Nursery levy at work: **Nursery Production Plant Health & Biosecurity Project. NY11001**

Nursery Production

Threat specific contingency plan for fire blight

Queensland Department of Agriculture, Fisheries and Forestry

November 2014

Nursery & Garden Industry Australia

Queensland

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Acknowledgements

This contingency plan was prepared by Andrew Manners and Lindy Coates, Queensland Department of Agriculture, Fisheries and Forestry. Thanks go to John McDonald (NGIQ) and Anthony Kachenko (HIA, formerly NGIA) for providing helpful comments that improved this contingency plan significantly. This document extensively refers to the “Revised Contingency Plan for Fire Blight” compiled and edited by Peter Merriman (2007) for the apple and pear industry.

Cover image is of *Pyracantha* in a nursery (photo by Florida Division of Plant Industry Archive, Florida Department of Agriculture and Consumer Services, Bugwood.org)

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1 Purpose and background of this contingency plan

This contingency plan provides background information on pest biology and available control measures to assist production nurseries with preparedness for an incursion into Australia of fire blight (*Erwinia amylovora*). It provides guidelines and options for steps to be undertaken and considered when developing a Response Plan to this pest. Any Response Plan developed using information in whole or in part from this Contingency Plan must follow procedures as set out in PLANTPLAN and be endorsed by the National Management Group prior to implementation. This contingency plan was developed for the Nursery & Garden Industry Australia (NGIA) and is focused on production nurseries. In the event of an incursion, operations not covered by the NGIA (e.g. retail outlets) will not be eligible for Owner Reimbursement Costs, as defined in the Emergency Plant Pest Response Deed, if affected by actions carried out under an approved Response Plan.

The information for this plan has been primarily obtained from “Revised Contingency Plan for Fire Blight“ compiled and edited by Peter Merriman (DPI Victoria) in 2007. Modifications have been made to the plan to make the information relevant to an incursion of fire blight in the nursery industry as per recommendations in Merriman (2007). As such, this document is designed as an amendment to Merriman (2007) dealing with the nursery industry specifically and should be used together in the event of an incursion.

2 Critical tasks

There are a number of areas which will require careful planning or implementation following the detection of fire blight that are not covered in this contingency plan. These tasks include (but are not limited to):

1. Determine if fire blight is notifiable as per the state/s legislation (e.g. fire blight is not currently notifiable in Northern Territory).
2. Establish approved laboratories capable of diagnosing relevant organisms for each state.
3. Establish if the current diagnostic protocol (Anon 2004) needs to be significantly updated.
4. Determine if an emergency permit for an appropriate antibiotic product could be obtained.

Since comprehensive lists of production nurseries across Australia do not exist, contact relevant state NGI organisations to obtain a list of known production nurseries that produce relevant host plant species. A list of retail outlets should also be compiled and include regular, rigorous and independent auditing by appropriate authorities.

3 Australian nursery industry

The Australian nursery industry is a significant horticultural sector with a combined supply chain (production to retail/grower) valued at more than $6 billion dollars annually. The industry employs approximately 45,000 people spread over more than 20,000 small to medium sized businesses, including production nurseries and retail outlets. The industry is located predominantly along the Australian coastline, and in major inland regions servicing urban and production horticulture.

Nursery production adds significant value to Australia’s primary industry’s sector annually, contributing more than $2 billion to the national economy. Nursery production is a highly diverse industry, providing a critical service to the broader horticultural sector, valued at $14 billion within Australia (Table 1).

Table 1. Nursery production supply sectors within Australian horticulture

Production nursery	Horticultural market	Economic value
Container stock [1]	Ornamental/urban horticulture	$2 billion retail value
Foliage plants [1]	Interior-scapes	$87 million industry
Seedling stock [2]	Vegetable growers	$3.3 billion industry
Forestry stock [3]	Plantation timber	$1.7 billion industry
Fruit and nut tree stock [2]	Orchardists	$5.2 billion industry
Landscape stock [1]	Domestic & commercial projects	$2 billion industry
Plug and tube stock [4]	Cut flower	$319 million industry
Revegetation stock	Farmers, government, landcare groups	$109 million industry
Mine revegetation	Mine site rehabilitation	Value unknown

4 Eradication or containment decision matrix

Production nurseries are important as pathways for the potential entry and spread of fire blight. Nursery production cropping systems are unique in that plants have out of season growth flushes occuring frequently due to optimum growing conditions and plant material is dispatched across a large geographical area. Eradication of fire blight is ideal to maintain Australia's pest free status and facilitate as great a domestic and international market as possible. Presence of fire blight in an area also would increase the costs associated with growing a crop through the cost of control and increase costs associated with disposing of diseased and dead plants.

The decision matrix to aid in the decision between eradication and containment is shown in Figure 1 and Table 2.

1 Data sourced from Market Monitor
2 Data sourced from Horticultural Handbook 2004
3 Data sourced from ABARE 2005
4 Data sourced from industry

Fig. 1. Decision outline for the response to an exotic pest incursion and a summary of the basis on which each decision could be made.

Basis for technical feasibility: o Early detection o Confined space/restricted area of dispersal o Known distribution of host plants o Effective, reliable, quick detection method o Support from industries, businesses and communities involved.
Basis for economic feasibility: o Value of crop destroyed by uncontrolled pest is more than cost of controlling the pest o Value of environmental amenity (native species lost) vs cost or loss of other amenity (loss of native insects due to spraying in native forests etc)
Basis for quarantine containment: o Legislation to create a pest quarantine area (PQA) o Resources to maintain the PQA, inspection points, staffing, detection equipment, diagnostics o Support of industry and community to make the PQA work
Basis for destruction/control strategies required: o How much destruction and or control measures are industry and individuals prepared to undertake? o What level of destruction is technically feasible? o Do the benefits of destruction outweigh the problems created?
What would containment or ongoing management look like? o Is containment feasible? o What would ongoing management really mean? o Many similar features to eradication, but at less intense / restrictive levels.

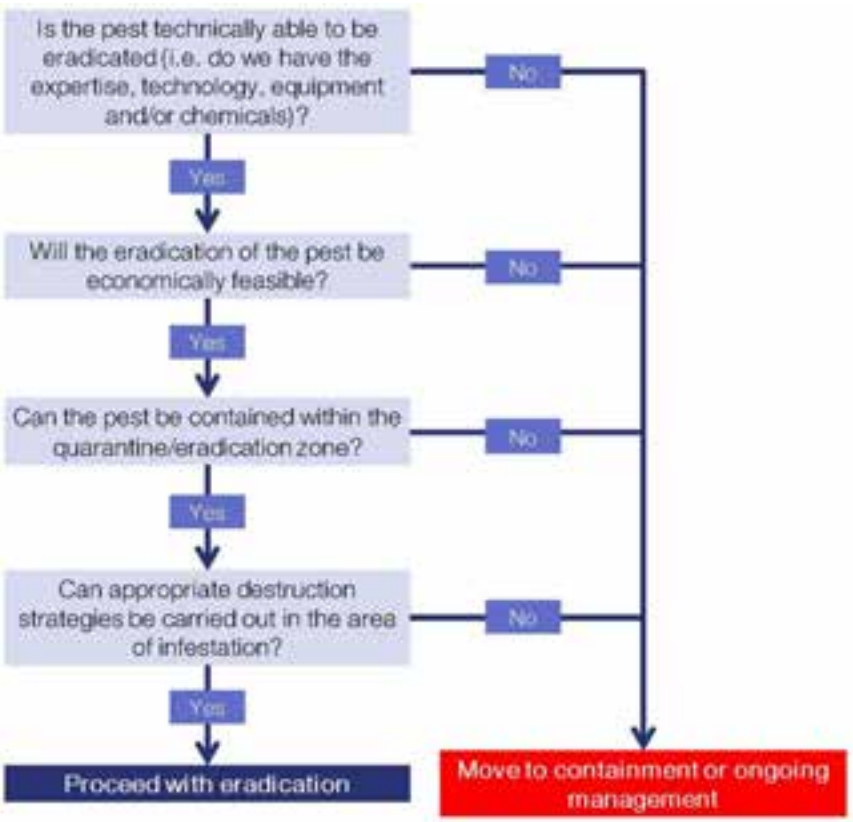

Table 2. Factors considered in determining whether eradication or alternative action will be taken for an EPP incident from PLANTPLAN (Plant Health Australia 2013, Table 2).

Factors that may favour eradication	Factors that may favour alternative action
• Cost benefit analysis shows significant economic loss to industry, the community and the environment if the organism established. • Physical barriers and/or discontinuity of hosts between production districts. • The generation time, population dynamics and dispersal of the organism favour more restricted spread and distribution. • Vectors discontinuous in distribution and can be effectively controlled. • Outbreaks few and confined. • Trace back information indicates few opportunities for secondary spread. • Weather records show unfavourable conditions for pest development). • Ease of access to outbreak site and location of alternate hosts. • Pathways for reintroduction from international trade closed	• Cost benefit analysis shows relatively low economic or environmental impact if the organism establishes. • Major areas of continuous production of host plants. • Short regeneration times, potential for rapid population growth and long distance dispersal lead to rapid establishment and spread. • Vectors unknown,continuous in distribution or difficult to control. • Outbreaks numerous and widely dispersed. • Trace back information indicates extensive opportunities for secondary spread. • Weather records show several optimum conditions for pest development. • Terrain difficult and/orproblems accessing and locating host plants. • Pathways for reintroduction from international trade open

Note: In the case of fire blight, considerable information is already available from overseas research for evaluating the prospects for eradication or containment. This includes cost benefit studies, effectiveness of control treatments, the influence of stage of growth and vectors, host susceptibility and influence of weather (Sosnowski et al. 2009) Kean *et* al., 2014.

5 Pest information/status – Fire blight

5.1 Pest details

Table 3. *Erwinia amylovora*

Common names	Fire blight
Scientific name	*Erwinia amylovora* (Burr.) Winslow et al.
Synonyms	Micrococcus amylovorus, Bacillus amylovorus, Bacterium amylovorus

5.1.1 Background

Fire blight, caused by the bacterium *Erwinia amylovora,* was first recorded on apple in the Hudson valley of New York in 11780, and has become one of the world's most devastating plant diseases. In the mid-nineteenth century it caused enormous damage in apple and pear orchards in the United States and Canada " blackening and blighting whole orchards - even whole valleys – in a single night " (Carefoot and Sprott, 1967). The bacterium is a native pathogen of wild rosaceous hosts which include hawthorn, serviceberry and native ash in eastern North America. Fire blight has now spread to many of the apple and pear growing regions of the world. It is also a serious disease of many ornamental and nursery plants.

Australia has strict quarantine laws on the entry of plant material that could introduce *Erwinia amylovora.* In 1997, fire blight was found on two trees (*Cotoneaster* and Sorbus) in the Royal Botanic Gardens in Melbourne by New Zealand Authorities, but following an eradication program (Rodoni et al. 1999) and extensive national survey was not detected anywhere in Australia (Rodoni et al. 2002).

5.1.2 Life cycle

While fire blight can affect the entire tree, the primary site of high population development and infection are flowers (Farkas et al. 2012). The bacterium is often vectored by bees that have visited flowers of plants infected with fire blight and flowers remain susceptible until petal fall. The combination of a high humidity within the flower and high sugar content facilitates rapid increases in populations. Typically these populations occur on the stigma of flowers and are not able to infect the plant until moved to the nectary of flowers, either by insects or rain. Infection may then stay locally within the flowers or extend into twigs and branches causing shoots to wilt. As flowers wilt, ooze is produced that increases inoculum load and infection risk. Bacteria can be moved by insects, rain and wind to wounds in the plant caused by insect feeding or other causes, e.g. wind-whipping and hail. More ooze is then produced. Scaffold limbs, trunks and root systems can also be infected and can kill highly susceptible hosts. Bacteria also multiply more quickly in growing shoots, thus conditions that favour rapid shoot growth increase damage to the plant. Younger plants are more susceptible than older plants as a result.

Fire blight bacteria overwinter in infected plant parts including twigs, branches or trunks. In spring, the bacteria become active, multiply and begin producing ooze that can then infect healthy plants and tissue. Insects, particularly bees are also attracted to the ooze and rain can then move the bacteria from flower to flower. Warm, humid, rainy and windy weather favours development and spread of fire blight, especially when night temperatures stay above about 13°C.

Fire blight bacteria can survive for a number of weeks on the surface of healthy plants as epiphytes, but generally are not able to infect healthy tissue unless the plant is wounded or bacteria are moved into a wound site. Such populations can increase by a billion fold, depending upon temperature.

