Draft Review of Post – Entry Quarantine Protocols for the Importation into Australia of Apple (*Malus*) and Pear (*Pyrus*) Budwood

August, 2001

AGRICULTURE, FISHERIES AND FORESTRY - AUSTRALIA

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Document produced by Biosecurity Australia, which is a group within the Commonwealth Department of Agriculture, Fisheries and Forestry - Australia.

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GLOSSARY OF TERMS AND ABBREVIATIONS

AAPGA ……………….	Australian Apple and Pear Growers' Association
ABARE ……………….	Australian Bureau of Agricultural and Resource Economics
aetiology ……………...	the science of the cause of disease
ALOP …………………	Appropriate Level of Protection is the level of protection deemed appropriate by the country establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health
AQIS ………………….	Australian Quarantine and Inspection Service
BA …………………….	Biosecurity Australia
DNA …………………..	Deoxyribonucleic Acid, usually consisting of two helical chains of polynucleotides that are responsible for the transfer of genetic characteristics
DNRE ……………..….	Department of Natural Resources and Environment, Victoria
epiphytic ……………..…	living on a plant, but not as a parasite
HRDC ……………..…..	Horticultural Research and Development Corporation
interstock ………………	scion variety on a rootstock into which a bud or graft is inserted
IPC …………………….	International Phytosanitary Certificate
IPPC …………………..	International Plant Protection Convention
pathogen …………..…..	a parasite able to cause disease in a particular host or range of hosts
PCR …………………..….	Polymerase Chain Reaction, where conserved nucleotide sequences are replicated to levels that can be detected by gel electrophoresis
PEQ …………………..	Post-Entry Quarantine

pest ……………………..…..	any species, strain or biotype of plant, animal, or pathogenic agent, injurious to plants or plant products
phytosanitary measure ...	any legislation, regulation or official procedure having the purpose to prevent the introduction and /or spread of quarantine pests
quarantine pest …………	a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and under official control
RNA ……………………	Ribonucleic Acid, consisting of a single helical chain of polynucleotides, the main function of which is the translation of the genetic code into protein synthesis
rootstock ……………...	plant into which bud or graft is inserted
scion ………………..…	shoots that develop from a bud or graft on a rootstock
SPS Agreement ……….	World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures
synonymy ……………..	listing of illegitimate name(s) not currently employed for the species or group under the current name
vector ………………….	an organism that carries and transmits a pathogen to the host which it attacks such as an insect carrying fungal mycelium or spores
WTO …………………..	World Trade Organization

EXECUTIVE SUMMARY

This document recommends revised post-entry quarantine (PEQ) conditions for the importation of apple and pear budwood. The scope of this review is limited to apple and pear budwood due to the economic importance of these crops in Australia and to address the pome fruit industry's wish to reduce the current mandatory PEQ period for apple and pear introductions.

In reviewing these PEQ protocols, Biosecurity Australia (BA) carefully considered the recommendations presented in a draft report of the Department of Natural Resources and Environment (DNRE), Victoria, published in April 1998 entitled “Proposed Post-Entry Quarantine Protocols for Pome Fruit” (HRDC Project No. AP 627).

As part of the revision, the quarantine status of pathogens of apple and pear budwood was reviewed. Three bacteria, 21 fungi, two phytoplasmas, four viroids, three viruses and one disease of unknown aetiology were identified as quarantine pathogens.

Major changes proposed for the PEQ protocols are:

- reduction of the PEQ period from the current four seasons to two growing seasons, which may take a minimum of 15 months if budwood is imported during November to February or 24 months if it is imported during other months; and
- use of *in vitro* diagnostic tests to detect quarantine pathogens.

From a risk perspective, the proposed PEQ approach, with its pro-active *in vitro* testing for quarantine pathogens, is more rigorous than current passive quarantine procedures.

Imported budwood must not be more than one year old, to minimise the risk of introducing quarantine bacteria and fungi. Budwood should be imported from November to February to allow testing to be completed within the minimum period.

The bacterium *Erwinia amylovora*, the cause of fire blight, presents the greatest potential threat to the apple and pear industries in Australia. Apple and pear introductions must be tested for this pathogen by using susceptible rootstocks and *in vitro* methods (once on arrival of budwood and twice during PEQ). Tests for the other quarantine bacteria, *Pseudomonas syringae* pv. *papulans* and *Xylella fastidiosa*, must be carried out once during PEQ by *in vitro* methods.

Introductions must be tested three times for fungal pathogens (on arrival, end of the first seasons growth and two months prior to release) by external and internal examination, and culturing for latent infections.

Tests for phytoplasmas, viroids and viruses must be carried out once during PEQ by woody indexing, herbaceous indexing or *in vitro* methods. Woody indexing for phytoplasmas requires a minimum period of two years to complete, and will delay release from PEQ if this test is used in place of an *in vitro* test. For two of the viroids, woody indexing can be completed within four months. *In vitro* methods to test for viroids are currently not available in Australia but can be developed by diagnostic services or quarantine pathologists. Meanwhile, tissue blots can be sent to overseas laboratories for hybridisation testing.

Apple rubbery wood is considered to be of quarantine concern. BA recommends a conservative approach, as the disease is latent in many commercial cultivars and can cause yield losses of up to 80% (Waterworth & Fridlund, 1989). Introductions must be tested for this disease by woody indexing (that takes a minimum period of six months to complete under greenhouse conditions) and rigidity and lignin staining tests. The other diseases of unknown aetiology are not considered to be of quarantine significance.

BA's proposed import conditions would apply to imported material from all sources.

The detection of non-quarantine pathogens is not the responsibility of the Australian Quarantine and Inspection Service (AQIS), although some of these pathogens are important to industry. Introductions could be tested for non-quarantine pathogens by industry plant health improvement programs or by the importer after the release of the introduction from PEQ. If resources permit, AQIS may be able to test for non-quarantine pathogens during PEQ on a full cost recovery basis by prior arrangement with the appropriate quarantine plant pathologist.

Release of the introduction is permitted upon completion of testing after the second growing season, subject to freedom from quarantine pathogens.

1 INTRODUCTION

The Australian Apple and Pear Grower's Association Inc. (AAPGA) commissioned DNRE (Agriculture Victoria) to undertake a project to address industry concerns at the four year period in PEQ for apple and pear introductions and the resulting delay in access to the latest varieties. The Horticultural Research and Development Corporation (HRDC) funded the project with financial support from the AAPGA. The report is entitled "Proposed Post-Entry Quarantine Protocols for Pome Fruit" (HRDC Project No. AP 627) and was published in April 1998. The DNRE report recommended reducing the PEQ period to 12 months (or 18 months including plant health improvement testing) by using modern *in vitro* diagnostic techniques for pathogen detection. The report also recommended that the list of quarantine pests be modified to include additional bacteria, fungi, phytoplasmas and viroids and to have certain viruses and graft-transmissible diseases of unknown aetiology deleted.

BA (formerly part of AQIS) commenced a review of PEQ protocols in January 1999. Since then, BA has actively sought the opinions of plant pathologists in Australia and overseas with regard to the PEQ requirements and diagnostic test protocols for apple and pear introductions. These plant pathologists, by virtue of their specialised knowledge of particular pome fruit pathogens, have provided valuable input to the review. This consultative approach was necessary to provide the information required for a thorough review of protocols so a reduction of the PEQ period could be considered while maintaining quarantine security.

2 SCOPE OF THE REVIEW

The scope of this review is limited to:

- budwood imported from all sources, as 90-95% of imported material is from non-accredited sources. However, BA would consider amending the PEQ protocols for material imported from accredited sources after a review of the current accredited sources.

- apple and pear (*Malus* spp. and *Pyrus* spp.) budwood. Quince (*Cydonia* spp.) and other Rosaceous plants are excluded. The review has not included tissue cultures, rootlings, seed or pollen.

- PEQ requirements for apple and pear budwood imported into Australia. It does not consider interstate quarantine regulations, as States and Territories in Australia have restrictions or specific conditions for the entry of apple fruit/budwood from other States and Territories, eg. Western Australia prohibits apple fruit and budwood from other States and Territories. For details of the interstate plant quarantine regulations, State quarantine authorities must be consulted.

3 PURPOSE OF THE REVIEW

The purpose of this review of PEQ protocols for the importation of apple and pear budwood is to:

- analyse the pathogen risks associated with the importation of apple and pear budwood for propagation;
- consider the recommendations presented in the Department of Natural Resources and Environment (DNRE) report entitled “Proposed Post-Entry Quarantine Protocols for Pome Fruit”; and
- present future requirements for PEQ and pathogen testing for the quarantine pathogens associated with budwood.

The DNRE report is available at http:www.aqis.gov.au/docs/plpolicy/dnrepome.doc

4 INTERNATIONAL FRAMEWORK

The Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) defines the basic rights and obligations of World Trade Organization (WTO) member countries, such as Australia, with regard to the use of sanitary and phytosanitary (SPS) measures. SPS measures are measures necessary to protect human, animal or plant life or health, including procedures to test, diagnose, isolate, control or eradicate diseases and pests. SPS measures may directly or indirectly affect international trade and should not be used as a disguised restriction on trade.

Member countries have the right to determine their appropriate level of sanitary or phytosanitary protection (ALOP) and take SPS measures to the extent necessary to protect human, animal, or plant life or health provided these measures are based on scientific principles and are not maintained without sufficient scientific evidence.

The SPS agreement encourages WTO Members to base their national SPS measures on relevant international standards, guidelines and recommendations. The International Plant Protection Convention (IPPC) is recognised by the WTO SPS Agreement as the convention under which international standards for phytosanitary measures are developed. Governments may choose national measures that provide a higher level of protection than relevant international standards, subject to conformity with obligations relating to risk assessment and a consistent approach to risk management.

In assessing risks, WTO Members are required to take into account available scientific evidence; relevant processes and production methods; relevant inspection, sampling and testing methods; prevalence of specific diseases and pests; existence of disease/pest free areas; relevant ecological and environmental conditions; and quarantine or other treatment.

5 AUSTRALIAN APPLE AND PEAR INDUSTRY

The Australian apple and pear industry is primarily based in growing regions at Stanthorpe in Queensland, Orange and Batlow in New South Wales, Goulburn Valley, Bacchus Marsh and outer Melbourne in Victoria, Huon Valley in Tasmania, Adelaide Hills in South Australia, and Perth Hills, Donnybrook and Manjimup in Western Australia.

In 1998/99, the industry produced a crop of 496,443 tonnes of fruit (334,353 t of apples and 162,090 t of pears) from over 11 million trees. Victoria is the major grower of apples and pears in Australia, producing 32 per cent of Australia’s apples and 87 percent of the nation’s pears. Production figures for New South Wales, Queensland, South Australia, Tasmania, Victoria and Western Australia are given in Table 1. The estimated fresh farm gate value of the apple and pear industry is $499 million.

The major apple varieties grown in Australia have traditionally been Red Delicious and Granny Smith (57% of production), but the newer varieties, such as Gala, Fuji, Pink Lady™ and Sundowner™, now account for 20% of total production and are expected to increase as younger plantings mature.

The pear industry is about half the size of the apple industry, with 85% of the total crop produced in the Goulburn Valley of Victoria. The main varieties are Packham, Williams (WBC) and Buerre Bosc, which make up 92% of production.

Apple and pear exports are focused on the premium markets of the United Kingdom and Europe, and the bulk markets of South East Asia. The chief export markets in South East Asia are India, Indonesia, Japan, Malaysia, Singapore, Sri Lanka and Taiwan. Australia produces 0.8% of world apple production and 1.4% of world pear production.

Table 1 Apple and Pear Industry Statistics (1998/99) - A snapshot

State	Production (tonnes)	
	Apple	Pear (incl Nashi)
New South Wales	68 175	. 2 116
Queensland	29 232	1 509
South Australia	25 161	6 076
Tasmania	62 271	769
Victoria	107 291	140 992
Western Australia	42 219	10 629
Total	**334 349**	**162 091**

Source: AAPGA web site available at http://www.aapga.com.au/stats2.htm

6 QUARANTINE PATHOGENS

In this review of the pathogens that could be introduced on apple and pear budwood, BA has used the IPPC definition of a quarantine pest to determine their quarantine significance. The IPPC defines a quarantine pest as a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and under official control.

In this pest categorisation process, BA reviewed:

- the bacteria, fungi, phytoplasmas, viroids, viruses and graft transmissible diseases of unknown aetiology recorded on apple and pear;
- the economic importance of these pathogens;
- the absence/distribution of the pathogens in Australia; and
- the probability that these pathogens would be introduced on apple and pear budwood.

The quarantine pathogens of apple and pear budwood identified by BA for Australia are listed in Attachment 1 - Quarantine Pathogens of Apple (*Malus*) and Pear (*Pyrus*) Budwood. Additional exotic fungi recorded on apple and pear, for which there was insufficient information on their potential economic importance and/or their likely occurrence on budwood to include as quarantine pathogens, are listed in Attachment 2 – Additional Exotic Fungi recorded on Apple (*Malus*) and Pear (*Pyrus*). These exotic fungi are discussed further in the section on fungi. Graft transmissible diseases of unknown aetiology of apple and pear are listed in Attachment 3 – Diseases of Unknown Aetiology of Apple (*Malus*) and Pear (*Pyrus*).

The numbers of quarantine pathogens currently tested for by AQIS in PEQ are compared in Table 2 with the numbers proposed for testing by DNRE and BA.

Table 2 Proposed changes in the number of quarantine pathogens of apple and pear budwood

Pathogen category	Number of quarantine pathogens			Comments
	Currently tested for in PEQ	Proposed for testing by DNRE	Proposed for testing by BA	
Bacteria	1	3	3	No change from DNRE proposal.
Fungi	5	60	21	BA proposes active screening for 21 high-risk fungal pathogens.
Phytoplasmas	2 + apple rubbery wood	2 + all diseases suspected to be caused by phytoplasmas, including apple rubbery wood	2	Apple proliferation and pear decline phytoplasmas accepted as quarantine pathogens by BA. Other diseases suspected to be caused by phytoplasmas are discussed in the section on diseases of unknown aetiology.
Viroids	0	4	4	No change from DNRE proposal.
Viruses	1 + all nepoviruses	1 + all nepoviruses	1 + 2 nepoviruses	BA proposes generic nepovirus testing if tests for specific nepoviruses are not available.
Diseases of unknown aetiology	9	0	1	Apple rubbery wood is considered to be a quarantine disease because of its unknown cause and its economic significance.

