native or introduced) becoming invasive to the extent that they need control. The moral, of course, is that prevention is better than cure.

Norfolk Island's economy has a well documented cycle of boom and bust. In 1907 a Royal Commission into the island's affairs included in its terms of reference the best means of securing increased production of the

most suitable exports (NSW State Archives 5195), and the Butland report of 1974 provides a summary that shows this boom/bust cycle was primarily based on production and export of a single product, hence the island economy was intrinsically vulnerable to market demands for that single product (Butland, 1974).

Norfolk's economy has depended on various forms of primary industries and tourism for external income. Primary industries have included lemon peel and seed, bananas, passionfruit pulp, kentia palms, gerbera flowers, bean seeds, whaling, fishing, guava pulp, butter and pine wood (Butland 1974). The sheer variety of products demonstrates that there is scope for significant levels of production of a variety of commodities, but in each case only one of those industries has been responsible for the bulk of exports at any particular time. Norfolk also has some environmental challenges, with soil nutrient deficiencies (for example boron) expressed as disease-like symptoms in some fruits and vegetables.

At present tourism is effectively the only source of external income for the island; but as tourism is inextricably linked with the health of the global economy, in times of financial downturn — as is currently being experienced — there is a consequential decrease in tourism and a significant impact on Norfolk's economy.

All sea cargo currently enters Norfolk Island via Auckland, New Zealand. New Zealand has a number of significant pests that are of concern to mainland Australia and that are not yet found on Norfolk Island, so if that pathway is not well controlled then the Australian mainland could be exposed to these risks; for example, varroa mite and bovine tuberculosis. Already there are a number of species detected on Norfolk Island that are present in NZ but not on mainland Australia; for example, tomato potato psyllid and its associated bacterium *Liberibacter solonacearum* and African mantid.

NIQS field survey work varied in scope and approach because of a variety of factors including existing knowledge of the island's pest and disease status, the needs of different disciplines, the effect of the island environment on organisms' ability to survive, reproduce and spread, the numbers of targets and hosts, and the state of knowledge of various organisms among the different disciplines. In general the work on plant pests was undertaken by collecting specimens of host material that was then examined for the presence of pests, or by broad scale trapping methods. For bees and domestic animals, in contrast, a set of target pests exists for each group so testing for these particular targets was undertaken with results noted for individual organisms or colonies.

In addition to primary survey work, strengthening of border capacity and capabilities for quarantine included provision of a quarantine detector dog and training for its handlers, public education, assistance to increase plant quarantine diagnostic capability and provision of information on plant quarantine was provided.

The data provided by this survey provide a basis for exports or imports of agricultural commodities to occur, but further work will have to be undertaken to develop appropriate measures for each commodity — and this must also be done in line with the relevant laws of each jurisdiction as well as appropriate international phytosanitary or sanitary measures. Risk analyses for plants, for example, must be in accordance with the International Plant Protection Convention (IPPC), of which Australia and NZ are contracting parties; Australia is responsible for Norfolk Island under the IPPC.

Personnel

The survey involved an array of people and organisations, all of whom contributed significantly to various components of the work encompassed by the Norfolk Island Quarantine Survey.

Norfolk Island Government
Hon. Lisle Snell (Chief Minister, Minister for tourism); Hon. Ron Ward (Minister for environment, agriculture, public works, Rds); Alma Davidson; Gaye Evans; Sharon Quintal — facilitation of access and support

Norfolk Island Administration
Personnel: Neil (Snow) Tavener, Jon Gibbons, Dean (Fitzy) Fitzpatrick, Alan (Kissard) Buffett, Peter (Feathers) Davidson, David (Bear) Graham; Margaret Buffett, Wes Cooper, Robert (Poss) Westwood, Kevin Randall, Darlene Buffett, Kim Davies, Matt Nola, Malcolm Douran, Simon Peapells, Martin Snell, Jason Evans, Sarah Randall, Joanne Adams — facilitation, logistics, survey work

Norfolk Island Community (in particular but not exclusively)
Merv Buffett, Lou Evans, Hayden Evans, Phillip Evans, Matt Bigg, Patricia Buffett, John Smith, Margaret Smith, Dave South, George (Puss) Anderson; Jonno and Jo Snell of Greenway's Press, Dave Bigg of Charter Marine, Caz Silick and Jack Marges of the Golden Orb café, Gary Robertson and Toni Wilson of Photopress International; Pete Meers, Steve Mathews, Mark Scott, Jeff Singer of Norfolk Island Building Supplies; Martin Cross of Agricultural supplies; Kevin Coulter, Jill Oates KC Industries; Charles Christian-Bailey, Kim Christian-Bailey, Steve Whelan, Brett Leigh, Raewynne Tarrant, Christian Bailey Agencies; John Christian-Bailey, JCB Cabinets

Australian Government Department of Agriculture
Glynn Maynard, responsible for the entire survey including development, implementation and facilitation of survey components; Catherine Walsh and Amelia Thomas, support and data processing; Bethany Reid, development and compilation of weeds booklet, data processing and support; Chris Dale, technology implementation and support; Ben Boyd, Michael Gorton, Darren Peck, Angus Sly, Tony Robinson, Jurgen Otto, Adam Broadley, Luke Watson and Jacquie Otley, invertebrate survey; Iain East and Richard Rubira, veterinary survey

Australian Government Department of Infrastructure and Regional Development
Kenton Godfrey, Simon Pellatt, Karen Willett, Kristina Varelas, Glenda Kidman, Paul McInnes, Roger Gotlob, Robyn Fleming, Catherine Foley, Ginny Maidment, Stephen Clay, Robin McKenzie, Hon. Neil Pope and Hon. Gary Hardgrave

Australian Government Department of Environment
Permits section, Managers and staff of Norfolk Island National Park

Queensland Government Department of Agriculture, Fisheries and Forestry
Roger Shivas, Dean Beasley, Yu Pei Tan, Thomas Marney, Christine Horlock, Alistair McTaggart, Louise Shuey, Malcolm Ryley, S. Thompson and Greg Platz, fungal plant pathogens

University of Queensland
John Thomas, Andrew Geering; Thomas Marney, Denis Persley, non-fungal plant pathogens

Commonwealth Scientific and Industrial Organisation Australian National Herbarium
Brendan Lepschi, Bronwyn Collins, Kirstin Cowley, weeds survey

Plant Health Australia
Sam Malfroy, bees

Consultants
Carson Creagh, communications and community engagement strategy
Oliver Strewe, Oliver Strewe Photography
Steven Dunbar, Samphire Publishing Partners
Sabine Perrone, BioSecurity and AgriSystems Protection Consultants
Laurence Mound and Alice Wells, thrips and related taxa
Jonathan Banks, Grainsmith, treatments and pathways

Survey work

Methods

Multi-purpose laboratory facilities were set up on the island to facilitate collection and preparation of field collected specimens for NIQS. The laboratory continues to serve as support for the Norfolk Island Quarantine Service as part of capability building in biosecurity.

The laboratory facilities supported all components of the survey work — botany, plant pathogens (fungal and non-fungal), plant invertebrate pests, bees and domesticated animals.

The survey work had three primary approaches:

1. Search and sample the presence of a potential pest organism (used for botanical surveys).
2. Search for target hosts to discover what is present and, if possible, comment on what is absent (invertebrates, bees and plant pathogens).
3. Test for the presence or absence of a known suite of target pests on specific hosts (vertebrates and bees).

The reason for the difference between these approaches is the extent of knowledge about the pest organism and the international rules that have been developed to manage their risk. The first two are managed by IPPC, which has a series of guidelines to govern thousands of plant pests. The third is managed internationally by the World Organisation for Animal Health (OIE), which has published a manual that provides testing methodologies and information on each of about 72 target pest species.

NIQS surveys differ from all preceding surveys in their broad scale and time span, encompassing the full variability of species present that occurs throughout seasons and rainfall fluctuations.

Herbarium collections of naturalised (and selected cultivated) plants were made using established collection techniques. Samples were taken and pressed in the field using a plant press. The specimens were returned to the NIQS lab and dried over several days to weeks. These surveys were undertaken by Bronwyn Collins (BMC; 2013), Kirsten Cowley (KJC; 2014) and Brendan Lepschi (BJL; 2013 and 2013) of the Australian National Herbarium from

22 September to 5 October 2013 and from 18–27 February 2014.

There were six rounds of surveys for invertebrates and plant pathogens: two summer surveys (2013/2014 and 2014/2015); two spring surveys (2013 and 2014) and one survey each in winter and autumn. The focus of these surveys was guided by a plant host target list that focused on horticultural and agricultural crops and related plants but that also included some native species to cover a range of plant families (see Appendix 4). Habitats included agricultural, amenity, urban, peri-urban and natural habitats, including the Norfolk Island National Park located on both the main island as well as Philip Island, around six kilometres south of Norfolk. Field data were collected using iPhones as data input devices, then transferred to computers and uploaded to spreadsheets for annotation on completion of diagnostic testing. iPhones enabled consistent data capture format, location data in terms of latitude and longitude and imaging of the collection location. (The iPhone's other important function — that it could be used to call for help in the event of an emergency — was fortunately not required.)

Host plants were mostly identified by reference to *Flora of Australia* Vol. 49 (1994); Coyne (2011), and with the assistance of NIQS botanists, who helped with plant identifications when visits from various professionals coincided.

Plant pests comprise weeds, vertebrate, invertebrates and plant pathogens as defined by IPPC. This survey encompassed weeds (botany), invertebrates and plant pathogens. Vertebrate plant pests were not included as they are unlikely to be encountered on export or import pathways, though crimson rosellas ('red parrots') *Platycerus elegans* and feral chicken *Gallus gallus* could be considered plant pests.

All collecting equipment was required to be either new or cleaned prior to taking to Norfolk, and similarly treated for return to mainland Australia.

Invertebrates

Six on-ground surveys sampling from target plants, by two teams, were undertaken as part of this project. One team of entomologists (Ben Boyd, Michael Gorton, Angus Sly, Tony Roberson, Darren Peck, Jurgen Otto, Adam Broadley, Jacqui Otley and Luke Watson) from the Australian Government Department of Agriculture Operational Science Program surveyed for mites and non-thrips related taxa from 21–28 September 2013; 17–28 February, 19–27 May, 6–17 October and 24 November–5 December 2014. The second team (Laurence Mound and Alice Wells) surveyed for thrips and related taxa from 21–28 December 2012; 9–12 July and 21–26 October 2013; 21–28 March, 21–26 October and 21 November–1 December 2014.

Bees

Honey bees were tested for the pests and pathogens considered most significant, including pests and pathogens that are absent on the Australian mainland and are of

significant concern as well as some that are present on the Australian mainland but pose a significant threat to the health of bees on Norfolk (see Apendix 3).

Most surveillance took place in September and October 2013, with some follow-up samples taken in October 2014.

Plant viruses and bacteria

Plant samples were collected primarily from material in the early to middle stages of disease, when the pathogen is still active. Symptomatic and asymptomatic target plants were noted at each site. Six field surveys were conducted by University of Queensland virologists and bacterialogists John Thomas and Andrew Geering on 11–18 June and 8–15 October 2013, 18–22 February (as well as Thomas Marney), 27–31 May, 11–14 October (as well as Denis Persley) and 11–22 November 2014.

Fungi

Plant samples were collected primarily from plant material in the early to middle stages of disease, when the pathogen is still active.

Six field surveys were conducted by Queensland Government Department of Agriculture, Fisheries and Forestry mycologists: 12–18 June (Dean Beasley, Roger Shivas) and 29 September–5 October 2013 (Dean Beasley, Roger Shivas, Alistair McTaggart, Malcolm Rylely, Sue Thompson); 15–22 February (Dean Beasley, Roger Shivas, Greg Platz), 24–31 May (Dean Beasley, Roger Shivas, Thomas Marney, Louise Shuey), 11–17 October (Dean Beasley, Roger Shivas, Yui Pei Tan) and 13–20 December 2014 (Dean Beasley, Roger Shivas, Christine Horlock).

Zoonoses and animals

Historical records as well as available reports from previous animal health surveys were used to design the NIQS survey over 2013–2014. Previous reports include a survey of horses, cattle, sheep, goats, pigs and poultry in 1965; Ferrar *et al.* 1975; Harper 1993; sera collection (as part of a broader Australian survey) from cattle 1964–8; disease in birds 1986; NSW Department of Primary Industries surveys of cattle 1988, 1992, 1993 and 1999, with particular focus on surveillance for bovine TB and brucellosis. An eradication campaign for bovine viral diarrhoea began in 2010 based on vaccination, testing and destruction of persistently infected animals; successful eradication was declared in September 2011. These accounts as well as information from the Department of Health, veterinary records and the targets for the Northern Australia Quarantine Survey were used in deciding targets for the animal health survey component of NIQS as well as the development of the final data.

Evidence for pathogens and pest presence or absences was gathered from human health status reports to the Australian Government Department of Health and Ageing, animal carcass inspection, records from the Norfolk Island veterinary surgery, records for movement of animals on to Norfolk Island, sampling from animals, and vector sampling.

Survey results

A synopsis of the data is provided in this report. A summary where testing of hosts occurred but no pests were found is also provided in some cases.

Botany

This component of the survey focused on documenting the island's naturalised flora. Four hundred and thirty naturalised species have been recorded; the NIQS survey made a collection of 306 (71 per cent of the total) of these, of which 52 species represent new records for Norfolk (see Appendix 3). Two species are not known from mainland Australia (see Appendix 2) and a further 11 species are of uncertain status, but are not considered to pose significant biosecurity risks for Australia.

In addition to the 306 naturalised species recorded during these surveys, a further 124 species have been recorded as naturalised on Norfolk by previous workers.

Invertebrates (includes animal pests)

This component of the survey focused on documenting invertebrates associated primarily with crop plants, amenity plants and pests associated with introduced flora (and vectors of human and animal diseases). More than 1190 species of invertebrates were recorded; 121 are resolved only to family level and 173 to genus level. A further 11 species are known to be new species not previously described. This report incorporates species recorded in Smithers 1998, Neuwager *et al.* and unpublished report by Grimshaw *et al.* 1999 to provide a comprehensive overview of invertebrates of Norfolk Island.

There are 421 new species records

for Norfolk in addition to those previously recorded, with 31 of these not known to occur elsewhere in Australia (see Appendix 2).

There are at least 145 species of invertebrates that occur on Norfolk that are not known to occur elsewhere in Australia (see Appendix 3). A significant number of these are Norfolk Island endemic species, but the list also includes a range of species found in New Zealand and/or New Caledonia. Some of this species distribution is natural; some reflects import pathways. The identity of some invertebrates remains unresolved. These specimens may belong to new (that is, undescribed) species; the life stage, sex or condition of specimens collected may have precluded accurate identification; the group to which the specimens belong may be taxonomically too complex to allow identification; or a combination of these factors may have made identification impossible.