Symptoms tend to begin in spring when host plants begin actively growing. Bacterial multiple in the previous year's cankers and other bacteria that may be present on or in plant tissues, including epiphytic bacteria present on the surface of plants. In general, only a small percentage of cankers become active in spring and are called "holdover cankers". This produces primary inoculum which may then infect flowers and exponentially increases the amount of inoculum present in the environment. Bacteria tend to stay active through summer and sometimes early autumn, depending on climatic conditions (van der Zwet & Beer 1991). During winter, symptoms are rarely expressed.

Trees with fire blight bacteria present may not always have symptoms; shoots of resistant varieties have had fire blight isolated where no symptoms exist in the orchard (Keil & Zwet 1972). Similarly, cankers may have active fire blight bacteria without symptoms being present. In general, cankers become active when moist warm conditions (> 17°C) for at least one day, but may not show symptoms for 1-3 weeks before blossom blight symptoms occur (Beer & Opgenorth 1976).

5.1.3 Dispersal

Fire blight is mechanically transmitted by insects, wind, rain and any other methods including human assisted movement (e.g. hands) which brings the bacteria in contact with open plant tissue. Infected plant material, equipment or machinery that has come in contact with infected material can also vector the disease. Honey bees and other insects that visit infected flowers are common and important vectors of fire blight over short distances. Such organisms may collect or have infected pollen on their body. When the insect visits a healthy flower, some of the infected pollen may remain in the flower and infect it. Infection of flowers is commonly known as blossom blight; prevention of blossom infections is the most critical for management of fire blight because blossoms greatly increase inoculum for secondary infections of shoots, fruit and rootstocks (Johnson & Stockwell 1998). Since bees can forage for a number of kilometres, management of bee hives is extremely important in the eradication or containment of fire blight.

Wind-driven rain spreads bacteria between plants and growing areas. Mechanical thinning of mature trees and pruning of nursery stock also increases the risk of infection, probably owing to increased numbers of sites on trees conducive to fire blight infection (Ngugi & Schupp 2009). As stated above, fire blight can survive on the

surface of healthy plants as an epiphyte on foliage, particularly over winter. Rain or heavy dew with warm temperatures during bloom and intense insect activity also serve to spread fire blight efficiently when present (Johnson & Stockwell 1998). Overhead irrigation commonly used in production nurseries and rainfall are also recognised as potential means for spreading fire blight across the cropping system.

5.2 Host range

The main hosts of fire blight are apple and pear, but it has also been recorded on a range of plant species mostly from the family Maloideae (previously Pomoideae) which can be common in parks, gardens and roadside verges. Eradication and containment of fire blight must take into account all host plants and the flowering times of these hosts, which is a critical infection period. For this reason estimated flowering times are presented for all host plants (Table 4).

Other plant species can become infected with fire blight if they are artificially inoculated but natural infection has not been recorded. These include the genera *Aruncus*, *Aronia*, *Cowania*, *Crataegomespilus*, *Docynia*, *Fragaria*, *Kageneckia*, *Osetomeles*, *Peraphyllum* and *Photinia* (Merriman 2007). It should be noted that the *E. amylovora* infecting *Rubus* spp. is considered to be distinct from other that infecting apple and pear and has thus been called *E. amylovora* f.sp. *rubi*; i.e. the apple and pear strain do not infect raspberry and vice versa (Starr et al. 1951).

Table 4. Distribution frequency and flowering period of host plants naturally infected by *Erwinia amylovora*. Plant genera in shaded rows represent those with highest risk, being both widespread in Australia and a common natural host of *E. amylovora*.

Genus	Common name	Known natural infection rate[1]	Estimated frequency in SE Australia	Flowering times estimated from Adelaide Botanic Garden[4]
Amelanchier	Serviceberry, June berry	Common	Rare	Spring
Chaenomeles	Japanese quince, flowering quince	Rare	Infrequent	Late winter to early spring
Cotoneaster	Cotoneaster	Common	Common	Late spring to summer
Crataegus	Hawthorn	Common	Common	Spring
Cydonia	Quince	Common	Infrequent	Spring
Dichotomanthes	NA	Rare	Rare	Late spring to summer
Dryas	Mountain avens	Rare	Rare	Late spring to early summer
Eriobotrya	Loquat	Common	Infrequent	Autumn to early winter
Exochorda	Pear bush	Rare	Rare	Spring
Geum	Avens	Rare	Infrequent	Summer
Hetermeles	Christmas bush	Rare	Rare	Late summer to autumn
Holodiscus	Cream bush	Rare	Rare	Summer
Kerria	NA	Rare	Rare	Spring to summer
Malus[2]	Apple	Common	Common	Late winter to early spring
Mespilus	Medlar	Common	Rare	Spring
Physocarpus	Ninebare	Rare	Rare	Summer
Potentilla	Cinquefoil	Rare	Rare	Spring to summer
Prinscepia	NA	Rare	Rare	Spring
Prunus	Plum, Japanese plum	Occasional	Common	Spring
Pyracantha	Firethorn	Common	Infrequent	Spring
Pyrus[2]	Pear	Common	Common	Spring
Raphiolepis	Indian hawthorn	Rare	Infrequent	Late winter to early spring

Genus	Common name	Known natural infection rate[1]	Estimated frequency in SE Australia	Flowering times estimated from Adelaide Botanic Garden[4]
Rhodotypos	Jetbead	Rare	Rare	Late spring to early summer
Rosa	Rose, Turkestan rose, potato rose	Rare	Common	Spring to Autumn
Rubus	Raspberry, thornless blackberry	Occasional	Infrequent	Spring
Sorbaria	False spirea	Rare	Infrequent	Summer to Autumn
Sorbus	Mountain ash	Common	Common	Spring
Stranvaesia[3]	NA	Common	Rare	Spring and summer

[1] Infrequent refers to hosts for which there are only occasional records of natural infection; rare refers to hosts for which there are only one or two records of natural infection by *E. amylovora*.
[2] Besides the common cultivars of apple and pear, these genera also include such species as crab apple and nashi.
[3] Some species of *Stranvaesia* are synonymous with *Photinia*.
[4] Flowering times here are just a guide. Plants grown in nurseries and in different parts of Australia may flower at different times of the year.

5.3 Current geographic distribution

Fire blight was originally recorded in eastern USA in 1780 and has since spread around many parts of the world (Zwet & Keil 1979). It has now been recorded through much of Europe, including Spain, England, Norway, Italy, Austria, Germany, Greece and through most of western and central Europe (but not Portugal). It is also present in Israel, Turkey, Iran, Egypt and Morocco. There are unconfirmed reports of fire blight in China, India, Korea, Saudi Arabia and Vietnam. It is present in most of North America (Canada, USA and Mexico), though many southern Central American countries are free of the disease. It is also present throughout all of New Zealand (Invasive Species Compendium, last modified Jan 2014).

5.3.1 Potential distribution in Australia

Fire blight could establish throughout most apple and pear producing areas of Australia (Merriman 2007). Its temperate and Mediterranean world distribution indicates that southern states and cooler regions of Australia are at higher risk than warmer, northern parts of the country. Areas with high summer rainfall will increase the spread of fire blight.

Temperatures that favour most rapid development are between 24-29°C. However, the pathogen can still multiply outside optimal temperatures between 4-32°C (van der Zwet & Beer 1991). As such, the majority of Australia in which suitable host plants grow should be considered as the potential distribution for fire blight.

5.4 Symptoms

The symptoms caused by fire blight on apples and pears are quite characteristic and readily distinguished from other diseases of these crops (refer to figs 2-3). In general, symptoms cause a blackening of twigs, flowers and foliage as though affected plant parts have been burned by fire, hence the common name. Different plant parts have different common names including blossom blight, twig blight, fruit blight, trunk blight and collar blight. The following description is largely from van der Zwet and Beer (1991).

Blossom blight normally appears first and occurs during spring. Single or entire clusters of flowers become water-soaked and then wilt, shrivel and turn brown to black. Flowers may drop but usually remain attached which allows infection to progress up the flower stem (peduncle). The flower stem turns dark green and then brown or black. During warm, humid weather bacterial ooze may form in droplets and exude from the flower stem. Subsequent young fruit often become infected and remain very small, turn black, appear dried and

shrivelled but normally remain attached to the stem. Neighbouring leaves often become infected through the petiole and then midrib and main veins. If infected flowers are located on main branches or near the trunk, the infection may girdle the branch or the entire tree; this occurs more often on dwarf and trellis-trained trees.

Shoot blight is the next most common fire blight symptom type. It occurs on succulent shoots and water sprouts or suckers. Symptoms are similar to blossom blight but progress more rapidly, particularly under certain weather conditions, and may move 15-30cm every few days. Infected shoots, bark and leaves usually turn light to dark brown in apples and dark brown to black in pears. The growing tips form shepherd's crook symptoms (a curling over of the dead stem) and bacterial ooze may be observed in humid conditions. If many stems have this symptom on one plant it gives the appearance that it has been scorched by fire. Similar symptoms occur if girdling occurs below shoot tips.

Leaf blight occurs when the fire blight pathogen enters leaves through stomata, insect damage, hail or wind whipping industry. Infection sometimes is limited to the leaf, which becomes necrotic and dries out, but more frequently travels through secondary veins to the midrib and then into the petiole, and supporting stem. The petioles blacken and ooze is frequently seen on the leaf midrib and petiole. In certain weather conditions, web-like bacterial strands may occur on leaf petioles and shoot tips.

Fruit blight is unlikely to be seen in production nurseries or retail outlets. However, it occurs from infection through lenticels in the skin, wounds or from infected spurs. Summer hailstorms frequently will trigger development of fruit blight. Fruit become water-soaked or grey-green around the area of infection. This then turns brown to black. Ooze can exude from lenticels and web-like bacterial strands have been observed on apples and pears. Fruit eventually shrivel and appear mummified, but most often remain attached to the spur.

Limb and trunk blight most often occurs in susceptible varieties and advances downwards from blossoms, shoots or fruit through larger twigs and older branches towards the trunk and main body of the tree. Ooze often flows down bark which can attract flies and cause further spread of the bacterium. Initial symptoms of trunk or body blight normally is accompanied by amber-coloured ooze drops and plant sap running down bark. Small cracks may also occur in bark tissue. Very susceptible varieties may have infection extend from the trunk into scaffold limbs and may kill the tree within a few months.

Limb and trunk blight frequently spreads in spring following warm weather. Infections can spread into adjacent water sprouts, shoots and limbs and increases the size of cankers in these areas. In such instances, bacterial ooze of these trees can be the earliest inoculum for the season and represents an important avenue for disease spread. Cankers can be as small as 3-8mm in shoots and as large as 15-20cm on large limbs and tree trunks.

Collar and root blight is often the most destructive type of symptom and often kills trees. Infection of the collar (crown) of trees can occur through burr knots or wounds created by woolly aphids. Infection may spread from the collar into roots or sometimes from the roots into the collar. Infections occur at the base of the trunk and appear dark, water-soaked and purplish. At first their margins are raised and blistered but then become distinctly marked by a crack or crevice as the symptoms advance. Plant tissue under the bark often has red-brown streaks and may occur in trees that do not have any other symptoms. As such, the symptoms can be confused with other root and collar diseases.

Bark on roots shows similar symptoms as that on the trunk. Root infection may occur from infection of suckers or water sprouts, washing of bacteria from infected twigs and fruit down the trunk and into the soil containing roots or by internal translocation of fire blight bacteria from infected plant parts above ground to the rootstock.

Symptoms of fire blight on other host plant species are generally quite similar to that described above on apple and pear. For example, dead leaves often remain on stems. Bacterial ooze often forms on the shoots of crabapple, hawthorn, cotoneaster and firethorn when they first become blighted and later on older wood. Infected succulent stems of firethorn and cotoneaster show characteristic shepherds crook symptoms. Bacterial strands can be present, e.g. on hawthorn.

5.5 The effect of climatic conditions on flowering

Flowering in different species is regulated in complex ways by genes interacting with environmental factors such as temperature, photoperiod*, soil moisture and environmental stresses. Flowering times are important as host plants are most susceptible to fire blight infection when they are in flower.

Fig. 2. Blossom blight of apple (top left), pear (top right) and Pyracantha (middle left); Shoot blight on apple (middle right), Pyracantha (bottom left—photo by Florida Division of Plant Industry Archive, Florida Department of Agriculture Consumer Services, Bugwood.org) and cotoneaster (bottom right—photo by R. Grimm, Bugwood.org).