6.1 *Erwinia amylovora*

Budwood a principal means of dissemination of the bacterium *E. amylovora*, the cause of fire blight (van der Zwet, 1994). The current PEQ procedure takes a minimum of four growing seasons to complete, and testing for *E. amylovora* is based on passive screening. Following establishment, apple and pear importations are grown for a minimum period of two years in an insect-proof screenhouse, followed by a minimum of one year's growth in a shadehouse under conditions that favour the development of *E. amylovora*.

Erwinia amylovora has not been detected on introductions of susceptible hosts in PEQ in Australia. Since 1961, approximately 1100 apple and pear introductions have been released from PEQ, while 206 introductions are currently being tested in PEQ as at February 2001 (AQIS, 1996; Anthony Wicks, personal communication). Reasons advanced to explain the absence of detections of *E. amylovora* in PEQ include:

importation of pathogen free budwood; elimination of the pathogen from buds by surface sterilisation during establishment; and the non-survival of epiphytic bacteria during the two years introductions are held under dry conditions in a greenhouse prior to the final year's growth in a shadehouse under conditions that favour the development of *E. amylovora*.

Since early last century, Australia has had strict quarantine controls on the entry of host material that could introduce *E. amylovora*. Until *E. amylovora* was reported to have been detected in the Royal Botanic Gardens in Melbourne in 1997 (AQIS, 1998b), Australia was considered to be free of this pathogen. Evidence for freedom included active surveys for symptoms of fire blight in some areas, and no detections/reports of fire blight despite the presence of highly susceptible hosts and conditions conducive for disease expression throughout Australia. After eradication of the source of infection in Melbourne, surveys confirmed that there was no evidence of fire blight in Australia (AQIS, 1998b; Jock *et al*., 2000).

6.1.1 Impact of *E. amylovora* on the apple and pear industry

Erwinia amylovora has been assessed as being the greatest threat to the Australian pome fruit industry. Certain pear varieties, including the major varieties grown in Australia, are particularly susceptible to this pathogen. Many of the apple varieties grown in Australia are also susceptible to *E. amylovora*. Studies by Wimalajeewa (1998), Penrose *et al.* (1988) and Roberts (1991) have used disease-forecasting models to predict the severity of fire blight on apples and pears under Australian conditions. These studies agree that *E. amylovora* would have a substantial impact if it becomes established in Australia. For example, an Australian Bureau of Agricultural and Resource Economics (ABARE) study (Bhati & Rees, 1996) suggested that losses could be $125 million per year if the pathogen was present in all regions of Australia. A study commissioned by AAPGA (1997) suggested that the Australian pear industry might not be viable if *E. amylovora* was present in Australia.

6.1.2 Environmental impact of *E. amylovora*

All the work on the impact of the introduction of *E. amylovora* into Australia is based on effects on commercial apple and pear crops. There are other hosts of *E. amylovora* grown in Australia that could also be affected by fire blight in areas where climatic conditions favour the development of the pathogen. A number of hosts of *E. amylovora* are common in parks and home gardens in Australia including *Cotoneaster* spp., *Crataegus* spp. and *Sorbus* spp. The establishment of *E. amylovora* in Australia could substantially reduce the amenity value of these plants, and directly affect the nursery trade supplying these plants (AQIS, 1998a). Control of bees and other insects is one of the measures that are used to prevent spread of *E. amylovora* during eradication programs. Honey production could be affected by this control measures in the event of an incursion of *E. amylovora* (DPIE, 1996).

6.1.3 Environmental conditions for survival and multiplication of *E. amylovora*

Erwinia amylovora requires relatively high temperatures and humidity to multiply, although survival can occur at lower temperatures. Development of disease epidemics typically takes place in warm, moist conditions (van der Zwet & Keil, 1979). These conditions are present in many areas of Australia. Roberts (1991) found that almost all major apple and pear production areas would be rated as high-risk areas for disease occurrence in most seasons.

6.1.4 Mode of transmission of *E. amylovora*

Budwood is recognised as one of the principal means of dissemination of *E. amylovora* (van der Zwet, 1994). Insects also play a major role in the spread of *E. amylovora*. (van der Zwet & Keil, 1979). The AAPGA submission (AAPGA, 1996) provided a list of 27 insects, drawn from a list of insects implicated in the spread of *E. amylovora* in other countries (van der Zwet & Keil, 1979) that are either present or have species in the same genus in Australia. Pollinating insects such as bees have a high potential to spread *E. amylovora*, and this is possible over more than 4 km (Hoopingarner & Waller, 1992).

6.1.5 Possibility of spread of *E. amylovora* in Australia before detection

Given the capacity for *E. amylovora* to exist epiphytically on plants (van der Zwet *et al*., 1994), and the fact that infection is dependent on favourable environmental conditions, it is possible that low levels of infection could escape detection after entry of the pathogen. This would allow *E. amylovora* to become widespread before action could be taken to eradicate the pathogen. In addition, casual observers may confuse fire blight symptoms with those of other diseases and disorders. Problems of early detection would be exacerbated by the diversity and distribution of hosts that would need to be monitored, and the fact that many of the hosts would be in home gardens in cities and towns and not subject to regular inspection and commercial management. Therefore, symptoms might not be reported for some time, thus greatly reducing the prospects for successful eradication. This highlights the need to ensure that apple and pear introductions are free of *E. amylovora*.

7 PEQ PROTOCOLS FOR IMPORTED BUDWOOD

The PEQ testing protocols proposed by BA are based on pro-active testing for quarantine pathogens, using *in vitro* techniques where these are currently available. This approach allows introductions to be screened in a minimum period of 15 months instead of the current four-year period. It also reduces the risk of release of plants infected with quarantine pathogens from PEQ by replacing visual screening with active testing.

Important advantages of the *in vitro* testing proposed by BA include:

- improved *in vitro* techniques can be adopted by AQIS as they become available, without the need for a complete review of PEQ protocols; and
- early detection using *in vitro* testing minimises the risk of spread of quarantine pathogens to other introductions in PEQ.

Details of the current PEQ protocols and the DNRE proposals are in the DNRE report at http:www.aqis.gov.au/docs/plpolicy/dnrepome.doc. Following is a summary of these protocols and BA's new testing proposals, including the rationale behind the proposed testing procedures.

7.1 Current PEQ protocols

1. Dormant budwood is usually imported in spring/summer, fumigated with methyl bromide and dipped in sodium hypochlorite.

2. Buds from the treated budsticks are budded onto two rootstocks (seedlings of Granny Smith for apples and *Pyrus calleryana* D6 for pears). The plants are established in a greenhouse during the first season. One plant is selected as the mother plant for each introduction and all material for propagation and testing is taken from this plant.

3. After scion growth on the mother plant is mature, daughter plants are propagated for possible release to the importer at the completion of PEQ.

4. Mother and daughter plants are held in an insect-proof screenhouse for the second and third seasons, with a fourth season in a shade house under conditions that favour the development of fire blight. These plants are inspected regularly for disease symptoms during PEQ.

5. In the second season, buds from the mother plant are budded onto woody indicator plants that are grown in PEQ for up to three seasons in a quarantine shade house. Indicator plants are inspected regularly for signs of viral and

phytoplasmal infection.

6. Leaves from the mother plant are tested for viruses using herbaceous indicator plants. Herbaceous indicators are carefully inspected for symptoms of viral infection.

7. There is currently no testing for viroids.

8. The current PEQ protocol takes four growing seasons to complete.

7.2 DNRE proposal

1. Dormant budwood is imported in spring/summer. One budstick is treated with methyl bromide and sodium hypochlorite, and the other remains untreated.

2. The untreated budstick is tested (*in vitro*) for the bacteria *E. amylovora* and *Pseudomonas syringae* pv. *papulans*. Visual observation is conducted in a greenhouse for the detection of *Xylella fastidiosa* or testing is conducted offshore as no laboratory in Australia is currently set up to test for this bacterium.

3. Buds from the treated budstick are budded onto two suitable pathogen-tested rootstocks between *Pyrus calleryana* "Aristocrat" laterals that are highly sensitive for *E. amylovora*. At this stage buds may be taken for testing for non-quarantine pests in a plant health improvement program. During the plant health improvement program, buds from the imported scionwood are budded onto appropriate virus-sensitive indicator plants (woody or herbaceous indicators). If necessary, leaves are tested for viruses using ELISA.

4. Plants are grown under conditions conducive to fire blight development, and carefully inspected for any signs of disease.

5. Tips from the imported scion and the *P. calleryana* "Aristocrat" laterals are removed and tested (*in vitro*) for quarantine bacteria.

6. Plants are screened visually for diseases of quarantine significance caused by fungal pathogens.

7. Leaves from the imported scion are tested for phytoplasmas, viroids and viruses.

8. The following spring, plants are again grown under conditions conducive for fire blight. Growing tips are taken and tested for quarantine bacteria. Plants are carefully inspected for any signs of disease.

9. This process (including plant health improvement testing) would take 18 months to complete.

7.3 BA's proposed PEQ protocol

7.3.1 Budwood

Recommendations

1. Imported budwood is to be not more than one year old to minimise the risk of infection of the budwood by quarantine fungi.

2. Budsticks must be disinfested on arrival by methyl bromide fumigation.

3. Budsticks must be surface sterilised with sodium hyphochlorite before buds are propagated onto rootstocks.

Rationale for BA’s recommendations

Restricting budwood to one-year-old material reduces the risk of fungal infection, since it would be exposed to fungal infections for a shorter period. It is also less likely to have been damaged, providing fewer infection sites for opportunistic wound pathogens. Disease symptoms are also more obvious on young tissue. Furthermore, most wood rot in living trees is confined to the older central wood of roots, trunks and branches.

While one year old budwood may be more sensitive to fumigation and dipping, there is no known horticultural disadvantage in using one year old budwood.

7.3.2 Post-entry quarantine

Recommendations

1. Budwood must be imported during November to February for New South Wales, November to December for Tasmania, November to January for Victoria, or November to February for Western Australia in order to allow testing for quarantine pathogens to be completed within two growing seasons in PEQ.

2. Buds from imported budsticks must be established on *E. amylovora* susceptible rootstocks or interstocks.

3. One plant is to be selected as the mother plant for each introduction and all material for propagation and testing is to be taken from this plant.

4. Mother plant is to be grown in PEQ for two growing seasons, with one year in a greenhouse at temperatures above 18.5°C with high humidity using mist or overhead watering to favour development of *E. amylovora* and fungal pathogens, and three months in a screenhouse.

5. Use of fungicides during PEQ should be avoided if possible to encourage disease expression. However, fungicides can be used as necessary to maintain the health of plants.

6. The mother plant must be carefully inspected for any signs/symptoms of disease for two growing seasons.

7. If the mother plant is found free of *E. amylovora* and other quarantine pathogens after two growing seasons, the introduction can be released from PEQ.

Rationale for BA's recommendations

Post-entry quarantine may be completed within a minimum period of 15 months under BA's proposed PEQ protocol. For budwood imported at other times of the year, testing would not commence until the following November and may require 24 months before PEQ testing is completed.

It is important that greenhouse conditions are suitable for disease development during the first year in PEQ. Temperatures must be kept above 18.5°C, with mist or overhead watering to maintain a high relative humidity. This will allow detection of fire blight and other bacterial and fungal diseases.

Mother plants are to be inspected regularly for symptoms of disease. While it is unlikely that bacterial and fungal pathogens will survive the initial treatment or escape detection in the initial screening, early detection of quarantine pathogens is important to minimise the risk of spread to other introductions in PEQ.

A potential problem in quarantine greenhouse facilities is the use of fungicides to maintain plant health in artificial environments. These fungicides may not only inhibit the immediate expression of disease, but may also have a residual effect in suppressing diseases. Where possible, plants should not be sprayed with fungicides. However, use of fungicides can be essential to maintain the general health of plants in quarantine greenhouses and to control diseases like powdery mildew. Powdery mildew, if not controlled, could mask the symptoms of quarantine diseases. Fungicides can be used in these situations to maintain plant health.

7.3.3 Bacteria

Recommendations

1. *Erwinia amylovora* (fire blight), *Pseudomonas syringae* pv *papulans* (blister spot) and *Xylella fastidiosa* (pear leaf scorch) are considered quarantine pathogens that require testing in PEQ.

2. Introductions must be tested for *E. amylovora* using fire blight susceptible rootstocks or interstocks and *in vitro* diagnostic methods.

   a. Buds from surface sterilised budstick are budded onto *E. amylovora* susceptible, virus tested:

      i. clonal rootstocks (Malling 26 for apples and *Pyrus communis* cvs Winter Nelis or Bartlett for pears); or

      ii. interstocks (Jonathan, Gingergold or Gala on seedlings of Granny Smith for apples and Bartlet or Bosc on *Pyrus calleryana* D6 for pears).

   b. *In vitro* diagnostic testing for *E. amylovora* must be done three times during PEQ:

      i. buds from the imported budsticks used for propagation before surface sterilisation;

      ii. leaves from the mother plant after bud burst during the first spring; and

      iii. leaves from the mother plant after bud burst during the second spring.

3. Leaves from the mother plant must be tested for *Pseudomonas syringae* pv. *papulans* using a selective medium in the second growth season.

4. Pear introductions must be tested for *Xylella fastidiosa*. Leaves from the mother plant are to be tested for the bacterium using *in vitro* tests in the second growth season.

Rationale for BA's recommendations

Erwinia amylovora susceptible virus tested clonal rootstocks or interstocks are recommended, as this allows direct screening of the bud from which all material for release would be derived for each introduction. Buds infected by *E. amylovora* will fail and the rootstock die following development of the bacterium. The apple cultivars Jonathan, Gingergold and Gala and the pear cultivars Bartlett, Bosc and Winter Nelis are considered as sensitive indicators for different strains of *E. amylovora* (Aldwinckle, personal communication).