During the work of NIQS tomato potato psyllid (*Bactericera cockerelli*) along with its associated bacteria was discovered. It was initially detected at extremely low levels on the island and was believed to have been a very recent arrival potentially able to be eradicated at that very early stage. However, eradication requires a highly specialised set of skills and a very large amount of resources that need to be mobilised very quickly; even on the mainland, where there is a vastly larger set of resources, many plant pests cannot be eradicated.

The population of this psyllid had increased exponentially by the end of the survey work, so it is no longer able to be eradicated. The Norfolk Island Government did consider taking action toward eradication and made efforts in this direction; however, eradication was not feasible due to the rapid increase and spread of the pest.

Bees

There are anecdotal reports of a variety of pests and pathogens of honey bees of Norfolk Island, but no published records — nor has there been a wide-ranging survey to determine the health status of these bees, though the island's honey bee population is clearly healthy and thriving.

European honey bees were introduced into Norfolk Island in the 1800s (they were introduced into the Australian mainland in 1822). Several introductions appear to have taken place but there have been no introductions since 1992 so the island's bees have been isolated for some time.

Norfolk's native bee fauna is almost unknown, with only a few specimens of two species of native bees recorded from the island, but there has never been a concerted effort to collect native bees. Those that have been collected are solitary bees that nest in the soil, so the highly disturbed nature of most of the island means populations may be low. The native flora of the island suggests there were or are several species of native bees.

All native bees of both New Caledonia and New Zealand as well as the majority of those from the Australian mainland are solitary, ground nesting bees in the family Colletidae. One of the reasons greater numbers of native bees have not been detected on Norfolk Island is that many of these species exist as winged adults for a very short time and are hidden in underground cells as juveniles. There is no indication that any social bees existed on Norfolk Island nor any species of the family Apidae, so there are no species closely related to honey bees that could act as repositories of pests.

Only three pests and/or pathogens were detected during this survey; *Achroia gresella*, *Nosema ceranae* and Lake Sinai virus1. The honey bees of Norfolk Island are thus extremely healthy — a situation that is rare, if not unique, in the world.

Further, no pesticides, antibiotics

or other interventions for the management of pests or pathogens of bees are currently used with Norfolk's bees. Isolation and good border management have maintained this status, so there is significant potential for Norfolk Island's bees to act as a standard for use in honey bee experimental work worldwide.

Plant fungi

There are 24 species of plant pathogenic fungi that occur on Norfolk Island currently not known to occur on mainland Australia. *Alternaria selini*, *Puccinia tiritea* and *Pseudocerospora fijiensis* have been previously recorded on Norfolk; *Acervuloseptoria* sp. *Alternaria selini*, *Cercospora pseudochenopodii*, *Colletotrichum aotearoa*, *Colletotrichum constrictum*, *Colletotrichum cordylinicola*, *Colletotrichum magna*, *Colletotrichum novae-zelandiae*, *Colletotrichum ti*, *Fusarium bactridioides*, *Golovinomyces macrocarpus*, *Hemileia vastatrix*, *Leveillula allii*, *Maravalia milletticola*, *Phakopsora* sp., *Phoma pedeiae*, *Pseudocercospora coprosmae*, *Pseudocercospora epispermogoniana*, *Sphaeronaemella fragariae*, *Stagonosporopsis cucurbitacearum* and *Toxicocladosporium* sp. are new records. A few years ago an attempt was made to eradicate *Pseudocerospora fijiensis* from bananas and many in the community thought that this had been successful, since the fungus does not seem to significantly affect banana production.

There are 129 species of fungi not previously recorded from Norfolk Island that are present on the mainland and a further 50 species that have previously been recorded and are present on the mainland. Putative new species were found in the genera *Acervuloseptoria* (1 species), *Colletotrichum* (14), *Cercospora* (1), *Diaporthe* (5), *Fusarium* (2), *Mycosphaerella* (1), *Phakopsora* (1), *Phoma* (1), *Phytophthora* (1), *Pseudocercospora* (1) and *Pyricularia* (2). There is also a significant number of new host-pathogen records for Norfolk.

Viruses and bacteria

Twenty-four virus species were detected as new records on Norfolk Island, of which 22 species are known to occur elsewhere in Australia: *Potyvirus potato virus Y, Alfamovirus alfalfa mosaic virus, Allexivirus garlic virus B, Badnavirus banana streak IM virus, Badnavirus banana streak OL virus, Carmovirus hibiscus chlorotic ringspot virus, Cucumovirus cucumber mosaic virus, Cytorhabdovirus Digitaria striate virus, Ilarvirus apple mosaic virus, Mastrevirus tobacco yellow dwarf virus, Polerovirus potato leafroll virus, Potexvirus Cymbidium mosaic virus, Potexvirus leek yellow stripe virus, Potexvirus white clover mosaic virus, Potyvirus bean yellow mosaic virus, Potyvirus Commelina mild mosaic virus, Potyvirus Narcissus degeneration virus, Potyvirus pea seedborne mosaic virus, Potyvirus potato virus Y* and *Tobamovirus Odontoglossum ringspot virus.* A further two species of plant viruses detected (*Potyvirus Alstroemeria mosaic virus* and *Potyvirus Veltheimia mosaic virus*) are not known to occur in Australia.

Additionally there were several viruses that were not determined to species level: *Carlavirus* on Russian garlic (*Allium ampelopras ampelopras*); *Crinivirus* on tomato (*Solanum lycopersicum*); *Potyvirus* on coriander (*Coriandrum sativum*); *Potyvirus* on *Catharanthus roseus*, rhubarb (*Rheum rhabarbarum*), Russian garlic; and sugar snap peas (*Pisum sativum var. marcroparon*); *Tobamovirus* on glossy nightshade (*Solanum americanum*); an unknown pritivirid on rhubarb; and undetermined viruses on Philip Island chaffy tree (*Achyranthes margaretarum*) and umbrella tree (*Schefflera actinophylla*). The status of all of these in other parts of Australia is unknown.

There were at least two species of bacteria diagnosed from Norfolk Island. *Liberibacter solanacearum* has not been recorded on the Australian

mainland. Further work is under way to determine identity of the species of *Xanthomonas* found on several hosts; these may prove to be more than one species, and the status of this in other parts of Australia is yet to be resolved.

Many species and samples of plants were tested where no bacteria or viruses were detected.

Zoonoses and animals

NIQS did not detect any pests or pathogens of domestic animals on Norfolk Island that are not already present on mainland Australia; however, there are many pests and pathogens of domestic animals that occur on the mainland that are absent from Norfolk.

Pests and diseases detected by NIQS were bovine viral diarrhoea virus, infectious bovine rhinotracheitis and *Leptospira pomona* (cattle); porcine circovirus (pigs); equine herpes virus type 1 (horses); avian influenza A virus, infectious bursal disease and Newcastle disease (chickens); feline immunodeficiency virus and cat influenza virus (cats).

A survey of the mosquitoes on Norfolk Island was conducted over a week in February 2014, with additional mosquito samples collected during other invertebrate surveys as part of wider NIQS work. Weather during the February 2014 mosquito survey was warm and very humid with rainfall common at night. Both adult and larval specimens were collected during the survey: adult specimens were collected using adult traps including BG traps and CO_2 light traps, while larval specimens were collected through dipping. Larval and ovi trapping was not conducted during the survey. Five species of mosquitoes (*Aedes antipodeus, Culex pervigilans, C. quinquefsciatus, Halaedes australis and Rampamyia notoscriptus*) were collected. *R. notoscriptus* is a new record for Norfolk. *Aedes antipodeus* and *Culex pervigilans* are not known from Australia and one species of *Culex* could not be identified to species level; the status of this species is unknown. Culicoides traps run periodically through the survey did not detect any *Culicoides* of concern.

Norfolk Island is essentially closed to the import of domestic animals except from the Australian mainland and New Zealand. Domestic animals from other locations must undergo quarantine in mainland Australia or NZ and be cleared of any health concerns before entering Norfolk. Australia and NZ have very similar animal health statuses with the exception of bovine tuberculosis and varroa mites; NZ has been unable to eradicate TB because introduced Australian possums provide a natural reservoir for the disease (though possums in Australia do not get TB) and varroa mite on bees is a major concern in NZ.

Bovine viral diarrhoea virus (BVDV) in cattle was the subject of a vaccination, testing and culling campaign on Norfolk in 2010–11. Eradication was declared in September 2011 but it appears the campaign was either unsuccessful or the disease has been reintroduced. Since the success rate of vaccination is around 80 per cent, reappearance is not surprising. BVDV was not detected in sheep.

An uncontrolled source of disease is from wild birds and feral poultry. Livestock have a fairly broad interface with wild birds, particularly on cliff faces and tops where cattle graze around bird nesting burrows.

Invertebrate pests of animals

Invertebrate pests or parasites of vertebrate hosts that have been recorded (both from this survey and in Smithers, 1988) from Norfolk include: *Chrysomya megacephala, Chrysomya rufifacies, Chrysomya saffranea, Haematopinus suis, Gasterophilus intestinalis, Laemobothrion tinnunculi, Actornithophilus ceruleus, Actornithophilus incisus, Actornithophilus ochraceus, Calliphora norfolka, Calliphora stygia, Austromenopon atrofulvum, Austromenopon beckii, Colpocephalum subzerafae, Eidmanniella albescens, Kurodaia cryptostigmatia, Myrsidea rustica, Pseudomenopon scopulacorne, Brueelia tenuis, Coloceras hemiphagae, Coloceras restinctum, Cuculicola kui, Degeeriella rufa, Halipeurus placodus, Pectinopygus annulatus, Philopterus excisus, Philopterus turdi, Quadraceps birostris, Quadraceps charadrii, Quadraceps hopkinsi, Quadraceps separatus, Saemundssonia conica, Saemundssonia lobaticeps, Saemundssonia puellula, Sturnidoecus sturni, Trabeculus hexakon, Trabeculus mirabilis, Centocephalides felis, Pulex irritans, Sarcophaga bifrons*.

Pathways

A pathway is a means by which an organism can move from one area to another. While many potential quarantine threats exist outside a particular location, their potential can only be realised if they are able to translocate to the area of concern. There must be pathways by which they can move or be moved, and much of the focus of quarantine measures lies in managing (including, where possible, eliminating) the movement of organisms of concern along such pathways. There are three broad categories of pathways:

Natural pathways by which organisms are introduced *passively*, propelled by wind or water, or *actively* by flying, crawling or swimming.

Accidental or incidental pathways by which organisms such as soil, seeds, insects, molluscs, spiders, mites, and plant and animal pathogens are introduced through hitch-hiking or on packaging, containers or vehicles; in travellers' personal effects and luggage; on agricultural, military or industrial equipment; or via ships' hulls or ballast water.

Deliberate pathways such as the introduction of legal or illegal animal stock or genetic material; pets; ornamental or land rehabilitation plants; pasture plants or crops.

For all pathways — but especially for deliberate pathways, whether legal or illegal — it is vital to consider not only the invasiveness potential of organisms but also what pests, parasites or pathogens they could be carrying.

For example, 463 pasture species of legumes and grasses were introduced into northern Australia for pasture improvement between 1947 and 1985. Only four of these species proved useful with no invasive consequences; 17 species proved useful but had weedy characteristics; and a further 60 species were invasive and had no useful characteristics (Lonsdale 1994). This demonstrates the difficulty of predicting how a novel organism will behave in a new environment, particularly if it is not considered a problem in its place of origin.

Organisms themselves can be considered pathways for invasive species if they are not invasive species themselves (see table).

Norfolk Island has many advantages for the study of the impacts of terrestrial organisms in an isolated and geographically contained environment. The island's isolation provides an ideal biological barrier to the natural spread of terrestrial (and many marine) species; the main pathways for the introduction of new terrestrial organisms are human-mediated via shipping or aircraft, so are able to be controlled; and the natural pathways for terrestrial organisms are relatively few; these being primarily things that can fly, float, be carried by birds or carried on the wind.

The primary controls for Norfolk Island are not dissimilar to those in Australia with the baseline being all biological organisms are prohibited unless specifically permitted. Hence

Organism	Part/state	Risks
Plants	Live whole plants	Invertebrate pests, plant pathogens, weed potential, soil borne risks
	Non-viable dried leaves	Plant pathogens (some)
	Non-viable dried stems and thicker parts	Plant pathogens, invertebrate pests
	Seeds	Weed potential, plant pathogens, invertebrate pests
Invertebrates	Live	Pest potential, pathogens, parasites
	Non-viable dead or dried	Pests, pathogens
Vertebrates	Live	Pest potential, pathogens, parasites
	Dead	Pathogens (some), invertebrate pests
Fungi	Live	Invertebrate pests, parasites (other fungi and pathogens), invasive pest potential with spores (propagative material)
	Non-viable dead	Invertebrate pests, parasites, spores
Bacteria	Live	Invasive pathogen potential
Viruses	Live	Invasive pathogen potential

the majority of fresh fruit and vegetables are prohibited with the exceptions being potatoes, garlic, ginger and onions. Animals require a permit and to fulfil certain conditions prior to entry being permitted. Hence the quarantine risks on imports is mainly achieved by these controls combined with inspections both on ships prior to landing and on-shore screening by inspection or detector dog and treatment if living organisms are found.

Shipping

Norfolk Island is currently served by two cargo vessels, each of which arrives and discharges cargo every six weeks. All cargo comes from or transits via Auckland, with Australian cargo carried to Auckland for despatch to Norfolk.

For cargo vessels, both cargo and ship pose quarantine risks. Ships are unloaded at anchorage just offshore. They are not tied up at a jetty or wharf for unloading; there is no direct connection between vessel and the island, reducing the quarantine risk from invertebrates or vertebrates.

At Kingston they anchor between Philip Island and Norfolk Island, and just offshore at Cascade.

Norfolk's weather is often unsuitable for discharging cargo, so ships spend one to several days in the lee of either Norfolk or Philip Island. There is a significant risk that important quarantine pests could fly to shore at these times, including burnt pine longicorn beetle (established in New Zealand but not found in Australia), and honey bees infected with varroa mite (also established in NZ); bees regularly fly up to five kilometres and have been known to fly up to 10 km in favourable conditions.

Cargo is de-consolidated on board before being loaded on to lighters, which are then towed to the wharf facilities at Norfolk Island. This method of transfer provides a level of quarantine protection since it enables cargo to be inspected as it is transferred from ship to lighter.