Fig. 3. Leaf blight and shepherds crook on apple (top left - M Hansen, Virginia Polytechnic Institute and State Uni, Bugwood.org), leaf and twig blight on loquat (top right - Florida Dept of Agriculture and Consumer Services, Bugwood.org), fruit blight on pear (middle left), Rubus tip dieback (middle right - B. Olson Oklahoma State University), Stem symptoms (bottom left - W. Jacobi, Colorado State University) and stem canker (bottom right - J. O'Brien, USDA Forest Service, Bugwood.org).

It is believed that the process is controlled by multiple triggers interacting, rather than by one signal. Natural selection pressures operating in different habitats may also influence the process. Some temperate plants flower in warmer month due to warmer temperature itself triggering flowering or promoting growth to a particular stage required for flowering. Other temperate species have a chilling requirement (which they get in the winter) and/or photoperiodic requirements to flower.

In any given season, flowering may occur at slightly different times depending on prevailing climatic conditions in that season. The effect of drought, unseasonable rain and other conditions are not known on the majority of host plant species. A guide has been provided for the flowering times of host plants (Table 4) but these may not be accurate under certain conditions or in a production nursery environment, particularly if day length has in the growing area.

* Photoperiod refers to day-length or more accurately, night-length because for photoperiodic control of flowering, plants actually sense and measure the dark period (night) rather than light.

5.6 Availability of control methods

Management practices for fire blight are mainly preventative and involve a combination of cultural, chemical and biological strategies.

Exclusion of the pathogen from production nurseries is a key strategy in the management of fire blight, and as such the adoption of sound nursery hygiene through best management practice is critical[5]. Failing this, early detection and complete eradication of infected plants is required. Steiner (2000) noted that the routine use of prophylactic chemical treatments in nurseries does not appear practical, economical or particularly effective, with the exception of copper treatments made just prior to planned bud and shoot removal efforts.

Other cultural practices for use in the field (and the nursery environment where applicable) include the use of resistant cultivars, removal of cankers (through inspection and pruning), careful control of nitrogen nutrition (to avoid flushes of succulent growth which favour disease development) and removal of alternative fire blight hosts.

There are currently no systemic chemical treatments registered for the control of bacterial plant pathogens in Australia. Copper-based protectant compounds can be used to prevent fire blight infection from occurring, but can have phytotoxic effects in some cases (e.g. flowers, young fruit and actively growing shoots). In some countries (e.g. USA, New Zealand) antibiotics such as streptomycin sulphate are used as a preventative treatment for fire blight on flowers, although the development of resistant strains has been reported (Cox et al. 2013). In the event of a fire blight incursion it is expected that application for an emergency permit for streptomycin sulphate (or alternative antibiotic) will be made by the State agency in which the outbreak occurs. The intent should be to use this only as a floral treatment in Restricted and Control Areas.

A range of biological products are registered in some overseas countries to assist in the management of fire blight, such as *Bacillus subtilis* QST713 (Serenade Max®), *Bacillus subtilis* var. *amyloliquefaciens* D747 (BacStar®), *Pseudomonas fluorescens* A506 (BlightBan® A506), *Pantoea agglomerans* (BlightBan® C9-1,Bloomtime®, BlossomBless), and *Aureobasidium pullulans* (Blossom Protect) (Stewart *et al*., 2011). There are currently no registrations for any of these products in Australia for the purpose of disease control. Generally speaking these products have not been found to be as effective as streptomycin for the management of fire

[5] Guidelines for best management practice in production nurseries (i.e. NIASA/BioSecure HACCP) are available from NGIA (Nursery and Garden Industry Australia).

blight due to inconsistent colonisation of blossoms, although may be more effective when used in combination with streptomycin as part of an integrated disease management program (Sundin et al. 2009).

5.7 Diagnostic information

Molecular and traditional methods of diagnosing *E. amylovora* should be used to ensure that accurate results are always achieved. Recent molecular methods can provide relatively fast results but should be tempered with traditional plate cultures in the rare event that a false negative is produced by molecular methods. Detailed descriptions of traditional methods are provided in Merriman (2007) and the fire blight diagnostic protocol (2004). It is recommended to complete an ooze test and initial isolation of bacteria from plant samples, based on Diagnostic Tests of the revised contingency plan (Merriman 2007). While molecular methods suggested in the 2007 contingency plan are valid, more recent techniques are more accurate and reliably detect all known strains of *Erwinia amylovora* (Buhlmann et al. 2013; Pirc et al. 2009). Loop-mediated isothermal AMPlification (LAMP) methods are also very fast (providing results within 15 minutes) and relatively mobile (Buhlmann et al. 2013). It therefore seems ideally suited within a response program.

It is important to use both traditional plate culturing techniques and molecular methods as sometimes both methods provide false negatives. LAMP and real-time PCR can detect bacteria when they are in a non-culturable state, for which traditional plate culturing will not, and traditional plate culturing can detect *E. amylovora* at concentrations below the detection limits of current molecular methods (Buhlmann et al. 2013). A positive result from any of the methods should be considered real, even if the results of the other method is negative. This method will minimise the risk of gaining a false negative. In conclusion, the following methods are suggested to be completed for all samples:

1. Ooze test
2. Plate culturing
3. LAMP or real-time PCR

If a positive result is gained from plate culturing, but not LAMP or real-time PCR, bacteria from plate cultures should be tested using LAMP and real-time PCR to confirm results. A positive result using LAMP or real-time PCR should always be considered positive.

The above section provides a logic from which a diagnostic protocol should be able to be produced using current methods. Cultures and plant samples should be destroyed hygienically, either in an autoclave or furnace. More test types and further description of ooze tests and plate culturing are described in Merriman (2007).

5.8 Pathogen risk ratings and potential impacts

While the potential for fire blight establishment and spread is considered to be high for the production nursery sector, entry potential and economic impact are classified as low, and overall risk rated as very low (Industry Biosecurity Plan for the Nursery Industry). This low overall risk, which contrasts to the high ratings of the Industry Biosecurity Plan for the Apple and Pear Industry, largely reflects the fact that susceptible hosts comprise only a very small percentage of overall nursery production in Australia.

6 Surveillance and Quarantine Areas

6.1 Overview of surveillance and summary of logic following a detection

No one recommendation can be made regarding how pest surveillance and eradication will take place following a detection of fire blight in Australia. A wide variety of factors will influence management decisions, the most important of which is the location of the detection in relation to host plants (i.e. production nurseries, retail outlets, apple and pear producers and rural and residential centres, particularly large cities). An important

course of action following the detection of an emergency plant pest (EPP) is to identify businesses and regions that could be associated with the movement of apple, pear and other host plant species to new areas, i.e. trace-forwards and trace-backs. Such high risk locations include, but are not limited to:

- Production nurseries supplying retail outlets
- Production nurseries supplying commercial growers of apple, pear and other hosts that can be infected by fire blight
- Retail outlets (hardware, garden centres, supermarkets, etc)
- Produce and garden outlets
- Local weekend markets
- Backyard (hobby) growers
- Residential home gardens
- Public gardens
- Proximity to commercial apple and pear orchards or abandoned orchards

There are no exhaustive lists of production nurseries, retail outlets, weekend markets, etc that could be supplying host plants of fire blight in Australia. It is therefore recommended that the response team first determine the locations within close proximity of the detection site. Consultation with the NGI State Association may assist in the rapid preparation of a list of relevant businesses (Appendix 1). However, urban and commercial areas that are at high risk have been suggested by Merriman (2007, see Appendix 2). Presence of production and retail outlets supplying relevant susceptible plant species within this zone represent one of the highest risks to long distance spread of fire blight. Production nurseries pose a greater risk as they are more likely to be trading with interstate retailers and/or orchards. Such businesses should be notified immediately and supply of host plants to areas outside the quarantine zone, without an approval (e.g. certificate verifying area freedom issued by a biosecurity inspector), must cease immediately. Posters alerting members of the public should be posted at all local retail outlets to increase awareness of the biosecurity threat. Furthermore, production and retail businesses within the zone should begin conducting surveillance for host species, described in detail below, keeping written records that could support area freedom.

Trace-forward and trace-back plant movements should be established from all production nursery businesses connected to the original detection. Movement of stock from within the quarantine zone during the previous six months should be considered as a minimum trace-forward. Trace-back movements should also be identified relevant to the infected plant material plus paying most attention to stock that was received within twelve months of the detection. This may require modification if the plants in which fire blight were detected had been imported prior to 12 months. For both trace-forward and trace-back plant movements the critical period could be longer than the stated time periods, as symptoms may take longer than this to appear. This period of time should, of course, be modified based on the individual circumstances of the detection. However, an initial period of six months for trace-forward and twelve months for trace-back is suggested as a suitable compromise between scientific rigour and the practicalities of responding to a detection. Refer to section 6.4.1 for more information.

Systematic surveys and sampling form the basis of locating outbreaks of fire blight, but are equally important in

defining pest free areas. Two types of surveys are required (a) for contact premises in Control Areas which surround the outbreak site (b) surveys outside Restricted and Control Areas which check for additional outbreaks and are the basis for future confirmation of pest free area status. The focus of surveys are plants which are recorded as natural hosts of *E. amylovora* and which are commonly or occasionally recorded in Australia (Table 4).

Surveys should conform to the International Standards for Phytosanitary Measures (ISPM) Guidelines for surveillance (ISPM No 6, 1997) and Requirements for the establishment of pest free areas (ISPM No 4, 1995) adopted by the International Plant Protection Convention (IPPC). ISPMs may be viewed at the IPPC website. These standards are recognised under the World Trade Organisation (WTO) agreement on the Application of Sanitary and Phytosanitary Measures. Australia is party to the IPPC and as a WTO member is required to base its phytosanitary measures on these international standards. Survey protocols using these guidelines will be significant in terms of international market access.

6.2 Proposed Strategies

There are few effective therapeutic treatments which are registered for control of fire blight in Australia, and strategies for eradication or containment will depend primarily on destruction of hosts, establishment of quarantine zones and development of hygiene and management strategies. Knowledge of the biology and methods of dispersal and survival of *E. amylovora* are used to formulate strategies for eradication or containment. For example the extent of the quarantine zones should, in part, be determined by the distance travelled by vectors of disease such as honey bees. Also hygiene practices should relate to known methods of transmission of disease.

Overall, control of fire blight relies on two basic principles:

- Stopping the multiplication of bacteria on infected plants.
- Preventing contact between susceptible plants and the fire blight bacterium.

These principles can be applied by:

- Application of protectant treatments to restrict secondary spread of fire blight (section 5.6).
- Restricting the spread of the bacterium (on hosts, vectors and contaminated equipment) through quarantine and movement controls. See section 6.4
- Decontamination of premises, vehicles, equipment and materials (section 6.5.1)
- Eliminating sources of infection by removal, careful disposal and destruction of infected plants or parts of plants on which the bacterium multiplies and survives (see section 8.1) and management of bee hives (section 7).

6.3 Surveys for early detection of an incursion in a production nursery

The first line of defence against fire blight is exclusion. However, early detection is critical, particularly in heavily built-up, residential areas, where host species are present in high numbers.

Greatest entry risks come from the illegal introduction of plants, budwood or cuttings or from the legal importation of host plants that have not been adequately inspected or treated (including internet sales). Awareness information should be targeted at managers of production nurseries and commercial apple and pear growers to ensure that they are familiar with the risks of importing illegal planting material. Material should also describe the legal method by which plants can be introduced and educate growers how to identify and inspect for the presence of the vector and disease symptoms.

Frequent (weekly) monitoring of production systems is recommended (refer to Biosecure HACCP guidelines) and staff must be familiar with the symptoms of fire blight. Appropriately kept records demonstrating the absence of fire blight symptoms, may assist in providing evidence of area freedom and in initial delimiting surveys.

6.3.1 Monitoring by production nursery managers and regulatory authorities

Systematic, regular and careful inspection of nursery plants and propagated material for signs of pests and disease, should be the basis of all monitoring processes. A range of detection methods should be implemented and performed by production nursery managers or consultants on behalf of the grower/owner. This will assist in minimising the risk of entry and establishment of fire blight in pest free areas.

- A representative sample of all host plant species should be visually inspected on a weekly basis for all insects and disease symptoms (weekly crop monitoring plan). Mother stock plants should be monitored for the presence of disease symptoms on at least a weekly basis. Symptoms consistent with fire blight should be reported to the emergency plant pest hotline (1800 084 881).
- The NGIA Nursery Production Farm Management System provides greater detail on crop monitoring, site surveillance and consignment inspections under the BioSecure *HACCP* program.