Pyrus communis cvs Winter Nelis and Bartlett are not routinely used as rootstocks. Trials will be necessary to evaluate their suitability as rootstocks. In the interim, introductions can be budded onto fire blight susceptible interstocks on the standard rootstocks. Seedlings of apple and pear varieties are not considered suitable for use as rootstocks, as their susceptibility to *E. amylovora* may be influenced by the susceptibility/resistance of the pollen parent.

The DNRE report recommended the use of *Pyrus calleryana* cv Aristocrat laterals on either side of the imported buds to test for *E. amylovora*. The reliability of this technique is not known, as there is no published evidence to confirm the effectiveness of this procedure. As the United States Department of Agriculture has recommended the use of *P. calleryana* cv Aristocrat as a street tree based on its resistance to fire blight, this cultivar has been excluded from BA's recommendations.

In addition to budding onto susceptible rootstocks or interstocks, BA has included *in vitro* tests for *E. amylovora* at three stages as described in the DNRE report. BA recommends the use of nutrient agar without sucrose as a permissive medium for enrichment prior to the PCR test, as this medium is known to work well for *E. amylovora* (Aldwinckle, personal communication). Details of the *in vitro* tests for *E. amylovora* are in the DNRE report at http://www.aqis.gov.au/docs/plpolicy/dnrepome.doc.

Leaves from the mother plant of each introduction must be tested for the presence of *Pseudomonas syringae* pv *papulans* using the differential selective agar medium of Burr and Katz (1982). *Pseudomonas syringae* pv. *papulans* can be differentiated by colony morphology (levan negative) from populations of *P. syringae* pv. *syringae* (levan positive) on this media that eliminates the growth of over 90% of other bacteria. This test must be done once during PEQ when the mother plant is around 12 months of age.

Xylella fastidiosa has been implicated as the causal agent of pear leaf scorch in Taiwan, where it is a significant problem in production orchards (Leu & Su, 1993). The pathogen is known to have different strains that infect a wide range of hosts in at least 23 plant families (Freitag, 1951; CABI, 1998). Currently, imported material is visually screened for pear leaf scorch during the four year PEQ period. With the proposed reduction in the PEQ period to a minimum of 15 months, active *in vitro* testing for *X. fastidiosa* is considered essential. Recent research suggests that *in vitro* techniques can be used to detect the pathogen (Wichman & Hopkins, 2000). Testing protocols for *X. fastidiosa* using PCR and selective media have been developed by

Department of Natural Resources and Environment, Victoria. These protocols could be adopted to test pear introductions for *X. fastidiosa*. In addition, ELISA kits are available to test for *X. fastidiosa*. Given the occurrence of *X. fastidiosa* in pears and the reduction in the time in PEQ in BA's proposed protocol, introductions need to be screened for this pathogen once during PEQ using *in vitro* tests when mother plants are around 12 months of age.

7.3.4 Fungi

Recommendations

1. Twenty-one exotic fungi that could be introduced on budwood are considered as quarantine pathogens that require testing by external and internal microscopic examination and culturing to detect latent infections.

2. The quarantine significance of a further 113 exotic fungi that have been recorded on apple and pear will require further assessment if they are found in PEQ.

3. Examinations and tests for quarantine fungi are to be carried out three times during PEQ on: budsticks used for propagation; scionwood from the mother plant at the end of the first season's growth; and scionwood from the mother plant two months before completion of PEQ.
    a. External and internal examinations using binocular and compound microscopes are to be carried out for evidence of infection by quarantine fungi. Any discoloured or diseased tissue is to be cultured and the introduction destroyed if a quarantine fungus is identified.
    b. Culturing of five buds is to be carried out to detect latent infections by quarantine fungi and the introduction destroyed if a quarantine fungus is identified.

Rationale for BA's recommendations

Until the publication of Quarantine Proclamation 1998, the only proclaimed fungal pathogen was *Monilinia fructigena*, although introductions were visually screened for *M. fructicola*, *M. laxa*, *Nectria galligena*, and *Venturia inaequalis* in PEQ.

The DNRE report expanded the list of proposed quarantine fungal pathogens from 5 to 60 and proposed visual screening during the proposed 12 month PEQ period. Fungal pathogens in tables "A," "B" & "C" of the DNRE report were reviewed by Biosecurity Australia using databases, including CABI (1998). Many changes were made to these fungal pathogen lists. Many species were removed, some added and others combined due to synonymy. Fungi that are recorded on dead wood, or recorded without any particular symptoms and/or not recorded across other data bases have been deleted from the lists presented in the DNRE report. The possibility of fungi coming in as saprophytes on budwood, yet posing a risk to other species, has also been considered. A list of alterations, together with brief explanations for the changes, is given in Attachment 4.

BA's review has identified 21 important exotic fungi that could be introduced on apple and pear budwood (Attachment 1). An additional 113 exotic fungi have been identified by BA's review as potential quarantine risks on apple and pear budwood (Attachment 2). However, based on the available information the significance of these fungi or their pathway on budwood (eg. many wood rot, sap rot and fruit rot fungi) could not be clearly established. The quarantine significance of these exotic fungi will require further assessment if they are found in PEQ.

The DNRE report recommended that fungal inspections should be carried out with the list of diseases of quarantine significance in hand, so that introductions are inspected for symptoms of these diseases. It strongly recommended that there should be an increase in the expertise of staff undertaking the inspections, and ideally quarantine pathologists should be supported by a fungal taxonomist or an experienced plant disease diagnostician who should be contracted to inspect the plants quarterly for symptoms. The report proposed that if symptoms were suggestive of fungal pathogens, the consultant would carry out isolations and identifications. BA considers that AQIS quarantine plant pathologists have the knowledge and experience necessary to examine introductions for quarantine fungi, and that quarantine plant pathologists should seek the assistance of fungal taxonomists when this is required.

BA considers that active testing of apple and pear introductions for quarantine fungi in PEQ is a necessary step to improve quarantine security. BA proposes that introductions are examined and tested for quarantine fungi at three stages in PEQ: the budstick used to propagate the mother tree; scionwood from the mother tree at the end of the first season's growth; and scionwood from the mother tree two months before completion of PEQ.

Budsticks used for propagation are to be scanned under a dissecting microscope for any wounds, callus tissue, cankers, fungal structures or unusual features. These, together with lenticels and buds, should be examined under high power of a dissecting microscope. Any abnormal tissue is to be examined for pathogens under a compound microscope, then cultured onto three Petrie dishes of acidified potato dextrose agar (PDA), incubated at 25^{o}C and monitored for fungal growth.

These budsticks should also be examined internally on a transverse section and a longitudinal section using a dissecting microscope. One transverse and one longitudinal cut per budstick are considered sufficient for an initial investigation. The transverse cut should be made towards the end of the budstick to minimise later handling difficulties. The longitudinal cut can be made anywhere along the budstick between two nodes. Care needs to be taken not to confuse vascular or cortical discolouration due to oxidation with symptoms of disease. Any abnormal tissue is to be examined for pathogens under a compound microscope, then cultured onto three Petrie dishes of acidified potato dextrose agar (PDA), incubated at 25^{o}C and monitored for fungal growth.

Scionwood from the mother plant should also be examined for signs of fungal infection at the end of the first season's growth and two months before completion of PEQ, using the method described above.

Currently, specific *in vitro* tests to detect latent fungi, such as *Alternaria mali*, *Botryosphaeria berengeriana* f.sp. *piricola* and *Diaporthe tanakae*, are not available. Until such tests are available, BA proposes that five buds are to be cultured for latent fungi from budsticks used for propagation, scionwood from the mother plant at the end of the first seasons and scionwood from the mother plant two months before completion of PEQ. These buds are to be surface sterilised, cultured onto acidified potato dextrose agar (PDA), incubated at 25^{o}C and monitored for fungal growth.

7.3.5 Phytoplasmas

Recommendations

1. Apple proliferation and pear decline phytoplasmas are considered to be quarantine pathogens.

2. Mother plants must be tested for apple proliferation and pear decline phytoplasmas using a generic nested primer polymerase chain reaction (PCR) test.

3. DNA for amplification is to be extracted from leaf petioles and midribs for apples in the second growing season and from dormant wood and roots for pears at the end of the first growing season.

4. If the *in vitro* PCR test is not available, introductions will have to be tested for phytoplasmas using woody indexing for two growing seasons as per the current AQIS protocol:

   a. apple proliferation phytoplasma - budded onto *Malus pumila* cv. Golden Delicious; and

   b. pear decline phytoplasma - budded onto *Pyrus communis* cv. William bon Chretien or *P. ussuriensis* cv. Ping Ding Li.

Rationale for BA's recommendations

Apple proliferation and pear decline phytoplasmas are considered quarantine pathogens of apple and pear that require testing in PEQ. While a decline associated with a phytoplasma has been reported in pears in Victoria (Schneider & Gibb, 1997), the symptoms were not identical to those of pear decline and BA considers that pear decline phytoplasma should remain a quarantine pathogen.

The titre of phytoplasmas in woody plants can be low or at levels that cannot be detected during cold seasons using non-PCR procedures. However, PCR test results correlate well with the known health status of the source trees. The DNRE report points out that the tests currently available to differentiate between phytoplasmas are time consuming and expensive, and recommends that all phytoplasmas infecting apples and pears be considered quarantinable until their disease aetiology has been resolved. BA agrees with the use of a generic PCR test that will detect all phytoplasmas in an introduction, even though only apple proliferation and pear decline phytoplasmas are considered as quarantine phytoplasmas for apple and pear.

The nested primer PCR test (generic test for phytoplasmas) recommended in the DNRE report is considered highly sensitive and is accepted by US regulatory officials as a suitable replacement for their three-year woody indexing procedure (Waterworth & Mock, 1999). Apple proliferation phytoplasma in apple root and shoot samples and pear decline phytoplasma in pear shoot samples have been detected by DNA amplification using universal primers (Lorenz *et al*., 1995). Green and Thompson (1999) have reported a method to extract DNA from leaf petioles and midribs of apples and from dormant wood and roots of pears. These general tests for phytoplasmas are routinely used by some of the diagnostic laboratories in Australia, such as Department of Natural Resources and Environment, Knoxfield, Melbourne. Quarantine plant pathologists can make arrangements for the phytoplasma PCR test to be carried out at the AQIS Plant Quarantine Laboratory, Eastern Creek, Sydney, or at another diagnostic laboratory where this test is available.

BA considers that apple rubbery wood is a disease of unknown aetiology. While the current AQIS PEQ protocol lists apple rubbery wood as a phytoplasmal disease, its cause has not been confirmed. Apple rubbery wood is discussed under diseases of unknown aetiology.

6.3.6. Viroids

Recommendations

1. Apple dimple fruit, apple fruit crinkle, apple scar skin and pear blister canker

viroids are considered to be quarantine pathogens.

2. Mother plants must be tested once for apple dimple fruit viroid during the first growing season in PEQ by:
   a. *in vitro* tests in Australia; or
   b. *in vitro* tests in an overseas laboratory.

3. Import of apple cultivars Ohrin, Jonathan, Starking Delicious, Mutsu and Fuji must be accompanied by an International Phytosanitary Certificate (IPC) stating that the mother plants have been inspected and are found free of symptoms of apple fruit crinkle viroid.

4. Mother plants must be tested once for apple scar skin viroid during the first growing season in PEQ by:
   a. *in vitro* tests in Australia; or
   b. *in vitro* tests by the National Research Support Project - 5 (NRSP-5), Washington State University, USA; or
   c. woody indexing by double budding on four plants of *Malus pumila* Stark's Earliest in a greenhouse at 18^{o}C for a minimum of 40 days.

5. Mother plants must be tested once for pear blister canker viroid during the first growing season in PEQ by:
   a. *in vitro* tests in Australia; or
   b. *in vitro* tests by the National Research Support Project - 5 (NRSP-5), Washington State University, USA; or
   c. woody indexing by double budding on four plants of pear cultivar Fieud 37 or Fieud 110 in greenhouse for a minimum of four months.

Rationale for BA's recommendations

In vitro tests for apple dimple fruit, apple fruit crinkle, apple scar skin and pear blister canker viroids are not yet available within Australia. However, published information is available on the nucleotide sequences of apple dimple fruit, apple scar skin and pear blister canker viroids. Molecular tests could be developed using these sequences by diagnostic services such as Waite diagnostics or by the AQIS Plant Quarantine Laboratory at Eastern Creek. It will be necessary to import inactivated viroids to use as positive controls in the development of *in vitro* tests. Offshore testing for apple dimple fruit, apple scar skin and pear blister canker viroids is an option as tests for these viroids are available in USA and other countries. Quarantine plant pathologists could arrange to send samples to overseas laboratories, such as NRSP-5, for testing.

Introductions can also be indexed for apple scar skin and pear blister canker viroids by double budding on woody indicators. Apple scar skin viroid can be tested on *Malus pumila* cv Stark's Earliest (Mink, 1997). This cultivar is available Australia. Pear blister canker viroid can be indexed on pear cultivars Fieud 37 or Fieud 110 in a minimum period of three to four months. Indicator material of this cultivar can be obtained from Lanxade Centre, France (Desvignes *et al.*, 1999).

Limited information is available on apple fruit crinkle viroid and nucleotide sequences have not been published for this viroid. *In vitro* tests are not available for this viroid in Australia and BA is not aware of any tests available overseas. Based on the available information, apple fruit crinkle viroid only occurs in Japan. Some apple cultivars, such as Ohrin, Jonathan, Starking Delicious, Mutsu and Fuji are known to be susceptible to this viroid (Ito *et al.*, 1998; Koganezawa *et al.*, 1989). Due to the limited information available on this viroid, BA recommends a conservative approach and considers that importations of susceptible cultivars must be accompanied by an IPC stating that the source trees have been inspected and are free of symptoms of apple fruit crinkle viroid.

Poly acrylamide gel electrophoresis (PAGE) is not considered to be a reliable diagnostic technique to test for viroids in apple and pear, due to the problems associated with extracting low concentration of viroid RNA from tissue (Jane Moran, personal communication).