Most large items and the bulk of Norfolk's mail arrive by ship. Quarantine controls in the transit area at Auckland are an issue; there is no meaningful quarantine isolation and cargo can wait weeks before being loaded. There is no quarantine inspection of in-transit cargo, nor is cargo kept in quarantine-secure facilities.

Until recently shipping to Norfolk Island came direct from Yamba, on the mid-north coast of New South Wales. These arrangements have changed so that all cargo shipping to Norfolk Island goes via Auckland, New Zealand. With regard to quarantine shipping from Yamba was problematic and caused high levels of quarantine contamination: the wharf at Yamba is within metres of crop-growing (in particular sugarcane) land, so loading under lights at night attracted large numbers of insects and these were loaded along with the cargo on to the ships.

Some businesses on Norfolk have lobbied for a move to containerisation and/or the construction of a new wharf where ships could tie up. Containerisation or a new wharf may have potential commercial efficiencies; however, consideration of quarantine risks would be needed to manage those risks, including:

- external and internal contamination of containers with inspection of all sides of the exterior of the container and construction of a quarantine controlled unpacking area so consignments could be inspected
- increased risk of hitch-hiking pests such as fire ants and other 'tramp' species inside containers
- risks of pests moving undetected from ship to shore via containers or,

especially, if vessels are tied up at a wharf
• containment of pests during unpacking
• facilities, resources and personnel for the treatment of contaminated materials and containers; and
• social and economic difficulties of rejecting a contaminated shipment if containers or vessel cannot be treated effectively.

Containerisation also brings with it challenges such as:
• difficulty of inspection and decontamination without appropriate lift and stands (specialised, well maintained stands and lifts are needed to handle standard shipping containers)
• workplace safety risks dealing with containers in particular if windy (Norfolk Island experiences moderate to high winds almost continually; containers can be dangerous under these conditions to handle particularly during discharge or loading as well as empties in stacks)
• where containers are going to be stored and stacked (on the mainland large areas are occupied by empty containers; this poses issues, particularly if high winds make them a hazard as well as the need for decontamination on arrival and prior to export)
• decontamination of containers prior to export is likely to be a requirement for entry into other locations
• pack and unpack facilities (stuffing and destuffing).

Norfolk imports all its gas, petrol, aviation fuel and diesel in bulk. The petroleum products bulk carrier and gas bulk carrier each sail three to four times a year, anchoring in Ball Bay where they anchor and attach underwater fuel lines to offload to storage facilities on the adjacent hillside. The island's quarantine officer meets each ship and checks for issues of quarantine concern — principally insects on the vessel's superstructure. Previous ports of call include Fiji or Kiribati for fuel and NZ or mainland Australia for gas.

Yacht visits to Norfolk Island are sporadic and motivated by tourism, shelter from weather, mechanical problems, need for supplies or illness or injury among crew. Most yachts stay at or near Norfolk for a few days to around a week, anchoring off Kingston or Cascade. The risks posed by yachts include hull fouling, superstructure contaminants, ship's stores, crew's personal effects and cargo contaminants.

Visits from itinerant vessels are also sporadic, with ships anchoring at Kingston or Cascade. They remain for highly variable periods — up to many weeks — so present quarantine risks through hull fouling, contaminated ballast water or superstructure, ship's stores, crew's personal effects and cargo contaminants.

Around 12 cruise liners visit Norfolk Island each year, but passengers are able to come ashore from only about a third of these because of adverse weather. Liners anchor at Cascade or Kingston and passengers are ferried ashore in small boats, with most passengers carrying only a small daypack. The risks posed by cruise liners include hull fouling, contaminated superstructure, ship's stores, crew's and passengers' personal effects and cargo contaminants.

Cruise liners come to Norfolk from a variety of ports, with the commonest being Auckland, Brisbane, Sydney or Noumea. Each port or origin has potential pests that do not occur on Norfolk Island.

For general cargo shipping and cruise liners, ballast water cannot be discharged at Norfolk Island so there should be limited risk from this source. There are similar controls on hull fouling from commercial vessels, so the main source of these risks is itinerant vessels and yachts.

Aircraft

Scheduled flights into Norfolk are currently two flights a week each from Brisbane and Sydney, and one flight

a week from Auckland. Airbus A320 aircraft carry around 150 passengers and crew as well as cargo and airmail.

Aircraft must conform to Australian standards for disinsection and require a valid disinsection certificate or be sprayed on arrival, prior to opening the hold or cabin. However, there are no airbridges at the airport and the terminal opens on to Douglas Drive — part of the central road that connects every part of the island. This means that any pests in aircraft holds or cabins have direct, immediate exposure to Norfolk Island.

Passengers disembark and walk across the tarmac to the arrivals hall, where they are then processed by quarantine, customs and immigration. A quarantine detector dog and an X-ray machine are stationed in the arrivals hall, and there is a high level of inspection and control of arriving passengers and crew.

Air cargo is held in the cargo shed after unloading until quarantine and customs clearance occur; the quarantine detector dog is also used to scan incoming cargo.

The risks from regular arrivals are materials imported in cargo or passenger and crew baggage; aircraft themselves are unlikely to pose a significant threat because all commercial aircraft entering Australia or NZ must be disinsected.

Occasional military aircraft (from mainland Australia, the southwest Pacific, New Caledonia and New Zealand), charter flights (from New Caledonia, mainland Australia and NZ) and transit aircraft for delivery to or from mainland Australia and NZ and a variety of small, private aircraft arriving at Norfolk are met by the quarantine officer. These aircraft pose variable quarantine risks: some have well managed decontamination processes while others require further decontamination on arrival. Pests potentially could arrive on these aircraft in holds or cabins.

At the airport the processes for detection of pests or risk items include inspection, X-ray and screening by a quarantine detector dog.

Specific risks

Almost all imported goods entering Norfolk Island originate within Australian or NZ biosecurity zones. This appears to limit potential invasive organisms to those established in these zones but some imports, including postal items, sourced from outside these zones may not be inspected, treated or comply with Australia/NZ import requirements. Some shipping and aircraft may visit Norfolk Island from outside Australian and NZ biosecurity zones. Some imported material at risk of carrying organisms of biosecurity concern, such as plant propagation materials, may require approved treatment offshore to be permitted entry. Additionally all animals entering Norfolk are required to have undergone species-specific testing and treatment within specified times prior to entry.

Transportation arriving at Norfolk Island is subject to treatment if pests are detected and may not receive clearance to unload cargo if appropriate treatment is not carried out or available. There are currently no wharf facilities that allow 20-foot containers to be unloaded without deconsolidation.

For the most part there are no biological barriers to the movement of pests on Norfolk Island; once a pest arrives on the island, unless it is detected and controlled very early in its establishment it will likely spread rapidly across the entire island and it will become impossible to identify or deal with discrete 'populations' or infestations of pests. This in turn creates challenges for pest control, particularly of species capable of rapid pesticide resistance. If poor pesticide management occurs in one area insecticide resistance is likely to spread across the island.

So far the rigorously controlled entry of domestic animals, plants, plant products and propagation materials has served Norfolk Island well. Importing a greater range of these commodities while continuing

to safeguard the island would require a significant expansion of resources to screen for and control a significant expansion in risk, with little benefit to the island environment or economy.

High freight and handling costs would make imported fresh produce expensive and inaccessible to most of the community, especially since airfreight would be required if quality is not to be compromised. High costs would make these items less attractive to tourists, and the fact of their being exotic to the island means increased risk of a high-impact pest or disease that could close local production of a range of commodities.

The entry of a high-impact pest or pathogen and loss of local production would be felt much more keenly than on the Australian mainland. Norfolk is an isolated community hundreds of nautical miles from the nearest producers: unlike on the Australian mainland, where if production ceases in one area other regions can usually supply commodities, Norfolk already experiences shortages or interruptions of supply simply because of the difficulties of transporting goods to the island. Interruptions to supplies of petroleum products and gas occurred several times during the 18 months of the NIQS survey.

Exports from Norfolk Island are very limited. Aside from personal effects and travellers' baggage, they currently include kentia palm seedlings and seed, recyclable metal items (batteries, metal scrap), materials such as asbestos that cannot be disposed of on the island, and associated packaging material. There are no commercial-scale exports of any commodity and the island's shrinking population and economy mean these are unlikely in the future.

On-island quarantine treatment options for imports or exports are limited to methyl bromide fumigation (one provider), insecticide treatment (two providers) and a heat treatment plant whose design and construction were supervised by a NIQS consultant. An incinerator is available for disposal of combustible items.

Given that Norfolk Island's domestic animal health status is equivalent to or better than those of mainland Australia and NZ, maintaining that status and managing issues arising from imports from NZ and mainland Australia are areas that need consideration. This situation is helped by the presence on the island of a full-time veterinarian who qualified on the mainland and who provides specialist resources for control of domestic animal pests and pathogens.

Imports of fresh produce, fresh flowers or foliage, growing media and nursery stock are complex, even if sources are limited to the Australian mainland and NZ, both of which have high health status. For the most part Norfolk's plant health status is better than that of mainland Australia and NZ, so the main issues that arise are, as for domestic animals, maintaining that status and managing issues arising from imports from mainland Australia or NZ. Individual risk analyses would need to be undertaken for any imports of these commodities, with appropriate management methods implemented.

In formulating measures to manage biosecurity risks the following issues need to be considered:

- there is almost no capacity on the island to manage a major outbreak of an agricultural pest
- there is no agricultural support for pest management or other agricultural issues such as plant nutrition, varietal selection, pest (including pathogen) identification capacity and so on
- there is no agricultural development officer to identify and develop markets for agricultural export products (including branding, quality maintenance and assurance, market facilitation and access negotiation, export inspection, and export or import risk analyses), so it is difficult to envisage Norfolk being able to fulfil market access requirements without technical assistance from the Australian Government Department of Agriculture or other suitably qualified and experienced service provider.

Capacity building and competencies

In conjunction with biological surveys, NIQS undertook work to support Norfolk Island's competencies and capabilities (including safe work practices) with regard to quarantine diagnostics and biosecurity processes. This work was done to ensure the stability of the island's animal and plant health status so that, for as long as is possible, the survey work remains relevant into the future.

The original intent of providing diagnostic reference collections of pest specimens to Norfolk was not undertaken, following an assessment of the resources and capabilities needed to support the maintenance of such a collection. While a diagnostic collection would an enormously useful resource for the island, climatic conditions would require specialist management skills.

However, as a result of NIQS Norfolk now has the capacity and capability to undertake an array of activities to support quarantine.

Diagnostics

Sampling equipment and techniques were provided to the Norfolk Island Quarantine Service, and a high-resolution microscope and image capture system was set up on the island not only to support work undertaken by NIQS specialists but also to provide resources and skills for the island's quarantine officer, who was trained in the use of the microscope and image capture equipment so specimens can be examined and photographed for consultation with offshore specialists, or preserved and sent to a specialist diagnostician on the mainland. Facilities were set up to enable quality specimen preservation, labelling and transport of plant-affecting pests, but the island would benefit further if this training were expanded.

Surveillance and monitoring

Several monitoring capabilities have been left in place on Norfolk, including:

- fruit fly traps at carefully chosen locations across the island, with up to five lure types at each location (for example, Med fly, Queensland fruit fly, papaya fruit fly), each targeting different fruit flies
- screw worm fly and sheep strike fly traps: LuciLure™ traps for sheep strike flies and modified LuciLure traps with BezziLure traps were set up to monitor for these pests at 10 sites around the island
- Culicoides traps were set up and monitored during the survey to determine the presence or absence of vectors of human and domestic animal pathogens. The traps are still on the island and can be used as needed. Traps used for other vector monitoring were returned to the mainland; and
- bee pest monitoring facilities and arrangements for diagnostics, in line with the Australian bee pest monitoring system run by Plant Health Australia. Data collected from the system will be incorporated into the Australian national bee monitoring system.

Electronic record-keeping was provided for the Norfolk Island Veterinary Surgery, with the clinic's records and historical data entered into the database to provide information on the presence or absence of particular target organisms. This initiative also helped build the profile for continuing reporting of the animal health status of domestic animals on Norfolk.

Detector dog

The Department of Agriculture donated a quarantine detector dog to the Administration of Norfolk Island. Training for handlers and support were put in place to ensure effective and efficient use of this resource. The dog has been in place since January 2015 and was immediately effective in detecting targets.

After the first month of operations the number of seizures declined significantly, indicating the community engagement value of the dog's presence and skills, and awareness of the risk of detection and possible punishment for offenders. Discussions are under way with Norfolk Island Central School to undertake education work, and there has been enormous engagement and acceptance by cruise liner passengers and crew.

Treatments

NIQS also carried out training and development of capabilities to undertake treatments for imports or exports to the level required by international biosecurity agencies. Capability training focusing on heat treatments and methyl bromide fumigation was carried out by

Dr Jonathan Banks. Additional training and assessment of capacity was undertaken by Gordon Weinert of the Department of Agriculture, who reported that there is the capability to undertake methyl bromide treatments to the level required by the International Standards for Phytosanitary Measures 15: regulation of wood packaging material in international trade (ISPM 15). This competency is required to enable export of timber packaging or products from Norfolk. Arrangements have been proposed for the certification of these goods and work on these processes still needs to be finalised.

Heat treatment training targeted the development of heat treatment facilities and their safe and efficient operation, with emphasis on treatment of imported or returning durable commodities. Because heat treatment provides a convenient, appropriate and effective non-chemical measure for elimination of pests in heat-tolerant goods, training included developing Norfolk's expertise to a level that would allow certification as a provider of ISPM 15 heat treatments capable of carrying out treatments to Department of Agriculture Heat Treatment Standard.

Methyl bromide fumigation training

The need for good monitoring of methyl bromide concentrations was emphasised during training, using the rubric 'If you're not monitoring, you're not fumigating.' Monitoring is required to comply with various standards for quarantine treatment, including the Australian methyl bromide fumigation standard (http://www.daff.gov.au/__data/assets/pdf_file/0010/734464/mb-standard-v2-1.pdf) and to ensure workplace safety during and subsequent to application of the fumigant.

The equipment used by Norfolk's sole methyl bromide fumigation provider was reviewed during the course of the training. The provider had an appropriate meter for reading fumigation concentrations of methyl bromide but no device for measuring methyl bromide concentrations in the region of the threshold limit value (5 ppm v/v in Australia) appropriate for showing that fumigant was fully cleared from a treated area or monitoring workspace concentrations around a treatment. No such device was available to Norfolk Island quarantine and customs personnel, though they may potentially be required to inspect or manage cargoes that could contain residual fumigant gas and require a means of checking cargoes and treated enclosures to see if gas levels are safe before entry. Subsequent to the training and on the recommendations of the training provider, a low-level methyl bromide monitor was provided to the Norfolk Island quarantine officer to enable safe monitoring of fumigations.