6.3.2 Surveillance by regulatory authorities

Biosecurity staff should regularly survey host plant species of fire blight in all areas of Australia as part of their regular surveillance. However, sole reliance on this surveillance is probably insufficient. Fire blight may not have been listed as a notifiable species in every state and territory. Inspection of mother stock plants in production nurseries or external plantings represents a more strategic, risk based method of conducting surveillance as their progeny will be sent to many regions across Australia. Retail outlets and production nurseries are infrequently monitored as part of regular biosecurity surveillance. Therefore, business owners are left responsible for reporting suspect EPPs. In relation to fire blight, surveys should be completed from spring to autumn and any time host plants are in flower.

Where the growing area of relevant host plants is small, it may be possible to inspect nearly all plants. In other cases, where large numbers of plants are being grown over vast areas, it may be possible only to inspect 10-20% at any one time. In this situation, different plants should be inspected each time. Priority for inspection should be given to plants which have abnormal growth, and to host genera which are known to be more susceptible to fire blight (Refer to Table 4). Mother stock plants should be inspected wherever possible.

6.3.3 How to survey individual plants for fire blight

Surveying an individual plant is simple but requires careful examination. All above ground plant parts should be methodically examined for the presence of water soaked lesions, dieback, cankers and bacterial ooze:

- Flowers
- Growing tips
- Branches and trunk
- Collar/crown
- Suckers and water sprouts (when present)

Roots can also be affected as per section 5.2.4 but are unlikely to have symptoms in the absence of above ground symptoms. Refer to 5.2.4 for details of fire blight symptoms. Plants should be monitored on foot and searched from all sides (when dealing with orchard plants).

Make sure you have obtained permission to enter the property before starting a survey. Enquire as to what pesticides have been applied recently as this may affect the abundance of insect vectors as well as preclude safe entry to a production nursery. Particular care must be taken when collecting individual specimens, to prevent contamination of samples and to maintain confidence in the sample from collection to its final result by a diagnostician. Collectors must exercise extreme care in handling specimens to ensure that hands, tools, and other collection supplies do not become a source of contamination between samples and particularly between individual sites. Other exotic pests and pathogens may be present if the infestation was via illegal importation of plant material.

Wash bottles containing soap and disinfectant must be provided to disinfect hands and small tools and articles. Special care must be taken with pruning instruments and other items used for sampling.

Care must also be taken with larger articles such as shoes, clothing and vehicles, to be certain that these do not become a means of contamination or spread of any pathogens that may be present. See Biosecure HACCP for on-farm monitoring, surveillance and inspection procedures and sample collection

6.4 Quarantine areas

In the event of a detection of fire blight, delimiting surveys are essential to inform the decision making process. The specific actions taken and the exact size of the quarantine area will vary depending upon the season and location; particularly in relation to highly built-up residential areas, commercial apple and pear growing areas, production nurseries and retail outlets and other potential sources of spread (e.g. weekend markets). Guidelines recommended by Merriman (2007) have been used extensively with some minor alterations, particularly with respect to the nursery industry.

Three categories of risk are identified which provide the basis for quarantine controls. The descriptors have been taken from the PLANTPLAN. The interpretation of the word premises requires some flexibility to cover situations where the outbreak of fire blight occurs on plants in parks, and public land.

Infected Premises (IP): premises (or locality) at which fire blight is confirmed or presumed to exist. Total movement control is imposed.

Contact Premises (CP): premises (or locality) containing susceptible host plants, which are known to have been in direct or indirect contact with an IP. Total movement control is imposed.

Suspect Premises (SP): premises (or locality) containing plants which may have been exposed to fire blight and which will be subjected to quarantine and intense surveillance (note: the surveillance period should be not less than the time between infection and the appearance of symptoms which, under optimal conditions is estimated at 5 days. This should be further extended when prevailing weather is unfavourable for disease development. Provided there is no evidence of infection the premises then revert to normal status.

Two categories of risk are identified to justify quarantine controls on an area basis.

Restricted Area (RA): restricted areas will be drawn around all IPs and CPs and include SPs until fire blight is shown to be absent. A high level of movement control and surveillance will apply to contain the disease and preserve the pest free area status of unaffected pome fruit production and nursery production areas.

The RA is not determined by drawing a circle of a certain diameter around the IP. The boundaries must be modified as new information comes to hand. Additional factors which need to be taken into consideration when determining the boundary of the RA include: terrain, the distribution of orchards, irrigation and management practices, the weather (particularly rainfall, temperature and prevailing winds), the distribution of other host plants on roadsides and home gardens, the flowering pattern/times of host plants and the distribution of pollen by feral and managed honey bees.

Control Area (CA): control areas will be imposed around the RA and include SPs until shown to be free of fire blight. The purpose of the CA is to control movement of susceptible plant species for as long as necessary to complete traceback and epidemiological studies. Once the limits of the disease have been confidently defined, the CA boundaries and movement restrictions should be relaxed or removed, where appropriate.

6.4.1 Tracebacks

Trace-backs and forwards are essential for delimiting survey activities following an initial detection. Trace-backs attempt to determine the source of the infection whereas trace-forwards further define potential spread of and dissemination of the infection. There are many potential sources of trace backs/forwards. These are summarised to assist in the investigations to locate potential populations of fire blight. However, not all of these will be relevant to all scenarios so one must determine the importance of certain lines of investigation on a case by case basis. In any case, tracebacks and traceforwards will identify movement linked to IPs and SPs.

- Trace-backs
    - Investigate where the infected material may have been purchased or obtained, this may include:
        - Retail nursery, produce store, weekend or road-side market or internet sale
        - Production nursery – trace-back to mother stock plants
        - Motherstock plants (budwood) located off-farm/on-farm
        - Rootstock produced on-farm/off-farm
        - Staff, visitors, etc both domestic & international
        - Self-propagated cutting
        - Illegal importation
        - Via internet, private sale or human movement across Torres Strait
        - Legal importation
        - Investigate the position of native and feral bee hives and their position in relation to fire blight host plants (section 7)
        - Items of equipment and machinery which have been shared between properties

        - Location of managed hives which have been moved from controlled and restricted properties
- Trace-forwards
    - Local movement of bees and other insects to other host plants in residential and native environments
    - Long distance movement of plants via
        - Sale of plants
            - At production nurseries there should be records of where consignments of plants have been sold. Sales of all host plants of fire blight and its vectors should be investigated from the last 12 months. Longer if deemed necessary (e.g. if the grower indicated that an importation occurred which may have been associated with the pest/pathogen in question and tracing each sale could result in having the EPP being declared as eradicated).
            - At retail outlets, markets etc will cause the scope of residential surveillance to be widened substantially
    - Within and around orchards, particularly at edges

6.4.2 Establishing a quarantine area

The trigger for the establishment of official quarantine action is either the appearance of “classic” symptoms of fire blight, or consistent positive results from selected diagnostic tests, which are normally available within 6 days. Experience has shown that these initial tests will provide sufficient information for quarantine action, and also avoid the problem of confounding factors such as false positives which can complicate quarantine management decisions.

The diagnostic process will continue through to completion of all the tests required (including pathogenicity tests) for confirmation of the identity of *E. amylovora*. This normally takes at least 12 days and as soon as these data are available they are conveyed immediately to the State Quarantine Manager, who is responsible for action under State Legislation.

In some instances a decision may be taken to establish interim quarantine bans on properties. This will reflect the circumstances at the time and the level of perceived risk. For example if the plants are in flower at the site where the suspect outbreak has been reported, then interim quarantine may be justified to reduce risk. Similarly if the outbreak is reported from a production nursery with commitments to interstate trade then interim quarantine can be justified. Initial quarantines around SPs may be implemented prior to diagnostic final results and modified as required after results become available.

Guidelines for implementation of quarantine zones following detection and or suspect detection of fire blight:

- The trigger for the establishment of quarantine action are either classic symptoms of fire blight or positive results from ooze, PCR and biochemical tests and pathogenicity on pear slices;
- Implementation of quarantine zone under relevant legislation – recommended area of **at least 2km radius, and at least 3km if plants are flowering,** from the edge of the infected premises or locality (see note at end of this section). **This represents the CA.**
- Advise the owners of commercial properties, private homes and agencies responsible for parks, public land, of the presence of suspect fire blight;
- Explain the need for implementation of quarantine action as a risk management measure until more test results are available;
- Explain the what will happen in relation to restrictions on movement of plants, plant products, equipment and people and consider the need for appropriate signage;
- Provide preliminary counselling, if required, to owners of affected properties;
- If host plants are in flower: (1) contact owners of managed hives in proximity to the IP and explain the need for quarantine by containment or isolation and (2) arrange for the application of approved chemical treatments to remove flowers;
- Arrange for the containment of hives by net enclosures at an adjacent site without hosts or the transport of hives in refrigerated containers to isolated areas of native vegetation where survey has confirmed the absence of hosts;
- Arrange immediate survey by qualified plant pathologist and quarantine officer(s) to define the extent of plants showing similar symptoms – affected plants should be mapped using GPS systems;

- Organise traceback and traceforward analyses from IP to identify Contact Premises;
- Record and map the Infected Premises, Contact Premises and commence the process of defining the quarantine area and associated buffer zones;
- Communicate the evolving situation to the CCEPP, peak industry and government;
- Consider and plan locations for the establishment of barrier controls including highways and transportation centres for freight and people;
- Advise the local authorities, police and appropriate road authorities of the intent to establish quarantine zones and barrier controls to restrict movement of plant material, plant products, hives and equipment to within the Restricted and Control Areas;
- Establish barrier controls including: road signs and barriers; roster teams and appropriate on-site accommodation; training in methods of communication and interaction with the public;
- Provide secure storage facilities for discarded plants and plant products and regular removal of collected material in secure containers to approved incinerator or burial sites.
- Implement appropriate actions as per PLANTPLAN.

Note: A national workshop of Industry, Quarantine Managers and expert plant pathologists took place in June 2000 and recommended 1) that a quarantine zone should extend by at least an additional 2km from the edge of the restricted area and 2) that during flowering of pome fruit orchards this zone is extended to at least 3km. Refer to appendix 3 for more details of outcomes from this workshop.

Refer to section 8.1 for guidelines on the treatment and removal of affected and suspect plants within a quarantine area.

6.5 Surveillance within the quarantine area

All host plants within 150m of IPs are to be destroyed if eradication is deemed feasible. More detail on response within IPs are provided in section 8.1.

After receipt of positive tests from initial diagnostic results (usually after about 12 days) a quarantine zone of up to 3km from the edge of the known affected area can be imposed. The area incorporates premises where fire blight has been confirmed (restricted area) and the control area where premises have been in direct contact with infected premises.

The proposed survey protocols apply to orchards, production and retail nurseries, parks and public land and home gardens. The operational requirements for surveys within these quarantine zones differ from others in that ALL host plants are systematically examined, including their growth stage particularly when flowering. Also recorded are the locations of ALL managed hives and feral nests of honeybees.

In addition, all host plants must have an application of insecticides every week for three weeks (and with streptomycin sulphate[6] if plants are flowering). Survey of each CP (including the sentinel plants), if possible, every 3 days for a further three weeks to confirm freedom from fire blight (note: this period may need to be extended if prevailing weather is unfavourable for the development of disease). At most, the interval between inspections should be not more than 7 days in high risk areas. This is recommended because it takes about 5 days from infection to the appearance of symptoms under optimum conditions. However, since development of the disease is asynchronous, symptoms will appear continuously.

Standardised procedures are proposed, by teams of at least 2 and up to 6, for survey and sampling of disease and recording information. All team members will be trained to recognise host plants and disease symptoms by using reference guides and demonstration samples. Team leaders will be appointed and trained in survey method, sampling procedure and recording principles. The team leader is the spokesperson for the group and the point of contact for property owners and managers.

[6] Not currently registered in Australia. Registered in the USA under the name of Agri-mycin® (Nufarm), and registered in New Zealand under the name Key Strepto™ (Key Industries). Other antibiotics registered overseas for management of fire blight include kasugamycin (Kasumin™- Arysta LifeScience) and oxytetracline (Mycoshield® - Nufarm).

Personnel management and planning of property visits is essential to minimise risks of transfer of disease from infested to “clean” properties. Dedicated teams should be used for visiting properties where fire blight has been confirmed and these should not then visit properties where disease has not been confirmed. Survey strategies also record the number and location of feral and managed bees which can spread the disease over relatively long distances during pollination of flowers of pome and ornamental plants which are hosts of fire blight (for detail see section 7.2-7.3 on surveys for honey and feral bees).