6.3.7. Viruses

Recommendations

1 Tomato bushy stunt *tombusvirus* (TBSV), tomato ringspot *nepovirus* (ToRSV) and cherry rasp leaf *nepovirus* (CRLV) are considered to be quarantine pathogens.

2 Mother plants must be tested once for TBSV during the first growing season in PEQ by:

   a. virus specific ELISA or PCR tests; or

   b. herbaceous indexing as per the current AQIS PEQ protocol.

3 Mother plants must be tested once for ToRSV and CRLV during the first growing season in PEQ by:

   a. virus specific ELISA or PCR tests; or

b. generic PCR test for nepoviruses; or

c. herbaceous indexing as per the current AQIS PEQ protocol.

Rationale for BA's recommendations

The importance and distribution of viruses of apple and pear were reviewed using the VIDE database (Brunt *et al*., 1996). Currently, introductions are tested in PEQ for apple mosaic *ilarvirus* and all nepoviruses. Apple mosaic *ilarvirus* is present in Australia and not under official control, so it no longer meets the requirements for a quarantine pathogen. Of the nepoviruses, only tomato ringspot *nepovirus* and cherry rasp leaf *nepovirus* could be introduced in apple and pear budwood. Tomato bushy stunt *tombusvirus*, while symptomless in apple and pear, is an important disease of tomato, capsicum and eggplant. This virus is not recorded in Australia and could be introduced in apple and pear budwood.

Commercial ELISA kits are available for TBSV and ToRSV. BA is not aware of commercial PCR kits for TBSV, ToRSV or CRLV.

A generic PCR test for nepoviruses is now available. The Australian National University (ANU) developed this test, Canberra, as part of a BA-funded consultancy. If the generic nepovirus PCR test is positive, the introduction must be destroyed, or a specific test used to identify the virus. Specific identification of nepoviruses require further nucleotide sequencing which can be arranged by quarantine plant pathologists on request at an additional cost. The Research School of Biological Sciences at ANU will be able to do nucleotide sequencing for a majority of nepoviruses.

6.3.8. Diseases of unknown aetiology

Recommendations

1 Apple rubbery wood disease is the only disease of unknown aetiology that is considered to be a quarantine disease.

2 Mother plants of apple and pear introductions must be tested for apple rubbery wood by indexing onto *Malus pumila* cv. Lord Lambourne:

   a. Four indicator plants are to be budded for each introduction and maintained in a greenhouse at 26°C for a minimum period of 180 days; and

   b. Woody indicators must be tested for rigidity and lignin staining using phloroglucinol after the 180-day period.

Rationale for BA's recommendations

Of the 52 diseases of unknown aetiology reported on pome fruit, 34 are rarely found and 9 have been recorded in Australia (Attachment 3). Only apple rubbery wood is considered to be quarantinable, due to its economic importance and its unknown aetiology.

Apple rubbery wood is of considerable economic importance in Lord Lambourne, Gravenstein, and other sensitive apple cultivars, with yield losses of up to 80% (Waterworth & Fridlund, 1989). Apple rubbery wood is latent in many commercial apple and pear cultivars, so it is important that all introductions are tested for this disease. Heat therapy at 37°C for three weeks has been used to free cultivars of rubbery wood. Many countries have adopted schemes for producing and distributing budwood free of this disease (Jones & Aldwinckle, 1997).

Currently in PEQ, introductions are tested for apple rubbery wood by grafting onto *Malus pumila* cv. Lord Lambourne, which is sensitive to all strains of the pathogen. The indicator plants are maintained in a shadehouse for three years, and tested for rigidity and lignin staining using phloroglucinol during this period. Under shade house conditions, symptoms generally begin to appear in the indicators after one to two years. To shorten the time required for symptom development, BA is proposing that indicator plants be held at 26°C in a greenhouse. Trial work is planned by AQIS to ensure that the 180-day period proposed by BA is adequate to detect all infected introductions. Woody indexing for apple rubbery wood needs to continue until an accurate and effective rapid *in vitro* test is available.

Symptoms of apple rubbery wood have been recorded in apple orchards in New South Wales, Queensland, South Australia, Tasmania and Victoria (Clarke *et al.*, 1998). However, BA proposes that apple rubbery wood remains a quarantine disease until its causal agent has been identified. To date, the identity of the graft-transmissible agent that causes apple rubbery wood remains uncertain. Viruses, phytoplasmas and xylem-limited rickettsia-like bacteria have been implicated and discounted as causal agents.

More recent studies using phytoplasma-specific PCR assays indicated the presence of an aster-yellows type phytoplasma in rubbery wood trees from Italy (Bertaccini *et al.*, 1997), although their presence was not detected in experimentally inoculated *Malus pumila* cv. Lord Lambourne trees (Pollini *et al.*, 1995). The phytoplasmas that occur in Australasia are quite distinct from those that occur in the Northern Hemisphere (Davies *et al.*, 1997). Hence, if apple rubbery wood is caused by a phytoplasma, Australian strains may be different from the strains that cause the disease overseas (Mink, 1997).

Currently during the four year PEQ period, some of the diseases of unknown aetiology that produce symptoms in leaves and bark can be detected and eliminated. These include apple brown ringspot, apple necrosis, apple russet ring, apple star crack, pear bud drop, pear bark necrosis and pear bark split diseases. Others, such as apple false sting and apple bumpy fruit that produce symptoms on fruit, as well as apple dead spur that produces symptoms on fruiting spurs at the centre of the tree, cannot be detected during the current PEQ period.

The DNRE report mentioned that “due to the difficulties of working with virus and virus-like organisms in woody plants, a number of graft-transmissible diseases that have unknown causal agents have been recorded in apples and pears. This is an extremely difficult area for plant quarantine, and a pragmatic approach is required based on the risk that these diseases pose to the apple and pear industry in Australia”. The DNRE report argued that the “diseases of unknown aetiology are only known to be graft transmissible and consequently, if these diseases come into Australia, they are confined to the initial consignment and pose virtually no risk to the industry as a whole”.

BA agrees that the risks to the Australian pome fruit industry posed by diseases of unknown aetiology, excluding apple rubbery wood, are very low. These diseases are of minor economic importance and do not meet the criteria of a quarantine pest. BA considers that it is the responsibility of the pome fruit industry to accept and manage the risks posed by these minor diseases. BA will review the status of these diseases when their aetiology has been determined and tests become available to identify them.

8 ACCREDITED SOURCES OF PROPAGATING MATERIAL

Recommendations

1. BA's proposed PEQ protocol would apply to all imported material from all sources.

2. BA will review the current accredited sources to evaluate their disease testing and certification protocols.

3. When overseas budwood schemes have been assessed, PEQ protocols and phytosanitary certification requirements for budwood imported from these sources will be reviewed by BA to avoid duplication in PEQ of tests completed by the accredited source.

Rationale for BA’s recommendations

Currently there are four AQIS accredited sources of pome fruit budwood: NRSP 5

(USA); East Malling Research Station (UK); Canadian Department of Agriculture (Canada); and Forshungsanstalt (Switzerland). These accredited sources have not been audited for many years and the status of these schemes needs to be reviewed. Under current AQIS import protocols, budwood material from these sources is not re-indexed in Australia for virus and virus-like diseases, and only plants exhibiting symptoms are actively tested. Plants propagated from this budwood still have to remain in PEQ for three years whilst they undergo screening for fire blight.

The DNRE report suggested that testing of budwood from accredited sources should be restricted on arrival to fungal and bacterial pathogens. This is based on the assumption that budwood from accredited sources has been tested for phytoplasmas, viroids and viruses in the country of origin. BA has not accepted this recommendation, as accredited sources need to be assessed in view of BA's proposed PEQ protocol and the revised list of quarantine pathogens. As well, 90-95% of current introductions are from non-accredited sources.

9 PLANT HEALTH IMPROVEMENT

Recommendations

1. AQIS has the responsibility to test for quarantine pests. Non-quarantine pests are not the responsibility of AQIS, even though some are important to industry.

2. Plant health testing for non-quarantine pathogens can be done at a government PEQ station on a full cost recovery basis by prior arrangement with the AQIS quarantine plant pathologist, subject to availability of resources.

Rationale for BA's recommendations

Use of disease-tested rootstocks and budwood is very important to control the spread of diseases caused by graft transmissible agents such as phytoplasma, viroids and viruses. Currently, AQIS is testing importations for the presence of viruses, such as apple chlorotic leaf spot, apple mosaic and apple stem pitting viruses, which are already present in Australia and are considered as non-quarantine pests. These non-quarantine pests, while important to industry, are not the responsibility of AQIS.

The DNRE report recommended concurrent testing of imported material for quarantine and non-quarantine viruses, with a partnership between pome fruit plant improvement programs, importing nurseries and AQIS. The DNRE report proposed concurrent testing wherein, after the initial testing of budsticks for fire blight and blister spot pathogens, some of the buds would be budded onto indicators in PEQ to test for quarantine pathogens while the remaining buds would be budded onto indicators to test for non-quarantine viruses. The total program should be completed within 18 months.

Concurrent testing would have to be done by an AQIS quarantine plant pathologist at a PEQ station, as untested material cannot be released from PEQ until the completion of PEQ testing for quarantine pathogens.

In view of AQIS's responsibility to only test imported material for quarantine pathogens, BA recommends that concurrent testing for non-quarantine pathogens in PEQ be permitted by arrangement with the AQIS quarantine plant pathologist at full cost recovery, subject to the availability of resources. In all cases, final release of the material from PEQ is subject to the completion of tests for quarantine pathogens.

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ATTACHMENT 1: Quarantine Pathogens of Apple (*Malus*) and Pear (*Pyrus*) Budwood

Scientific name	Common name	Host(s)	Comments
BACTERIA			
Erwinia amylovora **(**Burrill) Winslow *et al*. (synonym: *Micrococcus amylovorus* Burrill; *Bacillus amylovorus* (Burrill) Trevisan; *Bacterium amylovorum* Chester; *Erwinia amylovora* f.sp. *rubi* Starr *et al*.)	fire blight	apple; pear	The bacterium has been assessed as being the greatest threat to the Australian pome fruit industry (Wimalajeewa, 1998). Disease epidemics typically take place in warm, moist conditions (van der Zwet & Keil, 1979). Almost all major apple and pear production areas in Australia are high risk areas for fire blight occurrence in most seasons (Roberts, 1991). Affected plant parts appear scorched by fire. Blossoms, vigorously growing vegetative shoot tips and young leaves are typically affected by fire blight (Beer, 1997). Control methods for fire blight are difficult, expensive and not totally effective (Beer, 1997).
Pseudomonas syringae pv. ***papulans*** (Rose) Dhanvantari (synonym: *Bacterium papulans* (Rose) Elliott; *Chlorobacter papulans* (Rose) Patel & Kulkarni; *Phytomonas papulans* (Rose) Bergey *et al*.; *Phytomonas syringae* var. *papulans* (Rose) Smith; *Pseudomonas papulans* Rose; *Pseudomonas syringae* var. *papulans* (Rose) Smith)	blister spot	apple; pear	In the past blister spot was of economic concern on susceptible cultivars of apple, many of which are no longer in commercial production (Burr, 1997). Currently the disease is of economic importance on the cultivars Mutsu, which is highly susceptible. Blister spot results in purplish black lesions associated with fruit lenticels. The pathogen dose not cause significant fruit decay or detectable yield losses, but the quality of fruit can be greatly reduced (Burr, 1997). Affected leaves are curled and puckered and may exhibit white to necrotic spots. This bacterium overwinter in a high percentage of apple buds, leaf scars and diseased fruit on the orchard floor (Burr, 1997). Contaminated apple buds may appear healthy or have necrotic leaf primordia (Burr, 1997).
Xylella fastidiosa Wells *et al*.	pear leaf scorch	pear	*Xylella fastidiosa* causes Pierce's disease of grapevine (Goheen *et al*., 1973), as well as infecting other host plants, including alfalfa, almond, peach, plum, elm, sycamore, mulberry, oak, periwinkle, red maple, and citrus (Hopkins, 1989). Pear was described for the first time as a host of *X. fastidiosa* in Taiwan (Leu & Su, 1993). *Xylella fastidiosa* causes leaf scorch, dieback of twigs and branches and finally death of infected pear trees within a few years (Leu & Su, 1993).