Discussion

The work of the Norfolk Island Quarantine Survey has established a baseline for the plant pests and the pathogens of domestic animals on Norfolk Island.

As well, NIQS made significant progress in building capacity and capability in quarantine/biosecurity processes so that data will remain relevant. An insight into the level of contributions made to our knowledge of Norfolk Island is provided in 'Norfolk Island's invertebrates' at the end of this report.

These achievements provide a sound basis on which appropriate quarantine/biosecurity measures can be developed for the export of goods to external markets, and to make decisions surrounding possible changes in border arrangements including imports of produce and domestic animals into Norfolk.

Consideration will now need to be given to measures to continue to protect Norfolk Island from significant plant pests such as Queensland fruit fly and med fly that occur on mainland Australia but not on the island, or pests such as varroa mites, bee diseases and burnt pine longicorn beetles from NZ. Any of these could cause significant difficulties in food production for the island. Queensland fruit flies require an enormous control effort to ensure adequate production of oranges, apples, pears and other fruit crops. It is no exaggeration to say that the entry of varroa mites would swiftly and completely destroy honey production on Norfolk Island, and close off opportunities to export Norfolk bees or honey.

Conversely, it will also be important to consider to appropriate measures with regard to pests that exist on Norfolk but not on the mainland; for example, the presence of tomato-potato psyllid and *Liberibacter solanacearum* on Norfolk has closed the potential for export of fresh solanaceous products to the mainland without specific phytosanitary measures.

Other survey work

Two brief visits to Philip Island six kilometres from Norfolk were undertaken: a one-day trip to collect faecal material from various bird species to test for avian influenza, and a two-day trip (on which survey personnel were accompanied by Parks Australia staff) for a preliminary investigation to determine if there was any difference in plant health status between Norfolk and Philip Islands.

The faecal samples were negative for the presence of avian influenza, but the second visit revealed differences between the islands. Plague thrips was detected on Philip Island but it has not been found on Norfolk, even though the same host plants were sampled at the same time of year. European honey bees were also found on Philip Island. Both results indicate that it would be useful to carry out more intensive survey work on plants there. The detection of bees is an issue because cargo ships often anchor in the vicinity of Philip Island before discharging of cargo, and checks on the health status of honey bees is needed to detect pests (in particular varroa mite) from NZ.

Issues for consideration

If it is decided to import fresh produce into Norfolk Island, import risk analyses for each commodity will need to be undertaken from the markets being targeted. This work would need the support of personnel from the Australian government Department of Agriculture, those with appropriate demonstrated skills or recent retirees from that department; the work requires a particular set of skills to conduct the risk assessment and develop appropriate measures. NIQS data will provide the basis for most of this work.

For exports to be developed, market access proposals will need to be developed and the appropriate jurisdiction approached with the proposal and evidence of the animal or plant health status. NIQS data will provide the basis for the information required for these undertakings. Most work will be in regard to weeds, plant invertebrates and pathogens due to the island's similarities of animal health status with the Australian mainland. Market access requests for products to enter the Australian mainland need to undergo a pest risk analysis by the Department of Agriculture's plant biosecurity branch and would have to be prioritised among the other market access requests from governments around the world.

Extensions to the arrivals hall of Norfolk Island Airport may need to be considered to add to the efficiency and effectiveness of the quarantine detector dog.

NIQS did not undertake a coastal marine survey. Such a

survey is required as a matter of priority. Tourism is currently the principal industry that brings funds to Norfolk, and one of the island's main environmental and amenity attractions is the single, accessible coral enclosed lagoon at Kingston (that is, Emily Bay through to the Kingston jetty). Coupled with the fact that this is where most cargo is discharged and where cruise liners prefer to transfer passengers, it would be prudent to assess the area's marine intertidal areas. A survey would have the additional benefit of creating baseline data on coastal and inter-tidal organisms (with particular reference to Sydney Bay) from which to develop policies to protect Norfolk Island's major coastal assets from pollution, nutrient input, and ballast water and hull fouling organisms.

It would be useful to carry out further survey work to establish the plant health status of Philip Island and possibly to include the health status of migratory birds that nest on Phillip.

Considerable work needs to be undertaken in the area of agricultural support. The skill set for an agricultural support and market access position for Norfolk Island needs to include plant nutrition and management of climatic conditions, pest management, disease control, pathology, pesticide management, market research, market access management, brand development and support. The targets for agricultural products would be best suited to modest production of multiple high value, low volume products aimed at high-end markets with the aim of providing a high collective return to the community.

Additionally, controlled entry into production is recommended to maintain the quality and reputation of such exports and the maintenance of medium- to long-term markets. Previous attempts to create agricultural products for export from Norfolk Island reveal a regular pattern of initial high returns for a small number of producers, then the entry of large numbers of external players into production of the same items, diluting returns to the point that production is no longer viable. Norfolk Island has a very small production area and very limited capacity to produce any one commodity with a guaranteed (by government or other control body) of quality. It also needs to be noted that Norfolk must maintain production for local consumption.

Apples were raised as an issue of particular concern when NIQS was being set up. The Department of Agriculture was informed by commentators on the mainland that apples do not grow on Norfolk Island and that this has led to nutritional deprivation. The survey revealed that apples are indeed grown (including commercially) on Norfolk and there are a number of varieties, but that supply is variable because of production and storage issues. A number of low chill apple varieties are already grown on Norfolk, production of which could be increased by multiplying the number of trees through taking cuttings or grafting on to rootstock. Cold storage facilities would also make these and other locally produced commodities available for longer periods. The issue was also raised that apples are unavailable for tourists, but the cost of importing high quality fruit would be so great that tourists are unlikely to consume them. Importing apples or planting stock from outside Norfolk will require measures to manage pests and pathogens not present on the island.

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Norfolk Island's invertebrates

unique species in a unique environment

Michael Gorton (scale insects), Laurence Mound (thrips), Jürgen Otto (mites)

To illustrate the changes in knowledge this survey has produced, examples of three groups of invertebrates are provided below. Knowledge of each group was limited when the survey began, with two species of thrips, 19 species of scale insects and no species of mites known from Norfolk Island.

While most oceanic islands are characterised by a much smaller variety and numbers of plants and animals than larger landmasses, Norfolk Island has a rich fauna and flora that have radiated widely since the island emerged from the ocean around 2.5 million years ago. Norfolk's isolation has not been total, however, and many new colonisers have arrived borne by wind or currents.

NIQS scientists collected a sometimes surprising range of invertebrates; in some cases many more members of particular groups than had previously been known from the island. Among these are three groups with particular relevance to Norfolk's biosecurity status, since they include species that could become agricultural pests if they were to establish in new environments.

Scale insects

Most species of scale insects (Coccoidea) are parasites that feed on sap. Many scale insects are serious crop pests whose waxy covering protects them from most insecticides.

Thirty two species of Coccoidea were collected during NIQS surveys, of which 13 were recorded from Norfolk for the first time: three species of soft scale insects, six species of hard or armoured scale insects, four species of mealybug and one species of palm scale.

Prior to the NIQS survey only 18 species of Coccoidea had been published from Norfolk (Williams and Watson 1988; 1988a; 1990). Another four species were collected during an Australian Quarantine and Inspection Service plant health survey in 1999, but these detections were not published.

Of the 32 species now recorded from Norfolk Island, six have not been recorded from the Australian mainland; the mealybugs *Ripersiella oliveri*, an unidentified *Dysmicoccus*, *D. insulae* and *D. nesophilus*, and the palm scales *Colobopyga kewensis* and *C. palmicola*. The hard scale *Chrysomphalus pinnulifer* is also present on Norfolk Island and while there are no published records of an Australian distribution it has been recorded from several states in the Australian Plant Pest Database.

Ripersiella oliveri has only been recorded from Norfolk and New Zealand and was not collected in the current survey. Most likely indigenous to NZ, it is a root feeder on pasture grasses; though pasture grasses were included in the NIQS surveys these hosts were not strongly sampled and root feeding pests were not targeted unless symptoms were observed above ground. Targeted sampling may be required to detect its presence.

The undescribed species of *Dysmicoccus* was collected on two occasions from *Cordyline obtecta*. This species is likely to be one of the few species of coccoidea endemic to Norfolk but further work is required to determine its affinities. The Norfolk pine mealybug *Dysmicoccus insulae* is almost certainly endemic to the island and has not been recorded elsewhere. It was found on *Araucaria heterophylla* across Norfolk but never observed in large numbers. *D. nesophilus*, which was not collected during this survey (Williams and Watson 1988), appears to have a natural distribution across the Pacific (excluding Australia and NZ) and may also be native to Norfolk.

There are three species of palm scale on Norfolk, all of which have only been collected from kentia palm (*Howea*). The most abundant species was *Colobopyga kewensis*. This species is known from Tanzania, Hawaii, the United Kingdom and Lord Howe Island, where it most likely originated and from which it has since been dispersed with the kentia palm trade (Williams and Watson 1990). *C. kewensis* was collected during a plant health survey in 1999 but there are no published records of its presence on the island. A second species, *C. palmicola*, has been recorded from Norfolk but may also have been imported from Lord Howe (Williams and Watson 1990). Only one sample was collected of this species. *C. australiensis* is a new record for Norfolk; it was only collected on kentia palm fruit, while *C. kewensis* was only collected from palm leaves. It is reasonable to assume this species also originated on Lord Howe Island.

All remaining Coccoidea observed on Norfolk Island appear to be common adventive (non-indigenous)

species. Most feed on a wide range of hosts and are widespread, with a long history of human-assisted movement.

Some species were very common and found on a wide range of hosts, including native host plant species; for example, the hard scale *Chrysomphalus pinnulifer* and the tessellated scale *Eucalymnatus tessellatus* were collected from 14 and 12 host genera respectively. *E. tessellatus* was present on the greatest number of native host plants and was especially common on *Meryta* sp. and white oak *Lagunaria patersonii*.

Other common species were Lantana scale *Hemiberlesia lantaniae* and Chinese white wax scale *Ceroplastes sinensis*, each on nine host genera, and the green coffee scale *Coccus viridis* on seven host genera.

Others species appeared to be relatively common but had much more restricted host range; for example, *Lindingaspsis rossi* was near ubiquitous on the foliage of Norfolk pine but was found on few other species. Palm scales and *Lepidosaphes beckii* were also very common across Norfolk but were only collected from kentia palm and citrus respectively. In contrast, some common mainland Australia pest species such as the citrus mealybug *Planococcus citri*, pineapple mealybug *Dysmicoccus brevipes*, *Pinnaspis strachani*, nigra scale *Parasaisettia nigra* and common brown scale *Coccus hesperidum* were seldom collected and never in significant numbers despite a wide range of suitable hosts.

The soft scale *Saissetia oleae* and the armoured scale *Parlatoria pergandii* — both introduced species that attack a range of hosts — were recorded from Norfolk in 1939 and 1947 respectively but have not been collected since. Suitable hosts for these species were widely sampled in the current survey but neither was detected and their presence cannot be confirmed.

Many species of adventive scale common on mainland Australia seem to be absent from Norfolk despite a favourable climate and abundance of suitable hosts; the citrus pests *Aonidiella aurantii*, *Chrysomphalus aonidium*, *Lepidosaphes gloveri* and *Unaspsi citri* and *Aspidiotus destructor* are widespread on the mainland but are apparently absent from the island. There is also a general paucity of adventive mealybugs on Norfolk. These absences likely reflect limited early transfer of host plants and subsequent biosecurity measures.

Thrips

Thrips — Order Thysanoptera — are small (1 mm long or less), slender insects with fringed wings. About 6000 species have been described. Many thrips feed on plants by puncturing them and sucking up the contents; some species feed on the blood and other body fluids of animals. Many thrips species are significant pests of plants with commercial value; others are considered beneficial because they attack other insects or mites, while others feed on fungi or on pollen.

The native thrips fauna of Norfolk comprises a remarkably wide diversity of fungus-feeding species on dead branches and dead leaves, plus two phytophages (leaf-feeding species), one found on young terminals of Norfolk Is pine, the other in flowers of the endemic shrub *Myoporum obscurum*.

Historically only a few species of thrips are known from the island, but this apparent paucity appears to reflect the remarkably unpredictable nature of thrips populations on Norfolk. Despite repeated sampling at a number of sites, the discovery of further species suggests populations are curiously unstable; for example, in December 2013 a vigorously breeding population of *Hercinothrips bicinctus* was found damaging leaves on the rare and endemic *Euphorbia norfolkiana* at Captain Cook Point. In March 2014 no specimens of this thrips could be found on the *Euphorbia* but scarcely two metres away the same thrips was breeding on the leaves of *Commelina cyanea*. There may also be an unpredictable influx of thrips on winds or possibly associated with visitors

Six surveys revealed a total of 59 species of Thysanoptera from Norfolk island, of which more than 12 are undescribed new species. However, for 10 species only single specimens or samples were taken.

A wide range of vegetable crops was examined for thrips, including asparagus, basil, beans, brassicas, capsicums, coriander, cucurbits, lettuce, lucerne, melons, onions, parsnips, silverbeet, strawberries, tomatoes, watercress and zucchini. Aphids were collected from many of these, but the only thrips species was the ubiquitous onion thrips *Thrips tabaci* and, on the flowers of several, *T. novocaledonensis*.

While cabbage moth damage to various brassicas is widespread and extensive, thrips damage to these crops on Norfolk is broadly speaking of no more than very local significance. However, the reservoir of these insects in weeds and on crop residues has the potential to cause localised outbreaks and loss of income to individual growers.

Tree crops including apples, avocado, bananas, citrus, coffee and guavas, and a wide range of native plants including *Abutilon*, *Araucaria*, *Celtis*, *Cordyline*, *Euphorbia*, *Lagunaria*, *Meryta*, *Myoporum*, *Myrsine*, *Nestegis*, *Pittosporum* and *Rhopalostylis* were also checked.

The leaf-feeding (phytophagous) thrips *Hercinothrips bicinctus* was found in association with damage to bananas. In December 2012 there were huge populations of this species across the island, with serious damage to the skins of banana fruits. In contrast, a year later numbers were remarkably low, with a significant reduction in damage.

Of the very large family Phlaeothripidae no leaf-feeding species have been found on Norfolk, in contrast to the diversity of this group in eastern Australia and New Caledonia. However, a wide diversity of fungus-feeding Phlaeothripids was collected, including a small number of apparently endemic species. A new species of *Carientothrips* is specific to the dead fronds of the Norfolk Island palm; a second, new genus and species is specific to dead leaves of *Cordyline*; and a third, *Priesneriana uptoni*, breeds only on the dead leaves of Norfolk pine. *Macrophthalmothrips neocaledonensis*, previously known only from New Caledonia, was found on Norfolk breeding at several sites on dead branches.