Survey information is recorded on a form (Appendix 3) which captures necessary information on property or site details.

- Teams will be trained in recognition of host plants and disease by reference to illustrated guides and plant samples (if available); in methods of survey, sampling and recording; and in protocols for surveys on private and public lands.
- If possible avoid inspection of properties when wet because of the higher risk of transfer of *E. amylovora.*
- Equipment required includes:
    - disposable hats, overalls and gloves
    - gum boots
    - hypochlorite or other suitable bactericide**
    - illustrated field guides of symptoms and host plants (electronic & hardcopy)
    - secateurs,
    - spray bottle with 70% alcohol
    - hand held gas burner
    - self sealing plastic bags
    - labelling pens
    - GPS monitors
    - Electronic portable devices (e.g. tablets, smart phones, etc)
    - Camera
    - survey forms
    - eskies and ice/portable refrigerators
    - identification tags
    - portable cleaning kit – sodium hypochlorite solution, detergent, screw drivers, scrubbing brush, two foot baths**
- **Note: Antimicrobial soaps, (GX 1027: Hibiclens) can be used for decontamination of personnel; an antibacterial Dow Corning compound (5700) can be used to treat garments which may have come in contact with diseased trees;
- Quaternary ammonium chloride, or hot water and detergent can be used for treating vehicles.
- Where possible owners of properties will be advised in advance of the survey requirements, and requested to restrain pets if necessary. Note: Surveys are not to proceed if the owner refuses entry, this issue is to be referred to the State Manager Quarantine who will arrange documentation requirements under legislation and the possible need for escort onto the property.
- Where practical vehicles should not be taken onto properties, or parked in production nurseries or orchards.
- When operating in Restricted or Control Areas, teams should wear protective clothing and identification tags prior to entering each new property or area of public land.
- Team Leader to identify group to the property owner/manager and explain the objectives of the survey and, if appropriate, the purpose of protective clothing.
- A survey plan is devised for each property, which includes every host of fire blight (home gardens, hedges). Also the growth stage of pome fruit cultivars and alternate hosts is recorded.
- A survey strategy based on inspection of rows is developed (as explained above) by the team leader and explained to members.
- Host trees and alternate hosts (alternate hosts may be situated in or around production nurseries, orchards, retail outlets and in the home garden) are visually inspected on both sides. Checks should be made for brown to black discoloured fruitlets, similarly discoloured shoot tips, leaves and stems of extension shoots (also with shepherds crook shape of shoot tips). Winter surveys should check for diseased flower trusses and leaves which frequently remain attached to trees. Note: cankers are much more difficult to detect particularly those on small branches.
- Plants which show symptoms characteristic of fire blight are marked (e.g. fluorescent spray paint, tape, etc) prior to sample collection; details of the tree, row number and cultivar, and a sketch map of the position of the affected plant are recorded on the survey form.

- Secateurs are sterilised by dipping in at least 95% alcohol and flaming for 5 secs before taking samples.
- Samples should be taken to ensure that diseased tissue and at least 5 cm or more of unaffected stem is removed. Two such samples should be taken from each plant.
- Samples are placed in self sealing plastic bags and labelled with the standardised number – this number is the one which appears on the on the Fire Blight Survey Form and is used to identify the property.
- Sterilise secateurs and cutting implements by flaming before each use.
- Ensure completion of the survey form including the number and position of hives and, if available, the address and contact number of the apiarist.

Note: If available the GPS satellite positioning system should be used to locate properties. The fire blight survey form has provision for recording the growth stage of the host and the location of affected plants by sketch map. Copies provided to the property owner/manager, the diagnostic laboratory and the Local Control Centre (LCC).

- At the conclusion of survey the property owner/manager is advised of the results and provided with a copy of the survey data recorded on the form.
- Plant samples are stored at between 0°C and 5°C (e.g. portable refridgerator, under ice in esky, etc) and disposable items of clothing placed in autoclavable plastic bags. Boots and other items are washed and sterilised.
- If symptoms consistent with fire blight are found, the survey team is to advise the communication centre immediately and arrangements will then be made for rapid transport of samples to the diagnostic laboratory.
- Plant samples are checked to ensure labelling on the plastic bag and form are consistent, then repacked in cold storage and consigned immediately to the Diagnostic Laboratory, which is advised by email, fax, telephone, etc.
- Forms are sorted, details entered on the database and checked, 'bring-up' dates are entered to remind the LCC of the requirement to convey results to clients, of the need to re-inspect properties and sentinel plants.
- On completion of data entry, summaries are to be used by the State Coordination Centre (SCC) for preparation of briefings and for use in redefining restricted and control areas, and areas free from disease.

6.5.1 Decontamination during surveillance

Fire blight can be mechanically transmitted from affected to unaffected host plants on pruning equipment, vehicles and farm machinery, plants and plant products, on clothing and hands. It is important to minimise the risk of mechanical spread and all surfaces which are likely to have been in contact with diseased tissue should be decontaminated. Recommended measures include:

- Use of bactericidal treatments such as hypochlorite and heat (flaming, steam, hot water) on equipment, tools, containers and surfaces which have been in direct contact with diseased plants or plant parts.
- Low pressure washing of equipment, machinery and vehicles in an isolated area which will avoid splash dispersal of droplets to host plants.
- Washing hands and changing clothing when moving from affected to unaffected areas and when moving off farm or property.
- Use and inspection of fire blight susceptible sentinel plants which are strategically placed in "hot spots" and inspected for symptoms every third day (see section 8.1).

6.5.2 Additional Procedures for Home Gardens

- Advise property owners by press, radio, TV, electronic communication (e.g. social media) and mail drop, and follow similar survey procedures as for orchards but paying particular attention to symptoms on alternate host plants. Complete survey form and sampling as for production nurseries.

6.5.3 Additional Procedures for Parks, Public Land, Roadside, Bush Land

- Advertise in press, radio, social media and TV of intention to survey and advise appropriate government agencies. Use GPS to locate survey site and follow same survey procedures as for orchards but focusing particularly on alternate hosts of fire blight.

6.5.4 Communication Strategy

- Each state authority will have a known communication strategy for contact with the public, media and industry, listing designated contact officers for information on aspects of the survey. The communication strategy is to be recognised and referred to by every person involved in the survey program.

6.5.5 Awareness, Training and Operations

- A national fire blight “Information Sheet" is to be made available (perhaps based on that proposed in Merriman (2007) for general release to the public and industry. The sheet will contain information on the host plants, the symptoms, photographs of symptomatic plants and telephone, email, website, etc contact details for state agricultural offices to answer public queries. There is also a nursery specific factsheet available on fire blight available on the NGIA website.
- A national fire blight surveyors identification guide, in the form of a pocket-sized reference and electronic format for portable electronic devices, should be made available to survey team members and growers. The reference should include photographs of symptomatic plants, and text to describe the symptoms, and is designed to be used in determining whether plant samples need to be taken for further testing. It could be based on that in Merriman (2007).

6.5.6 Recording and Reporting Survey Findings

Make sure permission is obtained prior to entering the property and before starting a survey. Enquire as to what pesticides have been applied recently to ensure safe entry to commercial properties. Particular care must be given when collecting individual specimens, to prevent contamination of samples and to maintain confidence in the sample from collection to its final result by a diagnostician. Collectors must exercise extreme care in handling specimens to ensure that hands, tools, and other collection supplies do not become a source of contamination between samples and particularly between individual sites. Other exotic pests and pathogens may be present if the infestation was via illegal importation of plant material.

- Each state authority will use a reporting system that ensures that sampled trees can be traced properly and relocated if necessary.
- Survey teams in each state will use a survey book to record instances where plant samples have been taken for further diagnosis. Each page in the survey books will have an identifying letter and a four digit number to correspond with samples submitted for diagnostic purposes, i.e.
    - Q…..for Queensland
    - N…..for New South Wales
    - V…..for Victoria
    - S…..for South Australia
    - W.....for Western Australia
    - T……for Tasmania
    - No…for Northern Territory
- Each sheet in the survey books will be in triplicate. The first copy to go with the samples to the diagnostic laboratory, the second copy to go to the operational headquarters of that state, and the third copy to remain in the survey book. Alternative which allow for the same level of rigour might also be suitable, e.g. electronic datasheets which are printed in triplicate on site.
- Each state will record survey findings within predetermined areas, i.e.:
    - Production areas/districts in orchard surveys; and
    - Urban areas/townships for site surveys (based on either established trapping grids or other areas nominated as being at risk from fire blight infection).
- Each state will establish a database for storage and retrieval of survey information that can be audited.

- The detection of a positive sample(s) will be notified to OCPPO within twenty four hours.
- Summary reports of surveys will be supplied to OCPPO at the end of the state surveys. Summary reports will include:
    - The number of production nurseries, orchards or hectares surveyed per state;
    - The number of production nurseries, orchards or hectares surveyed per district;
    - The number of urban sites (parks, etc) and gardens surveyed; and
    - The number of retail outlets surveyed.

During surveys, data must be recorded according to guidelines set out in ISPM No. 9 (1998), especially at the site of detection or occurrence. Data collected during a preliminary investigation should be used to estimate the potential for spread, the anticipated rate of spread and to identify endangered areas. Information gathered and recorded on the Survey Form should include:

- Geographical location using GPS; see DAFF Work Instruction ST-W-001 [7].
- Hosts infested at the site including age, variety/clone, rootstock, phenology.
- Extent and impact of damage and level of pest prevalence.
- How the pest was detected and identified.
- Recent imports of plants or plant products including nursery stock movements.
- History of the pest on the property or in the area.
- Movement of people, products, equipment and conveyances.
- Mechanism of spread within the area, including likely source of inoculum (infected trees, infected budwood, spread by storm etc.).
- Climatic events and soil conditions including storms and prevailing wind directions.
- Condition of infested plants, including age of plant parts affected (spring flush/autumn flush etc).
- Orchard management including method of irrigation, cover crops and spray programs.

Refer to Appendix 3 for a suggested survey data sheet (Merriman 2007).

6.5.7 Meteorological Data

- Each state/territory agency responsible for survey operations will collect meteorological data for each production district and urban/township area. The data will be used to determine whether meteorological conditions were conducive for the expression of fire blight symptoms if *E. amylovora* was present.
- A single infection day constitutes a day on which the maximum temperature was above 18oC and there was rain on that day, or the relative humidity was above 70% with rain on the previous day.
- Multiple infection day periods are periods during which two or more single infection days occurred consecutively.
- A low risk day would be a day with:
    - >1.0mm rainfall and temperatures of <18°C
    - > 0.5mm rainfall and temperatures of 18-20°C or
    - No rainfall but temperatures of 21-23°C
- A medium risk day would be a day with:
    - >1.0mm rainfall and temperatures of 18-20°C
    - < 0.5mm rainfall and temperatures of 21-23°C
    - No rainfall but temperatures of 24-30°C
- A high risk day would be a day with:
    - >1.0mm of rain and a temperature of 21-30°C or
    - < 0.5mm or rain and a temperature of 24-30°C
- The minimum meteorological data required would be maximum temperature, rainfall and relative humidity records for the nominated production areas and the nominated urban areas and towns in production areas.

[7] Telford G. 2007. Global Position System (GPS) Unit Use and Calibration. QDPI&F Work Instruction ST-W-001.

6.6 Surveillance beyond quarantine areas

This section describes the survey methods for use beyond the restricted and control areas where there is a significantly lower risk of detecting plants with symptoms of fire blight. A major difference between survey strategies is that a biometrically based risk management approach is adopted for areas beyond the high risk quarantine zone. This was developed following in 1997 at a National Workshop of State Quarantine Managers with responsibility for survey operations during incursion management.

Outcomes from the workshop were nationally agreed guidelines on the implementation of surveys for fire blight. These covered – confidence levels, targets, timing, training, equipment and survey teams, protocols for communicating with property owners, survey procedures and recording survey results. Presented below are details of the planning, infrastructure and operational requirements for surveys to locate plants showing symptoms of fire blight.

Survey activities cover three general categories: orchards, nurseries trading in host plants of *E. amylovora* and urban areas. A biometric approach which achieves a 99% level of confidence for detecting fire blight is used for orchards.

In production nurseries and retail outlets that have host plants of fire blight, all hosts should be inspected by nursery managers and written records kept of the results to support claims of area freedom (assuming all are negative).

In urban areas and parks sampling strategies are based on a grid system the intensity of which is determined by the quarantine status of the survey area. These surveys could be completed by existing volunteer garden groups, local council workers and enthusiastic individuals. Datasheets could be submitted electronically to the relevant state biosecurity team responsible for fire blight surveillance and response. The recommended procedure for urban surveys outside the Restricted Area is based on a grid pattern used for surveying fruit flies, which is part of the Commonwealth/State early warning fruit fly trapping program.