Scientific name	Common name	Host(s)	Comments
FUNGI			
Alternaria gaisen Nagango (synonym: *Alternaria kikuchiana* S. Tanaka; *Alternaria bokurai* Miura)	black spot, Japanese pear blackspot, fruit rot	pear	The main hosts of this fungus are Japanese and Chinese pears (Simmons & Roberts, 1993). The fungus has not specifically been recorded from European pear. It has been found on wild *Pyrus* species in northeastern China (Tai, 1979). Regarded as pear pathotype of *A. alternata*. The fungus survives adverse conditions as microsclerotia or chlamydospores in the soil or on dead leaves fallen from infected trees (Smith *et al*., 1997). Transmission occurs by wind dispersal of airborne conidia (David, 1988). However, this natural dispersal is only local. The fungus is not likely to be carried on dormant planting material without leaves.
Alternaria mali Roberts	Alternaria blotch	apple; pear	The main host of this fungus is apple, both cultivated and wild (Smith *et al*., 1997). *Alternaria mali* has been referred to as the apple pathotype of *A alternata*, but this concept has not yet been widely adopted in Japan (Sawamura, 1997). The fungus infects mainly leaves, causing leaf spots (Sawamura, 1997). It does not typically infect fruits, except the very susceptible cv. Indo, which shows fruit spotting (Sawamura, 1997). The pathogen spreads by means of conidia and its dispersal is favoured by rainfall and high temperatures (Filajdic & Sutton, 1992). The fungus overwinter as mycelium in dead leaves on the ground, in mechanical injuries on twigs, and in dormant buds (Sawamura, 1997).
Biscogniauxia marginata (Fr.) Pouzar. (synonym: *Nummularia discinola* (Schwein.) Cooke; *Nummularia discreta* (Schwein.) Tul. & C.Tul.)	apple blister canker, nailhead canker	apple; pear	The disease is observed on branches of trees 10 years old or older. Affected branches produce few or no leaves and cankers form in their bark and wood (Hickey, 1997). Both ascospores and conidia are capable of causing infections. The ascospores play the predominant role in spread of the pathogen. Infection occurs through pruning wound (Hickey, 1997).
Botryosphaeria berengeriana de Notaris f. sp*.* ***piricola*** (Nose) Koganezawa & Sakuma.	apple wart bark on Japanese pears	apple; pear	Main host is Japanese pear, but European pear and apple are also attacked. Sporulation is most abundant on infected wood 2-3 years old. Incubation period for shoot infection is 90-120 days (USDA, 1999).
Diaporthe ambigua Nitschke	Diaporthe canker	apple; pear	The fungus produces small black spots on twigs during autumn and enlarges in the following spring to become twig cankers. The canker girdles the twig to cause blossom wilt and dieback (Nakatani *et al*.,

Scientific name	Common name	Host(s)	Comments
			1981). Nursery rootstocks infected by this fungus are readily killed, while mature rootstocks are killed over an extended period. (Smit *et al*., 1996). Similar results of mature apple and pear trees inoculated with *Diaporthe tanakae* has been reported in Japan (Fujita *et al*,. 1988; Nakatani *et al*., 1981). Characteristics symptoms of *Diaporthe ambigua* infections include sunken, pointed lesions with marginal longitudinal cracks (Smit *et al*., 1996). Similar symptom expression was reported for apple and pear cultivars infected by *D. tanakae* in Japan (Fujita *et al*., 1988).
Diaporthe tanakae Kobayashi & Sukuma (anamorph: *Phomopsis tanakae*)	Diaporthe canker	apple; pear	Diaporthe canker affects apple and European pear and is the most serious disease of pear in Japan (Nakatani & Fujita, 1997). On pear, lesions first appear on the bark of 1- and 2-year-old spurs and shoots in August. Initially, the lesions are small, brown dots; they turn black and enlarge to become cankers. A dieback of blossom and shoots begins at about the blossom stage of bud development when numerous spots are present or when individual cankers enlarge sufficiently to girdle spurs and branches. Entire flower clusters wilt, shrivel, and finally together with the spur, turn black and die. On apple, dark brown lesions first appear on 1-year-old shoots infected the pervious year. Perithecia begin to form in the bark of both cankered and dead twigs in autumn. The ascospores are primarily water-borne. Pycnidia are formed in cankers and are released during rainfall and are water-borne (Nakatani & Fujita, 1997). The current season's shoots are particularly susceptible to infection by conidia, and 1-year-old twigs are also susceptible.
Diplocarpon mali Harada & Sawamura (anamorph: *Marssonia coronaria* (Ell. & J.J. Davis) J.J. Davis; synonym: *Marssonina mali* (Henn.) Ito)	Marssonina blotch	apple	Marssonina blotch occurs on leaves and fruit. Leaf spots first appear on the upper surface of mature leaves. When lesions are numerous they coalesce, the surrounding tissue turns chlorotic and defoliation occurs. Sever defoliation may start in early summer and can result in failure of the crop the following season (Takanashi & Sawamura, 1997). Infection of fruit is uncommon and restricted to trees with numerous leaf infections. Primary infections are initiated by ascospores produced in apothecia on overwintered leaves. Mature ascospores are found just before the bloom stage of bud development. (Takanashi & Sawamura, 1997).

Scientific name	Common name	Host(s)	Comments
***Gymnosporangium* spp.** R. Hedw. Ex DC. in Lam. & DC.	rust	apple; pear	More than 21 species of rust fungi are recorded that can attack apple and pear, most requiring *Juniperus* as an alternate host (Aldwinckle, 1997). This genus has not been recorded in Australia on any host. Rust appears first as small, yellow-orange lesions on the upper surface of leaves, on petioles, and on young fruit. Fruit lesions are superficial (Aldwinckle, 1997).
Helminthosporium papulosum A Berg	black pox of apple, blister canker of pear	apple; pear	On apple, fruit lesions are smooth, black, circular and slightly sunken. Leaf lesions begin as red halos; they enlarge and turn tan to brown in the centre. Severely affected leaves may abscise 2-3 weeks after infection (Yoder, 1997). Lesions on twig are well-defined, conical, shiny black swellings on the bark. As they enlarge and increase in number, they may girdle small, heavily infected twigs (Yoder, 1997). On pear, purplish to black, blister like lesions form on twigs, branches and trunks. Heavily infected twigs and young branches grow poorly, defoliate prematurely, and eventually die (Yoder, 1997). The fungus overwinters and produces conidia in old bark lesions. Infections may remain latent on bark from mid-summer until the following spring, making it possible to introduce the fungus on infected nursery stock (Yoder, 1997).
Leucostoma auerswaldi (Nitschke) Hohn. (anamorph: *Leucocytospora personata* (Fr.) Hohn)	Leucostoma canker	apple	Large oval to elliptical cankers form at the base of limbs and enlarge until the limb or trunk is completely girdled. The bark in the centres of the cankers isnecrotic, rough and scaly. The cankers usually develop around pruning wounds or ragged stubs remaining where branches have been broken (Jones, 1997b).
Leucostoma cincta (Fr.) Hohn. (anamorph: *Leucocytospora cincta* (Sacc.) Hohn)	Leucostoma canker	apple	Large oval to elliptical cankers form at the base of limbs and enlarge until the limb or trunk is completely girdled. The bark in the centres of the cankers is necrotic, rough and scaly. The cankers usually develop around pruning wounds or ragged stubs remaining where branches have been broken (Jones, 1997b). This fungus overwinters in diseased wood, and perithecia with mature spores are present in spring. The fungus is most active at bud break and following harvest (Jones, 1997b).
Monilinia fructigena Honey in Whetzel (synonym: *Sclerotinia fructigena*, Aderhold ex Sacc.; anamorph: *Monilia fructigena* Pers.:Fr.).	brown rot of apple and pear	apple; pear	Fruit rot is the most common symptoms of brown rot of apple and pear. Superficial, circular, brown spots, which are frequently associated with wounds, expand outward on the surface of the fruit

Scientific name	Common name	Host(s)	Comments
			and result in a soft decay of the flesh (Jones, 1997a). It sometimes produces cankers on apples. The fungus overwinter in infected peduncles and twig cankers on branches. Conidia produced in cankers and on peduncles are disseminated by rain and infect blossoms. Fungal hyphae spread from the blossoms to the woody tissues. Conidia, produced on infected blossoms and twigs, infect wounded fruit as they mature. Occasionally the fungus spreads from infected fruit to young shoots (Jones, 1997a).
Monilinia laxa f.sp***. mali*** (Woronin) Harrison	blossom blight and spur infection	apple; pear	This fungus causes blossom blight and spur infection of apple (Jones, 1997a).
Nectria galligena Bres. in Strass. (anamorph: *Cylindrocarpon heteronemum* (Berk. & Broome) Wollenweb.)	European canker, nectria canker, crotch canker, eyerot, bark canker	apple; pear	Nectria canker is an economically important disease of apple and pear in many production areas throughout the world. It can kill young trees and branches of old trees. Epidemics in several regions have resulted in the removal of entire orchards (Grove, 1997). Young cankers are often first observed at nodes and appear as elliptical, sunken areas. As the cankers enlarge, they girdle infected twigs and branches, killing the distal portions of the shoot tissue. The fungus can also infect fruit lenticels, calyxes and wounds. The fungus overwinter as mycelium in twig and branch cankers and sporulates after the onset of moist conditions (Grove, 1997).
Pellicularia koleroga Cooke (synonym: *Corticium koleroga* (Cooke) Hohn.)	Thread blight	apple; pear	Thread blight is a disease of apple and pear and occurs on many host plants in tropical regions (Hartman, 1997). The sclerotia of the thread blight fungus are of primary importance in perpetuating it from season to season. Infected native woody plants growing near orchards may be source of inoculum. Once the fungus becomes established on a twig or branch, it spreads by means of rhizomorphs. The fungus invades new shoots each season, and new sclerotia develop. Basidiospores formed on newly infected leaves during summer are disseminated by air currents to initiate new infections on nearby trees (Hartman, 1997). Thread blight develops readily on trees growing in moist, shady environments. The type species, *P. koleoga*, is a nomen confusum (Farr *et al.*, 1989). The type culture is a mixture of the vegetative hyphae of a resupinate basidiomycetes and conidia of a deuteromycetes.
Phomopsis fukushii (teleomorph: *Diaporthe medusaea*	Japanese pear	pear	The fungus causes bark canker with superficial pycnidia and

Scientific name	Common name	Host(s)	Comments
Nitschke)	canker; Phomopsis fruit rot		immersed perithecia (Fukutomi *et al.*, 1991). It also causes disease on grape (Fukaya & Kato, 1994) and grapefruit (Timmer, 1974).
Phyllactinia guttata (Wallr.) Lév. (synonym: *Erysiphe betulae* DC.; *Phyllactinia corylea* (Pers.) P. Karst.; *Erysiphe liriodendri* Schwein.; *Phyllactinia suffulta* (Rebent.) Sacc.; *Phyllactinia suffulta* (Rebent.) Sacc. var. *macrospora* Atk)	powdery mildew of hardwoods	apple	Powdery mildew of hardwoods, especially Betulaceae. At least six formae speciales described (Farr *et al*., 1989). Not mentioned as a disease of apple or pear in Compendium of apple and pear diseases (Jones & Aldwinckle, 1997).
Phyllactinia pyri	powdery mildew	apple; pear	The symptoms first appearing as a white mouldy spot on the underside of a leaf, gradually covering the whole surface. Affected adult leaves are unchanged, while young leaves appeared wrinkled. The badly affected leaves dropped early (Liu & Gao, 1997).
Phyllosticta solitaria Ellis & Everh.	apple blotch	apple; pear	The fungus overwinter as dormant mycelium in branch and twig cankers or infected dormant buds (Yoder, 1997). Infections on twigs and small branches are often located at leaf nodes or at the base of spurs that have developed from dormant buds (Yoder, 1997).
Venturia inaequalis (Cooke) G. Winter (synonym: *Venturia inaequalis* (Cooke) G. Wint. var *cinerascens* (Fuckel) Aderhold; anamorph: *Spilocaea pomi* Fr.)	scab; black spot of apple	apple	Occurs worldwide in apple growing regions. Reported from a variety of plants in the Rosaceae family. Under official control in Western Australia.
Venturia nashicola Tanaka & Yamamoto	pear scab	pear	Pear scab is a serious problem of Japanese and Chinese pears (Shabi, 1997). Lesions on young, actively growing shoots appear as brown, velvet spots early in the growing season (Shabi, 1997). Note that it is distinct from *V. pirina*, which is widespread in Australia.
PHYTOPLASMAS			
Apple proliferation phytoplasma	apple proliferation	apple; pear	Apple proliferation (AP) phytoplasma is the most important graft-transmissible disease of Apple in Europe south of a line drawn from south Netherlands to the Black Sea coast of the Soviet Union. The restriction of AP to southern Europe is probably due to the distribution of its vectors and is not due to a limitation of the pathogen, since the disease develops in northern areas in trees inoculated by grafting (Seemuller, 1997a). Occasional infection of pear and apricot by the AP agent has been reported.
Pear decline phytoplasma	pear decline	pear	Pear decline (PD) is an economically important disease reported from most countries where pears are grown (Seemuller, 1997b).

Scientific name	Common name	Host(s)	Comments
			The PD phytoplasma is graft-transmissible and is naturally transmitted by the pear psylla (*Psylla pyricola* Forster). A decline-like disorder has been reported in Australia (Schneider & Gibb, 1997); however symptoms produced are not identical to published descriptions (Guinchedi *et al*., 1994).
VIROIDS			
Apple dimple fruit viroid	apple dimple fruit	apple	Symptoms develop on fruit. Recorded in Italy and South Africa. Nucleotide sequences have been published. Molecular tests available in Italy (Mink, 1997).
Apple fruit crinkle viroid	apple fruit crinkle, apple blister bark, Japanese pear fruit dimple	apple; pear	Bark symptoms appear on two to three year old shoots. Recorded in Japan. Limited information available. Nucleotide sequences not published. Some apple cultivars are known to be susceptible (Mink, 1997). BA is not aware of any in vitro or woody indexing tests for this viroid.
Apple scar skin viroid	apple scar skin, dapple apple, pear rusty skin	apple; pear	Symptoms develop on fruit. Recorded in Canada, China, Europe, France, Greece, India, Japan, Poland and USA. Nucleotide sequences published. Molecular tests available in all the preceding countries (Koganezawa, 1997; Mink, 1997).
Pear blister canker viroid	pear blister canker	pear	Symptoms appear on one to two year old shoots. Recorded in Italy, France, Europe. Nucleotide sequences published. Molecular tests available in Italy and France (Mink, 1997).
VIRUSES			
Tomato bushy stunt *tombusvirus* (synonym: TBSV; tomato bushy stunt virus)	tomato bushy stunt virus	apple; pear	TBSV can be transmitted mechanically to a wide range of plant species in 18 different botanical families (Schmelzer, 1958). Destructive outbreaks due to field spread of infection were recently reported from California, USA (Gerik *et al*., 1990) and Spain (Luis-Arteaga *et al*., 1996). Seed-borne infection by TBSV at an incidence of 50-65% was demonstrated in tomato plants grown from seed of symptomless infected tomato fruit (Tomlinson & Faithfull, 1984). The pathogen is also seed-borne in apple and has been found in cherry (*Prunus avium*) pollen (Kelger & Kegler, 1980). Seed transmission rates of 1.7-6% in apple have been reported (Kegler & Schimanski, 1982). Apples and pears infected by a poorly characterized TBSV strain from Eastern Germany were symptomless (Kegler & Kegler,