Also at these sites was a new species of *Sophiothrips*, and a single specimen of an unidentified species of *Plectrothrips*. Of particular interest was finding populations of *Hoplandrothrips leai*, described from specimens collected on Norfolk in 1915 that were subsequently lost.

Studies of Norfolk's native thrips fauna have yielded further interesting observations. The undescribed species of *Scirtothrips* that breeds only on the young terminal leaves

Scale insects on Norfolk Island

Species	First record
MONOPHLEBIDAE	
Icerya purchasi	Williams and Watson 1990
COCCIDAE	
Ceroplastes destructor	Williams and Watson 1990
Ceroplastes rubens	Williams and Watson 1990
Ceroplastes sinensis	Williams and Watson 1990
Coccus hesperidium	Williams and Watson 1990
Coccus longulus	NIQS 2013-2014
Coccus viridis	NIQS 2013-2014
Eucalymnatus tessellatus	Williams and Watson 1990
Parasaissetia nigra	NIQS 2013-2014
Saissetia coffeae	Williams and Watson 1990
Saissetia oleae	Williams and Watson 1990
DIASPIDIDAE	
Aspidiotus nerii	Williams and Watson 1988
Chrysomphalus dictyospermi	NIQS 2013-2014
Chrysomphalus pinnulifer	AQIS Plant Health Survey 1999
Diaspis bromeliae	NIQS 2013-2014
Fiorinia fiorinae	AQIS Plant Health Survey 1999
Hemiberlesia cyanophylli	NIQS 2013-2014
Hemiberlesia lantaniae	AQIS Plant Health Survey 1999
Hemiberlesia rapax	NIQS 2013-2014
Howardia biclavis	NIQS 2013-2014
Lepidosaphes beckii	Williams and Watson 1988
Lindingaspsis rossi	Williams and Watson 1988
Parlatoria pergandii	Williams and Watson 1988
Parlatoria pentagona	Williams and Watson 1988
Pinnaspis strachani	NIQS 2013-2014
HALIMOCOCCIDAE	
Colobopyga australiensis	NIQS 2013-2014
Colobopyga kewensis	AQIS Plant Health Survey 1999
Colobopyga palmicola	Williams and Watson 1990
PSEUDOCOCCIDAE	
Dysmicoccus sp.nov	NIQS 2013-2014
Dysmicoccus brevipes	NIQS 2013-2014
Dysmicoccus insulae	Williams and Watson 1988a
Dysmicoccus nesophilus	Williams and Watson 1988a
Planococcus citri	NIQS 2013-2014
Pseudococcus longispinus	Williams and Watson 1988a
Pseudococcus viburni	NIQS 2013-2014
RHIZOECIDAE	
Ripersiella oliveri	Williams and Watson 1988a

References

Cox, J.M. 1987. Pseudococcidae (Insecta: Hemiptera). *Fauna of New Zealand.* Duval, C. T. (series ed.), 11. DSIR Science Information Publishing Centre, Wellington

Williams, D.J. and Watson, G.W. 1988. In: *The Scale Insects of the Tropical South Pacific Region.* Pt. 1. The Armoured Scales (Diaspididae). CAB International, Wallingford

Williams, D.J. and Watson, G.W. 1988a. In: *The Scale Insects of the Tropical South Pacific Region.* Pt. 2: The Mealybugs (Pseudococcidae). CAB International, Wallingford

Williams, D.J. and Watson, G.W. 1990. In: *The Scale Insects of the Tropical South Pacific Region.* Pt. 3: The Soft Scales (Coccidae) and Other Families. CAB International, Wallingford

of Norfolk Island Pine appears to be parthenogenetic; no males were found despite females and larvae being common.

There is a remarkable disjunction between the thrips fauna of Norfolk Island and that of Eastern Australia, with several of the most abundant mainland thrips species not found during any of six visits to the island over two years.

There is only one phytophagous thrips species on Norfolk that is not known from the mainland and is of potential horticultural interest; *Thrips novocaledonensis*, which is also known from New Caledonia and Vanuatu. As this flower-living species attacks so many species it might be considered a potential threat to horticultural production on Norfolk and on the mainland.

In October 2014 a large number of *Thrips imaginis*, the Australian plague thrips, was collected on Phillip Island from the flowers of *Coprosma baueri* with some from *Lagunaria patersonia* flowers. This thrips was not found on Norfolk.

Finally, we would like to express our thanks to the continued encouragement and support we received from the various Norfolk Island growers on whose properties we worked, and to the enthusiasm and dedication of Quarantine Officer Neil Tavener.

Mites

Mites and their close relatives ticks are small arthropods that belong to the same class as spiders. Mites play important roles as plant or fungi feeders and predators: many of the 49,000-odd species described to date live freely in soil or water, but a large number are parasites on plants or animals and hence are significant agricultural pests: they make up around half of all invertebrates found by biosecurity authorities on agricultural commodities imported into Australia.

NIQS entomologists recorded around a hundred species of mites on Norfolk (which appear never to have been systematically studied). Most could not be identified to species; many of these may be undescribed and new to science, but surveys discounted species that live in leaf litter and soil. Most native plants on the island are likely to be inhabited by gall mites that are unique to their particular hosts and hence endemic to Norfolk, but again surveys targeted potential pests.

Three of Norfolk's mites are of particular scientific interest. *Amblyseius herbicolus*, the mite most frequently collected during surveys, is known from most parts of the globe and is also widely distributed on the Australian mainland. It is around half

Thrips species collected on Norfolk and Philip Islands

Aeolothripidae
Aeolothrips fasciatus
Merothripidae
Merothrips brunneus
Thripidae
Anaphothrips dubius
Anaphothrips sudanensis
Asprothrips nigricornis
Asprothrips seminigricornis
Bhattithrips frontalis
Chaetanaphothrips orchidii
Dendrothrips diaspora
Ensiferothrips primus
Frankliniella schultzei
Heliothrips haemorrhoidalis
Hercinothrips bicinctus
Scirtothrips inermis
Scirtothrips sp.nov
Tenothrips frici
Thrips australis
Thrips imaginis
Thrips nigropilosus
Thrips novocaledonensis
Thrips tabaci
Thrips sp.nov
Phlaeothripidae
Adraneothrips russatus
Anaglyptothrips dugdalei
Apterygothrips australis
Apterothrips apteris
Baenothrips moundi
Bamboosiella cingulata
Carientothrips snowi
Deplorothrips spp.
Gen. et sp.nov
Girault ithrips nigricoxa
Haplothrips avius
Haplothrips bituberculatus
Haplothrips gowdeyi
Haplothrips nigricoxa
Haplothrips robustus
Holothrips sp.nov
Holoengythrips maynardae
Hoplandrothrips leai
Hoplothrips orientalis
Karnyothrips melaleucus
Lissothrips sp.nov
Macrophthalmothrips neocaledonensis
Nesothrips propinquus
Ozothrips janus
Plectrothrips australis
Plesiothrips perplexus
Priesneria sp.nov
Priesneriana uptoni
Psalidothrips taylori
Sophiothrips martinae
Stephanothrips occidentalis
Strepterothrips tuberculatus
Stigmothrips russatus
Yarnkothrips kolourus

Two wingless thrips species found only on Norfolk Island: *Carientothrips snowi* lives only on dead leaves of the Norfolk Island Palm; *Priesneriana uptoni* lives only on the dead leaves of Norfolk Island Pine

a millimetre long and develops from egg to adult in just a week.

Amblyseius herbicolus also leads an interesting dual life: while it's a fast-moving predator of other mites, it's known to eat pollen — a useful attribute if it were to be employed to control pest mites.

Geckobia sp., which was found only on Philip Island, is a relatively large mite that like other members of this genus is a specialist parasite of geckos. These mites tend to be host specific and are sometimes found between geckoes' toes.

There is only one species of gecko on Philip Island — *Christinus guentheri*, the Lord Howe Island gecko, which once also lived on Norfolk itself. *Christinus guentheri* is classified as vulnerable, so the survival of the new mite depends on that of its host; if the gecko dies out, so will the mite.

A tiny gall mite tentatively identified as *Pentasetacus* (though it could be member of a closely related genus of Eriophyid mites) may be unique to Norfolk … and it may provide some important clues to how this group of plant-feeding mites (many of which are agricultural pests) evolved. It is found only on Norfolk pines.

Many gall mites are only a tenth of a millimetre long; thousands of species are already known and more are being discovered all the time. Most are host specific, and Norfolk's own species has what appear to be ancient or 'relic' characteristics. Specimens have been forwarded to a specialist on gall mites, who reports that she is excited to receive such unusual creatures.

MEMORANDUM OF UNDERSTANDING

Management of a Plant and Animal Pest and Disease Survey of Norfolk Island

Department of Regional Australia, Local Government, Arts and Sport (Regional Australia)

and

Department of Agriculture, Fisheries and Forestry (DAFF)

CONTENTS

MEMORANDUM OF UNDERSTANDING

Date

This Memorandum of Understanding (**MoU**) is dated 2012.

Parties

This MoU is made by:

1. **Department of Regional Australia, Local Government, Arts and Sport** (Regional Australia) - ABN 37 862 725 624; and

2. **Department of Agriculture, Fisheries and Forestry** (DAFF) - ABN 24 113 085 695.

Context

This MoU has been prepared in the following context:

A. The Commonwealth has constitutional powers over quarantine and biosecurity arrangements relating to Norfolk Island. The proposal is consistent with the review into biosecurity and quarantine arrangements, *One Biosecurity: A Working Partnership*, which recommended that the Commonwealth take a greater role in biosecurity across Australia, particularly pre-border.

B. DAFF is the Commonwealth Department responsible for safeguarding Australia's animal and plant health status to maintain overseas markets and protect the economy and environment from the impact of exotic pests and diseases, through risk assessment, inspection and certification, and the implementation of emergency response arrangements for Australian agricultural, food and fibre industries.

C. DAFF administers the *Quarantine Act 1908.*

D. Regional Australia is the Commonwealth Department responsible for the self-governing territory of Norfolk and has oversight of the *Norfolk Island Act 1979.*

E. Regional Australia have provided funding to DAFF to complete a plant andanimal pest and disease survey to progress consideration of Norfolk Island being included in mainland border security arrangements. That action will commence as soon as possible after execution of this MoU.

1. Interpretation

1.1. Definitions

1.1.1. Unless the contrary intention appears, a term in bold type has the meaning shown opposite it:

Commencement Date	means the date specified in Item A of Schedule 1;

Regional Australia	means the Commonwealth of Australia represented by and acting through the Department of Regional Australia, Local Government Arts and Sport (or any other Commonwealth department or agency that is, from time to time, responsible for the administration of this MoU) and includes, where the context permits, the officers, delegates, employees, agents and successors of Regional Australia;
Further Term	means any period specified in Item B of Schedule 1;
Initial Term	means the period specified in clause 2.1.1;
MoU	means this document, including any Schedule or annexure to it;
Schedule	means a Schedule of this MoU; and
Schedule of Works	means the Schedule of Works referred to in clause 3.1.1(a-h) of this MoU.

1.2. Purpose and Effect

1.2.1. The purpose of this MoU is to set out agreed arrangements, including roles and responsibilities, in relation to the conducting of plant and animal pest and disease survey of Norfolk Island.

1.2.2. Nothing in this MoU is intended to give rise to legally enforceable rights or obligations between the parties.

1.2.3. The parties will act and cooperate in good faith in accordance with the terms of this MoU.

1.2.4. In this MoU, where a party is required to do or refrain from doing something, that party will not do or refrain from doing that thing unreasonably.

2. Term

2.1. Commencement and Duration

2.1.1. This MoU commences on the Commencement Date and, subject to clause 2.2 or unless terminated earlier in accordance with clause 7, continues until 30 March 2015.

2.2. Further Term

2.2.1. If:

a. a Further Term is set out in Item B of Schedule 1;

b. a party wishes to extend the MoU for that Further Term commencing upon the expiration of the Initial Term;

c. the party gives written notice to the other party of that wish not less than 6 months prior to the expiration of the Initial Term; and

d. the other party agrees in writing to the extension of the agreement,

then, the MoU will be extended for the Further Term on the same terms contained in this MoU (excluding this clause 2.2).

3. Responsibilities

3.1. DAFF responsibilities

3.1.1. DAFF agrees to:

a. undertake work to assess the plant pest and disease status of Norfolk Island. The surveys will identify plant pests and diseases of biosecurity concern present on Norfolk Island and will inform decisions on the future quarantine status of the island and options for future quarantine arrangements. A decision regarding the possible extension of bioscurity services to Norfolk Island cannot be made until the plant pest and disease survey work is completed.

b. undertake six rolling surveys comprising the collection and identification of specimens on the island, diagnostic assessment of the specimens, and data capture, imaging and validation to retain the data and voucher specimens for future use and comparison as well as building of on-island capabilities in plant health surveillance, diagnostics, biosecurity processes. Six surveys are needed to capture the range of pests present across all seasons. Some pests are only detectable for relatively short time periods depending on their lifecycles and the season. To develop a report on the plant health status of Norfolk Island.

c. include an evaluation of the presence of zoonoses, the scope of this to be conducted on a similar basis as to those already undertaken in various areas in Australia, the extent of which will be determined upon an assessment of the perceived risks on Norfolk Island..

d. undertake at least 12 months fieldwork, commencing in late 2012;

e. provide finalised analyses and report by 30 March 2015 and interim reports with frequency and format as agreed in writing between DAFF and Regional Australia;

f. be the point of contact for all scientific and technical inquiries regarding the process and timeframe for the plant and animal pest and disease survey, having regard to information that can be provided by Regional Australia to assist in this role;

g. manage the project and report to Regional Australia at the end of every rolling survey to ensure that the proposal remains on track; and

h. prepare and submit to Regional Australia by 30 September every year an acquittal of expenditure against the expenditure projection for the preceding financial year.

3.2. Regional Australia responsibilities

3.2.1. Regional Australia agrees to:

a. consider the Schedule of Works and if acceptable provide Regional Australia consent;

b. consider the annual expenditure projection which the Parties agree will not exceed $1.5m and if acceptable provide Regional Australia consent;

c. consider proposed variations to the annual expenditure projection and if acceptable provide Regional Australia consent; and

d. subject to clause 3.3.1, pay monies to DAFF in advance and in accordance with the expenditure projections.

3.3. Regional Australia may withhold or suspend payment

3.3.1. Regional Australia has the right to withhold or suspend payment if DAFF does not provide an acquittal of expenditure or annual reports by the required date identified in clauses 3.1.1 and 5.1.1.