Outside the restricted and controlled areas, it is recommended that biosecurity inspectors survey plants on a one km grid up to 5km from the edge of the area under quarantine restrictions. Outside the 5 km radius, plants are surveyed on a 5 km grid pattern. At each grid point the closest individual host plant is inspected and its location recorded for future reference.

Note: This procedure was used for the 1997 program involving the Botanic Gardens in Melbourne and Adelaide.

Any suspicious symptoms should be reported to relevant biosecurity staff.

6.6.1 Surveys of Commercial Orchards

All apple, pear and nashi varieties are recommended for inspection outside the quarantine area either by biosecurity staff or by orchardists trained in the detection of fire blight symptoms. Refer to the APAL fire blight pest contingency plan (Recommendations for survey beyond the restricted and control areas, p.69) for further detail.

7 Surveys and Quarantine guidelines for managing honeybees

7.1 Background

Honeybees which are generally common in orchards, parks, gardens and bushland will normally only spread fire blight during flowering. However, it is most important to recognise that this risk period is not solely confined to the flowering times of pome fruit. Data from the Botanic Gardens, Adelaide, shows that the flowering pattern of alternate hosts of fire blight extends from early spring to autumn. This means that control of honeybees is essential for eradication or containment of fire blight.

Honeybees usually fly up to 2 or 3 kilometres from their host to collect pollen and nectar, but when food is scarce, flights can extend up to, or beyond, 6 kilometres. The fire blight bacterium contaminates bees' bodies during visits to diseased flower trusses and can also contaminate nectar and pollen grains. Bacteria can therefore be transmitted to unaffected flowers within or between neighbouring orchards, or to alternate hosts which are also flowering.

Tests have shown that *E. amylovora* can survive for a limited period of between one and two weeks either on pollen grains or in honey at a hive temperature of around 35°C (it is unable to survive at temperatures in excess of 36°C). This is considered to be the optimal temperature for maintenance of the brood nest. When the ambient temperature falls, the maintenance of 35°C throughout the hive can be difficult. At low temperature spots within hives it is considered that the survival time of *E. amylovora* can be increased, particularly on pollen.

Survival of *E. amylovora* varies in different areas of the hive and at varying temperatures (Alexandrova et al. 2002a; Alexandrova et al. 2002b; Sabatini et al. 2006; Wael et al. 1990) as follows:

- On or in bees
  - No more than 2 days on the bodies of honey bees or in their intestines
- In beeswax, debris and propolis (a sealant wax)
  - A maximum of about three weeks at 4°C in wax
  - A maximum of one day on debris and propolis regardless of temperature
- In honey
  - 8 weeks at 4°C, but only 1-2 weeks between 15-25°C; 2 days at 35°C
- In nectar
  - 11 weeks at 4°C, 1 week at 35°C
- In pollen
  - 50 weeks at 4°C, 40 weeks at 15°C, 1 week at 28-35°C.

These theoretical values probably represent longest periods of time. Other research indicates that fire blight bacteria survive for much shorter times than above under natural conditions; bacteria could not be detected after 1-3 days (Alexandrova et al. 2002b). This indicates that new inoculum would need to come into the hive on a regular basis for the hive to be a constant source of fire blight. Furthermore, when hives were purposely infected (by artificial injection and spraying and by placing infected plants around hives) no *E. amylovora* could be detected in the hive the following spring nor did symptoms occur on plants (research conducted in Belgium).

Pollen is stored in the broodnest combs of the hive where temperatures are 33 to 35°C. A large proportion of pollen can also be stored in the outer frames. Bees do not attempt to heat the entire hive and focus their energy on the comb where the brood nest is located. In cold weather bees congregate in the centre of the hive around the broodnest and outer combs are exposed to the lower temperatures. There is a risk that pollen contaminated with cells of *E. amylovora* may attach to bees exiting the hive on foraging activities. For this reason testing of residual pollen in hives is recommended as an additional check prior to hives being released from quarantine as per Sabatini et al. (2006).

7.2 Surveys of managed hives

Following an outbreak of fire blight, surveys for managed hives and feral bees will be conducted within a 3km radius from the edge of the quarantine area which includes Infected Premises, Contact premises and Suspect Premises. Later this should be extended to a radius of 5 to 6km. All such hives should be monitored for presence of fire blight on a monthly basis. Hives within the Restricted and Control Areas are to be quarantined as first order of business as they represent the greatest risk of natural fire blight spread.

The location of managed hives, both permanent and non-permanent, is systematically recorded by:

- Teams surveying for fire blight who will record the number and position of hives on properties.
- Interview of apiary inspectors, apiarists, property owners, members of the Crop Pollination Association, managers of public land.
- Checks of apiary registration records held by State Departments of Agriculture and administered by the Chief Veterinary Officer or equivalent.
- Aerial surveys could be considered for managed hives in orchards.

Registration records and those from interviews are entered on the database at the LCC and used to cross check information collected by teams surveying for fire blight. Special consideration and planning is required for the bumble bee which is endemic in Tasmania and may move to mainland Australia within the next few years. bumble bees may forage up to 8km from their nest and this will need consideration when establishing quarantine zones. At the moment bumble bees are essentially feral existing in colonies of up to 400 individuals usually in nests underground, and foraging can occur at lower temperatures than honeybees. There is a possibility of using managed bumble bees for pollination, particularly for glasshouse crops such as tomatoes.

7.3 Surveys for feral bee nests

Nests of feral honeybees are considered to be relatively common on commercial properties, (though rarely in the orchard plantation itself), in parks, gardens and adjacent bushland. Feral bees prefer nesting sites with volumes of approx. 30 litres, at or above 2.5 metres in semi-shaded positions. Typical sites include knot holes in trees, cavities in buildings, containers such as fruit bins, drums and other discarded containers.

Surveys for feral nests should be curtailed if temperatures fall below 15°C. At between 10-15°C only low numbers of bees may forage and nests can be overlooked by survey teams. Below 10°C honeybees general do not fly.

Teams of two trained in tracking and recognition of honeybee nesting sites are required, one team member should preferably be a State Department apiary inspector.

Equipment required for survey includes:

- Gum boots
- Bactericide
- Binoculars
- Detailed area maps, including local forested areas and river frontages
- GPS monitors
- Property identification maps
- Coloured plastic tape and spray paint
- Disposable protective clothing including overalls, gloves, hat and beekeepers veil
- Medi-haler epi for emergency use by personnel if stung by bees
- Portable cleaning kit for boots**

**Note: antimicrobial soaps, (GX 1027: Hibiclens) can be used for decontamination of personnel; an antibacterial Dow Corning compound (5700) can be used to treat garments which may have come in contact with diseased trees; quaternary ammonium chloride, or hot water and detergent can be used for treating vehicles.

7.4 Quarantine guidelines for managed beehives

At the national workshop (Appendix 3) apiarists expressed concern over an earlier proposal to destroy hives within the quarantine zone, and sought endorsement of alternative options. The workshop and subsequent consultations have endorsed two proposals for managed hives which are inadvertently involved in an orchard within a Restricted Area where fire blight has been confirmed:

1. Hives should be transported to an isolated area where no host plants of fire blight are present and retained under quarantine for 3 weeks where the average daytime temperature is above 25°C. The use of a refrigerated van should be considered to reduce/eliminate potential for overheating and smothering colonies during transit.
2. Hives should be transferred to a quarantine approved insect proof enclosure at an approved site within the RA for 3 weeks where average daytime temperature is above 25°C.

Orders for quarantining hives are issued under provisions of the Quarantine Act and relevant State legislation.

- State/territory CPHMs will need to consult with managing agencies of the remote sites to seek necessary approvals for their use in quarantining hives.
- Quarantine restrictions on the movement of managed hives apply as soon as information is available which confirms presence of fire blight and properties are placed under quarantine either as Infected Premises, Suspect Premises or Contact premises.
- Quarantine Managers should implement this action as quickly as possible to avoid the risk that hives might be moved considerable distances to other regions which will increase the risk of long distance spread of fire blight.
- beekeepers with hives in the RA and CA are to be formally advised of proposed quarantine by phone, fax or email.
- All registered apiarists are to be advised of the disease situation as it develops, of the boundaries of the quarantine zones and Pest Free Areas and of the need to consult with quarantine managers before moving hives.
- Teams of two are required for quarantine of hives (one member should preferably be a Government apiary inspector) and both should be appropriately trained.
- Apiarists and property owners are advised in advance of the time of the proposed action to isolate hives either at remote sites or by within insect proof enclosures.
- All persons, including media personnel, must be excluded from control areas from which hives will be transported. Warning signs will be posted around the diameter of a safety zone of minimum radius 100m, because honeybees can act aggressively when hives or nests are under threat.
- Persons known to be sensitive to bee stings should not be involved in hive or nest destruction.
- Movement of hives is usually conducted after dusk or in periods of inclement weather when bees are not foraging.
- Team leader to meet with the apiarist and the property owner/manage to plan action at a time when honeybees have returned to the hives.
- Hives should be transported to the remote site or a site within the RA for quarantine within insect proof enclosures, for a period of not less than 3 weeks. An enclosed refrigerated van is recommended for long distance travel.
- Before leaving the IP all equipment is washed or sterilised, including the vehicles.
- Hives should be escorted by a quarantine officer, or accredited apiary inspector, in a separate vehicle to audit the procedure and to deal with unanticipated eventualities such as breakdowns and accidents.
- The quarantine vehicle should be equipped to maintain contact with the communication centre, be it by mobile phone (assuming that coverage is continuous), satellite phone or radio. A contingency needs to be available, such as the emergency use of an insecticide to kill bees and to retrieve or destroy hives which are “spilt” as a result of an accident.
- In situations where quarantine within insect proof enclosures is selected quarantine staff will need to ensure that the nets comply with specifications in respect of mesh size and material and are applied correctly to hives to ensure there are no escape pathways.

- Team leader to check that all hives have been established at the quarantine site, post appropriate signage and secure the signature of the apiarist on an appropriate form which identifies the period of isolation before hives can be returned to commercial work.
- Prior to returning to commercial work, apiarists should obtain certification from quarantine managers which specifies that hives have been quarantined at isolated sites for a prescribed period.
- A diagnostic test is recommended to check that *E. amylovora* cannot be detected on pollen samples from the hives in question.
- Any pollen collected from hives by apiarists need not be destroyed but should be heat treated at 35°C for one week or gamma irradiated at an approved facility.
- Team leader to report action to SCC and return the signed forms and enter quarantine release date in the database.

Equipment required includes:

- protective clothing for use when applying chemicals
- beekeeper hat, veil and gloves
- beekeeper suit or light coloured overalls
- tan boots (preferably elastic sided)
- beekeeper gloves
- kerosene and soapy water duct tape, smoker, smoker fuel and safety matches
- atomiser and selected chemicals (check State control of use legislation)
- appropriate signage and barriers
- disinfectant and bactericide**
- trolley for transport of hives
- truck and mobile cool stores
- smokers and hive tool
- antihistamine tablets and medi haler - epi
- camera
- inventory form
- fork lift or similar device for moving hives and cool stores

**Note: Antimicrobial soaps, (GX 1027: Hibiclens) can be used for decontamination of personnel; an antibacterial Dow Corning compound (5700) can be used to treat garments which may have come in contact with diseased trees; quaternary ammonium chloride, or hot water and detergent can be used for treating vehicles.

7.4.1 Options for quarantining managed hives

- The quarantine of hives and destruction of feral honey bee nests are critical when host plants are flowering as pollination activities of bees represent a known long distance means of dispersal of *E. amylovora*.
- It is important that quarantine action should endeavour to preserve hives which are a genetic resource built up over years. Two isolation strategies should be considered – transport to a remote site or isolation by netting (insect proof enclosure).
- Isolation of hives at a remote site - this will require the identification of remote sites for isolation of hives, where previous survey has demonstrated absence of host plants of *E. amylovora*. Note: Quarantine Managers will need to secure approvals from agencies managing remote sites.
- Isolation of hives within an insect proof enclosure will also be equally effective as transport to a remote site and is considered a more practical option.
- Three weeks isolation is proposed during relatively warm weather. This period has been chosen because 21 days in warm conditions exceeds the known survival period of cells of *E. amylovora* in hives, either on pollen, bees bodies or in honey, wax and propolis (see section 6.6.1).