Scientific name	Common name	Host(s)	Comments
			1980).
Tomato ringspot *nepovirus* (synonym: tomato ringspot virus; Prunus stem pitting virus; blackberry (Himalaya) mosaic virus; Nicotiana 13 virus; Euonymus ringspot virus; Euonymus chlorotic ringspot virus; ToRSV; tobacco ringspot virus 2; peach stem pitting virus; prune brown line virus; grapevine yellow vein virus; grape yellow vein virus; red currant mosaic virus; winter peach mosaic virus; apple union necrosis nepovirus)	ringspot of tomato; yellow bud mosaic of peach; yellow vein of grapevine; apple union necrosis; peach yellow bud mosaic; yellow blotch curl of raspberry; prunus stem pitting; grapevine yellow vein	apple; pear	ToRSV has a wide natural host range. Primary hosts include: *Prunus*; *Malus*; *Rubus*; *Vitis*; *Fragaria*; and *Pelargonium* (CABI, 1999). ToRSV has a wide geographic distribution in North America and is capable of infecting both wild and cultivated plants. The occurrence of devastating diseases associated with the virus is correlated with the occurrence of high populations of nematode vectors belonging to the genus *Xiphinema*. Natural spread is confined to areas where there are moderate to high populations of nematode vectors belonging to the genus *Xiphinema* (Stace-Smith, 1984). Contaminated nursery stock is not considered to be an important source of infection. Because the virus is common in dandelions in apple orchards and survives in a proportion of seed from infected plants, infected dandelion seed is thought to be a major source for both inter-orchard and intra-orchard spread. The vector nematodes, which are prevalent in many orchards, may acquire the virus from orchard weed hosts and transfer it to apple trees (Powell *et al*., 1984). Apple union necrosis and decline is strongly associated with tomato ringspot nepovirus infection (Parish & Converse, 1981). The most reliable diagnostic symptoms are pitting, invagination and necrosis in the woody cylinder at the graft union, which is thought to result from differences in rootstock and scion susceptibility since the virus is often detected in rootstocks but not in scions of diseased trees (Stouffer *et al*., 1977). This virus has been recorded in Australia but with no evidence of spread.
Cherry rasp leaf *nepovirus* (synonym: apple flat apple virus; cherry rasp leaf virus; Flat apple virus)	Cherry rasp leaf virus	apple	First reported in *Prunus avium* from the USA. Found in Africa, Eurasia, North America and Australasia and Oceania. Found, but with no evidence of spread, in the U.K., China, Australia and New Zealand and possibly South Africa (Brunt *et al*., 1996). *Prunus avium* rasp leaf symptoms have been found in many countries associated with one or another of seven viruses (Brunt *et al*., 1996). Transmitted by the nematode vector *Xiphinema americana* (Brunt *et al*., 1996). Virus transmitted by mechanical inoculation, grafting and seed (10-20%).

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ATTACHMENT 2: Additional Exotic Fungi recorded on Apple (*Malus*) and Pear (*Pyrus*)

Scientific name	Common name	Host(s)	Comments
Alternaria pomicola A.S Horne	unknown	apple	This fungus has been reported from Washington and England (Farr *et al*., 1989). Limited data available. Not mentioned as a pathogen of apple in Compendium of apple and pear diseases.
Aposphaeria fuscomaculans Sacc. (synonym: *Plendomus fuscomaculans* (Sacc.) Coons)		apple	Reported from California, Michigan and Europe (Farr *et al*., 1989). Limited data available. Not mentioned as a pathogen of apple in Compendium of apple and pear diseases.
Armillaria tabescens (Scop.) Dennis, Orton & Hora (synonym: *Armillariella tabescens* (Scop.) Singer; *Clitocybe monadelphus* (Morg.) Sacc.; *Clitocybe tabescens* (Scop.) Bres.)	root rot, Clitocybe root rot	apple; pear	Armillaria root rot is widely distributed throughout the world and occurs on large number of host plants, including all fruit crops. It is of minor economic importance on apple and pear (Drake, 1997).
Bjerkandera adusta (Willd.:Fr.) P. Karst. (synonym: *Polyporus adustus* (Willd.:Fr.)Fr.; *Polyporus crispus* (Pers.:fr.) Fr.; *Polyporus halesiae* Berk. & M.A. Curtis)		apple	Widespread and recorded on wood, usually of hardwoods (Farr *et al*., 1989). Limited data available. Not mentioned as a pathogen of apple in Compendium of apple and pear diseases.
Butlerelfia eustacei Weresub & Illman (synonym: *Corticium centrifugum* Bres., sensu auct.)	fisheye rot of stored apples	apple; pear	The fungus is primarily a saprophyte that lives on dead or dying tissue in the apple orchard and is a minor post harvest disease (Rosenberger, 1997a). The disease is rare in modern storage and appears primarily in apples that have been held late into the storage season (Rosenberger, 1997a).
Cephalosporium carpogenum Ruehle	apple fruit rot	apple; pear	A minor post-harvest fungi (Rosenberger, 1997b).
Cercospora pyri Farl.(synonym: *Cercosporella pyri* (Farl.) Karakulin)	leaf spot	apple; pear	Reported from north-eastern America (Farr *et al*., 1989). Limited data available. Not mentioned as a pathogen of apple in Compendium of apple and pear diseases.
Cercosporella pyrina Ellis & Everh. (synonym: *Cercospora pirina* Ellis & Everh., nom. nud.)	leaf spot	apple	The fungus has been recorded on Aronia, and Malus in Illinios, Michigan and Wisconsin (Farr *et al*., 1989). Limited data available. Not mentioned as a pathogen of apple in Compendium of apple and pear diseases.
Ceriporia spissa (Schwein.) Rajchenberg (synonym:	wood rot	apple	Widespread and usually on hardwood and it has been

Scientific name	Common name	Host(s)	Comments
Physisporinus spissus (Schwein.) Murril; *Polypous crociporus* Berk. & M.A Curti; *Poria spissa* (Schwein.) Cooke); *Poria crocipora* (Berk. & M.A Curtis) Sacc.)			recorded on Malus (Farr *et al*., 1989). Limited data available. Not mentioned as a pathogen of apple in in Jones & Aldwinkle (1997).
Ceriporiopsis pannocinta (Romell) R.L. Gilbertson & Ryvarden (synonym: *Gloeoporus pannocinctus* (Romell) J. Eriksson; *Poria pannocincta* (Romell) J.Lowe)	wood rot	apple	On hardwood generally.
Cerrena unicolor (Bull.:Fr.) Murrill (synonym: *Daedalea unicolor* (Bull.:Fr) Fr.)	wood rot	apple	On hardwood generally.
Chaetomium funicola Cooke (synonym: *Chaetomium africanum* L. Ames; *Chaetomium setosum* Ellis & Everh.)	fruit rot	apple	Miscellaneous post-harvest decay.
Chaetomium trilaterale Chivers	fruit rot	apple	Miscellaneous post-harvest decay.
Cladosporium elatum (C. Harz) Nannf (synonym: *Cadophora elatum* (C. Harz) Nannf. in Melin & Nannf.)	fruit rot	apple	Miscellaneous post-harvest decay.
Cladosporium extorre Sacc.	unknown	apple; pear	Not recorded in other data bases searched.
Cladosporium malorum *Ruehle*	fruit rot	apple; pear	Miscellaneous post-harvest decay.
Climacodon septentrionalis (Fr.:Fr.) P. Karst. (synonym: *Hydnum septentrionale* Fr.:Fr; *Steccherinum septentrionale* (Fr.:Fr) Banker)	sapwood rot	apple	Occurs on living hardwoods.
Coniophora puteana Schumach.:Fr.) P. Karst. (synonym: *Coniophora cerebella* (Pers.) Pers.; *Coniophora laxa* (Fr.:Fr.) Quel.)	unknown	apple	On wood, usually of conifers, sometimes associated with decay of dead wood or with brown butt rot of living trees.
Coniothyrium convolutum A.S. Horne	unknown	apple	Limited data available.
Conithyrium cydoniae	unknown	apple	Limited data available.
Coniothyrium pyrinum (Sacc.) J Sheld.	fruit & leaf spot	apple; pear	*Coniothyrium pirolum* is listed in AQIS (1998), but it is not recorded elsewhere. Assumed to be a misspelling of *pyrinum.* Also recorded as causing severe dieback and canker on almond trees.
Coriolopsis gallica (Bull.:Fr.) Ryvarden (synonym: *Funalia gallica* (Bull.:Fr.) Bondartev & Singer; *Trametes hispida* Bagl.)	white rot	apple	Recorded on wood.
Coryneum longestipitatum Berl. & Bres.	unknown	apple; pear	Limited data available, identity of fungus in doubt.
Cristulariella moricola (Hino) Redhead (synonym: *Cristularia*	zonate leaf spot	apple	Produces sclerotia that germinate in 1st or 2nd year, giving

Scientific name	Common name	Host(s)	Comments
pyramidalis; teleomorph: *Grovesinia pyramidalis*)			rise to cup-shaped apothecia. Has a very wide host range.
Cystostereum murrayi (Berk. & M.A. Curtis) Pouzar (synonym: *Corticium effusum* Overh.)	white rot	apple	On hardwood generally; recorded as causing heart rot and stem cankers of living trees. Has many synonyms.
Cytospora leucosperma (Pers.:Fr.) Fr.(synonym: *Cytospora ambiens* Sacc.; *Cytospora celtidis* Ellis & Everh.; *Cytospora exasperans* Ellis & Everh.)	Cytospora canker, dieback	apple	Occurs on a variety of woody angioperms. *Cytospora* sp. recorded in Australia (Singh, 1994).
Cytospora leucosticta Ellis & Barth	Cytospora canker, dieback	apple	Limited data available. *Cytospora* sp. recorded in Australia (Singh, 1994).
Cytospora microstoma Sacc. (synonym: *Cytospora microspora* (Corda) Rabenh.; Teleomorph: *Valsa microstoma* (Pers.:fr.) Fr.)	Cytospora canker, dieback	apple	Occurs on a range of hosts. *Cytospora* sp. recorded in Australia (Singh, 1994).
Dendrophora albobadia (Schwein.:Fr.) Chamuris (synonym: *Peniophora albobadia* (Schwein.:Fr.) Boidin; *Peniophora albomarginata* (Schwein.) Massee; *Stereum albobadium* (Schwein.:Fr.) Fr.)	white rot	apple	Occurs on limbs, usually of hardwood.
Diapleella coniothyrium (Fuckel) Barr (synonym: *Leptosphaeria coniothyrium* (Fuckel) Sacc.; *Melanomma coniothyrium* (Fuckel) L. Holm; anamorph: *Coniothyrium fuckelii* Sacc.)	fruit rot, Leptosphaeria canker, bark canker	apple	Stem blight and canker of Rosaceae.
Dothiora pyrenophora (Fr.:Fr.) Fr. (synonym: *Dothidea pyrenophora* Fr.:Fr.)	unknown	apple; pear	Recorded on limbs and twigs.
Fomes fomentarius (L.:Fr.) J. Kickx fil. (synonym: *Fomes griseus* Lazaro; *Polyporus fomentarius* L.:Fr.)	white sponge heart rot	apple; pear	On dead or living hardwood.
Fomes truncatospor	heart rot	pear	Not recorded in other data bases searched.
Fusicladium alopecuri Ellis & Everh.	unknown	apple; pear	Limited information, included because of diseases caused by *Fusicladium* spp.
Fusicoccum pyrorum Chupp & Clapp	canker, dieback	apple	Limited information available.
Gloeophyllum sepiarium (Wulfen:Fr.) P. Karst. (synonym: *Gloeophyllum hirsutum* (Schaeff.) Murrill; *Lenzites sepiarai* (Wulfen:Fr.) Fr.)	sapwood rot	apple	Also spelt 'saepiara'.
Gloeophyllum trabeum (Pers.:Fr.) Murrill (synonym: *Lenzites trabea* (Pers.:fr.)Fr.; *Lenzites vitalis* Peck; *Trametes trabea*	wood decay	apple	Recorded on wood.

Scientific name	Common name	Host(s)	Comments
(Pers.:Fr.) Bres.)			Decays structural timbers.
Helicobasidium mompa Tanaka	violet root rot	apple	Causes serious losses, infects a wide range of hosts, including vegetable crops.
Hendersonia cydoniae Cooke & Ellis	unknown	apple; pear	Latest record from 1942.
Heterobasidion annosum (Fr.:Fr.) Bref. (synonym: *Fomes annosus* (Fr.:Fr.) Cooke; *Fomitopsis annosa* (Fr.:Fr.) P. Karst.)	root rot	apple	Usually on stump and trunk bases, occasionally hardwood, important forest pathogen.
***Hormiscium* sp.** Kunze	apple fruit rot	apple	Causes bitterness in apples.
Hymenochaete agglutinans Ellis	stem canker	apple	Notoriety as a pathogen. Limited data available.
Hypoxylon atropunctatum (Schwein.:Fr.) Cooke (synonym: *Albocrustum atropunctatum* (Schwein.:Fr.) C.G. Lloyd; *Numulariola atropunctatum* (Schwein.:Fr.) House)	sapwood rot	apple; pear	On bark of hardwood.
Hypoxylon mammatum (Wahlenberg) J.H. Miller, (synonym: *Hypoxylon blakei* Berk. & M.A. Curtis; *Hypoxylon morsei* Berk. & M.A. Curtis; *Hypoxylon pruinatum* (Klotzch) Cooke)	unknown	apple	On various hardwood, probably produces stem cankers.
Hypoxylon mediterraneum (De Not.) J.H. Miller, (synonym: *Diatrype clypeus* (Schwein.) Berk.; *Nummularia clypeus* (Schwein.) Cooke)	unknown	apple	On hardwood.
Hypsizygus ulmarius (Bull.:Fr.) Redhead (synonym: *Lyophyllum ulmarium* (Bull.:Fr) Kuhner; *Pleuotus ulmarius* (Bull.:Fr.) P. Kumm.)	wound rot	apple	Limited information available.
Illosporium malifoliorum J. Sheld.	leaf spot	apple; pear	Latest record 1946.
Ischnoderma resinosum (Schrad.:Fr.) P. Karst. (synonym: *Polyporus benzoinus* (Wahlenberg:Fr.) Fr.; *Polyporus resinosus* (Schrad.:Fr.) Fr.; *Trametes benzoina* (Wahlenberg:Fr.) Fr.)	sapwood rot	apple	On wood
Laetiporus sulphureus (Bull.:Fr.) Murrill (synonym: *Polyporus sulphureus* (Bull.:Fr.) Fr.)	sapwood rot	apple; pear	Causes heart rot of living trees.
Leptosphaeria mandshurica	leaf spot	apple; pear	Limited data available.
Leptosphaeria yulan (synonym: *Leptosphaeria pomona*)	leaf spot	apple	Limited data available.
Leptothyrium carpophilum Pass.	fly speck	apple; pear	Limited data available.
Macrosporium piricolum	Macrosporium leaf spot	pear	Not recorded in other databases searched. Note *nom. rej.*=