4. Good and Services Tax

4.1. GST

4.1.1. If the performance of DAFF's responsibilities under this MoU is a taxable supply within the meaning of *A New Tax System (Goods and Services Tax) Act 1999* (**the GST Act**) the amounts to be advanced by Regional Australia to DAFF will be increased by an amount equal to the GST payable on those advances as if they represent the value of the taxable supply for the purposes of the GST Act.

4.1.2. DAFF will issue Regional Australia with a tax invoice in accordance with the GST Act in relation to taxable supplies under this MoU.

5. Reporting

5.1. Monitoring and Reporting

5.1.1. The Parties agree to consult with each other on an ongoing basis. DAFF will report to Regional Australia at the end of every rolling survey, or as otherwise agreed in writing between DAFF and Regional Australia, to ensure that the proposal remains on-track to be completed by 30 March 2015.

6. MoU Review

6.1. MoU Review

6.1.1. The Parties will review the operation of this MoU 6 months after commencement or at such other time as mutually determined by the Parties to assess the suitability of arrangements under this MoU.

7. MoU Termination

7.1. Termination on Notice by DAFF

7.1.1. DAFF may terminate this MoU for any reason by giving 6 months written notice to Regional Australia.

7.1.2. If DAFF terminates this MoU in accordance with clause 7.1.1:

a. DAFF will pay for any payments that have been committed by DAFF in accordance with DAFF's responsibilities under this MoU; and

b. DAFF will return any monies that have not been spent or committed by in accordance with DAFF's responsibilities under this MoU to Regional Australia within 90 days of date of termination.

7.2. Termination on Notice by Regional Australia

7.2.1. Regional Australia may terminate this MoU for any reason by giving 6 months written notice to DAFF.

7.2.2. If Regional Australia terminates this MoU in accordance with clause 7.2.1:

a. Regional Australia will pay for all agreed and suitably completed works and any payments that have been committed to by DAFF in accordance with DAFF's responsibilities under this MoU.

8. Variations

8.1. Agreement may be varied

8.1.1. This MoU may be varied or amended by agreement in writing between the parties.

9. Notices

9.1. Format, addressing and delivery

9.1.1. A notice under this MoU is only effective if it is in writing and dealt with as follows:

a. *if given by DAFF to Regional Australia,* addressed to the following:

Director - Norfolk Island Unit
Local Government and Territories Division
Department of Regional Australia, Local Government, Arts and Sport
PO Box 803
CANBERRA ACT 2601

b. *if given by Regional Australia* to DAFF, addressed to the following:

Dr Glynn Maynard
Director Diagnostics Development and Support
Plant Biosecurity (Grains and Forestry)
Department of Agriculture, Fisheries and Forestry

PO Box 858
CANBERRA ACT 2601

9.1.2. A notice is to be:

a. signed by the person giving the notice and delivered by hand; or

b. signed by the person giving the notice and sent by pre-paid post; or

c. transmitted electronically by the person giving the notice by electronic mail or facsimile transmission.

9.2. When effective

9.2.1. A notice is deemed to be effected:

a. *if delivered by hand* - upon delivery to the relevant address;

b. *if sent by post* - upon delivery to the relevant address;

c. *if transmitted electronically* - upon actual receipt by the addressee.

9.2.2. A notice received after 5.00 pm, or on a day that is not a business day in the place of receipt, is deemed to be effected on the next business day in that place.

10. Costs

10.1. Parties pay their own costs

10.1.1. Each party must bear its own costs of and incidental to the negotiation, settlement, preparation and execution of this MoU.

SCHEDULE 1 - MOU DETAILS

A. Commencement Date
(Clause 2.1)

This MoU will commence, unless otherwise specified, when it is signed by the last party to do so.

B. Further Term
(Clause 2.2)

If required an extension may be given by agreement in writing between the parties.

Signatures

SIGNED for and on behalf of
COMMONWEALTH OF AUSTRALIA
represented by the Department of Regional Australia, Local Government Arts and Sport by:

MATASHA McCONCHIE
Name of signatory

Signature

19.12.12
Date

In the presence of:

Kenton Godfrey
Name of witness

Signature of witness

SIGNED for and on behalf of
Department of Agriculture, Fisheries and Forestry

Signature

Bill Magee
Name of signatory

7/12/2012
Date

In the presence of:

Catherine Crowley
Name of witness

Crowley
Signature of witness

Appendix 2: Species present on Norfolk not present on mainland Australia

Host common name	Host species	Pest family	Pest species
Phillip Island hibiscus	*Hibiscus insularis*	Mycosphaerellaceae	*Acervuloseptoria* sp.
Fennel	*Foeniculum vulgare*	Pleosporaceae	*Alternaria selini*
Fat hen	*Chenopodium album*	Mycosphaerellaceae	*Cercospora pseudochenopodii*
Kentia palm; coffee	*Howea forsteriana*	Glomerellaceae	*Colletotrichum aotearoa*
Sweet granadilla	*Passiflora ligularis*	Glomerellaceae	*Colletotrichum constrictum*
African lily	*Agapanthus africanus*	Glomerellaceae	*Colletotrichum cordylinicola*
Passionfruit	*Passiflora edulis*	Glomerellaceae	*Colletotrichum magna*
Begonia; Passionfruit	*Begonia* sp.; *Passiflora edulis*	Glomerellaceae	*Colletotrichum novae-zelandiae*
Norfolk Island cordyline, Ti	*Cordyline obtecta*	Glomerellaceae	*Colletotrichum ti*
Sandplain lupin, West Australian blue lupin	*Lupinus cosentinii*	Nectriaceae	*Fusarium bactridioides*
Marguerite daisy	*Argyranthemum* sp.	Erysiphaceae	*Golovinomyces macrocarpus*
Coffee	*Coffea robusta*	Incertae sedis	*Hemileia vastatrix*
Wild leek	*Allium ampeloprasum*	Erysiphaceae	*Leveillula allii*
Nasturtium	*Tropaeolum majus*	Erysiphaceae	*Leveillula tropaeolicola*
Native wisteria	*Millettia australis*	Chaconiaceae	*Maravalia milletticola*
Norfolk Island hibiscus, White oak, Cow itch tree	*Lagunaria patersonia*	Phakopsoraceae	*Phakopsora* sp.
African lily	*Agapanthus africanus*	Incertae sedis	*Phoma pedeiae*
Coprosma	*Coprosma* sp.	Mycosphaerellaceae	*Pseudocercospora coprosmae*
Grape	*Vitis vinifera*	Mycosphaerellaceae	*Pseudocercospora epispermogoniana*
Banana	*Musa paradisiaca*	Mycosphaerellaceae	*Pseudocercospora fijiensis*
Shrubby creeper, Pohuehue	*Muehlenbeckia australis*	Pucciniaceae	*Puccinia tiritea*
Strawberry	*Fragaria ananassa*	Incertae sedis	*Sphaeronaemella fragariae*
Pawpaw, Papaya	*Carica papaya*	Incertae sedis	*Stagonosporopsis cucurbitacearum*
African olive	*Olea europaea* subsp. *cuspidata*	Incertae sedis	*Toxicocladosporium* sp.
Capsicum; tomato; apple of Peru; glossy nightshade; eggplant; apple of Peru; apple of Sodom, devils apple; common thorn apple; glossy nightshade; potato	*Capsicum annuum*; *Solanum lycopersicum*; *Nicandra physalodes*; *Solanum melongena*; *Nicandra physalodes*; *Solanum linnaeanum*; *Datura stramonium*; *Solanum americanum*; *Solanum tuberosum*	Rhizobiaceae	*Liberibacter solanacearum*
Peruvian lily	*Alstroemeria* sp.	Potyviridae	Potyvirus *Alstroemeria* mosaic virus
Chinkerinchee	*Ornithogalum thyrsoides*	Potyviridae	Potyvirus *Veltheimia mosaic virus*
NA	NA	Euphobiaceae	*Euphorbia obliqua*
NA	NA	Santalaceae	*Exocarpos phyllanthoides*
Norfolk Island pine; various vegetables	*Araucaria heterophylla*; various	Ptiliidae	*Acrotrichis norfolkensis*
Grass	Unknown	Podoscirtidae	*Adenopterus norfolkensis*
Eucalyptus	*Eucalyptus* sp.	Aderidae	*Aderus norfolcensis*
NA	NA	Culicidae	*Aedes antipodeus*
Orange; Norfolk Island hibiscus, white oak, cow itch tree	*Citrus aurantium*; *Lagunaria patersonia*	Stigmaeidae	*Agistemus novazelandicus*

Host common name	Host species	Pest family	Pest species
Norfolk Island hibiscus, white oak, cow itch tree	*Lagunaria patersonia*	Stigmaeidae	*Agistemus subreticulatus*
Norfolk Island pine	*Araucaria heterophylla*	Microcystidae	*Allenoconcha basispiralis*
Palm trees	Unknown	Ameroseiidae	*Ameroseius sextuberculi*
Norfolk Island tree fern	*Cyathea brownii*	Cicadellidae	*Anzygina jowettae*
Sharkwood	*Dysoxylum bijugum*	Chrysomelidae	*Argopistes armipes*
Brush bloodwood, bloodwood, ivory birch	*Baloghia inophylla*	Tettigoniidae	*Austrosalomona personafrons*
Tomato; blue morning glory, purple morning glory; potato	*Solanum lycopersicum*; *Ipomoea indica*; *Solanum tuberosum*	Triozidae	*Bactericera cockerelli*
NA	NA	Tettigoniidae	*Beiericolya tardipes*
Kentia palm	*Howea* sp.	Chrysomelidae	*Brontispa norfolkensis*
Cabbage; broccoli; beans; pawpaw, papaya; tomato; avocado; fleabane; cordyline; elephant grass; hibiscus; potato	*Brassica oleracea* var. *capitata*; *Brassica oleracea* var. *italic*; *Phaseolus* spp.; *Carica papaya*; *Solanum lycopersicum*; *Persea americana*; *Conyza* sp.; *Cordyline* sp.; *Cenchrus purpureus*; *Hibiscus* sp.; *Solanum tuberosum*	Formicidae	*Cardiocondyla emeryi*
Norfolk Island palm; Brush bloodwood, bloodwood, ivory birch; dead palm leaves and wood; palm trees; Norfolk Island cordyline, ti	*Rhopalostylis bauera*; *Baloghia inophylla*; *Cordyline obtecta*	Phlaeothripidae	*Carientothrips snowi*
Norfolk Island pine; sweet potato, kumara; broccoli; sharkwood; bean; basil, brassica; bananas	*Araucaria heterophylla*; *Ipomoea batatas*; *Brassica oleracea* var. *italic*; *Dysoxylum bijugum*; *Phaseolus vulgaris*	Chrysomelidae	*Chaetocnema paspalae*
Palm trees	Unknown	Punctidae	*Christianoconcha orestias*
Palm trees	Unknown	Clubionidae	*Clubiona comta*
Carrot	*Daucus carota* subsp. *sativus*	Coccinellidae	*Coccinella septempunctata*
Norfolk Island pine	*Araucaria heterophylla*	Chrysomelidae	*Colaspoides norfolcensis*
Palm trees	Unknown	Theridiidae	*Coleosoma* sp.
Tomato	*Solanum lycopersicum*	Theridiidae	*Coleosoma floridanum*
Kentia palm	*Howea* sp.	Halimococcidae	*Colobopyga palmicola*
Palm trees	Unknown	Charopidae	*Cryptocharopa exagitans*
Norfolk Island pine	*Araucaria heterophylla*	Laemophloeidae	*Cryptolestes norfolcensis*
NA	NA	Culicidae	*Culex c.f. pervigilans*
NA	NA	Culicidae	*Culex pervigilans*
Palm trees; eucalyptus leaf litter; grass	*Eucalyptus* sp.; *Digitaria* sp.	Anthribidae	*Dasyanthribus* sp.
NA	NA	Chrysomelidae	*Dematochroma norfolkiana*
Palm trees	Unknown	Trigonidiidae	*Dictyonemobius lateralis*
NA	Unknown	Tenebrionidae	*Dioedus araucariae*
Palm trees; Norfolk Island pine	*Araucaria heterophylla*	Assimineidae	*Duritropis albocarinata*
Norfolk Island pine	*Araucaria heterophylla*	Pseudococcidae	*Dysmicoccus insulae*
Norfolk Island pine	*Araucaria heterophylla*	Cerambycidae	*Dysthaeta naevia*
Lord Howe Island palm, kentia palm	*Howea belmoreana*; *Howea forsteriana*	Clubionidae	*Elaver* sp.
Norfolk Island pine; broad leaved meryta; narrow leaved meryta; pawpaw, papaya; apple	*Araucaria heterophylla*; *Meryta latifolia*; *Meryta angustifolia*; *Carica papaya*; *Malus domestica*	Cerambycidae	*Enicodes fichteli*
Castor oil plant; grass	*Ricinus communis*	Cerambycidae	*Enicodes* sp.
Nectarine	*Prunus persica*	Stigmaeidae	*Eryngiopus nelsonensis*
NA	NA	Salticidae	*Europhrys c.f. terrestris*