7.5 Actions for feral nests in the quarantine zone

Feral nests of honey bees will almost certainly be present in the RA and CA and experience shows that a survey is essential. All feral honey bee nests in the quarantine zone should be destroyed. They can be difficult to find and bee lining methods should be used. Feral nests tend to be located in relatively inaccessible places in trees, unoccupied spaces in buildings. Access is also difficult and ladders or other equipment for reaching high areas will be required. Teams of 2 are required each with identification tags and an appropriate 4WD vehicle and enclosed tray. Teams should be briefed by an appropriate officer from Plant Quarantine on the legislative basis for destruction of feral nests.

Bait hives should be used in spring to attract and trap honeybee swarms that may fly into the Restricted Area, and these can then be destroyed using solvent or insecticide (check state control of use legislation).

Bait stations using scented sugar syrup solutions may be established to determine if any honey bee colonies remain undetected. Foragers which are attracted to bait stations can then be tracked using bee lining techniques to establish the location of the nest or hive, which can then be treated. Details of this method are available from state government apiary officers.

Important issues include:

- Apiarist and assistant to survey the RA and CA for feral nests and identify their location on a map.
- Property owners or occupiers and managers are to be advised in advance of the proposed action including its legal basis.
- Team Leader needs to review position and accessibility of feral nests to assess requirements for cherry picker or other specialised equipment.
- Nests should be treated with insecticide and where possible exposed combs should be burnt or buried; insecticide should be applied within cavities housing inaccessible nests and, if necessary, holes to these nest sites should be blocked off. Note: it will be necessary to revisit sites to assess the effectiveness of the treatments.
- Team Leader to record action and report to SCC.
- Repeat surveys commissioned to check the effectiveness of the treatments.

Equipment required includes:

- protective clothing for use when applying chemicals protective clothing for use when applying chemicals
- beekeeper hat, veil and gloves
- beekeeper suit or light coloured overalls
- tan boots (preferably elastic sided)
- beekeeper gloves
- kerosene and soapy water
- duct tape, smoker, smoker fuel and safety matches
- antihistamine tables and medi haler-epi
- atomiser and selected chemicals (check State control of use legislation)

An additional orchard practice is the use of pollen inserts or dispensers to enhance opportunities for pollination. Bees visit and collect pollen from these dispensers and transport it to flowers, and there is therefore a requirement to ensure that the source of pollen is from a fire blight free area.

7.6 Costs to Apiarists

Honeybees are a vector of fire blight and quarantining hives is an important component of quarantine action but costs should not be borne by apiarists. Costs should be met from Commonwealth:State cost sharing arrangements, or in the case of active containment from State Government and Industry. Apiary industry funds are earmarked for use against outbreaks of notifiable endemic and exotic bee diseases.

8 Course of action

This section deals with the specific actions required to contain and eradicate *E. amylovora*, should this be considered feasible. Actions required for the establishment of quarantine zones are covered in section 6. Actions required for surveillance and quarantine of managed hives and feral nests are covered in section 7.

Two fundamental principles are important when attempting eradication:

- stop the multiplication of bacteria on infected plants, and
- prevent contact between the susceptible plants and the fire blight bacterium.

These are applied by:

- restricting the spread of the bacterium (on hosts, vectors and contaminated equipment, hives/components, honey and bee collected pollen) through quarantine and movement controls;
- eliminating sources of inoculum by removal and careful disposal and destruction of infected plants or parts of plants;
- application of prophylactic treatments to restrict secondary spread of fire blight; and decontamination of premises, vehicles, equipment and materials.

8.1 Quarantine actions at infected premises

These guidelines are for operation at production nurseries, retail outlets, orchards and home gardens.

- Owners/managers of IPs are advised as soon as a positive diagnosis for fire blight has been made.
- A senior quarantine officer in collaboration with Technical Specialists will first visit the property owner to explain the basis for action, to decide which trees and shrubs are to be destroyed, and to explain what will happen. Note: action is not to proceed if the owner refuses entry, this issue is to be referred to the State plant health manager who will arrange documentation requirements under legislation and the possible need for escort onto the property.
- At this stage an assessment should be made to determine whether the proposed buffer zone of 150m from the edge of the affected area extends to other properties/areas, and these owners will also need to be advised of the proposed removal of host plants within the buffer zone.
- Within 24 hours, the Leader of the Eradication Team and contractor arrange a site inspection to plan the most efficient method of destruction of orchard trees and other host plants and then explain in more detail what will happen.
- Where practical, vehicles not directly involved in tree removal and disposal should not be taken onto affected properties.
- The plants for removal will have previously been marked with fluorescent paint, (includes all host plants to be destroyed within the buffer zone). This includes hedges of alternate hosts which are used to delineate property boundaries, roadsides and parks.
- Managed honey bee colonies will have previously been quarantined and feral nests destroyed (see section 7).
- Insecticide and sprays are applied across the affected area (consistent with the State Chemical use procedure) as a risk minimisation strategy to reduce spread of inoculum on insects migrating from the property.
- Sprays of a flower removal treatment are also applied if the outbreak coincides with flowering. Application of copper sprays should also be considered across the affected area.
- Standardised procedures are proposed by teams of at least 2 and up to 6. All team members will be trained to recognise host plants (demonstration samples) and disease symptoms by using reference guides. Team leaders will be appointed and trained in methods of tree removal, disposal and site clean up. The team leader is the spokesperson for the group and the point of contact for property owners and managers.
- Planning of property visits is essential to minimise risks of transfer of disease from infested to “clean” properties. Dedicated teams should be used for visiting properties where fire blight has been confirmed and these should not then visit properties where disease has not been confirmed.
- Equipment

    - Each team is provided with:
    - an appropriate 4WD vehicle with covered tray
    - radio or mobile phone
    - disposable hats, overalls, gloves, face masks; gum boots
    - hypochlorite (or other sterilants)**
    - mobile high pressure washing rig (mobile steam steriliser)**
    - 70% ethanol
    - hand held gas burner
    - secateurs
    - insecticide, copper protectant sprays, flower removal treatments (check on approvals for use)
    - kerosene/diesoline
    - mobile spray unit
    - chain saw, secateurs
- Contractors to also provide:
    - Back hoe or similar equipment for tree removal
    - Chain saw
    - Truck with secure enclosed tray

**Antimicrobial soaps, (GX 1027: Hibiclens) can be used for decontamination of personnel; an antibacterial Dow Corning compound (5700) can be used to treat garments which may have come in contact with diseased trees; quaternary ammonium chloride, or hot water and detergent can be used for treating vehicles.

8.1.1 General destruction protocols

- No plant material should be removed from the quarantine area unless part of the disposal procedure or as part of regulated movement approved by biosecurity organisations, i.e. when plant material is grown in a pest free area, treated appropriately and is certified by a trained biosecurity inspector. At this time there are insufficient registrations or minor use permits to facilitate this process.
- Disposable equipment, infested plant material or growing media/soil should be disposed of by autoclaving, high temperature incineration or deep burial either on site or off-site (after containing the equipment in a sealed container that allows treatment of the container).
- Any equipment or plant material removed from the site for disposal should be double-bagged.

8.1.2 Production nurseries and retail outlets

- For production nurseries, host plants in containers and grown inground (soil) should be transported in secure trucks and buried at an accredited site under protocols listed in 8.1.3. Prior treatment of the affected area by appropriate protectant sprays (see 8.1.3) is recommended. Containers should be consigned under supervision to an industrial waste site. Affected plants held in inground beds should be destroyed by burial and soil treated under supervision with steam or a registered fumigant chemical. Production areas should be disinfested and washed under supervision and sentinel plants posted at key locations and checked regularly.
- Prior to leaving the Infested Property all vehicles and equipment are washed under low pressure and steam cleaned. Also items of equipment which have been used to cut and remove trees are treated with a suitable sterilant[8]. This also includes all the property owners' equipment which may be contaminated by the fire blight bacterium.
- Disposable clothing is removed and placed in autoclavable bags for treatment at the LCC[8].
- Team Leader records action on an appropriate form and advises the SCC
- Sentinel plants are to be placed at strategic points and inspected at three day intervals for the remainder of the season, after which the situation is reviewed. Additional inspections required if infection periods or hail are encountered.
- Signs are posted to identify the quarantine area and hygiene practices apply.
- Movement of visitors other than quarantine personnel within the affected area is prohibited, home visits ok.

8.1.3 Orchards

For orchards, contractor removes trees under supervision and either burns on site (use kerosene) or transfers plants in sealed trucks for immediate burial. Contingency plans for burning and burial are essential, and issues for consideration include:

- Permits and approvals may be required for burning on site.
- For burial, trees should be uprooted by backhoe and loaded directly into the truck which is sealed and decontaminated prior to leaving the property[8].
- Transport to the burial site to be supervised by quarantine agency (radio contact) and contingency is in place for accidents.
- Burial to be supervised by quarantine agency to ensure material is covered by an effective barrier of soil (0.5m).
- Interior of truck, any tools, equipment and clothing to be decontaminated under supervision prior to leaving the burial site[8]
- Sites of tree removal are compacted and levelled. Consideration will need to be given on whether the soil at affected sites should be fumigated, or fallowed.

Fruit transported from the infected premises remains a high risk of spreading fire blight bacteria. Transport of fruit from infected premises to markets outside the Restricted Area is prohibited.

If fruit is harvested from outside the Restricted area, though is still from the same property (e.g. because the property is very large) all fruit should be forwarded for processing under supervision by quarantine agency. The area should be established as being pest free (see section 8.2) and should not enter the Restricted area. If fruit cannot reach the market without travelling through the restricted area the following procedure should be taken:

- Fruit is to be picked by dedicated staff into labelled bins.
- Bins are secured in a sealed truck.
- Truck is decontaminated before leaving the RA.

8.1.4 Home gardens

- Treatment and removal of affected plants from home gardens will need special consideration. Application of insecticide and, where necessary, copper sprays and flower removal treatments should be applied by an accredited contractor with equipment which minimises drift within and between properties. Methods of removal of affected trees will also need consideration because in some cases access problems may prevent entry of contractor's equipment. This may mean that in some cases neither burning nor removal of whole trees is possible. In such situations trees could be burned on site subject to space and owner's consent or removed in sections by chain saw. Special attachments will be required to capture dust and wood chips from chain saws. Since some plant material will inevitably escape capture it is recommended to disinfect the area with either a copper product or other appropriate antibiotic product.
- The individual pieces should be bagged and loaded into sealed trucks for transportation to burial sites under protocols described above. Disinfestation of hands clothing chain saws and other items of equipment will be required before leaving the property[8].
- The area occupied by affected plants should be levelled and left fallow for a prescribed period of several weeks to facilitate breakdown of roots and any associated *E. amylovora*.
- Consideration should be given to providing a replacement plant for home owners which is not a host of fire blight.

[8] Note: Antimicrobial soaps, (GX 1027: Hibiclens) can be used for decontamination of personnel; an antibacterial Dow Corning compound (5700) can be used to treat garments which may have come in contact with diseased trees; quaternary ammonium chloride, or hot water and detergent can be used for treating vehicles.

8.2 Establishing pest free areas

Following an outbreak of fire blight, it is likely that interim quarantine bans on interstate and international movement of host plants and pome fruit will be imposed until more accurate information is available which confirms the boundaries of both the affected and pest free areas as per ISPM 4 Requirements for establishment of pest free areas.

Surveys, which conform with the International Standard for Phytosanitary Measures (ISPM 6), are recommended to provide evidence of pest "freedom" which can be used in submissions to facilitate trade either nationally or internationally. Information from surveys to define pest free areas (together with other controls) will be considered by Sub-committee Domestic Quarantine & Market Access (SDQMA) which makes recommendations on interstate trade. At an international level the federal Department of Agriculture will lead negotiations with trading partners on area freedom.

Note the following:

> The protocol for establishing pest free areas was the subject of a separate project funded by APAL and HAL (AP01029). The three systems suggested in this 2001-03 study were: (1) using the network of commercial pest scouting services already servicing the pome fruit industry; (2) using volunteer orchardist observers (a lower-cost option); and (3) using a systems approach by supplementing grower observations with professional monitoring. A systems approach was recommended as it is in keeping with current quarantine thinking and represents the most thorough and convincing proof of the absence of fire blight.