Scientific name	Common name	Host(s)	Comments
			Alternaria.
Massaria pyri G. Otth In Tul. & C. Tul. (synonym: *Agaospora occulta* (Ellis) Farl., *Massaria pruni* Wehmeyer)	unknown	apple; pear	Limited information.
Monochaetia concentrica (Berk. & Broome) Sacc. (synonym: *Pestalotia concentrica* Berk. & Broome)	leaf spot	apple	Also on dead leaves of hardwood.
Mycosphaerella pyri (Auersw.) Boerema (synonym: *Mycosphaerella sentina* (Fr.) Schröter; Septoria pyricola Desm)	leaf spot, white spot or leaf fleck of pear	pear; apple	Mycosphaerella leaf spot is of minor economic importance on pear except possibly for nursery planting (van der Zwet, 1997). Infections are mainly confined to the foliage, Spots first appear on the upper leaf surface and are greyish white with purplish margins, have sharply defined margins at maturity and contain small, black, scattered pycnidia in their centre. Occasionally, the dead tissue in the spot drops out, giving a short-hole appearance to the leaves (van der Zwet, 1997). The fungus overwinter on dead leaves, and perithecia are formed in overwintering leaves discharge ascospores in the spring. Primary infections result only from ascospores. Secondary infections are most abundant when moisture is present to disseminate conidia (van der Zwet, 1997).
Mycosphaerella tulanesi (Jancz.) Lindau	fruit rot	apple; pear	Also called *Mycosphaerella tassiana* (de Not) Johnson.
Nectria coccinea (Pers.:Fr.) Fr. (synonym: *Cylindrocarpon candidum* (Link) Wollenweb.)	unknown	apple; pear	This fungus has a very wide host range.
Nectria ditissima Tul. & C. Tul.	canker	apple; pear	Very wide host range.
Neurospora sitophila Shear & B.O. Dodge, (anamorph: *Chrysonilia sitophila* (Mont.) Arx.	ripe rot, wood decay	pear	Also called *Monilia sitophila.*
Omphalotus olearius (DC.:Fr.) Singer (synonym: *Clitocybe illudens* (Schwein.) Sacc., *Monodelphus subilludens* Murrill, *Ompohalotus illudens* (Schwein.) Bresinsky & Besl.)	root rot	apple	Lignicolous, common on hardwood stumps.
Oospora mali M.N. Kidd & A. Beaumont	unknown	apple; pear	Causes sour rot of citrus. Also named *Geotrichum candidum.*
Oxyporus latemarginatus (Durieu & Mont.) Donk (synonym: *Poria ambigua* Bres.; *Poria latemarginata* (Durieu & Mont.) Cooke)	white rot	apple	On dead wood of hardwood.
Pestalotia disseminata Theum (synonym: *Pestalotiopsis*	leaf spot	apple	Mostly recorded on Eucalyptus leaves.

Scientific name	Common name	Host(s)	Comments
disseminata (Thuem.) Steyaert)			
Pestalotia hartgii Tub. (synonym: *Truncatella hartigii* (Tub) Steyaert)	leaf spot, wilt, root rot	apple; pear	Seed-borne. Also on stems, branches or twigs, associated with necrosis of pine needles.
***Pestalotia* sp.** De Not.	Pestalotia leaf spot	apple; pear	Listed in AQIS (1998).
Pestalotiopsis maculans (Corda) Nag Raj (synonym: *Hendersonia maculans* (Corda) Lev.; *Pestalotia maculans* (Corda) S.J. Hughes; *Sporocadus maculans* Corda)	leaf spot	pear	Causal agent of grey leaf spot of Camellia. Limited information available.
Pezicula pruinosa Farl. (synonym: *Cryptoriopsis pruinosa* (Peck) Wollenweb.	unknown	apple; pear	Recorded on twigs, limited data available.
Phaeosclerotinia nipponica	leaf spot	apple	Not recorded in other data bases searched. Note anamorph is *Monilia* spp.
Phaeospora nashi	leaf spot	pear	Not recorded in other data bases searched. This species is generally associated with lichenized green algae.
Phellinus gilvus (Schwein.:Fr.) Pat. (synonym: *Hapalopilus gilvus* (Schwein.:Fr.) Murrill; *Polyporus gilvus* (Schwein.:Fr.) Fr.; *Polyporus licnoides* Mont.)	sapwood rot	apple; pear	On living and dead hardwood.
Phellinus ignarius (L.:Fr.) Quel. (synonym: *Fomes igniarius* (L.:Fr.) J. Kickx Fil.)	white heart rot	apple; pear	On living and dead hardwood.
Pholiota adiposa (Fr.:Fr.) P. Kumm. (synonym: *Pholita aurivella* (Fr.) P. Kumm.	brown cubical heart rot	apple	On wood.
Phoma fuliginea M.N. Kidd & A. Beaumont	unknown	apple	Limited data available.
Phyllosticta clypeata Ellis & Everh.	unknown	apple; pear	On leaves, petioles and twigs. Limited data available.
Phyllosticta pyrorum Cooke	leaf spot	pear	Limited data available.
Phyllosticta zonata Ellis & Everh.	leaf spot	apple; pear	Limited data available.
Phymatotrichopsis omnivora (Duggar) Hennebert (synonym: *Ozonium omnivorum* Shear; *Phymatotrichum omnivorum* Duggar)	root rot	apple; pear	Serious root pathogen on many plant species.
Polyporus admirabilis Peck (synonym: *Polyporus underwoodii* Murrill)	sapwood rot	apple	On living hardwood, stumps and roots.
Polyporus squamosus (Huds.:Fr.) Fr. (synonym: *Agaricus squamosus* P. Mich. ex Huds.; *Polyporus westii* Murrill)	wood destroying fungi	pear	On living or dead hardwood.

Scientific name	Common name	Host(s)	Comments
Postia caesia (Schrad.:Fr.) P. Karst. (synonym: *Oligoporus caesius* (Schrad.:Fr.) R.L. Gilbrtson & Ryvarden; *Polyporus caesius* (Schrad.:Fr.) Fr.; *Tryomyces caesius* (Schrad.:Fr.) Murrill)	sapwood rot	apple	On wood, usually hardwood.
Postia stipticus (Pers.:Fr.) Julich (synonym: *Polyporus immitis* Peck; *Polyporus stipticus* (Pers.:Fr.) Fr.; *Oligoporus stipticus* (Pers.:Fr.) R.L. Gilbertson & Ryvarden)	sapwood rot	apple	On wood, usually hardwood.
Potebniamyces discolor	apple bark canker	apple; pear	Limited data available.
Potebniamyces pyri	unknown	apple; pear	Limited data available.
Pseudocercospora mali (Ellis & Everh.) Deighton. (synonym: *Cercopora mali* Ellis & Everh.; *Cercospora minima* Tracey & Earle)	leaf spot	apple	This fungus has been recorded on apple and pear (Farr *et al*., 1989), but limited data is available. Not mentioned as a disease of apple or pear in Compendium of Apple and Pear Diseases (Jones, & Aldwinckle, 1997).
Pyrenochaeta mali M.A. Sm.	fruit rot	apple	Possibly same as *Phoma herbarum.*
Pythium dictyosporum Racib. (synonym: *Nematosporangium dictyosporum* (Racib.) J. Schrot.)	unknown	pear	Isolated from roots and crowns of pear trees.
Pythium megalacanthum de Bary	unknown	pear	Isolated from roots and crowns of pear trees.
Pythium pulchrum Minden (synonym: *Pythium epigynum* Hohn.)	unknown	pear	Isolated from roots and crowns of pear trees.
Roesleria pallida (Pers.) Sacc. (synonym: *Coniocybe pallida* (Pers.) Fr.; *Roesleria hypogaea* Thuem. & Pass.)	root rot of seedlings	apple	On bark - especially of dead roots often well below soil level.
Rosellinia aquilina (Fr.:Fr.) De Not.	wood destroying fungus	apple	Root rot of mulberry, also on many hardwoods.
Schizothyrium perexiguum (Roberge) Hohn	fly speck of fruit	apple	On cuticle of living and dead stems of various plants.
Scytinostroma galactinum (Fr.) Donk (synonym: *Corticium galactinum* (Fr.) Burt)	root rot, eastern white root rot	apple	Root, butt and collar rot of conifers and hardwoods.
Seimatosporium caudatum (G. Preuss) Shoemaker	unknown	pear	On leaves and stems.
Seimatosporium discosioides (Ellis & Everh.) Shoemaker (synonym: *Pestalotia discosioides* Ellis & Everh.)	unknown	pear	Also recorded as causing leaf spot on *Eucalyptus* spp.
Septobasidium bogoriense	felt fungus	apple	*Septobasidium* Pat., *nom cons*. Most species occur on scale insects, but are often reported on their plant hosts.

Scientific name	Common name	Host(s)	Comments
Septobasidium tanaka	felt fungus	apple; pear	Limited data available.
Sphaerulina potebniae Sacc.	leaf spot	pear	Limited data available.
Spongipellis spumeus (Sowerby:Fr.) Pat. (synonym: *Polyporus spumeus* (Sowerby:Fr,) Fr.; *Spongipellis occidentalis* Murrill; *Tyromyces spumeus* (Sowerby:Fr.) Imazeki)	sapwood rot	apple	On hard wood.
Steccherinum ochraceum (Pers.:Fr.) S.F.Gray (synonym: *Hydum ochraceum* Pers.:Fr)	sapwood rot	apple	On hard wood.
Taphrina bullata (Berk.) Tul.	on leaves	apple; pear	Limited data available.
Trametes pubescens (Schumach.:Fr.) Pilat (synonym: *Coriolus pubescens* (Schumach.:) Quel.; *Polyporus pubescens* (Schumach.:Fr.) Fr.; *Polyporus velutinus* Fr.:Fr.)	white rot	apple	On hard wood.
Trichoseptoria fructigena Maubl.	soft rot	apple	Storage disease.
Tripospermum mytri (Lind) S.J. Hughes (synonym: *Triposporium myrti* Lind)	unknown	apple	On scab lesions.
Tryomyces chioneus (Fr.:Fr.) P. Karst. (synonym: *Polyporus albellus* Peck; *Polyporus chioneus* Fr.:Fr.)	sapwood rot	apple	On hardwood.
Tryomyces fissilis (Berk. & M.A Curtis) Donk (synonym: *Polyporus albosordescens* Romell; *Polyporus fissilis* Berk. & M.A. Curtis; *Polyporus fuscomutans* C.G. Lloyd)	sapwood rot	apple	On hardwood.
Tyromyces galactinus (Berk.) J. Lowe (synonym: *Polyporus galactinus* Berk.; *Polyporus iowensis* C.G. Lloyd)	sapwood rot	apple	On hardwood.
Tyromyces subgiganteus (Berk. & M.A. Curtis) Ryvarden (synonym: *Polyporus spumeus* var. *malicola* C.G. Lloyd; *Polyporus subgiganteus* Berk. & M.A. Curtis; *Tyromyces spumeus* var. *malicola* (C.G. Lloyd) J. Lowe)	sapwood rot	apple	On wood.
Valsa papyriferae (Scheiwn.) Cooke (synonym: *Valsella papyriferae* (Schwein.) Berl. & Voglino)	unknown	apple	Limited data available; possibly a *Diatrypella* spp.
Valsella melastoma (Fr.) Fuckel	unknown	apples	Limited data available.
Xylaria longiana Rhem	root rot	apple	On wood, limited data available. *Xylaria* sp. has been recorded in Australia.
Xylaria mali Fromme	black root rot	apple; pear	Virulent pathogen of apple with the potential for damaging

Scientific name	Common name	Host(s)	Comments
			other hardwood. *Xylaria* sp. has been recorded in Australia.
Xylaria polymorpha (Pers.:Fr) Dumort. (synonym:*Xylosphaera polymorpha* (Pers.:Fr) Dumort.)	black root rot	apple	Occurrence is minor in comparison to *X. mali*. *Xylaria* sp. has been recorded in Australia.