Host common name	Host species	Pest family	Pest species
Norfolk Island pine	*Araucaria heterophylla*	Microcystidae	*Fanulena insculpta*
NA	NA	Tenebrionidae	*Gonocephalum insulanum*
NA	NA	Rhyparochromidae	*Hebrolethaeus concisus*
Norfolk Island palm; olive; hibiscus; Norfolk Island hibiscus; white oak; cow itch tree; leaf litter; Philip Island hibiscus;		Herminiidae	*Hydrillodes norfolki*
Red cedar, Australian red cedar; dead branch; palm trees;		Immidae	*Imma celtiphaga*
lichens	*Rhopalostylis bauera*; *Olea* sp.; *Hibiscus* sp.	Podosciritidae	*Insulascirtus christiani*
Lagunaria patersonia; Hibiscus insularis; Toona ciliata		Ascidae	*Iphidozercon gibbus*
		Phlaeothripidae	*Holoengythrips maynardae*
Maple (NI), tamana; red cedar, Australian red cedar; olive; Norfolk Island hibiscus, white oak, cow itch tree; leaf litter; peach and neem; Norfolk Island pine; silky oak	*Elaeodendron curtipendulum*; *Toona ciliata*; *Olea* sp.; *Lagunaria patersonia*; *Araucaria heterophylla*	Phlaeothripidae	*Hoplandrothrips leai*
NA	NA	Herminiidae	*Hydrillodes norfolki*
NA	NA	Immidae	*Imma celtiphaga*
NA	NA	Podoscirtidae	*Insulascirtus christiani*
Palm trees	NA	Ascidae	*Iphidozercon gibbus*
Eucalyptus; Norfolk Island hibiscus, white oak, cow itch tree	*Eucalyptus* sp.; *Lagunaria patersonia*	Ptinidae	*Leanobium marmoratus*
Palm trees; Eucalyptus leaf litter	*Eucalyptus* sp.	Reduviidae	*Leaylia norfolkiana*
Palm trees	Unknown	Lepidopsocidae	*Lepolepis graemei*
Norfolk Island pine; maple (NI), tamana; brush bloodwood, bloodwood, ivory birch; Norfolk Island hibiscus, white oak, cow itch tree; dead branch	*Araucaria heterophylla*; *Elaeodendron curtipendulum*; *Baloghia inophylla*; *Lagunaria patersonia*	Phlaeothripidae	*Lissothrips* sp.nov.
Norfolk Island pine; yucca	*Araucaria heterophylla*; *Yucca aloifolia*	Tenebrionidae	*Lorelus fumatus*
White cedar, Persian lilac; dead branch; Norfolk Island pine; Red cedar, Australian red cedar; Norfolk Island hibiscus, white oak, cow itch tree; leaf litter; silky oak	*Melia azedarach*; *Araucaria heterophylla*; *Toona ciliata*; *Lagunaria patersonia*	Phlaeothripidae	*Macrophthalmothrips neocaledonensis*
Yellow guava; Orange	*Psidium guajava*; *Citrus sinensis*	Chrysopidae	*Mallada metastigma*
NA	NA	Microcystidae	*Mathewsoconcha belli*
Norfolk Island cordyline, ti; citrus oleander pittosporum	*Cordyline obtecta*; *Citrus* spp.; *Pittosporum bracteolatum*	Microcystidae	*Mathewsoconcha suteri*
Avocado	*Persea americana*	Tydeidae	*Metalorryia* sp.
Norfolk Island pine; Norfolk Island cordyline, ti; rockmelon; Eucalyptus; apple; olive	*Araucaria heterophylla*; *Cordyline obtecta*; *Cucumis melo*; *Eucalyptus* sp.; *Malus domestica*; *Olea europaea cuspidata*	Curculionidae	*Microcryptorhynchus rufimanus*
Norfolk Island hibiscus, white oak, cow itch tree; native cucumber	*Lagunaria patersonia*; *Zehneria baueriana*	Curculionidae	*Microcryptorhynchus setosus*
Norfolk Island pine; Norfolk Island hibiscus, white oak, cow itch tree; New Zealand flax; apple	*Araucaria heterophylla*; *Lagunaria patersonia*	*Neocalvolia* sp.	
Phormium tenax; Malus domestica	Cerambycidae	*Microlamia norfolkensis*	*N*
Grass; Norfolk Island hibiscus, white oak, cow itch tree	*Digitaria* sp. *Lagunaria patersonia*	Cerambycidae	*Microlamia viridis*
Cordyline	*Cordyline* sp.	Mantidae	*Miomantis caffra*

Host common name	Host species	Pest family	Pest species
Norfolk Island pine	*Araucaria heterophylla*	Curculionidae	*Mitrastethus lateralis*
Various young vegetables; African boxthorn; corn and broccoli; fern; celery, brassicae; Norfolk Island hibiscus, white oak, cow itch tree; Norfolk Island cordyline, ti	*Lycium ferocissimum*; *Nephrolepis* sp.; *Lagunaria patersonia*; *Cordyline obtecta*	Mordellidae	*Mordella norfolcensis*
Norfolk Island pine	*Araucaria heterophylla*	Acaridae	*Neoacotyledon* sp.
Orange	*Citrus sinensis*	Winterschmidtiidae	*Neocalvolia* sp.
NA	NA	Arctiidae	*Nesiotica cladara*
Palm trees	Unknown	Chernetidae	*Nesochernes gracilis norfolkensis*
NA	NA	Noctuidae	*Ophiusa tirhaca*
NA	NA	Tineidae	*Opogona psola*
Castor oil plant; cucumber; tomato	*Ricinus communis*; *Cucumis sativus*; *Solanum lycopersicum*	Winterschmidtiidae	*Oulenzia* sp.
Citrus; Norfolk Island hibiscus, white oak, cow itch tree	*Citrus* spp.; *Lagunaria patersonia*	Phlaeothripidae	*Ozothrips janus*
Coastal coprosma	*Coprosma baueri*	Thomisidae	*Ozyptila* sp.
Norfolk Island pine	*Araucaria heterophylla*	Curculionidae	*Pachycotes kuscheli*
Palm trees	Unknown	Diplommatinidae	*Palmatina quintali*
NA	NA	Cerambycidae	*Papuandra norfolkensis*
Grass	Unknown	Acarophenacidae	*Paracarophenax* sp. nov. ?
NA	NA	Lycosidae	*Pardosa paludicola*
NA	NA	Carabidae	*Pentagonica atkinsoni*
Norfolk Island pine	*Araucaria heterophylla*	Curculionidae	*Pentamimus nepeanianus*
Norfolk Island pine	*Araucaria heterophylla*	Curculionidae	*Pentarthrum millingtoni*
Yellow guava; wild tobacco; strawberry; pomegranate; Norfolk Island hibiscus, white oak, cow itch tree; elephant grass; Various vegetables; ginger	*Psidium guajava*; *Solanum mauritianum*; *Fragaria ananassa*; *Punica granatum*; *Lagunaria patersonia*; *Cenchrus purpureus*; *Zingiber* sp.	Formicidae	*Plagiolepis alluaudi*
NA	NA	Curculionidae	*Platypus norfolkensis*
Norfolk Island hibiscus, white oak, cow itch tree; dead branches	*Lagunaria patersonia*	Phlaeothripidae	*Priesneria* sp.nov.
Norfolk Island pine; leaf litter; maple (NI), tamana; leaf litter; silky oak	*Araucaria heterophylla*; *Elaeodendron curtipendulum*; *Grevillea robusta*	Phlaeothripidae	*Priesneriana uptoni*
Norfolk Island pine	*Araucaria heterophylla*	Stigmaeidae	*Primagistemus loadmani*
Norfolk Island pine	*Araucaria heterophylla*	Blaberidae	*Pycnoscelus indicus*
Norfolk Island hibiscus, white oak, cow itch tree	*Lagunaria patersonia*	Cosmopterigidae	*Pyroderces anoista*
Palm trees	Unknown	Acaridae	*Rhizoglyphus minutus*
Palm trees	Unknown	Microcystidae	*Roybellia platysoma*
Kentia palm	*Howea* sp.	Geometridae	*Sauris curvicosta*
NA	NA	Ephydridae	*Scatella septempunctata*
Norfolk Island pine	*Araucaria heterophylla*	Thripidae	*Scirtothrips* sp.nov.
Tahiti pohutakawa and Ipomoea	*Metrosideros* sp.	Thripidae	*Scirtothrips* sp.nov.
Indian almond	*Terminalia catappa*	Cunaxidae	*Scutopalpus* sp.
Palm trees	Unknown	Cunaxidae	*Scutopalpus* sp.
Various vegetables	Various	Coccinellidae	*Scymnus loweii*
NA	NA	Simuliidae	*Simulium norfolkense*

Host common name	Host species	Pest family	Pest species
Dead branch; bush lemon, rough lemon; cherry guava, strawberry guava, red guava; Norfolk Island hibiscus, white oak, cow itch tree; sandalwood, bastard ironwood, popwood; citrus; Araucaria and silky oak	*Citrus jambhiri*; *Psidium cattleyanum*; *Lagunaria patersonia*; *Myoporum obscurum*; *Citrus* spp.; *Araucaria heterophylla*; *Grevillea robusta*	Phlaeothripidae	*Sophiothrips martinae*
Norfolk Island pine	*Araucaria heterophylla*	Succineidae	*Spirancinea norfolkensis*
Citrus; peach; mulberry; custard apple; taro	*Citrus* spp.; *Prunus persica*; *Morus* sp.; *Annona reticulata*; *Colocasia esculenta*	Coccinellidae	*Stethorus obscuripennis*
Norfolk Island pine	*Araucaria heterophylla*	Curculionidae	*Sympiezoscelus norfolcensis*
Norfolk Island pine; palm trees	*Araucaria heterophylla*	Assimineidae	*Telmosena suteri*
Whitewood, investigator tree, native Celtis; little yellow wood	*Celtis paniculata*; *Zanthoxylum pinnatum*	Tenuipalpidae	*Tenuipalpus antipodus*
NA	NA	Tetragnathidae	*Tetragnatha obtusa*
NA	NA	Formicidae	*Tetramorium caldarium*
Apple of Peru; Avocado; Banana; Basil; Bean; Beans, celery, carrots; Beech; Bird of paradise; Broccoli, cauliflower, capsicum; brush bloodwood, ivory birch; Butterfly bush; Cape gooseberry; Capsella?; Capsicum; Carnation; Carrot; Cherry guava, strawberry guava, red guava; Citrus; Clover; Coastal coprosma; Coastal morning glory and Lycium sp.; Coastal morning glory, mile a minute; Cobblers pegs; Coffee; Coriander; Corn; Corn with clover; Day lily; Eggplant; Elephant grass; Formosan lily; Frangipani; Ginger; Gladiolus; Goosefoot, fat hen; Grape; Grass with clover; Grasses; Grasses and olive; Grevillea; Hawkweed; Hibiscus; Isaac wood, Hawaiian roughwood; Jacaranda; Japanese honeysuckle; Jasmine; Lantana; Leek; Lettuce; Lucerne; Macadamia; Mango; Medic; Montbretia; Murraya, mulberry and dead wood; Native frangipani; Nectarine; Norfolk Island cordyline, ti; Norfolk Island hibiscus, white oak, cow itch tree; Norfolk Island pine; Norfolk Island tree fern; Oats; Olive; Orange; Oxeye daisy; Palm, pea, taro, cassia; Parsley; Paspalum grass; Passionfruit (Hawaiian); Pawpaw, papaya; Pea, spring onions, weeds; Peach; Pentas, star cluster; Philip Island hibiscus; Pinto peanut; Rattlepod; Rosemary; Roses; Sandalwood, bastard ironwood, popwood; Shallots, spring onions; Shrubby creeper, Pohuehue; Spider lily; Sugarcane; Tahiti pohutakawa and Ipomoea ; Tomato; Weeds (Physalis sp., Bidens pilosa, etc); Weedy plant; White cedar, Persian lilac ; Wild tobacco; Yucca; Zucchini	*Allium cepa*; *Allium porrum*; *Arachis pintoi*; *Araucaria heterophylla*; *Avena sativa*; *Baloghia inophylla*; *Bidens* sp.; *Buddleja* sp.; *Capsella?* sp.; *Capsicum annuum*; *Carica papaya*; *Cenchrus purpureus*;*Chenopodium* sp.; *Citrus sinensis*; *Citrus* spp.; *Coffea* sp.;*Coprosma bauera*; *Cordyline obtecta*; *Coriandrum sativum*; *Crinum* sp.; *Crocosmia* sp.; *Crotalaria* sp.; *Cucurbita pepo*; *Cyathea brownii*; *Daucus carota*;*Dianthus* spp.; *Gladiolus* sp.; *Grevillea* spp.; *Hemerocallis* sp.; *Hibiscus insularis*; *Hibiscus* sp.; *Hieracium* sp.; *Hymenosporum flavum*;*Ipomoea cairica*; *Jacaranda* sp.;*Jasminum* sp.; *Lactuca sativa*;*Lagunaria patersonia*; *Lantana camara*; *Leucanthemum vulgare*; *Lilium formosanum*; *Lonicera japonica*; *Macadamia integrifolia*;*Mangifera indica*; *Medicago sativa*; *Medicago* sp.; *Melia azedarach*; *Metrosideros* sp.; *Muehlenbeckia australis*; *Musa* sp.; *Myoporum obscurum*; *Myrsine ralstoniae*; *Nicandra physalodes*; *Ocimum basilicum*; *Olea europaea*; *Paspalum*; *Passiflora edulis var. flavicarpa*; *Pentas lanceolata*; *Persea americana*; *Petroselinum crispum*; *Phaseolus* sp.; *Physalis peruviana*; *Pisum sativum*; *Plumeria* sp.; *Prunus persica*; *Psidium cattleyanum*; *Rosa* spp.; *Rosmarinus officinalis*; *Saccharum officinarum*; *Solanum lycopersicum*; *Solanum mauritianum*; *Solanum melongena*; *Streblus pendulinus*; *Strelitzia* sp.; *Trifolium* sp.; *Veronica?* sp.; *Vitis vinifera*; *Yucca aloifolia*; *Zea mays*; *Zingiber* sp.	Thripidae	*Thrips novocaledonensis*
Sandalwood, bastard ironwood, popwood; brush bloodwood, bloodwood, ivory birch; dodonaea; palm trees	*Myoporum obscurum*; *Baloghia inophylla*; *Dodonaea* sp.	Thripidae	*Thrips* sp.nov.
Lord Howe Island palm, kentia palm	*Howea belmoreana*; *Howea forsteriana*	Acaridae	*Thyreophagus gallegoi*

Host common name	Host species	Pest family	Pest species
Norfolk Island pine	*Araucaria heterophylla*	Tortricidae	*Tracholena hedraea*
Pittosporum	*Pittosporum* sp.	Triozidae	*Trioza vitreoradiata*
NA	NA	Geometridae	*Xanthorhoe sodaliata*
Norfolk Island pine	*Araucaria heterophylla*	Curculionidae	*Xyleborus norfolkensis*
Norfolk Island pine	*Araucaria heterophylla*	Cerambycidae	*Xylotoles selwyni*
Tree nettle	*Boehmeria australis*	Stigmaeidae	*Zetzellia oudemansi*
Ironwood	*Nestegis apetala*	Araneidae	*Zygiella* sp.