- Relevant publication – requirements for the establishment of pest free areas (ISPM 4) are prepared by the International Plant Protection Convention (IPPC) as part of FAO's global program of policy and technical assistance in plant quarantine. The intent is to achieve international harmonisation of phytosanitary measures with the aim of avoiding the use of unjustifiable measures as barriers to trade.
- Definition: Pest free area – an area where a specific pest does not occur as demonstrated by scientific evidence and in which this condition is being officially maintained.
- Additional cautionary note: IPSM 10 (requirements for the establishment of places of pest free production and pest free production sites) under the definition, a pest free place of production can exist within an area where the pest is present. The relevance of this category clearly will need more consideration during eradication, because it may contravene recommendations on movement controls which are imposed on properties within the Restricted and Control Areas.

The requirements for the establishment of a pest free area include:

- systems to establish pest freedom
- verification that pest freedom has been attained
- systems to maintain pest freedom
- product identity, consignment integrity and phytosanitary security
- the establishment and maintenance of a buffer zone
- documentation and records
- review and audit

ISPM 4 specifies that OCPPO has a lead role in the establishment of standards. In Australia the Government agencies would work with industry in the establishment and audit of pest free areas and OCPPO would review and ratify these protocols.

8.3 Minimising risk of re-entry and establishment of fire blight

Growers in pest free areas will need to consider the introduction of additional management measures to minimise the risk of the introduction and establishment of fire blight. The measures recommended below are intended as a guide and further information should be sought from the State Quarantine and Agriculture Departments:

- Regularly inspect the production nursery as per the international standard referred to above.
- Control movement of visitors and contractors, especially those who may have been into quarantine zones.
- Always check the origin of new propagation/planting material, either production nursery, orchard or home garden plants, and bud wood before purchase and import onto the property.
- If relevant seek evidence from apiarists either to ensure the hives have not been adjacent to or within quarantine zones, or that the hives which have been within quarantine areas have undergone the necessary period of quarantine.
- Avoid the introduction of dirty bins onto the property which contain trash from unknown sites.
- Ensure that second hand equipment is thoroughly cleaned before entry onto the property.
- Use fire blight prediction models (Maryblyt and Cougar Blight) to predict infection periods especially during flowering of host plants and inspect when an “alert” is identified.
- Consider the application of registered protectant flower treatments during fire blight alert periods.
- Where possible remove any secondary blossoms.
- Record the activities which can be used to authenticate/validate the pest free area for trade purposes.

8.4 Owner reimbursement costs

The main objective in providing Owner Reimbursement Costs (ORC) is to provide an incentive for growers to report suspicious pests or pathogens under the basic principle of no one being worse off or better off as a result of reporting a suspected exotic pest incursion. Providing for these ORCs also provides for social justice for growers who, through no fault of their own, are detrimentally affected by a plan to eradicate an Emergency Plant Pest.

If the positive detection of fire blight in a host requires its removal and destruction then destruction records must be kept by the LCC of the lead agency(s) involved in order to correctly calculate ORC entitlements.

For further details of ORC guidelines and evidence requirements refer to the Plant Health Australia website: www.planthealthaustralia.com.au

9 Technical debrief and analysis for stand down

The response is considered to be ended when either:

- Eradication has been deemed successful by the lead agency, with agreement by the Consultative Committee on Emergency Plant Pests and the Sub-committee on Domestic Quarantine and Market Access.
- Eradication has been deemed impractical and procedures for long-term management of the disease risk have been implemented.

A final report should be completed by the lead agency and the handling of the incident reviewed.

Eradication will be deemed impractical if, at any stage, the results of the delimiting surveys lead to a decision to move to containment/management.

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Appendix 1: Important nursery industry contacts

It is important to note that the Industry Development Officers (IDOs) change from time to time. Therefore, the current list may become out of date relatively quickly. For this reason, one can always refer to the NGIA website for the latest details for the NGI for each state and territory. In addition, some states may have more than one IDO, the below list are important contacts who may then direct you to the most appropriate person.

Northern Territory Website: http://www.ngia.com.au/Category;jsessionid=57FAB91F4A656937462E3F34A910B531?Action=View&Category_id=266 Michele Shugg Public Officer/NT Farmers Representative Nursery & Garden Industry Northern Territory PO Box 348 Palmerston NT 0831 Ph: 08 8983 3233 Fax: 08 8983 3244 Email: ngint@ntha.com.au	Western Australia Website: http://www.ngia.com.au/Category?Action=View&Category_id=308 Esther Ngang Chief Executive Officer Nursery & Garden Industry of WA PO Box 135 Mount Helena WA 6082 Mob: 0411 056 966 Email: esther.ngang@ngiwa.com.au
South Australia Website: www.ngisa.com.au Grant Dalwood Development Officer Mob: 0412 692 600 Fax: 08 8372 6833 Ph: 08 8271 1012 Email: gdalwood@ngisa.com.au 505 Fullarton Rd (Gate A) Netherby SA 5062	NSW and ACT Web: www.ngina.com.au Michael Danelon Nursery Industry Development Officer (NIDO) 344-348 Annangrove Road (PO Box 3013) Rouse Hill NSW 2155 Ph: 02 9679 1472 Fax: 02 9679 1655 Mob: 0400 010 049 Email: michael@ngina.com.au
Queensland Website: www.ngiq.asn.au John McDonald Industry Development Manager PO Box 345 SALISBURY QLD 4107 Ph: 07 3277 7900 Mob: 0419 683 457 Fax: +61 07 3277 7109 Email: nido@ngiq.asn.au	Victoria Website: www.ngiv.com.au David Reid Nursery Industry Development Officer PO Box 2280 Wattletree Road LPO East Malvern Victoria 3145 Ph.: 03 9576 0599 Fax: 03 9576 0431 Email: david@ngiv.com.au
Tasmania Website: http://www.ngia.com.au/Category?Action=View&Category_id=307 Karen Brock PO Box 3009 Rosny Park Tasmania 7018 Email: Brocklands@bigpond.com Mob: 0439 972 793	Australia Website: http://www.ngia.com.au Robert Prince Chief Executive OfficerNursery and Garden Industry Australia Ph: 02 8861 5107 Fax: 02 9659 3449 Mob: 0404 111 685 Email: Robert.prince@ngia.com.au

Appendix 2: Guide of proposed urban and commercial orchard production areas of high risk by state

This list does not include high risk production nurseries and retail outlets. All areas of Australia are high risk from a nursery perspective.

State	Urban areas/townships			Commercial orchard areas/districts
New South wales	Armidale Bathurst Canberra Dubbo Forbes	Goulburn Inverell Riverina Orange Sydney	Tumut/Batlow Wagga Wagga Young	Orange Tamut/Batlow Windsor (Bilpin)
Victoria	Midura Swan Hill Robinvale Echuca Cobram Shepparton Mooroopna Harcourt	Rutherglen Beechworth Bright Wangaratta Tatura Kyabram Murchison Bendigo Benalla	Monington Red Hill Pakenham Drouin Warragul Portland Geelong Frankston	Goulburn Valley Sourthern Harcourt Northeast Southwest Bacchus March Mildura Swan Hill East Gippsland
Tasmania	Hobart Launceston Burnie Devonport Scamander Sithton Stanely	Huon Valley Spreyton Tamar Valley Parramattta Creek Tasman Peninsula Derwent Valley Cygnet Channel	Wynyard Westbury	Huon Valley Cygnet Esperance Tasman Peninsula Tamar Valley Spretyon Sassafras
South Australia	Port Pirie Port Augusta Whyalla Ceduna Paringa Renmark Berri	Morgan Blanchtown Kalagadoo Penola Mount Gambier Port Lincoln Murray Bridge	Loxton Glossop Monash Barmera Waikeirie Cadell	Adelaide Hills Southeast region Riverland
Western Australia	Perth Bunbery Albany	Esperance Geraldton Carnavarvon		Perth South West Loer Great Southern Upper Great Southern Midlands
Queensland	Stanthorpe			Stanthorpe

Appendix 3: Survey data sheets

Below is a survey data sheet suitable for a production nursery or retail outlet. Refer to APAL contingency plan (Merriman 2007) for survey sheet suitable for orchards.

Production Nursery and Retail Outlet Survey Form

PROPERTY OWNER No: _____
Name: _____

Business name:_____

Postal Address:_____

_____Postcode:_____
Telephone No: _____ Fax No:_____
Mobile phone: _____ Email: _____

PROPERTY DETAILS:

Manager:_____

Property Address:_____

Postal Address:_____
Telephone No._____ Fax No:_____
Mobile phone: _____ Email: _____
Map Ref: _____ Area of host plants_____
GIS Ref> _____

Source of Scions and Rootstocks: _____

In-house or contract budding/grafting: _____

Target market (orchard, retail, etc) details:_____

_____

_____

_____

_____

_____

_____

Distribution of product:

_____

_____

_____

_____

_____

CONTACTS FOR TRACEBACK Source of propagation material, Contractors (irrigation, drainage, pesticide, etc), Company Reps Other (specify)

OTHER PROPERTIES: Location:_____
Map Ref: _____

Sampling Date:

Host plant species and variety	Flowers present Y/N	Growth state – rootstock, grafted, etc	Container and plant size	# of plants	# of plants with symptoms	Symptoms present	Sample #	Result

Recommendation:_____

Sampling Officer: _____Signature:_____

Mud map of site or attach a site plan on a separate sheet:

Appendix 4: Recommendations from the national workshop

The following recommendations were developed at a National Workshop in June 2000. Industry and Government were challenged with developing responses to a range of anticipated issues which are predicted to arise following confirmation of an outbreak of fire blight in a commercial orchard.

Some of the major issues for which recommendations were developed include:

- When should the interim quarantine arrangements be introduced;
- How extensive should the quarantine zone be;
- Who (and how) should communicate messages to property owners;
- What treatments should be applied to the affected area;
- What are the agreed destruction protocols for affected trees;
- Should managed honey bee colonies be destroyed;
- What controls should be introduced on the marketing of fruit.

Four syndicate groups at the workshop considered the same questions and their summarised responses are presented below. In many instances consensus was not achieved between groups and where the recommendations differed on a 50:50 split, a precautionary approach has been adopted in favour of controls on fire blight or its vectors.

Examples of workshop recommendations include:

- application of insecticides to affected trees prior to their destruction, and of flower removal treatments (should host plants be flowering);
- application of copper treatments as a protectant against infection by *E. amylovora*;
- controls on bird movements;
- controls on managed honey bee colonies by either containment under nets or by isolation at remote sites without hosts;
- removal of affected trees and roots (backhoe) together with plants within a 150m buffer (see Note below) and other adjacent host plants (parks, gardens and roadsides);
- all host plants are destroyed on site by burning or by transportation off site (enclosed truck) and burial;
- affected home garden plants are first treated with an approved insecticide and bactericide before removal and chipping on site (stumps also ground out) with appropriate controls on dust and debris.

“On the day variations” will be decided by the Consultative Committee on Emergency Plant Pests and must be considered on a case by case basis. For example should the proposed 150m buffer zone be modified if host plants areflowering. Approvals will be required from the APVMA and State agencies for use of non approved chemical treatments, and authorisation may be required from the appropriate authorities if a decision is taken to burn affected material on site.

Appendix 5: Resources and facilities – diagnostic service facilities in Australia

The below diagnostic facilities should be contacted prior to sending any samples to ensure that necessary equipment and reagents to complete all tests required. The fire blight diagnostic protocol (2004) indicated that there were only two laboratories with the capacity to test for fire blight.

Facility	State	Details
DPI Victoria – Knoxfield Centre	Vic	621 Burwood Highway Knoxfield VIC 3684 Ph: 03 9210 9222; Fax: 03 9800 3521
DPI New South Wales – Elizabeth Macarthur Agricultural Institute	NSW	Woodbridge Road Menangle NSW 2568 PMB 8 Camden NSW 2570 Ph: 02 4640 6327; Fax: 02 4640 6428

In addition, the below facilities are likely to have the capacity to conduct fire blight diagnostic tests and should be contacted in the event of an incursion in their state.

Facility	State	Details
SARDI Plant Research Centre – Waite Main Building, Waite Research Precinct	SA	Hartley Grove Urrbrae SA 5064 Ph: 08 8303 9400; Fax: 08 8303 9403
Grow Help Australia	QLD	DAFF Ecosciences Precinct Dutton Park Q 4102 Ph: 07 3255 4365; Fax: 07 3846 2387
Department of Agriculture and Food, Western Australia (AGWEST) Plant Laboratories	WA	3 Baron-Hay Court South Perth WA 6151 Ph: 08 9368 3721; Fax: 08 9474 2658
Department of Primary Industry and Fisheries	NT	Department of Primary Industry and Fisheries Plant Industries Division BAL building, Berrimah Farm, Makagon Road, Berrimah NT 0828 Ph: 08 8999 2261; Fax: 08 8999 2312