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ATTACHMENT 3: Diseases of Unknown Aetiology of Apple (*Malus*) and Pear (*Pyrus*)

Disease	Pathogen	Host(s)	Present in Australia	Quarantine/ importance	Reference
Apple blister bark 1	viroid?	Apple	?	no/minor	http://www.nrsp5.wsu.edu/ddp00002.html
Apple blister bark 2	unknown	Apple	?	no/minor	http://www.nrsp5.wsu.edu/ddp00003.html
Apple blister bark 3	unknown	Apple	?	no/minor	http://www.nrsp5.wsu.edu/ddp00004.html
Apple brown ringspot	virus?	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00005.html
Apple bumpy fruit (India)	viroid?	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00090.html
Apple bumpy fruit (Ben Davis)	virus?/ viroid?	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00006.html
Apple bunchy top	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00007.html
Apple dead spur	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00011.html
Apple decline	phytoplasma?	Apple	no	no/minor	http://www.nrsp5.wsu.edu/nrspgtp.html
Apple decline (*Malus robusta* No. 5)	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00013.html
Apple depression (McIntosh)	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00015.html
Apple false sting	virus?	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00016.html
Apple flat limb	unknown	Apple	yes	no/minor	http://www.nrsp5.wsu.edu/ddp00020.html Singh (1994)
Apple freckle scurf	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00021.html
Apple fruit blotch (Stayman)	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00022.html
Apple fruit wrinkle (Newton)	virus?	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00024.html
Apple green crinkle	virus?	Apple	yes	no/minor	http://www.nrsp5.wsu.edu/nrspgtp.html Singh (1994)
Apple green mottle	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00027.html
Apple horseshoe wound	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00028.html
Apple internal bark necrosis	unknown	Apple	yes	no/minor	http://www.nrsp5.wsu.edu/ddp00029.html Singh (1994)

Disease	Pathogen	Host(s)	Present in Australia	Quarantine/ importance	Reference
Apple junction necrotic pitting	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00030.html
Apple leaf fleck, bark blister, fruit russet and distortion (Granny Smith)	unknown	Apple	?	no/minor	http://www.nrsp5.wsu.edu/ddp00001.html
Apple little leaf	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00033.html
Apple narrow leaf	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00036.html
Apple necrosis	virus?	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00091.html
Apple necrotic spot and mottle	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00037.html
Apple painted face	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00038.html
Apple pustule canker	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00040.html
Apple red ring (Red Delicious)	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00041.html
Apple ring and line pattern (Jubilee)	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00042.html
Apple ring russeting (Delicious)	unknown	Apple	yes	no/minor	http://www.nrsp5.wsu.edu/ddp00043.html Singh (1994)
Apple rosette	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00045.html
Apple rough bark	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00046.html
Apple rough skin	unknown	Apple	yes	no/minor	http://www.nrsp5.wsu.edu/ddp00047.html Singh (1994)
Apple rubbery wood	unknown	Apple; pear	yes	yes/important disease	http://www.nrsp5.wsu.edu/ddp00048.html Singh (1994)
Apple russet ring	unknown	Apple	yes	no/minor	Singh (1994)
Apple russet wart	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00050.html
Apple scaly bark (*Malus platycarpa*)	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00052.html
Apple small fruit	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00054.html
Apple star crack	unknown	Apple	yes	no/minor	http://www.nrsp5.wsu.edu/ddp00055.html Singh (1994)
Pear bark measles	unknown	Apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00062.html

Disease	Pathogen	Host(s)	Present in Australia	Quarantine/ importance	Reference
Pear bark necrosis	unknown	apple	?	no/minor	http://www.nrsp5.wsu.edu/ddp00063.html
Pear bark split	unknown	apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00064.html
Pear bud drop	unknown	apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00066.html
Pear concentric ring pattern	unknown	apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00088.html
Pear corky pit	unknown	apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00067.html
Pear freckle pit	unknown	apple	no	no/minor	http://www.nrsp5.wsu.edu/ddp00069.html
Pear mild mosaic	unknown	pear	no	no/minor	http://www.nrsp5.wsu.edu/ddp00071.html
Pear rough bark	unknown	pear	no	no/minor	http://www.nrsp5.wsu.edu/ddp00075.html
Pear stony pit	virus?	apple	yes	no/minor	http://www.nrsp5.wsu.edu/nrspgtp.html Singh (1994)
Pear unknown	unknown	pear	no	no/minor	http://www.nrsp5.wsu.edu/ddp00070.html
Pear yellow blotch	unknown	pear	no	no/minor	http://www.nrsp5.wsu.edu/ddp00081.html

Diseases that are rarely found are represented by shaded areas.

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ATTACHMENT 4: Alterations to Lists A, B & C in the DNRE Report.

Deletions:

Those recorded in Australia

Chaetomella sp. Fuckel - recorded on *Banksia marginata* in Australia (USDA, 1999).

Colletototrichum acutatum J.H. Simmonds - fruit rot of a variety of plants, recorded in Australia (USDA, 1999; Singh,1994). Many older reports of *C. gloeosporioides.*

Cytospora rhizophorae Kohlmeyer & E. Kohlmeyer. - recorded in Australia under synonym, *Cytospora rubescens* Fr. (Singh, 1994). Note also recorded as *Leucostoma cincta* (Fr.) Hohn, preferred name *Valsa cincta* Sacc. (CABI, 1998). Other synonyms used include *Cytospora personata* Fr., *Cytospora rhuina* Fr., *Cytospora rubi* Schwein & *Cytospora cincta.*

Diaporthe citri F.A. Wolf - listed in AQIS (1998b) as quarantinable, but has been recorded in Australia (USDA, 1999; CABI, 1998).

Diaporthe eres Nitschke - listed as non-quarantinable in AQIS (1998a); see also Singh (1994).

Diplodia malorum Fuckel syn. *Botryosphaeria obtusa* - recorded in Australia (Singh, 1994).

Elsinoe piri (Woronichin) Jenk - recorded in Australia (NCOF, 1998).

Eutypella scoparia (Schwein.:Fr) Ellis & Everh. - recorded in Australia on Melville Is. (Yuan-ZiQing, 1996).

Hendersonia mali Thuem - recorded in Australia (Singh, 1994).

Leucostoma persoonii Hohn - present in Australia (Singh, 1994).

Monilinia spp. - this genus cannot be included because it is recorded in Australia (Singh, 1994).

Mycosphaerella pomi (Pass.) Lindau - occurs in Australia (Singh, 1994; CABI, 1998).

Nectria cinnabrina (Tode:fr.) Fr. - occurs in Australia (Singh, 1994).

Pestalotia breviseta (Sacc.) Steyaert - recorded in Australia on Banksia leaves (USDA, 1999).

Phoma macrostoma - Mont. - recorded in Australia (USDA, 1999; Singh, 1994).

Ramularia destructans Zinssm. - recorded in Australia (CABI, 1998).

Stemphyllium vesicarium - recorded in Australia (USDA, 1999).

Ulocladium consortiale (Theum.) E. Simmons - recorded in Australia (Singh, 1994).

Valsa ambiens (Pers.:Fr.) Fr. - listed in AQIS (1997) as quarantinable; recorded in Australia (Singh, 1994).

Valsa ceratosperma (Tode:Fr.) Maire - listed in Australia (AQIS, 1998a).

Valsaria insitiva (Tode:Fr.) Ces. & De Not. - recorded in Australia (Yuan-ZiQing, 1996).

Others

Note: Most of the fungi listed below were recorded in Farr *et al*. (1989), and USDA (1999) but had no record in the CABI (1998) or Winspirs for the data bases searched (see references). Most of these organisms are also single records in the various fungal databases in which they are recorded. They are not recorded as causing any pathogenic symptoms on their substrate material; indeed many records are from dead material, or not causing / associated with any symptoms.

Berkleasmium moriforme (Peck) R.T. Moore - recorded on dead apple wood (Farr *et al*., 1989).

Cenangium tuberculiforme Ellis & Everh. - on dead apple limbs (Farr *et al*., 1989).

Clonostachys arauriaria Corda - isolated from dead bark of pear (Farr *et al*., 1989).

Coniothyrium pirolum - not recorded in other data bases searched. Only reported in AQIS (1998b). Possibly a misspelling of *pyrinum*.

Cristinia gallica (Pilat) Julich - on apple wood (Farr *et al*., 1989).

Cylindrocarpon angustum Wollenweb. in Zeller - on apple bark. Note that Booth (Mycol. Pap. 104:50, 1966) was not able to characterise this species which is known from the initial report.

Daedaleopsis confragosa (Bolton:Fr.) J. Schrot. - recorded on apple wood (Farr *et al*., 1989).

Dendrophora erumpens (Burt) Chamuris - unknown symptom on apple (Farr *et al*., 1989).

Dendrophora versiformis (Berk. & M.A. Curtis) Chamuris - unknown symptom on apple (Farr *et al*., 1989).

Dendrosporium lobatum Plakidas & Edgerton ex J.L. Crane - isolated from pear bark (Farr *et al*., 1989).

Diatrypella nitschkei (Fuckel) L.C. Tiffany & Gilman - unknown symptoms on pear (Farr *et al*., 1989).

Eutypella leprosa (Pers.:Fr.) Berl. - unknown symptom on apple; on wood of hardwoods (Farr *et al*., 1989).

Eutypella prunastri (Pers.:fr) Sacc. - unknown symptoms on apple (Farr *et al*., 1989).

Fumago vagans Pers., nom. conf. - this is an invalid genus, consisting of two entirely discordant elements, *Aureobasidium pullulans* and *Cladosporium herbarum*, both of which occur in Australia.

Glyphium corrugatum (Ellis) H. Goree - unknown symptom on apple (Farr *et al*., 1989).

Haplotrichum conspersum (Lnk:Fr.) Holubova - Jechova - in hollow stump of apple tree (Farr *et al*., 1989).

Hyphoderma litschaueri (Burt) J. Eriksonn & A. Strid in Eriksson - recorded on apple bark (Farr *et al*., 1989).

Hysterium pulicare Pers.:Fr. - unknown symptoms on apple, but has been recorded from the bark of living trees and dead wood (Farr *et al*., 1989).

Jattae microtheca (Cooke & Ellis) Berl. - recorded on the limbs of apple (Farr *et al*., 1989).

Leucostoma cincta (Fr.) Hohn - see *Cytospora rhizophorae* (syn. *C. personata*, *C. rubescens*, etc.).

Melanopsamma improvisa (P. Karst.) Sacc. - unknown symptom on apple (Farr *et al*., 1989).

Mollisia caespitia (P. Karst) P. Karst - On dead twigs and bark of apple (Farr *et al*., 1989).

Monilina pyrina - no information in databases searched.

Monilinia fructicola (G. Wint.) Honey - no longer under official control in WA (Simon McKirdy, pers. comm.).

Nectria vulpina (Cooke) Ellis - recorded on dead wood of apple (Farr *et al*., 1989).

Oospora otophila C. Harz - unknown symptom on apple (Farr *et al*., 1989).

Otthia amica Sacc., E. Bommer & M. Rousseau - unknown symptom on apple (Farr *et al*., 1989).

Panellus serotinus (Pers.:Fr.) Kuhner - unknown symptom on apple (Farr *et al*., 1989).

Panellus stipticus (Bull.:Fr.) P. Karst. - unknown symptom on apple (Farr *et al*., 1989).

Perennipora tenuis (Schwein.) Ryvarden - unknown symptom on apple (Farr *et al*., 1989).

Peziza repanda Pers. - unknown symptom on apple (Farr *et al*., 1989).

Pezizella regalis (Cooke & Ellis) Sacc. - recorded on apple bark (Farr *et al*., 1989).

Phanerochaete flavido-alba (Cooke) S.S. Rattan - recorded on apple wood (Farr *et al*., 1989).

Phellinus ferruginosus (Schrad.:Fr.) Pat. - Recorded on apple wood (Farr *et al*., 1989).

Phlebia merismoides (Fr.:Fr) Fr. - unknown symptom on apple (Farr *et al*., 1989).

Phlebia rufa (Fr.:Fr.) M. Christiansen - unknown symptom on wood (Farr *et al*., 1989).

Phlebia tremellosus (Schrad.:Fr.) Nakasone & Burdsall - unknown symptom on apple (Farr *et al*., 1989).

Pleurotus dryinus (Pers.:Fr.) P. Kumm. - unknown symptom on apple (Farr *et al*., 1989).

Postia tephroleuca (Fr.:Fr.) Julich - unknown symptom on pear (Farr *et al*., 1989).

Protleurotus sp. - no records of this fungus in databases searched.

Psathyrella incerta (Peck) A.H. Sm. - on roots around stumps of apple (Farr *et al*., 1989).

Pulcherricium caeruleum (Schrad.:Fr.) Parmasto - recorded on wood of apple (Farr *et al*., 1989).

Sarcontia setosa (Pers.) Donk - unknown symptom on apple (Farr *et al*., 1989).

Schizoxylon albo-atrum Rehm - unknown symptom on pear (Farr *et al*., 1989).

Scolicosporium pedicellatum Dearn. & Overh. - unknown symptoms on apple bark (Farr *et al*., 1989).

Sporidiobolus pararoseus J. Fell & Tallman - recorded on rusted apple leaves (Farr *et al*., 1989).

Steccherinum hirsutum - unknown symptoms, not recorded on databases searched.

Sticis radiata Pers.:Fr. - unknown symptom on pear (Farr *et al*., 1989).

Tympanis alnea (Pers.:Fr.) Fr. - unknown symptoms on apple (Farr *et al*., 1989).

Tympanis conspersa Fr. - unknown symptoms on apple twigs (Farr *et al*., 1989).

Xenotypa aterrima (Fr.:Fr.) Petr. - recorded on apple bark (Farr *et al*., 1989).

Xylaria carpophila (Pers.:Fr.) Fr. - unknown symptom on pear (Farr *et al*., 1989).

Xylaria curta Fr. - recorded on apple roots and wood, cosmopolitan (Farr *et al*., 1989).

Synonyms

Ceratobasidium stevensii & Corticium stevensii & Pellicularia koleroga - preferred name is *Corticium koleroga* (Cooke) Hohnel.

Cytospora personata & Cytospora rubescens - preferred name is *Cytospora.rhizophora*. See deletions.

Gymnosporangium species - there are 21 *Gymnosporangium* species listed, 2 as the aecial state, *Roestelia* (Jones & Aldwinckle, 1997). Since *Gymnosporangium* species do not occur in Australia, the entire genus was listed as quarantinable.

Mycosphaerella pyri (Auersw.) Boerema syn. *Mycosphaerella sentina* anamorph *Septoria pyricola* (Desmaz). Desmaz. - listed in AQIS (1997), AQIS (1998b) and Jones & Aldwinckle (1997).

Phyllactinia corylea (Pers.) P. Karst - listed in AQIS (1997), synonymous with *Phyllactinia guttata* (Wallr.:Fr.) Lev.

Additions

Macrosporium piricolum - listed in AQIS (1998b), although not recorded in other databases searched, *note nom. rej. = Alternaria*.

Pestalotia sp. De Not. - listed in AQIS (1998b). Note *Pestalotia breviseta* Sacc., which is listed as quarantinable in AQIS (1998a) is recorded in Australia (USDA, 1999). *Pestalotia disseminata* is recorded as quarantinable in AQIS (1998a) but not recorded on pome in other databases searched.

Potebniamyces discolor - recorded in Ainworth & Bisby (1995) as causing apple bark canker.

Septobasidium bogoriense - listed in AQIS (1998a) & USDA (1999).

Steccherinum ochraceum (Pers.:Fr) S.F. Gray - Causes apple sapwood rot.

Xylaria polymorpha (Pers.:Fr) Grev. - Black root rot, wood rot.

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