Appendix 3 Pest and disease targets and survey records

Bee pests and diseases tested for during surveys

Paenibacillus larvae, *Braula coeca*, *Ascosphaera apis*, *Melissococcus plutonius*, *Galleria mellonella*, *Achroia grisella*, *Aethina tumida*, *Tropilaelaps clarae*, *Tropilaelaps mercedesae*, *Varroa destructor*, *Varroa jacobsoni*, *Aparavirus* (acute bee paralysis virus, Israeli acute paralysis virus and Kashmir bee virus), *Cripavirus* (black queen cell virus), *Iflavirus* (deformed wing virus, sacbrood virus and slow paralysis virus, Lake Sinai viruses 1 and 2, chronic bee paralysis virus), *Nosema apis*, *Nosema ceranae*, *Malpighamoeba mellificae* and *Acarapis woodi.*

New plant species records for Norfolk Island

Acacia longifolia subsp. *sophorae*, *Ailanthus altissima*, *Amaranthus caudatus*, *Ammi majus*, *Arachis pintoi*, *Banksia integrifolia* subsp. *integrifolia*, *Brassica oleracea*, *Cardamine flexuosa*, *Carex leporina*, *Catharanthus roseus*, *Cestrum nocturnum*, *Chlorophytum comosum*, *Cotoneaster glaucophyllus*, *Crotalaria incana* subsp. *purpurascens*, *Cucurbita maxima*, *Cynoglossum amabile*, *Dietes grandiflora*, *Dimorphotheca ecklonis*, *Diplotaxis tenuifolia*, *Einadia trigonos* subsp. *stellulata*, *Emex australis*, *Epilobium ciliatum*, *Eragrostis tenuifolia*, *Eruca sativa*, *Freesia leichtlinii*, *Galium divaricatum*, *Gamochaeta americana*, *Gamochaeta pensylvanica*, *Hypoestes aristata*, *Iberis umbellata*, *Ipomoea batatas*, *Lactuca saligna*, *Lantana montevidensis*, *Lophospermum erubescens*, *Lotus uliginosus*, *Macrotyloma axillare* var. *axillare*, *Medicago arabica*, *Musa acuminata*, *Nerium oleander*, *Papaver rhoeas*, *Pelargonium hortorum*, *Rumex crispus*, *Salvia coccinea* (group cultivar), *Senna pendula* var. *glabrata*, *Setaria parviflora*, *Setaria sphacelata* var. *anceps*, *Setaria viridis*, *Toona ciliata*, *Verbena brasiliensis*, *Verbena incompta*, *Watsonia meriana* var. *bulbillifera*

New invertebrate species records for Norfolk Island

Aceria fica, *Aceria sheldoni*, *Aculops lycopersici*, *Acyrthosiphon kondoi*, *Acyrthosiphon pisum*, *Adraneothrips russatus*, *Aeolothrips fasciatus*, *Aethina concolor*, *Agistemus novazelandicus*, *Agistemus subreticulatus*, *Agistemus collyerae*, *Agistemus longisetus*, *Alosextius carinatus*, *Amblyseius herbicolus*, *Ameroseius sextuberculi*, *Ameroseius ornatus*, *Anaglyptothrips dugdalei*, *Anaphothrips dubius*, *Anaphothrips obscurus*, *Anaphothrips sudanensis*, *Anthomyia punctipennis*, *Anystis baccarum*, *Aphis nerii*, *Apterothrips apteris*, *Apterygothrips australis*, *Apterygothrips sparsus*, *Aptinothrips rufus*, *Asprothrips seminigricornis*, *Athetis thoracica*, *Aulacorthum solani*, *Australophiloscia nichollsi*, *Austroasca viridigrisea*, *Bactericera cockerelli*, *Badumna longinqua*, *Baenothrips moundi*, *Balaustium medicagoense*, *Balclutha incisa*, *Balclutha lucida*, *Bamboosiella cingulata*, *Bdellodes harpax*, *Bethelium signiferum*, *Bhattithrips frontalis*, *Blastopsylla occidentalis*, *Bourletiella hortensis*, *Brachycaudus helichrysi*, *Brachycaudus helichrysi*, *Bradysia impatiens*, *Brontispa norfolkensis*, *Bryobia vasiljevi*, *Cardiaspina fiscella*, *Carientothrips snowi*, *Carientothrips flavitibia*, *Carpophilus dimidiatus*, *Carpophilus maculatus*, *Cartodere constricta*, *Ceroplastes sinensis*, *Chaetanaphothrips orchidii*, *Chaetosiphon fragaefolii*, *Cheletogenes waitei*, *Chrysomphalus dictyospermi*, *Chrysomphalus pinnulifer*, *Cicadulina bimaculata*, *Clubiona comta*, *Coccinella septempunctata*, *Coccinella transversalis*, *Coccinella undecimpunctata*, *Coccus longulus*, *Coccus viridis*, *Coleosoma floridanum*, *Colgar peracutum*, *Colobopyga australiensis*, *Colobopyga kewensis*, *Colomerus vitis*, *Culex australicus*, *Cuspiconia simplex*, *Czenspinskia transversostriata*, *Dendrothrips diaspora*, *Diaspis bromeliae*, *Diomus notescens*, *Dioxyna brachybasis*, *Dioxyna hyalina*, *Dioxyna sororcula*, *Dysmicoccus brevipes*, *Ectoneura insularis*, *Enicospilus insularis*, *Ensiferothrips primus*, *Epilachna vigintioctopunctata*, *Eriophora pustulosa*, *Eristalis tenax*, *Eryngiopus nelsonensis*, *Euborellia annulipes*, *Eucolaspinus brunnea*, *Exaireta spinigera*, *Fiorina fioriniae*, *Frankliniella schultzei*, *Gaeolaelaps queenslandicus*, *Giraultithrips nigricoxa*, *Glycaspis granulata*, *Gymnochiromyia nigridorsum*, *Gynaeseius christinae*, *Hadeodelphax pluto*, *Hadrobregmus australiensis*, *Haplothrips avius*, *Haplothrips bituberculatus*, *Haplothrips gowdeyi*, *Haplothrips leucanthemi*, *Haplothrips robustus*, *Heliothrips haemorrhoidalis*, *Hemiberlesia cyanophylli*, *Hemiberlesia lataniae*, *Hemiberlesia rapax*, *Hercinothrips bicinctus*, *Hercinothrips femoralis*, *Holoengythrips maynardae*, *Hoplothrips orientalis*, *Howardia biclavis*, *Hydrellia tritici*, *Hyleoides concinna*, *Hyperomyzus lactucae*, *Hysteroneura setariae*, *Iphidozercon gibbus*, *Karnyothrips flavipes*, *Karnyothrips melaleucus*, *Kuzinellus scytinus*, *Lamprolonchaea brouniana*, *Lepidoglyphus destructor*, *Lepinotus patruelis*, *Leptolamia lunata*, *Lipaphis pseudobrassicae*, *Liriomyza brassicae*, *Liriomyza electa*, *Lobesia transtrifera*, *Lycoriella sativae*, *Lyctus brunneus*, *Macrocheles gamma*, *Macrophthalmothrips neocaledonensis*, *Macrosiphum euphorbiae*, *Macrosiphum rosae*, *Maiestas knighti*, *Melanostoma apicale*, *Merothrips brunneus*, *Merothrips floridensis*, *Mesohomotoma hibisci*, *Microsmaris hirsti*, *Microsmaris joannae*, *Miomantis caffra*, *Monomorium fieldi*, *Myzus persicae*, *Naupactus cervinus*, *Naupactus leucoloma*, *Neochetina eichorniae*, *Neophyllaphis araucariae*, *Neoseiulella novaezealandiae*, *Neoseiulus womersleyi*, *Nesidiocoris tenuis*, *Nesogaster halli*, *Nesothrips propinquus*, *Nesothrips propinquus*, *Nesticodes rufipes*, *Nysius caledoniae*, *Octotoma scabripennis*, *Ophiusa tirhaca*, *Ornithonyssus bursa*, *Oxychilus alliarius*, *Ozothrips janus*, *Parasaissetia nigra*, *Parasteatoda tepidariorum*, *Pardosa paludicola*, *Parthenothrips dracaenae*, *Pentalonia nigronervosa*, *Phoracantha semipunctata*, *Phyllocoptruta oleivora*, *Phytoseiulus persimilis*, *Phytoseius rubiginosae*, *Piezodorus oceanicus*, *Pinnaspis strachani*, *Plagiolepis alluaudi*, *Planococcus citri*, *Platylister sulcisternus*, *Plectrothrips australis*, *Plesiothrips perplexus*, *Plodia interpunctella*, *Polyphagotarsonemus latus*, *Porcellionides pruinosus*, *Porcellionides sexfasciatus*, *Primagistemus loadmani*, *Pronematus ubiquitus*, *Psalidothrips taylori*, *Pseudococcus viburni*, *Pseudonapomyza spinosa*, *Rampamyia notoscriptus*, *Rhizoglyphus minutus*, *Rhopalosiphum maidis*, *Rhopalosiphum padi*, *Rhopalosiphum rufiabdominale*, *Scatella septempunctata*, *Scirtothrips inermis*, *Scutopalpus latisetosus*, *Scymnus loweii*, *Sidymella longipes*, *Sitophilus oryzae*, *Sogatella kolophon*, *Sophiothrips martinae*, *Spathulina acroleuca*, *Sphaerophoria macrogaster*, *Spinibdella cronini*, *Steatoda capensis*, *Steganopsis melanogaster*, *Steneotarsonemus ananas*, *Stephanothrips barretti*, *Stephanothrips occidentalis*, *Stomorhina discolor*, *Strepterothrips tuberculatus*, *Sylvicola dubius*, *Syndelphax disonymos*, *Tenothrips frici*, *Tenuipalpus antipodus*, *Tetragnatha obtusa*, *Tetranychus lambi*, *Tetranychus lombardinii*, *Tetranychus neocaledonicus*, *Tetranychus urticae*, *Thrips novocaledonensis*, *Thrips australis*, *Thrips imaginis*, *Thrips nigropilosus*, *Thrips simplex*, *Thrips tabaci*, *Thyreophagus gallegoi*, *Thysanoplusia orichalcea*, *Trialeurodes vaporariorum*, *Trichopoda giacomellii*, *Trioza vitreoradiata*, *Tydeus californicus*, *Typhaea stercorea*, *Tyrophagus curvipenis*, *Tyrophagus putrescentiae*, *Uroleucon erigeronense*, *Uroleucon sonchi*, *Yarnkothrips kolourus*, *Zetzellia oudemansi* and *Zetzellia maori*

Appendix 4 Norfolk Island Quarantine Survey plant target list

Family	Species	Particular issues for examination
Alliaceae	*Allium fistulosum* (spring onion) *Allium schoenoprasum* (chive) *Allium* (leek)	
Amaranthaceae	*Beta vulgaris* (silverbeet, beetroot) *Spinacia oleracea* *Chenopodium alba* (fat hen)	
Anacardiaceae	*Mangifera indica* (mango)	
Apiaceae	*Anethum graveloens* (dill) *Apium graveolens* (celery) *Coriandrum sativum* (coriander) *Daucus carota* subsp. *sativus* (carrot) *Foeniculum vulgarae* (fennel) *Petroselinum crispum* (parsley)	
Apocynaceae	*Plumeria* sp. (frangipani)	
Araucariaceae	*Araucaria heterophylla*	Beetles and beetle distribution in National Park Endemic – not listed
Arecaceae	*1. Howea* spp. (Lord Howe Is palms) *2. Rhopalostylis baueri* (Norfolk Is palm)	Endemic – not listed
Asparagaceae	*Cordyline obtecta* (ti)	Endemic – vulnerable
Asteraceae	*Chrysanthemum morifolium* *Gerbera* sp. *Lactuca sativa* (lettuce) *Senecio australis* (daisy) *Senecio hooglandii* (daisy)	Endemic – vulnerable
Brassicaceae	*Brassica oleraceae* (Asian greens, cabbage, broccoli) *Brassica rapa*	
Bromeliaceae	*Ananas comosus*	
Capparaceae	*Capparis nobilis*	
Caricaceae	*Carica papaya*	
Convolvulaceae	*Ipomea batatas* (sweet potato)	
Cucurbitaceae	*Citrullus vulgaris* (watermelon) *Cucurbita maxima* (pumpkin) *Cucumis sativas* (cucumbers)	
Cyatheaceae	*Cyathea brownii*	
Dennstaedtiaceae	*Hypolepis dicksonioides* (downy ground fern)	Endemic – vulnerable
Euphorbiaceae	*Acalypha* sp. *Baloghia inophylla* *Euphorbia peplus* (petty spurge)	
Fabaceae	*Medicago sativa* (lucerne) *Phaseolus vulgarus* *Trifolium repens* *Vicia faba*	
Lamiaceae	*Mentha* spp. (mints) *Rosmarinus officinalis* (rosemary) *Salvia officinalis* (sage)	
Lauraceae	*Persea americana* (avocado)	
Loranthaceae	*Ileostylus micranthus* (mistletoe)	Endemic – vulnerable
Malvaceae	*Hibiscus insularis** *Hibiscus rosa-sinensis* *Lagunaria patersonia*	*Critically endangered – sampling only from cultivated specimens
Meliaceae	*Dysoxylum bijugum* (sharkwood)	Endemic – vulnerable
Mimosaceae	*Acacia* spp.	
Moraceae	*Streblus pendulinus*	Causative agent of damage Endemic – endangered

Family	Species	Particular issues for examination
Musaceae	*Musa* spp. (banana, plantains)	
Myrtaceae	*Eucalyptus* spp. *Eugenia uniflora* *Psidium* spp.	
Oleaceae	*Ligustrum* spp.	
Oxalidaceae	*Oxalis* sp.	
Pasifloraceae	*Passiflora edulis*	
Piperaceae	*Macropiper excelsum*	
Pittosporaceae	*Meryta angustifolia* * *Pittosporum bracteolatum**	Insects in particular *Endemic – vulnerable
Poaceae	*Digitaria ciliaris* (summer grass) *Pennisetum clandestinum* (kikuyu grass) *Sorghum halepense* (Johnson grass) *Zea mays*	
Primulaceae	*Rapanea ralstoniae*	Disease Endemic – vulnerable
Psilotaceae	*Tmesipteris norfolkensis* (hanging fork fern)	Endemic – vulnerable
Rosaceae	*Eriobotrya japonica* *Fragaria* (strawberry) *Malus* spp. *Prunus persica* (peach) *Rhaphiolepis umbellata* *Rosa* sp. (rose) *Rubus* spp.	
Rubiaceae	*Coffea* spp.	
Rutaceae	*Citrus aurantifolia* (lime) *Citrus limon* (lemon) *Citrus reticulata* (mandarin) *Citrus sinensis* (orange) *Melicope littoralis* (shade tree)* *Zanthoxylum pinnatum* (little yellow wood)**	*Endemic – vulnerable* **Endemic – not listed** Insects in particular
Solanaceae	*Solanum lycopersicum* (tomato) *Nicandra physalodes* (apple of Peru) *Solanum tuberosum* (potato) other Solanaceae species *Nicotiana tabacum*	
Sterculiaceae	*Ungeria floribunda* (bastard oak)	Endemic – vulnerable
Verbenaceae	*Lantana camara*	
Violaceae	*Melicytus ramiflorus* (whiteywood)	Endemic – vulnerable


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